SEPTEMBER PRACTICAL ELECTRICAL ENGINEER No. 13

QUESTIONS AND ANSWERS BY PRACTICAL MEN NEW FEATURE

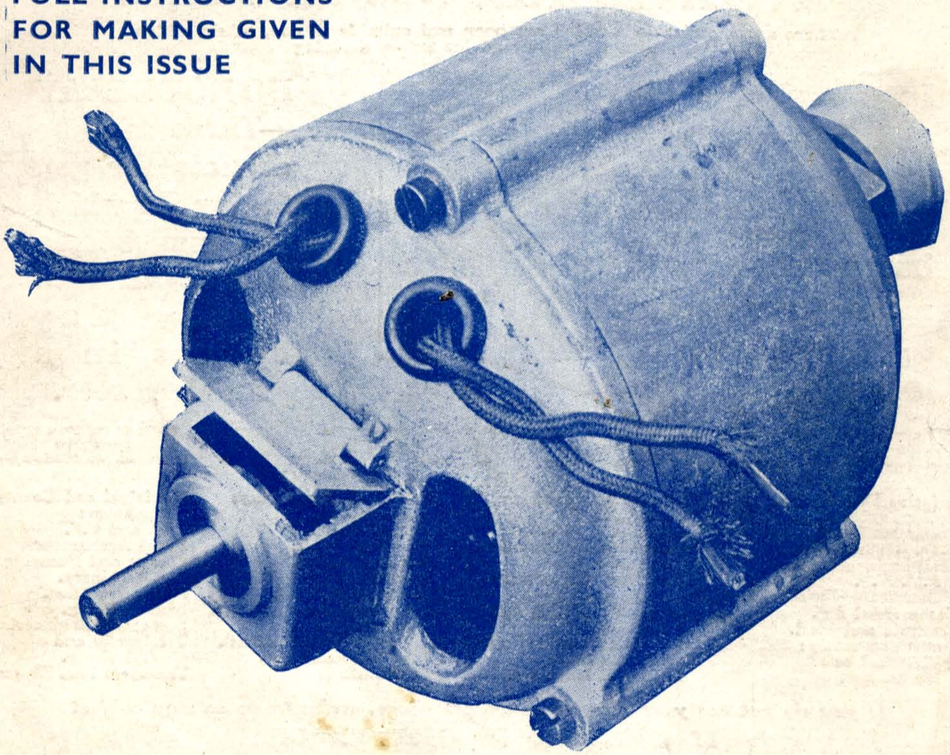
The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY MAGAZINE OF ELECTRICAL PROGRESS

VOL. II.—No. 13 SEPTEMBER 1933

DESIGN FOR A $\frac{1}{8}$ H.P. INDUCTION MOTOR

FULL INSTRUCTIONS FOR MAKING GIVEN IN THIS ISSUE



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GEORGE NEWNES LTD.

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

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A Striking Example of how Science can help Business.

We hear many examples in these days of how science is being brought to bear on improving the production side of industry. A striking example of this is given on pages 6-11, where are shown some details of the use of the Weston illumination meter. While there are, of course, other instruments of a similar high standard available, they all have one point in common, they enable the busy, practical man to demonstrate to his customer, i.e., the works manager, whether his lighting is up to the standard which will give the best output. Years ago photometry was regarded as a science which could only be practised in the photometric laboratory. To-day it is still a science, but it has been brought out of the laboratory and made easily available to installation engineers and contractors to whom it should prove the means of securing new business during the coming winter months.

Further Development of Gas-discharge Tubes.

We have already referred in a previous issue to the "Osira" discharge lamp. The development and practical application of the electric discharge lamp is one of the most important recent advances in the technique of light production, and the latest development is the Mazda Mercra lamp. It will be remembered that the "Osira" lamp works at a low temperature. The Mercra lamp, however, has a double-walled bulb, the inner container of which becomes exceedingly hot while the lamp is in operation. Readers will be interested in the description of this new development, which appears on page 3. It is a subject on which we hope to keep our readers fully informed in forthcoming issues.

For Wireless Engineers.

The subject of alternating current bridge methods of electrical measurement is one which has for years been regarded by electrical engineers as a highly technical one, and we believe that one or two very learned treatises have been devoted to the subject. We are glad to be able to publish an article which illustrates some practical methods of using an alternating current bridge for measuring and comparing inductances such as are used in wireless receivers. The principle employed is, of course, similar to that of the Wheatstone bridge and anyone who is familiar with the principle of this will have no difficulty in following the methods described in the article on page 33.

Our Motor Design.

The original design for a $\frac{1}{8}$ h.p. induction motor, which is given in the article on page 21, has been included at the special request of several readers. It is not suggested that it would be cheaper to make such a motor than to purchase one of the many excellent designs obtainable from electrical manufacturers. There are, however, hundreds of electrical engineers who, we believe, will thoroughly enjoy building this little machine from the instructions given. It cannot be denied that there is a pleasure to be obtained from seeing it work which will appeal not only to the student but to the engineer who believes in using his hands as a relaxation from using his brains. Incidentally, an actual motor has been constructed by the designer, and has been running very satisfactorily, and as the instructions for making it are quite clear, no difficulty should be experienced by those readers who decide to build the motor.

Development in the Mercury Arc Rectifier.

It is interesting to think that had the Thyratron or grid-controlled mercury vapour rectifier reached its present state of perfection ten years ago, it is not inconceivable that the present grid system would have been planned on entirely different lines. There is no doubt that the possibility of dealing with very large currents by means of the Thyratron rectifier is of very great importance in the future development of electrical transmission and distribution. As will be seen from the article on page 14, the Thyratron makes it possible not only to rectify currents of hundreds of amps, but to stop or start them or to control their magnitude, the power necessary for control being only of the order of a few milliwatts.

Planning a Distribution System.

The problem of planning the distribution system for a house is one that requires a good deal of care, as not only must immediate requirements be considered, but some provision should be made for future extensions. In the article on page 15 Mr. J. V. Brittain, A.M.I.E.E., deals with the problem in a thorough manner, and his article will, we think, be of considerable interest to many of our readers.

Telecontrolled Radio.

The idea of being able to place a wireless set in some out-of-the-way place, and then be able to control it from anywhere in the house has a tremendous fascination about it. A practical means of doing this has recently been placed on the market by Halford Radio, Ltd., whose system of telecontrolled radio consists of an operating unit and a small control box suitable for carrying about in one hand and which has a length of flex attached to it so that it can be plugged in at any point in a room where most convenient, after, of course, the house has been suitably wired. Thus, you can sit in a comfortable armchair or lie in bed, with the control box by your side, and choose any station that your wireless set is capable of receiving. Practically any modern set can be converted for telecontrol, the only essentials being that the condenser spindles must permit of attachment to the drive of the operating unit; the volume control must be of the variable bias type; and it must be possible to fit the wave-change switch without disturbing the balance of the receiver.

Safety in Mines.

For many years mining engineers have been seeking a solution to the question of providing an adequate lighting system in coal mines. The main consideration is, of course, that it must be free from danger when operating in the presence of firedamp or coal dust. While battery lamps have been improved considerably, the fact that their candle power is limited, since weight has to be considered, makes them unsuitable for the purpose. On page 40 will be found details of a self-contained pneumatic electric lamp and generator, operated from compressed air line, which has been specially developed for improving the lighting of collieries without increasing the danger of explosion.

A Visit to the Cossor Works.

We were recently privileged to spend an interesting morning at the works of Messrs. A. C. Cossor, Ltd., where we watched the evolution of a valve from the raw materials to the finished article. Each valve takes roughly three hours to make, during which time it goes through about 20 named processes. Some of the machines for certain processes are capable of dealing with as many as 64 valves at a time.

The efficient manner in which the Cossor people are turning out their products in readiness for the coming winter months is an encouraging sign of the healthy state of the radio industry.

Questions and Answers by Practical Men.

We believe that many readers will welcome the new feature under the above heading, which appears on page 44. It is our aim to help readers as much as possible with practical problems that crop up in the course of everyday work, and we feel that one of the best methods of doing this is to obtain the advice of practical men in the industry, who may have found themselves faced with similar difficulties from time to time. If you have a problem, or if you have an answer to any question published, we shall be interested to hear from you. Any answers published will, of course, be paid for at our usual rates.

THE MAZDA MERCRA LAMP

A FURTHER DEVELOPMENT OF GAS-DISCHARGE TUBES

Readers will remember the recent article dealing with the "Osira" lamp. Another development of gas-discharge tubes is the Mazda Mercra lamp, developed by the British Thomson-Houston Co., details of which are given in this article

SHOWING THE USE OF MAZDA MERCRA LAMPS FOR FLOODLIGHTING THE ROYAL BATH HOTEL, BOURNEMOUTH.

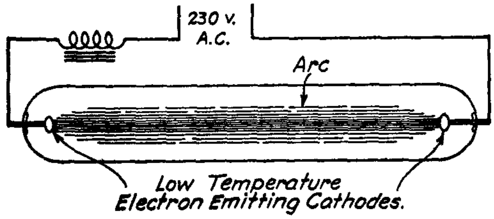
THE problem of obtaining still higher efficiencies from electric lamps continues to engage the attention of some of the best brains in the electrical industry. The Mazda Mercra lamp is the most recent development. Briefly, it consists of a special form of mercury vapour lamp, with a double-walled bulb. The inner glass container becomes exceedingly hot while the lamp is in operation ; the outer container is separated from it by a vacuous space, as shown in the diagram at the foot of the following page.

Consumes 400 Watts.

There were many practical difficulties that had to be overcome before the high-power gas-discharge lamp became a practicable light source capable of operation on the usual voltages ; but these difficulties have been overcome in the B.T.H. Lamp Works and Laboratories, and lamps have been constructed in the form shown in one of the diagrams. The lamp illustrated operates on 230 volts A.C., and consumes 400 watts. The hot cathodes are of the self-exciting electron-emitting type, i.e., they are heated only by the energy of the discharge ; and the high temperature of the vapour necessary for the efficient production of the light is maintained by surrounding the inner tube (containing the electrodes and the metallic vapour) by a vacuum jacket.

Changes that Occur When Lamp is Switched On.

It is especially interesting to observe the changes in the form of the arc and the luminous output when the lamp is first switched on and is quickly heating up. At first the lamp is filled with a uniform pale blue glow. As the temperature rises and the vapour pressure increases, the luminous column leaves the walls of the tube and narrows down until finally it appears as a brilliant narrow cord in the centre of the tube. It is at this final stage that the luminous output is high, and also the quality of the light is much improved as compared with that of the ordinary mercury glow.



THE MAZDA MERCRA LAMP.

Suitable for street and highway lighting, floodlighting, etc.

Efficiency is 40 Lumens per Watt.

Spectrographic records of Mazda Mercra lamps have been taken during this rapid warming up process, and the progressive increase in the red radiation is clearly indicated. The lamps need a small stabilising choke in series with them, and power factor can be corrected readily by means of a condenser. The efficiency of the lamps is approximately 40 lumens per watt.

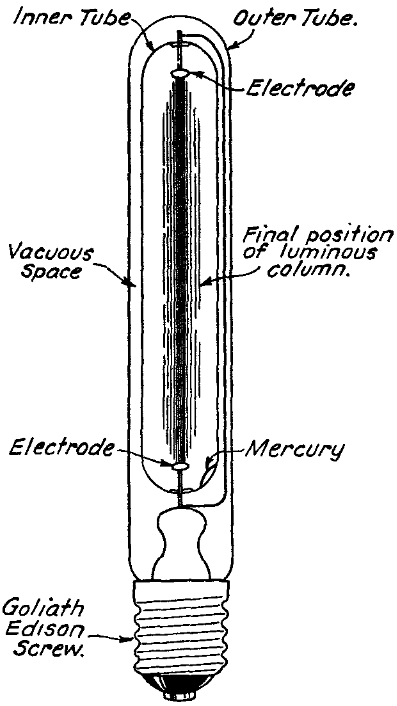
Floodlighting and Road Illumination.

A photograph of the Royal Bath Hotel, Bournemouth, flood-lit with Mazda Mercra lamps in specially designed projectors, is shown on the previous page. Lanterns designed to cast narrow fan-shaped beams and to establish even road illumination and favourable driving conditions, are generally employed in the modern highway lighting schemes using the new gas discharge lamps.

Further Cathode Developments.

The cathodes used in the present Mazda Mercra lamps are of small size, suited to the 400-watt capacity of the lamps; but it is interesting to note that it would be possible to arrange lamps of very high power. The cathode in question is known as the indirectly heated, heat-shielded cathode. It differs from the ordinary hot cathode, in that its electron emissive surface is of much greater area than that of its heat radiating surface, and furthermore, the heat losses are reduced by the use of a number of polished metal heat-shields. It consists usually of a cylindrical metal structure containing a large number of vanes coated with the electron-emitting material.

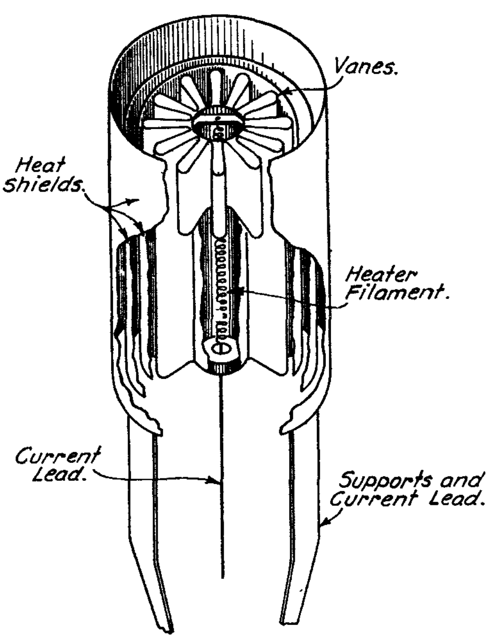
As many as possible of these electron-emitting surfaces are packed into the pot-like container, which is surrounded by two or more heat shields, and the net result is a cathode of high electron emission and low heat loss—in other words, one of high efficiency, Another advantage of this type of structure is that loss of emitting material is reduced by the heat shields, and liability to



DETAILS OF THE MAZDA MERCRA GAS DISCHARGE LAMP.

This operates on 230 volts A.C., and consumes 400 watts.

troubles due to diminution of activity and glass blackening is thereby lessened. The diagram on the right shows the general arrangement of a cathode of this type.



A HEAT-SHIELDED CATHODE.

Three Examples.

Some idea of the efficiency and relative sizes of these heat-shielded cathodes can be obtained by consideration of three examples. A very small non-heat shielded cathode is used in certain standard Mazda valves; it consumes 4 watts and permits of anode current of 20 to 50 mA. The next example is a heat-shielded cathode in a Mazda Thyratron; it takes 50 watts and will give an anode current of six amperes. Finally, there is a large-size heat-shielded cathode consuming 300 watts and giving a current of 100 amperes.

Chief Use for Special Cathodes.

The chief use of these special cathodes in future gas discharge lamps will probably be in such applications as floodlighting, and for beacon lights. Cathodes that will deliver an anode current of 1,000 amperes have been made for B.T.H. "Thyratrons," and this cathode comparison has been mentioned to indicate that cathode design will not determine the limit of capacity of luminous discharge lamps. The possibility of constructing very efficient and exceptionally large single sources of light is of considerable interest.

SODIUM VAPOUR LAMPS.

Whilst the mercury lamp for high efficiency needs a vapour pressure of one or two atmospheres, other metal vapour lamps may be constructed in which the requisite pressure is only a few thousandths of a millimetre of mercury, that is to say, a small fraction of one atmosphere. The chief among these to be produced so far is the sodium lamp, and Mazda lamps of this nature have been developed and demonstrated.

The sodium lamp makes no pretence of giving a colour rendering approximating to daylight. In fact, the light from it is virtually monochromatic and is, of course, yellow.

How the Yellow Light is Produced.

The sodium lamp has a separately heated hot cathode, with one or more anodes in a bulb, which, for heat conservation, is mounted inside a vacuum jacket. The lamp is filled to a suitable pressure with one of the rare gases such as argon, and contains a little sodium. The electrical characteristics are not appreciably altered by the presence of the sodium, a trace of which, however, converts the faintly luminous glow of the rare gas into a brilliant yellow light. The lamp starts with a low-voltage arc of from one to five amperes in the rare gas, and the energy liberated in this heats up the sodium until finally a temperature of about 200° C. is reached. At this temperature the sodium vapour is at such a pressure that a bright yellow light is produced.

Other Problems that Have to be Considered.

The further development of both mercury and sodium lamps, which is being pursued actively in the B.T.H. works, presents many problems connected with electrical discharges in gases.

We are indebted to the engineers of the B.T.-H. Co. for the information given above. We hope through their courtesy to keep our readers informed of further developments.

THE ILLUMINATION METER

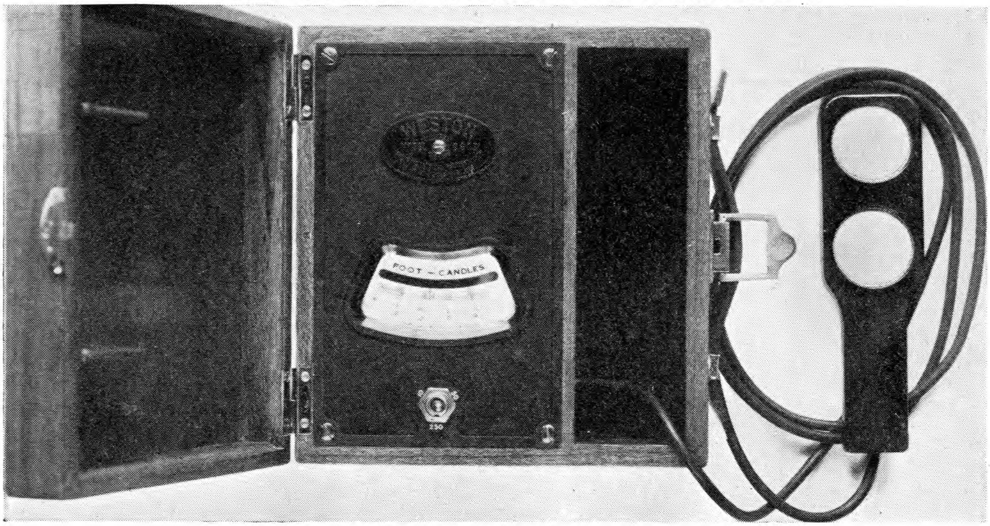


Fig. 1.—THE WESTON PORTABLE ILLUMINATION METER.
This enables the intensity of illumination to be seen at a glance. It consists of two "Weston" cells connected to a micro ammeter, with a scale calibrated to give a correct reading in foot candles.

THE late Mr. Leon Gaster was one of the pioneers of illuminating engineering in this country, and owing largely to his efforts the scientific study of illumination has been practised by electrical engineers and consultants for many years.

The recent innovation of the portable illumination meter, of which the "Weston" instrument is an excellent example, has now rendered it possible for the busy installation engineer to deal with the subject of illumination in a scientific manner without having to make elaborate calculations on the subject.

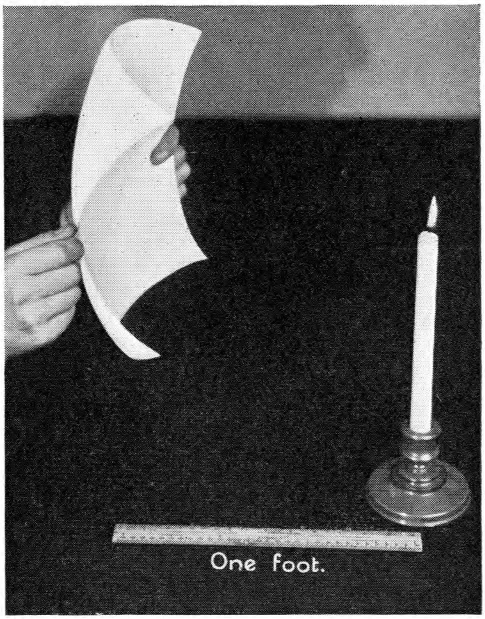


Fig. 2.—THE FOOT CANDLE AND THE LUMEN.
The foot candle is the illumination received from a source of one candle at a distance of 1 foot. The lumen is the flux of light falling on a spherical surface 1 square foot area distant 1 foot from a standard candle flame. The amount of light caught on the sheet of paper above is approximately one lumen.

Minimum Illumination Necessary for Different Classes of Work.

Tables issued by the Electric Lamp Manufacturers' Association show at a glance the minimum illumination which is necessary for different classes of work. A table of typical values appears on page 10.

Is the Intensity Sufficient?

Equipped with one of the portable illumination meters, the installation

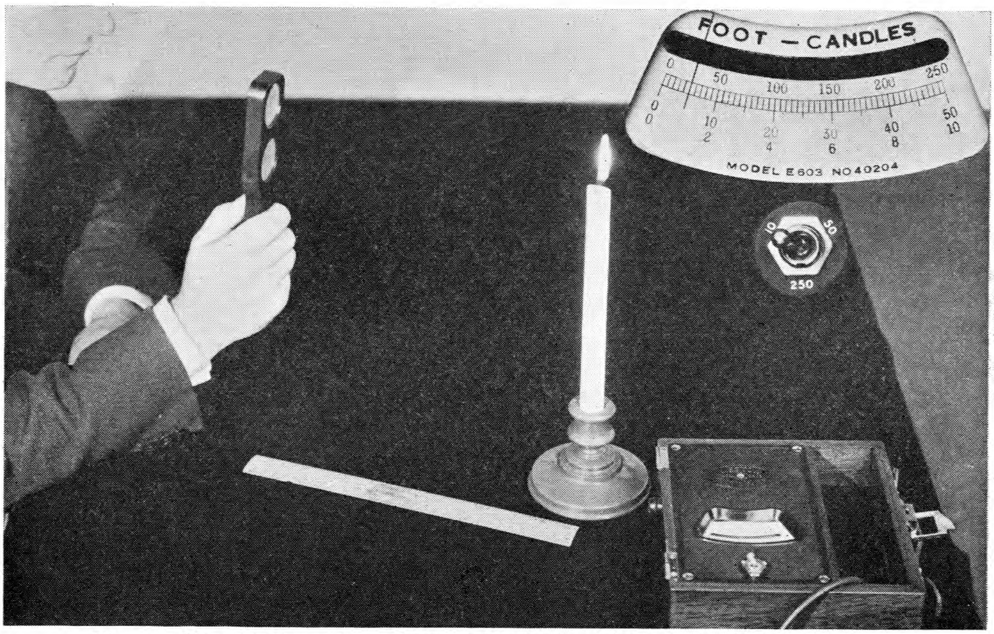


Fig. 3.—MEASURING A FOOT CANDLE WITH THE WESTON ILLUMINATION METER.

Notice that the discs are being held 1 foot away from a standard candle, thus giving a scale reading of 1 foot candle on the lower scale.

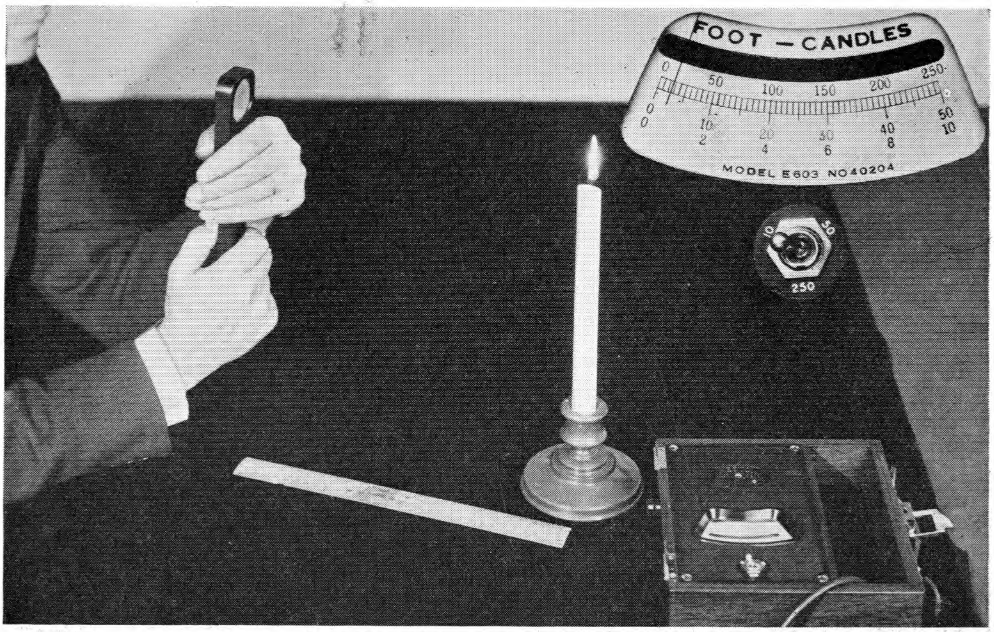


Fig. 4.—ONE DISC ONLY GIVES HALF THE DEFLECTION.

The above photograph illustrates a useful property of this instrument. By covering up one disc the scale readings are exactly halved. If half the remaining disc is covered the scale readings must be multiplied by four to give the true foot candles.

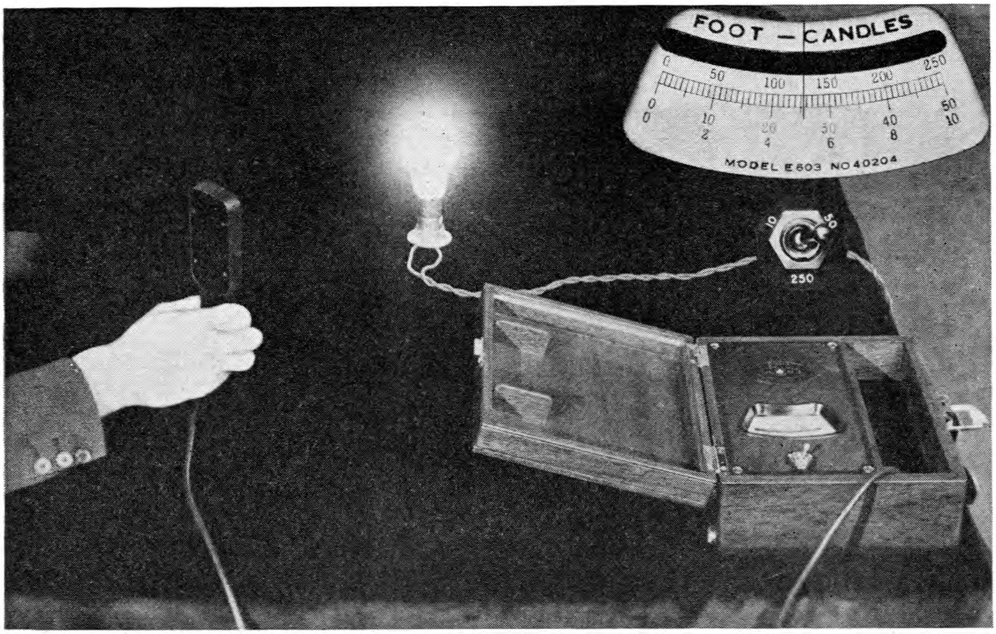


Fig. 5.—Measuring the Brightness of a 40-Watt Pearl Mazda Lamp.
Note that instrument switch is on the 50 mark, indicating that the centre scale must be used. The reading obtained is 25½ foot candles.

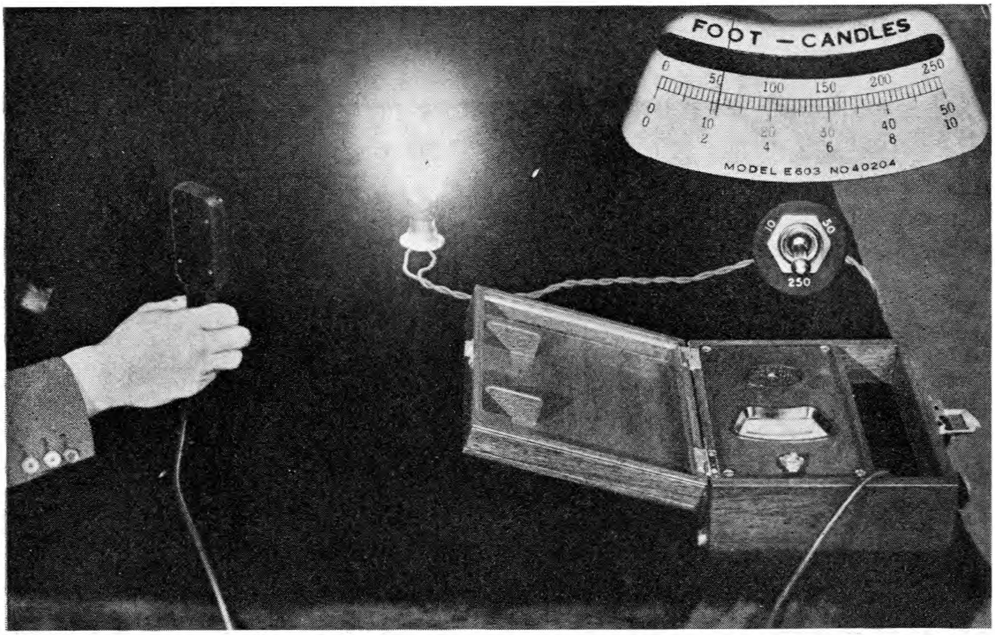


Fig. 6.—Measuring the Brightness of a 60-Watt Pearl Mazda Lamp.
Here the instrument switch is in the 250 position, so that the top scale must be used. The reading is 55 foot candles.

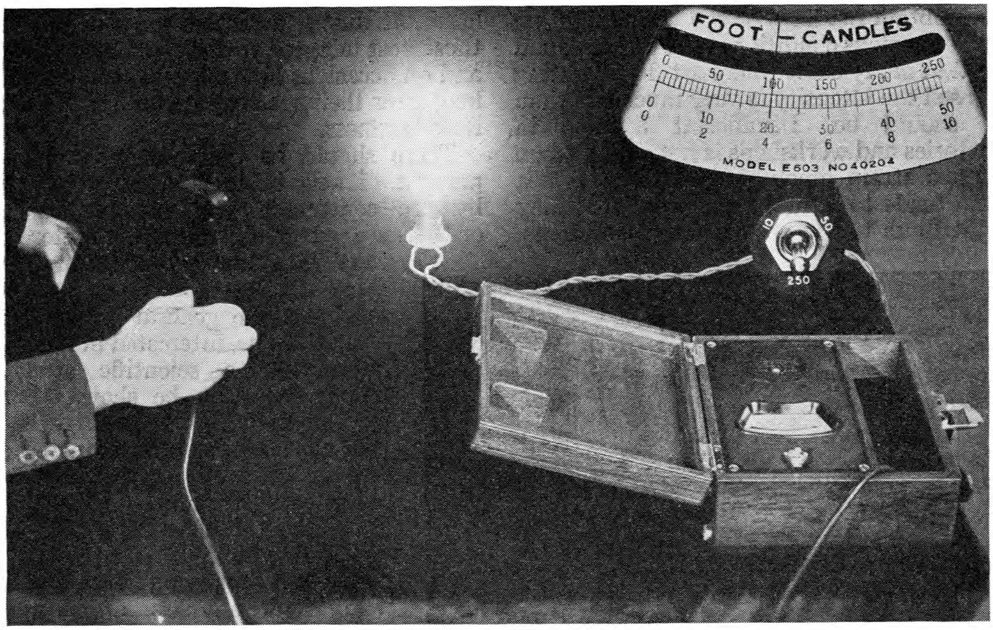


Fig. 7.—Measuring the Brightness of a 100-Watt Pearl Mazda Lamp.

It will be seen that the reading in this case is 100 foot candles. In all cases the discs are being held approximately 12 inches from the light source.

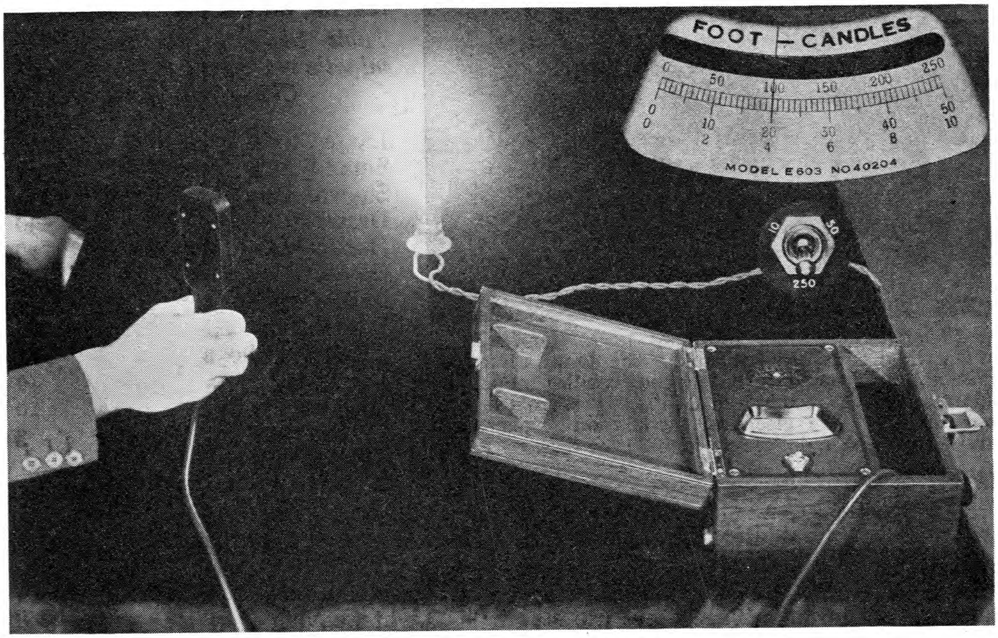


Fig. 8.—A Striking Result.

Here a 100-watt clear glass Mazda lamp is being used in place of the 100-watt Pearl Mazda shown above. The intensity of illumination is, however, exactly the same, viz., 100 foot candles.

engineer can visit a works, office or factory, and obtain readings of the actual lighting under various conditions. It will be found that in many cases where artificial lighting is used the intensity is very much less than it should be. Insufficient lighting in factories and workshops is not only a cause of eye strain amongst operatives, but it also tends to reduce the output and may contribute to the occurrence of accidents.

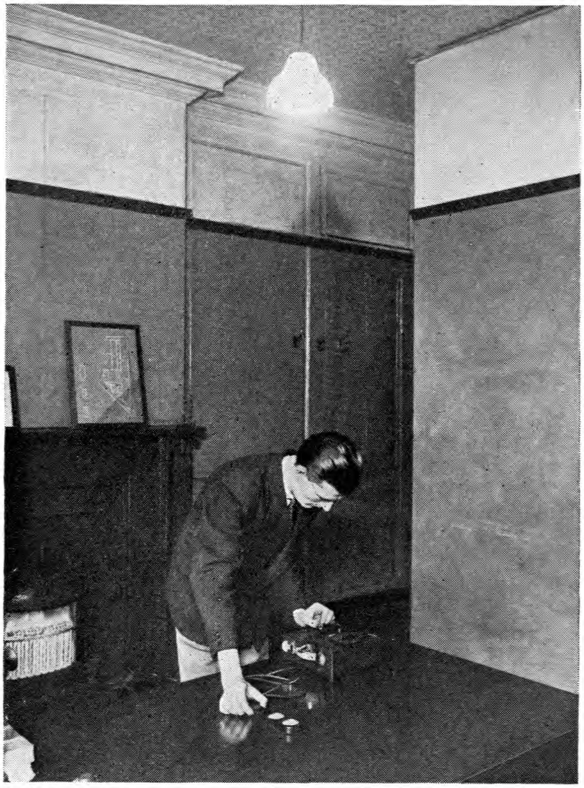


Fig. 9.—ARTIFICIAL LIGHTING IN AN OFFICE.
On the disc immediately under the 60-watt lamp the illumination is found to be 3.7 foot candles. For most efficient work the recommended intensity is from 11 to 13 foot candles. The electrical installation engineer will advise the use of a desk lamp to meet the case.

Causes of Inefficient Lighting.

Although the spread of knowledge of the principles of illumination amongst architects and consulting engineers has led to the provision of adequate lighting in the majority of new buildings, there are still thousands of workshops, offices, factories, and houses where the existing lighting leaves much to be desired. Lamps and reflectors become obscure through accumulation of dust; reflectors are not always those best adapted to the purpose in view, and on occasions lamps are kept in service long after their specified useful life.

New Business.

There should be quite an appreciable amount of new business to be obtained by the contractor who can buy, beg, or borrow a portable illumination meter to take with him when calling on some of his customers. Business men and the general public are not, of course, interested in illumination as a scientific study, but if they can be shown that by modernising their lighting they can lessen eye strain, increase output, or avoid accidents, very few of them will refuse to consider the comparatively trifling expense which may be involved in this.

The accompanying pictures do not illustrate any elaborate scientific experiments. Using a portable illumination meter is about as simple as reading the voltmeter or ammeter, and rather easier than reading an electricity meter.

Table Showing Minimum Illumination Necessary for Different Classes of Work.

	Foot Candles.
Large Stores	15–20
Small Shops	10–15
Showrooms	15–20
Drawing Offices	25–50
Hotels—General rooms	7–9
Offices	11–13
Public Halls	7–9
Bakeries	8
Assembly Shops	8
Laundries	10
Machine Shops	10
Warehouses	3
Textile Mills—	
Cotton—	
Carding rooms	5
Warping and weaving	8
Silk—	
Throwing, etc.	12
Light weaving	8
Wool—	
Light weaving	8
Combing	4

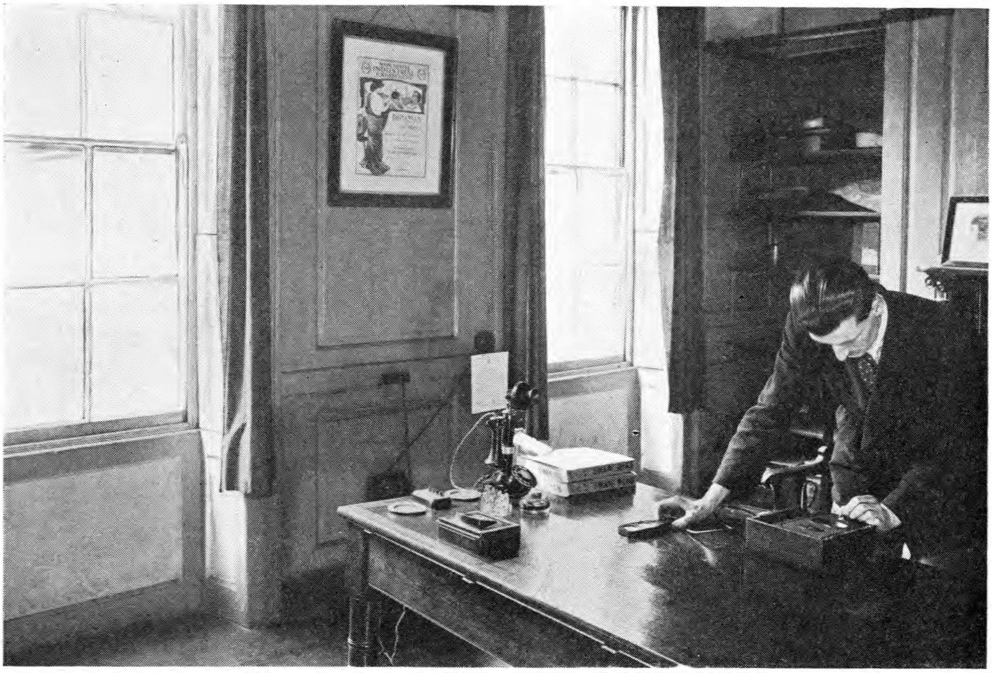


Fig. 10.—Daylight Illumination in an Office.

Here the reading has been taken on a table near two windows. The illumination reading is found to be 39.5 foot candles. Compare this with the reading obtained by artificial light. See Fig. 9.

Fig. 11.—Another Reading on the Same Office Table.

When the disc is held directly facing the windows the illumination is found to be 75 foot candles. The previous picture shows that the horizontal illumination on the same table is roughly one-half of this value.

SYNCHRONISING TURBO-ALTERNATORS

By W. T. WARDALE, A.M.I.E.F.

TO synchronise an alternator of any size, the speed of the set must give exactly the same periodicity as the system, the voltage of the incoming machine must be the same as that of the system or slightly higher, and the incoming machine must reach the crest and bottom of the wave in exact step with the system. Fig. 1 shows the instruments used for synchronising. The voltmeters for the system and the machine have been omitted to keep the diagram simple. In Fig. 1, R, W and Y indicate the phase windings. The machine is connected to the busbars through the oil switch.

Excite the Exciter Field.

Whilst the turbine is being run up to speed, excite the exciter field and see that its voltage comes up steadily with the speed of the turbine. This proves the exciter to be in order. On the exciter attaining half its working voltage, close the main field switch and adjust the current in the main field to the point at which the machine synchronises easily; this point is usually marked. Adjust the machine volts so that when full speed is signalled, the machine voltage will be slightly higher than that of the system.

Now Watch the Synchroscope.

Then put synchronising plug into holes S.P.S.P. and watch the synchroscope. The pointer will revolve slowly in one direction or the other according to whether the machine periodicity is higher or lower than that of the system. If the machine is a little above full speed the synchroscope pointer will travel in a clockwise direction very slowly.

Signal for the speed to be lowered a little, or, if on a modern switchboard, lower the speed yourself by means of the special switchboard control. Get the pointer just crawling in a clockwise direction and when the pointer is in the position shown, or rather nearer to the vertical, close the oil switch promptly. The machine is now on the bars and you can signal to the turbine driver to open the stop valve and so bring the load gradually on to the machine.

A Simple Process.

The explanation of the process is simple. Leads from two of the phases on each machine, in this case, R and W, are taken to a small potential transformer, which gives a very low tension supply, say, 110 volts, to the synchronising leads when the four-pin plug is inserted in the holes S.P. and S.P. These leads go to one side of the synchroscope. The other side is connected to a similar low tension supply taken from the system, through the transformer. The two sets of leads are so connected inside the synchroscope, that when the system and the machine are out as regards periodicity, a small motor or a set of vanes will revolve.

Now note carefully that the greater the difference in periodicity between the machine and the system the faster will be the speed of the motor or vanes, and hence

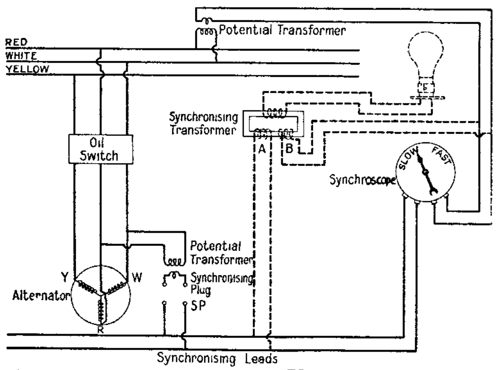


Fig. 1.—THE INSTRUMENTS USED FOR SYNCHRONISING.

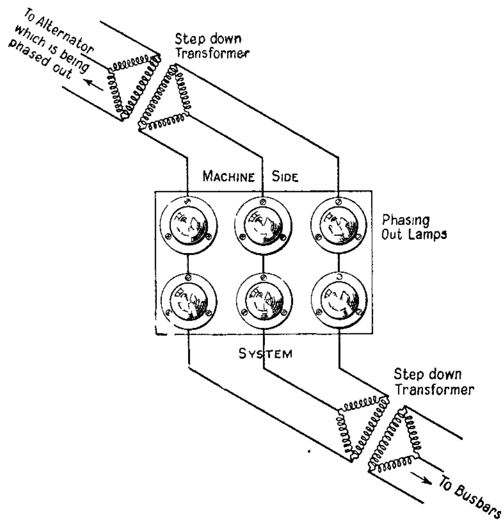


Fig 2.—SHOWING THE USE OF PHASING-OUT LAMPS FOR SYNCHRONISING ALTERNATORS.

of the synchroscope pointer to which they are attached.

The Synchroscope Connections.

The internal connections of the synchroscope are so arranged that when the machine periodicity is higher than the system the pointer revolves with the clock, but that when the machine periodicity is lower than the system the pointer will turn in an anti-clockwise direction. The connections are usually made so that when the arrow of the pointer is vertical the machine and the system are rising and falling in absolute agreement.

Therefore, get the voltage right, then the synchroscope pointer revolving very slowly in a clockwise direction, and when the arrow is almost vertical, say at "*five minutes to,*" close the oil switch.

Two Points to Watch.

Watch two points: never close the oil switch after the arrow has passed the vertical position, and, if you have to bring the speed of the set up from too low, and so cause the pointer to stop revolving anti-clockwise and start turning with the clock, do not take the first turn which comes up after the change of direction. The pointer has had to be stopped and reversed, and is going really quicker than it appears; that is, it is travelling too fast with the clock and the system and machine are too far out to synchronise. Let the first two revolutions in the new direction pass, and then make any further slight adjustment to the speed of the set to give just the crawl on the pointer which is best for synchronising.

The Lamp Method.

The method of using phasing-out lamps is not employed on the most modern plants. The connections are shown in Fig. 1. The synchronising transformer, it will be seen, has two primary windings, A and B, in *opposition.* The single secondary winding supplies a synchronising lamp. When the system and the machine are in synchronism, the windings A and B being in opposition, will allow no voltage to rise in the secondary winding, and the lamp will be *dark.* When the system and the machine are dead out of phase, the lamp will glow brightly. This method may be used with any voltage on the alternator, as all instruments and plugs are at low tension. It is, however, not fine enough when dealing with really large sets, and so is not much used to-day.

Putting a New Alternator into Service.

When a new alternator is about to be put into service for the first time, it is first necessary to know that the phases in the new machine and the system rotate in the same order. It must be, say, R.W.Y. for both machine and system, or any other combination desired; but it must not be R.W.Y. for the machine and R.Y.W. for the system. A simple method of checking this point is to take the busbar leads through a transformer and bring them out, giving a low tension supply on each phase. A similar transformer is then connected to the machine main terminals, and the machine run up excited and to proper speed. The two low tension supplies are then connected to a bank of lamps as shown in Fig. 2. Each phase from the machine on to the top contacts, and the same phase from the system on to the bottom contacts, this, of course, being done through small switches. The lamps should be chosen so that if the dead out of phase voltage is, say, 220, then the lamps will stand it. Two 115-volt lamps in series on each phase would suffice with a L.T. pressure of 110 volts.

If the two sets of phases, machine and system are rotating together in the *same sequence,* the lamps will all glow and darken together. If they do not, then shut down the set and cross over two of its high tension terminals. Run up again and if the lamps darken and glow together, the change over has succeeded.

If, however, they are not yet correct, then shut the set down again, and *first restore the crossed over leads* to their *original position.* Then cross over the two E.H.T. leads at the other end, and run up again.

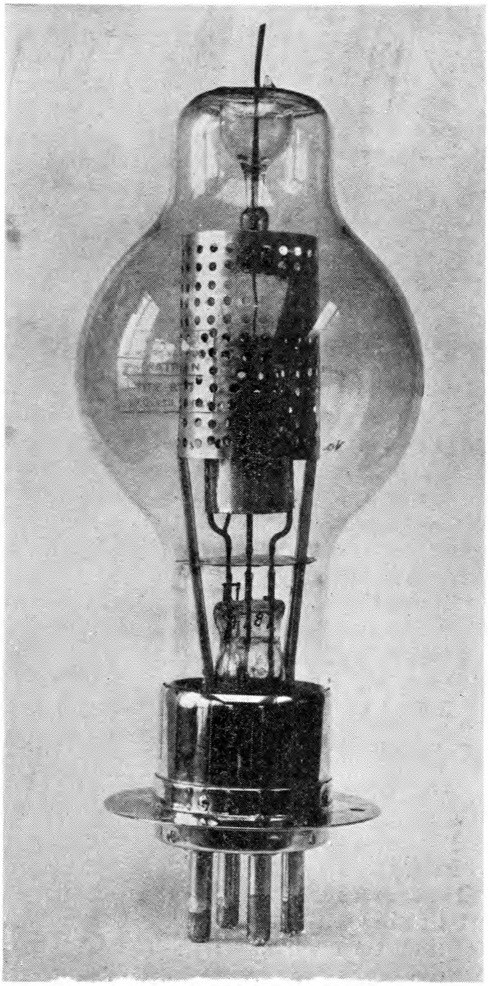
THE HOT-CATHODE THYRATRON VALVE

THE latest development in rectifying practice is exemplified in the Mazda Thyratron valve, which is a hot-cathode grid-controlled mercury-vapour rectifier. A grid or control electrode is provided between cathode and anode, and it is possible not only to rectify currents of hundreds of amps., but to start or stop them, or to control their magnitude, the power necessary for control being only of the order of a few milliwatts.

The photograph given here shows a typical hot-cathode Mazda Thyratron valve which is being made for use in high speed spot and seam welders, and many and diverse are the applications of the different sizes of Thyratrons.

Possibilities of Future Development.

The possibility of dealing with very large currents by means of the Thyratron or grid-controlled mercury vapour rectifier is one which has very great possibilities in the future development of electrical transmission and distribution. Had this discovery been brought to its present state of perfection 10 years ago it is not inconceivable that the present grid system would have been planned on entirely different lines.



THE MADZA TYPE BT7 THYRATRON VALVE.

Power Transmission.

The use of grid-controlled mercury-vapour rectifiers renders it practicable to transmit large amounts of power at high voltages on direct current. Such a system of power transmission has certain advantages as compared with the present A.C. system. It would be fatuous to suggest that there is any possibility of the existing system being altered in the near future, but there can be no doubt that the extended use of the Thyratron principle may effect great changes in heavy electrical engineering practice during the next few years.

PLANNING THE DISTRIBUTION SYSTEM FOR A HOUSE

By J. V. BRITTAIN, B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E.

In this article, the author deals with the method of distribution employed for a small six-roomed house and for a larger house using electricity for most domestic purposes, and explains how the various requirements of the Regulations are fulfilled

THE distribution of electricity to various parts of a house requires a certain amount of care in planning with a view to providing for all the points and services which will be required and avoiding any unnecessary cable runs. It is also worth while in better-class work to make some provision for extensions, or at least to make the system such that extensions are easily added without upsetting the whole layout.

There is also the matter of protection. By this is meant the provision of a satisfactory arrangement of fuses which are correctly graded according to the circuits which they control so that each circuit is adequately protected. By adequate protection is meant that should the current in any circuit approach a value at which the cable is likely to get hot it will be immediately disconnected by means of the fuse blowing. It should be borne in mind that to-day there are very few supply authorities who do not have fairly strict rules as to their requirements in switch and fuse gear and if an installation does not come up to their requirements they will not, of course, connect up.

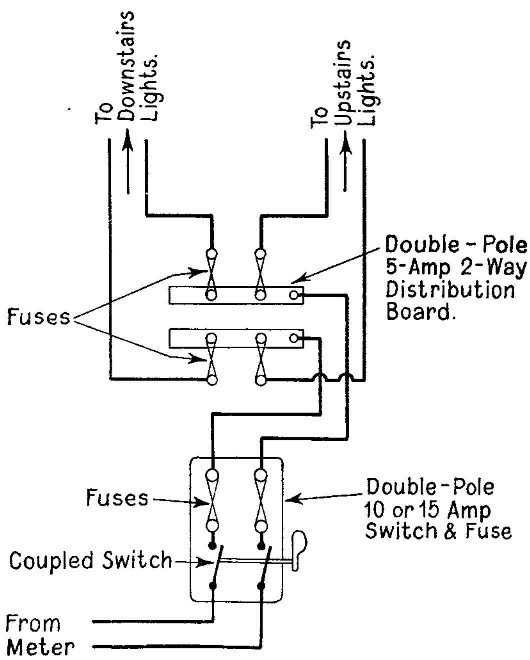


Fig. 1—TYPICAL DISTRIBUTION ARRANGEMENT FOR A SMALL SIX-ROOMED HOUSE.
This incorporates a double-pole switch and fuse, together with a two-way distribution board.

The Regulations.

The main guidance for the wiring of buildings for both light and power is found in the *Regulations for the Electrical Equipment of Buildings* which are issued by the Institution of Electrical Engineers and which are periodically reviewed. These regulations are now accepted as standard by the majority of electricity supply authorities and are also used by insurance companies as the requirements for a satisfactory installation.

There is a definite section of these regulations which deals with *distribution* and the interpretation of certain portions of this section will be dealt with in this article. There are, however, one or two main points which apply to every installation and these are as follows :—

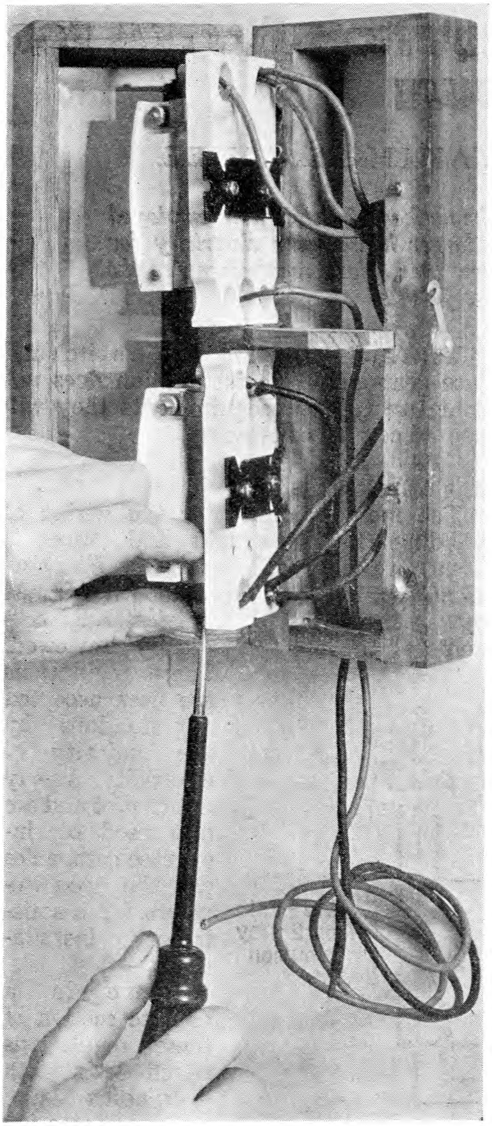


Fig. 2.—A Two-way Fuse Board showing Connections.

When connecting up fuse wires care must be used to ensure that the red and black wires of each circuit are connected to the upper and lower carriers opposite each other, as these form a pair.

Suitable Controlling Apparatus.

(a) *Every installation shall be adequately protected by suitable controlling apparatus which shall be easily accessible to the consumer and situated as near as possible to the point of entry of the service main.*

This means, of course, that the control gear must be in a convenient position where the main comes in and this is carried out by the erection of the meter board at some point previously agreed upon. It is only natural that the supply authority will not allow long lengths of cable to run about the house or building without any protective gear.

Both Lines Must be Isolated Simultaneously.

(b) *For a two-wire supply there must be a double-pole linked switch and a fuse in each conductor.*

This refers to the provision of a switch which will isolate both lines *simultaneously* and a pair of fuses. The regulation also allows circuit breakers, but these are not yet much used for house wiring and will not be dealt with here. Most readers will be familiar with the ordinary iron-clad double-pole switch and fuse which is normally used. The ironclad type is, however, being displaced to a large extent by switchgear made of insulating material such as bakelite. This is particularly the case in the smaller sizes.

Sub-distribution Board.

(c) *Every final sub-circuit shall be connected to a sub-distribution board.*

As practically the smallest installation is divided into at least two circuits some arrangement must be provided to give separate fuses on each circuit. This means that as a rule a double-pole distribution board is required, but there are one or two cases where this extra feature is combined with the main control switch, and this will be explained later.

How These Requirements are Fulfilled.

In order to explain how these and various other requirements are fulfilled two examples will be taken: first, the lighting of a small six-roomed house and, secondly, a modern villa using electricity for most domestic purposes.

A Small Six-roomed House.

The normal control gear for a six-roomed house is shown in Fig. 1, and it will be seen that this incorporates a double-pole switch and fuse, together with a two-way distribution board. There are several reasons why a small installation like this should be divided into two circuits. One of these is that the number of points on one circuit must always be limited to a reasonable figure and another is that should one fuse blow, the whole house will not be plunged into darkness.

Method of Distribution.

In Fig. 1 the leads from the meter first come to the main switch and fuse which may be of the ironclad type or made of bakelite or a similar material which is an insulator. There are many different types of these on the market which are quite satisfactory. The size or rating on this switch fuse is usually 10 amps. at 250 volts. This is the smallest size which should be used as apart from its capacity as a controlling switch there is the consideration of mechanical robustness. A smaller switch would be too frail to be reliable for this duty.

Capacity of the Fuses.

From the main switch and fuse, leads are taken to the distribution board which in this case is double-pole two-way. As the circuits which it protects are lighting circuits the capacity of the fuses will be 5 amps., which is the smallest size of distribution board made.

Division of Lights into Two Circuits.

The division of the lights into two circuits depends slightly on the actual layout of the house, but it is found most convenient to divide them into downstairs and upstairs. There will then be about four lights on each circuit, and this will be quite satisfactory.

Using a Splitter.

An alternative method of distribution for this type of installation is the use of a *splitter*. Since there are only two circuits the distribution board proper can be combined with the main switch and fuse and instead of the two pieces of gear we get a unit comprising a double pole switch with two pairs of fuses. This is shown diagrammatically in Fig. 3 and it will be realised at once that this type of gear means a saving both in money and time. A splitter also has the advantage that the supply MUST be cut off before any of the fuses are examined. With the arrangement in Fig. 1 the distribution board can be opened while the main switch is still on and so a shock may be felt. A large proportion of the smaller houses now being built are therefore fitted with splitters. These are made in the 10-amp. size similarly to the ordinary switch and fuse and are obtainable both in ironclad and all insulated types.

Distribution in a Larger Home.

In our larger house we have to provide for both lighting and power and it will be assumed that electricity is used for practically every purpose for which it would be found useful. Before actually planning the layout it is advisable to summarise the actual points that will be required and we will take these as follows :—

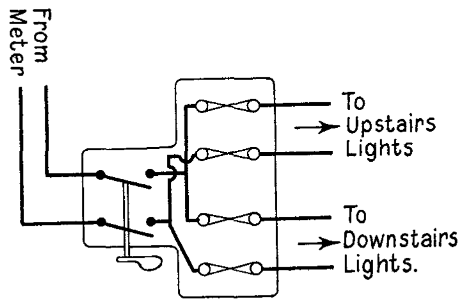


Fig. 3—Diagram Illustrating the Use of a Splitter.

This is an alternative method of distribution. Since there are only two circuits, the distribution board proper can be combined with the main switch and fuse.

Lighting.

Reception rooms . . .	6 points.
Kitchens, garage, etc. . .	5 points.
Bedrooms, etc.	6 points.
Heating.	
15-amp. plugs in reception rooms and bedrooms, etc.	6 points.
Cooking.	
One 4kW. cooker with plug for kettle	1 point.
Washing.	
One 15-amp. plug for washer	1 point.

Hot Water.
One connection to immersion heater .. .. .. 1 point.
Refrigerator.
One 5-amp. plug .. .. 1 point.

Separate Control Gear for Lighting and Heating.

In order to provide for these services it will be necessary to have separate control gear for lighting and heating with the usual separate special circuit controlling the cooker. It is now necessary to decide how the circuits shall be split up and although there are many variations in the permissible arrangement there are certain features which are definitely desirable in a good installation. The actual requirements of the local supply authority will affect the distribution considerably and these requirements must be taken into account when putting any scheme into practice. Alternatively, where the regulations laid down are not very strict a somewhat simpler arrangement can be put in although it is not possible to " get away " with very much now that wiring installations are receiving so much attention.

Three-way Lighting Distribution Board.

With reference to the lighting this can be grouped practically as tabulated above. The grouping already given will probably be quite convenient and a three-way lighting distribution board will be required. This is shown in Fig. 4 and it should be noted that the lighting is entirely independent of any other part of the installation. There are separate leads from the meter and a separate main switch and fuse is provided. The rating of this main switch and fuse should be 15 amps. in this case as the total current which could be taken on lighting would be more than is usually considered suitable for a 10-amp. switch and fuse.

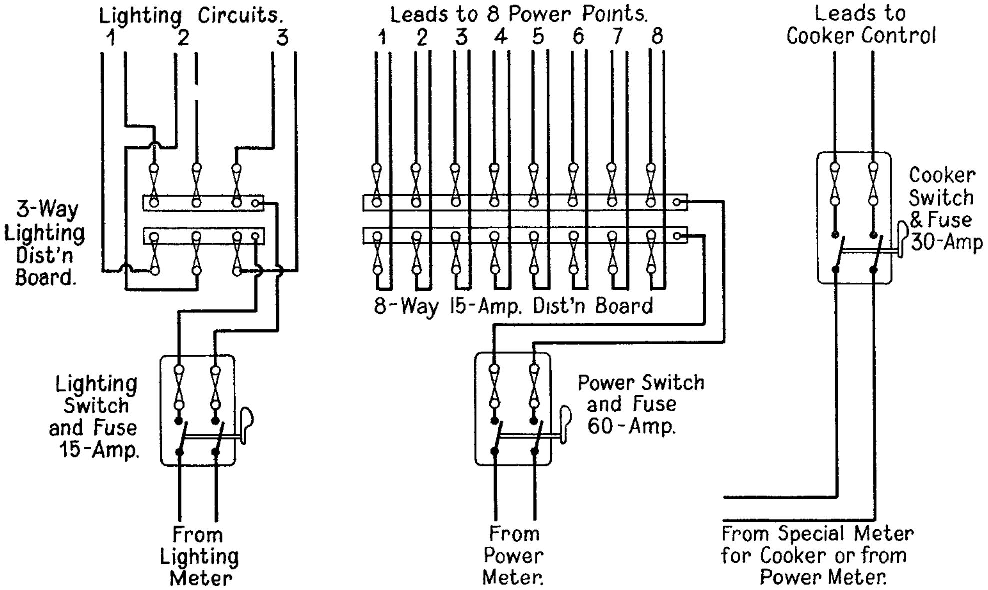


Fig. 4.—DISTRIBUTION SCHEME FOR A LARGER HOUSE.
Note that the lighting is entirely independent of any other part of the installation.

When a Four-way Distribution Board Should be Used.

If the amount of lighting was much in excess of that tabulated above a four-way distribution board would be desirable as it has been accepted that 7 points are the most which should be put on one lighting circuit. The dividing up of the lighting into a larger number of circuits also has the advantage that in the case of trouble on

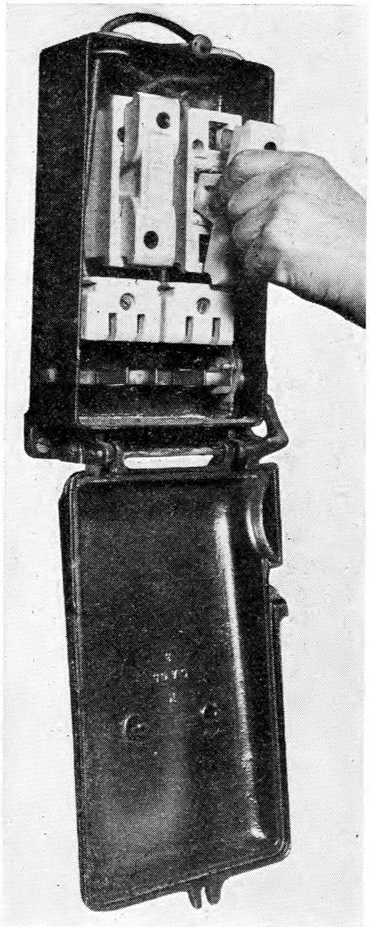


Fig. 5.—An Ironclad Main Switch and Fuses of an Installation.

one circuit there are not so many rooms put in darkness.

Heating or Power Circuits.

With reference to the heating or power circuits it is here where a fair amount of variation may occur. First there are 8 main heating points (i.e. points using 15-amp. plugs), comprising the 6 points for fires, the washer and the immersion heater. It is assumed that the hot water heater is in the nature of an auxiliary heater in the ordinary hot water tank.

Only Two Points Allowed on One Circuit.

The number of points which can be put on one circuit is definitely limited to two with points rated above 10 amps. but there are several authorities who will only allow ONE 15-amp. point on each circuit. In order to make full provision for a case like this an eight-way distribution board would be required and this is shown in the arrangement of Fig. 4. The capacity of the distribution board would have to be at least 15 amps. per way—this being the size usually marketed for this purpose. Certain makers list a 20-amp. range which of course will be quite suitable.

Why the Number of Points is Limited.

The reason for limiting the number of points on one circuit can readily be understood when it is realised that 3-kW. fires are often used where electrical heating is in regular use and a 3-kW. fire on 230 volts takes approximately 13 amps. If, therefore, there were two points on one circuit and both these were in use to the fullest extent at the same time, the total current would be 26 amps., which is too large for one circuit.

The Main Control Switch and Fuse.

The main control switch and fuse for heating or power circuits will have to be able to break the circuit with the maximum current flowing. It can be assumed, however, that all the points will not be full on at the same time. If this were so the capacity of the main switch would have to be 120 amps. The size of switch and fuse which would generally be installed for this purpose would be the 60-amp. size. This switch and fuse will isolate all the heating supply and is fed by separate leads from the meter as shown in the diagram.

The Smaller Power Points.

The question of the smaller power points must now be dealt with and in the schedule given there is only one of these—namely the refrigerator point. It is usual in a case like this to allow a small capacity

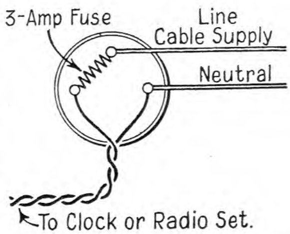


Fig. 6.—Diagram showing the Principle of the Fused Plug Point.

point to be added to a circuit especially when the load which is likely to be connected is not large. The refrigerator point would therefore in this case be added to the circuit supplying the washer since the latter would only be in use for short periods. A refrigerator for household use takes very little current and it is also not very usual for an electric washer to be fitted with electrical water heating although the 15-amp. plug is provided for this purpose in case it is wanted. The washing mechanism would be quite in order fed from a 5-amp. plug.

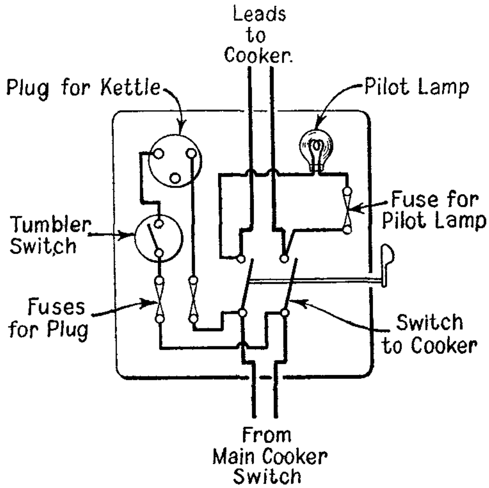


Fig. 7.—COOKER CONTROL.
Showing fuses protecting plug and pilot lamp.

Wiring to the Smaller Plug Must Not be Less than that Connecting Larger Plug.

It should be mentioned in connection with this extra plug point (which is connected in parallel with the 15-amp. plug), that the wiring which supplies the smaller plug must not be less than that connecting the larger plug. This is on account of the size of fuse which protects the circuit. This fuse will blow presumably at 15 amps. and the conductors supplying the 15-amp. plug will carry this amount of current quite safely. If now the extension to the 5-amp. plug was carried out with wire suitable for only 5 amps. this would be unsafe in the case of a fault which allowed a current of, say, 12 amps. to pass. This current of 12 amps. would not blow the fuse and the cable to the 5-amp. plug would thus be dangerously overloaded. This situation would also arise in the case of some apparatus being incorrectly connected to a 5-amp. plug such as a 3-kW. fire. If possible distribution gear should always be arranged to provide for these possibilities.

Fused Plugs for Electric Clocks and Radio Sets.

The question of electric clocks and radio sets is also one which requires attention and these are provided for by means of *fused plugs.* The principle of these is shown in Fig. 6 where the clock or radio plug is connected as an extension to the 15-amp. heating plug in the same room. The current taken by a clock or radio set is so small that it is quite allowable to add this to a 15-amp. plug but since this apparatus is usually connected by means of " flex " it is necessary to provide a fuse before the size of conductor is stepped down. In this case it will be seen that should a fault develop in the circuit supplied by the flex the fuse (which would be about a 3-amp. fuse) would prevent the current from reaching a value which would damage the flex or other apparatus.

The Cooker Circuit.

With reference to the cooker, it is usual to provide an entirely separate circuit for this and the part which would be at the main control board is shown in Fig. 4. This control switch is usually a 30-amp. double-pole switch and fuse—generally ironclad—and this again has a separate feed from the meter. This switch is in the nature of a main control and the actual cooker control will be seen from Fig. 7. This cooker control is situated as as near as possible to the cooker at the other end of the leads to the cooker.

Special Ironclad Switch.

This cooker control unit is a special ironclad switch which includes a pilot lamp to indicate when the power is on to the cooker. This pilot lamp ensures the supply to the cooker being switched off when it is not in use.

HOW TO MAKE A $\frac{1}{8}$ H.P. SQUIRREL CAGE INDUCTION MOTOR

By K. H. GREENLY, B.Sc. (Eng.)

In the following article will be found full details for constructing a $\frac{1}{8}$ h.p. squirrel cage induction motor for A.C. mains. All the components or raw materials are easily obtainable and the design has been especially developed for practical men who own or have access to a 3-in. or larger screw-cutting lathe and a modest stock of other workshop appliances

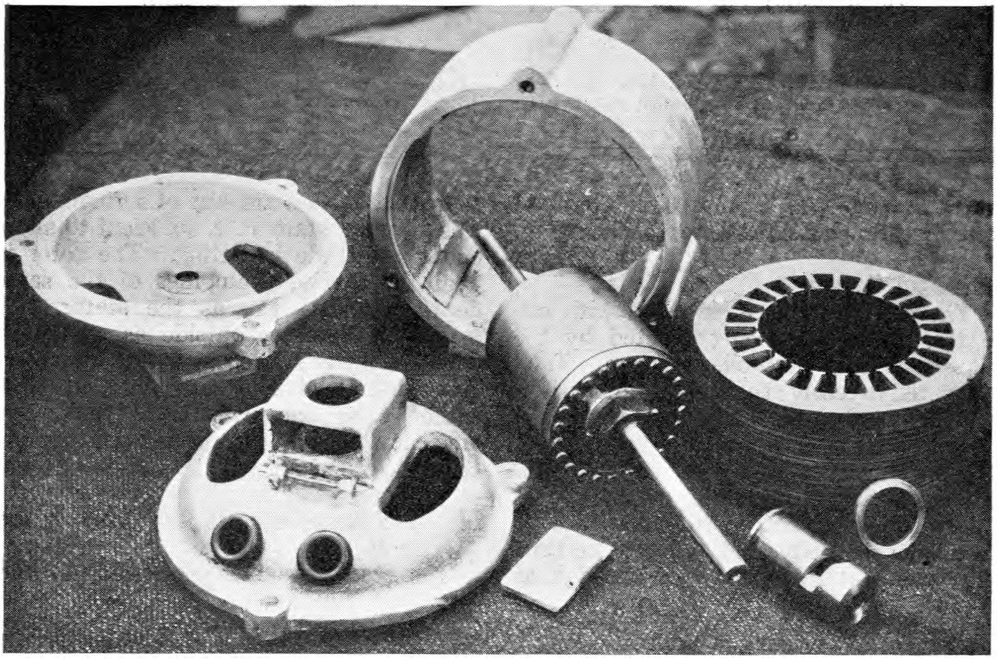


Fig. 1.—A VIEW OF THE COMPONENT PARTS REQUIRED FOR THE $\frac{1}{8}$ H.P. INDUCTION MOTOR.

AN induction motor has been chosen for the sake of simplicity of construction. The armature winding is formed by 23 copper bars connected together by end rings. An actual motor has been built from the specification given and has given satisfactory results on test.

In Fig. 1 is an assembly of the various components. These may be divided into four main heads :—

(*a*) The stator stampings corresponding to the field magnets of a D.C. machine.

(*b*) The rotor assembly and shaft.

(*c*) Body casting in aluminium.

(*d*) End covers (aluminium) with bearings and lubricators.

From the photograph and the general arrangement drawing it will be seen that to avoid machining a large surface and to facilitate the fitting of the stator stampings in the machine body, the latter casting has four internal facings or "lands" $\frac{1}{2}$ in. wide and raised $\frac{1}{16}$ in. above its inner surface. They are also of slight

MATERIALS REQUIRED FOR CONSTRUCTION

Castings.

Two End Covers (Aluminium).
One Outer Casing (Aluminium).
Two Bearings (Gunmetal).
Two Lubricator Rings (Brass).
Two Lubricator Covers (Aluminium).
Two Rotor Spiders (Aluminium).
Two Rotor Short-circuiting Rings (Copper).

Stampings.

8 Dozen Stator Stampings, as specified } Stalloy.
8 Dozen Rotor Stampings, as specified. } Stalloy.

Wire and Insulating Material.

1¼ lbs. No. 25 S.W.G. Copper Wire, Enamelled and Single Cotton covered.
¼ lb. No. 32 S.W.G. Copper Wire, Double Cotton Covered.
6 ft. No. 8 S.W.G. Copper Wire, Bare.
One Sheet 10 mils. (.010″) Leatheroid, 10 in. by 9 in
One Sheet Vulcanised Fibre, 32 mils. (.032″) thick, size 6 in. by 3 in.
6 yards Cotton Tape, ½-in. wide.
2 yards 5-amp. Flex.
2 ins. Ebonite Rod, 1-in. diameter.

Raw Metallic Material.

1 ft. $\frac{5}{16}$-in. Round Bright Mild Steel.
1 ft. ⅛-in. Round Bright Mild Steel.
3 ins. $\frac{1}{16}$-in. Brass Pin Wire.
½ in. $\frac{3}{16}$-in. Round Bright Mild Steel.
Two Mild Steel Nuts, tapped ¼-in., 26 threads per inch.
Three Mild Steel Bolts, ¼-in diameter, 3¾-in. long under head
Three ¼-in. Whit. Nuts for the above.
Two $\frac{7}{16}$-in. Steel Washers.
Two $\frac{1}{32}$-in. by 1¼-in. Split Pins.

Small quantity of Tinman's Solder, Chatterton's Compound, Oil-resisting Varnish for Windings, and Paint for Motor Metalwork.

value in cooling as air may circulate more readily through the machine when running.

The End Covers.

The end covers are provided with oil-boxes, lubrication being effected by the time-honoured ring oiler system. They are bored to receive the gun-metal bearings and spigoted into the body casting to preserve the alignment. Furthermore, this spigot serves the purpose of clamping the stator stampings and must be just long enough to bolt right home face to face with the body, and at the same time grip the stator. It will be found that there is a certain amount of springiness in this group of stampings, sufficient to allow enough latitude in fitting. The rotor is again of Stalloy stampings of the same depth, viz., 2¼ in., as the stator, but 2.492 in. diameter outside as compared with the latter's 2.500 in. inside diameter. The air-gap of .004 in. obtained is a rather close one which will make for efficiency though .006 in. or even .010 in. could be tolerated.

How the Stampings are Supported on the Shaft.

The stampings are supported on the

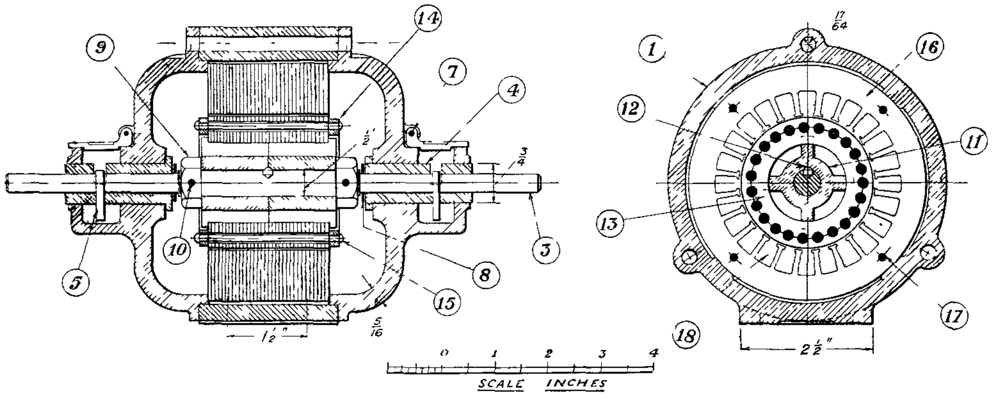


Fig. 2.—HERE WE SEE THE GENERAL ARRANGEMENT OF THE VARIOUS COMPONENTS.

shaft by a pair of cast aluminium spiders secured by a snug instead of the usual key and keyway, and bolted up from each end. It will be noted that the shaft is extended beyond the rotor at each end so that the drive may be taken from either side.

CONSTRUCTION.

Riveting Up the Stator Laminations.

Eight dozen laminations will make up the $2\frac{1}{4}$ in. depth required for the stator. As they are very accurately stamped and quite flat, there will be no difficulty in obtaining a smooth assembly if certain points are watched. On the edge of each plate will be found a small nick from which they may be registered up. One side is covered with a whitish insulating compound ("Insuline") whose purpose is to prevent eddy currents straying from one lamination to the next.

The notch will be found very convenient for location and each stamping should be placed the same way up on the last, in the correct register, so that the notches resolve themselves into a long groove. The position of these notches can just be seen on the extreme right in Fig. 1. Before riveting up through the four holes provided, check the depth by lightly squeezing the stampings up in the vice or clamp. Soft iron rivets should be used, and any slight burrs on the outside of the assembly cleaned off with a file.

Machining the Outer Casing.

The overall diameter of the body casting being a little under 6 in., it may be swung in a 3 in. lathe.

The facing and boring is a face plate job for a small lathe, and the casing bolt holes are convenient for bolting the job up during this operation. It may be

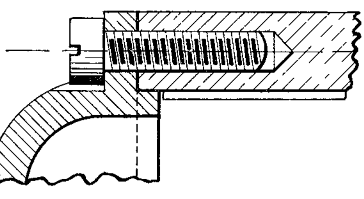


Fig 4.—Showing Alternative Method of Securing End Covers

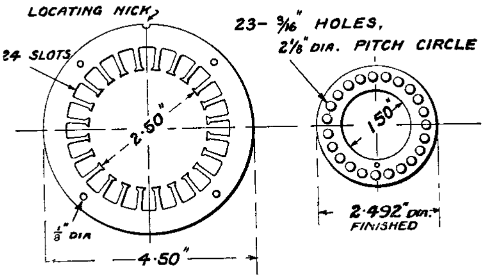


Fig. 3.—Details of the Stampings.

necessary to drill special holes in the face plate to accommodate these, but this is an advantage as the same holes may be used for mounting the end covers. There are two alternatives open in the matter of casing bolts, i.e., through bolts, a clearance fit through the carcase or stud bolts tapped into it. In either case, they should be $\frac{1}{4}$ in. diameter. If the former method is adopted, first mark out the casing carefully on each side, drill $\frac{3}{16}$ in. for a depth of about $\frac{1}{2}$ in. and tap $\frac{1}{4}$ in. Whitworth. Short set-screws through the face plate screwed into these holes will then secure the casting rigidly enough for ensuing operations, the holes being afterwards drilled through $\frac{1}{4}$ in. clearance.

Fig. 5 shows the casting rigged up for the first machining operations. The internal "lands" should be carefully bored to a good fit with the stator stampings and these should be tried in several positions in case they are not quite in register at some particular spot round their periphery. Before this casting is removed, face the ends, and counterbore to $4\frac{3}{4}$ in. diameter, for a depth of $\frac{3}{16}$ in. full.

Jigging the Carcase Casting.

The corresponding counterbore at the reverse end *must* be quite concentric with the first. Some form of jig to locate the as yet unfinished casting is essential, and a thin disc of brass or aluminium bolted through the face plate suggests itself. The photograph shows the jig plate bolted to the face plate through the slots and skimmed up to a push fit in the work.

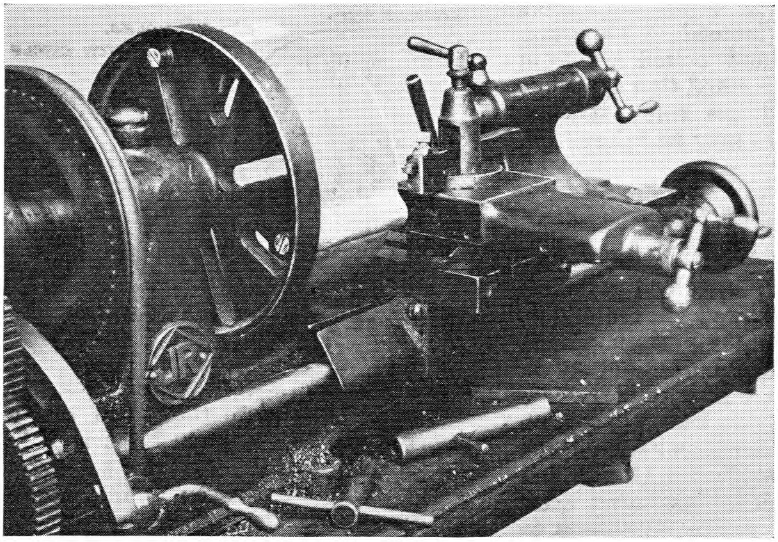


Fig. 5.—The First Operation in Facing the Motor Carcase.

The End Covers.

The end covers should be marked out and drilled to suit the carcase and using the same holes bolted to the face plate, bored $\frac{3}{4}$ in. for the bearing bush, and the front boss faced. Here again, before the work can be reversed for turning the spigot, an arbor, held either in the chuck or between centres, must be made up (Fig. 7) in order to ensure perfect alignment of the rotor and stator. The gun metal bearings are a plain turning job, but a point to watch is the relieving of the sharp corner at the inside shoulder about $\frac{1}{64}$ in. for a length of $\frac{1}{32}$ in.

When machining is completed the oiler slot is filed away far enough to allow a clear run for the oiling ring when resting on the shaft. Oil ways leading from this slot towards each end of the bush should be cut with D-shaped chisel, finishing in an annular groove whose purpose is to prevent the lubricant working out.

The Rotor.

The main work on the carcase is now complete, and the rotor assembly should next be tackled. The rotor-shaft is a straightforward between centres job on which little comment is necessary. If a travelling steady is available it should be used, and in any case the last few cuts must be very light and the tailstock adjusted if the lathe has any tendency to turn tapered.

A length of 4 in. (bare) in the centre of the shaft is left $\frac{1}{2}$ in. diameter, and screw

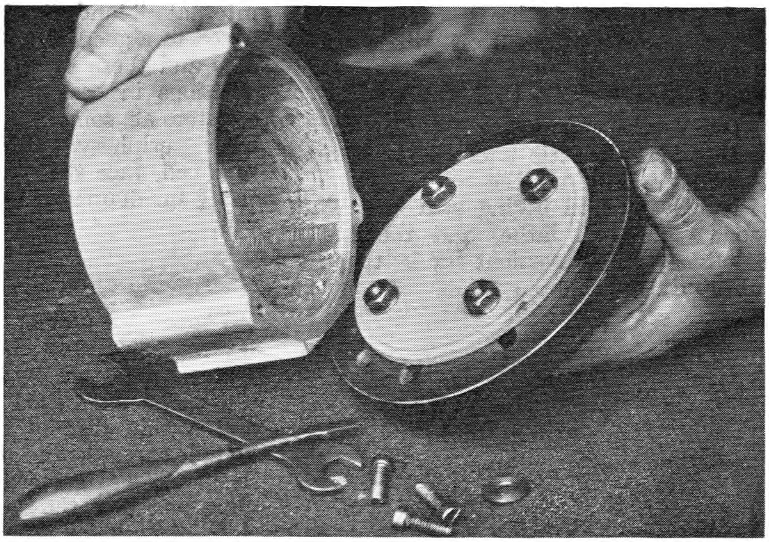


Fig. 6.—Registering the Jig for Machining the Carcase.

cut 26 T.P.I. at each end for a length of $\frac{1}{2}$ in. while the rest is reduced to $\frac{7}{16}$ in., a good running fit on the bearings. A shallow hole $\frac{3}{16}$ in. diameter accommodates the snug or "dutchman."

The rotor spiders are best held in a 4-jaw chuck for boring and facing the inner surface, after which the arms of the "star" may be turned to fit the rotor stampings either on a special arbor or on their own shaft. The final fitting of the snug should be left until the stampings are ready for assembly. There must be just sufficient stampings to allow the two halves to press firmly against them and at the same time engage the snug with no trace of looseness. A badly fitting snug will be a constant source of trouble and may eventually fail.

The Short Circuiting Rings.

A pair of copper rings will be required drilled with 23 holes .161 in. diameter (No. 20 drill) at $2\frac{1}{8}$ in. diameter pitch circle. In the absence of a dividing head a single stamping makes an excellent jig for marking out the holes. The two rings should be clamped together and drilled without parting, and two locating marks made for reference when the time comes for the final assembly.

The 23 $2\frac{15}{16}$-in. long rotor bars should be cut from No. 8 S.W.G. copper wire, previously softened, if necessary, and the assembling of the rotor can then be commenced.

Assembling the Rotor.

As in the case of the stator laminations, a small locating hole will be found in each rotor stamping, through which a piece of thin copper wire may be temporarily threaded to keep the stampings in place, but it is important that no further riveting shall be commenced until the laminations are safely on the spiders.

The exact number will have to be arrived at by trial and error. It must be remembered that once the bars are in position the snug cannot be got at save by completely dismantling the whole rotor. The same precautions with regard to the insulated side of the stampings should be observed as in the case of the stator. Having got the laminations safely housed on the spiders and clamped up by the shaft nuts, the riveting up of the rotor bars can be proceeded with. Do not forget location marks on the short circuiting rings. The actual riveting may be a two handed job unless the vice jaws are used as an anvil, but care should be taken not to damage or bend the shaft. The ends of the bars must be scrupulously clean to ensure a good electrical connection (the more complete the short circuiting the higher the efficiency) and also to facilitate the subsequent soldering up. When the heads

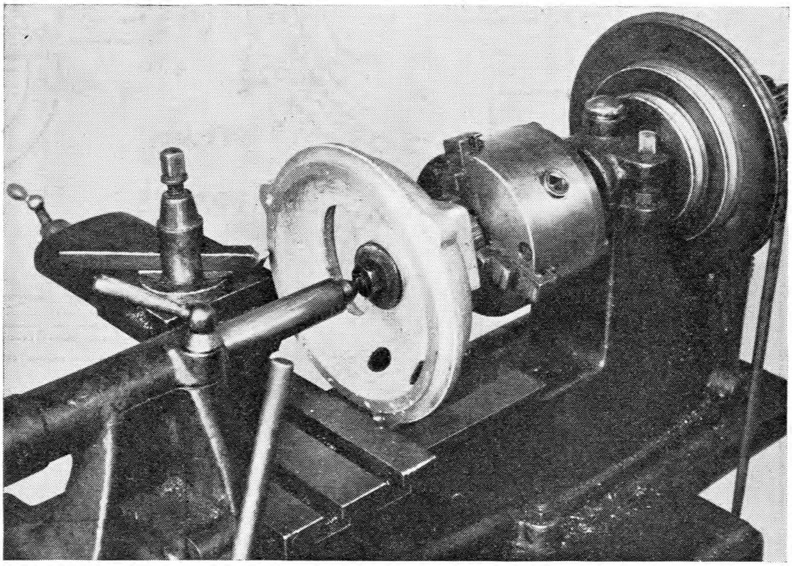


Fig. 7.—TURNING THE SPIGOT OF THE END COVER CASTING ON A SPECIAL ARBOR.

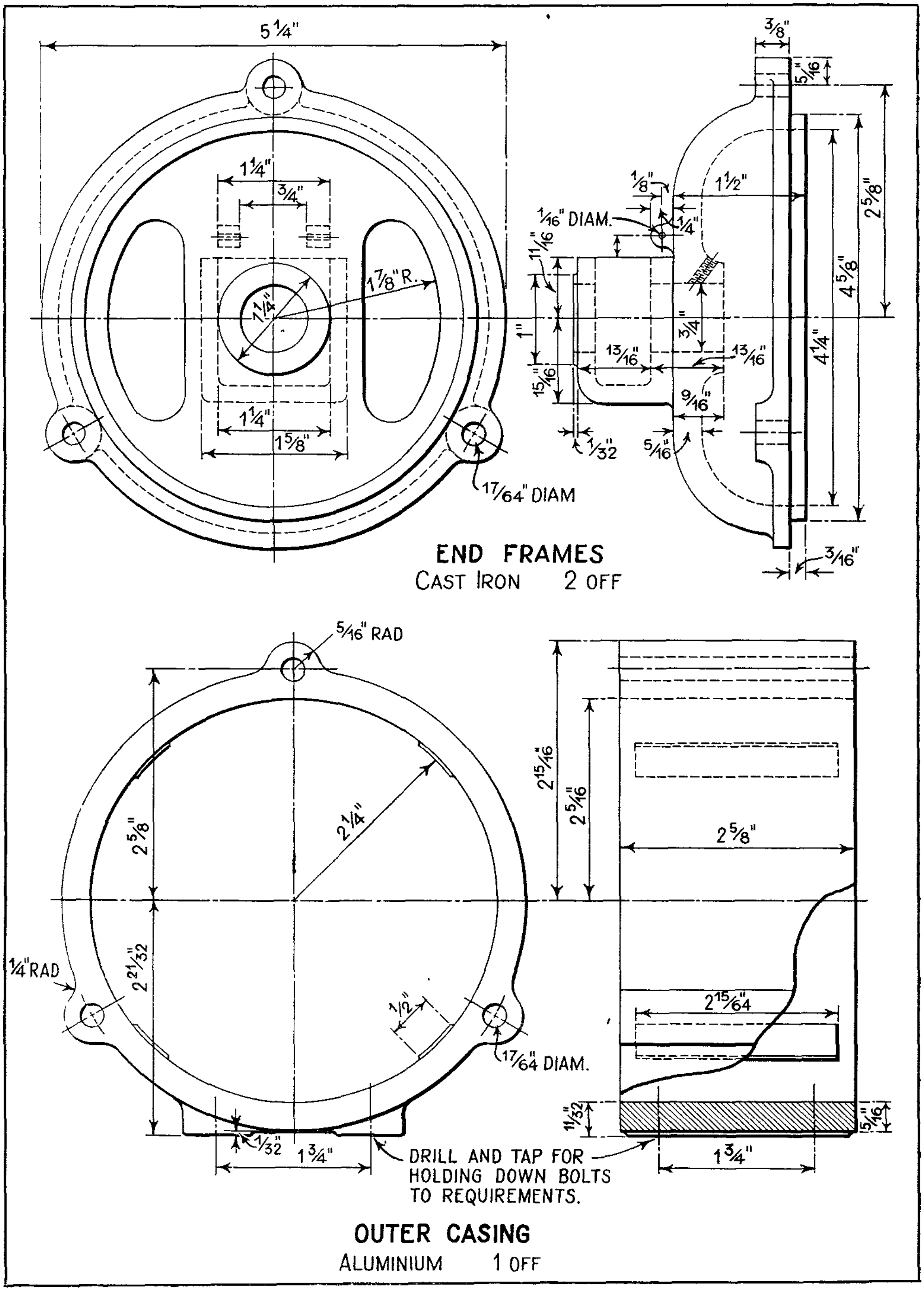


Fig. 8.—Showing Dimensions of the End Frames and Outer Casing.

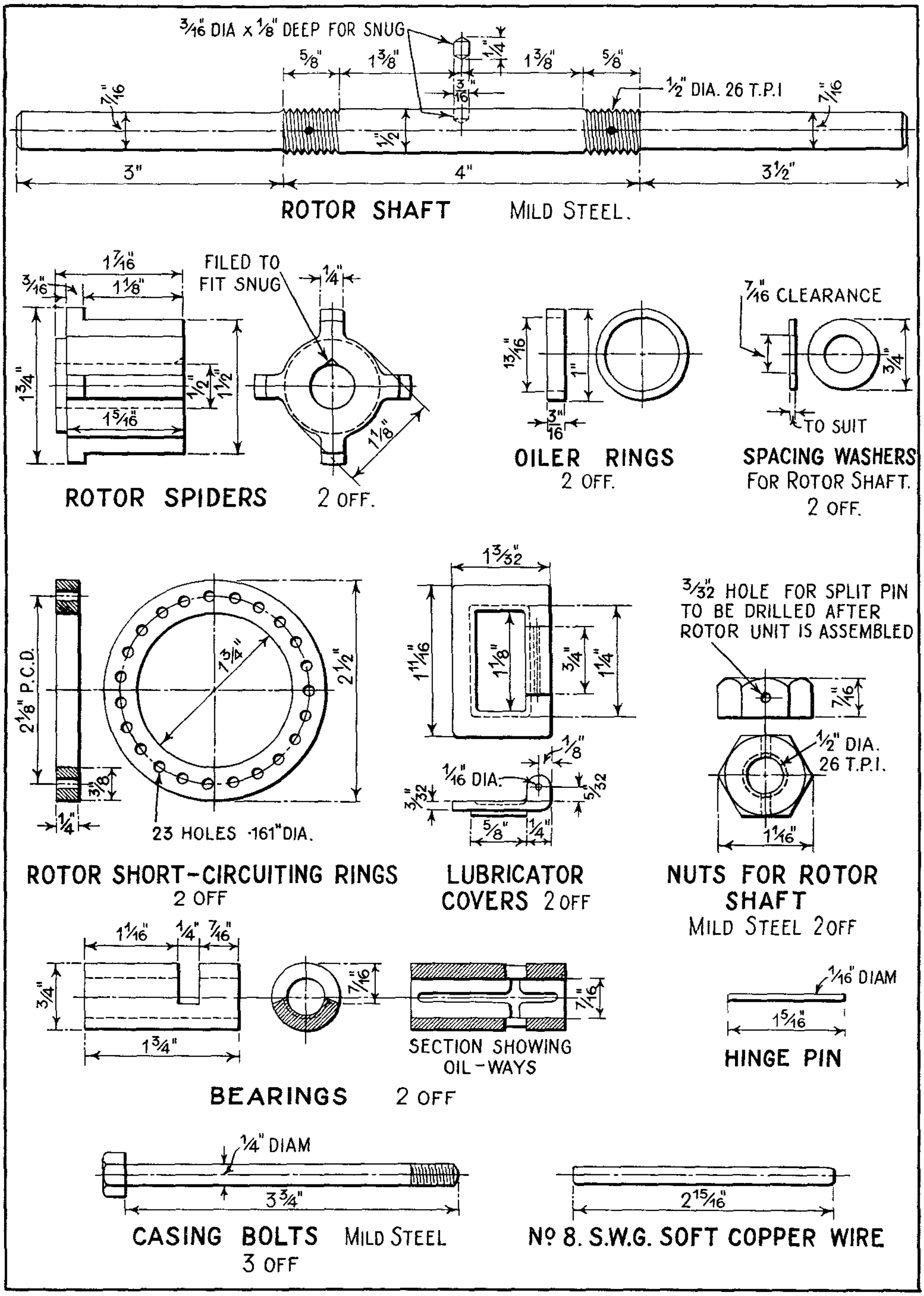


Fig. 9.—Showing Dimensions and Details of Various Parts of the Motor.

have been brought over a final shaping may be accomplished with a cup-shaped "snap" (Fig. 10). As a precaution the nuts are finally drilled $\frac{3}{32}$ in. and pinned with a split cotter.

The whole job should now be heated up together with the shaft vertical and plenty of soft solder run round the heads of the rivets, dealing with one end at a time. A non-corroding flux should be used.

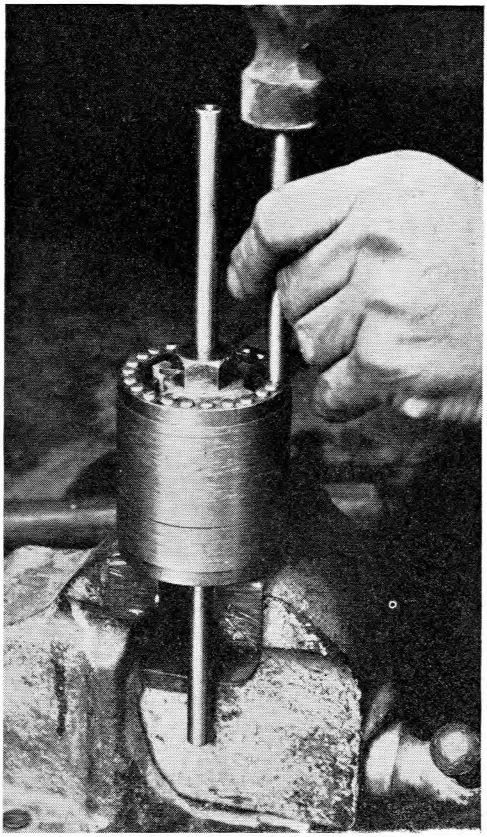


Fig. 10.—Riveting Up the Rotor Bars.

Reducing the Rotor to Size.

There will probably be a number of high spots and burrs standing up in the laminations which must be taken down before the rotor will clear the stator teeth. However, it is best to avoid turning the surface as there will be a tendency for one lamination to be forced into good electrical contact with the next, so partially defeating the object of preventing the flow of eddy currents through the iron core. The rotor unit may be mounted in the lathe between centres and carefully filed or ground down until it is 2.492 in. in diameter, and all roughness removed. As against the 2.500-in. bore of the stator, this will provide an air gap of .004 in.

Checking Rotor for Balance.

The rotor cannot be deemed complete until it has been checked for balance. As a matter of fact, if the earlier marking out and machining has been reasonably accurate, there should be little the matter with it ; but even a slight error in balancing is going to make itself noticeable at 2,800 r.p.m.

A suitable rig for the purpose may be very simply improvised from two domestic knives set into a couple of pieces of 3 × 2 in. timber, as illustrated in Fig. 11. They should be very carefully checked for level both along the blades and at right angles to them before the rotor is rested across them. It will be easier to chalk the light side and then carefully remove any blob of solder or high rivet head equally from each end ring opposite the mark until the rotor shows no tendency to spin to rest in any particular place.

It is scarcely possible to check it for dynamic balance, but as long as the static balancing is reasonably accurate no trouble should ensue.

Trial Assembly.

A trial assembly can now be made. Carefully tap the stator laminations into the casing with a wooden mallet, avoiding damage to the teeth, until it just covers the raised facings inside the casting. One end cover with bearing complete can then be slipped on, and the rotor shaft run into it. The oiler ring must, of course, be assembled at the same time as the gunmetal bearing is driven home into the casting. The other end casting is now ready for fitting and the casing bolts lightly tightened up. The rotor must run without a trace of stickiness anywhere. Check the air gap for even-ness at three or four points round the circumference, say at 12, 3, 6 and 9 o'clock, revolving the rotor a quarter turn each time. There should be very little variation at any point, as each part is accurately registered by the various spigots and facings, and it is unlikely that anything more than 1 or 1½ "thous" difference will be noted. The shaft should run, of course, quite freely, and the mechanical side being in order, the machine can be dissembled for winding.

Winding the Stator.

The process of winding the stator may not be anticipated with much keenness, but there is no need to be apprehensive of many difficulties. A plain two-pole winding of this type is a good deal easier to put on than, say, the winding of a drum armature, and providing a few elementary rules are followed, failures are unlikely.

For starting purposes, a separate winding is provided, placed at right angles to the running coils and switched on for an instant at starting only, and then disconnected from the mains. In Fig. 13 the disposition of the running and starting coils is illustrated, the former being shown by heavy lines and the latter by light.

The starting coils are wound with a much finer gauge of wire than the running coils, and occupy less slot space in the stator —eight slots as compared with 16 in this machine. The difference in resistance between the two is sufficient to alter the phase of their respective currents and converts the winding temporarily into a two-phase one, biasing the fields in a certain direction. The rotor will pick up in speed in that direction until it is near synchronism and the auxiliary winding must then be cut out of circuit immediately.

We shall therefore need two separate sets of coils, producing four poles for starting and two for running. In Fig. 12 the stator is drawn as it would be photographed by a panoramic camera making a complete revolution at its centre. The teeth are represented by black rectangles and the space between them is, of course, the slot space available for housing the conductors. For the sake of simplicity each heavy line indicates not one wire, but a bundle of conductors running through that particular slot.

Why Coils are Concentric.

It will be noticed that the coils are concentric, i.e., they are not lapped one ahead of the next, as in a drum armature winding, and, furthermore, the direction of rotation is reversed between the two pole groups. This is necessary to produce opposite poles at a spacing of 180 degrees, considering the starting and running coils separately.

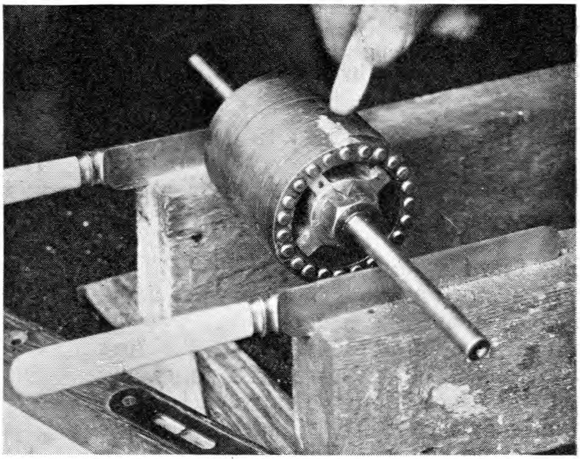


Fig. 11.—HOW TO BALANCE THE ROTOR.

A suitable rig for the purpose can be improvised from two knives set into two pieces of 3 × 2 in. timber. It will be found easier to chalk the light side and then carefully remove any blob of solder or high rivet head from each end ring opposite the mark.

The Running Winding.

Referring again to Fig. 12 we can trace out the method of winding. Commencing with the running winding, the first coil consists of 85 turns of 25 S.W.G. wire spanning slots 9 to 4 in an anti-clockwise direction. Continuous with this are a further 85 turns each between slots 10 and 3, 11 and 2, and 12 and 1, all in the same direction. The end leading

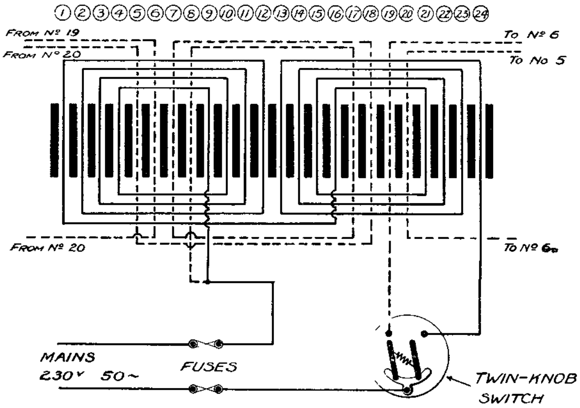


Fig. 12.—A DEVELOPMENT OR "PANORAMIC" SKETCH OF THE WINDINGS.

Note how each opposing coil-group has its direction of winding reversed when seen from the centre of the stator tunnel. The running winding is shown by full lines and the starting winding by dotted lines.

from No. 1 is continued to the opposite side of the stator and 85 *clockwise* turns laid between slots 16-21, 15-22, 14-23 and 13-24.

The Starting Winding.

The starting turns are accommodated in the remaining eight slots. The 32 gauge wire is used here, and the first two coils to lay on are Nos. 8 to 17 and 7 to 18 (clockwise), 150 turns each. The end leading from No. 18 is passed across to No. 20 slot and is used to start the last two coils, 20 to 5 and 19 to 6, again 150 turns per slot, but wound in an anti-clockwise direction.

The accompanying table gives the details of a winding for 220-250 volts, 50-cycle single phase supply :—

Running winding	Gauge of wire ..	25 S.W.G. enamelled and single cotton covered
	Conductors per slot	85
	Slots per complete coil	8
	Coils per phase ..	2
Starting winding	Gauge of wire ..	32 S.W.G. double cotton covered
	Conductors per slot	150
	Slots per complete coil	4
	Coils per phase ..	2

What to Do Before Winding is Begun.

Before winding is begun, the slots are numbered from 1 to 24 to conform to the developed winding diagram and assist in tracing the connections. Each slot must be lined with a strip of 10 mil leatheroid cut to such a length as to overhang at each end about $\frac{1}{8}$ in. and wide enough to cover the whole inside surface and be flared out at the slot opening as shown in Fig. 16.

The protection this offers will prevent damage to the wire as it is slipped into the narrow space between the teeth; the ends can be trimmed after the slot has been filled, folded in and the opening closed with a strip of $\frac{1}{32}$ in. fibre $2\frac{1}{4}$ in. long by $\frac{1}{16}$ in. wide, which will effectively prevent any wire becoming displaced in subsequent service.

Important Points to Remember.

Having studied Figs. 12 and 13, the actual winding can be started. The most important fundamentals are as follows :—

Never let the wire get kinked; work the wire gently into the space between the stator teeth without resort to ham-

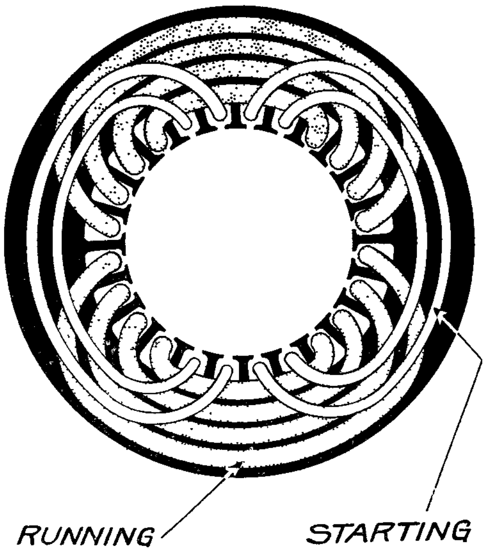


Fig. 13—END VIEW OF THE STATOR.
Showing the disposition of the starting and running windings.

mering; and, finally, do not damage the insulation.

For the running coils enamelled and single cotton covering has been specified. For amateur use it forms an ideal insulation, far superior to plain enamelled covered, though a good deal more expensive. The single cotton covering affords a strong fibrous insulation, is quite difficult to damage and at the same time takes up less space than the common double cotton covering.

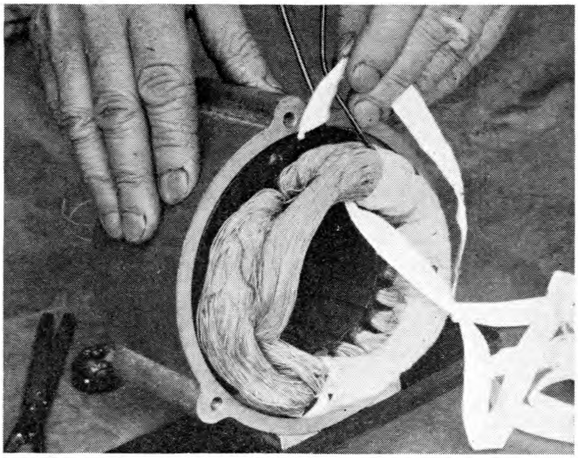


Fig. 14.—Taping the Finished Windings.
Plain white linen tape is employed here, secured at intervals with a touch of Chatterton's compound.

First, the Running Coils.

The running coils should be tackled first. It will be found easier to handle the stator if it is slipped into the body casting and all subsequent operations performed with the two units assembled. It is really quite immaterial where the windings are begun, so long as the coil pitch is correct. Hand winding is best for these coils as the natural stiffness of the 25 gauge wire is sufficient to keep the turns in place. The bobbin should not be passed through the stator tunnel, but a loop of wire formed and one conductor at a time fed into its particular slot. The end or "dead" turns not enclosed by the stator iron must be carefully formed to a small arc and not pulled tightly to a sharp corner, but if too much wire is left here it may be difficult to house the bundles in the end covers.

Now the Starting Coils.

The starting coils are best wound on two sizes of wooden former and afterwards housed in the remaining slots. A few conductors at a time are carefully slipped in, and when the whole of one side of a coil has been accommodated the leatheroid insulation should be tucked in and the slot closed by a fibre strip. However, there is the disadvantage of having to connect the appropriate ends of the coils together in the correct polarity. The actual sizes of the formers are best obtained by trial, as much will depend on the running winding previously laid on.

Testing Polarity of Windings.

It is a wise precaution to test with a compass needle. Deal with the starting and running windings separately. Connect the leads of one of these to a 2 or

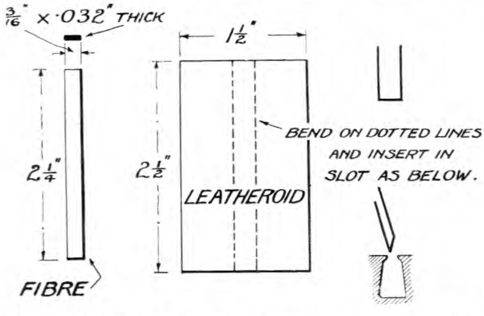


Fig. 15.—Details of Insulation for the Stator Slots.

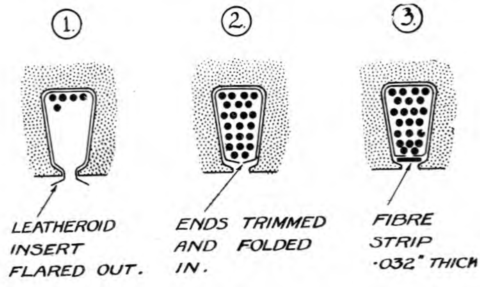


Fig. 16.—How the Stator Slots are Insulated.

4-volt accumulator, and with the stator lying horizontally on the bench, lower a small compass needle into the bore, keeping it quite close to the stator teeth. As the needle is passed round, it should indicate two quite definite unlike poles at 180 degrees to each other, concentrated at the centre of the appropriate winding.

If everything is in order, the remaining winding may be dealt with in the same way, and the end turns taped. For this purpose plain white linen tape ½ in. broad will answer very satisfactorily, and may be held in place by a touch of Chatterton's compound where required.

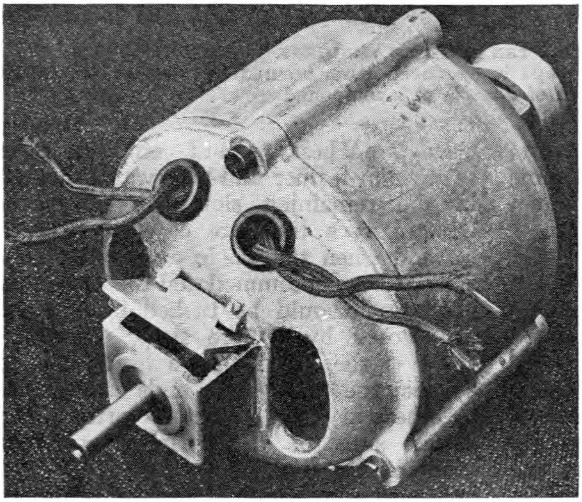


Fig. 17.—General View of the Completed Motor. The leads to the starting winding are on the left; the leads to the running winding on the right.

The stator can then be thoroughly dried out in an oven before the windings are "doped." It is important from the point of view of insulation to dispel any moisture in this way first. Any good oil-resisting varnish may be used, applied quite liberally and allowed to run right down into the slots from each side.

Assembly of Motor.

The motor is now ready for assembly. Be careful not to damage the windings as the end covers are put on. When tightened up they should clear the winding by a fraction of an inch, but if there is any tendency for the windings to be squeezed up, a layer of thin presspahn round the inside of the covers will obviate a possible "short" to earth. The starting and running coil leads may be brought out through insulating bushes in the end covers direct to the switchboard, or, alternatively, via an insulated terminal box.

Cutting Out the Auxiliary Winding.

As previously mentioned, the auxiliary winding is required only for a short time while the motor is speeding up, after which it must be cut out of circuit. The easiest way of accomplishing this is by means of a special type of switch known as the "twin knob." In appearance it is similar to a tumbler lighting switch, with the exception that there are two levers, one recessed into the other, which control two sets of contacts. While the hand is on the switch, both knobs are operated, and the starting and running circuits are made simultaneously, but when the hand is removed the inner knob is returned by a spring and breaks the starter circuit.

Connections to Mains.

The actual connections to the mains are shown in the winding diagram Fig. 12. There is always a momentary rush of current at starting, amounting to four or five times the full load current, i.e., 3 to 4 amps. The supply leads must therefore be fused to at least 5 amps., but there is no reason why the machine should not be run from lighting mains if required in a portable capacity such as for fan driving.

Finally a word about the availability of the material. The Queen's Engineering Co., of 60, Queen's Road, Battersea, S.W.8, are supplying a complete kit of components in the unfinished state, comprising castings, stampings, wire and insulating materials and full-sized blue prints at the inclusive price of 45s.

Sets of castings and stampings are also available as separate items.

PRACTICAL DETAILS OF A BRIDGE METHOD OF MEASURING AND COMPARING INDUCTANCES

THE following particulars relating to the measurement or comparison of inductances such as L.F. chokes, intervalve and output transformers may prove of assistance to experimenters who are desirous of conducting their own tests and measurements.

The basic circuit is that of the Wheatstone Bridge and is illustrated in Fig. 1. The four arms of the bridge are of equal value and the bridge is supplied with alternating current at points A and B, whilst the galvanometer or detector is connected across C and D. Under these conditions the bridge will "balance" and the galvanometer will show no deflection.

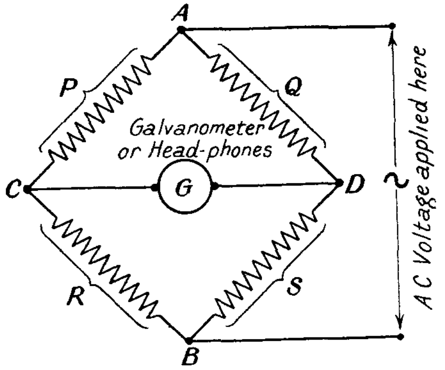


Fig. 1.—A SIMPLE BRIDGE CIRCUIT. Where the arms P, Q, R and S are all equal in value.

The Circuit Actually Employed.

The circuit actually employed is shown in Fig. 2 and will be seen to be a modification of that in Fig. 1. The "arms" of the bridge are P, Q, R and S, and it will be noted that P, Q and R are identical. The arm S consists of two resistances in series—N a fixed resistance and X a variable resistance. This arm is shunted by a variable condenser C, and the inductance under test L. The self capacity of the inductance coil, shown in dotted lines, acts as if it were in parallel with C.

Alternating current is fed to the bridge at A and B, and the galvanometer or detector is connected across C and D.

Prior to describing the operation and values of components required it will be worth our while to consider the principle employed.

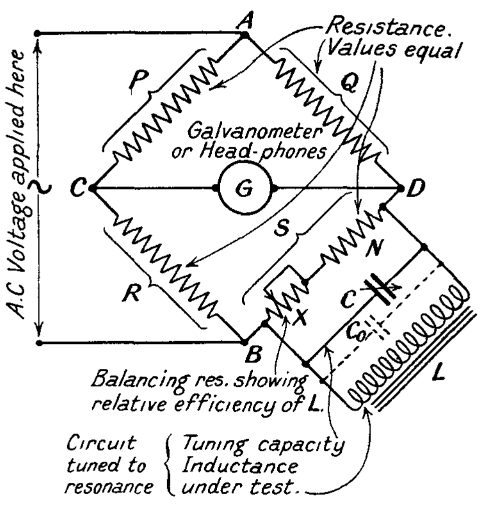


Fig. 2.—THE ACTUAL BRIDGE CIRCUIT EMPLOYED FOR THE INDUCTANCE MEASUREMENTS DESCRIBED IN THIS ARTICLE.

The Principle Employed.

To obtain a balance it is necessary in this form of bridge that the arms have the same electrical value. Now arms P, Q and R are made equal at the commencement, therefore arm S is the one to be considered.

Referring to Fig. 3A, we see the equivalent of arm S, where the capacity C and the inductance L are in parallel across the resistances N and

X in series, the whole combination forming the arm S.

Now this looks very complicated, but it is not so bad as it looks. If we resonate the inductance L by means of capacity C to the frequency of the supply, we then have in place of C and L what is known as a dynamic resistance Rd, and our equivalent electrical circuit becomes that shown in Fig. 3B. Since two resistances in parallel give a sum total less than either of them taken singly, it is obvious that if the sum of N and X in series with Rd in parallel is to equal that ot the other arms then the value of N and X (without Rd in parallel)

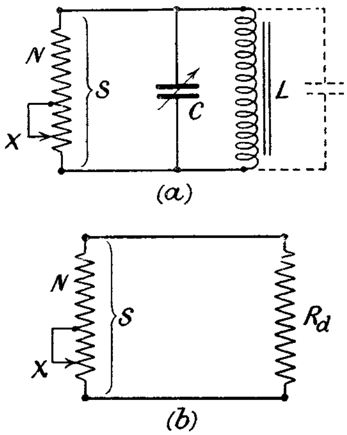


Fig. 3.—The Arm S.

At (A) we see the equivalent of arm S, where the capacity C and the inductance L are in parallel across the resistances N and X in series, the whole combination forming the arm S. (B) shows the equivalent electrical circuit when L is resonated by C to the frequency of the supply, so that in place of C and L there is a dynamic resistance Rd.

must be greater than any of the other arms. Therefore, we make resistance N equal to the other arms and use the variable resistance X to compensate for the effect of Rd, the dynamic resistance, in parallel.

The Component Parts of the Bridge.

For general purposes arms P, Q and R may consist of 1,000 ohms resistance each. Resistance N should then be 1,000 ohms, and resistance X 0 to 50 ohms variable (calibrated). These resistances should have low inductance or preferably be non-inductive.

The galvanometer, G, should be sensitive and suitable for use with alternating current. If the frequency is suitable a pair of telephones may be used. A resistance in place of the galvanometer with an amplifier transformer-coupled to it may be used if necessary and a variable shunt may also be needed across the galvanometer, which can be set to requirements when adjusting the bridge.

The A.C. Supply to the Bridge.

This should preferably be taken through a transformer and the variable and fixed resistances should be shielded and the shields earthed and the transformer should have a shield between primary and secondary which should be earthed. These precautions will minimise electrostatic effects due to hand capacity, etc.

The Variable Capacity.

The value required will depend upon two factors—the inductance of the choke or transformer and the frequency used when measuring. If 50 cycles be taken as the lowest frequency likely to be used, then for inductances from 10 to 50 hys. a capacity variation of from .22 mfd. to 1.0 mfd. will be required.

A table is given showing the capacity values required for various inductance values at a frequency of 50 cycles.

Table of Capacity Values for Use to Resonate Various Values of Inductance at 50 Cycles.

Inductance L in Henries.	Capacity C in Microfarads.
10.14	1.0
20.28	0.5
30.00	0.338
40.00	0.251
50.00	0.228
60.00	0.169
70.00	0.144
80.00	0.126
90.00	0.112
100.00	0.101
150.00	0.067
200.00	0.050
250.00	0.040

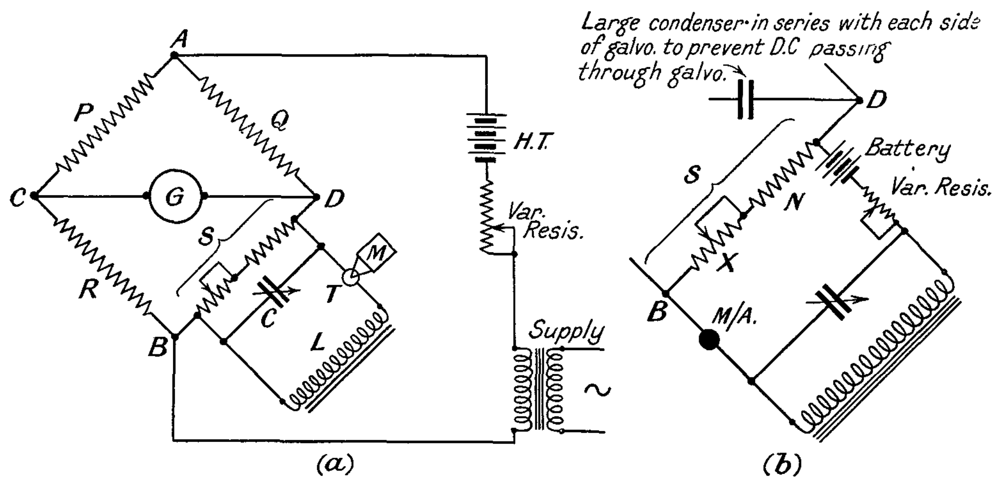


Fig. 4.—Two Methods of Applying a Polarising Current to the Inductance Under Test.

These values may be obtained from the combination in parallel of various other values such as 4, 3, 2 and 1 giving 10 units or 5, 2, 2 and 1 or 3, 3, 2 and 1 or 5, 3, 1, 1. To cover the range from .001 to 1.111 mfd. a total of 12 condensers is all that is required. These may consist of groups as follows:—

.001 mfd.	.01 mfd.	.1 mfd.
.002 mfd.	.02 mfd.	.2 mfd.
.003 mfd.	.03 mfd.	.3 mfd.
.004 mfd.	.04 mfd.	.4 mfd.

It is worth while obtaining these with a reasonable accuracy and most reliable firms will supply these for a slight extra charge.

Use Condensers of Reasonably Good Power Factor.

Condensers possessing a reasonably good power factor should be used if considerable accuracy is desired, otherwise poor condensers may introduce considerable loss into the tuned circuit L.C. For general comparison purposes it is not essential to use expensive condensers and reasonably good ones of the non-inductive variety will be found to suffice.

Method of Adjusting for Test.

Having set up the bridge the first thing to be done is to see if the zero setting is in order.

Disconnect the test inductance L and the variable capacity C.

Set the variable resistance, X, to zero and a balance should now be obtained since, by construction, the resistances P, Q, R and N were made equal. For preliminary tests the voltage across the bridge points A and B need not be high —say two to four volts. The maximum voltage which may be applied to the bridge will depend upon the safe current carrying capacity of the components and it should be borne in mind that, if the resistances are allowed to warm up, their values will in all probability change.

Connect across B and D a resistance of 100,000 ohms, and observe the galvanometer deflection. If too small increase the value of the galvanometer shunt or the volts on the bridge. Next bring the bridge back to balance by varying X a few ohms. Then remove the shunt resistance and reset X to zero when the bridge should again balance. At balance there should be no galvanometer deflection or, if phones or an amplifier be used, the sound should be nil or at a minimum.

To Operate Bridge.

Connect up the variable capacity C and the test inductance L, and switch on the A.C. supply to bridge. Vary the capacity till deflection or sound is at a minimum—

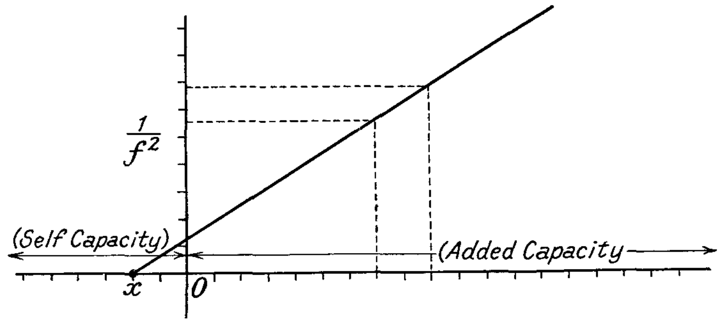


Fig. 5.—METHOD OF PLOTTING A GRAPH FOR DETERMINING SELF-CAPACITY.

a perfect zero will *not* be obtained. Then next vary X until a minimum or perfect zero is obtained. From the values of the capacity and X we can now ascertain the inductance value and the value of the dynamic resistance Rd and from these other values may be obtained.

The *inductance* is equal to L, where L is given by :—

(1) $L = \frac{1}{4\pi^2 C f^2}$ henries (neglecting the self-capacity C_0) ;

(2) Or $L = \frac{1}{4\pi^2 (C + C_0) f^2}$ henries (including the self capacity).

If our supply frequency be 50 cycles, then L is equal to :—

$$L = \frac{10.15}{C \text{ mfd.}} \text{ henries (1)}$$

$$\text{or } L = \frac{10.15}{(C + C_0) \text{ mfd.}} \text{ henries (2)}$$

The *dynamic resistance* is equal to :—

$$Rd = \frac{N^2}{X} + N \text{ ohms or to } \frac{(N + X)(N)}{X}$$

If N was made equal to 1,000 ohms, then

$$Rd = \frac{1{,}000{,}000}{X} + 1{,}000 \text{ ohms.}$$

Since the dynamic resistance Rd is equal to $\frac{L}{Cr}$ where r is the effective resistance and since L and C are known r can be calculated. Once this value r has been secured the impedance of the choke or coil can be calculated for the frequency at which it was measured and will be found equal to Z where Z is given by $\sqrt{(2\pi f L)^2 + (r^2)}$ which at 50 cycles would be equal to the square root of 314 × L (squared) + r (squared). If r is only a very small proportion of the value $2\pi f L$ it can usually be neglected.

An example is given of an actual measurement showing how these figures are obtained.

Further Variations with the Circuit.

In Fig. 4 two methods are shown for applying a polarising current to the inductance under test so that its inductance value may be read for various values of D.C. flowing. It will be found that this is a very important factor, especially with L.F. intervalve transformers and chokes as, after the polarising current reaches a certain value the inductance value commences to fall with increased polarising or "magnetising" current.

In Fig. 4A, the A.C. is measured by means of a thermo-couple T and a meter M, whilst in Fig. 4B the D.C. is measured by the milliammeter M/A.

In order to minimise the effect of any D.C. on the galvanometer suitable condensers are inserted in series with it.

Ascertaining the Self-capacity.

To do this it is necessary to observe the change of variable capacity with various frequencies (keeping the volts on the bridge constant the whole time), and to plot a graph as in Fig. 5. The amount of self capacity is shown as *o x* and is measured in terms of the same units as the added capacity.

Effect of Leakage Inductance.

If, say, the primary of a transformer be connected to the bridge and the inductance measured (with the secondary open-circuited) it will be found, when the secondary is short circuited, that the balance is upset and if the value of inductance remaining be measured it will be very much less than before. This inductance value is the "leakage inductance," and it should not be high in the case of a good transformer—about 1 per cent.

Many other interesting experiments may be carried out in a like manner and much useful information obtained.

It will be noticed that the setting of the variable resistance x is a measure of the dynamic resistance Rd of the tuned circuit LC. The higher this dynamic value the less value of x and vice versa.

If we set resistance N at 1,000 ohms we can very speedily obtain the dynamic resistance value from the formula

$$Rd = \frac{N^2}{x} + N.$$

An Example.

The bridge was originally balanced with 1,000 ohms in each arm and N = 1,000 ohms. The inductance L was added and it was found that in order to resonate this to the supply frequency of 50 cycles a value of C = .05 mfd. was required. Further, in order to secure the best balance the variable resistance x had to be set at a value of 5 ohms.

What was the value of :—

(1) The inductance ;

(2) The dynamic resistance ;

(3) The effective resistance, r, ot the inductance ;

(4) The impedance of the inductance—by itself—at the supply frequency of 50 cycles.

The self capacity C_0 being low was neglected.

Ans.

(1) The inductance $L = \frac{1}{4\pi^2 f^2 C \text{ (mfds.)}}$

$$= \frac{10.15}{C \text{ (mfds.)}} = \frac{10.15}{.05} = 203 \text{ henries.}$$

(2) The dynamic resistance $Rd = \frac{N^2}{x} + N$

$$= \frac{(1,000)^2}{5} + 1,000 = 201,000 \text{ ohms.}$$

(3) Effective resistance r.

Now $Rd = \frac{L}{Cr}$ therefore 201,000

$$= \frac{203}{Cr} \text{ henries} = 201 \times 10^3 \, r = \frac{203}{.05 \times 10^{-6}}$$

$$= 10,050 \, r = 203 \times 10^6 \text{ and } r = 20,199 \text{ ohms.}$$

(4) Impedance $= \sqrt{r^2 + (2\pi f L)^2}$

$$= \sqrt{(20,199)^2 + (203 \times 314)^2}$$

$$= \sqrt{(20,199)^2 + (63,742)^2}$$

$$= 66,910 \text{ ohms.}$$

Tabulating these results we obtain :—

(1) Inductance L = 203 henries.

(2) Dynamic resistance Rd = 201,000 ohms.

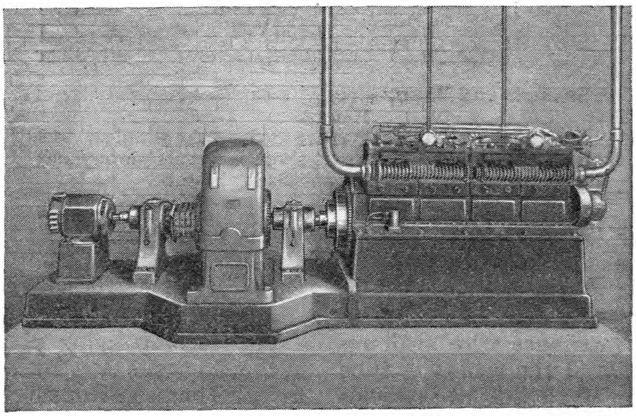
(3) Effective resistance r = 20,199 ohms.

(4) Impedance Z = 66,910 ohms.

A PETROL ENGINE DRIVEN ALTERNATOR

An interesting application of a large petrol engine to the driving of electrical generating plant is illustrated by the 100 kVA standby motor-alternator supplied to the Congella Power Station, Durban. It is a "straight-eight" Parsons engine, with cylinders giving a minimum of 150 h.p. at 1,500 r.p.m. continuously.

The alternator driven by this petrol engine is of the standard G.E.C. 3-phase revolving armature type.

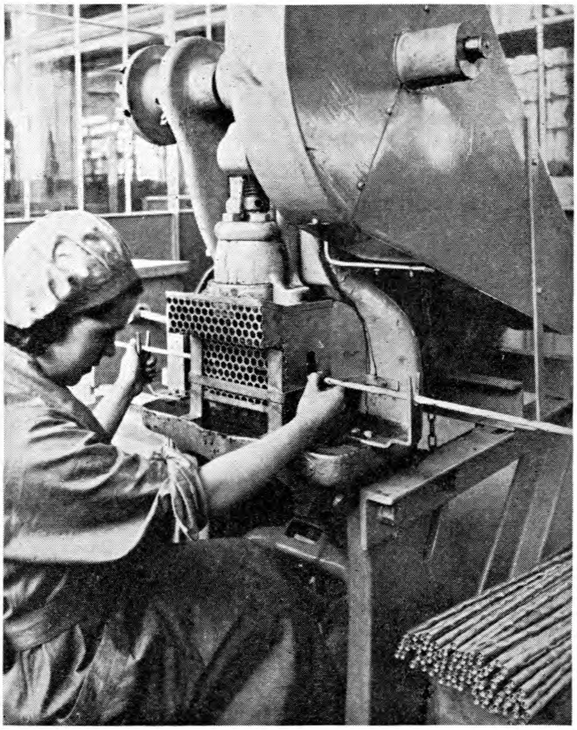


150 H.P. 1,500 R.P.M. PETROL ENGINE DRIVING 100 KVA 390 VOLT G.E.C. ALTERNATOR AT THE CONGELLA POWER STATION, DURBAN.

A New Heating Element for Electric Cookers and Water Heaters

In the early days of electric cookers, users were often disappointed at the length of time required for boiling kettles and saucepans placed on top of the range. This was due to the fact that the heating elements were embedded in a mass of metal which had first to be heated before the heat could be transmitted to the cooking utensil.

The "Torribar" heating elements which have been developed by the British Thomson-Houston Company, and which are used in the construction of "Hotpoint" cookers and water heaters provide a practical solution of this serious difficulty



A Stage in the Manufacture of the Torribar Heating Element.
Showing how indentations are made in the stainless steel tubes, two at right angles at short intervals throughout the length to centralise the spirals in the tube.

The "Torribar" element consists of nickel chrome wire embedded in magnesium oxide which is contained in thin tubes of stainless steel. In order to ensure that the resistance wire shall remain at the centre of the enclosing tube the latter is indented slightly at intervals throughout its length. This holds the central wire securely in place whilst the insulating powder is inserted. A later process removes the indentations. The complete tube with resistance wire is then bent to any desired shape for insertion in the heating or cooking appliances. In use, the heat from the central wire passes easily through the magnesium oxide and causes the steel tube to glow with a dull red heat.

Vessels can be placed directly on the element without any danger of causing either electrical or mechanical damage. The magnesium oxide is a reasonably good conductor of heat and yet gives perfectly good insulation between the resistance wire and the walls of the steel tube.

How Torribar Elements are Manufactured.

The accompanying photographs taken in the Domestic Appliances Factory of the British Thomson-Houston Works at Rugby show some of the stages in the manufacture of this new type of heating element.

FITTING THE TERMINALS AND FERRULES TO THE TORRIBAR HEATING ELEMENTS.

The complete process step by step is as follows :—

Winding and Cutting the Resistance Spirals.

First comes the winding by machine of the Nichrome wire into spirals to form the heating element. This is then cut into exact lengths as required by the voltage on which they will ultimately work. Each length is then inserted in a tube of stainless steel.

How the Spirals are Centralised in Tubes.

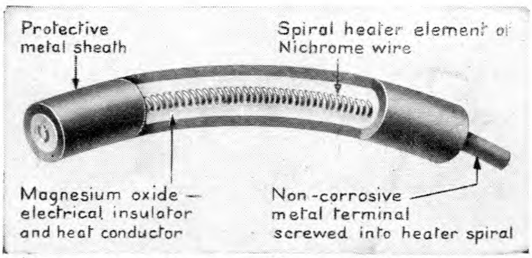
At the commencement of this operation the spirals are securely held at each end of the tubes by terminals. Next, indentations are made in the tubes, two at right angles at short intervals throughout the whole length, thus centralizing the spiral in the tube.

The tubes are then filled with dry magnesium oxide, and the ends sealed. The spirals are now firmly secured by the magnesium oxide in the centre of the tubes, and the indentations are next taken out by " swaging " machines.

Annealing and Swaging.

The tubes are then annealed, afterwards again passing through a " swaging " machine, which reduces their diameter and compresses the magnesium oxide into a homogeneous mass so that the spirals are held rigidly concentric with the tube. The magnesium oxide acts as an electrical insulator, but at the same time freely conducts the heat from the spiral to the outer steel sheath, which when in use glows with a visible red heat. Thus the finished element is immune from oxidization or damage from spilt liquids.

The final stage in the manufacture of the heating elements is the bending operation, and assembly of the ferrules and terminals.



A SECTION OF PART OF A TORRIBAR HEATING ELEMENT.

PNEUMATIC ELECTRIC LIGHTING FOR FIERY MINES

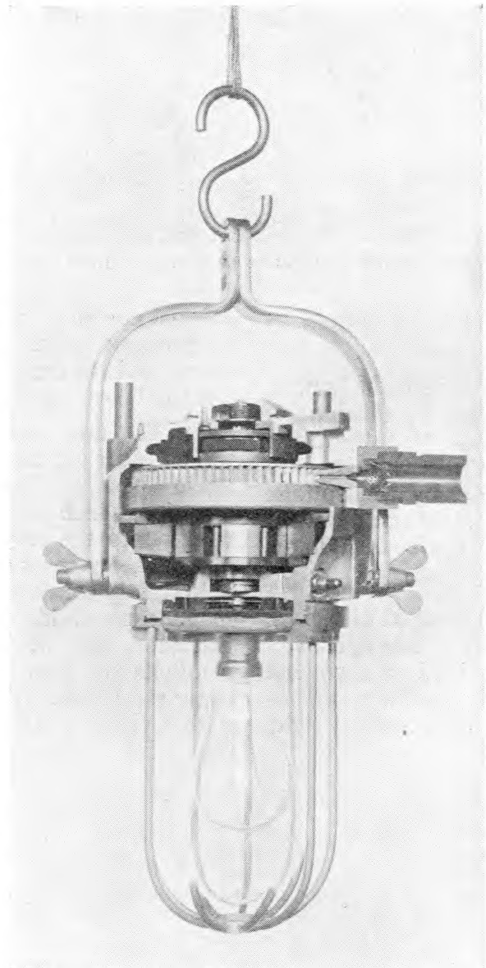
By R. HARCOURT WOODALL, A.M.I.E.E.

The article gives details of a self-contained electric lamp and generator operated from compressed air line, specially designed for improving the lighting of collieries without increasing the danger of explosion. Hints on installing and servicing are given.

THE question of providing an adequate lighting system in coal mines has been a problem for mining engineers for many years. Such a system to be applicable in all instances must be free from danger when operating in the presence of firedamp or coal dust. Battery lamps have been improved considerably, but their candle power is limited, since weight has to be considered, and it is not feasible to increase the lighting power of the hand or cap safety lamp beyond 9 c. p.

For the efficient running of a colliery, this light ng power is inadequate. It has been proved that poor illumination is one of the chief causes of accidents, and in addition, is responsible for a large amount of dirt being brought up with the coal.

The M-L pneumatic electric lamp was introduced to meet the need for better illumination, both at the working face and in the roads.



60-WATT PNEUMATIC ELECTRIC LAMP.
The alternator casing is partly cut away to illustrate the construction.

A Power Plant in Miniature.

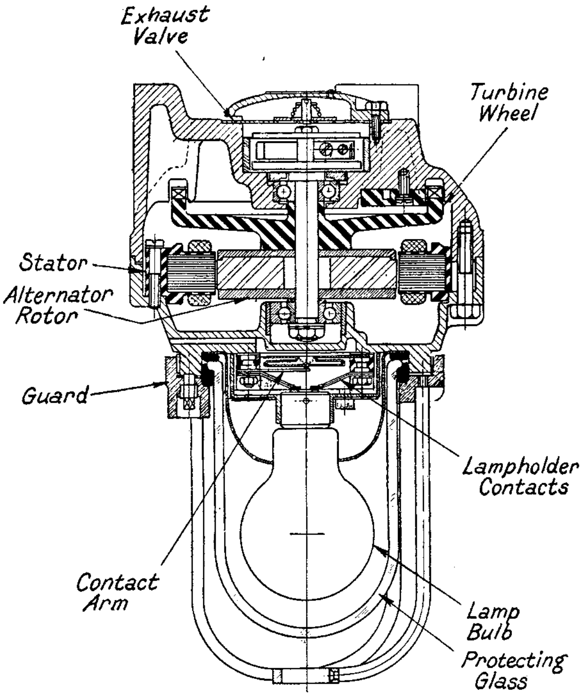
The lamp is self-contained and is designed to operate from a compressed air main. Briefly, it comprises an air turbine coupled to a permanent magnet alternator, the whole being contained in a substantial casing consisting of two castings bolted together.

Air at any pressure between 40 and 100 lb. per square inch is fed into the lamp through a connection, a filter and a reducing valve.

The Air Delivery.

This reducing valve automatically reduces the air pressure to 40 lb. per square inch so that with increased air pressures on the line, there is no fear of the turbine overspeedi ng.

A piston carrying a small valve is pressed back against a spring and the valve, moving in its seat, controls the flow of air so as to maintain a constant pressure on the jet. The spring pressure is adjusted by a screw which having once been set at the works, requires no further adjustment. It is therefore locked with a key and a brass cap is screwed on.



SECTION OF 60-WATT LAMP ASSEMBLY.
Note the air-driven turbine and alternator mounted on a vertical spindle above the lamp.

The air passes from the reducing valve through the nozzle, which is of rectangular cross-section, and impinges on the turbine wheel, carried on a shaft running on two ball bearings. The wheel consists of a bakelite moulding with the blades formed on the periphery.

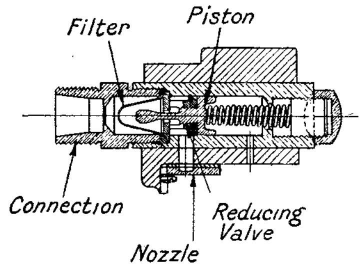
The Air Turbine.

The turbine is of the two stage type, the air traversing the vanes first of all in an inwards direction, then through a transfer port and through the vanes in the opposite direction. This increases the efficiency of the turbine.

The Alternator.

The turbine wheel is driven at about 8,000 r.p.m. On the same spindle is carried the alternator rotor, which consists of an 8-pole cast cobalt magnet held by copper rivets between two brass plates. The copper rivets act as "damping bars" and prevent the demagnetization of the magnet, by allowing for the induction of "eddy" current in themselves by any opposing field.

The rotor runs in the alternator stator which consists of a laminated "Stalloy" core having 8 poles carrying the windings. The laminations are moulded into a bakelite former so that the winding can be carried out without further insulation of the slots. It should be noted that as the windings are stationary, there are no brushes or rubbing contacts and therefore there is no risk of a spark occurring. The cutting of the lines of the magnetic field which is produced by the magnet, by the conductors, causes an electromotive force to be induced in the latter.



SECTION OF CONNECTION, FILTER AND REDUCING VALVE, THROUGH WHICH COMPRESSED AIR IS FED INTO THE LAMP.

The Lamp Holder.

The two ends of the winding are connected across the lamp holder contacts which are carried on a bakelite moulding. This moulding also houses a flexible walled chamber, the interior of which is in communication with atmosphere through a small port to the exterior of the casing. The top diaphragm carries a silver contact point and is in electrical connection with one end of the stator winding. This point normally makes contact with another fixed point carried on an arm which is connected to the other end of the winding. When the turbine is stationary, the alternator is short-circuited.

It is arranged that when air is supplied to the lamp, there is always a back pressure of about 2 lb. per square inch inside the body of the lamp and inside the protecting glass. This excess of pressure acts on the flexible diaphragm and causes the points to separate. The bulb then lights.

Safety Features.

It will be realised that if the protecting glass is broken by a piece of coal or if any attempt is made to remove the glass (normally this is locked in position by a special key), the back pressure vanishes and the lamp is immediately short circuited. The back pressure is controlled by a spring loaded exhaust valve.

There are a number of small holes in the body castings through which a scavenging stream of air flows while the lamp is operating. Any gas which may have gained access to the lamp while it has been standing is thus driven out before the lamp lights up.

An additional feature is a centrifugal type of governor which prevents the racing of the turbine in the event of the bulb burning out. Two brass weights lined with Ferodo pads fly outwards when the speed becomes excessive and engage with a steel drum. The air, before reaching the exhaust valve, passes through the governor and keeps this same reasonably cool.

A stout guard, carrying the locking screw mentioned above, is provided to prevent the glass being accidentally broken.

Capacity of the Lamp.

The alternator described above is rated to give 60 watts at 25 volts and a standard opal gas-filled bulb of this rating is used. The candle power is approximately 90. It should be noted that the actual bayonet holder is of the shock-absorbing type to ensure long life of bulbs. The consumption of free air per minute at 40 lb. per square inch is approximately 8 cubic feet. The weight of the lamp complete is 16 lb.

A Smaller Model.

A smaller model similar in principle to the above, has a series of holes in the top casting for the exhaust air, in place of the exhaust valve. A cowl fixed over these holes prevents the exhaust air from disturbing any coal dust. The governor is omitted, sufficient regulation being provided by the reducing valve.

A sectional photograph of this smaller lamp is given in Fig. 3. The bulb employed is of 12 v. 36-watt rating, the candle power being approximately 50. The consumption of free air per minute at 40 lb. is 4 cubic feet. A frosted protecting glass is used with this lamp.

Other Applications.

These lamps have many other applications, apart from their use in fiery mines. They can be used with advantage for providing illumination for tunnelling operations, for quarry work, in fact in any location where an air supply is available and where an electric supply is not at hand. Also they can be used in any explosive atmosphere, such as in a petrol tank, a chemical factory, etc.

SERVICE HINTS.

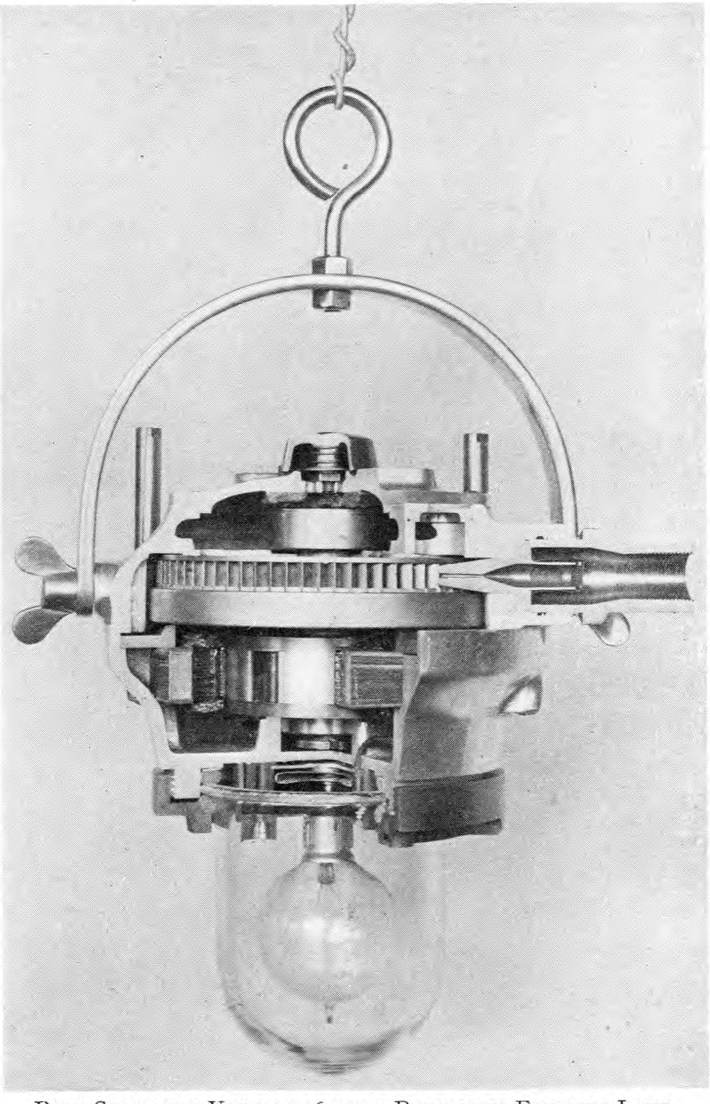
Since there are over 1,200 lamps of this type installed in the leading collieries of Great Britain, the following hints are given for the benefit of colliery electricians who may have to instal or service them.

Installation.

When installing a lamp, it should be borne in mind that a ½-in. pipe is ample for carrying the necessary air. A cock should be inserted in the pipe for the purpose of cutting off the air supply when disconnecting the lamp. The lamp can be adjusted to any desired position by slackening the two wing nuts which hold the lamp rigid with the strap which carries the hook. It is important to see that the guard ring which clamps the protecting glass in position is locked before the lamp is put into use. A special key is provided for this purpose.

Lubrication.

The lubrication of the bearings of the lamp is carried out by means of a special grease gun, through the two nipples situated on the side of the lamp. If in continuous use, a charge of oil should be given to each bearing every two days. An absorbed oil such as Vaughan's " L.1 " must be employed. A heavy grease will slow up the turbine with resulting loss of output. Having filled the gun, screw on to the nipple and turn the handle until some resistance is felt. Then turn handle through one complete turn, afterwards unscrewing the gun from the nipple.



PART SECTIONAL VIEW OF 36-WATT PNEUMATIC ELECTRIC LAMP.

Attention to Air Filter.

The air filter which is clamped between the valve seat and the hose connection is an extremely important component, and the lamp should on no account be run without it. It prevents dirt in the air supply from getting into the nozzle or on to the blades of the turbine. If allowed to get through, dirt could completely block the nozzle, causing the turbine to stop. Naturally, the filter will require cleaning at periods and it is recommended that this operation be carried out about once a fortnight.

Hunting for Trouble.

In the event of the lamp refusing to function when the air is on and the turbine running, the bulb should first of all be examined to see whether this is burnt out or has a broken filament. If this is intact, an examination should be made to see whether there is a leak between the glass and the metal casting in which this is seated. Two rubber rings are used to effect an airtight joint. It will be realised that any air leak at this point will cause the points to come together, short-circuiting the alternator and extinguishing the light.

If this joint is in order, the only other likely cause of failure is the stopping up of the hole from the outside of the casting to the inside of the flexible walled chamber. This would have the effect of operating the safety device. A piece of wire should be used to clear the obstruction.

Replacement of Bulbs.

It is important when replacing a bulb, to employ one of the correct rating. This should be definitely of the gas-filled type to comply with the requirements of the Mines Department.

Dismantling of Lamps—60-watt Model.

When it becomes necessary to dismantle the lamp for cleaning or examination of the bearings, the exhaust valve cover and valve itself should be removed by unscrewing the three hexagonal headed screws. Then the six bolts holding the two body castings together should be removed. The two castings should now come apart, the spindle, rotor and turbine wheel coming away with the top casting; the stator, etc., coming away with the bottom casting to which the lamp guard, etc. are fixed. If there is any difficulty in separating the castings, hold the lamp by the guard with the stirrup hanging downwards and tap with a wooden mallet.

To dismantle the rotor, turbine wheel, etc., remove nut holding bottom ballrace and withdraw spindle through top ballrace. Do not attempt to adjust the diaphragm.

After reassembly, tap the top governor plate with a mallet to place the bottom ballrace in its normal position. It is important to make certain that iron filings, etc., are not picked up by the magnet unit when the lamp is down, since the airgap is small and any foreign body in the gap may make the rotor foul the stator.

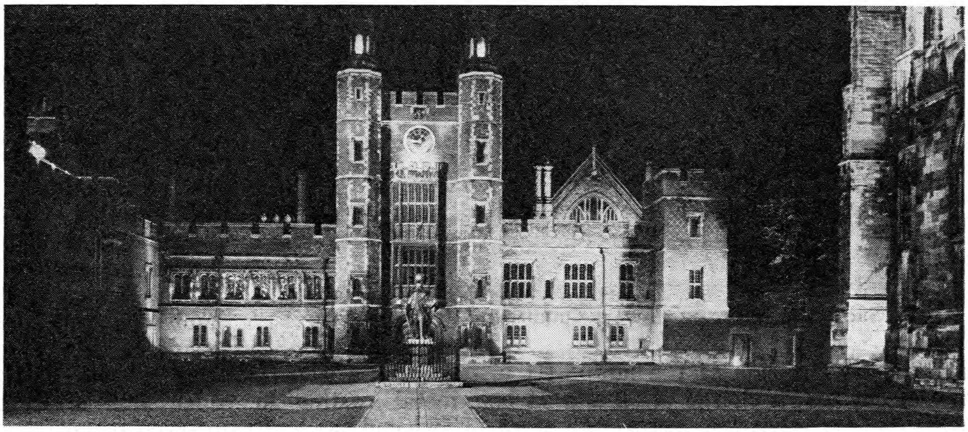
Dismantling of Lamps—36-watt Model.

First remove the three screws which hold the two body castings together. The rotor, turbine wheel, etc., on the spindle will come away with the top casting. The lock nut holding the lower ballrace should be removed and the spindle can be drawn through the upper ballrace and the hole in the upper casting. The top bearing can be removed by withdrawing lock nut.

Cleaning of Reducing Valve.

First of all remove hose connection and filter and draw out valve seat. The piston and valve can then be withdrawn for cleaning together with the spring. Do not disturb the adjusting screw. Grease the spring well and replace it with the larger end towards the adjusting screw.

ETON COLLEGE FLOODLIGHTING



A Striking Example of Floodlighting Effect Carried Out by the General Electric Co., Ltd., at Eton College Recently.

Nearly 100 floodlights were used, giving a total illumination of some 5 million beam candles. A special feature was the method of controlling the lighting by dimmers, which allowed a constant change of light and shade effects.

QUESTIONS AND ANSWERS BY PRACTICAL MEN

Readers are invited to send problems of practical interest. Letters should be addressed to "The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C.2. Envelopes to be marked "Problem" in the top left-hand corner

QUESTION 1.

The sub-station (traction) at which I am employed has two H.T. feeders and three interconnectors (one of these interconnectors feeding a static sub-station for office lighting and power). The accompanying diagram shows the protection arrangements on each feeder; the reverse relays being of the B.T.-H. type and the leakage relays are Metropolitan-Vickers type. The interconnectors are protected by double-pole self-resetting inverse time-lag overload relays and leakage relays. I wish to know the voltage of the potential transformers (ratio 60 : 1), i.e., across the outer conductors, and desire to know the formulæ for determining this voltage. I should also like to know something of the working of the reverse relays and interior connections.

L. A. J. B.
(Tottenham).

ANSWER.

Reverse current relays are used in A.C. transmission systems to prevent the flow of a reverse current in a system of parallel feeders.

Meaning of a Reverse Current.

Since an alternating current reverses its direction every half period, the meaning of "reverse current" is not too obvious. What is meant, is the direction of flow of the mean power developed. Under normal circumstances, the difference in phase between the voltage and current may vary between certain limits, depending upon the power factor of the system generally. If the phase difference becomes 90 degrees, then the power developed is zero, but if this phase difference exceeds 90 degrees, then the alternating current becomes "reverse." In the case of an alternator, or feeder from it to a sub-station, the machine will absorb more power in a period than it will give out; the power being supplied from another machine which will be connected in parallel with the system, and therefore the mean power transmitted by the feeder will be reversed.

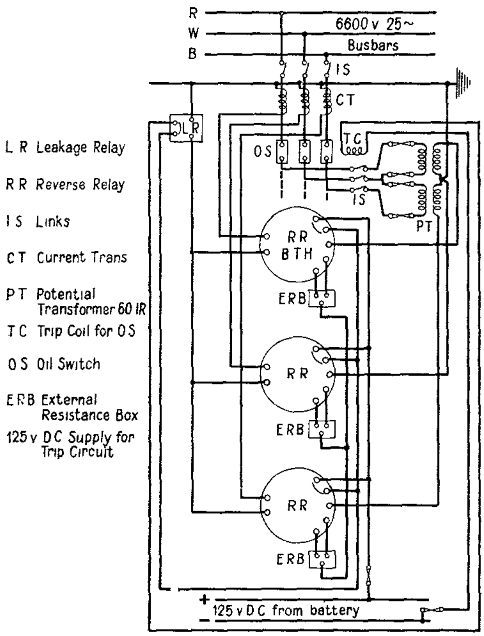


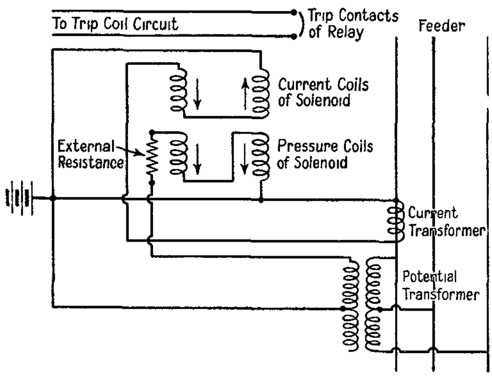
DIAGRAM SHOWING PROTECTION ON EACH FEEDER OF A TWO-FEEDER SUB-STATION.

Construction and Action of the B.T.-H. Reverse Current Relay.

The relay consists of two differentially wound solenoids, with plungers coupled by a balance arm. The solenoids act in opposition and tilt the balance arm towards one coil or the other according to whether the main current be normal in direction or reverse. When the main current is forward the coils of one solenoid help each other, whilst those of the other solenoid are in opposition. When the current is reverse then the coils of the solenoid which were assisting each other are now in opposition, and the coils of the solenoid which were in opposition are now assisting each other.

The current coils of the solenoids are connected in series and energised by the secondary current of a current transformer connected in the feeder which is to be protected.

The pressure coils of the solenoids are also connected in series and energised by the secondary current of a potential transformer whose primary winding is connected across the feeder.



THE EXTERNAL CONNECTIONS OF A B.T.-H. REVERSE CURRENT RELAY.

Complete protection to a three-phase feeder is given by installing a triple-pole relay.

When there is a reverse current the balance arm tilts and, by shortcircuiting two contacts in the relay, closes the trip circuit of the oil switch, which now opens and disconnects the feeder from the system.

The internal connections of the relay are given in the above diagram. The arrows are inserted to indicate the relative action of currents in the current and pressure coils of the solenoid.

Calculating the Secondary Voltage.

If the ratio of the potential transformer is 60 : 1 and the voltage on the primary between lines is 6,600, then the voltage of the secondary between lines will be

$$\frac{6{,}600}{60} = 110 \text{ volts}$$

The pressure coils of the solenoids are wound for 100 to 110 volts, with an external resistance which absorbs 30 to 40 watts.

The approximate voltage across the secondary winding of a transformer may always be obtained by dividing the primary voltage by the ratio of transformation, for example :—

Primary voltage, 33,000.
Ratio 30 : 1. (Step-down transformer).

$$\text{Sec. voltage} = \frac{33{,}000}{30} = 1{,}100 \text{ volts.}$$

Or :—

Primary voltage, 2,000.
Ratio 1 : 5. (Step-up transformer.)

$$\text{Sec. voltage} = \frac{2{,}000}{\frac{1}{5}} = 10{,}000 \text{ volts.}$$

QUESTION 2.

I would like to have some advice on how to build a transformer for arc welding, 250 volt, 60 cycle, A.C. I also want wiring diagrams for A.C. motors showing all connections from line to switchboards, with all meter connections and diagrams of transformers for single 2 and 3 phases.

P. J. K. (South Africa).

QUESTION 3.

I should be very glad if you could give me some information regarding an emergency stand-by installation for electric incubators and brooders.

These are at present running on 230 volt A.C. The consumption is about 7 kw. Is it possible to obtain an A.C. generator of this voltage and output?

J. and C. (Heathfield, Sussex).

QUESTION 4.

I wish to change a D.C. motor 2 b.h.p., 240 v., 1,550 r.p.m. (max.) to A.C. single phase, without loss of velocity, but am not sure of method to employ. Can you please enlighten me ? R. E. S. (Manor Park).

Readers are invited to reply to the above questions. All replies published will be paid for at our usual rates, and should reach us not later than October 2nd, 1933. Address letters to "The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2.

Recent Progress in Television

The PRACTICAL ELECTRICAL ENGINEER

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Broadcast Reception of the Future.

Whilst the private receiving set will always remain popular amongst many classes of listeners, there are a large number of people who undoubtedly will wish to avail themselves of the relay radio system. Reference to this has already been made in these columns. There is reason to believe that the system of receiving programmes at a central receiving station and distributing the programme to private subscribers will be considerably extended during the next few years. A further article which appears in the present issue is worthy of careful study, as it contains practical details of such a system which has given every satisfaction in actual practice.

Sound Amplifying Equipment.

Sound amplifying equipment for use in connection with open air gatherings or in lecture and concert halls is another development of light current engineering which has considerable possibilities in the future. We have been fortunate in obtaining from one of the engineers of the B.T.H. Company a fine practical article which tells exactly how to install such an equipment. Whilst most readers are no doubt familiar with the broad principles involved—in practice it is the little refinements which make all the difference between good and bad reproduction. A sound amplifying equipment which has not been installed with these refinements will give results which leave a great deal to be desired. That there is need for the dissemination of knowledge of this kind cannot be doubted by anyone who has attended at gatherings where sound amplifying equipment has been in use.

A Fine Engineering Achievement.

A few days ago the last tower of the transmission system projected under the Grid Scheme was completed. The general public quite naturally assume that the main object of the Grid is eventually to provide cheaper electricity. Engineers still say that this is not so. Is it not time that engineers as a whole got more in touch with the viewpoint of the man in the street? From now onwards the prosperity of the electrical industry will depend very largely upon the man in the street. Surely if the Grid is to justify its existence the net result must in the end be translated into terms of £ s. d. for the actual consumer. Unless electricity can be sold at a price which will enable it to compete with other sources of light and power, it will never be universally adopted. To secure a wide and rapid adoption of electricity in undeveloped districts we suggest that the price must be from ¾d. to 1½d. per unit. This is not an economic figure at present for many undertakings, because there are not enough units sold to cover the production costs and capital charges. Unless the price which the consumer has to pay is an economic price *so far as he is concerned,* no amount of advertising will be effective in securing the rapid extension which has now become of vital importance to the Industry as a whole.

Earthing Regulations.

Mr. Winton Thorpe continues his interesting series of articles commenting on the regulations for the electrical equipment of buildings. We find that many readers are intrigued by the way in which he goes straight to the heart of the subject and also by the pictorial illustrations which he employs to emphasise important points.

Voltage Regulation.

During the past few years the question of voltage regulation has become increasingly important. Mr. Brittain in an article beginning on page 57 outlines the systems employed, viz., tap changing, the induction regulator, and the single and multi stage booster.

Television.

It would be interesting to know how many people to-day are in a position to receive the television broadcasts of the B.B.C. Presumably the number is small compared with the total number of licence-holders. There is no doubt, however, that these television broadcasts have stimulated manufacturers to develop television beyond the laboratory stage, and we have reason to believe that television receivers employing cathode-ray tubes will be placed on the market in the near future. The article beginning on page 49, written by an author in close touch with developments on the manufacturing side, is worthy of close study.

Lamp Prices.

Readers of the Magazine will remember that in our issues of March and April we dealt with the question of the lamp manufacturers and ring prices. It will be extremely interesting to see the result of the new policy adopted by the Crompton-Parkinson Kye Sales Organisation. 40-watt and 60-watt British-made lamps are now available at the retail price of 1s. each. Judging from the response to their sales campaign, this price reduction is likely to prove highly beneficial to the instigators. If this substantial reduction in price leads to greatly increased use of electric lamps, the change will undoubtedly be for the good of the Electrical Industry as well as for the good of the Crompton-Parkinson Kye combine. This increase may come about in two ways :—

(*a*) People may renew lamps more frequently than formerly, or

(*b*) The lower cost of lamps may induce people to adopt electric lighting who would otherwise have refrained from doing so.

Gaseous Discharge Tubes.

Whilst there have been rumours that the lower price of electric lamps may lead to a price war, we believe that it is equally probable that this price reduction will help to speed up the development of gaseous tube lamps which will undoubtedly provide the lighting of the future, and which will, therefore, ultimately displace metallic filament lamps whether of the gas filled or vacuum types. Let us hope that the first gaseous discharge lamp suitable for domestic use is developed in this country.

An Engineer's Solution to the Economic Problem.

Departing from our usual custom, we give on page 60 a brief review of Mr. A. P. Young's book "Forward from Chaos." We believe this book will interest many readers of the Magazine who, we know from our correspondence, are of the thoughtful and yet practical turn of mind. Mr. Young combines a certain amount of philosophy with many practical suggestions.

Sir Ambrose Fleming.

The recent news of the marriage of Sir Ambrose Fleming created great interest in electrical circles.

It is no exaggeration to say that were it not for the early researches of Sir Ambrose, which led to the discovery of the Fleming valve, present-day broadcast reception would be non-existent. This is a very striking example of the way in which the laboratory research of to-day may be the foundation of important industries of to-morrow.

We learn with interest that Sir Ambrose is supervising the preparation of a comprehensive work of reference entitled *Principles of Electrical Engineering*, which is to be issued very shortly in about 32 weekly parts. This work, we understand, deals with every aspect of electrical engineering, and the first part—which is appearing on October 4th—contains a unique series of photographs illustrating by laboratory experiments the development of gaseous discharge tubes, cathode ray tubes, and X-ray tubes.

Electrical Engineering Up to Date.

Hitherto in the average technical college course in electrical engineering very little attention is devoted to the study of electric discharges through rarefied gases. With the advent of neon tube lighting, the sodium lamp, the Osira lamp, the Mercra lamp, and the extended popularity of the cathode ray oscillograph, the study of gaseous tube discharges has acquired great importance. Until recently this subject has been left almost entirely to the scientific worker. We believe that in the near future every student of electrical engineering will be expected to acquire a fair knowledge of the elementary principles of this branch of the subject.

THE PROGRESS OF TELEVISION

Has television yet reached a stage when it can be called a commercial and practical success? We believe our readers will find much to interest them in the following survey of the progress of television

IN the following article we give a brief survey of the development in the progress of television.

THE BAIRD TRANSMITTER.

In the first Baird arrangement the subject was flooded with an intense light and on the other side of the scanning disc was a photo cell or selenium cell, the light from the various scanning holes being focused on to this cell. A better arrangement is that in which the illuminating light is placed behind the scanning disc and falls upon the subject of transmission as a moving spot of light which travels down the subject, in strips or lines. It is this light which is reflected by the subject on to a photo cell. It is to be noted that this is a reflected light and, therefore, the amount of light falling on the photo electric cell will depend largely on the reflecting properties of the subject.

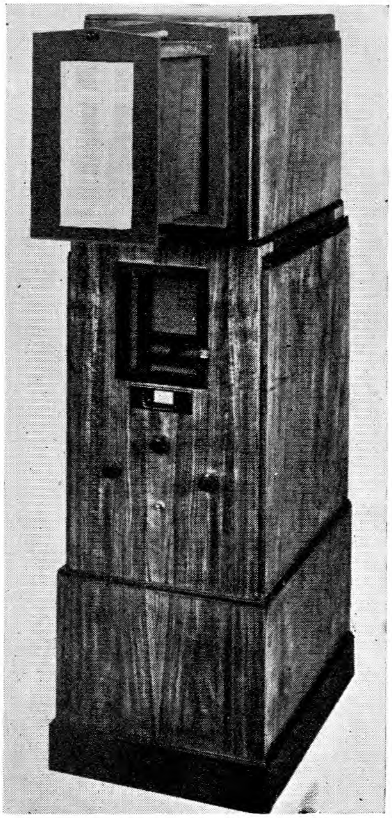


Fig. 1.—A COMPLETE TELEVISOR WITH SCREEN EXTENDED. (*Bush Radio.*)

Only Reflected Light Available for Photo Cells.

It is important to remember that the cells rely on reflected light, sometimes from a surface which is not a very good reflector. This is the first serious disadvantage of the disc method and, indeed, any reflected light method, such as the direct scanning lens wheel or mirror drum.

Since only reflected light is available for the photo cells, if the light spot falls on a dark portion of the subject the amount reflected to the cell is small, producing a correspondingly small electrical impulse; if on a lighter portion of the subject more is reflected, causing a greater electrical impulse from the photo cells. A further aggravation of the light problem is that the size of the holes in the disc introduces a limiting factor that has tended to put this system out of favour, except for very simple images such as diagrams and lettering with intense black and white differences. It is, however, interesting to note that the B.B.C. have in their Television Studio a disc scanner which may be used for simple subjects, such as written announcements on cards.

How the Disc Receiver Works.

The secret of success is that any one hole of the receiver disc must be in exactly the same position as the relative hole in the transmitter disc.

The transmitter sends out its succession of strip signals one after the other and the result is a series of variations in the anode current of the output valve of the receiver. (See Fig. 9.)

The illumination of the neon lamp in

the anode circuit of the receiver valve varies, therefore, with the strength of the signals from the photo cell at the transmitter.

Referring to Fig. 6, the curved strips A, B, C, D, etc., we can, as far as the radio transmitter and receiver signals are concerned, put all these strip signals in a line one after the other and interpret them in terms of neon glow at the receiver. (See Fig. 8.)

Connection of the Neon Tube with the Scanner Disc.

The receiving disc scans the glowing plate of the neon tube exactly as the transmitter disc scans the subject, the glow of the neon varying exactly as the light reflected off the subject is picked up by the transmitter photo cell.

The Importance of Synchronisation.

It is, of course, absolutely essential that the receiving disc should revolve at exactly the same speed as the transmitter, and elaborate precautions have been taken by various investigators to ensure this. But the synchronisation of a vision receiver is still a matter of very great difficulty and it is not easy to keep the picture steady even at the present stage of the art.

How a Receiver is Synchronised.

The method employed is to adjust the speed of revolution of the receiving disc and therefore its position once every sweep of a scanning hole, that is to say, once every time a line of the picture has been completely swept over by a scanning hole.

Reference to Fig. 9 shows that the output of the wireless receiver passes through the neon tube normally to high tension positive, and that if no signal is being received from the photo electric cell at the transmitter no signal will pass through the neon tube at the output stage of the receiver, or at any rate, only a signal below a certain value, and there will be little or no glow.

The Scanning Mask.

It is arranged at the transmitter that as each scanning hole begins to scan its allotted strip of the subject it passes a mask or dark portion—that is to say, there is an instant 30 times per picture scanned when no signal is passed. (See Fig. 6.) If the picture were being scanned only once every second there would be a condition of the output valve of the receiver every $\frac{1}{30}$ of a second when no current was flowing, and that condition would occur as each scanning hole starts to sweep downwards from the top of the picture.

Actually on the Baird system as at present broadcast in order to get a *moving* picture, the subject is scanned completely $12\frac{1}{2}$ times per second, so that the number of strips actually transmitted is $12\frac{1}{2} \times 30$ or 375 strips per second. The synchronising impulse, therefore, will occur at that speed, and it can be heard quite clearly as a 375-cycle note if the transmission is listened to through an ordinary sound radio receiver.

In Fig. 8, the points "X," "Y," "Z," and "W" are the "no signal" impulses caused by the mark shown in Fig. 6.

How the "No Impulse" Points are Used to Synchronise.

Fig. 7 shows that two magnets are connected in series with the H.T.+ and neon tube of the output valve; between these magnets revolves a cogged wheel. Each time a scanning spot passes the mask at the transmitter the anode current of the output valve of the receiver will drop, and there will be little or no current flowing through the magnets.

It must be understood that the magnets shown in Fig. 8 are not actually driving the motor, and that if no current is flowing through the magnets in the anode circuit of the output valve they will have no effect whatever on the teeth of the cogged wheel which is attached to the receiver disc driven motor shaft. If, on the other hand, they become magnetised as a tooth is approaching the magnet they will draw that tooth towards the magnet and hasten the speed of the cogged wheel. If an impulse passing through the magnet occurs just as one tooth is opposite to it, it will tend to try to keep the tooth of the cogged wheel in position against the magnet and give a braking action; in the same way, if a tooth has gone too far past the magnet and the impulse comes on from the transmitter it will tend to pull the tooth back, and again exercise a retarding force on the motor, tending to slow it up.

The Question of Picture Detail.

There was, however, and still is to-day, a far more important limitation to the success of the television art, and that is the amount of picture detail offered.

At present transmitters scan the subject by dealing with it in strips or " lines " ; the greater the number of lines the finer will be the picture detail. At present only 30 such lines are used.

There is a school of thought which believes that the amount of detail provided by a transmitter which divides the subject up into only 30 lines can never give the artistic detail which will eventually be demanded by the public to make television reception an understood and commercially accepted proposition.

One of the most striking exhibits at the Television Exhibition was a film by Kodak Co., showing the same picture at different scanning frequencies. From 40 lines up to 100 it was of scientific interest only. At about 120 lines it began to show real artistic and entertainment value.

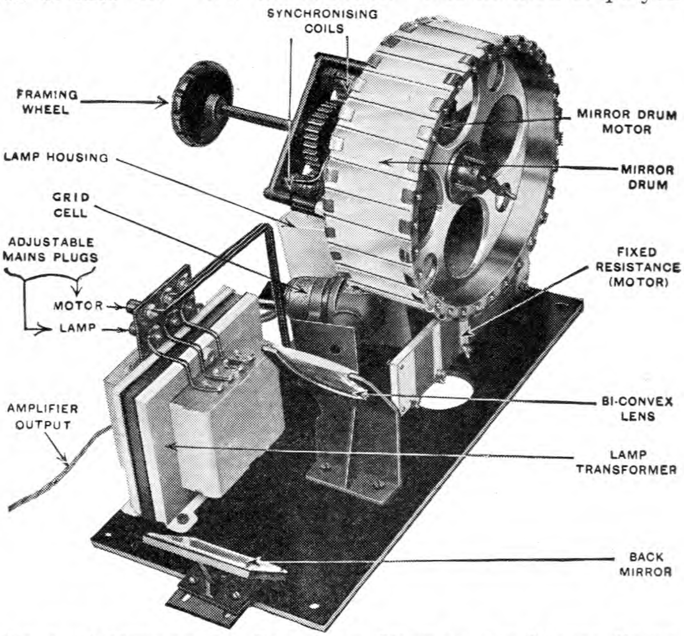


Fig. 2.—A VIEW OF THE PROJECTOR USED IN THE LATEST BAIRD TELEVISOR. (*Bush Radio.*)

How the Mirror Drum Transmitter Operates. (Fig. 10.)

We have got the idea of splitting up the subject to be televised into strips and we have seen that it can be done, either by flood lighting the subject and then picking up the light through the small holes or lenses in a disc, or by allowing only a spot of light to fall on the subject and moving that up and down the subject in a scanning motion ; in both cases picking up the reflected light by the photo electric cell.

Neither of these systems permits a very large amount of light to be thrown on to the cell.

The mirror drum arrangement, which has been tried for a number of years, is one which is used now by the Baird Television Company, and has been demonstrated in various forms by other organisations, notably " His Master's Voice " in a demonstration they gave about two years ago.

The idea of using a mirror wheel for scanning the subject is quite an old one and was invented originally by Weiller. It makes ingenious use of the rotation of a drum and tilted mirrors placed on the circumference of that drum. Fig. 10 shows how this is done. The method employed is to cast a scanning spot of light on to the subject, and it will be seen that as the drum rotates it gives a horizontal searching motion to the mirror ; since each mirror in turn is tilted consecutively they look after a lower section of the subject in turn, the whole subject will be scanned from left to right and downwards, in sections at a time.

The sequence of signals sent from the mirror transmitter will be in the same form as those sent from the disc type of transmitter.

The Mirror Drum Receiver. (Fig. 11.)

The mechanical difficulties of commercial high-speed scanning still exist in the mirror drum transmitter, but the greater intensity of light offered is an enormous improvement over the disc receiver, although it should be remembered that however good is the illumination, if the picture detail is no better, still further advance remains to be made in that respect.

The mirror-drum receiver has an added feature which still further improves the lighting in that, so far as the latest Baird receiver is concerned (marketed by the Bush Radio Company), no attempt is made actually to modulate or flicker the light itself. The intensity of the light is varied by passing it through a special light cell which modulates the amount of light passing through it, due to the action of the electrical impulses received from the transmitter photo cells.

This means that a comparatively powerful constant source of light can be used for the receiver, which makes it possible actually to project the image on to quite a large screen.

THE SCOPHONY SYSTEM.

This method makes use of the optical peculiarities of cylindrical lenses.

As we have seen, with both the mirror drum and the disc method of scanning, the subject is mechanically divided up into strips by the action either of a series of holes in different positions on the scanning disc or by a series of mirrors each differently tilted on the circumference of a mirror drum. The Scophony system uses only one scanning slit and arranges the strips of the picture in practically a continuous length. The method is based on the fact that a cylindrical lens will, through one axis, take any object and spread it out sideways into a strip.

A series of cylindrical lenses are all mounted together in echelon, so that the image is split up into a series of strips, each one below the other handled by this bank of cylindrical lenses.

The Scophony Lamp.

The projection lamp which is being used by the Scophony concern is also of great interest since it has a very high illumination efficiency for a given electrical input, and is of the sodium type. Examples of this lamp used as a street lighting element can be seen outside Croydon Aerodrome by anyone driving up Purley Way, and it represents the very latest in illumination efficiency.

THE CATHODE RAY SYSTEM.

The advantages of the Cathode Ray receiver depend upon the fact that its moving part is not a mechanical mass but a stream of electrons, having no mechanical weight or inertia which is absolutely instantaneous in action, being controlled by fluctuations of current which deflect the spot of light either sideways or upwards or downwards in a scanning motion.

How the Ray is Produced.

The Cathode tube produces electrons from a heated filament or cathode much as an ordinary valve, but they are confined electrically and mechanically in a shield from which they are shot out in a high speed concentrated stream.

How the Electrons are Shot from the "Gun." (See Figs. 14 and 15.)

The screen arrangement is known as the Electron "Gun," and the method employed to shoot the electrons is much similar to that used in the German light-spray lamp. In both cases the electrons are confined in a screen, but attracted out through a hole by a positively charged anode which, however, has a hole in it.

The electrons rush out, but in their hurry shoot through the hole in the anode and pass on, in the case of the light-spray lamp, as a fiery glowing flame, and in the case of the cathode ray tube to strike the screen at the end of the tube.

Such a stream of electrons can be bent or deflected in two ways, either by placing charged plates near them, or magnetic coils. The television cathode ray tube has two sets of such plates or coils, one pair to move the ray up and down and the other pair to move it sideways. By combining and adjusting the relative potentials in the case of the plates, or currents in the case of the coils, the ray

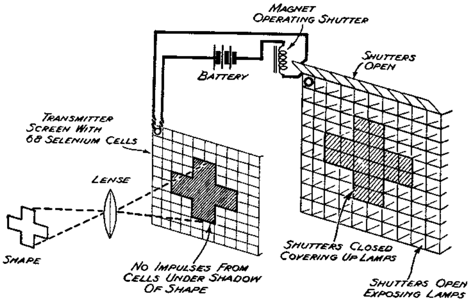


Fig. 3.—DIAGRAMMATIC REPRESENTATION OF EARLY TELEVISION ARRANGEMENT.

This apparatus, built in 1906, relied on a multiplicity of selenium cells controlling a large number of lamps.

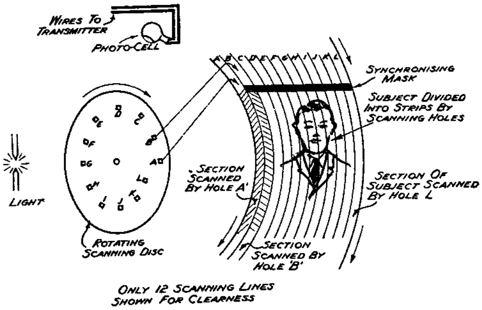


Fig. 4.—A NIPKOW DISC ARRANGEMENT. Consisting of a disc of metal into which were drilled a spiral series of holes.

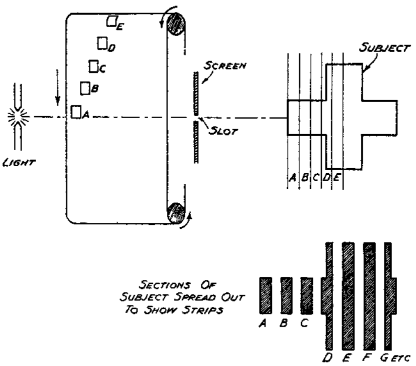


Fig. 5.—DETAILS OF AN EARLY ATTEMPT AT SCANNING ON THE SAME PRINCIPLE AS THE NIPKOW DISC.

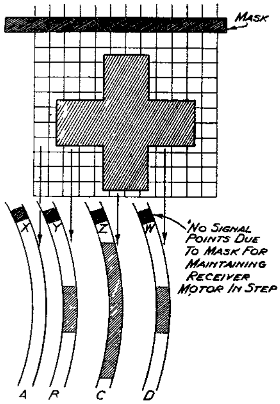


Fig. 6.—SHOWING HOW THE DISC SCANS THE SUBJECT WITH A CIRCULAR MOTION.

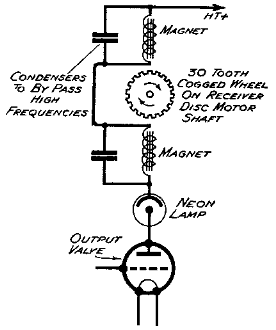


Fig. 7.—HOW TWO MAGNETS ARE CONNECTED IN SERIES WITH THE H.T.+ AND NEON TUBE OF THE OUTPUT VALVE.

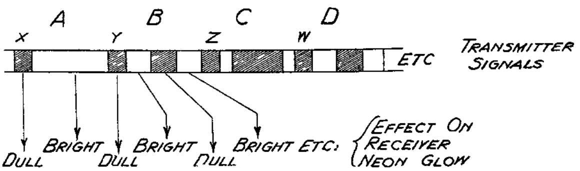


Fig. 8.—HOW ALL THE STRIP SIGNALS CAN BE PUT IN A LINE ONE AFTER THE OTHER AND INTERPRETED IN TERMS OF NEON GLOW AT THE RECEIVER.

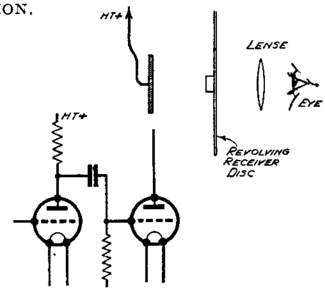


Fig. 9.—WORKING OF DISC RECEIVER.

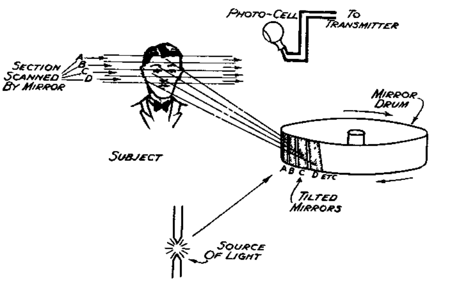


Fig. 10.—HOW A MIRROR DRUM IS USED FOR SCANNING THE SUBJECT

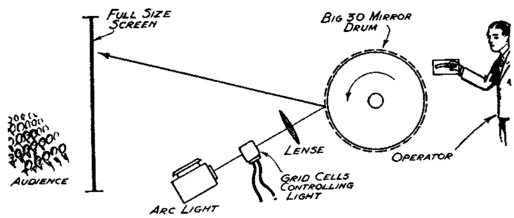


Fig. 11.—THE MIRROR DRUM RECEIVER.

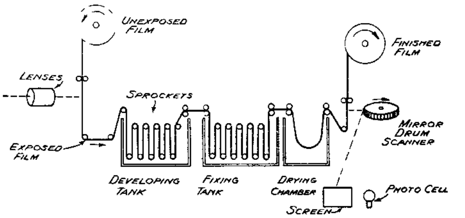


Fig. 12 —THE FILM SCANNING TRANSMITTER.

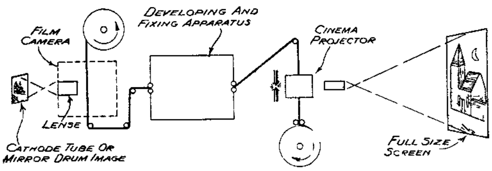


Fig. 13 —THE FILM PROJECTION RECEIVER.

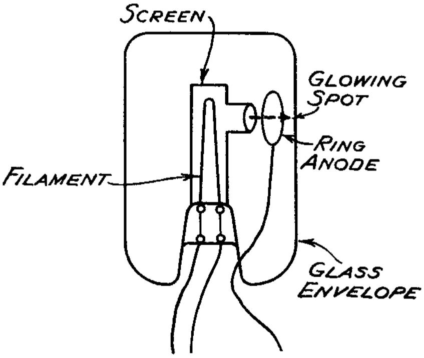


Fig. 14 —DETAILS OF THE GERMAN LIGHT SPRAY LAMP.

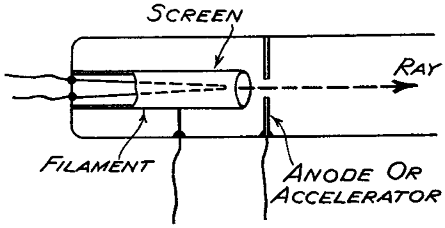


Fig. 15 —DETAILS OF THE CATHODE RAY GUN.

The electrons rush out, but in their hurry shoot through the hole in the anode to strike the screen at the end of the tube.

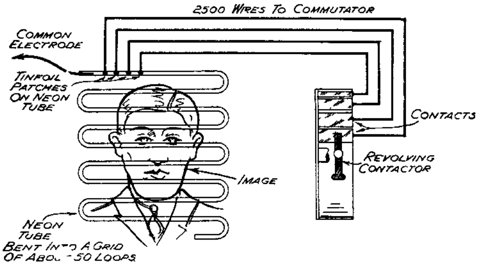


Fig. 16 —DETAILS OF A METHOD BY WHICH A BIG SCREEN IMAGE WAS PRODUCED.

Showing the use of a long neon tube curled into a flat spiral.

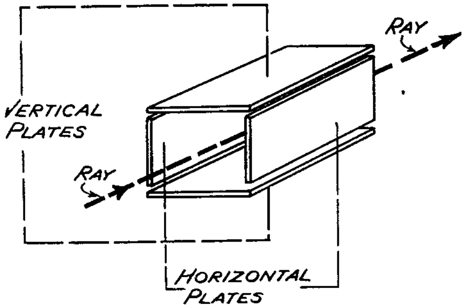


Fig. 17.—ARRANGEMENT OF PLATES IN CATHODE RAY TUBE.

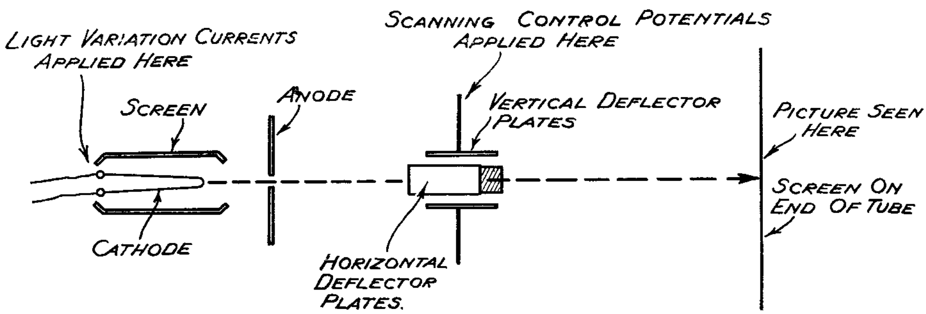


Fig. 18.—DIAGRAMMATIC REPRESENTATION SHOWING HOW CATHODE RAY TUBE SCREEN IS SCANNED.

can be aimed to strike any point of a screen on the end of the tube, a glowing spot being produced where the ray strikes it.

How the Tube Screen is Scanned. (See Figs. 17 and 18.)

We have seen that to scan we want a vertical sweep 30 times across the screen, the scanning spot being moved over 1-30th of its travel each time it sweeps down. This horizontal movement was achieved in the case of the drum by tilting the mirrors. The ray of the cathode tube is kept moving both horizontally and vertically by condensers, which are arranged to charge and discharge at the speeds which will give correct scanning—stationary electrical components instead of complicated revolving mechanical devices.

How the Light is Modulated.

In the case of the disc a neon tube glowed in sympathy with the photo cell impulses at the transmitter, and in the case of the projection mirror drum light modulating cells were used. In the cathode ray tube, however, all that is necessary is to put fluctuating potentials on the screen surrounding the cathode to control the number of electrons which will strike the screen, controlling, therefore, the brilliance of the spot on the screen.

THE "ELECTRIC EYE" OR "ICONOSCOPE."

The Very Latest Development.

There have been a number of vague references to a new television device known as the "Electric Eye," but beyond the fact that it has been made clear that it consists of a large number of tiny photo cells, which can simultaneously appreciate an image, such as that thrown by a lens on to a photographic plate, not very much has been said about it, but it looks as if it may in time solve the scanning problems.

The Advantage of the Iconoscope Method.

The most important point to bear in mind is that the output of a photo cell in electrons depends not only on the intensity of the light, but on the time of exposure to the light.

Output Dependent on Time of Exposure as Well as Intensity of Light.

In order to get away from the complexity of a multiple cell, "Electric Eye," inventors such as Nipkow and others, tried to scan by a series of different impulses, but always using a single spot of light or a single impulse from one small piece of the image. Since the output of the cell is dependent upon the *time* that the light is falling on the cell as well as its brilliance, it is very severely restricted by this method of scanning.

If, for instance, we assume that to get a detailed picture, we have to divide it up into 50,000 elements, and that to get good continuous motion reproduction we are going to reproduce that picture not 12½ but 20 times a second, we have got to reproduce a million picture elements every

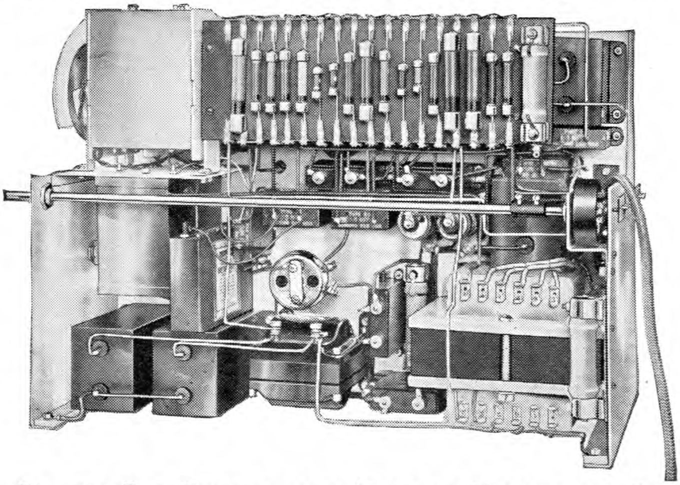


Fig. 19.—THE RECEIVER AND AMPLIFIER USED IN THE BAIRD TELEVISOR.

This comprises H.F. and Detector stages followed by a powerful four-valve resistance-coupled amplifier, which is required for reception of the "vision" broadcast and for the accurate synchronisation between transmitter and receiver.

second. The time, therefore, during which the spot light falls on one photo cell under the present systems for any given one instant, can only be one-millionth of a second.

How the Iconoscope Works.

In the "electric eye" the picture is presented to a surface which has a large number of photo electric elements which all continue to discharge electrons during the whole time that the image is presented to them.

These small specks of photo electric material are mounted on an insulating material which is backed by metal, so that in effect they each constitute a small condenser.

A Series of Small Condensers.

The sheet of insulating material being a common di-electric, the metal backing constituting a common pole and the specks of photo electric material forming small separate condenser poles.

The plate of the Iconoscope is, therefore, a mass of small condensers. The intensity of the light will, since they are all exposed for the same period, determine the charge of each little condenser which will vary for a light or dark portion of the picture.

Since the action of light is to cause electrons to leave the photo electric surface they will become positively or less negatively charged with relation to the common pole.

The effect, therefore, at any picture instant is a multitude of small condensers, each holding a different charge determined by the light or shade of the picture.

How the Condensers are Discharged.

The impact of a cathode ray scanning the plate in zigzag fashion is employed to discharge each small condenser in turn once every 20th of a second.

The control of the cathode ray is similar to the usual method of scanning a cathode ray receiver screen, except that in the case of the Iconoscope the ray scans with a zigzag motion the plate on which the image is projected.

Actually, the tube has been mounted in a box not unlike a camera, which can be fixed or moved about with the same facility and which can take full advantage of the fine optical properties of the modern photographic lens, as the multiple cell plate is as receptive of an image as a photographic plate on which the image is focused in exactly the same way.

The perfection of the Iconoscope is of first-class importance, even at its present stage of development, and while it is hailed rightly as the most important development in television it is curious to reflect that the multiple cell idea is 30 or 40 years old, which has been developed into a revolutionary new device by an invention very nearly as old as itself—the cathode ray.

Short Waves for Television.

One of the chief reasons why only 30 line images are being broadcast at present is that if a greater number of lines is attempted, serious interference would be caused on neighbouring programmes on the medium wave band. For this reason, the Baird Company, the Marconi Company, "His Master's Voice," and the B.B.C. are all doing experimental work; some is already advanced, on very much lower wave lengths of the order of 7 and 5 metres. On such wave lengths it is quite possible to use very high scanning speeds with an ultimate picture of far greater detail with enormously enhanced entertainment value.

The Optical Limitations of Short Waves.

Short waves have, however, peculiarities which in some measure counteract their advantages. Their reliable range is not known entirely at the present time beyond the fact that it is known to be far shorter than that of medium waves, and a great deal of work remains to be done, since the properties of these waves have something of an optical nature.

A short wave transmitter will probably have to be put in an optical line with those who wish to receive the transmission; that is to say, on some eminence high above a town.

There also seems to be a definite limit to the range, whatever the power is; that limit may be for practical broadcasting purposes within 15 miles unless high altitude stations are used.

VOLTAGE REGULATION IN TRANSMISSION AND DISTRIBUTION

By J. V. Brittain, B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E.

In the following article Mr. J. V. Brittain deals with the various methods used to regulate voltage drop in transmission and distribution lines

ONE of the problems which the electrical engineer has had to solve during the last few years has been that of counteracting voltage-drop or voltage regulation on both transmission lines and distribution schemes. The necessity of counteracting the fall in voltage may be due to several reasons, the main ones being unforeseen overloads and the long distances over which electrical energy is now transmitted.

It is not always a matter of installing cables or overhead lines of sufficient capacity, as in many cases it is necessary to provide a more or less constant delivery voltage on a fluctuating load and the cables would have to be of unreasonable size to give the negligible variation required. Again with overhead lines there is a volt drop due to reactance and increasing the size of the conductors does not affect this to any extent.

Supply Authority Must Keep its Voltage Within Certain Limits.

Another cause of the difficulty is when the load at a particular point increases far more rapidly than was at first anticipated, and unless some steps are taken to counteract the large volt drop caused by this overloading the voltage at the consumer's terminals will be lower than can be allowed. Readers will be aware that a supply authority is bound to keep its voltage within certain limits and arrangements must always be made to see that the variation in voltage is within the allowable range. Normally this allowance is + or − 4 per cent. so that on 230 volts the pressure must be kept between 239 and 221 volts. This will seem quite a large margin, but particularly in rural districts where consumers are large distances apart, this margin is easily exceeded, and on that account a larger variation is allowed in certain cases.

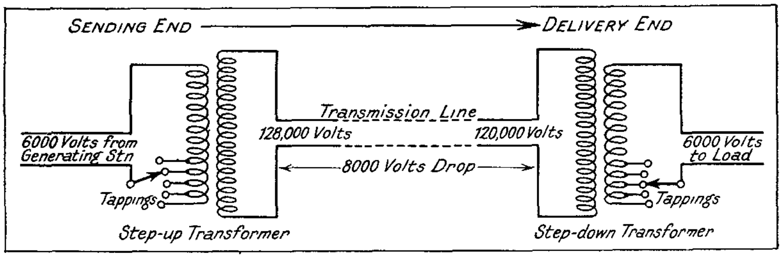


Fig. 1.—How Volt-drop is Overcome on High Tension Transmission Lines.
The system is shown as single-phase for simplicity.

Bulk Supply at High Voltage.

For bulk supply at high voltage the allowance is $12\frac{1}{2}$ per cent., but this fall in pressure has got to be remedied at some stage or other. With the "Grid" scheme the transmission lines are used to connect up two or more generating stations, working at the same voltage in many cases, and as the power must be able to flow in either direction at will it is evident

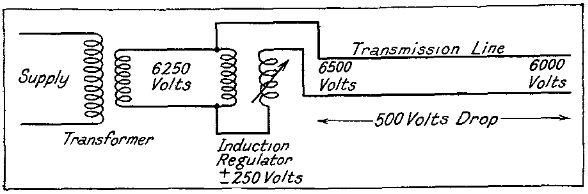


Fig. 2.—Diagram Showing the Use of an Induction Regulator.

that any fall in voltage must be dealt with by some means or other.

Methods Used to Deal with Fall in Voltage.

In this article a rough outline of the various methods used will be given and imaginary voltage values will be taken to illustrate how the voltage variation is remedied. The diagrams are drawn as for single phase but in all cases to-day three-phase is used. Single phase diagrams are however easier to follow and are used on that account.

HIGH-VOLTAGE TRANSMISSION.

Taking the "Grid" scheme as an example, the control of voltage is generally by means of tapped transformers as shown in Fig. 1. It will be seen that the pressure at the generating station bus-bars is kept constant at, say, 6,000 volts and this 6,000 volts is connected to the primary of the step-up transformer. The secondary of this transformer gives a normal pressure of 120,000 volts, but instead of this being fixed it is variable by means of the tappings on the primary winding as shown.

Effect of Altering the Position of the Tapping On the Primary.

Thus while the supply to the primary is constant at the 6,000 volts mentioned, the actual voltage output of the secondary winding will vary according to the position of the tapping on the primary. The effect of altering this position is to alter the ratio of the transformer, and thus the input voltage to the transmission line can be increased to counteract the drop in voltage from one end to the other.

Voltage Correction At Sending End.

Taking the values given in Fig. 1, it is assumed that at the delivery end the transformer tappings are set so that the high-tension line should deliver 120,000 volts to the step-down transformer, in which case the voltage actually delivered to the receiving station bus-bars will be correct (in this case it is assumed to be 6,000 volts as in the sending station, but this is not necessarily so).

If now the voltage drop on the line for the load which is being transmitted is 8,000 volts then the input to the line must be 128,000 volts and this is obtained —as nearly as possible—by means of the setting on the sending transformer.

Voltage Correction At Delivery End.

Alternatively the necessary voltage correction can be made at the delivery end, and in this case the input to the receiving transformer: i.e., the voltage delivered by the transmission line can be assumed to be 112,000 volts. The tapping on this transformer will have to be such that the output on the low tension side will be 6,000 volts with 112,000 volts input instead of the 120,000 volts in the former case.

Tapping Positions Can Be Either Automatically or Manually Controlled.

The control of the tapping positions can

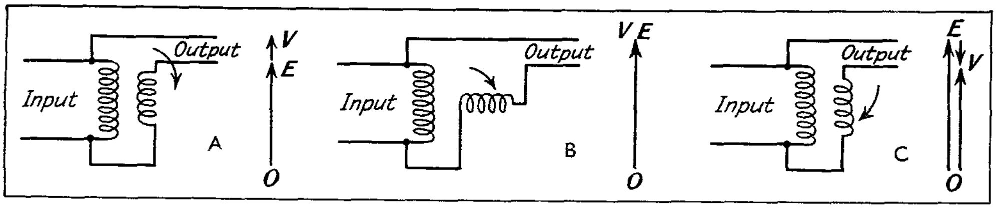


Fig 3.—Three Positions of the Induction Regulator

A, Position of regulator for maximum positive boost (full load) OE = incoming volts; EV = boost of regulator; OV = outgoing volts B, midway position of regulator giving zero boost (half load) Outgoing volts = incoming volts. C, Position of regulator for maximum negative boost (no load) be either automatic or manually operated but this is one of the cases where automatic control is very satisfactory, and it can be arranged to give a constant voltage at any specified point irrespective of the load which is being transmitted.

MEDIUM-VOLTAGE TRANSMISSION.

For lower voltage transmitting less power the same method can be used, except that in this case it is not usual to require the power to be sent in both directions at will, and thus only one tapped transformer is required.

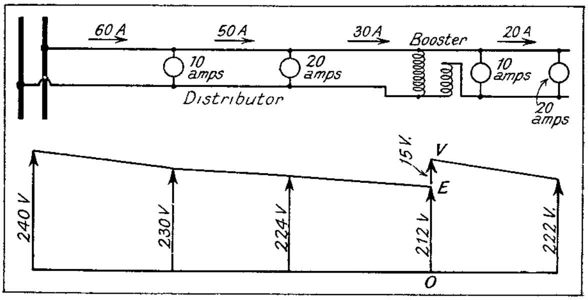


Fig 4.—DIAGRAM SHOWING HOW A BOOSTER IS USED TO MAINTAIN VOLTAGE AT THE END OF A DISTRIBUTOR

Voltage diagram gives hypothetical full-load values. OE = input voltage to booster; EV = boost; OV = output voltage from booster

Using the Induction Regulator.

This, however, is an example where the induction regulator can be used to advantage and this is shown in Fig. 2. The induction regulator consists of a transformer in which one of the windings is movable. The effect of this is not only to make the step-up in voltage (or *boost* as it is called) variable but to make it either positive or negative.

Three Positions of the Regulator.

This will be seen from Fig. 3, which gives three positions. In position (*a*) the regulator will give the maximum boost and will thus step up the voltage to counteract the volt drop on maximum load. In position (*b*) the movable winding is in a neutral position and the regulator will have no effect whatever. This should be arranged to occur when the load is about half the maximum. For no load (in which case there will be no appreciable volt drop), the movable winding will have been moved right round and will be in opposition so that it will be subtracted from the incoming voltage. The voltage diagrams are shown for each position, these also being drawn for single phase to make the action clearer.

A Numerical Example.

As a numerical example, assume that the voltage at the delivery end of the line is required to be kept constant at 6,000 volts and that the volt drop on full load will be 500 volts. In a case like this the transformer at the sending end would be arranged to deliver 6,250 volts to the line. This is the delivery voltage plus half the voltage drop.

On no load the induction regulator would be in the negative position to deduct the extra 250 volts given by the sending transformer, whereas on full load it would be in the positive position to add another 250 volts, so that 6,500–500 will give the delivery voltage required.

LOW-TENSION DISTRIBUTION.

Boosters.

Voltage troubles with distribution lines occur mainly in rural areas as mentioned, and various types of boosters have been devised to counteract excessive volt drop. The principle of the booster is shown in Fig. 4, the appropriate voltage diagram being drawn to indicate how the voltage is boosted up. The action is similar to the induction regulator, except that the amount of added voltage is not variable,

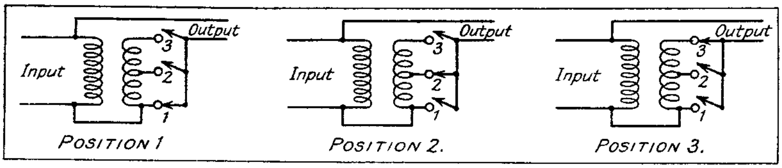


Fig. 5.—SIMPLIFIED DIAGRAM OF 3-STAGE BOOSTER.

and the voltage is given a fixed positive boost.

This method of voltage control is useful at the end of an overloaded line which is supplied from the common low-tension feeders, and in which case the pressure at the end of the long line would be exceptionally low when on load. When there was no load the pressure on the delivery side of the booster would be high, but this is a lesser evil than the low voltage which would otherwise prevail on load.

Two or Three Stage Booster.

A development of the fixed booster is the two or three-stage booster which works automatically as the load comes on. A diagram of this is given in Fig. 5, which shows the windings in a simplified form. On no load the booster will be out of action and the line will be connected direct by means of contact No. 1. As the load comes on the voltage drop on the line will be counteracted by switching over to contact No. 2, and the voltage will be boosted by an amount equal to half the maximum boost. When approaching full load, the line will be switched over to contact No. 3, when the total boost will be applied.

How This Type of Booster is Controlled.

The control in a booster of this type is usually by means of contactors operated by means of current relays. Assuming the booster to be in position 1, as soon as the current reaches a certain value the relay causes contactor No. 2 to close and No. 1 to open. On the current increasing still further, contactor No. 3 is connected instead of No. 2, and should the current fall, the reverse actions take place.

AN ENGINEER'S SOLUTION TO THE ECONOMIC PROBLEM

In his book "Forward from Chaos" (Nisbet, 6s.), Mr. A. P. Young, O.B.E., M.I.E.E., M.I.A.E., deals with the acute and puzzling world problem presented by the coexistence of highly developed productive machinery, abundant foodstuffs and raw materials and millions of unemployed. He approaches the problem as an engineer—which is, most of us will feel, a more useful angle than that of the economists, whose opposing counsels seem to cancel out to zero. After analysing in detail the functions of production, management and distribution, he outlines, on the principle that we must organise for service in place of profit, a scheme of planning for industrial service.

"Democracy," he declares, "can only survive within a system of planned national effort which, while in no way impeding the full development of individual initiative and freedom of thought and conscience, yet exerts a higher control, constraining the united team effort of the nation to produce a world-wide human service."

The machinery proposed is a National Planning Control Board which "would virtually co-ordinate and control the whole industrial activity of the country, in respect of both production and distribution." The methods by which such a board might operate are clearly set forth, specific illustrations being drawn from the electrical industry. The importance of international planning is also emphasised, the creation—as "a wonderful beginning"—of a British Empire Planning Control Board being urged to provide "the supreme industrial authority within the Empire for solving those basic and common problems in accordance with scientific and ethical principles."

To those who feel that he is indulging in an idealistic and impracticable vision, Mr. Young replies that "the vision of the idealist of yesterday has frequently been made a reality by the practical man of affairs in a not too distant to-morrow." He also emphasises the responsibility that falls upon each and all of us to study this world problem for ourselves and to play our part in evolving a solution. Towards this end there could be no better aid than this thoughtful and stimulating work.

A. G. W.

The Installation of Sound Amplifying Equipment

The following article deals with the installation of sound amplifying equipment suitable for reproduction either from microphone or gramophone records in a large hall or in the open air. The equipment described will give an undistorted output of 10 watts

FOR the sake of simplicity, it is proposed in this article to deal with the permanent installation of an equipment designed for an undistorted output of 10 watts, suitable for an A.C. supply of 200 to 250 volts, 50 cycles, and for reproduction from microphone or from gramophone records. Such an equipment would be suitable for use in a hall with a capacity of up to 100,000 cub. ft., or for use in the open air for a gathering of 2,000 to 3,000 people.

The Equipment.

The equipment consists of the following components :—

(*a*) A 10-watt amplifier, complete with the following valves : two Type AC/HL, one Type AC/P, two Type PP5/400, one Type UU 120/500.

(*b*) Two 8-in. R.K. wound field loud-speakers, each complete with rectifier for loud - speaker field.

(*c*) Single or double turn-table cabinet with tone-arms and 0.05-volt pick-ups.

(*d*) B.T.H. carbon microphone and battery.

(*e*) Microphone control box.

(*f*) Suitable baffles or cabinets for the loud-speakers.

A complete wiring diagram for the sound amplifying equipment to be described is given below.

The wiring for a permanent installation of this nature should always be contained in an earthed metal sheath electrically continuous throughout, such as screwed conduit or lead-covered cable.

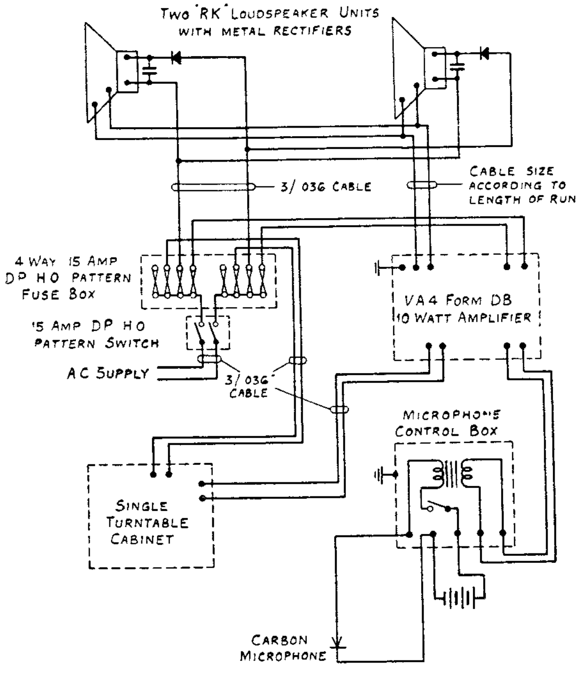


Fig. 1.—DIAGRAM OF CONNECTIONS FOR B.T.H. 10-WATT SOUND AMPLIFYING EQUIPMENT.
Suitable for reproduction from microphone or from gramophone records.

Main Switch, Fuse Board, etc.

It is desirable to have the main switch, distribution fuse board, amplifier and turntable cabinet all located at one point. The electricity supply should terminate in a double-pole 15-amp. Home Office pattern main switch controlling a four-way double-pole 15-amp. Home Office pattern fuse box. There should also be one pair of fuses each to control the amplifier, the turntable motor, the loud-speaker field circuit; and one pair of spare fuses, already wired for use in case of emergency.

It is sometimes more convenient in wiring to supply the loud-speaker fields from a circuit near the loud-speaker, and if this is done, care should be taken to ensure that the fuses controlling the circuit are sufficiently light to provide adequate protection to the loud-speaker fields. It is also necessary to include an additional switch in the loud-speaker field circuit so that the fields may be switched off when the sound amplifying equipment is not in use.

Fig. 2.—A Single Turntable Equipment. This is fitted with plugs for making connection to the gramophone motor and electrical pick-up, the pick-up being connected direct to the appropriate terminals on the amplifier by the cables contained in an earthed screen.

It will be found that 3/.036 cable, which has cross-section of .003 sq. in., is of ample size for all the circuits of the installation, with the exception of the speech circuit from the amplifier to the loud-speakers.

Amplifier.

The amplifier is a compact portable unit, fitted with plugs for all the external connections with the exception of the earth wire, which must be attached to a screwed terminal on the chassis. The net weight of the amplifier is 36 lb.; the overall dimensions and location of the various leads connected to the amplifier are shown in Fig. 1.

Mounting the Amplifier.

It is only necessary to provide a small table, shelf or bracket to support the amplifier in a horizontal position. If preferred, the amplifier may be mounted on the wall in a vertical position by means of a suitable iron wall bracket.

The voltage adaptor plug on the amplifier chassis should be inserted in the correct socket to suit the electricity supply voltage available.

Output Transformer Leads.

The output transformer on the amplifier has three leads brought out from the coil so that the transformer can be connected to suit a load of $7\frac{1}{2}$ ohms impedance or 15 ohms impedance. The amplifiers are despatched from the B.T.H. works with the leads from the output transformer connected to the loud-speaker plug socket suitable for a load impedance of 15 ohms.

Fig. 3.—A B.T.H. Carbon Microphone.

This is connected in series with the primary winding of the transformer and a 6 to 10-volt polarising battery.

The nominal impedance of the B.T.H. R.K. speaker is 15 ohms, so that the 15-ohm load on the output transformer should be used when one R.K. loud-speaker or four R.K. loud-speakers connected in series-parallel are to be used. If only two R.K. loud-speakers are to be used, they should be connected

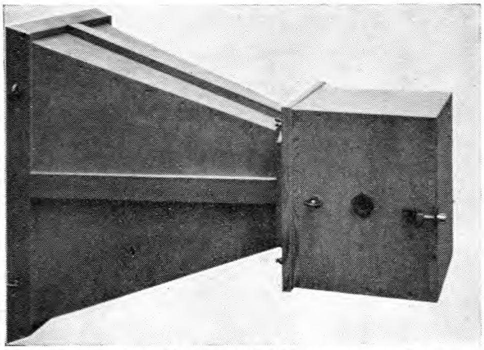


Fig. 4.—The Type RK Moving-coil Loud-speaker with Directional Baffle for Outdoor Work or where Directional Effect is Desired.

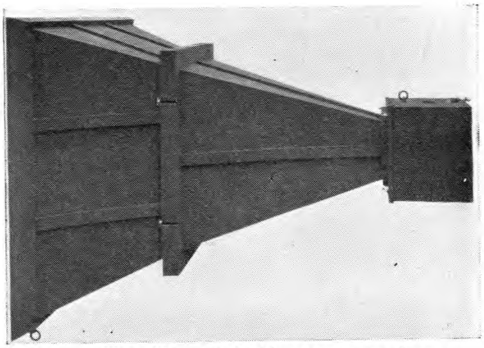


Fig. 5.—The Type RK Moving-coil Loud-speaker Fitted with a Straight Exponential Horn for Use in Large Halls, Theatres, etc.

in parallel to the amplifier output transformer with the transformer leads connected so that it is suitable for $7\frac{1}{2}$-ohm load.

Obtaining Maximum Output from the Amplifier.

In order to obtain the maximum output from the amplifier the power loss in the loud-speaker output leads should be reduced to a minimum, and the D.C. resistance of the output lead, considering lead and return, should be kept within 10 per cent. to 15 per cent. of the nominal load impedance. From this basis it is possible to decide what size of cable should be used between the amplifier and the loud-speaker.

Turntable Cabinet.

A single turntable cabinet is illustrated in Fig. 2. The overall dimensions are 16 in. × 15 in. × 9 in., and the net weight is 14 lb. It is fitted with plugs for making connection to the gramophone motor, and electrical pick-up, the pick-up being connected direct to the appropriate terminals on the amplifier by the cables contained in an earthed screen.

Microphone and Microphone Control Box.

The B.T.H. carbon microphone, illustrated in Fig. 3, is usually supplied flexibly mounted on a metal table stand, but any form of stand may be adopted to suit local conditions, or the microphone may be flexibly suspended from above. It should be connected in series with the primary winding of the transformer in the microphone control box and a 6 to 10-volt polarising battery. An accumulator or large capacity dry battery should be used for polarising, the type of battery depending on the length of time the microphone is likely to be in service.

The maximum safe polarising current is 25 milliamps., but sufficient sensitivity is usually obtainable for general purposes without approaching the maximum polarising current. The voltage required will depend upon the line resistance and the particular microphone being used.

Importance of Switches and Plugs.

Care should be taken in selecting any switches or plugs for use in the microphone circuit to ensure that they make good rigid contact so that the resistance does not vary, otherwise noises are likely to be introduced which are often difficult to trace.

Type of Plug and Socket for Use with Portable Microphone.

If it is necessary to use a plug and socket in the microphone circuit, it is advisable, for a portable microphone, to adopt a type which has a locking ring so that the plug can be held firmly in position in the socket. It is also advisable to use soldered connections wherever possible as ordinary binding screws are likely to cause a variation in contact resistance.

A flexible cable used for portable micro-

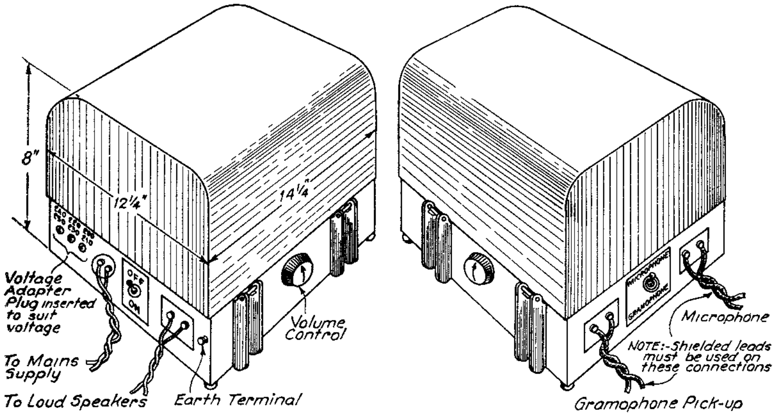


Fig. 6—HERE WE SEE THE EXTERNAL CONNECTIONS USED WHEN THE AMPLIFIER IS IN OPERATION.

phones need not necessarily have an earthed screen, but this depends rather on the length of the flexible lead and its proximity to sources of electrical interference.

Connections to Microphone Control Box.

The microphone control box and microphone battery should preferably be located near the amplifier so that all the controls are within reach of the operator. There are five terminals on the control box terminal board: Nos. 1 and 2 should be connected to the microphone, Nos. 2 and 3 to the microphone polarising battery, and Nos. 4 and 5 to the amplifier microphone terminals.

Control Box Should be Earthed.

The microphone control box case should be efficiently connected to earth; the leads between the control box and amplifier are in a very sensitive portion of the input circuit, so that special care should be taken with the screening and clearance from sources of electrical interference in order to ensure silent operating conditions.

Loud-speakers.

The choice of loud-speakers and their location will, of course, vary with every installation. There are available the following types of loud-speaker baffles:—

(*a*) Fumed oak cabinet with ornamental grill, which is suitable for interior work. The cabinet has a high-class finish which presents a pleasing appearance and will harmonise with most decorative schemes. It may be used in all cases for reproduction from gramophone records or radio, and for reproduction from microphones when the microphone is placed at a sufficient distance from the loud-speakers to prevent sound coupling.

(*b*) An 18-in. directional baffle, complete with felt-lined loud-speaker box as illustrated in Fig. 4. These are particularly suitable for out-of-door installations where it is necessary to protect the loud-speaker unit from the weather, and where a directional effect is required. A baffle of this type is also necessary with installations for the reproduction of speech from microphones, if the enclosure is at all reverberant. The directional effect of the baffle makes it possible to focus the sound on to the area to be served and mitigate the detrimental effects of the enclosure reverberation.

When a microphone is to be placed in the same enclosure as a loud-speaker, it is necessary to arrange the relative position of the microphone and loud-speakers so that no sound from the loud-speaker strikes the microphone diaphragm, or sound coupling will result.

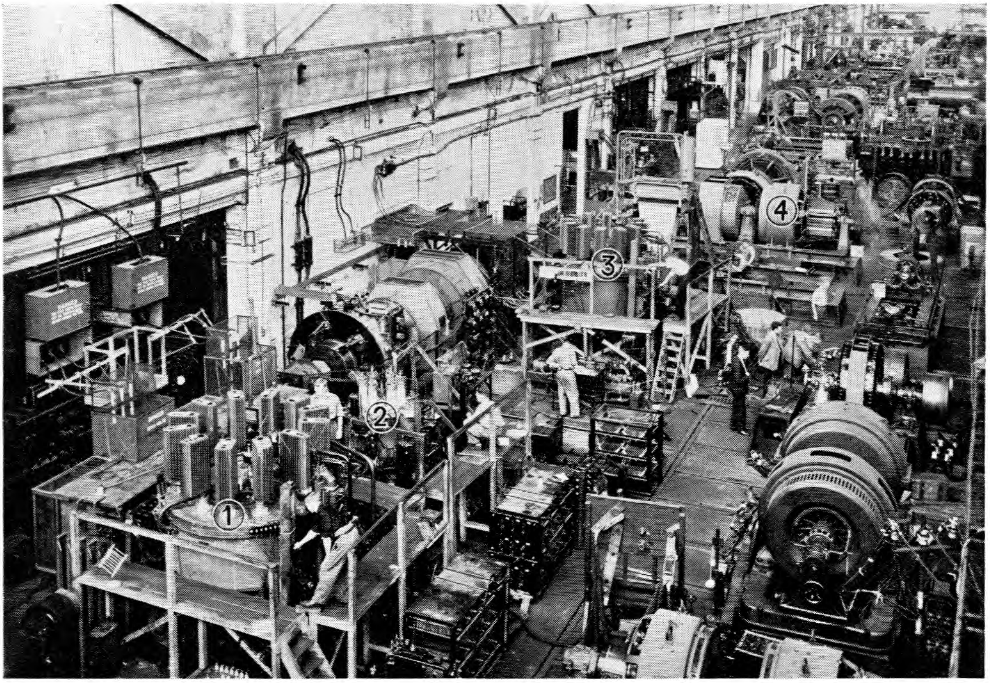
(*c*) A 52-in. exponential loud-speaker horn, complete with felt-lined sound box, as shown in Fig. 5. This type of loud-speaker horn is suitable for use in large halls, theatres, amusement parks or any enclosure where large volume is required to overcome high initial noises.

Tests.

It is advisable to install loud-speakers temporarily and conduct a few tests in order to determine the position which will give the best results, as a slight change in the position of a loud-speaker will sometimes make a big improvement.

A Trend of Development in Electrical Manufacturing

BASED ON IMPRESSIONS ON A RECENT VISIT TO THE RUGBY WORKS OF THE B.T.H. CO.

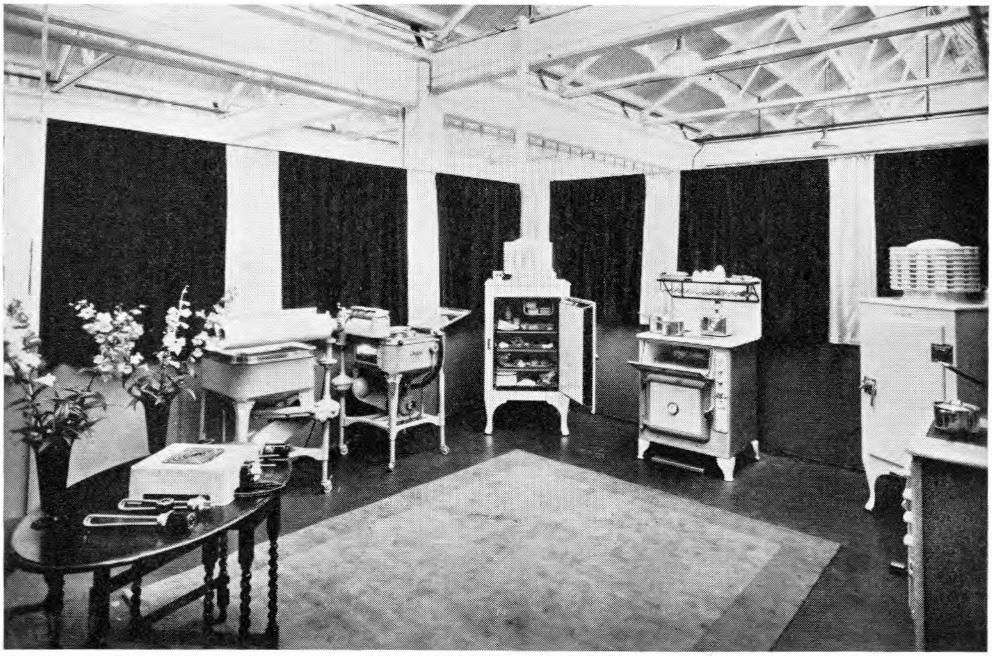


An Encouraging Sign of the Strength of the Electrical Industry.
Showing converting plant of exceptional interest being tested at the Rugby works of the B.T.H. Co. (1) Rectifier tested to over 10,000 amps. (2) Rectifier for 20,000 volts D.C. (3) Rectifier with grid control type tested to 12,500 kW. (4) Motor convertor, rated 1,500 kW at 750 r.p.m.

It is an encouraging sign of the strength of the electrical industry to see that whilst many of the important industries of the country are still working at far below their normal capacity, the works of the British Thomson-Houston Company at Rugby provide tangible evidence of this firm's prosperity.

The photograph above was taken recently in the main assembly shop, and in it can be seen, amongst many other items, four different types of converter plant which bear some testimony to the gradual but steady expansion of electrical distribution under the grid scheme. The men responsible for the policy of this great firm have not been slow to realise that as the grid scheme nears completion the amount of extra high-tension plant and machinery required is bound to be a diminishing quantity. The extension of railway electrification schemes and of the use of electrical machinery in factories and workshops will certainly provide much work for specialists in heavy machinery manufacture during the next few years, although most of this plant will necessarily be designed to operate at low and medium voltages.

There is, however, another very im-

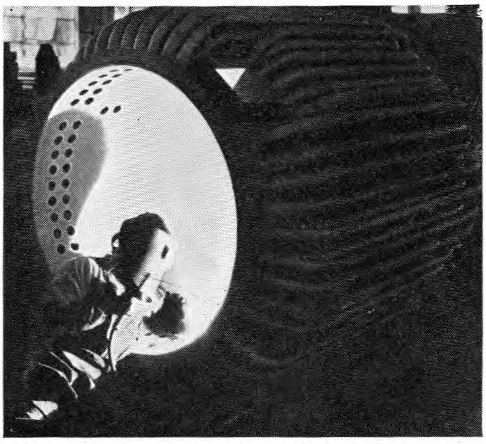


A GROUP OF HOME ELECTRICAL APPLIANCES AT THE B.T.H. WORKS, RUGBY.
Here can be seen the Hotpoint cooker, the Hotpoint washing and wringing machine and the refrigerator.

portant side of the industry which, doubtless for good reasons, has not until recently received quite as much attention from the larger electrical manufacturers —this is the manufacture of domestic electrical appliances.

A New Departure.

During the past few months the B.T.H. Co. have converted a portion of their factory to the manufacture, on high-class mass production lines, of three important domestic accessories, namely, the Hotpoint - B.T.H. electric cooker, the B.T.H. refrigerator, and the Hotpoint-B.T.H. electric washing and wringing machine.



METALLIC ARC-WELDING IN PROGRESS AT THE B.T.H. WORKS, RUGBY.
Showing cooling tubes being welded in a transformer tank.

As an example of the research work and scientific skill which has been brought to bear on this subject may be mentioned the development of the Torribar heating element which is used in the Hotpoint cooker, and the construction of this simple but very important advance in element design, was fully described last month.

We believe that the application of the best engineering practice to the manufacture of domestic electrical appliances will be of immense benefit to the industry. The market has been for too long flooded with cheap and unreliable goods of foreign origin.

PRACTICAL NOTES ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF BUILDINGS (I.E.E. WIRING RULES)

By D. WINTON THORPE, A.M.I.E.E.

EARTHING AND FITTING OF DOMESTIC APPLIANCES

THE whole question of earthing is subject to more ignorant and careless handling than is probably any other which arises in wiring installations. It must be remembered that if we subscribe to the principle of earthing —and if we follow these Regulations we must subscribe to it—then the job must be properly done, and earthing leads must not be treated merely as a little bit of embellishment stuck on at the end of an installation. An earthing lead may have current to carry, and it may have a substantial amount of current to carry; that is why it is there.

Now if a conductor is expected to carry current it must be of dimensions large enough to carry the anticipated current and, more important still, its connections at either end, on the one hand to the sheathing of the system and, on the other, to the point of earthing, whether it be to a water pipe or an earth plate, must be thoroughly well made.

Earthing Leads.

Regulation 102 states :—

A. Every conductor used as an earthing lead shall be of high conductivity copper, and shall be protected against mechanical injury, and where necessary, against corrosion. Its sectional area shall not be less than one-half that of the largest of the conductors to be protected, provided that:—

(a) *No conductor larger than* 0.1 *sq. in. sectional area need be used ;*

(b) *For the main connection of the installation to the earthing system no conductor smaller than* 0.0045 *sq. in. sectional area* (7/.029) *shall be used.*

(c) *In the case of flexible cords of* 0.0048 *sq. in. sectional area and smaller, the sectional area of the earthing lead shall be equal to that of the live conductors.*

B. All connections of the earthing lead to the installation and to the earthing system itself shall be easily accessible.

C. If more than one plate or tubular earth be employed for one earthing system, they shall be efficiently and permanently connected together.

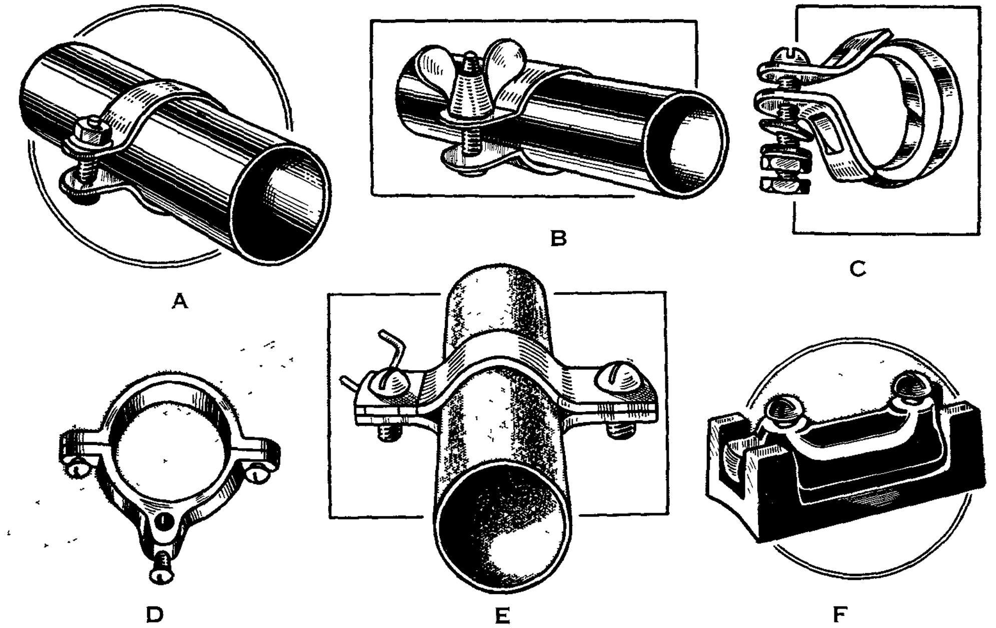
D. Wherever an earthing lead is connected to a pipe, conduit, cable, sheath, armour or other cylindrical earth, a substantial metal clip shall be used and the contact surfaces shall be clean. For armoured cables such clips shall be so designed as to grip firmly the whole of the wires of the armouring without damage to the insulation. For lead-sheathed armoured cables the principal contact shall be with the lead, but the clip shall be so designed as also to grip the armouring firmly without damage to the lead.

E. The ends of all earthing leads having a sectional area of 0.007 *sq. in.* (7/.036 *in.*) *and above shall be provided with a soldering socket, preferably conforming in all respects to British Standard Specification No.* 91 *of such a size that all the strands of the conductor can enter the socket simultaneously.*

As to the size of the conductor itself the Regulation is perfectly well defined and no comment of mine can make it clearer. With regard to Sub-section B, it is important to remember that because an earth connection is liable to be forgotten and develop a bad connection or even a break, this particular sub-section has been drafted in order that the state of those earth connections shall always be in evidence.

Metal Clips Must be Substantial.

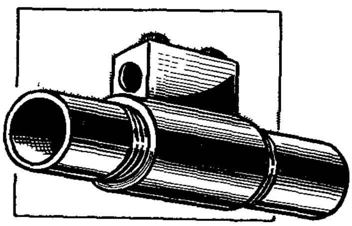
With regard to Sub-section D, I should like to draw attention to the use of the



A Group of Typical Earthing Clips.
A and B, Single earthing clips ; C, Adjustable earthing clip ; D and E, Double earthing clips ; F, Adjustable earthing clamp.

word " *substantial* " metal clip. There is a great tendency to regard any device which apparently bonds the earthing lead to, let us say, a cold water-pipe, as being satisfactory for the job ; it must be remembered, however, that a flimsy earthing clip, such as one frequently sees put on the market by less reputable manufacturers and in some cases made up by the electrician on the spot, is liable to very quick corrosion and, since the position where the earth contact is made is in many cases a damp one, nothing but a substantial clip can be considered to be fulfilling its function properly.

Sub-section E sounds obvious, but here again one does sometimes see very large earthing leads—far larger than the 7/.036 in. referred to in the sub-section — inefficiently connected to an ordinary little flimsy clip. If the demands of the installation are such that a large earthing lead is required, it may be taken for granted that the demands of the connection also require the use of soldering sockets.



An Earthing Socket Screwed on to Conduit.

Provision of Earthing Terminals.

Regulation 103 states :—

All domestic appliances whether portable or fixed, and all portable metal fittings, designed for pressures exceeding 30 *volts alternating current or* 100 *volts direct current, shall be provided, for use where necessary under Regulation* 96, *with a terminal or other suitable means for earthing all exposed metal liable to become alive in the event of the insulation becoming defective.*

Regulation 96 referred to here deals with the precautions necessary for earthing and was dealt with by me in the August issue of The Practical Electrical Engineer. Regulation 103 is completely and utterly ignored by the majority of manufacturers. With the exception of electric fires and a few of the larger pieces of apparatus which, in many cases, are provided with special earthing terminals, the average piece of domestic apparatus—and it will be noticed that this section merely refers to *all domestic appliances whether portable or fixed*—are sent out without any particular provision in the way of an earthing terminal.

I have no doubt that the manufacturer justifies his action by relying on the fact that somewhere or other about the apparatus there is a nut or bolt which is primarily intended as part of the construction of the apparatus, but which can be loosened to admit of an earth wire being connected underneath. To my mind this is not a satisfactory solution of the problem of earthing domestic apparatus, since in the first place it implies a very casual acceptance of these Regulations; and, in the second place, many of the nuts and bolts used in the construction of apparatus of this sort have been painted over and unless the electrician is particularly careful he will find he is making his earth connection on to a painted surface which will give him no proper continuity.

The absence of an earthing terminal on so many pieces of apparatus should make it all the more essential for electricians to examine apparatus carefully before they hand it over to the customer, and either make some provision themselves or, alternatively, take great care to see that the earth wire which they do attach to the apparatus is properly connected.

In the case of electric fires, this terminal is usually underneath the frame or at the back.

Construction of Fittings.

Regulation 104 states :—

A. Fittings must be so designed and constructed that the passages for the insulated conductors are of ample size and are free from rough projections and sharp angles or bends. All outlets shall have well-rounded edges or shall be bushed.

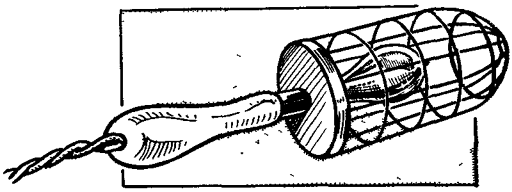
B. Fittings shall be so designed, and the insulated conductors so installed, that no stress can be applied by the conductors to any terminal to which they may be connected.

C. Fittings shall be so designed and fixed that neither dust nor moisture can readily accumulate on live parts.

D. Where a fitting exceeds 10 *lb. in weight it shall be supported by several flexible cords so that the maximum weight to which any cord is subjected shall not be greater than that specified in Regulation* 81 *C, or other means of support such as a metal chain shall be provided.*

E. Open type fittings shall not be furnished with inflammable shades unless such shades be kept free from contact with the lamps by suitable guards or supports. Celluloid shall not be used for shades or candle-tubes or in any situation near a lamp.

F. Enclosed-type fittings shall be provided with a removable glass receptacle arranged to enclose the lamp completely and of such size or construction as to prevent undue heating of the lamp; and if the position of the fitting be such that the glass receptacle is liable to mechanical damage, the glass shall be protected by a suitable wire guard.



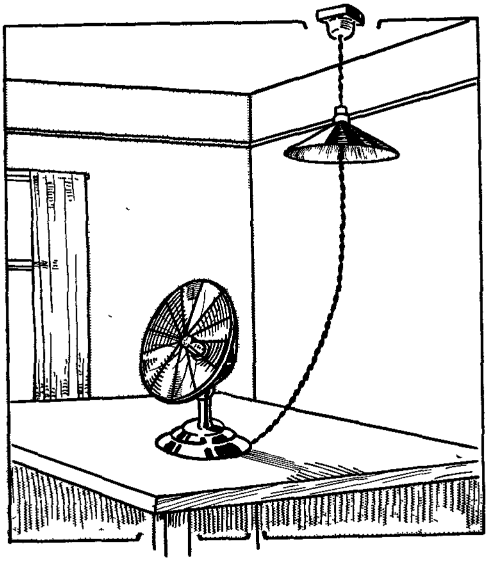
TO CONFORM WITH REGULATION 105B, THE LAMP MUST BE PROTECTED BY A SHADE OR GUARD WHEN IN POSITIONS IN WHICH THE LAMP IS EITHER NEAR TO OR COULD SWING INTO CONTACT WITH INFLAMMABLE MATERIALS.

G. Fittings, whether fixed or portable, wherever exposed to drip or externally condensed moisture shall be of the weatherproof type.

The question is very often asked me, why a fitting made by one manufacturer is so much more expensive than an apparently similar fitting manufactured by another. The answer in very many cases is that Regulation 104 (here quoted) has been observed by one manufacturer and ignored by another. If a contractor is called upon to examine and choose a fitting for submission to his customer he should always make sure that the wiring passages inside it—particularly in the case of bracket fittings—are free from rough projections and sharp angles or bends. Apart from the spirit of the Regulation, he will find that the time spent in wiring up a badly made fitting will add to the job quite as much as the extra cost of the better article in the first instance.

Fittings Made Up on the Job.

This Regulation again applies in the case of fittings which sometimes have to be made up by the electrician on the job, as in the case of brackets from the wall in positions where the customer does not feel inclined to pay for specially made



THIS IS WRONG.
Showing a 600-watt bowl fire connected to a lampholder adaptor, which is prohibited by Regulation 111B.

fittings and the electrician offers to set some conduit into the required shape and fix a lampholder on the end.

Sub-section C sounds quite obvious and appears to refer only to the manufacturing of the article, but in this connection I would draw attention to the word "*fixed.*" A fitting which has been designed to hang in a particular way should not be erected upside down, as is frequently done. Sometimes a bracket fitting with the lampholder pointing downwards appears to be appropriate to a particular job if it is reversed, with the lampholder sticking upwards. This may entirely destroy the observance of this sub-section.

Maximum Weight to be Carried by a Twin-twisted Flexible Cord.

With regard to Sub-section D, which refers the reader back to Regulation 81 C, it is perhaps worth recording that this particular Regulation lays it down that the maximum weight carried by a twin-twisted flexible cord shall be as follows :—

Number and Diameter of Wires Comprising Conductor.	Maximum Permissible Weight.
14/.0076 in.	3 lb.
23/.0076 in.	5 lb.
40/.0076 in.	10 lb.

Note.—Where a weight greater than 10 lb. has to be supported, Regulation 104 D shall apply.

Sub-sections E and F are matters for the manufacturer rather than for the electrician himself, but Sub-section G, though perfectly self-explanatory, may reasonably be emphasised inasmuch as there is a great tendency to place in positions exposed to weather or exposed to moisture, fittings which have not been designed for this purpose and which will not only not give satisfaction if used for this purpose, but may constitute a danger to the installation.

Fittings in Special Positions.

Regulation 105 states :—

A. In spaces where inflammable or explosive dust or gas is liable to be present or where inflammable goods are stored, enclosed fittings shall be used. In such situations the fittings shall be of strong construction having airtight external globes of thick glass provided with substantial guards.

B. In positions in which the lamp is either near to, or could swing into contact with, inflammable materials, it shall be enclosed or protected by a shade or guard.

This Regulation again needs no comment beyond a reminder that the onus for deciding whether inflammable or explosive gases are liable to be present or not, or whether inflammable materials are near, must lie with the installing engineer.

Portable Fittings.

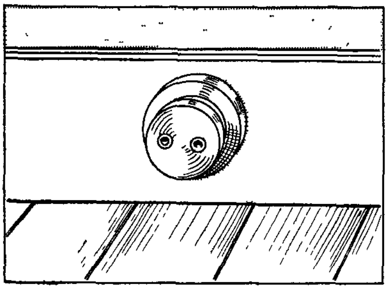
Regulation 106 states :—

A. In all cases where portable metal fittings have to be earthed in accordance with Regulations 96 *to* 103, *all metal parts shall be connected to earth by means of a third conductor in the flexible cord. If this flexible cord have a metal armouring, this armouring shall, in addition to the aforementioned conductor, be efficiently connected electricially at one end to the metal frame of the fitting, and at the other end to the earthed metal of the plug-and-socket connection. Such fittings shall have strong metal guards in metallic contact with the rest of the uninsulated metal of these fittings.*

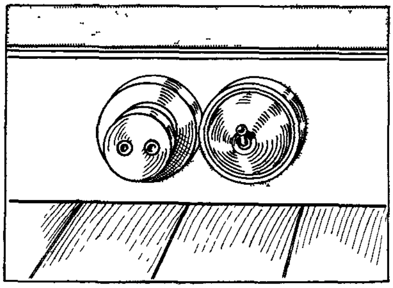
B. Portable fittings with non-metallic frames, or the only metal parts of which are the guards surrounding the lamp or lamps, need not be earthed as described in 106 *A, provided that these guards are not, and cannot come, in metallic contact with the lampholder or lampholders. Such fittings shall be made of ash, beech, birch, box, cocos, mahogany, oak (English), teak or walnut, or of some suitable non-ignitable composite material capable of withstanding rough usage in service.*

C. Where portable fittings, appliances, or accessories are likely to be used, the pressure between any two points in one room or compartment shall not exceed 250 *volts unless the fittings, appliances or accessories between which there may be a higher pressure are so situated that they cannot be brought within* 6 *ft. of each other or, alternatively, are earthed.*

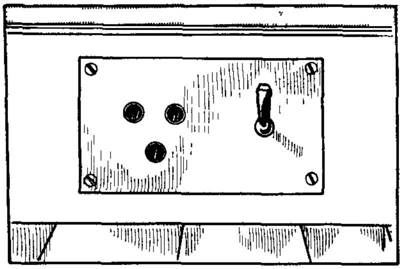
If we take the case of an ordinary domestic iron having only a twin flex connected either to a two-pin plug or, worse, to an adaptor, being used in a kitchen within reach of a water-pipe or kitchen range, we are defying this particular Regulation, for Regulation 96 A (*b*) very clearly states that in such circumstances earthing must be applied, and Regulation 106 A (which we are for the moment considering) equally clearly demands triple flexible and three-pin plugs. Similar instances of defiance of this Regulation can be very easily thought of or, if the imagination is weak, they can be seen by a walk round the average household to-day.



NOT PERMITTED UNDER REGULATION 112D.
Every socket of a rated size exceeding 5 amperes must be controlled by a switch immediately adjacent.



THIS IS PERMITTED.
Showing a plug socket with a separate controlling switch.



THIS IS RECOMMENDED.
Showing an interlocked switch plug, specially advised for plug sockets of rated size over 5 amperes.

"The Six-foot Rule."

Sub-section B needs no comment, but Sub-section C is very interesting, inasmuch as it is the one and only Regulation in the book which gets anywhere near to what is generally known as "the six-foot rule." There is in existence a very queer view (and one which I myself shared for a time) that these Regulations forbid the introduction of opposite phases in domestic installation work to within 6 ft. of one another.

Now there is definitely no broad rule of this sort; on the other hand, Sub-section C of the Regulation which we are now considering does state that if two phases are introduced into one room—since two phases are likely to be at a greater potential difference than 250 volts—then any fittings, appliances or accessories connected to them respectively must not be brought within 6 ft. of each other and must not be erected in such a way that they can be brought within 6 ft. of each other, or, *alternatively, are earthed.* So that actually the earthing of such appliances would seem to clear one entirely of any charge of defying this particular Regulation.

My own view on the subject is that, earthed or not, it is safer not to bring them within 6 ft. of each other, but since for the moment we are considering only the Regulation, my view does not matter.

Regulations 107, 108 and 109 are like all the Regulations important, but since they are not likely to be disregarded by an electrician, I shall omit reference to them here.

Switch Lampholders.

Regulation 110 concerns the manufacture of lampholders and may be conveniently omitted with the exception of Sub-section C, which states that "*Switch lampholders shall be provided with further means of control in the same room.*" No qualified electrician is likely to disregard this sub-section; on the other hand, many amateurs, thinking it is an easy matter to tap off from the busbars of a fuseboard and run a single pair of cables straight to a lighting point, consider that they are doing the job correctly if they merely put a switch-holder in place of the ordinary holder on their lighting point. Any electrician visiting a house and noting this should point out to the occupant that this is in contravention of these Regulations.

Lampholder Adaptors.

Regulation 111 is very important :—

A. Every lampholder adaptor shall be controlled by a switch fixed in an adjacent and easily accessible position on a wall or partition.

B. A lampholder adaptor shall not be used in connection with any appliance taking more than 2 amperes.

Lampholder adaptors have come into being not because they are efficient components in themselves so much as because of the unwillingness on the part of the householders to have plug-sockets for every electrical outlet. A lampholder adaptor relies for its contact upon the pressure of two pins on two brass surfaces. The contact which is good enough for very small currents in the case of a lamp, is definitely insufficient to cope with large currents, the more so since a lampholder adaptor is subject to a certain amount of movement while it is passing current, as in the case of anyone using a domestic iron; whereas the lamp, which would normally be in the lampholder, is at least stationary.

For this reason these two sections have been placed in the Regulations. The control must be a switch fixed in an adjacent and easily accessible position. Easily accessible, since one never knows when a lampholder adaptor may decide not to behave itself and immediate action in the way of switching off is necessary. Secondly, it may not be allowed to carry more than 2 amperes. That is to say, that with the fairly standard voltage of supply of 230 volts nothing over 500-watt loading must be connected to a lampholder adaptor. This rules out the evil practice of putting bowl fires on to adaptors, a practice which unfortunately is encouraged by many manufacturers who send out such fires wired to an adaptor.

Plugs and Sockets.

Regulation 112 states :—

A. Plugs and sockets shall be so designed and constructed that :

(a) *For rated sizes exceeding 2 amperes they shall conform in all respects to the British Standard Specification which is applicable.*

(b) *For rated sizes up to and including 2 amperes they shall conform to British Standard Specification No. 73 in so far as the materials of which they are constructed, overhead capacity, provision of a hand shield, and side entry of the flexible cord are concerned; and, in addition, the socket shall be so constructed that it cannot be accidentally short-circuited whether the plug be in or out and that a pin of the plug cannot be made to earth a live contact of the socket.*

B. Plugs and sockets shall not be used to carry currents greater than those for which they are rated in the applicable British Standard Specification.

C. Sockets of rated sizes not exceeding 5 amperes may be fitted, without the further protection of a switch, provided that where more than two sockets of these sizes are fitted in one room they shall be controlled individually or collectively by switches fitted in an accessible position within the room, excepting that not more than two of the sockets may, if desired, be omitted from the switch control.

D. Every socket of a rated size exceeding 5 amperes shall be controlled by a switch immediately adjacent and preferably so interlocked that it is impossible to insert or withdraw the plug when the switch is in the "on" position.

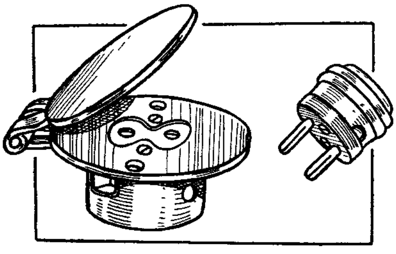
E. Where the socket is attached to a floor the contacts shall be below the floor level so that there can be no risk of contact between the live metal and the floor cover. Sockets so fitted shall be provided with a strong non-ignitable cover, either hinged, or screwed, and secured by a chain.

F. Where tough-rubber-sheathed flexible cord is used, a suitable clamp shall be provided to grip the protecting covering of the flexible cord.

G. Weatherproof plugs and sockets shall be used wherever exposed to rain, drip or externally condensed moisture. Such accessories shall be of specially robust construction and be provided with efficient means to maintain the socket weatherproof when the plug is removed therefrom. When a loose cover is employed for this purpose, it shall be anchored to the socket by means of a chain. When the plug is inserted in its socket the combined fitting and interlocking switch, if any, shall also be weatherproof.

H. In places where petrol-driven conveyances are stored or repaired, plugs and sockets shall be placed not less than 6 ft. above the floor level.

I. When sockets and plugs have provision for earthing, the current-carrying capacity of the earthing contact shall comply with the requirements in regard to earthing (see Regulations 96 to 103).



HINGED COVER TYPE FLOOR PLUG SOCKET.
Regulation 112E states that where the socket is attached to a floor the contacts shall be below the floor level so that there can be no risk of contact between the live metal and floor covering. Sockets so fitted must be provided with a strong non-ignitable cover.

Sub-section D refers to plug sockets of a rated size exceeding 5 amperes, which to all intents and purposes nowadays means 15-ampere plugs as used for power purposes in domestic electrical installations. These, it will be noted, must in each case be individually controlled by a switch conveniently placed. It is perfectly permissible to place a 15-ampere plug socket on the skirting and to place by it a suitable 15-ampere switch directly connected so that the switch controls the socket. Nothing in this Regulation requires that the switch and the socket shall be mounted in the same fitting. On the other hand, it is definitely *recommended* that the electrician should go further and install an interlocked switchplug.

Suitable Clamp for Tough-rubber-sheathed Flexible Cord.

Sub-section F asks for a suitable clamp in the case of tough-rubber-sheathed flexible cord. As a matter of fact most of the reputable plugs on the market to-day are provided with some clamping system for contingencies such as this.

How to Make an Instrument Switchboard for A.C. Tests

The maintenance engineer frequently has to carry out tests on A.C. plant, and when this is of the two or three phase type he is sometimes handicapped by not having sufficient meters available to put an ammeter in, and a voltmeter across, each phase. The present article describes how a simple switchboard may be built up very cheaply which overcomes the above difficulty by making all kinds of A.C. tests possible with the use of only one voltmeter, one ammeter, and, where energy measurements are required, one wattmeter

EVERY maintenance man knows of cases where tests have been curtailed through lack of the necessary instruments, and where tests which should have included readings on each phase have been limited to voltage readings on all phases (sometimes) and current readings on one phase only. Under such circumstances no reliance can be placed on the test figures, for there is no guarantee that conditions are identical in all the phases, and quite wrong conclusions are often arrived at from considerations of tests made in this manner.

Often the only instruments at the works engineer's disposal are a portable voltmeter-ammeter and a portable wattmeter.

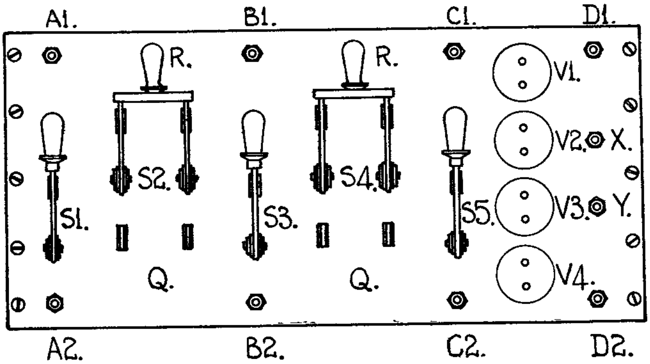
Yet providing the electrician's store contains a few switches, a plug and some sockets, some terminals (screws and nuts will do), and something from which a panel may be made, together with a little cable for connections, there is no reason why every test should not be complete, for it is only a matter of a few hours' work to build up a little instrument switch panel from this material which will make it possible to take readings in each phase of two or three-phase apparatus without using more than the meters mentioned above, i.e., one voltmeter, one ammeter and (where required) one wattmeter.

These instruments, by the way, should form the absolute minimum equipment for the maintenance engineer of any reasonable-sized factory, and the provision of the panel to be described is equivalent to having three times the number of instruments available.

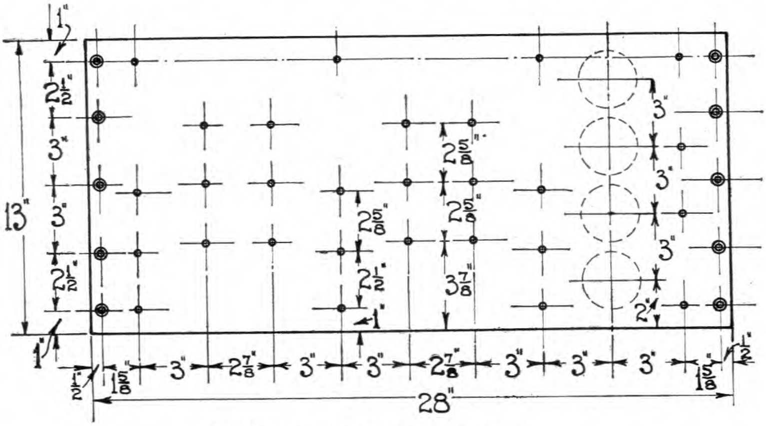
The Materials Required.

The first step is to gather the necessary material. Most of it will be found to be already in the stores, since it is standard material; we will require :—

Three single-pole, single-throw knife switches. Unmounted.
Two double-pole, double-throw knife switches. Unmounted.
Four 5-amp. two-pin sockets.
One 5-amp. two-pin plug.
Ten terminals.
One panel, for above components.



ASSEMBLY OF COMPONENTS ON THE PANEL.
The switches are here shown mounted on the panel, together with the voltage sockets and the terminals. The descriptive lettering by which the switches and switching operations are referred to in the text, is also given.



PLAN OF THE PANEL DRILLING.
The dimensions given are suitable for standard 60-amp. switches, and all holes should be $\frac{5}{16}$ in. clear except those at the extreme edges of the panel which are shown by double circles. These should be of suitable size for the wood-screws which are to fasten the panel to its supporting blocks, and they should be countersunk.

(Slate, ebonite or any suitable insulating material.)

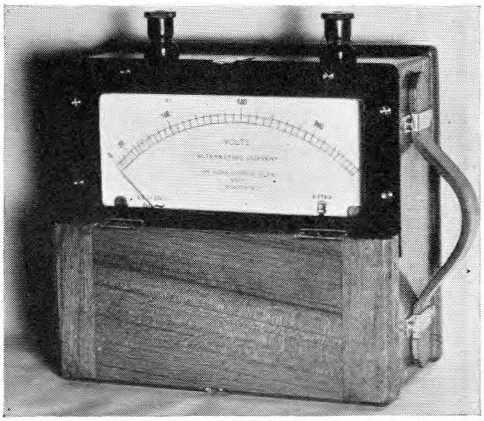
Switches and Panel.

The switches need not be of the quick break type, since they will not be called upon to break circuit, merely acting as shorting switches, and so far as their size and that of the terminals is concerned, this will depend on the usual current capacity of the apparatus to be tested. A convenient size of panel is one for about 50 amps., and as this will cover motors up to about 35 or 40 h.p. on the usual A.C. voltages, it is generally found that a panel of this size is adequate for factory maintenance work. The switches, then, should be about 50-amp. size, and the terminals and connecting cable should be capable of carrying the same current continuously, while any cable eyes used in the connections should be of the same capacity.

Plugs and Sockets.

For the panel itself any suitable insulating material will serve, perhaps ebonite or bakelised paper board would make the best job, but in the interests of economy no fear need be felt in using a piece of dry hardwood. If this last material is employed it is advisable to give the drilled panel several coats of varnish before mounting the switches, etc., on it so as to render it fairly moisture proof. The size of the panel must be sufficient to accommodate all the switches and plugs with adequate clearances between them; the drawings give suitable dimensions and drilling centres for a panel incorporating standard 50-amp. switches.

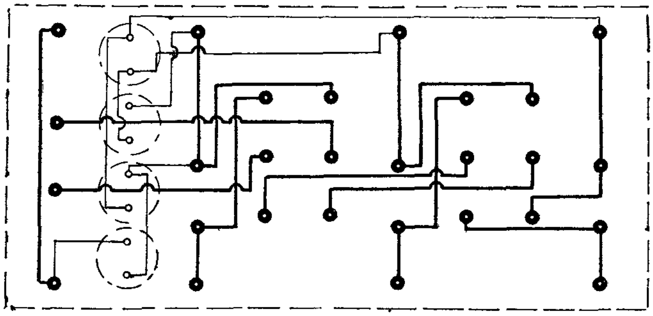
With regard to the five pin plugs and sockets, these items should be suitable for the maximum voltage on which the panel will be used, but as they are to be used for the voltmeter connections we need not pay any particular attention to their current capacity, beyond assuring ourselves that they make good contact.



A PORTABLE A.C. VOLTMETER.
This is the type of instrument which is most convenient for maintenance tests and contractors. The meter shown is of the single-range type, but it may also be obtained with several ranges for both large and small measurements.—(*Record Electrical Company, Ltd.*)

Building Up the Panel.

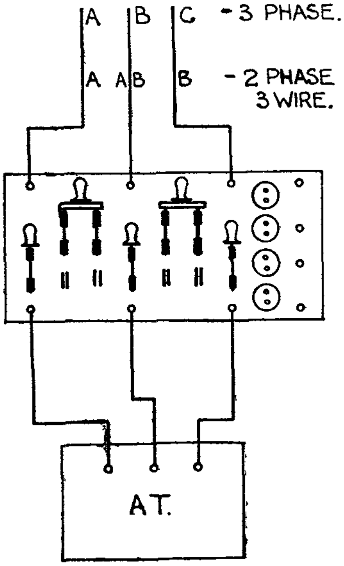
Having collected all the material we may proceed with the building up, and the first step is to drill the panel for the switches, sockets and terminals. If switches having dimensions different from those for which the drawing is made are used it will be necessary to alter the centres of the holes for the switch stems to suit them. The method of arranging the components is quite clear from the sketches, however, and there will be no difficulty in making the necessary modifications to the dimensions given.



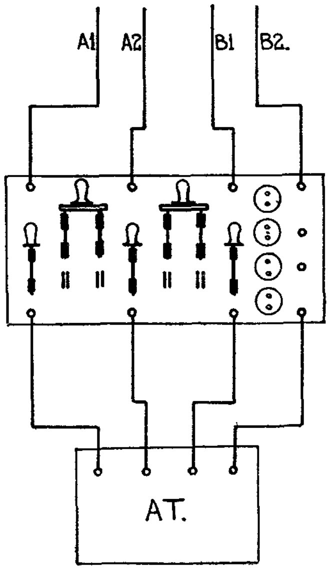
PANEL WIRING DIAGRAM.
Here are shown the wiring and connections of the instrument panel. The thick lines denote wiring which must carry the full current, while the thin ones show voltage wiring. It will be noticed that the components are shown reversed in position from right to left, this is because we are looking at the back of the panel

Drilling for the Knife Switch Parts.

Care must be taken, when drilling for the knife switch parts, to keep all the holes for each blade in accurate line, since if this is not done there will be difficulty in operating the switches which will be stiff, or if the lining up is very bad the blades will not enter the jaws at all. A little time and care spent on this part of the job will be amply repaid by ease and facility of working of the completed panel.



CIRCUIT CONNECTIONS
The connections for putting the panel in a three-phase, or a two-phase three-wire circuit are here shown. The wires lettered A, B, and C (or A, AB, and B), are connected to the main switch load-side terminals, while the other side of the panel is connected to the gear to be tested. AT is the apparatus under test.



TWO-PHASE FOUR-WIRE CONNECTIONS.
As in the previous diagram A1, A2, and B1, B2 go to the main switch while the apparatus under test is marked AT.

Mounting the Parts.

When the panel has been drilled it should, if of wood, be given a couple of coats of fairly thick shellac varnish, which should be well worked down into the holes in which the switch stems are to be placed. This varnishing is for the purpose of sealing the wood against moisture, since if the panel is allowed to

A Multi-range Combination Meter.

This single instrument consists of two meters one of which measures volts in five ranges (0-6, 0-30, 0-150, 0-300, and 0-750), while the other measures six ranges of amps. (0-1, 0-5, 0-15, 0-50, 0-150, and 0-600). The whole of the equipment necessary for the above range of measurements is contained in one case and weighs only eleven pounds, while the instruments have British Standard first-grade accuracy on both A.C. of normal supply frequencies and also D.C. circuits. This instrument is most desirable for maintenance and on-site testing work.—(*Record Electrical Company, Ltd.*)

become fairly damp it will be possible for the current to leak between the phases. This state of affairs must, of course, be prevented, and it will be found that varnish, brushed well into the wood as directed, will be quite effective.

Assembling the Switch Parts.

When the varnish has dried the switch parts may be assembled in their correct places on the panel and the nuts holding same should be made as tight as possible. It will be found of assistance, in mounting the knife switches, if the switch is finally tightened up in position with the blade within the jaws; that is, in the normal "closed" position. If this is done it will be easier to make sure of the alignment of the switch parts which was mentioned in a previous paragraph. At the same time as the switches are mounted the sockets and terminals should be secured in their correct positions, and when everything is in place the building up is complete and the connecting may be proceeded with.

Making the Connections.

The panel, complete with the switches, etc., must now be turned over so that the connections may be made at the back, where they will be out of the way and well protected. The actual connections should be made in line with the diagram given, and care must be taken to use well-insulated cable and to sweat the cable eyes at the end of each connection securely in place. The cable used for making the connections to the knife switches should be of the size which is normally used to carry the current for which the switches are rated, but the wiring to the sockets may be made in any suitable size of cable, no matter how small, providing it is well insulated. Care must be taken, of course, to see that all the connecting cable used is quite sound so far as its insulated covering is concerned.

Sizes of Cables.

For the convenience of readers the following sizes of cable are given as suitable for the current connections (shown thick on the diagram) of instrument panels of popular current capacities.

Up to 30 amps... 7/0.044 or 0.01 sq. in.
30 to 60 amps. .. 19/0.044 or 0.03 „
60 to 120 amps... 19/0.064 or 0.06 „

Finishing Touches.

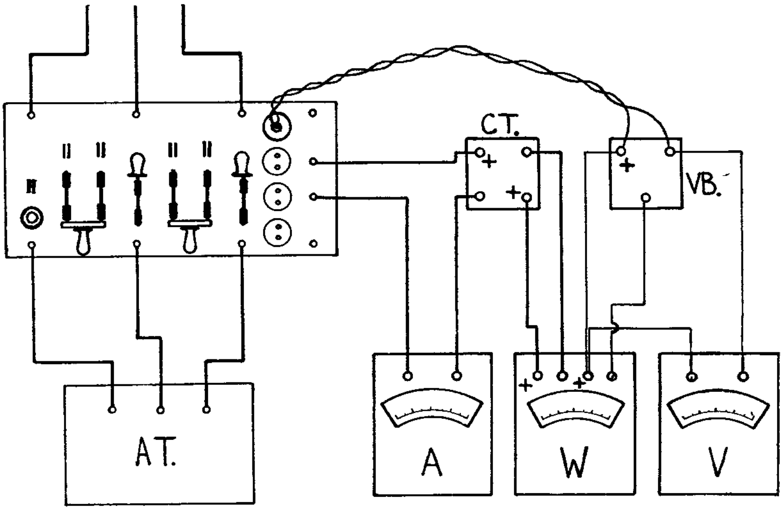
Having made all the connections and checked same very carefully against the diagram, the supporting strips may be screwed to the sides of the panel so as to hold the switch stems, etc., well clear of the surface on which the panel is placed, and when this has been done the equipment is completed and ready for use. If desired distinguishing letters or numbers may be painted by the different terminals or switches, or ivorine or other non-metallic labels may be used for the same purpose, but this refinement is by no means necessary since once the principle of using the panel is grasped no distinguishing marks are required. However, this matter can be left to the choice of the builder, who may, if he wishes for them, use the markings which have been employed, for descriptive purposes, in the drawings.

Connecting in Circuit.

The method of placing the completed panel in circuit with the plant on which meter readings are to be taken is very simple, since it is only necessary to disconnect the cables which run from the main switch which controls the current to the plant in question, take them off the main switch terminals and place them on the panel terminals marked A2, B2, C2 and D2, leaving any terminals vacant for which there are not cables. For instance, if there were three cables running from a main switch to the starter of a three-phase motor we would take them off the main switch terminals and place them on panel terminals A2, B2 and C2, leaving D2 unoccupied. In cases where there are four cables, as in two-phase four-wire circuits, all the terminals would be used, while when the panel is used for tests on single-phase apparatus which have only two cables we would leave both terminals C2 and D2 unconnected.

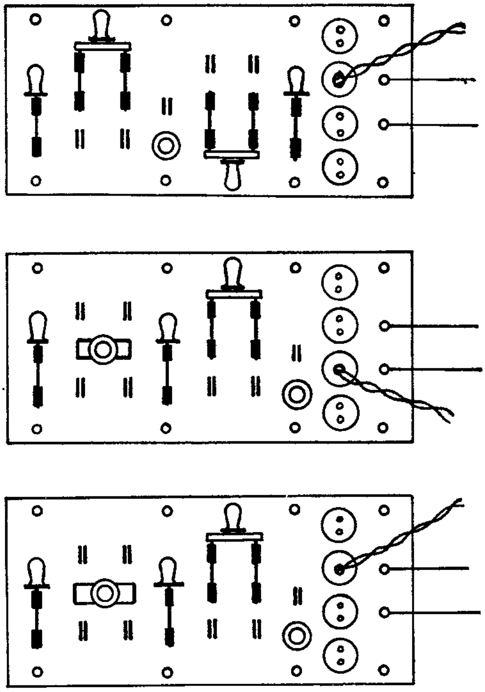
Having made these alterations in the permanent wiring to the plant under test we must make connection between the panel and the main switch, and for this purpose short lengths of cable, of suitable size, are used. These cables are connected to the terminals A1, B1, C1 and D1, and from them are run to the main switch terminals in such a manner that the main switch terminal which originally carried the cable which is now connected to A2 is joined, by means of the short length of temporary cable, to panel terminal A1; while that which was connected to B2 is now wired to B1, and so on.

In making these alterations to the con-



Connections Between Panel and Meters.
The wiring between instrument panel and meters is very simple as is here shown. A denotes the ammeter, W the wattmeter, and V the voltmeter, while the current transformer and volt-box for the wattmeter are shown by CT and VB respectively. These last two are not always needed, of course. The switches are shown set to read Amps A, Volts A-B, and Watts W1, i.e., S1 is "open," S2 and S4 both at "Q," and the voltage plug is in V1.

nections due care must be taken, of course, to see that the insulation of the temporary connecting cables is good, and the main switch must be in the "off" position before any terminals are touched or connections moved. The method of making the connections between the panel, main switch and apparatus under test is shown clearly on the diagrams.



SWITCH POSITIONS.
This diagram shows the positions of the switches for different readings, as follows :—
(*Top*)—S2 at "R," S3 "open," S4 at "Q," and plug in V2.—Readings Amps B and Volts B-C.
(*Centre*)—S2 "open," S4 at "R," S5 "open," and plug in V3.—Readings Amps C and Volts C-A.
(*Bottom*)—S2 "open," S4 at "R," S5 "open," and plug in V2.—Reading Watts W2.

Connecting Meters to Panel.

When the above connections have been completed the knife switches S1, S3 and S5 should be closed, and the gear under test may then be used in the normal manner, as though the connections to it had never been disturbed. Care must be taken, of course, to guard the instrument panel against any machine operatives, since the switch blades and terminals will be alive, and for this purpose a shallow wooden box may be constructed with which the panel may be covered.

As soon as the meters are available, or when it is desired to take the tests, the meters should be connected as follows. The ammeter, and the current coil or current transformer of the wattmeter in series with it if one is used, must be connected by short lengths of cable to terminals X and Y, while the voltmeter, with the wattmeter potential side in parallel, should be wired to the two-pin plug.

These connections may safely be made while the panel is still in circuit and carrying current if the two double-pole double-throw knife switches are left open while they are being made, since under these conditions the X and Y terminals are completely isolated from the supply. The wiring between instruments and panel is shown clearly in the diagram, which also depicts the correct method of connecting a wattmeter, if this instrument is to be employed.

How to Use the Panel.—(I) Current Readings.

The connections of the panel are so arranged that current readings may be taken in the three lines connected to terminals A, B and C. No provision is made for observing the current in the D line, since this is only provided for use in two-phase four-wire tests, and in these cases the current in line D will be the same as that in line C, since these two lines will form the connections of the same phase. This is clear on reference to the diagram of connections for this type of circuit.

In order to take readings of the current in each phase, while using only one ammeter, we set the double-pole knife switches so that the ammeter terminals are connected across the terminals of each of the single-pole knife switches in turn, and when this has been done we open the particular single-pole knife switch, thus making the phase current flow through the ammeter, causing it to deflect and give a reading of the current flowing. For instance, suppose that we wish to take a reading of the current in line A, we should proceed as follows :—

First set S4 in position "Q" so that the ammeter terminals are connected across the blades of switch S2, then set S2 also in position Q, thus transferring the ammeter connections to switch S1 in such a manner that X is connected to the A2 side, and Y to the A1 side of the single-pole switch. If now S1 is opened the only path between A1 and A2 which is available to the current in the A line is via the ammeter, which is thus caused to read the current in that line.

The principle of taking current readings in the other lines is identical, so that to read the B phase current we would set switch S4 at Q, S2 at R, and open S3, while the observation on the C line would be taken simply by putting S4 at R and opening S5. These switching operations place the ammeter in circuit with each phase as desired, so that a reading of its current may be taken.

(II) Voltage Readings.

In order to take readings of the voltage across each phase it is only necessary to place the plug in the correct socket, as will be clear from the diagram of connections, so that to read the voltage between lines A and B the plug is inserted at V1, for the volts between B and C at V2, while V3 gives the voltage A to C and V4 that between lines C and D. We are thus able to take either the three voltage readings required by a three-phase test, or the two which a two-phase investigation entails.

(III) Wattmeter Readings.

In order to obtain a wattmeter reading we must combine the procedures already described for taking ammeter and voltmeter measurements, because a watts meter may be said to measure both volt- and amps. and to combine their effects and indicate the effective product of their values. More than this, in a three-phase test by the "two wattmeter" method, although one phase is apparently omitted from the test by the fact that only two readings are obtained the fact is that all three phases are considered since the current readings are taken in two of the phases, while the voltage portion of the test consists in measuring the voltages from these two phases to the third phase in which no current observation has been made. Therefore, for either two-phase or three-phase tests, two wattmeter readings may be taken by following the procedure laid out below.

To read W1. Combine the readings of amps. in line A with the voltage between lines A and B, that is to say, set both S2 and S4 in the Q position and open S1, and at the same time place the voltage plug in socket V1.

To read W2. Combine the readings of amps. in line C and voltage between lines B and C; in order to accomplish this set S4 at R and open S5, and at the same time place the voltage plug in socket V2.

When the two-phase test is made on a two-phase four-wire circuit the voltage plug should be placed in socket V4 instead of V2 when the reading of W2 is being taken.

General Notes on Using the Panel.

When using the instrument switch panel of this type it is best to form a definite procedure in taking readings, so as to expedite the taking of readings and safeguard the tester and instruments, the following precautions should be observed:

Always set the two-pole switches, S2 and S4, *first*, and note that before S1 or S3 is opened S4 *must* be in position Q.

Never open S1 unless both S2 and S4 are at Q.

Never open S3 unless S2 is at R and S4 at Q.

Never open S5 unless S4 is at R.

Never open more than one single-pole switch (S1, S3 or S5) at once.

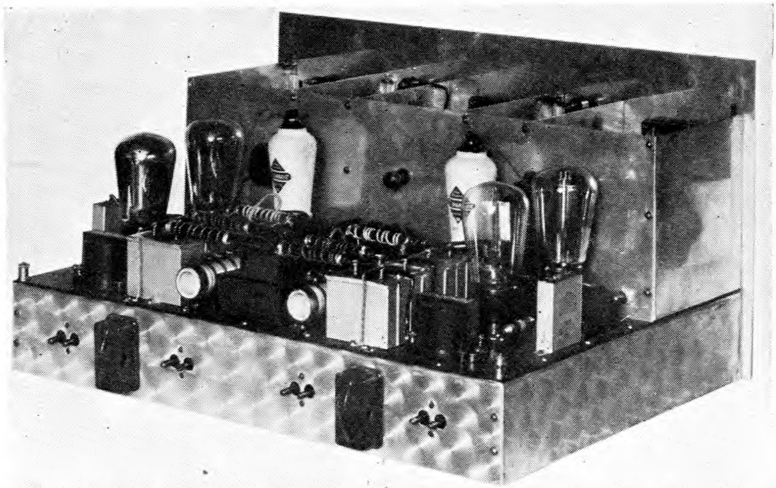
At first sight these instructions may appear complicated, but the method of using the panel is soon grasped, and the above procedure then becomes automatic. The writer has knowledge of one large manufacturer's works where the induction motor testing switchboards incorporate this method of instrument switching with perfect success and with a very considerable saving of instruments.

Design and Operation of a Radio Relay Station

By C. W. Watson

In the August issue we dealt with the various methods used for transmitting broadcast programmes from a relay station to its subscribers. We now give some details regarding the design and operation of the relay station itself

IN designing a radio relay station it is first necessary to determine, not only the immediate requirements, but possible future demands. As a guide in this respect it is found from experience that with efficient management a radio relay company operating in a densely populated area can reasonably expect to secure the patronage of one house out of every 12 in its area within the first 12 months and one house in six or seven within two years.



A Dual Receiver Capable of Receiving Two Programmes From One Aerial.

The two local programmes may be pretuned on a receiver of this description. Note the elaborate decoupling and smoothing arrangements. This set has a self-contained filament transformer and takes high tension from a generator. (*By courtesy of J. S. Ramsbottom and Co., Ltd., Keighley*)

As the system grows, more and more time is demanded by business matters, often at the expense of the technical side, and in consideration of this the beginner in relay will be well advised to cater for the first 12 months' requirements at the outset.

Having once settled on premises, the relay operator should make up his mind to overcome any local technical difficulties which may arise, as a relay station, when once established, cannot easily be moved. A compromise is usually made between reception, distribution and accessibility.

The Power Supply.

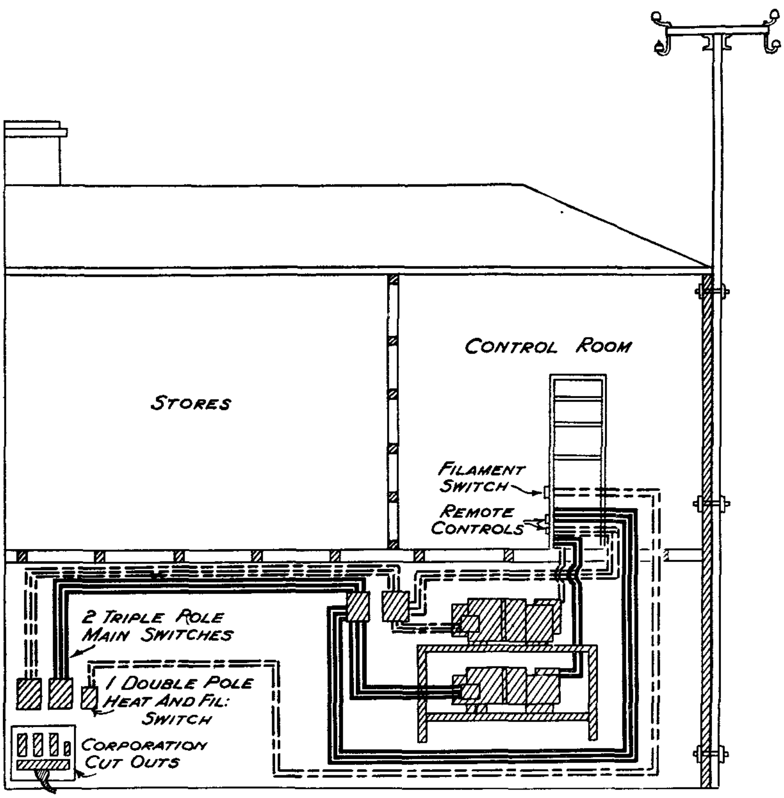
Having chosen the station, the first point to be considered is the power supply. D.C. mains, if possible, should be avoided, but as it is almost certain that in the comparatively near future almost all D.C. supplies will be changed to A.C. this should not debar an enterprising firm from beginning operations in premises which are otherwise most suitable.

Stations are best classified by their probable ultimate demand :—

A .. Up to 250 loud-speakers.
B .. 250 to 500 loud-speakers.
C .. 500 to 1,000 loud-speakers.
D .. 2,000 loud-speakers and upwards.

As there is no doubt at all that successful relay systems must give alternative programmes, it is proposed to consider dual programme working mainly in this article.

In the case of A and B stations, the H.T. supply is best arranged in each unit, whether receiver or amplifier, whilst in a station to operate more than 500 loudspeakers it is found more reliable and efficient to arrange one source of H.T. for the whole station, the reason for this being that with less than 500 subscribers a station must necessarily operate with less attention than can be afforded to a larger station, and no matter what the operator's initial intentions are in this respect the smaller station will undoubtedly eventually be left to a large extent on time switch, whilst the operator with the larger station can well afford to, and therefore should, provide constant attention during service hours.



TYPICAL LAYOUT FOR A RELAY STATION.

Providing Against Breakdowns.

In a well-designed station breakdowns are almost unknown, but, nevertheless, have to be provided against, and each piece of apparatus actually in operation should be provided with a stand-by, whilst in the case of a small station which is often unattended a complete shut-down should be impossible except in the case of failure of electricity supply. For this reason, as before mentioned, it is advisable that such a station should be provided with H.T. supply to each receiver or amplifying unit so that if one programme closes down through failure of a component, the alternative programme will continue uninterrupted.

Aerial System.

A radio relay station must be arranged with due consideration to local conditions. Two aerials are usual, one being, say, 30 to 40 ft. in length, and the other 50 to 60 ft. in length. These should be arranged with a double pole, double-throw switch in such a manner that a single operation of the switch changes the aerials about, whilst a second switch earths both aerials. The aerials should be erected as remote from the out-going lines as possible and supported on a hollow steel mast.

The Lead-in.

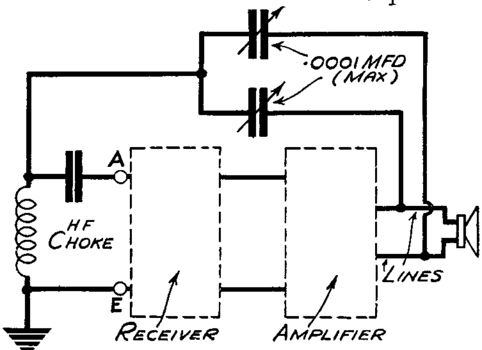
The lead-in is best arranged by carrying an insulated conductor down the inside of the mast, and this should be continued, still in tubing, right to the aerial terminals of the receivers. By this means, interference from the surrounding apparatus is minimised. To keep down the capacity of the lead-in, corks may be attached to the insulated wire in order that these may be as well spaced from the metal tubing as possible.

Where electrical interference is very bad, a centre tapped frame aerial may be used, together with an amplifying valve, the output from which may be fed to any ordinary receiver. This unit may be tuned if desired, but will operate quite satisfactorily without tuning and without attention.

Earth System.

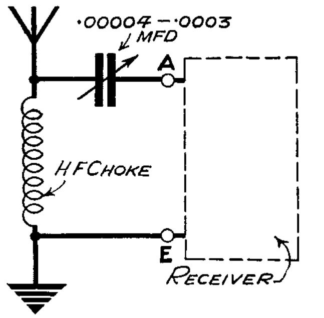
In any kind of a relay station it is advisable to run a heavy earth lead throughout, and where a common source of H.T. is used for the whole station it is a good plan to earth the high tension negative at the source of H.T. supply and arrange H.T. returns through the metal chassis of the various units, which, in turn, should be efficiently earthed.

Attention should be paid to the light and power wiring of the building itself, and where tubing or lead-covered conductors are used, these should be very efficiently bonded and earthed, or mysterious rustling will be experienced when any vibration takes place. Speaking from experience, it is probably most advisable where possible, to carry out the wiring, except in the case of D.C. mains, in cab-tyre cable.



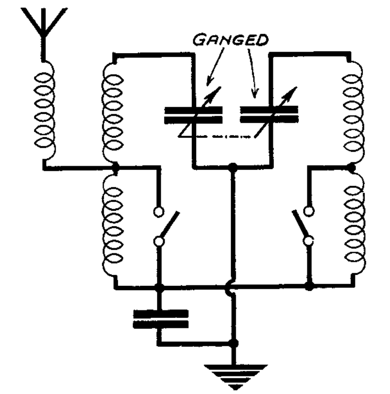
USING RELAY LINES AS AERIALS IN A RELAY STATION.

As a general rule with radio relay stations, two aerials are usual, one being say, 30 to 40 ft. in length and the other, 50 to 60 ft. These should be arranged with a double-pole double-throw switch in such a manner that a single operation of the switch changes the aerials about while a second switch earths both aerials.



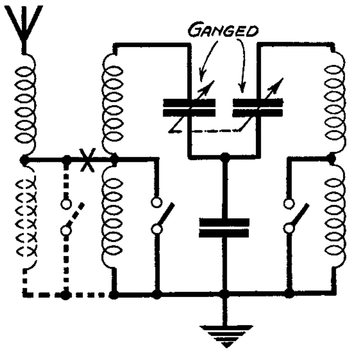
SIMPLE FILTER ARRANGEMENT TO CUT OUT INDUCED LOW FREQUENCY FROM AERIAL COIL OF RECEIVER.

This is often an advantage when incorporated in a private receiver.



AN ORDINARY BAND PASS CIRCUIT WITH COUPLING CONDENSER IN PATH OF AERIAL CURRENT.

This would be of no use for relay station work. Compare with the next illustration.



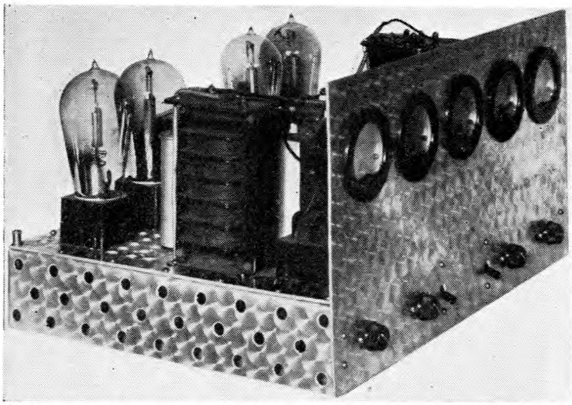
A BAND PASS CIRCUIT REARRANGED FOR RELAY STATION WORK.

A further improvement would be possible by earthing the aerial coil direct.

RECEIVERS.

Tuning.

Owing to the heavy induction of low



A SINGLE STAGE AMPLIFIER CAPABLE OF RUNNING 500 LOUDSPEAKERS AT GOOD VOLUME.
Note the separate anode milliammeters and grid bias controls.
(*By courtesy of J. S. Ramsbottom and Co., Ltd., Keighley.*)

frequency currents from the amplifiers and out-going lines, receivers for radio relay service must be chosen, or designed, with this in mind. Most manufactured receivers of to-day have coils wound with too fine a gauge of wire for satisfactory operation under relay station conditions, the ohmic resistance of the wire being sufficient to feed back quite an appreciable amount of L.F. to the valves, whilst many band pass circuits and coupling arrangements at present in common use offer too high an impedance to the low frequency signals picked up by the aerials from the out-going lines.

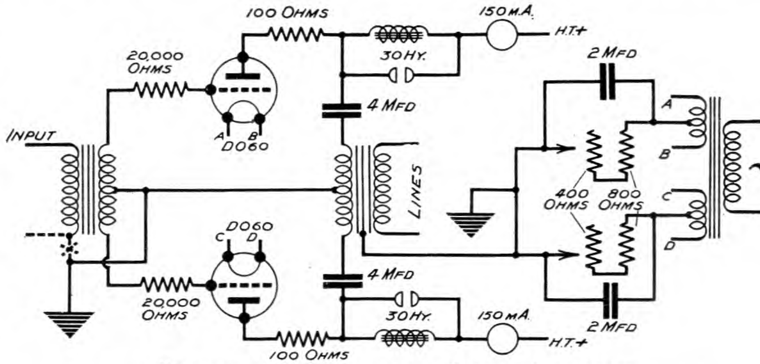
Common offenders in this respect are well-known band pass tuning units using reactance coupling, the coupling condenser often being in the path of the aerial current. This arrangement although satisfactory for ordinary broadcast receivers, is sure to give trouble in a relay station. This trouble may be eliminated by earthing the coils directly and coupling in the condenser earth leads; some difficulty may be found in carrying out this suggestion unless the ganged condenser can be insulated from the chassis and where this is carried out it will be found that in the case of a receiver with two stages of H.F. the coupling condenser is also in series with the inter-valve tuning circuits. This may be overcome by two twin-gang condensers, but a far better plan is to use "top end" capacity coupling, or still more preferably the well-known method of link coupling.

Programme Value.

Many stations received by the ordinary listener are not of sufficient programme value to be transmitted over a radio relay system. Radio relay subscribers are concerned only in the quality of reception and entertainment value and are not particularly interested in the source from which the programme is transmitted. This, of course, is with the exception of the items such as the transmissions of the Test Match, running commentaries, etc. Further, a successful relay service must be able to give reliable advance information on its programmes, which, in the case of the majority of foreign stations, it is at present impossible to obtain.

Two Programmes from One Aerial.

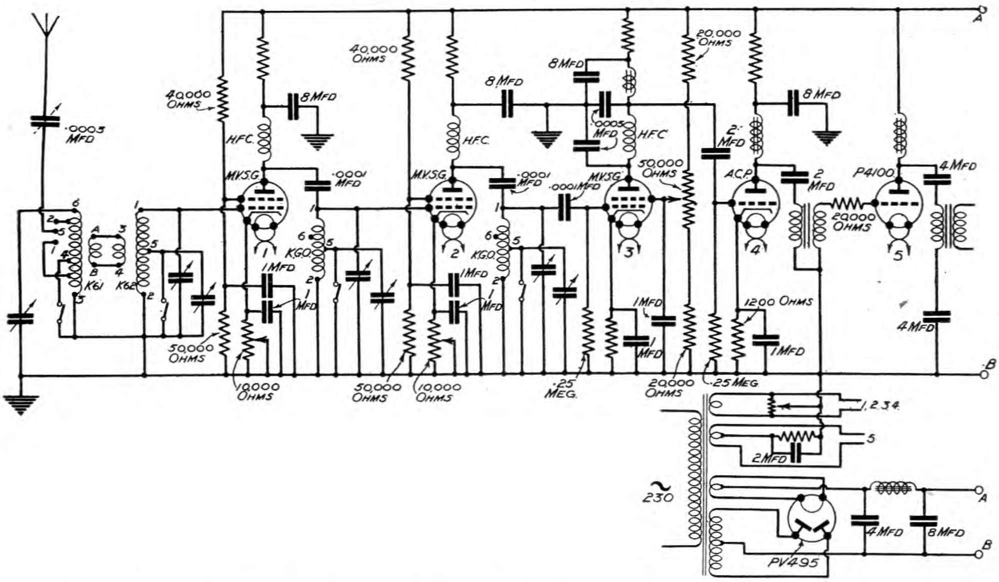
To facilitate operation it is now fairly



CIRCUIT FOR A TWO-VALVE POWER AMPLIFIER.
This would be capable of giving 22 watts undistorted output.

A SELF-CONTAINED LONG DISTANCE RECEIVER WITH LINK COUPLED BAND PASS TUNING GIVING 4½ WATTS OUTPUT.

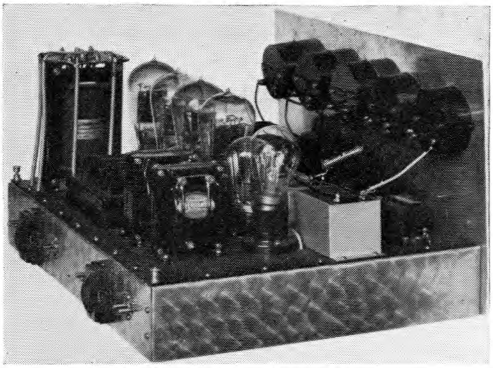
This receiver is capable of feeding any number of single stage power units without intermediate amplifier. *(By courtesy of J. S. Ramsbottom and Co., Ltd., Keighley.)*



CIRCUIT OF A 5-VALVE RECEIVER CAPABLE OF GIVING 4 WATTS UNDISTORTED OUTPUT.

This consists of 2 V.M.S.G., 1 Det. and 2 L.F. valves.

common practice for a relay station to have a dual receiver capable of receiving two programmes from one aerial. The two local programmes may be pretuned on a receiver of this description and except for minor adjustments the tuning is seldom disturbed. The most satisfactory arrangement of a dual receiver aerial circuit is to use one aperiodic aerial coil inductively coupled to two band pass primaries, which in turn may be coupled by the "top end" capacity method to their respective secondaries. The coupling condenser may with advantage be adjustable from the front of the panel where the circuits are individually tuned.



A Two-stage Amplifier.
Consisting of one A.C.P. valve and four D.O. 24's. This amplifier is capable of running 250 loud-speakers at good volume and is arranged for external high tension supply.
(*By courtesy of J. S. Ramsbottom and Co., Ltd., Keighley.*)

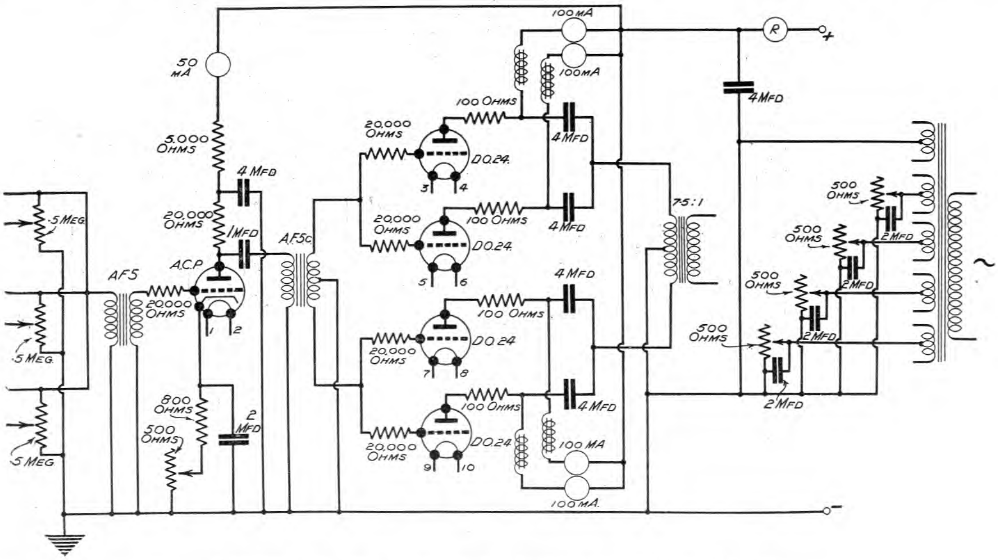
Output from Receivers.

A large output from receivers is neither advisable nor to be desired, the best arrangement being one low gain stage of low frequency amplification with quite a moderate-sized power valve and a heterodyne filter between the power valve and the detector.

Amplification.

Having incorporated one stage of low frequency amplification in the receiver two more stages will be necessary to give a suitable output, and it must first be decided how many amplifiers will be required.

Here again, the ultimate demand to be expected must be considered. The output valves at present available may be best utilised in amplifiers suitable for operating 120, 250 and 500 loud-speakers at full load. It is not wise to employ units with too large an output owing to the fact that line faults on one line connected to a large amplifier seriously affect the quality



CIRCUIT OF THE TWO-STAGE AMPLIFIER SHOWN ABOVE.

of reproduction of the whole of the amplifier output.

Are Intermediate Amplifiers Advisable?

Having determined the number of amplifiers to be employed the next consideration is whether, or not, intermediate amplifiers are advisable. If more than two output units are to be employed the most efficient method is to use a single-stage intermediate amplifier, the output from this being fed to the inputs of the power bank which are arranged in parallel. For dual programme working the various receiver outputs should be connected through faders to switches or jacks which will connect any receiver to either of the intermediate amplifiers or output units as the case may be. With this arrangement and careful monitoring, programmes can be superimposed on each other in any desired manner and such effects as fading in an announcement superimposed on the fade-out of the preceding item may be obtained with ease and add greatly to the entertainment value of the service.

The chief advantage in the use of intermediate amplifiers is that any number of single stage output units may be added as the demand of the station increases, these additions in no way interfering with the working of the existing apparatus provided that the output units are constructed as near to standard as possible. A further advantage of using a standard output unit is that these units may, in certain cases, with advantage be employed with their outputs in parallel, whereas if amplifiers which are not standardised are operated with their outputs in parallel these outputs may be seriously out of phase with each other and results will be unsatisfactory both from an acoustic and an economical point of view.

L.F. Valves Should be Choke Capacity Coupled.

In radio relay practice all low frequency valves should be choke capacity coupled or transformers parallel fed in a similar manner, the chokes and condensers used for this purpose being of robust construction and generous margins of safety allowed. Each valve in the second and final stages of amplification should be equipped with individual anode milliammeters, and chokes in the output stage may with advantage be fitted with spark gaps adjusted to discharge at about three times the anode voltage. The filament transformers of each chassis should have a separate centre tapped secondary for each valve.

Automatic Grid Bias.

All power valves of suitable size at present available being of the directly heated triode type, automatic G.B. is best obtained by inserting resistances between the filament winding centre tap and earth; these resistances should to a reasonable extent be adjustable from the front of the panel.

When using high power amplifying valves particular attention must be given to prevent high frequency oscillation and, in addition to laying out the components in such a manner as to prevent feed back from anode to grid of the valves, resistances must be inserted in the anode and grid leads as near to the valve holder as possible. Suitable values of resistances for these purposes are recommended by the valve makers.

Push-pull Amplification.

This may be employed with advantage in power banks and intermediate amplifiers, the arrangement being more satisfactory than the ordinary paralleling of valves. Under favourable conditions, one pair of 5-watt (output) valves will supply 100-120 subscribers, whilst a pair of 11-watt valves will supply 250 subscribers. The output of an amplifier may be doubled by using two valves on each side of a push-pull circuit, but each valve should be wired with its own grid stopper, anode stopper, filament winding, automatic G.B. anode choke and milliammeter.

Matching.

In matching radio relay amplifiers to the lines the usual methods are unsuitable. A well-designed amplifier built on the lines indicated will give a definite signal voltage from a given input whether working at normal load or on a monitor speaker only.

DISTRIBUTION AND CONTROL GEAR FOR POWER PURPOSES

By J. V. BRITTAIN, B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E.

THE general scheme of distribution for supplying the various motors of a factory should be based on the normal system of having :—

(*a*) A main control switch with either fuses or overload trips.

(*b*) A distribution panel having fuses on each line supplying a particular section.

(*c*) A control switch at the motor either with fuses or overload trips.

(*d*) A starter for each motor (except for fractional h.p. motors which are switched straight on).

Single-line Diagrams.

This is shown diagrammatically in Fig. 1, where a single line is used to represent the circuit. When planning the scheme in its initial stage a diagram of this description is extremely useful and enables the layout to be seen at one glance. If for instance on a 3-phase scheme all the wires or lines are drawn, the diagram becomes sufficiently complicated to make it necessary to follow out the wiring step by step to see what is suggested. With a single-line diagram alterations or additions can be made quite easily when discussing the matter with a non-electrical man.

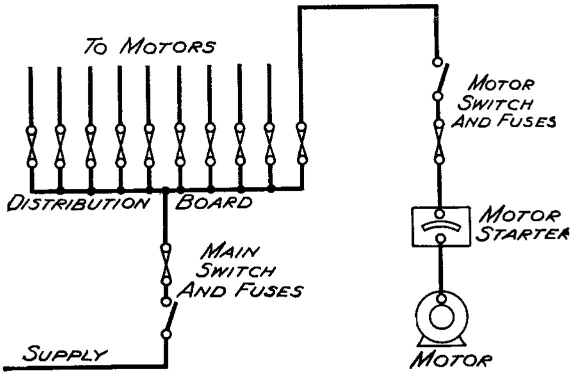


Fig. 1.—DISTRIBUTION SCHEME FOR POWER IN A SMALL FACTORY.
A single line is used to represent the circuit as it enables the layout to be seen at a glance.

Size and Type of Apparatus.

The actual size and type of apparatus which will be required depends on the size of the motors to be supplied, the voltage and the type of factory or situation. For this article only voltages up to 500 volts will be considered, as the majority of factories having a large number of motors will use either 400—440 volts 3-phase A.C. or either 230 or 460 volts D.C.

For large motors working direct off 3,000 volts the control gear is in the nature of a substation and requires consideration on different lines from that outlined here.

The First Point to be Considered.

The first point which affects the layout of the wiring is the actual number of motors to be supplied, and in conjunction with this much depends on whether these are situated in one compact building or not. Referring to Fig. 1, if there are not more than 10 or 12 motors these can conveniently be supplied from one distribution board, when the line diagram will be as shown in this sketch.

A Typical Example.

As an example of this we will assume that a factory consisting mainly of one room or building has 10 motors varying from 5 to 15 h.p. If the supply is from the Corporation it can be taken as 400 volts 3-phase A.C., as most undertakings have now changed over to this system, especially for a supply of this size. For 230 or 460 volts D.C. the subsequent remarks hold good, except that the current taken by each circuit will be different from that worked out for the A.C. case and all the gear will be double-pole instead of triple-pole.

Deciding on the Size of Gear Required.

It will now be necessary to decide on the size of gear which will be required, and in connection with this point it is considered by many engineers that distribution boards should not be made with fuse-carriers of varying capacity. In the case we are taking there may be three motors of 5 h.p., five motors of 10 h.p. and two of 15 h.p. Assuming that we are going to install fuses which are just sufficient to control each motor there will be three different sizes inside the distribution board.

While manufacturers are generally prepared to supply a board of this type to any special order there are many objections to this policy and these include :—

(1) Lack of adaptability—should one of the smaller motors require replacing with a larger one the fuses are not large enough.

(2) Spare loaded fuse-carriers not so easily provided—three sizes are necessary. (3) Boards are not standard and, therefore, have to be made specially involving extra time and cost.

Put in a Uniform Distribution Board.

With these points in view it is advisable to put in a uniform distribution board the size of each fuse being that which is required to supply the largest motors. This policy must not of course be carried to extreme, and if there were, for instance, one 100 h.p. motor and all the others were less than 20 h.p., a separate distribution unit would probably be put in for the 100 h.p. motor.

With a load as originally outlined however, a uniform distribution board should always be used, and in the case of any extensions involving larger motors no alterations in the fuse gear will be required, assuming that the capacity of the fuses is not exceeded.

Calculating the Current Taken by the Largest Motor.

In the case specified the largest motor

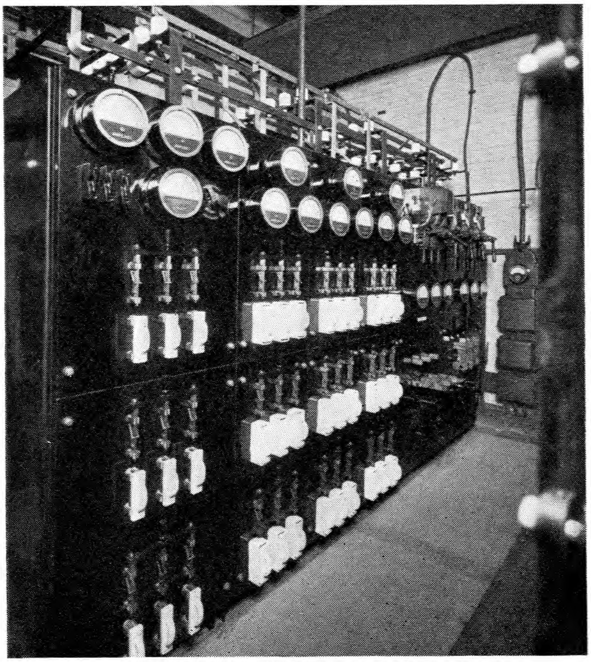


Fig. 2.—A Typical Works Lighting Panel.
This consists of six slate panels, two of which control the incoming 200-volt supply cables from the 100 kVA. and 200 kVA. transformers, and the four others the outgoing feeders to the triple pole distributing fuse boards situated in suitable positions in the works.

is 15 h.p. and the current taken by this will be found from the following calculations :—

Current in amps.

$$= \frac{\text{H.P.} \times 746}{\sqrt{3} \times \text{volts} \times \text{power-factor}} \times \frac{100}{\text{efficiency } (\%)}$$

(The above is for 3-phase A.C. only.)

Power-factor and Efficiency.

The power-factor and efficiency will

vary with the type and size of motor and these values can be obtained from manufacturers' catalogues or sufficiently correct values for this purpose can be obtained from one of the usual pocket books or engineers' diaries. The efficiency of a 15 h.p. 3-phase motor on full-load can be taken as 90 per cent. with a power-factor of 0.85. This gives us the following value :—

$$\text{current} = \frac{15 \times 746}{\sqrt{3} \times 400 \times 0.85} \times \frac{100}{90}$$
$$= 21 \text{ amps. (approx.)}$$

As it must always be assumed that a motor will occasionally be overloaded, we can say that the fuses must be of such a size that they will normally carry a current of 25 or 26 amps. In this case the smallest fuses which should be installed are the 30-amp. size, giving us as a distribution board a 10-way 30-amp. 500-volt unit.

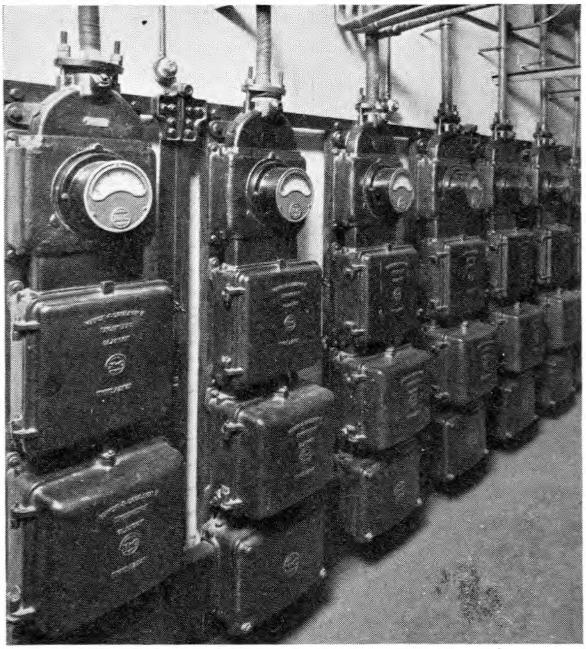


Fig. 3.—UNIT TYPE SWITCH PANELS.
Each panel controls a single machine or group of machines so that any desired section of the works can be isolated from the main supply when required. Compare with the circuit diagram shown in Fig. 5.

The Range of Voltage.

When specifying control gear of this type it is necessary to state the range of voltage for which it will be used and in gear of this type there are normally two ranges, i.e. up to 250 volts and up to 500 volts. As the voltage assumed is 400 it is necessary to have gear designed to work at the higher voltage.

One Amp. per h.p. Output.

In connection with the above calculation it will be seen that for a 15 h.p. motor we have used 30-amp. fuses. It can generally be assumed that on 400 volts 3-phase the maximum current will be 2 amps. per h.p. output, and this can generally be taken as a guide in working out maximum currents for motors of 5 h.p. and upwards.

The Main Control Switch.

We now come to the main control switch which has to carry the whole current. As there are 10-ways and each may (at some future time) take 30 amps., this main control switch should—theoretically—be of 300 amps. capacity. It is generally accepted, however, that owing to all the motors not being on full load at one and the same time a smaller unit will be satisfactory, and in this particular case a 200-amp. switch would probably be installed. This item would, therefore, be either a 200-amp. 3-pole combined switch and fuse unit or a 200-amp. 3-pole oil-immersed circuit breaker.

Gear At or Near the Motor.

The gear which is required at or near the motor depends mainly on the type of motor used but assuming the star-delta method of starting, the usual control is shown in Fig. 4. The supply from the distribution board comes into a combined switch and fuse and from there to the starter itself. The size of the combined switch and fuse will depend on the h.p. of the motor and for the 15 h.p. motors should be 30 amps. In no case will this unit be less than 15 amps. as apart from current carrying capacity a switch for use in a factory should be of a robust nature, and switches smaller than 15 amps. are usually rather fragile.

In Fig. 4 the wiring shown connecting up the motor is that usually adopted for star-delta switches and the starter will have a diagram showing the actual details.

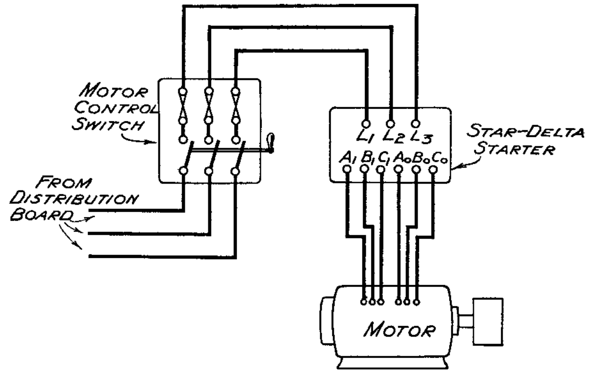


Fig. 4.—Full Diagram Showing Control Gear at Motor.

An Oil-immersed Starter.

As an alternative to the separate switch and starter described above, a single unit consisting of an oil-immersed starter can be used. This must have at least two overload releases and the usual no-volt coil. In this case the overload releases take the place of the fuses in the switch unit.

A Larger Scheme.

There will be, however, a limit to the size of factory in which this simple method of distribution is practicable. It will be seen that in Fig. 4, there is a supply from the distribution board to each motor and this may entail long runs of wiring. Again, in a factory having several rooms or buildings, it is an advantage to have the point of distribution for each building or department at some point nearer to the actual motors themselves. This brings us the larger scheme in Fig. 5, where it has been assumed that there are three sections to the factory and that each section has several motors.

Advantage of Separate Circuit Switches.

The line diagram given in Fig. 5 shows the simplest arrangement and it has the advantages of using a minimum length of wire together with central distribution. The main supply is controlled by the usual main switch from which is taken three circuits—one for each department. These circuits are again controlled individually by a combined switch and fuse. The advantage of these separate switches is that any section can be made dead at will at the main board, in case that section is not working or repairs are being carried out.

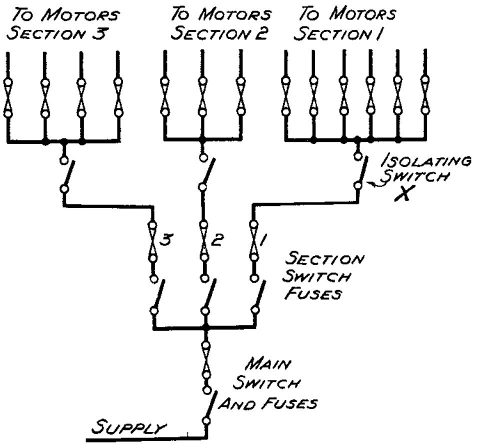


Fig. 5.—Distribution Scheme with Sectionalised Distrifution Board.

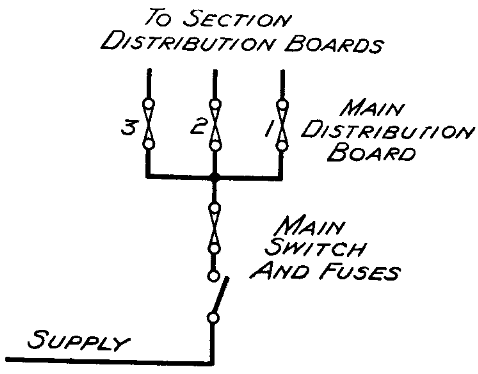


Fig 6.—Line Diagram Showing Use of Main Distribution Board Instead of Section Switch Fuses as in Fig. 5.

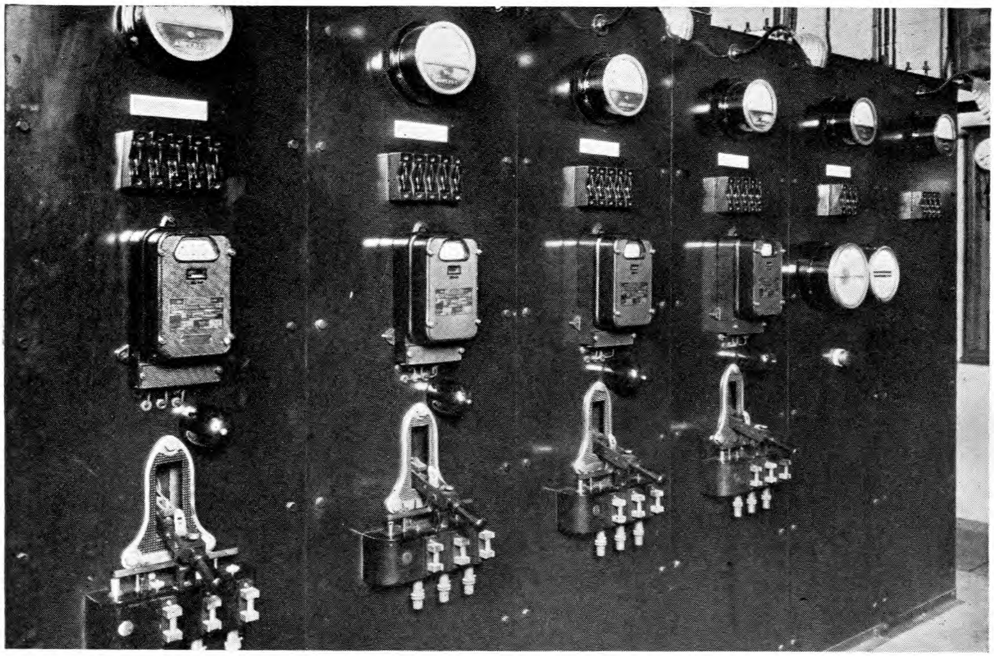


Fig. 7.—A TYPICAL POWER CONTROL PANEL.
Incoming supplies are from four 250 kVA. transformers each controlled by oil circuit breakers. Outgoing feeders are of 400 amps. capacity, with air break isolating switches.

A Main Distribution Board Can be Used.

If this control is not considered necessary, instead of the three separate switches a main distribution board can be used as shown in Fig. 6—this will of course be cheaper than the other method but lacks the advantages stated.

Final Distribution to the Motors.

The final distribution to the motors is by a distribution board situated at some convenient point of that section of the factory which it controls. This makes the runs to the motors as short as possible and in the case of a fuse blowing it can be replaced without walking back to the main control board. For this purpose the isolating switch marked X is essential, as fuses must not be replaced with the power on.

If, however, the fuses are correctly graded it will only be in case of serious trouble that the fuses in the sectional distribution board will be blown. The actual fuse wire used in the control switch at the motor itself should be lighter than that used in the distribution board. If the motor fuse fails then it can be replaced without affecting any of the other motors in that section.

Grading the Fuses.

In any scheme of distribution the fuses should be graded so that in the event of trouble the " shut-down " is limited to as small a portion of the system as possible. In this connection it should be borne in mind that the actual fuse-wire used should be carefully considered irrespective of the capacity of the fuse carriers, except that this must not on any account be exceeded. Because a 30-amp. fuse carrier is provided there is no need to use 30-amp. fuse wire, and in a case such as that described for the scheme in Fig. 1, the size of the fuse wire should be clearly stated in any plan or instructions. It is usually better to specify the size of fuse wire by the current at which it will blow.

While these notes do not cover the whole field of planning power distribution, it is hoped that they will give the reader the general principles which should be followed in tackling a problem of this nature.

QUESTIONS AND ANSWERS BY PRACTICAL MEN

Readers are invited to send problems of practical interest. Letters should be addressed to " The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2. Envelopes to be marked " Problem " in the top left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTH'S NEW QUESTIONS.

Finding the Live Wire on a D.C. Circuit.

When testing for a live wire on A.C. it is possible with a pair of leads, a lampholder and lamp, to make the lamp light when the " live " wire and an earth are touched on. Is it correct that on a D.C. circuit by this method you cannot tell which is the live wire? If this is so, would you kindly tell me the best way to find a " live " wire on a D.C. circuit?

F. W. Clarke (Edmonton).

Miniature Circuit Breaker for House Lighting.

Is there any definite regulation prohibiting the use of a miniature circuit breaker on the live leg of an ordinary house lighting circuit, the neutral being connected direct to a neutral bar. I have in mind a subcircuit as above, permitting the one control only and therefore dispensing with the usual fuse in either leg and a tumbler switch on the live leg.

The neutral is at earth potential, and provided the neutral wire can easily be disconnected for testing, is there any reason for insisting upon two fuses?

R. W. Kane (Johannesburg).

Trickle Charger for a Model Railway.

I wish to set up a trickle charger in connection with a model railway. The power is obtained from a 12-volt car accumulator of 40 amp.-hour capacity.

It is proposed to use a Westinghouse metal rectifier giving 12 volts 1 amp. as this is the most convenient. However, since one cell when fully charged gives 2.2 volts, six such cells will give 13.2 volts; in other words, the accumulator is never fully charged.

Is there any way of getting over this difficulty other than, say, charging three cells at a time from the rectifier?

B. W. Hind (Pinner).

REPLIES TO PREVIOUS QUESTIONS.

I should be very glad if you could give me some information regarding an emergency stand-by installation for electric incubator and brooders.

These are at present running on 230-volt A.C. The consumption is about 7 kW. Is it possible to obtain an A.C. generator of this voltage and output?

J. and C. (Heathfield, Sussex).

There will be no difficulty in obtaining the installation mentioned. As a rule, such small sets are coupled to D.C. generators; these being a standard line, would prove a cheaper plant to purchase than an A.C. set. The use of either A.C. or D.C. supply is immaterial to the heaters in the incubators or brooders, so long as they are furnished with the requisite current; it is the current and not its pressure or type which furnishes the heat. As long as the D.C. generator gives 31 to 35 amps., with voltage regulation between, say, 220 and 235 volts, it would do the work as perfectly as the public supply. Several makers of such plants advertise in the electrical press. Three or four firms should be written to and the problem placed in front of them. It must be emphasised that (*a*) the private plant must run up automatically and switch itself on to the incubator circuits as soon as the public supply has been off for five to ten minutes, and must disconnect itself automatically, when that supply has been restored and has remained on continuously for 20 minutes. These " Come on " and " Drop out " time limits are necessary to prevent spasmodic coming on and going off by the private plant. They can be settled at just such points as the experience of the proprietors shows to be safest. (*b*) Incubation or brooding requires the heat to be constant throughout the whole process. Thus, if the public supply is off, the private plant must run 24 hours a day at full load until the public supply is restored. Insist on this point when placing your scheme before the manufacturers. They can then put forward an engine to meet the conditions safely. (*c*) Let the makers know that whilst you are prepared to make an approved foundation in a suitable engine-house to their requirements, that everything else must be supplied, erected, connected up and set to work by them ; left running to your satisfaction, and with the usual maintenance guarantee. Give the contractor to understand he must supply, fix, wire and connect up, both water tanks for the engine and wiring to the incubator circuits, and he will know where he is, quote accordingly, and carry through the whole matter with the minimum of expense, and, especially worry, to yourselves. One portion you will have to supply and fix is the pipe and ball tap to supply the make-up water to the engine-cooling tanks.

On receiving the offers from various firms, compare them as follows :—

(1) Diameter and stroke of engine cylinder or cylinders.

(2) Revolutions per minute.

(3) Simplicity of set generally, and accessibility for cleaning and overhaul.

(4) Petrol and lubricating oil consumption.

Items 1 and 2 are the more important. Choose that set of which the engine has the largest cylinder volume, and the lowest rate of revolution per minute.

The automatic gear which brings the private set into service should contain a "no volt" coil fitted in the public supply so that when this fails a warning bell rings in a place in which it must be noticed ; the warning bell to cease ringing as soon as the private set is supplying the incubator circuits. When this bell rings, always go down to the set and see it come in, or, if the auto gear hangs up, start up by hand. It will be sound practice to set the auto gear into action once each week by tripping the A.C. supply and seeing that the set comes into work correctly ; after running it on full load for 15 minutes, close the public supply again and see that the set drops out. Such a set will work for many years with slight attention and at a very low cost for maintenance.

Frothing of Celluloid Accumulators.

Can you tell me why some celluloid type of wireless accumulators froth so much after being on charge a few hours? They are from a year onwards old. Is there any cure?
H. Boyce (Glastonbury).

"Frothing," when charging accumulators, may be due to two causes.

1. The impregnating chemicals used for treating wooden separators, to prevent their deterioration through continued immersion in the electrolyte.

2. A chemical action, which apparently occurs between the electrolyte and the surface of celluloid containers, which have been in use for some considerable time.

In the case of old accumulators having celluloid cases, if frothing commences shortly after the charging is started, then it may be due to the second cause. The electrolyte should be drained from the container and the container cover removed. The accumulator plates are now taken out of the container, and immersed in clean cold water, until they are replaced.

Wash out the container with clean cold water, and thoroughly clean the interior with a soft clean rag, which is dipped from time to time in a solution of amyl acetate. This solution will remove all traces of precipitation from the surface of the container. After cleaning polish the surface with a soft cloth.

New electrolyte should now be made up with pure sulphuric acid and distilled water to the correct specific gravity, and allowed to cool down.

The plates are now replaced in the container, which is now filled with the electrolyte to the correct level.

The accumulator is then placed on charge in the usual manner.

A Book on Neon Tubes.

Can you give me the title of a good book on neon tubes? J.A.C. and others.

There is a book entitled "Neon Tube Practice," by W. L. Schallreuter (Blandford Press, Ltd., 10s. 6d), a review of which will be published next month

Recent Developments in Luminous Signalling

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY MAGAZINE OF ELECTRICAL PROGRESS

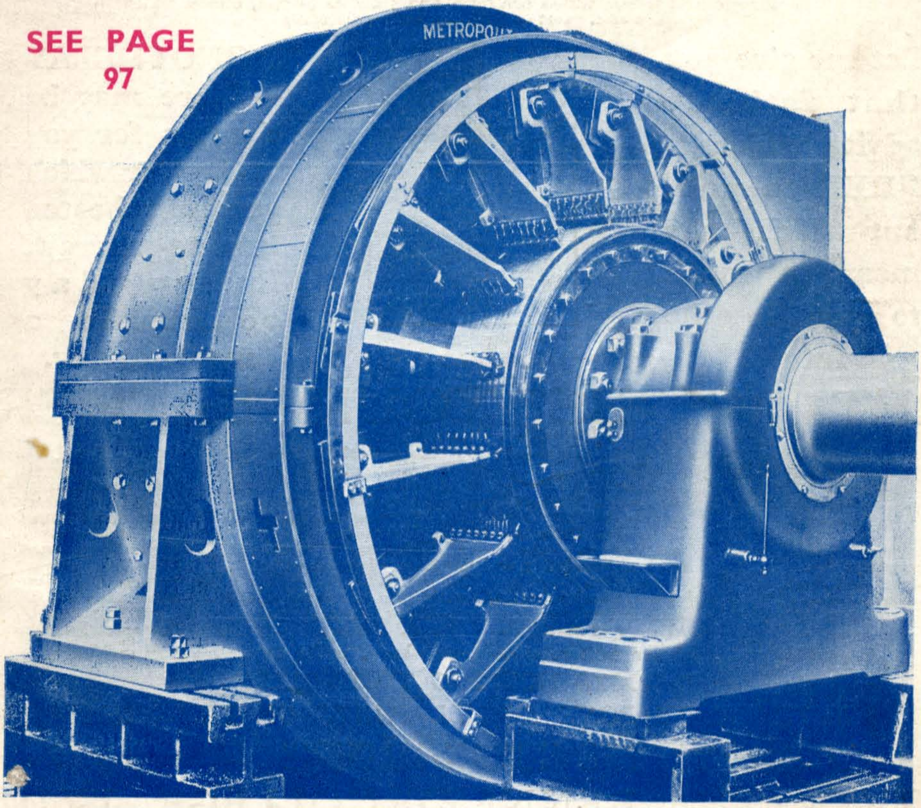
VOL. II.—No. 15

NOVEMBER, 1933

SPECIAL ARTICLE ON DYNAMO DESIGN

By MILES WALKER, M.I.E.E., F.R.S.

SEE PAGE 97



GEORGE NEWNES LTD.

NOVEMBER PRACTICAL ELECTRICAL ENGINEER No. 15

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

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Enterprise and the National Grid.

Through the enterprise of Messrs. Johnson and Phillips, Ltd., a Rural Electrification Scheme has been brought into successful operation to serve the districts of Ringmer, Alfriston, Asham, Plumpton and Glynde. The area covered by this scheme lies behind Brighton, Newhaven and Seaford on the South Coast and is approximately 63 square miles, and is under the Ringmer and District Electricity Co., Ltd., who purchase supplies from the Grid and distribute to their consumers. The latter include factories, farms, houses and shops. Already the undertaking is distributing at the rate of 3,000,000 kilowatt hours per annum. The prices charged to consumers range from $\frac{3}{4}$d. per kilowatt hour for off-peak water heating to a flat rate of 1$\frac{1}{2}$d. per kilowatt hour for power consumers taking more than 5 h.p.

These are the kind of prices which we believe will do more than anything else to stimulate rapid expansion in the use of electricity. We offer our congratulations to the firm of Johnson and Phillips, Ltd., on an achievement which sets a fine example.

Selling Electric Lamps.

The lamp situation continues full of interest. Mr. Os and Mr. Ram continue to amuse everyone with their witty remarks, whilst the Crompton-Kye organisation are gradually spreading the news that good British lamps are now obtainable at the price of 1s. Supply voltages are still far from uniform all over the country—200 volts, 205 volts, 210 volts, 220 volts and 230 volts are to be found within a short radius of Charing Cross.

Electrical engineers know that a slight variation from the rated voltage of a lamp may make a big difference in the light obtained or in the length of life of the lamp. We venture to think that not more than 50 out of every 100 consumers of electricity know the exact voltage of their supply. We suggest that a rather interesting lamp advertisement would be one containing the supply voltages for different districts. It might not be possible to cover all districts in a single advertisement, but we believe that the firm who ran a series of advertisements on these lines would have made the first step in educating the public to think electrically.

Mr. Winton Thorpe.

The new Northampton College of Technology possesses one of the best electrical equipments of its kind in the country. Readers will be interested to hear that the Consulting Engineer was Mr. D. Winton Thorpe, A.M.I.E.E., to whom we offer congratulations.

Ultra Violet Lamps.

A few years ago there was a growing demand for ultra-violet ray lamps for use in the home. Articles were then published in the newspaper press drawing attention to the dangers of the unscientific use of these lamps. These articles had the effect of greatly reducing the demand. It is quite certain that a great deal of new business could be obtained during the coming winter by the sale of suitable domestic equipment. Full instructions should be given as to the correct methods of using the lamps. Ultra-violet lamps improperly used are dangerous, but so are motor cars. This is just another example of the fact that electrical manufacturers must realise that if they wish to extend their business they must be prepared to spend time, trouble and money in educating the public. Who else is there to do it?

A Great Designer.

Modern electrical generators are amongst the most efficient machines produced by the ingenuity of man. Efficiencies of 98 per cent. and higher have been obtained. That is to say, for every 100 h.p. used in driving a large dynamo it is possible to obtain an output equivalent to about 98 electrical h.p. There are very few other machines capable of such a performance.

Professor Miles Walker, F.R.S., who has contributed an interesting article on Dynamo Design to the present issue is one of the engineering geniuses whose work has conduced to these astonishing results. His article is well worth careful study.

A.C. Motors.

The gradual adoption of A.C. supply all over the country is leading to increased use of induction motors. Like most other electrical machinery, once the motors have been correctly installed little or no skill is required to operate them. Upon the works engineer rests the responsibility of seeing that this installation is carried out correctly. The article beginning on page 102 contains much useful information for the man who is, or intends one day to be, the engineer-in-charge of a works or factory.

An Electrified Pump.

On page 106 we show an interesting example of an electric motor for driving one of the old hand-operated pumps. There must be thousands of such pumps all over the country. The profit on installing a 1 h.p. motor and accessories may not be very large, but little fish are sweet. In many rural districts it is easier to find 20 customers who can spend £5 or £10 than it is to find one or two customers who can spend £100 or £200.

The Westector.

An interesting application of the Westinghouse dry plate rectifier is described in the article beginning on page 125. This development is known as the Westector and can be used in place of a rectifying valve in wireless sets containing at least two stages of high frequency amplification.

I.E.E. Regulations.

We have much pleasure in acknowledging the courtesy of Messrs. Evershed and Vignoles for allowing us to use in this month's issue a number of diagrams taken from their new publication, "How to Avoid Electrical Breakdowns." Every reader interested in this subject is strongly advised to write immediately to Messrs. Evershed and Vignoles for a copy of the publication in question. Write to Evershed and Vignoles, Ltd., Acton Lane Works, Chiswick, London, W.4, mentioning THE PRACTICAL ELECTRICAL ENGINEER.

Luminous Signalling Systems.

We are fortunate in being able to include in this month's issue advance particulars of some of the latest developments in luminous signalling systems.

The author, Mr. S. W. Richards, of the General Electric Company, has developed the subject clearly by easy stages from the simplest relay circuit so that readers who have not specialised in this subject can now bring themselves right up to date by a careful study of this article.

Questions and Answers by Practical Men.

Since this new feature was started we have had a great pressure on our space. This feature promises to become one of the most popular in the magazine. We have been obliged this month to hold over a number of questions and answers, but readers may rest assured that every letter is receiving attention and will be dealt with as and when our space allows.

Have You Had Your Copy ?

We have examined a copy of the first part of Sir Ambrose Fleming's new work *Principles of Electrical Engineering*. It is compiled on original lines and makes study a pleasure. Items included in Part 1 are "Laboratory Demonstrations," "How to Read Electrical Circuits," "Resistance of Wires," "Principles of Neon Tubes, Cathode Ray Tubes and X-Ray Tubes," and "Designing Electrical Circuits." An excellent shillingsworth, and we hear that the first number has been sold out.

THE UTILISATION OF SPACE IN DYNAMO DESIGN

By Professor MILES WALKER, F.R.S.

THE space taken up by a dynamo is occupied mainly by four materials: (1) iron; (2) copper; (3) insulation; and (4) air. In a good design the right amount of space is allotted to each of these. Although air costs nothing, the spaces occupied by it inside a dynamo increase the size of the machine and the amount of iron and copper, and for that reason the air space must not be unreasonably extended. If we had no air spaces the cooling would be bad.

AIR SPACE.

The very greatest diversity of opinion exists among dynamo designers as to the allocation of air space. Before we decide upon the amount of air to allow, we must know how fast the air will be moving. In turbo generators, where an elaborate system of ventilation is provided and the velocity of the blast reaches high values, the total amount of air space is relatively small; whereas, in the old-fashioned slow-speed, self-cooled machines the amount of air space was relatively large. Two important considerations must be kept in view:—

(*a*) Enough air must be provided to carry away the heat.

(*b*) Enough surface must be provided to communicate the heat from the solid parts to the air.

Calculating the Amount of Air Required to Carry Away Heat.

The amount of air required can be arrived at by making an estimate of the total losses. The amount measured in cubic metres per sec.

$$= \frac{\text{watts lost}}{\text{temp. rise of air} \times 1{,}150}$$

This assumes a barometric pressure of 760 millimetres of mercury and a mean temperature of 35° C. To get the volume at any other pressure, p in millimetres and mean temperature, T in °C., multiply by

$$\frac{273 + (T - 35)}{273} \times \frac{760}{p}$$

It is usual to allow a considerable margin over the figure derived from this formula because a good deal of air escapes without being heated very much. The margin to be allowed will depend upon the system of ventilation adopted. Where, as on a turbo generator, the paths for the air are very definite, and one can rely upon each channel for the air doing its share of the cooling, only a small margin need be allowed; but, in general, one allows about 50 per cent. more than the amount theoretically required.

Designing the Air Ducts.

After deciding upon the amount of air required, the next step is to allow a sufficient area of cross-section of air ducts for the air to pass through. The smaller the cross-section of the channel the greater the speed of the air, and therefore the greater the number of watts which can be passed to the air with a given temperature difference. But if the channels are not given sufficient cross-section, the pressure required to drive the air through them will be too great. The pressure required goes up as the square of the velocity; whereas the specific cooling only increases as the first power of the velocity. In many machines one is contented with a mean velocity of about 3,000 ft. per minute, or, say, 10 metres per second. Higher velocities than these would, in general, require some special form of blower. On small diameter machines the velocity is still smaller. This gives one an approximate idea of the amount of room required for the air passages.

The provision of sufficient cooling surface* to pass the heat from the solid parts to the air is a matter which does not fall within the province of this article.

APPORTIONING THE SPACE BETWEEN IRON, COPPER AND INSULATION.

The method to be adopted in apportioning the space between iron, copper and insulation depends on whether we are dealing with an armature or a field magnet.

D.C. Armatures.

In the case of armatures such as are used for direct current machines or synchronous converters, the output depends upon the amount of space available in the armature; for the field magnet, being external, can be made as large as we like. In the case of revolving field magnets for A.C. generators, the output is often fixed by the amount of space available in the field magnet. This latter case we will consider after we have dealt with the D.C. armature.

Consider a D.C. armature of large diameter so that the taper of the tooth is not sufficient to greatly affect the result. In Fig. 1 the slots and teeth are drawn as if the armature had an infinite radius. The effect of a taper is shown by the dotted line.

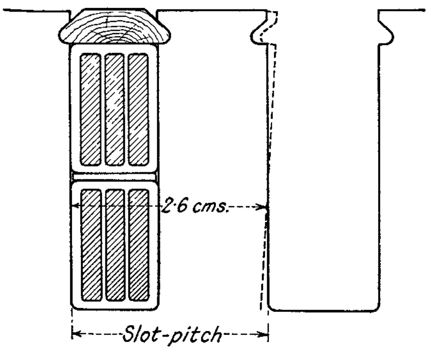


Fig. 1.—SHOWING THE SPACE OCCUPIED BY COPPER, INSULATION AND IRON IN A D.C. ARMATURE WHEN THE SLOT IS 1.15 CMS. WIDE AND THE TOOTH IS 1.45 CMS. WIDE.
The effect of taper of the tooth is shown by the dotted line.

The dimensions upon which the output mainly depends are: (1) the cross-section of the iron of the teeth; (2) the cross-section of the copper; (3) the thinness of the insulation.

Fixing the Depth of Slots.

The greater the depth of the slots the more room there is for copper; but to get good commutation the slots must not be made too deep. In actual practice it is not found advisable to make the slot depth greater than 10 per cent. of the pole pitch. To fix upon the optimum depth of slot for any particular machine is a rather complicated matter as it involves the consideration of the eddy currents in the conductors as well as the effect of depth upon commutation. For the purpose of this article we will assume that the depth of the slot is fixed at, say, 10 per cent. of the pole pitch.

Thickness of Insulation.

The thickness of the insulation will depend upon the voltage of the machine. The amount of room taken up will depend upon the number of slots per pole and the number of conductors per slot. In D.C. armatures the thickness of the insulation depends mainly on getting sufficient mechanical strength.

Number of Slots per Pole.

In order to improve the commutating conditions the number of slots per pole must not be made too small. The fewer the number of slots the cheaper the machine; but designers will not risk putting very few slots per pole except on very small machines. For machines of 100 kW. and more, 10 slots per pole should be regarded as a minimum, and numbers up to 24 slots per pole are usual on machines of large output. For the best commutating conditions it is inadvisable to have more than six conductors per slot, though eight or even 10 conductors per slot are sometimes found operating well on fairly big machines. One can work the copper at a higher current density when fewer conductors are used per slot, and this in a measure compensates for the extra insulation space required when more slots are

* See "Specification and Design of Dynamo Electrical Machinery" (Longmans).

used. When we are given a certain depth of slot and a certain pitch of slot (Fig. 1), and also a certain total thickness of insulation per slot, the question arises how shall we apportion the space between the iron and copper.

The more room we allow for the iron, the greater the total flux per pole, and therefore the greater the voltage generated for a given number of conductors.

The more room we allow for copper the greater the current the conductors can carry.

Since the output of the machine is the product of voltage and current, it is seen that both the iron and copper make important claims for space, and since the space is limited what we give to the one must be taken from the other.

In order to see clearly how the output of the machine varies as we alter the proportions between iron and copper, we may make a diagram like that shown in Fig. 2.

The abscissæ in this figure represent distances along the periphery of the machine or along the slot-pitch. To simplify matters and fix our ideas, we have drawn Fig. 1 as if the armature had such a large radius that the taper of the teeth can be neglected. In practice, when the taper of the teeth is not excessive, we may take the dimensions of the tooth at one-third of a tooth length from the bottom of the slot and then regard the tooth as parallel for all practical purposes. The slot-pitch has been taken as 2.6 centimetres. This would give $15\frac{1}{2}$ slots per pole with a pole-pitch of 40 centimetres. The circumference of the armature in a 10-pole machine being about 400 centimetres. The depth of the slot is 4 centimetres and the depth of the copper 3 centimetres. With six conductors per slot the total thickness of insulation (on a 600-volt armature) with suitable clearance would be about 0.4 centimetre.

We set off the slot-pitch 2.6 centimetres along the horizontal line at the base of the figure and mark off 0.4 centimetre for insulation and clearance. The remaining 2.2 centimetres are available for iron and copper, and the problem is to find how the output of the machine varies as we vary the proportions.

How the Flux per Pole Depends on the Size of the Teeth.

The total flux per pole will be almost proportional to the width of the teeth. To fix our ideas we will take the flux density in the teeth at 21,000. Assuming one ventilating duct 0.8 centimetre wide for each 5 centimetres of iron, when the tooth is 1.1 centimetres wide and the slot 1.1 centimetres wide the ratio of (iron + air space) to iron space is 2.8, and at an actual flux-density of 21,000 the apparent density is 23,000. Dividing 23,000 by 2.8 we get 8,200 as the density in the air-gap when the 2.2 centimetres of space is divided equally between iron and slot. Above the point 1.5 centimetres, plot the point B = 8,200. There will be about 5,000 A.T. on the pole, so that even if there were no iron at all the flux density would not be zero. The normal air-gap of 0.5 centimetre would be increased to 4.5 centimetres, so that the flux density for no iron would be :—

$$\frac{5,000}{4.5 \times .8} = 1,400$$

Plot the point B = 1,400 above the abscissa 0.4. This is the case where the slot space completely eliminates the iron of the teeth.

Next take the case where there is no room for copper at all. The ratio of (iron + air) to iron is now 2.6×5.8 to 2.2×5 or 1.37, so that a density of 21,000 in the teeth will give 15,400 in the gap. Plot this point above 2.6.

The line marked flux density in Fig. 2 gives the density in the gap for any width of tooth. The voltage generated is proportional to the density in the gap. For the purpose of this example it is convenient to fix our ideas and work out the relation between flux density and voltage, though it will be seen later that this part of the calculation can be omitted in actual practice.

Let the speed be 600 r.p.m., the axial length of the armature 30 centimetres and the ratio of pole-arc to pole-pitch 0.7. Then, as there are 93 conductors per pole,

$$\text{volts} = 0.7 \times \frac{600}{60} \times 93 \times 30 \times 400 \times B \times 10^{-8}.$$

When B = 8,200, the volts = 640.

We can plot the line marked volts in Fig. 2.

We have taken the simple case where the tooth density is constant Theoretically the density can be increased slightly as the teeth are made narrower.

How the Current Depends on the Copper Space.

Next we must see how the allowance of room for the copper affects the amount of current that the machine will deliver without overheating. Let us allow 15° C. difference of temperature between copper and iron and assume that the thickness of insulation is 0 13 centimetre, while the heat conductivity of the insulation is .0012 watt per square centimetre per degree difference of temperature. Then the heat flow (measured in watts) per square centimetre will be :—

$$15 \times .0012 \div 0.13$$
$$= 0.138 \text{ watt.}$$

One metre of coil will have an effective area of 800 square centimetres, so it can get rid of 110 watts. The I^2R loss in a metre length of coil ought not to exceed this. In practice there will be eddy currents in the conductors which will increase the losses, but the allowance of 15° C. rise above iron is so conservative that we may neglect these eddy current losses. They will, of course, take up the temperature to points higher than 15° C. above iron.

In the case where the tooth is 1.1 wide and the copper space 1.1 wide, the resistance of the six conductors (each 0.3675 × 1.5 centimetres) in one metre length of coil is 0.0022 ohm. The current I that can be permitted in this case is obtained from the equation :—

$$I^2 \times .0022 = 110$$
$$I = 224$$

The watts dissipated by one metre length of coil may be taken as approximately constant. It is true that when the copper strap is wider the surface of the coil is a little greater, but that fact is compensated for by the poorer heat conduction of the thinner teeth. So we may work out the currents that can be carried by various thicknesses of conductor on the assumption that the watts dissipated will be 110. Since the resistance of the strip varies inversely as the thickness and the watts vary as I^2R, an increase of the resistance to double will reduce the permissible current by the divisor 1.41 (the square root of 2). Applying this rule at various points along the abscissæ and plotting the permissible currents, we get the curve in Fig. 2 marked " Amperes."

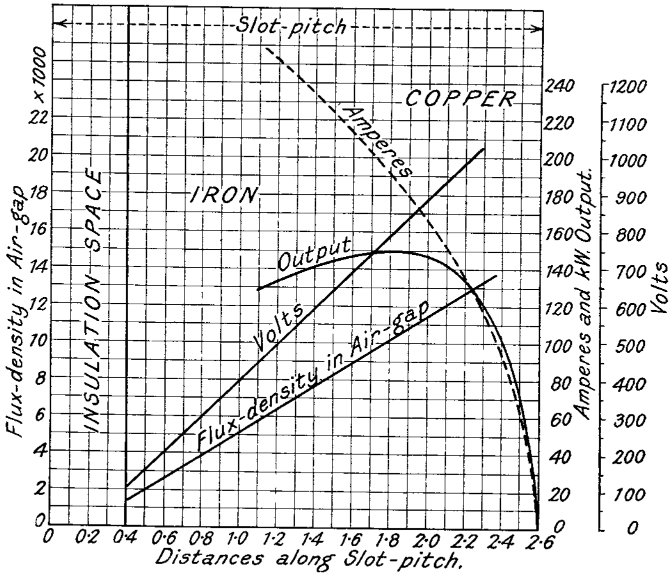


Fig. 2 —Diagram for Finding How the Output of a D.C. Armature Varies as we Change the Relative Spaces for Iron and Copper, keeping the Insulation Space Constant.

How to Develop the Output Curve.

Multiplying the volts by the amperes for various proportions between iron and copper, we get the curve marked " output." The figures in the margin give output per pole. If the machine has 10 poles, we must multiply them by 10. Thus the maximum output is 1,500, at the abscissa reading 1.8. The copper space is here 0.8, making with the insulation a slot space of 1.2 centimetres. This leaves 1.4 centimetres for the width of the tooth.

It is very important to observe, however, that the output curve is fairly flat on the top. All the way between the abscissæ 1.4 and 2.05 the output is higher than 1,400. That is to say, with a tooth only 1 centimetre wide, leaving 1.2 centimetres for copper, we get the same output as if we make the tooth 1.65 wide and leave only 0.5 for copper. And note that over the whole of this range the output, while it is over 1,400 kW, is never more than 1,500.

Copper Space and Iron Space may be Widely Varied.

This illustrates a fact well known to designers of D.C. machines that the ratio of iron space to copper space may be varied over a fairly wide range without affecting much the output of the machine so long as we do not go to extremes. It will be seen that after the copper space has been narrowed to 0.4 centimetre the output drops rapidly, and, of course, if there is no copper there is no output. By reducing the teeth and making them narrower than 1 centimetre the output is also rapidly reduced ; but we cannot plot the curve for very narrow teeth without introducing a number of other considerations. When the teeth are very narrow the heat conductivity along them can no longer be relied upon to carry away the heat received from the copper. Moreover, the ventilation is bad. We have, therefore, not plotted the " amperes " curve beyond the 1.2 abscissa, where the tooth is only 0.8 centimetre wide.

End Connections.

The reader may raise the question: How about the end-connections in a D.C. armature ? Do not these also limit the output ? The answer is that with modern systems of ventilating the end-connections on D.C. generators the copper at these parts keeps cooler than the copper in the slots. There is no iron in their vicinity creating additional loss, and the air blows directly on the insulation of the coils, so that we may have a permissible difference of temperature of perhaps 45° C. between copper and iron instead of only 15° C. as we allowed in the above calculation. We may in most modern D.C. generators rely upon a good deal of the heat generated in the slots being conducted along the copper to the end-connectors. This still further increases the possible output.

Choice of Proportions.

When we realise that the proportions of copper to iron may be varied over fairly wide limits without greatly affecting the output, the question arises : Shall we make rather narrow slots and wide teeth or *vice versa.*

Twenty years ago, when iron was very cheap and copper dear, one could save quite a lot of money by making narrow slots and running the section of the copper down to a point corresponding to the abscissa 2.2 in Fig. 2. This did not make an efficient machine. It had a high iron loss and a fairly high copper loss (considering the current output). The copper was worked at a higher current density than would be permissible in an ordinary machine, so that the I^2R losses were high. Even in these days when iron is not so cheap and copper is cheaper than it was 20 years ago, we may make a fairly cheap machine by keeping down the weight of copper ; but the saving is not worth while when the loss of efficiency is taken into account. Machines with almost equal slot and tooth spaces are made by nearly all makers, though there is a tendency to make the tooth rather greater than the slot.

If we wish to build a machine which will give a very high all round efficiency when running at varying loads (often running light), we should cut down the teeth and put in more copper.

Consider two machines. One has a slot 1 centimetre wide, there being three straps side by side each 0.2 centimetre wide, and the other has a slot 1.4 centimetres wide with four straps side by side each 0.25 wide. The iron loss of the second machine is reduced in a rather greater ratio than 4 to 3 for the same voltage generated, while the copper loss at full load is only increased 6 per cent. Now if the machine is running light a good part of the day with very little copper loss, the second design is greatly to be preferred.

The Installation and Operation of Induction Motors

DURING recent years there has been an increased demand for A.C. motors of the induction type, and in the following article are explained many interesting points which have to be considered when installing and putting these machines into operation, with a view to helping the engineer engaged on work of this nature. Some of the information will perhaps appear rather elementary, but nevertheless all the details should be carefully observed, and are particularly useful to engineers at works which are changing over to A.C. supply.

The Location of an Induction Motor.

The location of the motor is a primary consideration, as it is essential that it be placed where it is readily accessible for inspection, cleaning, oiling or repairs. Unless it is a totally enclosed machine, every precaution has to be taken to prevent it being exposed to moisture, dirt or coal dust. Adequate ventilation must be provided, and the motor should be mounted so that there is sufficient distance between its pulley and the pulley on the machine which it is driving to permit the belt to drive efficiently and without excessive tension.

Foundations to be Used.

The best foundation for the motor is concrete, as this is sufficiently heavy to obviate the risk of vibration when the motor is running. The driving motor should be set in its foundation in such a position to the machine which it is driving to ensure that the two shafts are parallel. This is so that the rotor of the induction motor will float in its bearings.

Precautions to be Taken When Lining Up a Belted Induction Motor With the Driven Pulley.

It is important that the position of the motor with respect to the driven machine should be arranged so that the belt is tight enough to run without slipping, but not too tight so that the bearings become overheated. In order to prevent the belt from wobbling, the crowns of the two pulleys should be as nearly similar as possible, with the largest diameter in the centre, so that the belt will travel true and allow the rotor shaft to float. All dirt and grease must be

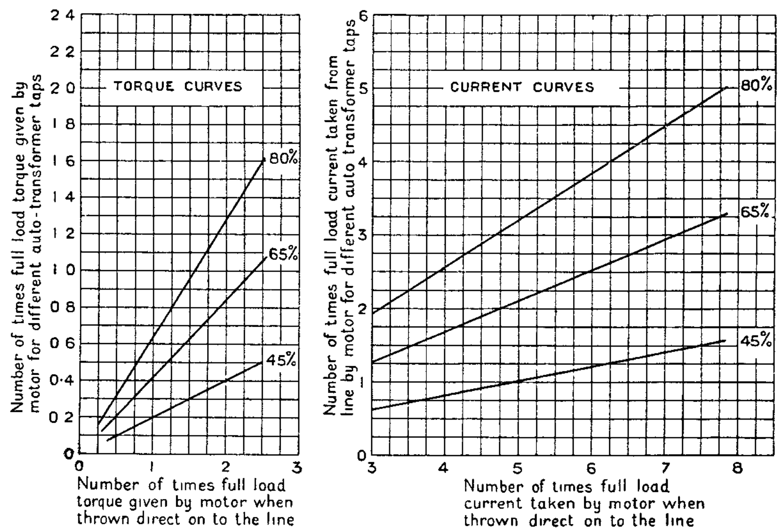


Fig. 1.—Indicating the Relation Between the "Percentage" Taps, Starting Current and Torque.

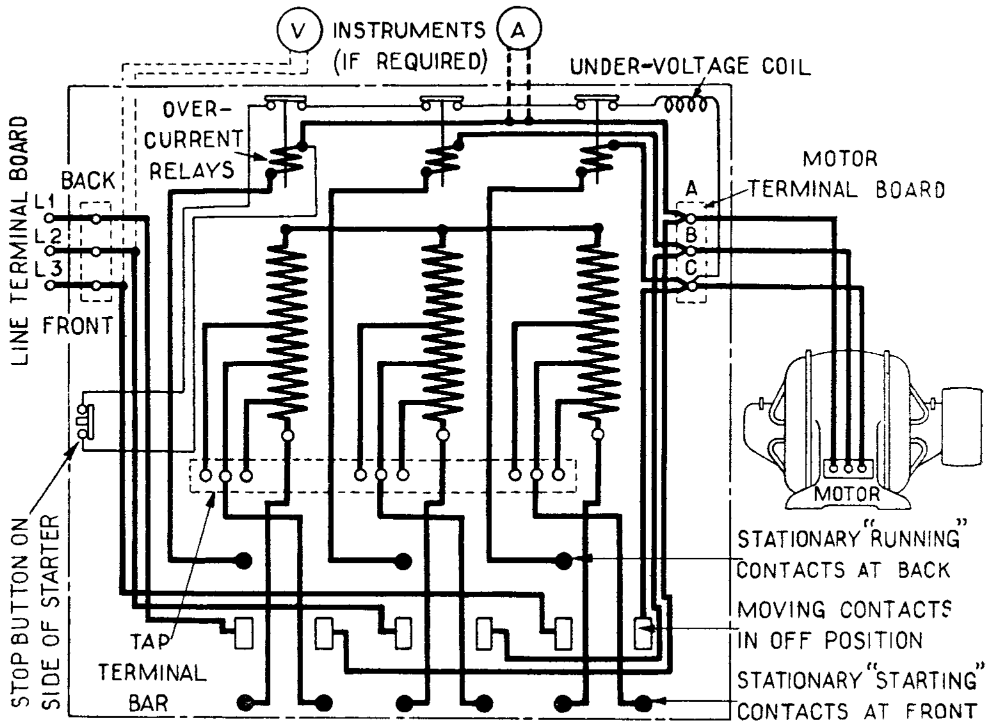


Fig. 2.—A Typical Diagram of Connections for Operating an Induction Motor with Auto-transformer Starter.

wiped off the belt to prevent it slipping, and it should stretch equally so that there is no sidewise movement of the belt on the pulleys.

Precautions When Aligning a Direct and a Geared Motor.

When a motor is to be direct connected to the machine which it is intended to drive, the shafts of the two machines must be in perfect alignment. Every precaution should be taken to ensure that the alignment is maintained, and the foundation of each machine should be such that there is no fear of vibration.

Where a motor is to be geared to its load, the shafts must be adjusted to absolute parallelism, and set the required distance apart. Although the pinion should fit securely on the shaft of the motor it should not be so tight that it can only be forced off when undue pressure is brought to bear. If heavy blows or great pressure are required to drive on the pinion it is likely that the rotor conductors will be moved out of place and damaged.

Size and Capacity of Conductors and Fuses.

Of course, the size of conductor to be used is determined by the amount of current the motor takes, this being stamped on the name-plate in most cases. The conductors and fuses for ordinary service should have a capacity $1\frac{1}{2}$ times the full load, but wherever there are heavy starting conditions the capacity of the fuses should be $2\frac{1}{2}$ times the full-load current.

Operation.

The starting conditions of different induction motors vary widely. Some start with full-load current and full-load torque, while others, operating under similar conditions, require over twice their full load current in starting. Single-phase induction motors start with a lower torque and higher current than 2-phase and 3-phase induction motors.

The starting of a squirrel-cage induction motor by switching directly on the line is liable to disturb the voltage regulation of the A.C. system, since it involves a heavy starting current amounting to from four to seven times full-load current.

It is necessary, therefore, to employ an auto-transformer, so that a reduced voltage is applied to the motor during starting, the current drawn from the line, and the starting torque of the motor, being reduced as the square of the reduction of voltage.

When supplying an auto-transformer, manufacturers usually provide the customer with a wiring diagram and also instructions regarding transformer tapping connections.

Transformer Tappings.

In Fig. 1 are shown curves indicating the relation between the "percentage" taps, starting current and torque. By means of the curves and the following table of starting current taken, and torque given, by induction motors when connected direct to the line, it is possible to find approximately the current taken from the line and the starting torque given by a motor using any of the taps provided on a typical auto-transformer.

In the following are given examples of how to find the current taken, and torque exerted at starting, by a 40 h.p. motor, when using a 45 per cent. transformer tap.

To Find Current.

From the table of mean starting currents and torques a 40 h.p. motor is found to take, when thrown direct on to the line, a maximum starting current of 5½ times that of full load. Look up the point on the horizontal scale having the value of "5.5" and from thence follow a vertical line to a point on the 45 per cent. tap curve, then a horizontal line produced from this point on to the left-hand vertical scale gives the required value in terms of "number of times full-load current" (in this case 1.1 times full load current).

Conversely, it is possible by means of the curves to find which transformer tap should be used, in order that a fixed limit for the starting current shall not be exceeded.

To Find Torque.

From the table previously referred to, a 40 h.p. motor gives, when thrown direct on to the line, a minimum starting torque of 1.25 times that at full load. Look up the point on the horizontal scale having the value "1.25" and from thence follow a vertical line to a point on the 45 per cent. tap curve, then a horizontal line produced from this point on to the left-hand vertical scale gives the required value in terms of "number of times full load torque" (in this case 0.25 times full load torque).

Starting the Motor.

To start the motor the starting handle must be pushed backwards into the "starting" position, thus connecting the transformer windings to the supply, and the motor across a portion of the transformer windings, as determined by the tap selected. The starter handle must be held in this position until the motor is up to speed, or the strong spring will bring the handle back to the "off" position, thus necessitating a fresh start.

H.P. Rating of Motor.	Approx. max. starting current taken by Motor when thrown direct on the line.	Approx. min. starting torque exerted by Motor when thrown direct on to the line.
0.5 to 1	4.5 times full load current ..	1.0 times full load torque.
2 ,, 5	5.5 ,, ,, ,, ,, ..	1.25 ,, ,, ,, ,,
6 ,, 10	5.5 ,, ,, ,, ,, ..	1.25 ,, ,, ,, ,,
11 ,, 20	5.5 ,, ,, ,, ,, ..	1.5 ,, ,, ,, ,,
21 ,, 40	5.5 ,, ,, ,, ,, ..	1.25 ,, ,, ,, ,,
41 ,, 100	6.0 ,, ,, ,, ,, ..	1.0 ,, ,, ,, ,,
100 ,, 150	6.0 ,, ,, ,, ,, ..	0.66 ,, ,, ,, ,,
151 ,, 300	6.5 ,, ,, ,, ,, ..	0.66 ,, ,, ,, ,,

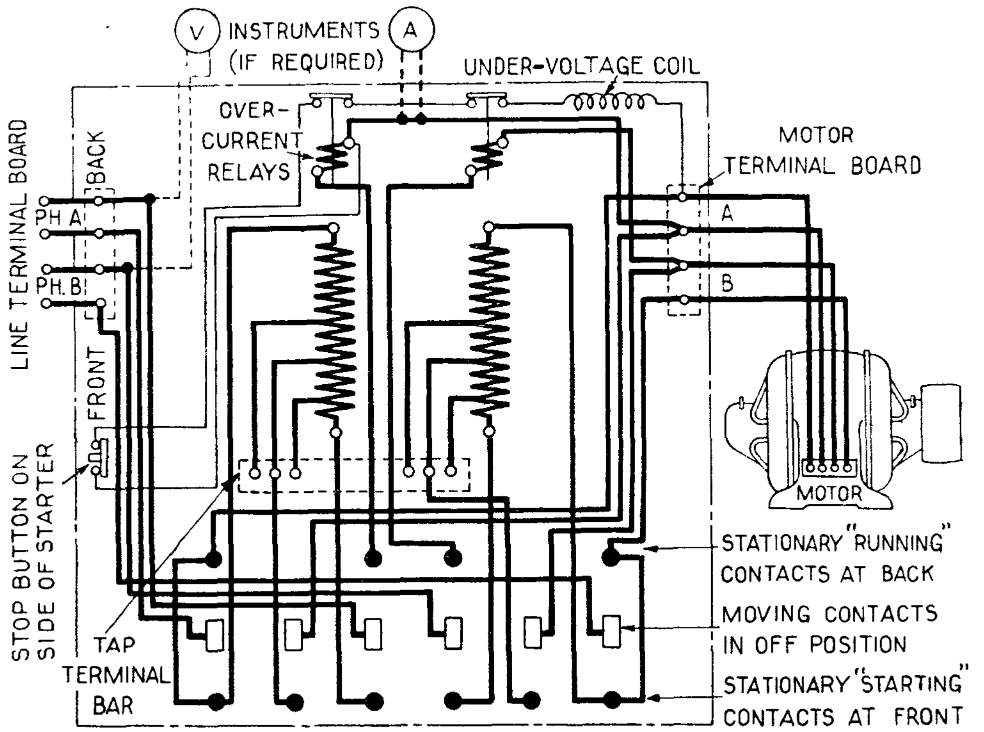


Fig. 3.—TYPICAL DIAGRAM OF CONNECTIONS OF TWO-PHASE, FOUR-WIRE AUTO-TRANSFORMER STARTER.

When the motor is up to speed, the "starting" handle must be pulled rapidly forward through the "off" position to the "running" position; this cuts out the transformer winding and connects the motor direct to the supply through over-current relays (if supplied).

Fig. 2 is a typical diagram of connections for starting an induction motor by means of an auto-transformer starter, while Fig. 3 shows a diagram of connections of a 2-phase, 4-wire auto-transformer starter.

The operator should remember that under no circumstances should the motor be started by "inching," that is by throwing the starting handle a number of times into the "starting" position. This does not reduce the starting current, but on the contrary, it causes a number of successive high-current peaks, leading inevitably to severe burning of the contacts and overheating of the transformer windings.

Protective Devices.

In many cases where auto-transformer starters are used, over-current relays are fitted, and when the current taken by the motor exceeds the value for which the over-current relays have been previously set, the latter operate—after a time delay—and interrupt the circuit of the under-voltage coil, this causing the motor to be shut down.

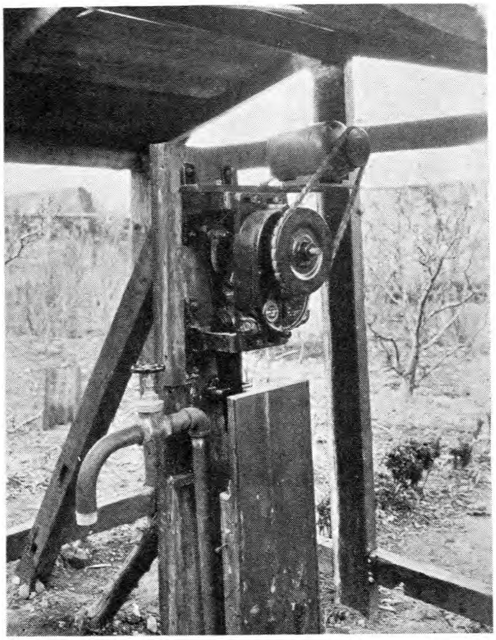
In the event of the voltage failing, or being considerably reduced in value, the under-voltage release causes the starter to return to the "off" position.

Shutting Down the Motor.

All that is necessary to stop the motor is to press the button on the side of the switch box (see Figs. 2 and 3). This interrupts the circuit of the under-voltage release, and shuts down the motor. In this position both motor and transformer windings are entirely disconnected from the line.

An Electrified Pump

The Pump Before Conversion to Electric Operation. (*B.T.H.*)



Showing How the Electric Motor Was Fitted. (*B.T.H.*)

An interesting conversion to electric operation was carried out recently near Wrexham, in connection with a manually operated water pump.

The pump, which was of the old-fashioned type, as will be seen from the first illustration, stands in the garden of what was once a country house, about a mile from Wrexham. The stables of the house have now been converted, and are used by a wholesale and retail butcher for the making of pork pies, sausages, etc. The business required a refrigerator, and, of course, a considerable water supply, and it was decided that instead of purchasing water from the town, the well on the premises should be used efficiently by converting the pump to electric drive, and arranging for a supply of electricity, which comes overhead for about a quarter of a mile from the Wrexham mains.

Water Supply Automatically Controlled.

The water supply for the refrigerator is controlled automatically, according to the temperature of the atmosphere, from a tank and in turn the water supply to the tank from the pump is controlled by a contactor starter and float switch.

The pump, when operated by hand at the normal rate, had a capacity of about six gallons per minute, the surface of the water being about 36 ft. below ground level. It was impossible to mount the pump down in the well, so it was decided to make use of the existing pump barrel, which is fixed at the water level. A pumping equipment, manufactured by Messrs. Abell & Smith, and driven by a B.T.H. 1 h.p. motor, was then installed by Messrs. E. N. Jones, electrical contractors, of Wrexham.

This converted pump, which is shown in Fig. 2, is giving most successful service.

The motor is a B.T.H. 3-phase, 400-volt, 50-cycle machine running at 1,420 r.p.m., and is controlled by a B.T.H. contactor starter operated by a float switch.

DEVELOPMENTS IN LUMINOUS SIGNALLING SYSTEMS

By S. W. Richards, M.E.

In this article Mr. Richards, who is an acknowledged authority on the subject, gives a most interesting survey of present-day practice. This is a most valuable article for electrical installation engineers, workshop engineers and engineers responsible for the maintenance of electrical equipment of hotels, theatres, hospitals and other large buildings

THE advantages of luminous signalling over the ordinary mechanical replacement and pendulum type of indicators are generally known and appreciated.

The possibilities of luminous signalling are infinite and particularly varied, and it is the purpose of this article to describe some of the most recent developments in this direction.

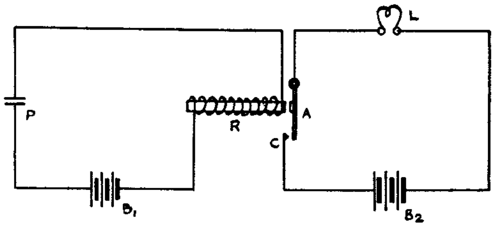


Fig. 1.—The Simplest Application of a Luminous Signalling System.
A circuit is given by pressing the push P, which closes the circuit of the battery B1, around the electro-magnetic relay R, which then attracts armature A, causing contact to be made at C. This closes the lamp circuit from battery B and lamp L is illuminated while push P is held closed.

Basic Operation of a Luminous Signalling System.

First, we must understand the basic operation of such a system and in Fig. 1 is shown the simplest application of same, shown schematically.

A signal is given by pressing the push P which closes the circuit of the Battery B1, around the electro-magnetic relay R. This magnetises the relay which attracts armature A and contact is made at contact C. This closes the lamp circuit from battery B and lamp L is illuminated while push P is held closed. When push is released, the relay is demagnetised and the armature falls back. It is only a logical step to arrange for a small spring catch to hold armature A in position when it is attracted by the relay and thus keep the lamp lit even when the push is released. The lamp can be extinguished and the relay reset by releasing such a catch with a lever or push. This would be called a locking or resetting relay. This gives us the basic idea of a luminous call, but generally an audible call is required in addition. If such audible call is desired to operate continuously, it would be a simple matter to connect a bell or buzzer in parallel with the lamp so that the relay would close both the bell and lamp circuits.

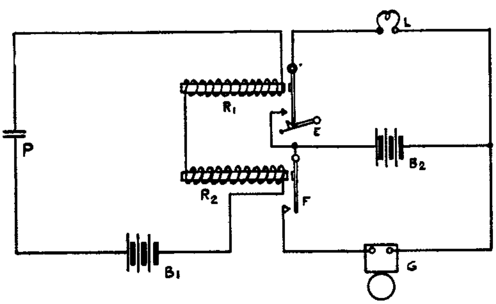


Fig. 2.—A Slightly More Elaborate Circuit.
This enables the bell to be rung only while the push is depressed, but the lamp remains lit until reset.

Lamp Remains Lit Until Reset.

Usually, however, the bell is only required to ring during the time the push is depressed, while the lamp should remain lit until reset.

This is usually performed as shown in Fig. 2. Here we see the same circuit as regards the push operation, but we have two relays in series, R1 being a locking relay and R2 being a non-locking relay. When the push is pressed, both the relays

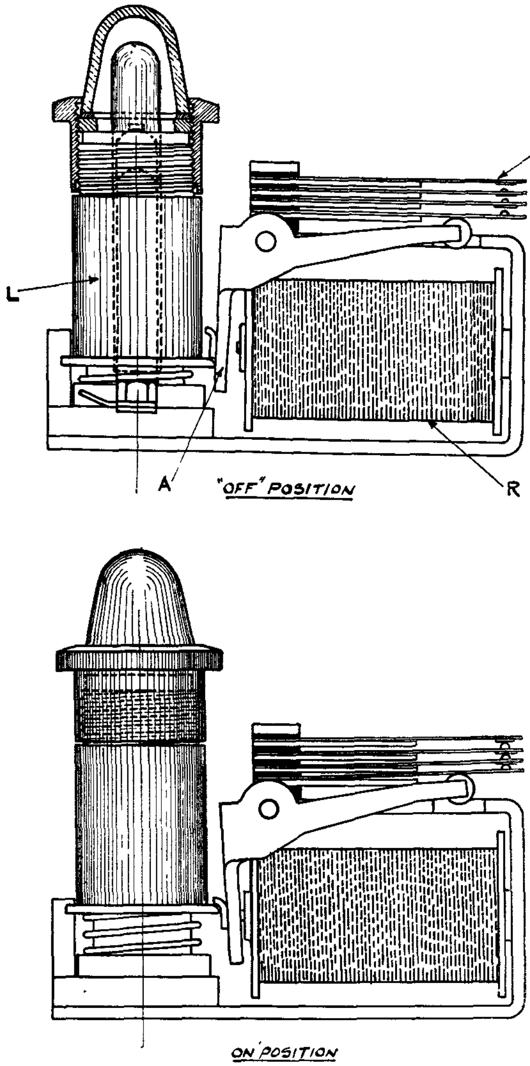


Fig. 3 —THE PUSH LAMP SYSTEM UNIT.
Showing the relay coil R which attracts the armature A. When the armature is attracted it closes the bank of contacts C.

are energised, relay R1 attracting armature which lights the lamp and R2 the armature which closes the contacts of a bell G. The armature of R1 being locked by the trigger E remains in contact after the push is released, but the armature of R2 is released and the bell is silent.

This then, represents the basic principle of luminous signalling.

The Resetting Medium.

Modifications and conditions require the relays, bells and pushes to be in various positions, but the usual practice in luminous signalling systems is for the resetting medium to be near the point of call; for instance, in hotel, hospital or ship installations, it is usual to have same mounted outside or inside the door of room where the push is fitted. The bell or buzzer obviously is fitted in the service room and also the source of the current. It follows also that as there must be a great number of calling points operating on the same bell, that the relay controlling the bell should also be in the servery. The signal light should be placed at a convenient spot near the point of call, usually in the form of an overdoor lamp, and sometimes this is duplicated in the service room.

Earlier types of apparatus consisted of the overdoor lamp and a push button resetting relay fitted alongside the door, but the most recent development is to mount an indicating lamp inside the resetting button.

The Push Lamp System.

This is done in the push lamp system and a drawing of the unit is shown in Fig. 3.

Here will be seen the relay coil R which attracts armature A. This armature when attracted closes the bank of contacts C. Immediately the armature is attracted to the relay coil, it releases the spring loaded lamp tube L which locks the armature in position. Inside the lamp tube is fitted a small telephone lamp of the tubular type. One terminal of this lamp is continuously connected to one pole of the supply system; the other terminal of the lamp is connected to the second spring of the contact bank. The lowest spring is connected to the remaining pole of the supply so that when the relay is energised, the lamp is lit.

Pressure upon the lamp cap releases the armature and so extinguishes the light. The remaining springs are connected to the group or section lights and function in the same manner.

Some Applications of the Push Lamp System.

Having described the general principle and the unit which is the base of this system, we will consider some applications of same.

Four Calling Points.

Fig. 4 shows one system where four calling points desire to call to a centre point, the calls being audible as well as visual.

Here we see the supply wires connected to the central station indicator, the positive wire being connected to the bottom springs of each push lamp and also commoned to each of the calling pushes. The other side of the calling pushes are each connected to the relay coils of their respective push lamp. The other terminals of the coils are connected in common and then connected to one terminal of the bell relay, the remaining terminal of this relay being connected to the negative terminal of the supply.

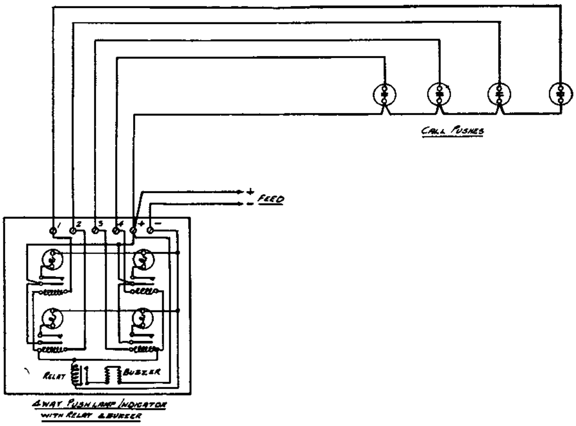


Fig. 4.—Diagram of a System where Four Calling Points Desire to Call from a Centre Point, the Calls being Audible as well as Visual.

It will easily be traced how this system functions, the respective push lamp being locked up by a call and the buzzer simply sounding during the time the push is depressed.

Ten-way Indicator.

Fig. 5 shows an elaboration of the above system. Here we have a ten-way indicator at a central station, on which five ways are shown schematically. Ten special call pushes are supplied, each fitted with one push and a pilot lamp. In this system we see that the relays are energised in the same manner as formerly, saving that no audible call is given in this instance. When the relay is set up, however, it lights both its own lamp and the pilot lamp on its corresponding push, which is shown connected to one of the springs of the relay. This system fulfils a dual purpose—it gives an indication of a call at central station; it also gives to the caller an indication that his call has been registered and also when the person at the central station cancels the call by pressing the push lamp, indicates to the caller that his call is being attended to.

Four-way Indicator in an Outside Office.

In the foregoing systems, calls are made to a central station and the next system, Fig. 6, shows a system where a central station such as a manager's room calls out to a four-way indicator in an outside office; a logical elaboration of this system would be to have four single-way indicators fitted with lamp and buzzer at four different positions.

Referring to the diagram, we see a four-way call unit fitted with four pushes, P.U.C.V. and also four push lamp units.

Outside we have a four-way wall indicator, fitted with four pilot lamps and buzzer.

What Happens When the Push is Pressed.

Upon the manager calling any person, he presses the corresponding push which puts up his own corresponding push lamp. This lights up the pilot lamp on the indicator relating to the person called and the buzzer is sounded during the time the push is depressed. In this instance, the bell relay is unnecessary as the distance is usually short, the buzzer coils functioning

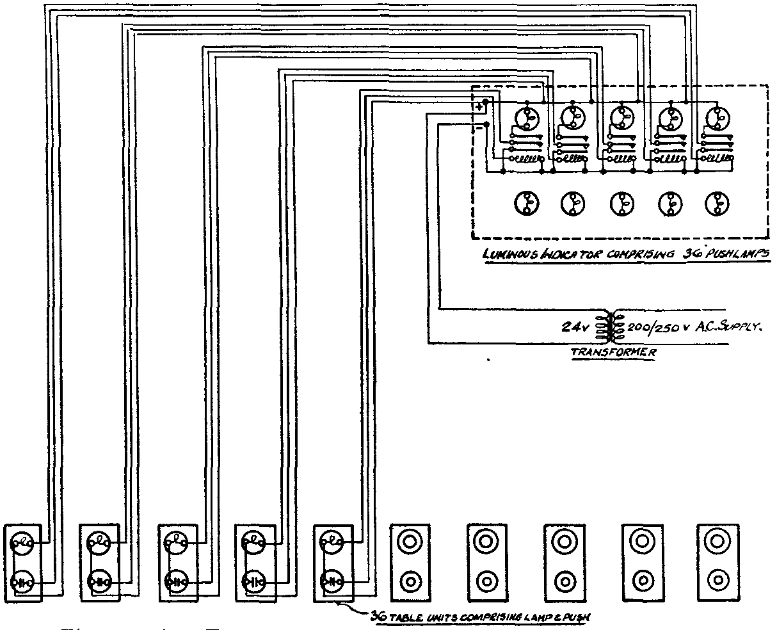


Fig. 5.—AN ELABORATION OF THE SYSTEM SHOWN IN FIG. 4. This is a 10-way indicator at a central station on which five ways are shown schematically. Ten special call pushes are supplied, each fitted with one push and a pilot lamp.

in the same manner as the bell relay in previous systems.

One advantage of this system is that if the person called is absent from his room, the manager can cancel the call.

A Modification of this System.

A modification of the above system is shown in Fig. 7, where the manager again calls out to members of the staff.

In this case, the push lamp resetting units are placed with the staff, usually in the form of desk units. The manager is supplied with a desk unit consisting of a multi-push board with a corresponding number of pilot lamps. When he calls out to a member of the staff he sounds the buzzer at the member's desk unit and puts up the push lamp unit there. This lights his own pilot lamp which shows him that the call has been given. Upon receiving the call, the person called presses the lamp cap and extinguishes both his own and the manager's pilot lamp, indicating to the manager that his call has been received.

One slight drawback to this system is that if the person is not in his room, the light remains up until cancelled by someone going to his room.

This, however, may be advantageous in another way, as it would show the person when returning to his room that a call had been made.

To get over the above difficulties, a system has been devised and patented where the call can be cancelled from either end. This dual-control system has the advantage that it notifies the caller when the call is answered, and allows the caller to cancel his call. This is described

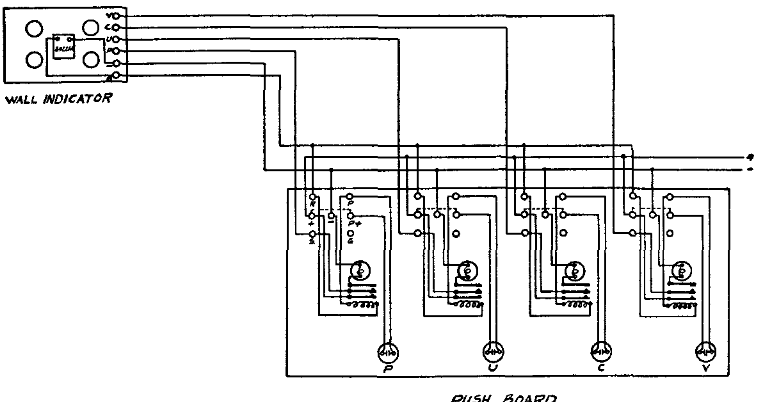


Fig. 6.—ANOTHER TYPE OF SYSTEM IN WHICH CALLS ARE MADE A TO CENTRAL STATION.

later. This improved system can of course be used in a variety of ways and to conform with varying conditions.

Application of Push Lamp Units for a Hospital Call.

Fig. 8 shows an application of push lamp units for a hospital call and the diagram shows a room in two sections with their attendant overdoor fitting and also the connections to the common servery or rooms.

It will be seen on this schematic drawing that a three-way system is used, but only two, viz.: the Maid and Nurse calls, are taken along to the serving rooms. The remaining call is an Engaged call and only operates on the local lamp in the resetting unit and the red lamp in the overdoor unit.

The calling unit consists of a two-way push with an additional switch attachment.

What Happens When a Call is Made.

Following the diagram, we see that if a call is made for Maid or Nurse the reset unit is energised and also the bell relay in the serving room, calling either the Maid or Nurse. Simultaneously, both the push lamp and the coloured lamp in the serving room are put up, together with the coloured lamp in the overdoor unit.

In this case, red was used for the " Engaged " signal, green for the " Maid " and amber for the " Nurse." When the attendant answered the call, she would press the corresponding push lamp cap and cancel the call, extinguishing all the lamps.

With regard to this, if another call is already up in the same section, she would only cancel the push lamp and overdoor lamp ; the section lamp would remain up until all the calls were cancelled in the section.

The overdoor " Engaged " lamp is put up by operating the switch provided on the push unit. The push lamp unit is fixed inside the room to indicate to the patient that he had given a call.

A Master Indicator.

It might be desired that the matron or someone in authority should have evidence of a call having been made and to check the time such call would remain unanswered.

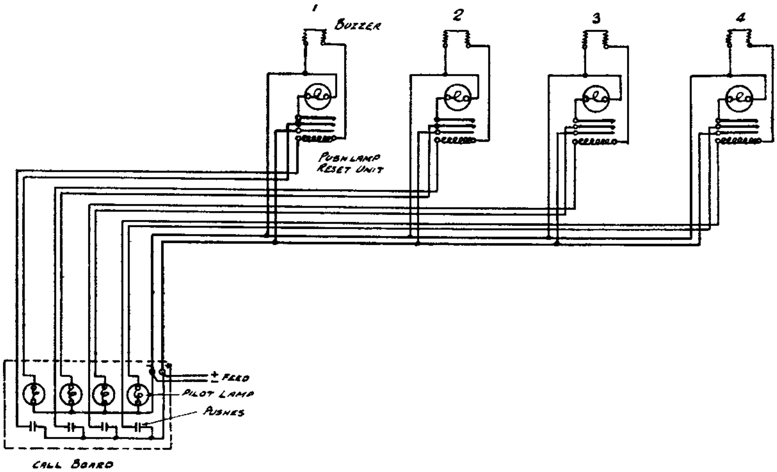


Fig. 7.—A MODIFICATION OF THE SYSTEM SHOWN IN FIG. 6.
The push lamp resetting units are placed with the staff, usually in the form of desk units.

This is arranged by means of the addition to the system as shown in Fig. 9.

Here we see the system as Fig. 8, but with each push lamp unit connected to a master indicator. This indicator is fitted with pilot lights which are controlled in a similar manner to the section or servery lights, i.e., they would remain alight until all units in the section had been reset.

" Engaged " and " Enter " System.

Another feature of luminous signalling which has been recently developed is the " Engaged " and "Enter" system.

In this system—illustration of which is

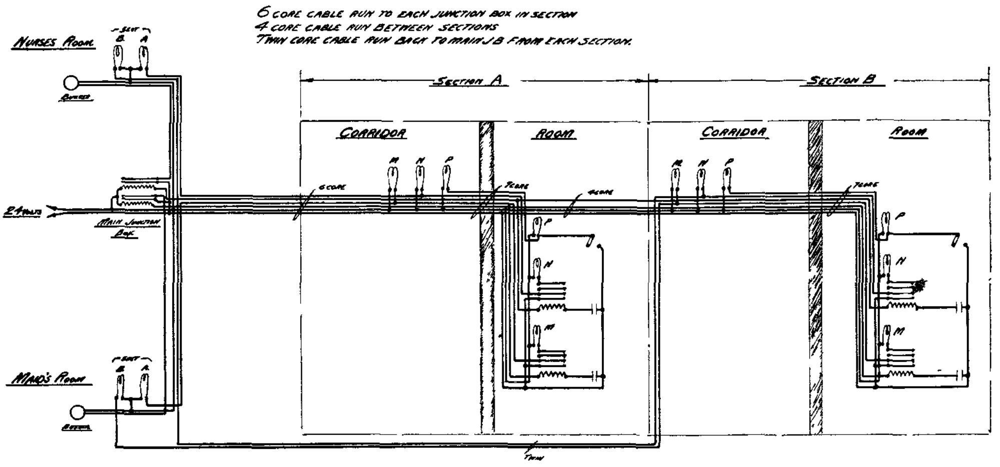


Fig. 8.—AN APPLICATION OF PUSH LAMP UNITS FOR A HOSPITAL CALL.
Showing a room in two sections with their attendant overdoor fitting and also the connections to the common servery or rooms.

given in Fig. 10, a luminous indicator consisting of a small box with the words "Engaged" and "Enter" written in ground glass screens is fitted outside the room door, either flush or surface fitting. This is connected to a call unit placed upon the desk of the person within the room.

In the schematic diagram, the lever is shown beneath the essential contact springs and magnet.

When the lever is depressed, it closes two contacts and these energise the electro-magnet through the pilot light on the indicator and the "Engaged" light outside the door. By the depression of the lever, the armature on the end of the lever is brought up to the pole piece of the electro-magnet which, being magnetised, holds it in the "On" position.

The magnet coils, however, are supported on a flexible support, so that by a further pressure on the lever, the magnet coils allow a further travel of the lever. This enables the lever to break the contact A, extinguishing the "Engaged" lamp and

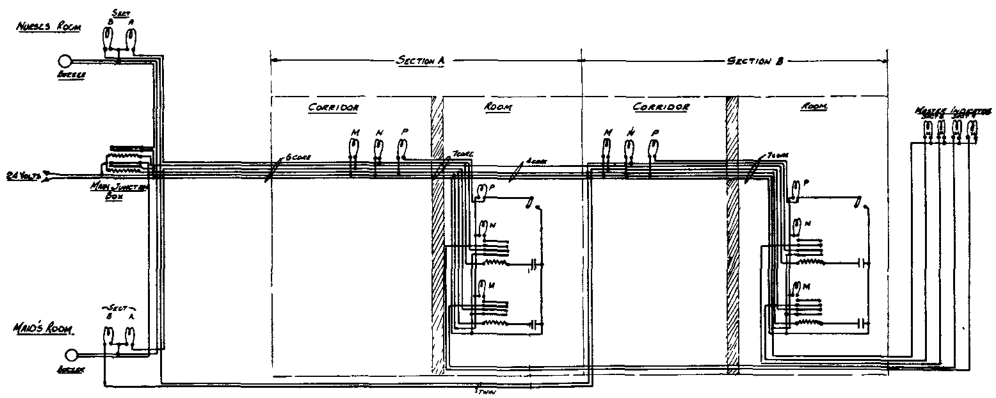


Fig. 9—HOW A MASTER INDICATOR CAN BE ADDED TO THE CIRCUIT SHOWN IN FIG. 8
Each push lamp unit is connected to a master indicator.

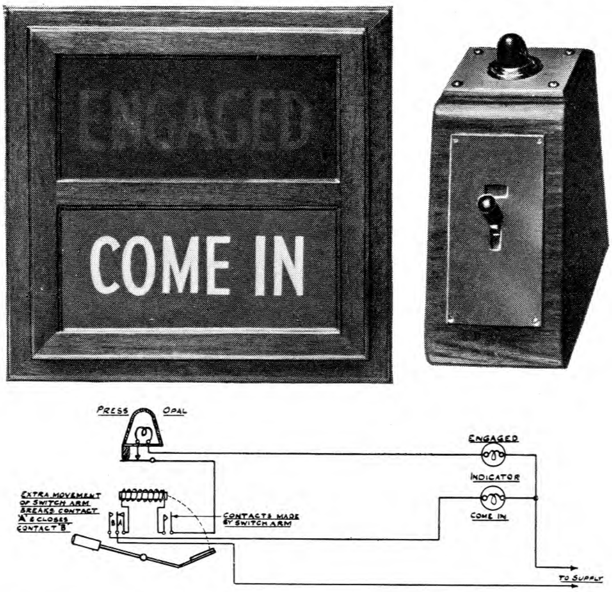


Fig. 10.—THE "ENGAGED" AND "ENTER" SYSTEM. Showing the luminous indicator box, the call unit and the circuit used.

puts up the "Come in" signal. Upon releasing the lever, it automatically falls back into the "Engaged" position.

If this is required to be cancelled, mere pressure on the lamp cap accomplishes this by breaking the holding current of the magnet. This system has been patented and is now on the market.

DUAL-CONTROL SYSTEM.

Fig. 11, shows another application of luminous signalling, previously referred to where a call set up can be cancelled at either end. The calling unit is generally the same as in Fig. 10, save that one contact is done away with and also the pilot lamp. The position of the lever gives evidence of a call having been put up.

As will be seen, pressure upon the lamp cap of the called unit will cancel the call by demagnetising the calling unit.

SOURCE OF SUPPLY FOR OPERATING LUMINOUS SYSTEMS.

Luminous systems can be operated from various sources of power, primary and secondary batteries and also transformers.

The decisive factor to determine the type of supply, naturally, is the probable amount of current which will be needed, and in this direction perhaps a few practical observations would be in place.

Leclanche Cells and Secondary Accumulators.

The usual pressure of the supply is 24 volts and this can be supplied by batteries of sac type Leclanche cells for small systems, or secondary accumulators for larger systems; while for a very large system, even a motor generator or rotary converter is necessary.

Transformers for A.C. Supply.

Transformers of various ratings will also supply the current where A.C. is not disadvantageous. In connection with the latter type of current, it is sometimes practically impossible to eliminate hum or chatter on the relays. In order to overcome this disadvantage, rectifiers are

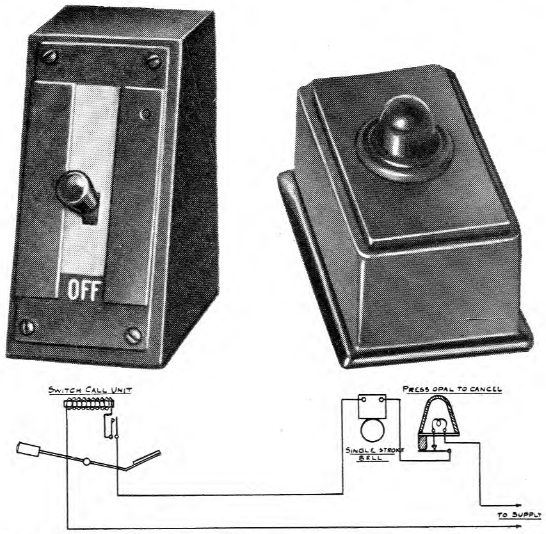


Fig. 11.—ANOTHER APPLICATION OF LUMINOUS SIGNALLING WHERE A CALL SET UP CAN BE CANCELLED AT EITHER END.

often used, but the inherent disadvantage of a rectifier is its fluctuating voltage under a variable load.

This is not particularly disturbing where relays and bells only are used in a system, but where luminous signals are used, a fluctuating voltage obviously means either a lack of luminosity at one end of the fluctuation, or burnt out lamps at the other end. This can be overcome by using a very much larger unit than what normally would be necessary—the fluctuation factor would thus be very much less, with the normal load.

To explain this, a rectifier unit which would give 24 volts with a load of 3 amps., might easily give 32 volts on open circuit or 29 to 30 volts on .25 amp. Whereas, if we were to have a rectifier to give us 24 volts at .25 amp., there would be a considerable drop to approximately 16—17 volts at 3 amps. and a maintained load at this current would seriously overload the unit. If, however, we obtain a unit capable of giving 5 to 6 amperes at 24 volts, the ratio of voltage increase when using .25 amp. is not so considerable, but, naturally, such a unit would be considerably more expensive than the former.

How to Estimate and Determine Source of Supply.

To estimate and decide upon our source of supply, we must ascertain the probable consumption, and for this, we require to know the approximate current of lamps, relays and bells in the circuit.

Adopting the voltage of 24 volts as standard, we can assume the following currents as being fairly approximate.

The small telephone tubular lamps in the units consume .1 amp. while the festoon bulbs often used in indicators and overdoor lamps take .25 amp. The relays usually require 15 to 20 milliamperes and small indicator and extension bells take approximately .15 to .2 amp.

Assessing Total Current Required.

To assess the current required, it is unnecessary to sum up the total possible current required and act upon this ; it is usually sufficient to assume that in normal installations, one-sixth to one-eigth of the total current may be required at any instant.

A.C. or D.C. Compared.

In comparing A.C. and D.C., the lamps act in a similar manner with the two types as respecting current consumption, but in the case of relays and bells, the resistance of the windings enters very seriously into the calculations. It can always be assumed that relays and bells require a very much greater resistance when operating with D.C. of the same voltage as A.C.

As a concrete example, if we take the push lamp unit referred to earlier in this article—if this unit is used on 24 volts D.C., the resistance is 150 ohms, while if used on 24 volts A.C., the resistance has to be reduced to 12 ohms.

This is, of course, due to the very much increased impedance of an inductive winding, where used on A.C. working.

A NEW THREE-IN-ONE VALVE

One of the most interesting of the new types of valve produced recently is the Mullard double-diode-triode, Type T.D.D.4.

In the double-diode-triode, the two duties of the valve—detection and amplification—are carried out by separate sets of electrodes. The T.D.D.4 consists of two small diodes (or two-electrode valves) and one triode (or three-electrode valve) contained in one bulb, the only element common to all three sections being the cathode.

One method of using the T.D.D.4 is to employ both diode portions for full-wave rectification, the output of this section of the valve being then passed to the grid of the triode portion for low frequency amplification prior to the output stage.

This valve also enables a more perfect form of volume control to be applied, namely that which is known as amplified and delayed control.

PRACTICAL NOTES ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF BUILDINGS (I.E.E. WIRING RULES)

By D. WINTON THORPE, A.M.I.E.E.

THE regulations dealt with in this article concern some important subjects, namely, incandescent lamps, the control of motors, etc., and the testing of complete installations.

Incandescent Lamps.

Regulation 113:—

A. Incandescent lamps shall be provided with caps of a pattern as follows:—

Up to and including 100 *watts: Standard Bayonet (B.C.).*

Above 100 *watts and not exceeding* 200 *watts: Edison Screw (E.S.).*

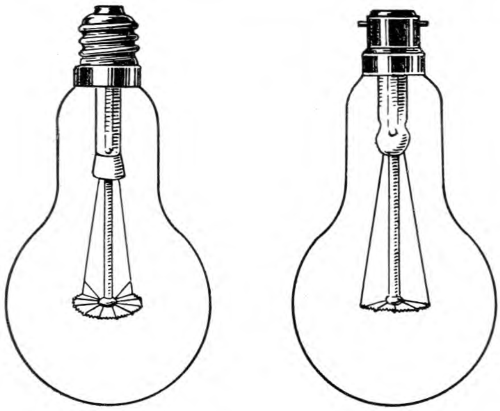
Above 200 *watts: Goliath (G.E.S.).*

Sub-sections (B) and (C) do not really concern us, but Sub-section (D) states: "Fittings for lamps shall be so designed as to provide for adequate dissipation of heat from such lamps." Both Sub-sections (A) and (D) require some comment. We have it quite definitely here, in black and white, that above 100 watts and not exceeding 200 watts Edison screw-holders and caps shall be used. In point of fact, most manufacturers manufacture lamps with B.C. caps up to 150 watts, and, personally, I have not found them give any trouble. It is probable that when a revision of these Regulations is published, definite permission for B.C. caps for 150-watt lamps will be given. At present, however, such a practice is, strictly speaking, against the Regulations. It may, however, be worth noting that the reason for this Regulation is that the bayonet cap and holder, while providing an adequate contact for small current, is, after all, dependent entirely on the spring plunger pressing against the fairly uneven surface of soldered terminals on the lamp cap, and this is not a first-class contact where heavy current has to be carried.

TEST TO EARTH ON A HOUSE INSTALLATION.
The Regulations which cover this important branch of electrical installation engineers' work are dealt with in this article.

(Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication "How to Avoid Electrical Breakdowns.")

With regard to Sub-section (D) the electrician may occasionally find himself placing in an existing fitting a lamp of a higher wattage than that for which the



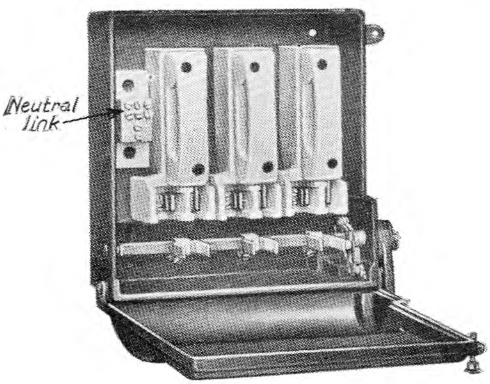
SCREW AND BAYONET CAP LAMPS.

fitting was originally designed. Very often this cannot be helped, and although it is not a very efficient practice it sometimes solves one's immediate difficulties. Nevertheless, it must be remembered that a larger lamp gives off more heat, so that a fitting designed to provide for "adequate dissipation," say, from a 60-watt lamp, will not necessarily dissipate the heat in an adequate manner from a 100-watt lamp. In the case of metal reflector fittings this difficulty may sometimes be overcome by drilling extra holes in the tops of the fittings.

Concerning Arc Lamps.

Regulation 115 deals with arc lamps and states :—

A. Arc lamps shall have the whole of their live parts insulated from the frame or case.



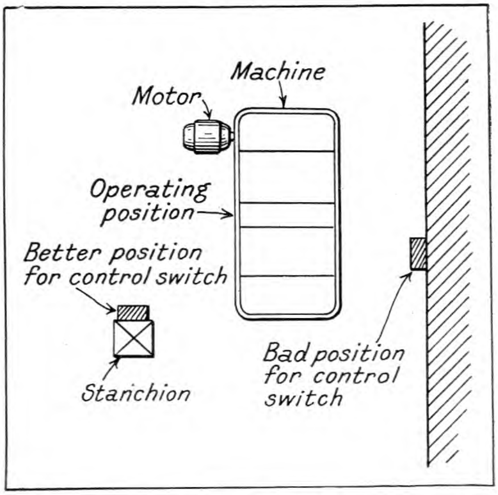
EXAMPLE OF THREE-PHASE IRONCLAD SWITCH WITH NEUTRAL LINK. (*G.E.C.*)

B. Needs no comment.

C. In situations in which an open arc is essential, as in photographic work, the floor immediately underneath the lamp shall, if necessary, be protected from falling particles of carbon by a non-ignitable covering.

F. Every arc lamp circuit shall be controlled by a fuse and switch on each insulated pole. When more than one pole is insulated the switches shall be linked.

To all intents and purposes the use of arc lamps to-day is confined, so far as the

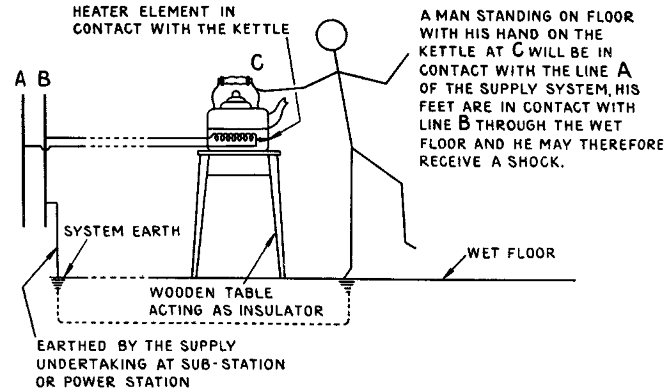


PLAN VIEW OF A MACHINE, MOTOR AND CONTROL GEAR.

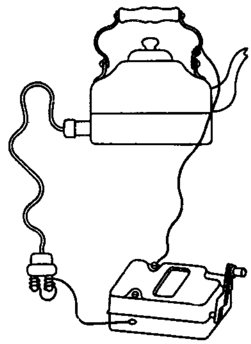
Showing operator's normal position and example of bad and good position for control switch.

average electrician is concerned, to photographic work and projection work such as in cinemas. With regard to the latter, an entirely over-riding set of precautionary Regulations are enforceable, due to the licences under which such operations are carried out, and the subject is rather too large to enter upon here. I may, however, remind readers that when dealing with cinematograph projection apparatus, it is as well to be quite sure as to what bye-laws and County Council Regulations must be adhered to.

With regard to photography, this Regulation 115 is fairly liberally disregarded. This is not always the electrician's fault,



SHOWING HOW A SHOCK MAY, UNDER CERTAIN CONDITIONS, BE OBTAINED FROM THE CASING OF A PIECE OF APPARATUS. (*This and the diagram on the right are taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication "How to Avoid Electrical Breakdowns."*)



TEST ON KETTLE BETWEEN CIRCUIT AND FRAME OR EARTH.

since it may be argued that he can scarcely be responsible for the material of which the floor is made or with which it is covered. It is, I think, his job, however, when called in to install or carry out work upon an arc light, to point out to his customer or client that this Regulation is being disregarded if he finds that the conditions do not conform with this particular sub-section.

Earthing Terminal on Motor Frame.

Regulation 117 deals with Motors, and Sub-section (B) states that: "The frame of every motor shall be provided with a suitable terminal to which the earthing lead may be connected." There is only one comment necessary here, and that is obvious but very important, *the frame of motors must be earthed.*

Position of Motors.

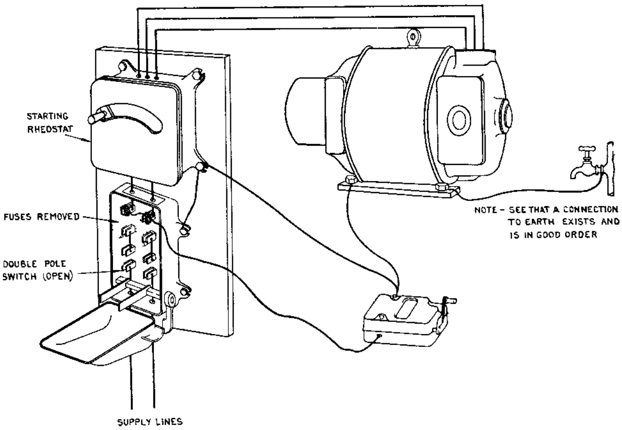
Regulation 118 deals with the Position of Motors and should be read by electricians carrying out motor work, if only as a guide to good practice. All the sub-sections, however, are so much qualified and so vague and indefinite that they cannot be considered to be much more than indicating good practice and the principles involved.

Control of Motors.

Regulation 119 deals with the Control of Motors.

A. Every motor shall be protected by efficient means suitably placed and so connected that the motor and all apparatus in connection therewith may be isolated from the supply; provided, however, that when one point of the system of generation or supply is connected to earth, it shall not be necessary to disconnect on that side of the system which is connected to earth.

B. Every motor shall be provided with an efficient switch or switches for starting and



FIRST TEST TO FRAME OR EARTH ON MOTOR AND SWITCHGEAR (*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication "How to Avoid Electrical Breakdowns."*)

stopping, so placed as to be easily operated by the person controlling the motor; and every motor having a rating exceeding one-half horse-power shall in addition be provided with :—

(a) *Means for automatically opening the circuit if the supply pressure falls sufficiently to cause the motor to stop ;*

(b) *In the case of direct-current motors*

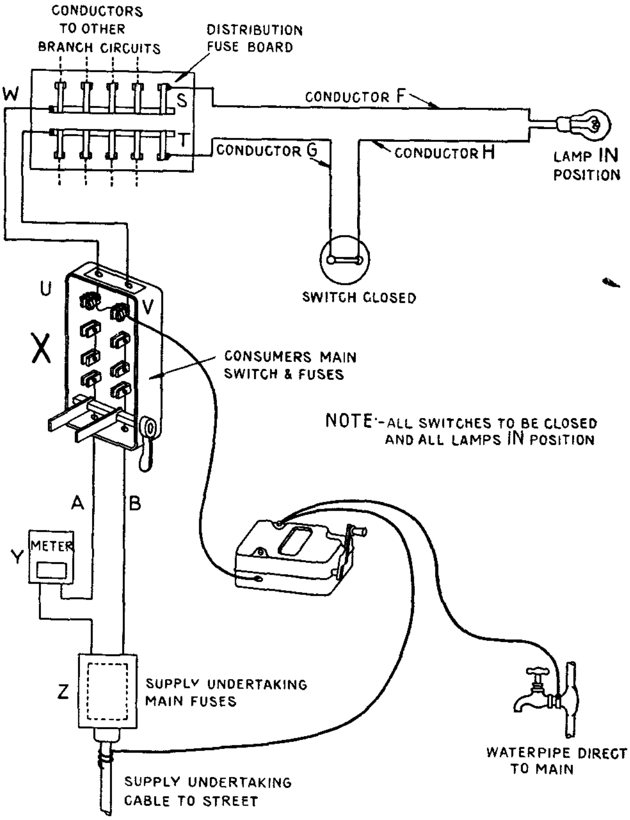


FIG 14
FIRST TEST TO EARTH ON WHOLE INSTALLATION

TEST TO EARTH ON AN INSTALLATION WHICH IS ALREADY CONNECTED TO THE SUPPLY MAINS.

Showing alternative methods of making earth connection. (*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns."*)

a starter or switch for limiting the current taken when starting and accelerating ;

(c) *In the case of alternating-current motors, such starter or switch for limiting the current taken, when starting and accelerating, to the value (if any) required by the supply undertaking.*

C. In every place in which a machine is being driven by a motor there shall be means at hand for either switching off the motor or stopping the machine if necessary to prevent danger.

The whole question of the control of motors is very important, and it must be borne in mind that in many places, if not in most, where any large number of motors are in operation, the premises are likely to be governed by the provisions of the Factory Act and to call for a certain amount of study of the Home Office Regulations in this connection.

Complete Isolation of a Motor on Both Poles.

We are dealing here only with the Regulations for the Electrical Equipment of Buildings, and it must be noted that in Sub-section A the possibility of complete isolation of the motor is called for on both poles ; except that when one point of the system of generation or supply is connected to earth, this need not be isolated. In the case of a single-phase motor, operating from one phase to earthed neutral, a single-pole switch isolation seems to fulfil the conditions of this Regulation. In actual practice the fact that a neutral is earthed does not necessarily mean that it is not " alive." Sometimes an out-of-balance potential arises giving a fairly substantial potential difference between the neutral and earth at the points where it may come in contact with a human being.

Starting and Stopping Switch.

Sub-section B asks, in the first place, for a starting and stopping switch to be placed in a position where it is easily operated by the person controlling the motor. Walking round many factories to-day, one is apt to be struck by the inaccessible position of starting switches where, for convenience of wiring, the switch has been placed, perhaps, on the wall at a distance from the actual motor and machine which it is operating.

No Volt Release.

Sub-section (*a*) refers generally to what is known as the " no volt release " designed to eliminate the possibility of a sudden application of the full voltage to the closed and loaded circuit, and also to avoid the possibility of an idle motor, which has ceased working through some temporary drop in voltage, being regarded by the operator as being out of circuit. It needs a very little intelligence to realise the serious possibilities of accidents which might arise from an apparently idle motor suddenly starting up without the operation of any switch.

The other sub-sections speak for themselves, though Sub-section (*c*) is interesting, inasmuch as it is one of the few, if not the only, reference in these Regulations to the necessity for bowing to the requirements of the supply undertaking. Personally, I cannot see that the requirements of the supply undertaking, which are in a sense of a purely commercial nature, have any place in technical Regulations of this sort.

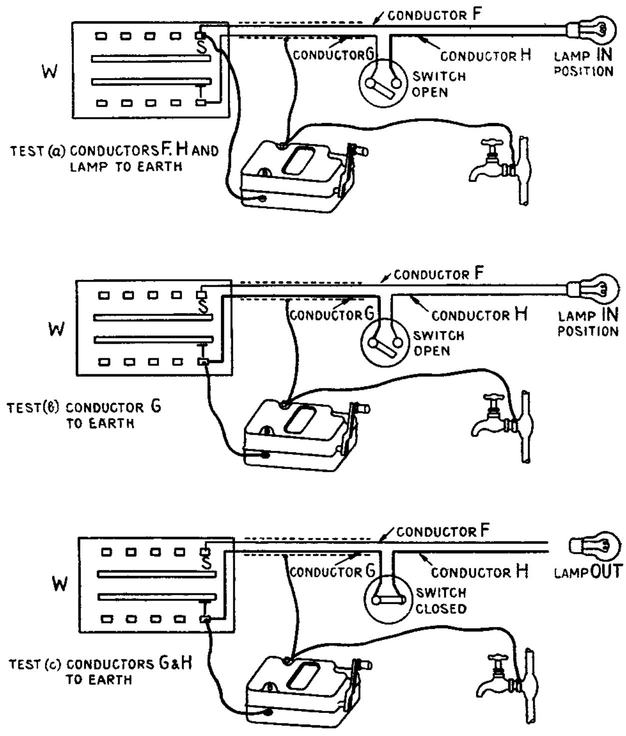
Sub-section C is, in a way, a qualification of Sub-section A, and appears to call for push-buttons or some other immediate control on or adjacent to the machine for emergency stopping.

Regulations 120 and 121 are in much the same category as Section 118, that is to say, they represent good commonsense precautions which should be taken, but do not provide any serious pitfalls.

Lifts.

Regulation 122 again refers to Lifts, which is such a specialist occupation that the ordinary electrician is unlikely to find himself concerned with the Regulations under consideration.

Regulation 123 deals with the General Construction of Heating and Cooking Appliances and contains Regulations which are entirely the concern of manufacturers.



TEST TO LOCATE FAULT TO EARTH ON BRANCH CIRCUIT.
(*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns."*)

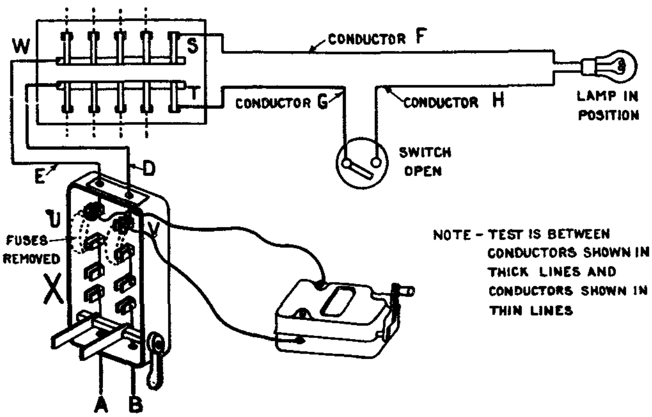
Control of Heating and Cooking Appliances.

Regulation 124, however, deals with the Control of Heating and Cooking Appliances and is important to the electrician to observe.

Sub-section A states :—

Appliances shall be protected either individually or collectively by a fuse on each insulated pole.

B. Fixed appliances shall be controlled as a whole by a switch which may, if desired, be on the apparatus. Portable appliances may be controlled by a switch or switches



FIRST TEST BETWEEN CONDUCTORS ON WHOLE INSTALLATION.
(*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns."*)

be served from one way of a distribution fuseboard provided that a fuse on each leg is provided. This clearly is not intended to suggest that large current-consuming appliances, such as electric fires, can be grouped under a collective fuse of this sort. Indeed, Section 95, which I have already dealt with in this series (August, 1933), must be regarded as an over-riding Regulation and taken into consideration when applying the requirements of the Section that we are at the moment considering.

on the apparatus, but shall be controlled as a whole by a switch fitted on a wall or ceiling, or by a plug and socket (where such are permitted under Regulation 122) *fitted on a wall.*

Note.—*Where non-luminous heaters or heating appliances, smoothing irons, etc., are used, an effective indicator such as a red pilot lamp is desirable.*

C. Where a switch or switches are fixed on the frame of a portable luminous heating appliance, at least one section of the heating element shall not be controlled by such switches, so that the luminous heating element is permanently connected to the wall plug or similar device in order to indicate that the circuit is broken and that current is still flowing.

The phrase "heating and cooking appliances" is apt to suggest something in the nature of electric fires or cookers only; in point of fact it includes independent hot plates, irons, toasters, and a lot of small appliances, and this apparently explains the implicit permission given in Sub-section A for such appliances to be protected collectively.

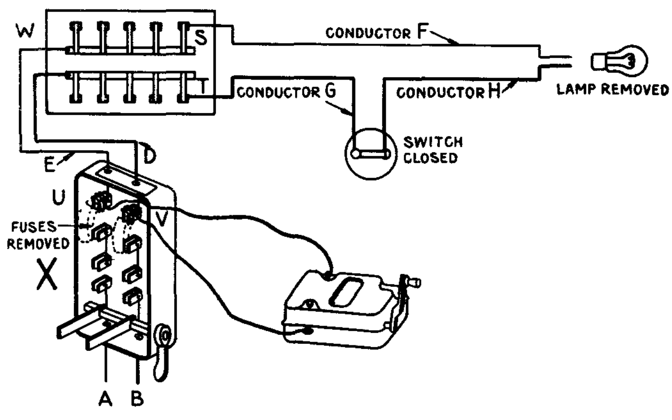
According to Sub-section A, a number of circuits serving such appliances can

Fixed Appliances.

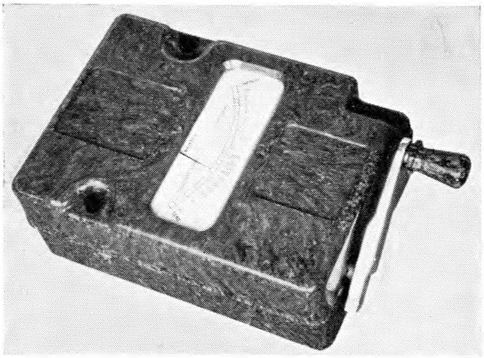
Sub-section B refers to fixed appliances, and I think the term " fixed " here is intended to cover all appliances which, from their weight or from any other reason, are not conveniently transportable such as electric cookers, etc., in addition to the definitely fixed appliances such as water-heaters; it is to be noted that in such cases they shall be controlled by an independent switch.

Use of Pilot Lamps.

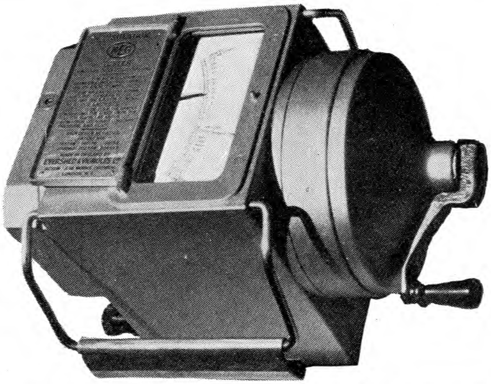
With regard to the Note as to the use of pilot lamps, some modification is probably desirable in this case. There is no doubt



SECOND TEST BETWEEN CONDUCTORS ON WHOLE INSTALLATION
(*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns "*)



THE WEE-MEGGER-TESTER. (*Evershed and Vignoles, Ltd.*)



THE MEG INSULATION TESTER. (*Evershed and Vignoles, Ltd.*)

that a pilot lamp with cookers and one or two appliances of that sort is extremely desirable and comparatively easily fitted. But the use of non-luminous heating appliances is growing so much to-day that it is questionable whether the installation of pilot lamps is really a practical possibility. For instance, if we have a large institution heated by tubular heaters, although it might be a very delightful refinement to have each tubular heater giving evidence that it is on circuit by means of a pilot lamp, such a measure would unnecessarily increase the cost of the installation and, in addition, detract from the æsthetic qualities of this form of heating.

Switch on an Electric Fire.

Sub-section C may appear at first sight to refer only to the manufacturers. Most luminous electric fires sold to-day are arranged in such a manner that they cannot be entirely switched off by any switch on the apparatus itself, the last independent element having to be switched off by means of the main controlling switch on or adjacent to the plug on the wall. It does sometimes happen, however, that a householder who has a particularly inaccessible switch-plug controlling a fire, asks an electrician to fix a switch on the radiator itself which shall control the third element and make it possible for him to switch off the fire by operating switches on the fire. The purpose of this Regulation is definitely contravened if an electrician does so fit a switch, since it is possible to have the fire turned off, and left perhaps throughout the summer with the flexible cord connecting it to the plug still alive.

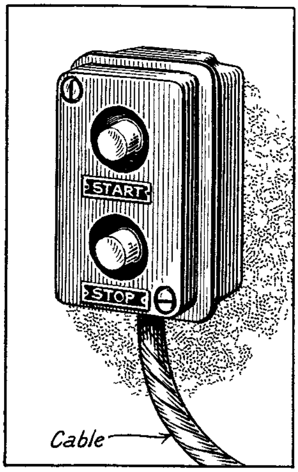
Regulation 125 calls for the very obvious precaution of not fixing heating or cooking appliances near to inflammable materials.

Regulation 126 may be conveniently omitted so far as these notes are concerned.

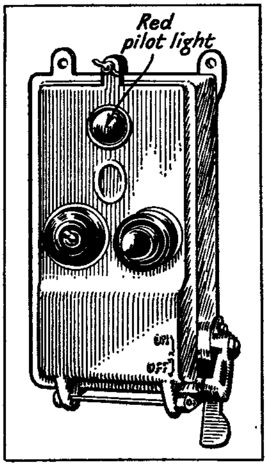
TESTING OF COMPLETE INSTALLATIONS.

The next and final two sections refer to the Testing of Complete Installations and Additions to an Existing Installation. Before quoting the Regulations perhaps it is worth mentioning that the testing of installations generally is a matter of considerable misapprehension in the eyes of most laymen and some engineers. The tests as prescribed by these Regulations are sound tests and the only ones which can reasonably be applied. On the other hand, they achieve little more than does the stethoscope of a doctor when he examines a patient. No doctor would be foolish enough to state that he can give a patient a clean bill of health merely on the result of the use of his stethoscope ; nor would he say that what he hears through his stethoscope on one occasion will remain unchanged on a future occasion.

The testing of a completed installation is a formality which must be performed to



APPARATUS FOR PUSH-BUTTON CONTROL.



COOKER CONTROL SWITCH WITH PILOT LIGHT.

satisfy both the installing engineer and client and also to satisfy the supply undertaking that the installation has an insulation resistance sufficiently high to connect up. For it is laid down—and here we come into contact with one of the very few statutory regulations referring to electrical installations—that a certain standard of insulation *must* be reached before the supply undertaking is empowered to connect up to its mains. But the conscientious engineer will look over the entire installation, in addition to taking the prescribed tests, before he hands it over as being in perfect order.

In addition, it must be remembered that the initial test must not be taken as a guarantee against deterioration for many years, but that a periodical test is extremely desirable, if not necessary, in the case of most electrical installations.

Requirements to be Complied With.

Regulation 127, which is entitled Testing: Requirements to be Complied with, states: " Before an installation is permanently put into service it shall comply with the requirements of the following tests :—

A. Insulation Resistance :—

(a) *The insulation resistance shall be measured by applying between earth and the whole system of conductors or any section thereof, with all fuses in place and all switches on, a direct current pressure of not less than twice the working pressure. Where the supply is derived from a three-wire (alternating or direct current) or polyphase system the neutral of which is connected to earth either direct or through added resistance, the working pressure shall be deemed to be that which is maintained between the outer or phase conductors and the neutral.*

(b) *The insulation resistance of an installation measured as in A* (a) *above shall not be less in megohms than* 25 *divided by the number of points on the circuit, provided that—*

(i) *Any installation shall not be required to have an insulation resistance greater than* 1 *megohm ;*

(ii) *Lighting circuits shall be tested with all lamps in place, except in the case of earthed concentric wiring systems ;*

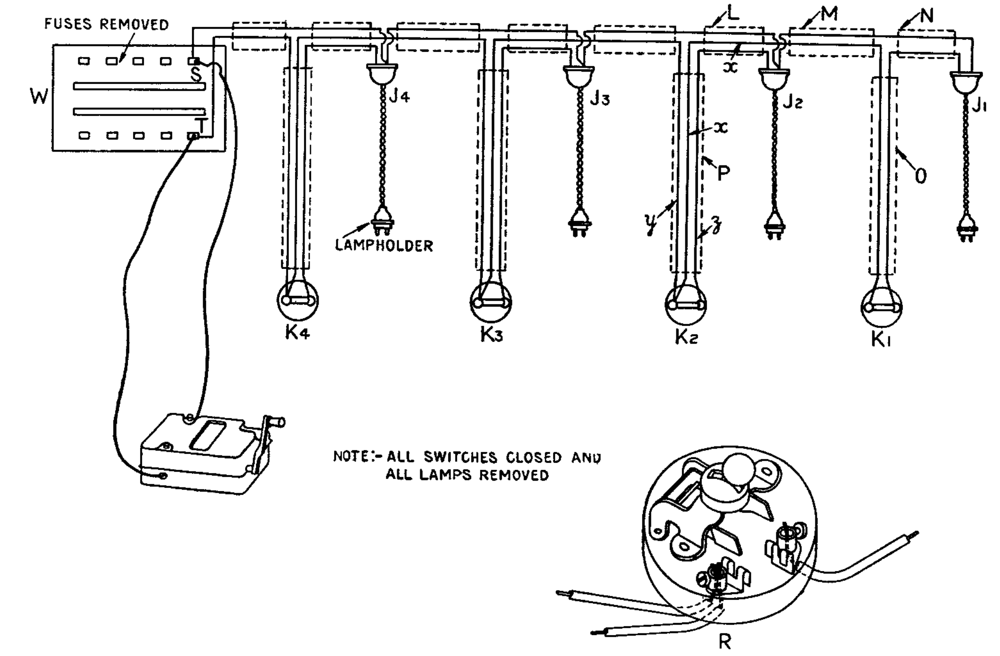
(iii) *Heating and power circuits, with or without lighting points, may be tested, if desired, with the heating and power appliances disconnected from the circuits, but with the lamps (if any) in place ;*

(iv) *The insulation between the case or framework and every live part of each individual dynamo, motor, heater, arc lamp, control gear or other appliance shall not be less than that specified in the appropriate British Standard Specification, or, where there is no such specification, shall not be less than half a megohm.*

Note.—*In addition to the foregoing tests, it is advisable, wherever practicable, to take an insulation test between all conductors connected to one pole or phase and all the conductors connected to the other pole or phase of a system.*

B. Continuity of Metal Sheathing:—

The metal conduits or metallic envelopes of cables in all cases where such methods are used for the mechanical protection of



TESTING A BRANCH CIRCUIT WHERE SEVERAL POINTS ARE LOOPED TOGETHER.
(Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns.")

electrical conductors shall be tested for electrical continuity, and the electrical resistance of such conduits or sheathing, measured between a point near the main switch and any other point of the completed installation, shall not exceed 2 ohms.

C. Earthing:—

(Investigations are being made with a view to specifying the conditions required for the satisfactory earthing of an installation, and it is proposed to include such specification in a later edition of these Regulations.)

Here, then, in a comparatively small compass, we have what may be considered the official tester's bible; whatever other fancies he may have as to ensuring that an installation is in order, he must observe the requirements of this Section 127.

Making the Measurement.

The actual measurement of insulation resistance called for, it will be noted, is not between pole and pole—a very common fallacy—but between all conductors bunched and earth. The test may be taken in any convenient manner by which, given the voltage and the current, the resistance can be calculated; or, as is more usual, it can be taken on one of the instruments known as an Insulation Tester, which is designed to do this mathematical calculation itself for the operator and record in terms of ohms and megohms the insulation resistance reading. It is important that a good earth be obtained for the earth connections of the insulation testing apparatus, and it is usually found that there is adjacent some water pipe which has a direct connection with earth. Unless the conduit or sheathing has been already tested and proved to be satisfactorily earthed according to Sub-section B, it is unwise to use such conduit or sheathing as the earth connection for insulation testing.

Pressure.

Reference is made in Section 127 (A) to the application of a pressure of at least " twice the working pressure." Since, to all intents and purposes, in two-wire installations the working pressure to-day never exceeds 250 volts, the pressure of 500 volts—which is usually applied in such instruments as the Insulation Tester mentioned—satisfies this condition. In the case of three-phase motors operating, for instance, at 415 volts, it will be in accordance with the Regulation to consider the working pressure only to be 230, that is to stay, the pressure between the phase-conductor and the neutral.

Measuring Insulation Resistance of an Installation.

Sub-section A (*b*) merely calls for a mathematical calculation and, to make matters a little clearer, perhaps I may add that if we have an installation with 100 points, the insulation resistance must not be less than one-quarter of a megohm, that is 250,000 ohms. On the other hand, if we have an installation with only five points, our mathematical calculation will give us a minimum of five megohms, but this is not required owing to the provision of A (*b*) (i).

The Note at the end of this section suggests that, where practicable, it is desirable to take the insulation test between conductors as well as between the bunched conductors and the earth. The reason for this is obvious, since it is possible to have a short circuit between conductors (where neither conductor is at earth potential) which will not necessarily show itself at the time.

Continuity of Metal Sheathing.

With regard to Sub-section B—Continuity of Metal Sheathing—the usual practice in the past has been to test for continuity by means of a 4-volt battery and a bell; that is to say, to make an artificial circuit which contains as part of the conducting circuit the whole length of tube or sheathing to be tested; if the bell rang the continuity was considered to be O.K. Recently, however, there has come on to the market an insulation tester which incorporates a switch by which readings of low resistance can be taken. This makes it possible to use the same instrument both for testing the insulation and subsequently for testing continuity. It has the great advantage that one does in this manner get a definite record as to whether or not the continuity satisfies these Regulations by not exceeding 2 ohms.

Care Required in Making Additions to Existing Installations.

Finally, Regulation 128, which is entitled, Care Required in Making Additions to Existing Installations, is self-explanatory, but should be quoted:

Before an addition is made to an existing installation care shall be taken to ascertain whether the existing conductors, switches, etc., affected by the additions are of sufficient capacity for the augmented current which they may have to carry.

Note.—*Alternative plug positions are often provided for electric heating appliances, and in such cases it should be ascertained whether the existing conductors are of sufficient size to allow of the silmultaneous use of apparatus connected to more than one plug.*

Only too often where alternative plug positions are provided for electric heating apparatus the circuit wires are not capable of carrying sufficient current to cope with both these alternative plug sockets if they are simultaneously loaded. Whatever may have been the original intention of the consumer, the existence of two plug sockets may prove too great a temptation and cause him to use both at the same time. Hence the necessity for careful observance of this Regulation and Note.

THE WESTECTOR

THE Westector has been evolved on the same principles as the well-known Westinghouse metal rectifier. It is a small form of metal rectifier specially designed for use in place of a valve in detector circuits. It will operate exactly as a rectifying valve and in the same circuits, although its simple nature enables it to be used in circuits which are preferable to those already developed.

It is designed for use as a detector handling high voltages, and it must be remembered that it will not operate satisfactorily in low-power circuits, nor as a "crystal" detector. For detection purposes, it is best used in a receiver preceded by at least two stages of high frequency amplification and is, therefore, particularly suitable for superheterodyne receivers. It will be realised, of course, that its sole purpose is to rectify, and it does not give any amplification to the signal.

For this reason, although it may replace the detecting function of a power grid, anode bend or diode detector, the sensitivity must be maintained by utilising the valve stage released as an additional I.F. or L.F. amplifier with appropriate couplings and grid bias.

The Westector does not require any high tension supply, neither is there a filament to heat, and it is, therefore, a simple matter to incorporate it in a receiver, especially as no valve holder is required, terminals being provided on the Westector itself, so that it can be included in the wiring of a set.

Fig. 1.—A TYPE WA WESTECTOR.

Simplest Detector Circuit.

A detector circuit using a Westector and reduced to its essentials is shown in Fig. 2. It will be seen that this is similar to a simple half-wave rectifier circuit, with the exception that the input transformer is replaced by a tuned circuit, which may be either condenser or transformer coupled to the preceding amplifiers. This is shown in Figs. 2 and 3.

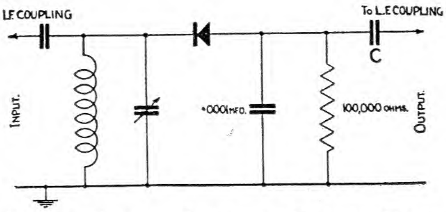


Fig. 2.—SIMPLE DETECTOR CIRCUIT USING A WESTECTOR.

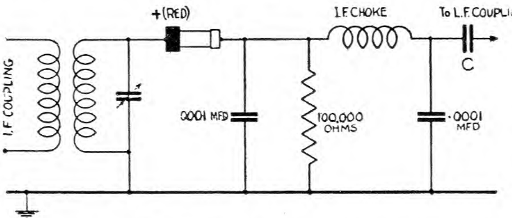


Fig. 3.—HOW FURTHER FILTERING CAN BE OBTAINED.

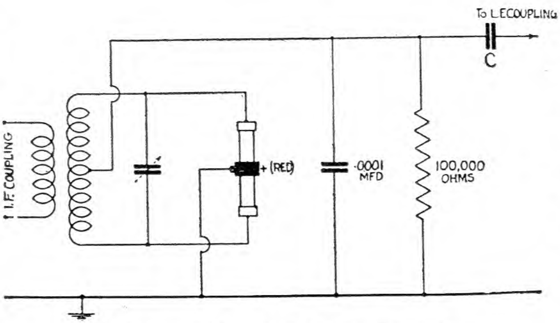


Fig. 4.—A DOUBLE-DIODE CIRCUIT.

Why a Tuned Anode Circuit Cannot be Used.

Note that a tuned anode circuit cannot be used because it is essential that there should be a D.C. conducting path from the Westector through the tuned circuit to the load resistance, i.e., there

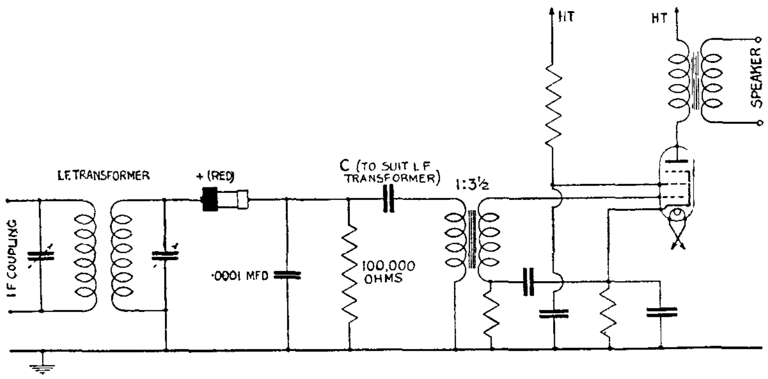


Fig 5.—Pentode Output, Transformer-coupled to Westector. Output Transformer Ratio 1 to 3½ or 4

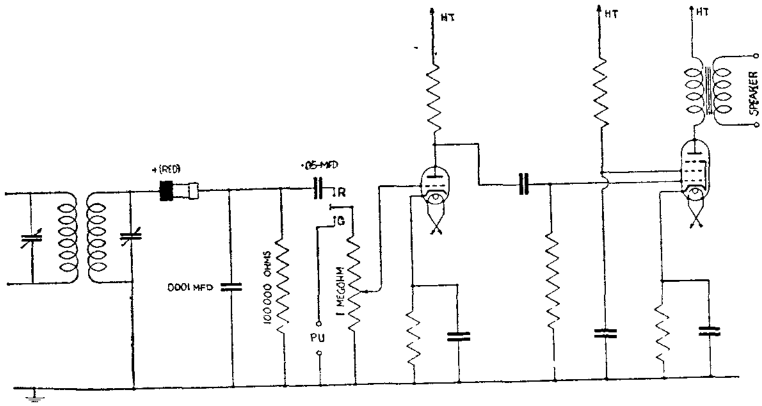


Fig 6.—Pentode Output with Intermediate Low Frequency Valve Resistance Coupled.

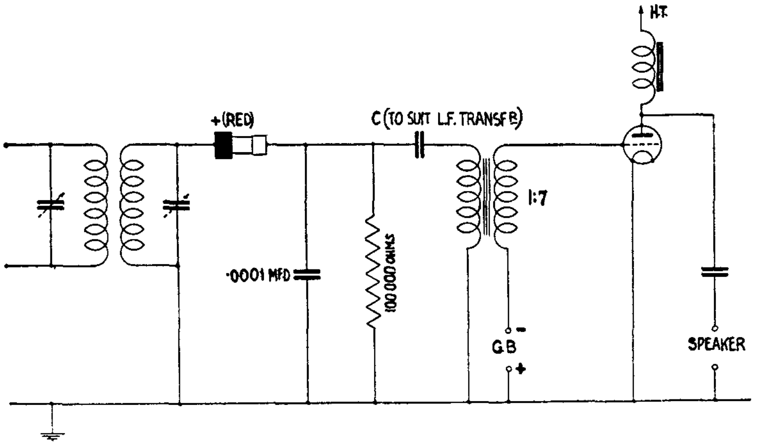


Fig 7.—Small Power Valve Output with High-ratio Step-up Transformer. Ratio about 1 to 7.

must not be a blocking condenser in series with the tuned coil.

A suitable value for the load resistance is 100,000 ohms. By the addition of a reservoir condenser, the output of the Westector may be increased, the maximum size of this condenser being limited by the range of audio frequencies it is desired to receive. A suitable value is 0.0001 mfd. The L.F. output from this load circuit is fed to the succeeding L.F. amplifier through the condenser C to a transformer, L.F. choke or resistance coupling. By employing the Westector in the above way, the reservoir condenser is used to obtain a valuable amount of filtering of the I.F., a result which cannot be obtained by any other detector circuit except the double diode. Further filtering can be obtained in the usual manner by inserting an I.F. choke and an additional 0.0001 mfd. condenser.

Double Diode Westector Circuit.

A double diode Westector circuit is shown in Fig. 4. The only advantage of this circuit over that described is a further improvement in filtering, but this improvement is not sufficient to merit the additional complications involved.

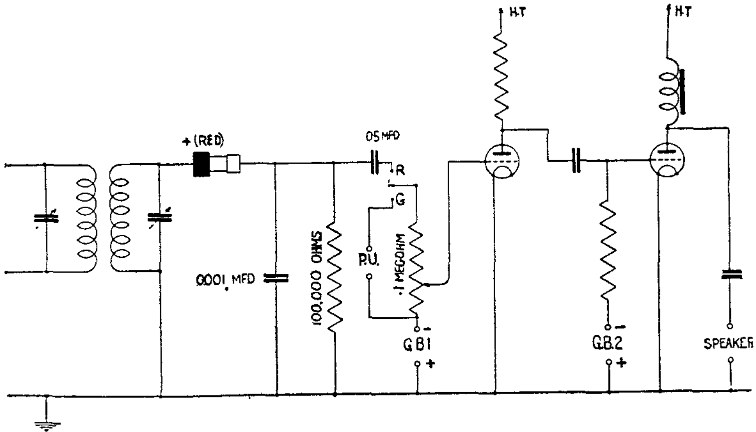


Fig. 8.—Small Power Valve Output with Intermediate L.F. Valve Resistance Coupled.

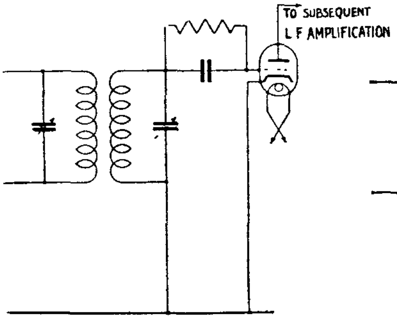


Fig. 9A.—Power Grid Circuit Before Converting.

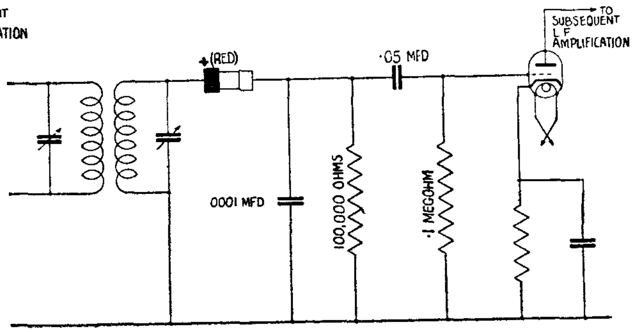


Fig. 9B.—Circuit After Converting.

Amount of L.F. Amplification Required.

Figs. 5-8 are examples intended as a guide to the amount of L.F. amplification required when the Westector is used as recommended. When it is desirable to use an L.F. amplifier in conjunction with a gramophone pick-up, an intermediate L.F. valve is necessary, and the pick-up should be connected at the points marked P.U. in Fig. 8.

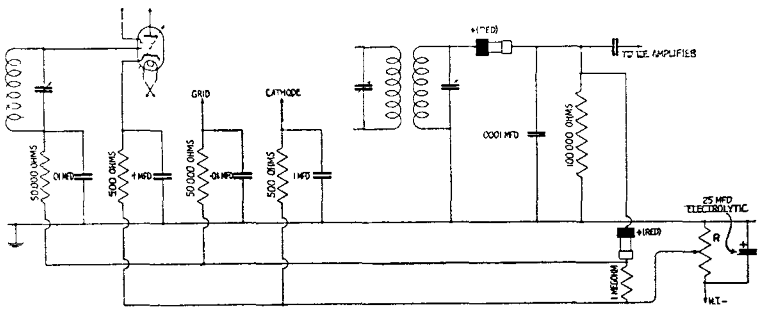


Fig. 10.—Circuit for Automatic Volume Control.

Converting an Existing Receiver.

Figs. 9A and 9B show a typical conversion from a power grid to a Westector unit, in which the released valve has been arranged as an L.F. amplifier. This

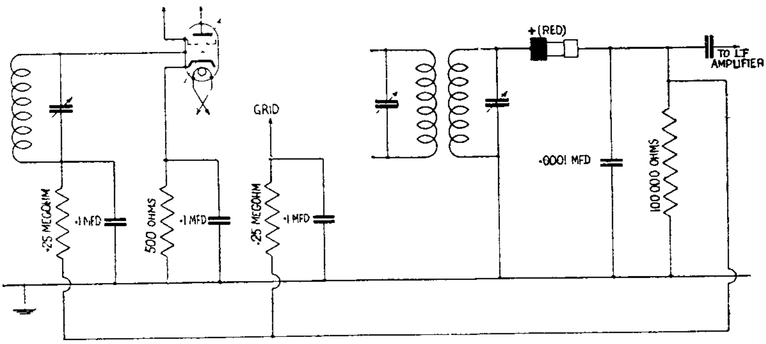


Fig. 11.—Method of Obtaining Delayed Automatic Volume Control

This and the previous diagrams are taken from "The All-metal Way, 1934," published by the Westinghouse Brake and Saxby Signal Co., Ltd.

and one controlled H.F. stage with all subsidiary apparatus omitted. It must be understood that the load resistance and detector are arranged to provide a point at negative potential with respect to earth. The voltage across this load resistance is not steady D.C. but has the L.F. component superimposed upon it, and this component must not be allowed to feed back into the grid circuit of the H.F. valves. To avoid this a resistance-condenser filter is used. The valves of components used are such as to give good filtering down to the lowest probable audio frequencies and yet, at the same time, leave the response quick enough to follow the fastest likely period of fading.

A method of obtaining delayed automatic volume control is shown in Fig. 11, the function being to make the automatic volume control inoperative on moderately weak signals and only begin to function on signals of more than a certain preset value. The potentiometer R determines the particular value at which the control becomes operative.

conversion should only be made when the power grid detector is easily overloaded, as otherwise it is unlikely that the available input voltage will be sufficient to operate the Westector to its best advantage. In making such a conversion care must be taken to see that there is a D.C. conducting path through the preceding tuned circuit, while it may be found necessary to re-adjust the trimming condensers on the preceding I.F. transformer after converting to the Westector circuit.

Automatic Volume Control.

Figs. 10 and 11 show how the Westector can be used as a means of obtaining automatic volume control. Fig. 10 gives a typical theoretical circuit of a detector

NEON TUBE PRACTICE

The practical application of Neon lighting is a subject that is rapidly becoming of increasing importance to electrical engineers. We believe, therefore, that many readers will be interested in Dr. W. L. Schallreuter's book, "Neon Tube Practice" (Blandford Press, Ltd., 10s. 6d.).

Dr. Schallreuter covers the subject from many angles. Not only does he give some very interesting details about the physical and electrical conditions of a gas discharge, but he deals thoroughly with the practical use of Neon and the erection of a Neon sign.

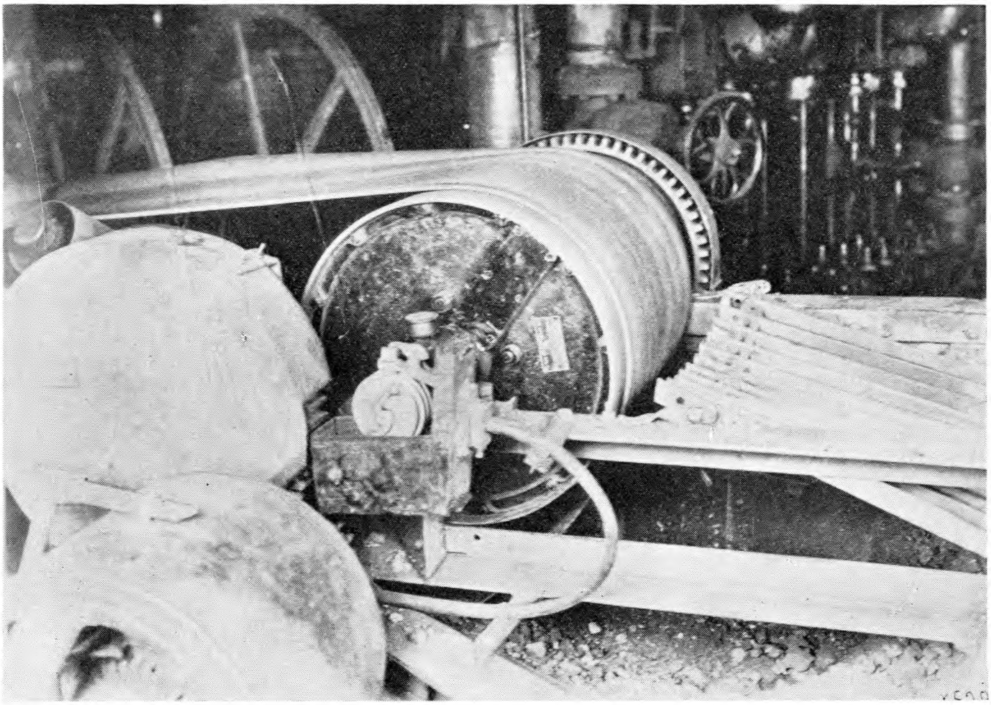
Dealing with the question of electrodes and the pressure in the tube, he says :—

"For pure neon gas, the most favourable pressure regarding conductivity and efficiency is approximately .95 mm. (roughly $\frac{1}{800}$ of an atmosphere). With such pressure the efficiency of neon is .64 watt per candle power, so that such tubes do not compare unfavourably even with the best gas-filled incandescent lamps. In practice, however, neon tubes must be filled with a pressure of at least 5 to 15 or even 25 mm. (i.e., from $\frac{1}{150}$ to $\frac{1}{30}$ of atmospheric pressure)."

Perhaps one of the most important chapters from our readers' point of view is that dealing with the electrical supply for Neon tubes.

A useful and interesting treatise for the serious student of the subject.

Magnetic Separation for Protection of Pulverising Machinery



The Igranic Magnetic Separator Pulley Used for Removing Bolts, Spikes, Nuts, Etc., in the Manufacture of Coal Briquettes.

CONSIDERABLE development has recently taken place in the use of pulverised fuel for boiler firing. Coal which is delivered to coal pulverising plant invariably contains a surprising amount of stray iron such as nails, bolts, nuts, hammer heads, pick heads, etc. which would cause considerable damage to the delicate pulverising mill. The elimination of such stray or tramp iron can easily be accomplished by means of a magnetic separator pulley.

How the Magnetic Pulley Works.

The separator pulley is inserted in the conveyor line to the mill, and as the material is passed over the separator pulley, the tramp iron is attracted and held firmly against the belt with which it remains in contact until it leaves the magnetic zone, which is at a point beyond the under side of the magnetic pulley. The tramp iron drops from the belt after leaving the pulley, and is delivered into containers by means of a chute ; the coal continuing its course to the mill without interruption. The principle of the magnetic pulley is clearly shown in the accompanying diagram.

The separator pulley consists of a number of steel discs keyed to a shaft, an electromagnetic winding being placed between alternate discs. The magnetising coils are wound on steel bobbins, which are dowelled to the discs to prevent shifting.

The coils are vacuum impregnated with a moisture repelling and insulating compound ; this ensures perfect protection from moisture and since the compound is a better heat conductor than dead air, cooler operation of the pulley is secured.

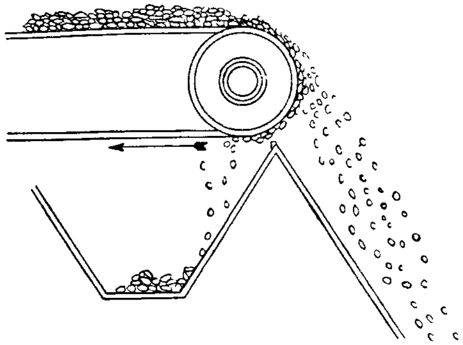
How the Coils Are Connected.

The coils are all connected in series and terminal wires brought through a hole in the centre of the shaft to a pair of collector rings fixed far enough beyond the edge of the pulley to permit a bearing between the collector rings and the pulley.

A tubular brass spacer which also performs the function of a coil shield, is placed between adjoining steel discs. After assembly the pulley is turned and crowned.

Main Features of a Magnetic Separator.

In judging a magnetic separator pulley it should be borne in mind that dimensions and weight are not the only features to be considered; in fact, two separator pulleys of the same weight and dimensions could be made that would not be of equal efficiency. One may have less copper and more steel to secure a cheaper construction, while the other, which has an abundance of copper and is not cheap, may be spoiled by the lack of steel in the magnetic circuit.



THE PRINCIPLE OF THE MAGNETIC PULLEY. The separator pulley is inserted in the conveyor line to the mill and as the material passes over the pulley, the tramp iron is attracted and held firmly against the belt until it leaves the magnetic zone which is at a point beyond the underside of the magnetic pulley.

Magnetic pull varies as the square of the number of lines of force per square inch of pole area, from which it may be seen that a small reduction as from 100,000 lines per square inch to 90,000 lines per square inch reduces the pull to 81 per cent. Too much steel in the poles reduces the number of lines of force per square inch just as too little copper does.

The windings, if placed near the shaft instead of near the outside of the pulley, will require much less copper but the efficiency will be reduced on account of excessive leakages.

The pulley is magnetised by passing direct current through the coil winding in its interior.

The current sets up a magnetic flux which passes through the belt and attracts any iron or steel that may be contained in the material carried by the belt.

Large Diameter Pulleys Give Best Results.

It should be borne in mind that large diameter pulleys will in every case give better results than those of small diameter from the standpoint of magnetic separation and will reduce wear and tear of the belt.

Assuming the belt speed to be the same in both instances, it is obvious that the rate at which the direction of motion of a piece of iron or steel is changed will be lower on a large diameter pulley than on a small one; consequently with the same intensity of magnetisation of the separation accomplished by a large pulley will be more perfect than that by a small one.

From the standpoint of belt life, the desirability of using a large diameter pulley is universally recognized. The pulley diameter must be large enough to give the required traction and to suit the thickness of the belt. Good practice allows 3 inches diameter per ply; as for example, 18 inches diameter for a 6-ply belt.

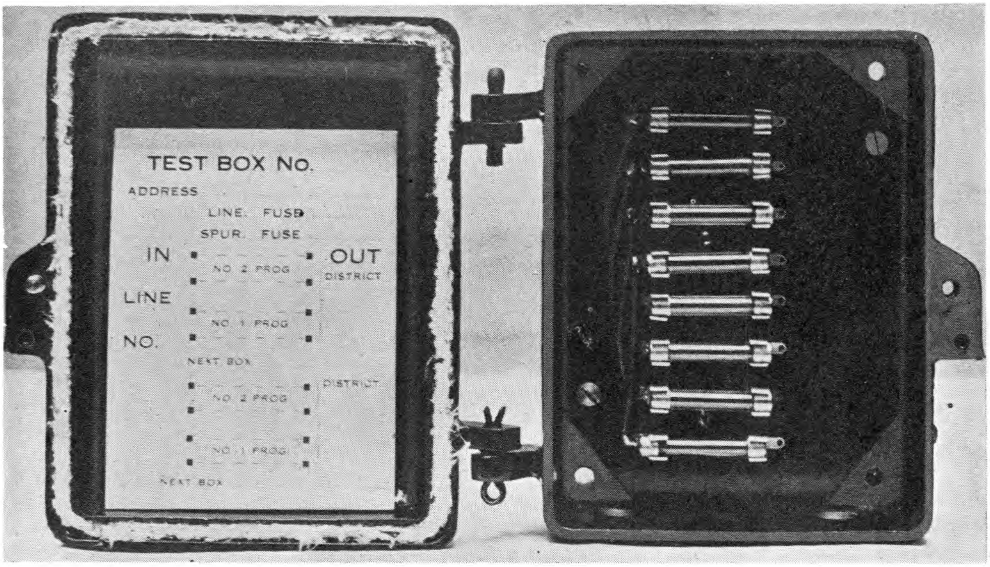
When Small Diameter Pulleys Would Be Permissible.

Small diameter pulleys, however, are much lower in first cost, and where a short belt is installed, their use is permissible. Where conveyor flights are long and especially where the magnetic pulley is a driving pulley for the conveying belt system, it is frequently economical to use a large diameter narrow face pulley because of the saving effected in the cost of a narrow belt.

ERECTING RADIO RELAY LINES

By C. W. Watson

This article describes the practical methods of erecting radio relay lines and describes the apparatus required



Test Boxes with Protection Devices should be Arranged at Each Point where the Spur Leaves the Main Line.
Showing a box containing eight fuses for D.P. lines.

RADIO relay lines to the "man in the street" differ very little from telephone and other lines, but even a little consideration proves that this is not the case. Telephone lines, for example, are nowadays composed of individual circuits, that is, so far as town wiring is concerned, and a fault on a pair of lines affects only one subscriber, whilst, on the other hand, power wires form a network with many branches to different districts, and a fault on any particular circuit, except as provided for in the protection devices, affects the whole system.

One Pair of Wires Feeds Upwards of 500 Installations.

In radio relay lines we have a sort of compromise between the power wires and the telephone lines, one pair of wires often feeding upwards of 500 installations, though the materials used and the current carried have much in common with the telephone system. Many people with little or no experience of overhead wiring have ventured into the relay business, and in many cases experience has been gained at considerable cost.

Protection of Outgoing Wires from Lightning.

The outgoing lines from the radio relay station should be protected against lightning, and a suitable distribution board provided in order that the lines may be changed over between the various amplifiers or linked together as may be desired; it should also be possible to isolate each line for testing purposes.

Use P.O. Type Protectors.

Where more than six pairs of wires are to be used, the most suitable arrangement is to provide P.O. type 4106 protectors, fitted with heat coils and an alarm bell circuit, and wired in such a manner that a short circuit on one of the lines will drop one or both of the heat coils in circuit with that line and operate the alarm bell. The alarm bell transformer should be wired in parallel with the mains transformer to the amplifiers so that there is no fear of the alarm bell operating in the middle of the night or at some time when no operator is in attendance. This precaution may seem unnecessary, but is nevertheless advisable, experience having proved that whether amplifiers are operating or not, one never knows what some "kind friend" may couple to the lines elsewhere.

Adjusting the Coils for Different Currents.

This type of protector is obtainable from Standard Telephone and Cables, Ltd., Hendon, and the heat coils which are designed to operate at .5 amp. may readily be adjusted for different currents according to the size of the lines and the amplifier which is feeding same. This is done by shortening or lengthening the coils as may be necessary and reading resistance on an "Avometer."

For a medium-sized station supplying, say, up to 1,000 subscribers, about six pairs of lines should be provided for single-programme working and six sets of four wires for dual programme, whilst for larger stations lines should be provided for each 200 or so loud-speakers as necessary. If, however, wayleave difficulties arise, there is no great difficulty in arranging as many as 500 subscribers on one line.

The Distribution Pole or Mast.

Where it can conveniently be arranged, it is perhaps best for the distribution pole or mast to be some distance, say 50 yards, from the station itself in order to isolate same from the aerials, and lead-covered cables, underground if possible, run from the station to the point of distribution. These lead-covered cables act fairly well as condensers in case of lightning and cut down a certain amount of static interference. In any case, the distribution post for the lines should conveniently be arranged so that in case of mysterious faults, tests can readily be made to ascertain whether the fault is in the outgoing leads or in the open line. It is also advisable that this mast should be as high as possible in order that longer shots may be taken if nearby wayleaves are scarce.

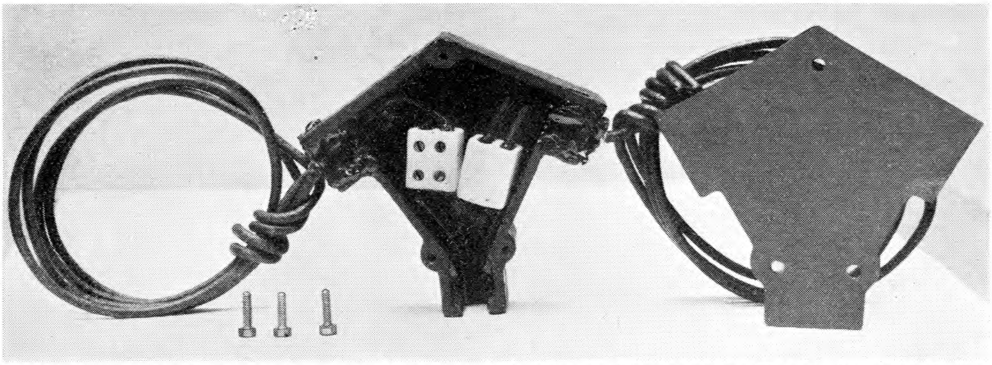
Wire and Cables.

Systems at present in operation employ open-span wiring with bare conductors, two-core insulated cables with self-contained earth wires, open-span wiring with insulated conductors, certain amount of underground wiring, suspended lead-covered multi-core cables and lead-covered cables running along masonry. Suspended insulated conductors often develop numerous minor faults and they are only suitable for erection on permanent runs. The most popular system by far in this country is, therefore, that of open span wiring, whilst chiefly on account of cost and to keep down weight, bare conductors predominate.

Insulators.

To facilitate testing, all insulators used for radio relay work should be of the double-groove type in order that the loops may be cut when necessary to isolate a portion of the line. Where single-groove insulators are used it is often found necessary to unpick one wire and remove it from the insulator altogether before a test reading can be taken, otherwise both wires being in the same groove cannot be separated

On a small system, say up to 500 loud-speakers, fairly good results can be obtained by using reel-type insulators if these are of the two-groove variety. This type of insulator is much cheaper to erect and can be made very neat in appearance, but owing to its short leakage path to the bolt it is not advisable to use reel insulators where large networks are concerned. The most popular type is, therefore, the Sinclair double-groove, double-skirt pattern used in conjunction with P.O. or similar types of brackets.



WHEN FOUR-CORE CABLES ARE TO BE USED AND ELABORATE PRECAUTIONS TAKEN AGAINST CROSS-TALK BETWEEN PROGRAMMES, A JOINT BOX SUCH AS THAT SHOWN SHOULD BE USED.

Brackets.

It is to the advantage of the relay operator to erect all lines as high as possible, thus enabling longer spans to be erected and usually carrying the wires well over the average aerial and remote from Post Office lines, which are mainly erected as low as reasonably possible. For these reasons the majority of radio relay lines are carried on chimney stacks and the brackets used for this purpose are generally of the type known as band brackets. These brackets are strapped round the chimney by means of galvanised stay wire, corner plates and draw bolts.

Brackets erected in this manner do not become fixtures under the Property Acts and do not in any way harm the masonry ; as a matter of fact, in many instances chimney stacks are actually strengthened by their presence. These brackets should be designed to take one or more double " J " bolts as may be necessary, these bolts carrying two insulators each. Where difficulty is experienced in crossing over a ridge of a building it is often found necessary to use the inverted type of " J " bolt or, in some instances, to carry an insulated conductor to a bracket on the opposite side of the ridge.

Leading In.

Where two-core cab tyre or lead-covered cables are used for leading in it is not generally considered necessary to use a joint box at the bracket whilst the pot-head type of insulator, in which the insulated lead-in wire is carried up inside the insulator, are usually considered too expensive, but where four-core cables are used and elaborate precautions are to be taken against cross talk between programmes, a joint box is essential, if an efficient service is to be maintained. A very useful type of box for this purpose being shown in the accompanying photograph.

Keep Lead-in Cables as Short as Possible.

The lead-in cables being more expensive than those used for inside wiring, and inside wiring being easier to maintain, it is advisable that the lead-in cables should be kept as short as possible, and for this reason, where possible, the leads should be taken through the roof at the base of the chimney stack.

Insert Wire Under Guide Slate.

This method is generally facilitated by the presence of a guide slate at this point. This guide slate can generally be identified by the lead strip which holds it in position, and when this strip is turned down the slate can usually be easily withdrawn, the wire passed under, and the slate replaced without any damage to the building, secured in position again by the lead strip and an application of a little " Rito " or other roof compound will seal the inlet and prevent any moisture following the wires into the building.

Inside the Building.

Inside the building, as near to the point of entry as possible, protection devices should be fitted which also provide a connection for the cheaper form of bell wire which is used to carry the programmes to the point where the loud-speaker is to be installed.

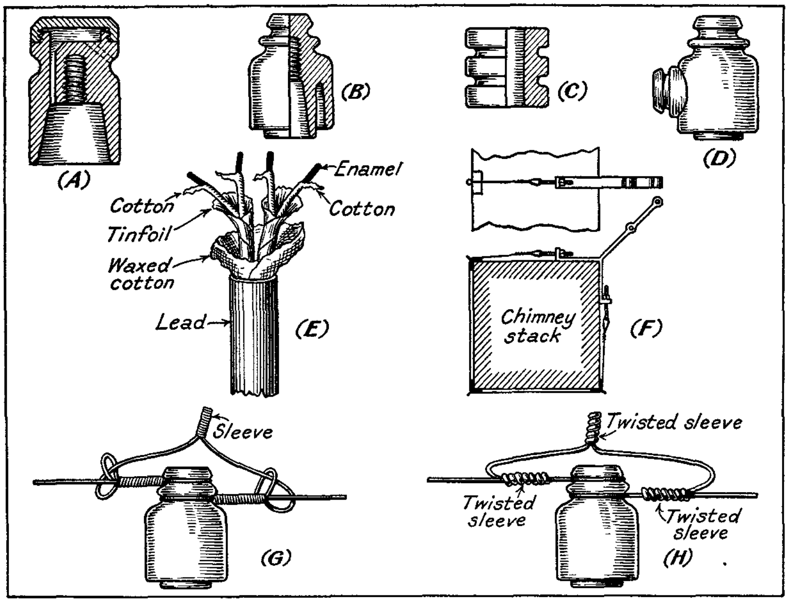
Best Form of Protector.

The best form of protector is found to be a fuse of about 60 milliamps. carrying capacity one of which would be used in each lead; the usual form of tubular fuse, fitted in a miniature screw holder, is quite suitable for this purpose, but a much neater effect is obtained by using the new four-way fuse holder designed for this purpose by Belling Lee, Ltd. This device has also the advantage that it may be sealed to prevent interference by unauthorised persons.

When these types of fuses are used, samples should be carefully tested to ascertain their fusing point, which should not be over 100 milliamps.; they should also be tested in the relay station to ensure that the output from the amplifiers is sufficient to break them down. As a guide in this respect, a pair of DO25's or LS5A or similar valves will easily break down a 60-milliamp. fuse if the amplifier is not already overloaded.

Branch Lines.

Where a spur is taken from a single pair of lines a double bracket with four insulators should be used to avoid the necessity of two wires being in one groove and to facilitate testing, whilst where a spur is taken from a two-pair line, precautions must be taken against the wires branching from inside the bracket making a contact with the outside pair at the point where they cross. It is quite common to see two or more brackets attached to a chimney in order to get over this difficulty, but a much simpler remedy is found in the cranked type of bracket, which is arranged so that one wire from each pair crosses mid way between the other pair, and there is no danger whatever of a contact unless the spur is taken at an angle very far from the horizontal.



DETAILS OF THE INSULATORS FOR USE WITH RADIO RELAY LINES.
A, B, C and D show various types of insulators; E shows how the end of the lead-covered cable is exposed; F the method of erecting band bracket round a chimney stack; and G and H, how two wires are joined at an insulator. In connection with the band brackets, it should be noted that these are strapped round the chimney by means of galvanised stay wire, corner plates and draw bolts.

DUAL PROGRAMME LINES.

Precaution Against Cross Talk.

In dual programme, four-wire circuits

precautions have to be taken against cross talk, the commonest being the transposing of wires. The most efficient and simplest method is to carry one pair of lines straight through and transpose the other pair at frequent intervals. In telephone circuits a special type of insulator is often used for transposing, these having extra grooves and a small extra skirt to provide for the lines being changed over between the insulators, but for radio relay work where higher voltages are employed it is advisable to use six insulators on a transposition bracket.

A Good System of Wiring.

A good system of wiring for dual programme is to use white insulators for one programme and brown for the other. Thus at a transposition point, two white and four brown insulators would be employed, if the brown line was the one to be transposed. Transpositioning should be arranged in the case of heavy systems at about every fourth bracket, and it is often found good practice to use a transposition bracket in every case where a spur is tapped off from the main line. If the spur is a large one, further transpositions will also be necessary along the spur itself.

In the case of small spurs with, say, four or five spans and no transposition, care should be taken to see that two adjacent spurs are not connected in the same phase relation. The lead-in wires used for this purpose should be two separate twin lead-covered cables with their coverings bonded and earthed, or a four-core cable, laid up in pairs and screened between the pairs. These cables should be connected to the lines by means of a joint box and sealed leaders as previously mentioned.

Testing.

To facilitate the location of faults and to restrict the area affected by these faults when they occur, test boxes with protection devices should be arranged at each point where the spur leaves the main line—an illustration of a test box containing eight fuses for D.P. lines appears on page 131. In the lid of each box is inserted a card, duplicates of which should be kept in the engineer's office for reference. With the use of these boxes it is not necessary for a linesman to be particularly familiar with the lines, as the card in each box bears the address where the next box on the line is and also what spur is affected. It is, therefore, only necessary to work from box to box to the point where the fault is found to be back along the line, then examine the line between the two boxes, whilst the fuse can be left out at the last box, thus leaving only a portion of the line dead until the fault is cleared.

Earth Leaks.

Earth leaks on radio relay lines should be particularly avoided, especially in the case of dual programme working, as two earths on a transpositioned line, if they occur on the opposite wires, produce, if not a short, a very heavy load on the line in question; whilst earth leaks on two lines which may be a mile apart and in no way connected, can, if they occur on opposite programmes, produce puzzling cross talk effects. For this reason it should be the duty of the station operator to read the resistance of each line to earth, first job each morning, in order that these faults may be remedied without delay. For earth leaks and short circuits on the line an Avometer is invaluable, readings being obtainable over very useful ranges without the trouble of operating a generator, as would be necessary if a megger were used.

Crossing Streets.

Difficulty may be experienced in erecting wires over busy streets, but a little ingenuity greatly simplifies the task. Where a busy street has to be crossed by wires it is generally best to erect the ladders at the rear of the buildings on each side; the linesman on each building then lowers an end of his rope, which is an indispensable part of his equipment; during a lull in the traffic the ends of the two cords are joined together; one linesman should then draw up the cord as far as possible and attach the free end of his own cord to it, the man at the other side then draws the cord across until the knot reaches him and taking the free end of his own line ties the two ends together, forming an endless rope over the street.

This operation can be carried out unobtrusively and the coils of wire can then be passed to and from each building at will. Where tram wires have to be crossed, insulated wire must be used, and after all preparations have been made to ensure a quick crossing a telephone message to the tramways depot will usually result in the tower waggon being immediately on the spot and a very few minutes should see the job complete. This is a far better method than throwing ropes over live wires and the tramway authorities are always ready to oblige in this respect, if only in their own interests.

H.F. on the Lines.

Where radio relay lines pass closely to overhead trolley wires and through industrial areas, it is quite common for H.F. radiated from trolleys and electrical machinery to follow the course of the line back to the relay station and cause an appreciable amount of interference with the reception. A good plan for guarding against this is to earth each line through a condenser of .01—.1 mfd., when the interference will be found to disappear ; in fact, lines arranged in this manner, in practice, seem to aid reception if tests are carried out with and without the condensers.

Effect of Weather on Brackets and Conductors.

Experience over a few years of climatic effects on overhead equipment go to prove that although galvanising of brackets is undoubtedly an advantage, these should be painted on erection, particularly the " make-offs " of the stay wires, and repainted at least once a year. A good practice is for the linesmen to carry paint and brush with them and give another coat to each bracket on which they operate. Copper wires are particularly susceptible to smoky climates and as most relay systems are operated in industrial areas, the cadmium copper alloy is found to be most suitable. Although many companies use heavier gauges, single 18's conductors give quite satisfactory results, and the weight, working out in the region of 40 lb. per mile, does not involve too great an expense.

Resistance of Conductors.

Most new-comers to radio relay attach great importance to the resistance of the conductors and go to great trouble and expense to keep these resistances as low as possible. In practice, however, it is found that the resistance of the lines, particularly in the case of large networks, is very useful, because a short circuit in one area does not always seriously affect the reception of subscribers on the same line, and restricts in a measure the area affected. In the writer's opinion, although resistance of the lines should be kept reasonably low, a moderate resistance is useful.

NOVEL DOG TRACK LIGHTING SYSTEM

The lighting system chosen for London's newest greyhound racing track at Stamford Bridge consists of 70 G.E.C. reflectors similar to those employed with so much success at the White City and other well-known tracks. These are equipped with 1,000-watt lamps.

An interesting feature of this installation is the use of a new type of collapsible standard specially designed by the G E.C. for the track. Inclined poles are used, and these can be swung round from over the track and lowered by means of a ball and socket joint incorporated in the base, to the side of the track, where the fittings are protected by the wire fence. A folding support is also incorporated in each standard for use in the " down " position. These poles are sufficiently light to be handled by one man, and can be very quickly raised and lowered. The obstruction to vision due to the poles is practically non-existent. When football matches are being played the poles are completely out of the line of sight of spectators, and by arranging some of the poles to lay to the left, and others to the right, provide a clear path to the ground.

QUESTIONS AND ANSWERS BY PRACTICAL MEN

Readers are invited to send problems of practical interest. Letters should be addressed to "The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2. Envelopes to be marked "Problem" in the left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTH'S NEW QUESTIONS

Solenoid Coil for A.C.

I wish to make a solenoid coil for A.C. 230 volts, 50 watts, with a pull of 20 lb. for ¼ in. (I just want the first pull up or slam acting for about a second just to get something up in position). I do not wish to use any form of converter if I can help it.

ARTHUR S. NUNN (Nottingham).

Converting a D.C. Motor into an A.C. Motor.

I have a 200-230-volt D.C. shunt-wound fan motor, the dimensions of which are shown on the enclosed sketch, and wish to convert into an A.C. series motor to run from 230-volt, 50-cycle mains. Please be good enough to furnish me with a winding specification for same. Will you tell me how the coils should be disposed on the armature?

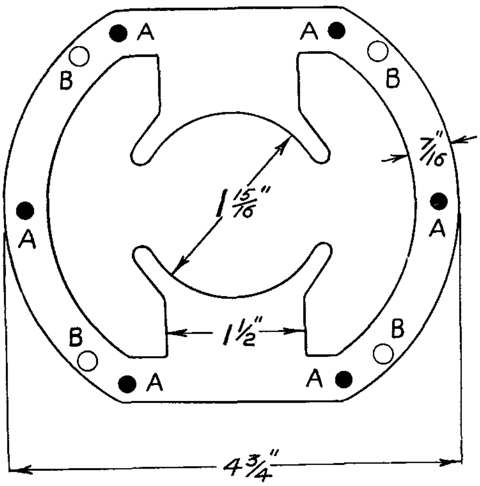
The dimensions and details of the motor are as follows:—

Length of armature, $1\frac{5}{16}$ in. Diameter of armature, $1\frac{13}{16}$ in. Diameter of armature tunnel, $1\frac{15}{16}$ in. Number of armature slots, 12. Depth of armature slots, $\frac{5}{16}$ in. Width of armature slots at the top, ¼ in. Width of armature slots at the bottom, ⅛ in. Number of commutator segments, 24.

The six thick dots on field magnet marked A are rivets holding the laminations together. The field magnet is laminated to a thickness of 1¼ in.

Also the four holes on field magnet marked B beside them are for passing the long screws through to clamp up the end covers of the machine.

G. E. HOLSINGER (Ceylon).



DIMENSIONS OF THE SHUNT-WOUND FAN MOTOR REFERRED TO BY MR. HOLSINGER.

Windings for a Small Motor.

Could you please advise me the gauge and number of turns to wind a small motor for 30 volts, 2 amps. D.C.? The particulars are as follows: Armature, 2½ in. diameter, 3 in. long. Fifteen-slot circular about ⅜ in. diameter. Fifteen-part commutator. Four fields, 2 × 1½ × ½ in. each.

A. T. WILSON (Ayr).

D.C. or A.C. for Shipping Purposes.

What are the advantages of using D.C. current in preference to A.C. for shipping purposes? Also, why is a 25-cycle current better for power purposes than 50-cycle?

JAS. H. FRANCIS (Liverpool).

REPLIES TO PREVIOUS QUESTIONS.

Enamelling the Outside of a Floodlight.

I shall be glad if you would give me advice on the following points :—

(1) *For enamelling the outside of a 300-watt sheet metal floodlight, what would be a suitable heat-resisting black enamel to give :*

(a) *a dull finish ;*

(b) *a glossy finish ?*

(2) *Can you give me the name of a firm who wholesale or manufacture mounted or unmounted lenses and glass reflectors suitable for spotlights and projectors ?*

C. W. S. (Chingford).

The three enamels given below will all stand great heat :—

(*a*) Dullite.

(*b*) Blackall.

(*c*) Raphaelite.

The first-named will give a dead flat finish, while the second and third mentioned enamels give a glossy surface.

A very pleasing eggshell finish can be obtained by using (*b*) or (*c*), and when dry and quite hard slightly "flat" the surface by rubbing with a wet rag impregnated with powdered "rotten stone," or very fine pumice-stone.

The best firm specialising in the manufacture of high-class lenses is Messrs. Ross, Ltd., Old Town, Clapham, S.W.4. This firm also make reflectors at a subsidiary factory ; in fact, they deal with all types of optical work. H.J.B.

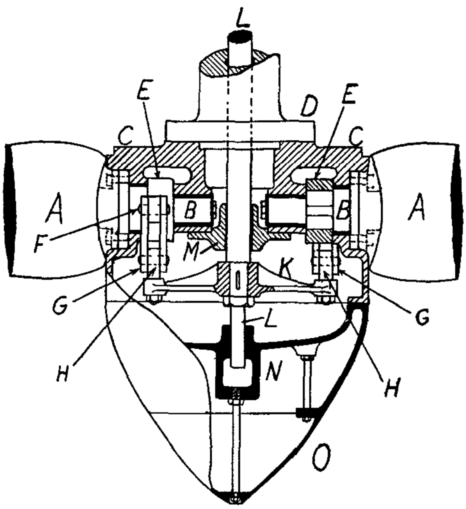
The Kaplan Turbine.

Could you give more information as to how the adjustable blades of the Kaplan turbine are arranged and worked ? The article in which this turbine was mentioned was published in the December, 1932, issue of THE PRACTICAL ELECTRICAL ENGINEER *in the article on " Power Distribution in Sweden."*

W. A. B.

The Kaplan water turbine is of the vertical shaft type and has adjustable impellors for the purpose of obtaining a high efficiency over a wide range of loads (see page 159, Vol. I of THE PRACTICAL ELECTRICAL ENGINEER).

Each of the four impellers, A, is coupled to a short horizontal shaft, B, and each of these shafts is mounted in separate bearings in the upper portion, C, of the boss, which is coupled to the lower extremity of the vertical main shaft, D.



THE ADJUSTABLE BLADES OF THE KAPLAN TURBINE.

Each of the impellor shafts is fitted with a crank E, and each crank pin, F, is connected by links, G, to an eye bolt, H, fitted to a four-armed spider, K. This spider is keyed to the regulating shaft, L, which is located inside the main shaft, its lower end being guided by the bearings M and N. This shaft, as already explained in the above-mentioned article, is given limited up and down movements by a servo motor controlled by the governor of the turbine, and by means of the spider and links these movements are imparted to the crank pins F, thereby causing corresponding angular movements of the blades of the impellors.

The lower portion of the boss and the cap O are shaped as shown in order to give minimum resistance to the passage of the water.

A. T. DOVER.

Miniature Circuit Breaker for House Lighting.

Is there any definite regulation prohibiting the use of a miniature circuit breaker on the live leg of an ordinary house-lighting circuit, the neutral being connected direct to a neutral bar? I have in mind a sub-circuit as above, permitting the one control only and therefore dispensing with the usual fuse in either leg and a tumbler switch on the live leg.

The neutral is at earth potential, and provided the neutral wire can easily be disconnected for testing, is there any reason for insisting upon two fuses?

R. W. Kane (Johannesburg).

The use of a single-pole circuit breaker is never prohibited, except in the neutral of a complete three-wire D.C. system, which does not apply in ordinary house lighting. If your neutral were to develop a dead-short to earth, and if, simultaneously, a very large leak were to go to earth on one of the lines in your neighbourhood, the leakage current might try to return to the neutral via your system, with disastrous results, unless your connection to the neutral is protected by a fuse or circuit breaker. If your circuit breaker is carefully set, the inclusion of fuses need never give you any bother. W.M.

Trickle Charger for a Model Railway.

I wish to set up a trickle charger in connection with a model railway. The power is obtained from a 12-volt car accumulator of 40 amp.-hour capacity.

It is proposed to use a Westinghouse metal rectifier giving 12 volts 1 amp., as this is the most convenient. However, since one cell when fully charged gives 2.2 volts, six such cells will give 13.2 volts; in other words, the accumulator is never fully charged. Is there any way of getting over this difficulty other than, say, charging three cells at a time from the rectifier?

B. W. Hind (Pinner).

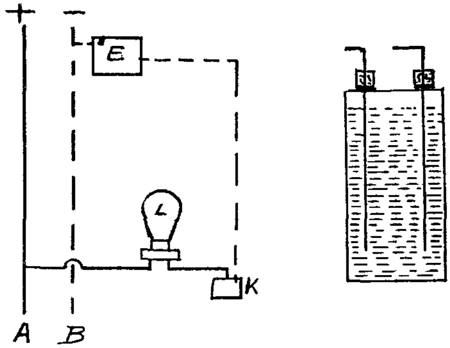
It will be quite all right to use the 12-volt, 1-amp. Westinghouse metal rectifier and charge the 12-volt accumulator without altering the arrangement of the cells, as although the rectifier is rated at 12 volts, it takes a much larger voltage than this to send 1 amp. through the 12-volt battery, and this is allowed for by the makers of the rectifier. If a transformer with a suitable winding is chosen, so that when the battery is discharged, i.e., down to 10.8 volts, the voltage is sufficient to send 1 amp. through the battery, then, when the back pressure of the battery rises the only result is a fall in the value of the charging current, to something less than 1 amp. J.S.M.

Finding the Live Wire on a D.C. Circuit.

When testing for a live wire on A.C. it is possible with a pair of leads, a lamp holder and lamp, to make the lamp light when the "live" wire and an earth are touched on. Is it correct that on a D.C. circuit by this method you cannot tell which is the live wire? If this is so, would you kindly tell me the best way to find a "live" wire on a D.C. circuit?

F. W. Clarke (Edmonton).

Tramway systems and many private plants work on a D.C. two-wire system with one pole earthed at the generating station. On such plants it is always possible to find the positive wire by means of testing leads and lamps as shown in the diagram. If the positive testing lead be put in contact with the positive wire A and any good earth as at K, a circuit will be established back to the station earth E, and the lamp L will light up. On a D.C. system in which both poles are insulated, or on the three-wire D.C. system which has the neutral earthed and the main negative and positive poles insulated, other means can be used. Pole indicating paper is sold made up in books like books of litmus paper. One of the leaves is taken out, damped, and both testing



Two Methods of Finding the Live Wire on a D.C. Circuit.

leads held on to it. The wire attached to the negative lead will turn red. If an ordinary D.C. voltmeter suitable for the circuit voltage is available this can be used. Try the voltmeter across the bus-bars to test its polarity. Voltmeters of this type read from left to right and have the positive terminal on the left; often this is marked. If this be placed across the wires to be tested, the voltmeter will give a reading from left to right when its left-hand terminal is placed on the positive line, and the right-hand terminal on the negative side; if the leads are then reversed, the voltmeter needle will read in the reverse direction; that is, the needle will come hard up against the stop at the left hand of the scale; thus giving a check on the test. On a three-wire system the same test can be made, but the voltmeter must, of course, be capable of reading the full pressure across the outers.

Another method is to take two strips of lead—old lead sheathing from cables, hammered out flat and cleaned, will do—and suspend them in a tub as shown in the diagram. Fill the tub well up with water, keep the lead plates, say, 4 in. apart, and throw into the water a table-spoonful of salt and connect the testing wires to the lead plates Adjust the distance between the lead plates so that a current of, say, 10 amps. is maintained. In a few minutes the plate attached to the positive pole will turn brown There is also a glass tube tester sold, containing two electrodes in a transparent liquid When the testing wires are attached to the terminals of the electrodes, the negative electrode becomes surrounded with a bluish tinge; this colour being absorbed into the liquid again when the test wires are disconnected.

W.T.W.

Finding the Live Wire on a D.C. Circuit.

If a D.C. moving coil voltmeter of a suitable range be available, the "live" side of a D.C. circuit may be found quite simply. The moving coil voltmeter will only indicate over its scale when the positive wire of the circuit is connected to the positive terminal of the instrument. If the connections are reversed the voltmeter merely tends to give a negative reading.

Should the system be D.C. 3-wire at 460 volts between outers and 230 volts outer to neutral, care must be taken. As far as positive to neutral is concerned the above instructions apply, but when the voltmeter is connected between the neutral and the negative outer the neutral wire is the "positive" and should be connected to the positive terminal of the instrument.

Should no voltmeter be available, the live side can be found by other methods. The neutral wire of the 3-wire system is always earthed, and the outers may be found by using the test lamp as suggested in the question.

To discover which is the positive outer and which the negative, use may be made of pole finding paper. This paper may be bought in small rolls. A portion of the paper must first be damped; the two ends of the live circuit are then applied to the paper at a safe distance apart. The "negative" wire of the two will make a distinct mark on the paper.

With a two-wire D.C. circuit, the pole-finding paper may alone be used.

Further possible methods, though only suitable for low voltages, would be to rig up a water voltmeter for the electrolysis of water, or a copper sulphate bath as used for plating.

THOS. G. FRANCIS, B.Sc., A.M.I.E.E.

Finding the Live Wire on a D.C. Circuit.

Is it possible that you are confusing "finding the live wire" with finding the polarity. The live wire being the one which is at a potential different from that of earth, may always be found with a test lamp, but on a D.C. circuit (3-wire) this gives no indication of polarity, which may be found by means of pole paper, using the test lamp as a resistance. The reason for this is that both the positive and negative "outers" are live wires.

W. M.

A Modern Telephone System for Hotels

The PRACTICAL ELECTRICAL ENGINEER

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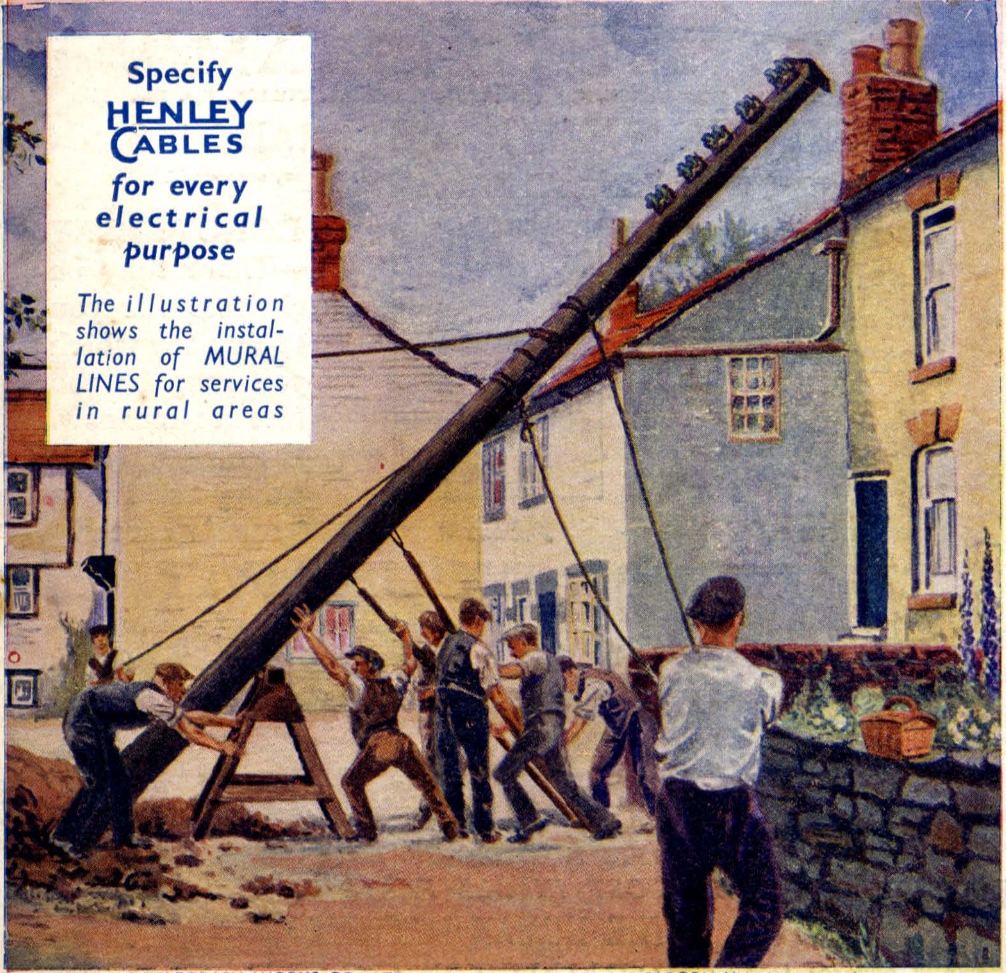

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The Cable Makers' Association.

Electric wires and cables are to the electrical engineer what steam and water piping are to the mechanical engineer. It is, we think, fairly obvious to everyone that pipes which could safely be used for conveying low-pressure steam for heating purposes would be quite unsuitable for supplying steam at, say, 100 lb. to the square inch pressure to a reciprocating engine. Again, pipes suitable for 100 lb. steam pressure could not safely be used for supplying pressure at, say, 300 lb. to the square inch. If the most efficient conditions are to be attained, not only would the thicknesses of the pipes have to be varied, but also the methods of jointing, and the lagging or heat insulating would have to be suitably designed to meet the working conditions. Unless these matters are attended to it is obvious that :—

(*a*) The piping for the particular installation would be far more expensive than it need be.

(*b*) The pipe line would be definitely unsafe for the working steam pressure.

This provides a very good analogy to the case of electrical wires and cables. The Cable Makers' Association have drawn up various specifications for different qualities and types of cables. These are explained in an interesting article by Mr. Winton Thorpe, which appears on page 159, and which will well repay careful study by every practising electrical engineer. In this article Mr. Thorpe describes the differences between C.M.A. (Regd.), "NONAZO," "VICMA," "VINAZO" and other types, and the reader who carefully studies this need never in future select his cables by guesswork.

The Internal Telephone Requirements of a Modern Hotel.

Whilst in most offices and factories it is an advantage for the various executive branches to be able to communicate instantly with each other without having to go through a central switchboard, the requirements in hotel work are entirely different. The larger hotels often have, as guests, people who wish to maintain a certain amount of privacy. In an hotel equipped with an intercommunication telephone system it would be an easy matter for an enterprising reporter to engage a room at the same hotel as some celebrity, and use the interphone system to the annoyance of the distinguished guest. For this and other reasons, the modern tendency is to install in hotels some form of simplified central-battery telephone system. An excellent example of one of the latest systems which has been devised to meet the above requirements is the Siemens Neophone system, which is described in an article on page 143.

Speaking Before the Microphone.

The rapid extension of the Public Address System, by which a speaker's voice is picked up by microphone, suitably amplified and delivered to a large audience through loud speakers conveniently situated, has introduced a new problem for public speakers and actors. When one is confronted by the microphone the natural tendency is to address one's remarks to the microphone diaphragm.

This has a tendency to prevent a speaker getting over his personality to an audience who are watching as well as listening. Many speakers, singers, and violinists unconsciously make use of movement to hold the attention of an audience.

The new buttonhole microphone, which is described on page 150, and which has been introduced by the Igranic Company, offers a solution to the problem outlined above. This microphone is worn as a buttonhole and by its use the speaker or singer can walk to and fro on the platform and speak to his audience in a natural and convincing manner.

Progress in Valve Design.

During the last year or so there has been unusual activity in this direction. The Variable Mu Valve, the Class B Valve, the Double Diode Triode, the Single Diode Tetrode, the High Frequency Pentode, the Pentagrid, are a few of the new types which have come into fairly wide use during the past 12 months. In an article beginning on page 157, "Omicron" summarises the characteristics and uses of these special types.

Voltage Control On Car Dynamos.

For many years, in fact since car lighting dynamos came into use on pleasure cars, the usual method of regulating the dynamo output at varying engine speeds has been by use of the third brush control. This method of control gave an approximately constant current output so that a fully charged battery would receive the same charging current as a battery which was nearly flat. To-day the great tendency is to replace this method of control by a constant voltage regulator which operates very much on the lines of the well-known Tirrell Regulator. This innovation in automobile electrical work is described by Mr. Harcourt Woodall in an article beginning on page 168.

The Grid and its Influence on Circuit Breaker Design.

As more and more districts receive their supply from the Grid the problem of designing suitable circuit breakers becomes more and more important. On a system supplied from a single generating station only the power from that station is behind a flashover or short circuit, whereas at any point on the grid system the power behind a "spill over" is that from all the generating stations which are feeding into the grid. A survey of recent developments in high speed circuit breaker practice will be found on pages 172 to 176.

Electro-magnets for Handling Materials.

The improved conditions in the heavy industries, particularly in regard to iron and steel manufacture, is likely to lead to an increased demand for electro-magnets as an adjunct to the high-speed electric crane. An interesting point raised by a contributor on this subject (see page 177) is that as the resistance of the magnet windings is lower when cold than when hot, the initial lifting power of the magnet will be greater when it is first switched on than after it has been in use sufficiently long for the coils to have warmed up. The lifting capacity also depends upon the material which is being lifted. For instance, a magnet which will lift 100 cwt. of solid steel ingots will only handle 1½ cwt. of scrap.

Electric Flashing Signs.

The value of electricity as an advertising medium is fully appreciated by advertisers in large towns and cities. There is, however, still an immense field to be explored by the electrical installation engineer who is to have a share in the increased business which is sure to follow from the extended use of electric supply.

There are hundreds of small towns in which there are thousands of advertising sites suitable for electric flashing signs. On page 170 our contributor, Mr. H. J. Baldwin, describes a simple form of motor-operated switch which can be used for operating such a sign. Obviously any desired sequence can be obtained by a suitable arrangement of cams on the actuated shaft.

Readers who are mechanically minded will find much interest in working out some flashing signs for prospective clients in their district.

The Three Ifs.

If every member of the public who uses electricity were electrically minded; if every installation engineer were 100 per cent. efficient, and if manufacturers never made a mistake, there would be no faults in electric lighting and power installations. Unfortunately, the three ifs mentioned above are likely to be always with us. Therefore, Mr. H. W. Johnson's article, which begins on page 152 should be read by everyone who is interested in the consumer's end of the Electricity Supply Industry. In this connection remember that it is the unexpected fault which always occurs. Therefore, the more faults you expect and provide against, the less likelihood there is that your work will give rise to faults. A word to the wise is sufficient.

THE NEOPHONE HOTEL SWITCHBOARD

A RECENT DEVELOPMENT IN C.B. TELEPHONE SYSTEMS

By S. S. DANKS

THE system described in this article has been designed to supersede bell and indicator systems in hotels, service flats, etc.

The limitations of bell and indicator systems are well known; irritating delays occur and much unnecessary running about on the part of the staff is involved.

Intercommunication telephones are unsuitable, as complete and unrestricted communication between all stations is highly undesirable for obvious reasons. In any case, where more than twenty stations are required the expense of multiple cable alone renders the adoption of such a system impracticable.

The Neophone hotel switchboard solves the problem of providing an adequate means of communication between visitors and service room management and staff, etc., in an economical but effective way by the use of a simplified central battery system embodying the use of high-efficiency telephones.

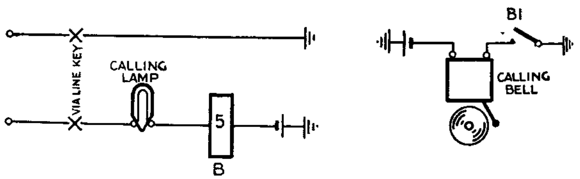


Fig. 1.—SIMPLIFIED LINE CIRCUIT.

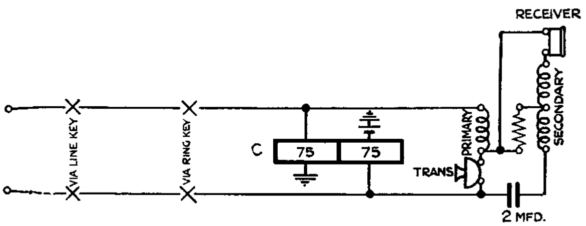


Fig. 2.—CALL ANSWERED.
Calling lamp and relay switched clear.

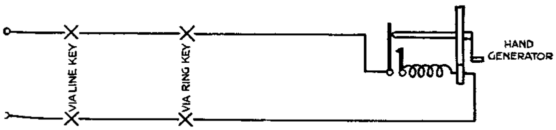


Fig. 3.—WANTED STATION BEING RUNG.
Generator on line, all other apparatus switched clear.

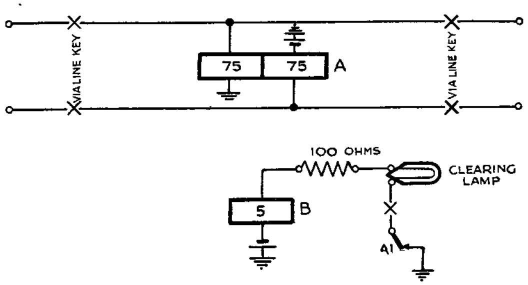


Fig. 4.—CIRCUIT CONDITIONS WHEN TWO STATIONS ARE CONNECTED.

Central Battery Signalling.

Luminous signals, requiring no mechanical restoration, are generally acknowledged to be far in advance of any other type, but an audible signal must also be used to ensure prompt attention at all times. Fig. 1 shows the signalling circuit employed: when a micro-telephone is removed from the rest at any of the stations, battery flows through a low resistance relay B, through the appropriate calling lamp, over the line and instrument of the calling line, to earth. This causes the lamp to glow, identifying the calling station, and energises the relay, which operates and closes, at contact B1, the circuit of the call bell. The bell rings continuously until the call is answered.

Central Battery Speaking.

Fig. 2 shows the circuit when the call is answered: the central battery is fed through a double wound retardation coil to both calling and attendant's telephone instruments in parallel. The high impedance of the coil prevents voice currents from flowing back to the battery and these currents flow, therefore, through the telephone instruments only.

Magneto Ringing From Switchboard.

The circuit is so arranged that the attendant can ring the magneto bells at the extensions by a hand generator (Fig. 3): the line at that time is switched clear of feeding coils or other apparatus. The use of magnetos and polarised ringers ensure good audible signals over lines of considerable resistance.

Supervision on Through Connections.

Where communication is permitted between stations the circuit conditions are as shown in Fig. 4. Battery is fed to the instruments concerned through a double wound relay A, which remains operated until both stations replace the micro-telephones on the rests. When the relay releases, battery flows through relay B, 100-ohm resistance, clearing lamp, and contact A1, to earth. The clearing lamp glows and relay B is energised, closing, as before, the circuit of the call bell.

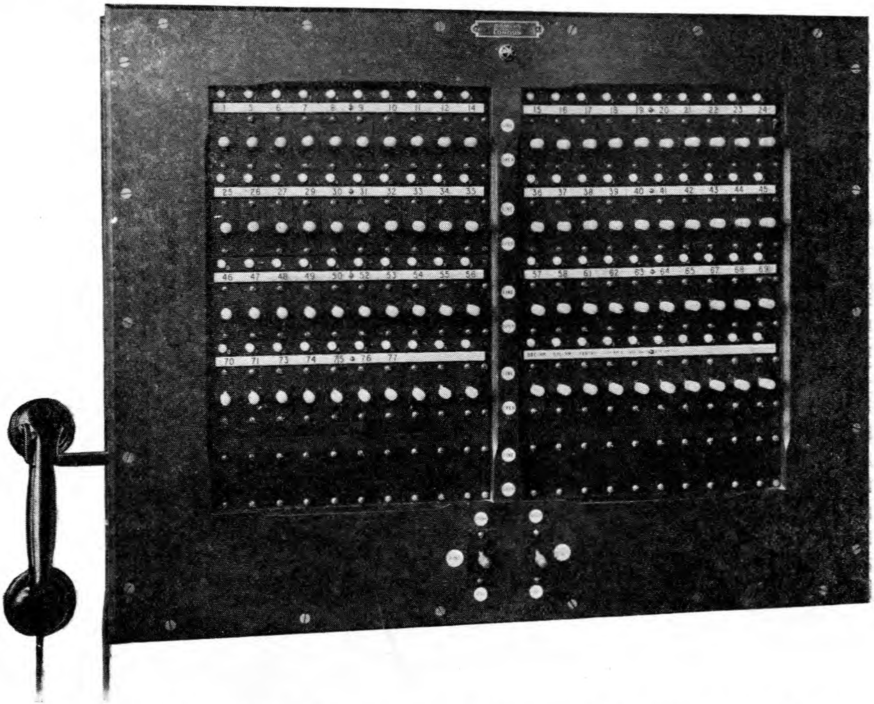


Fig. 5.—Switchboard, Equipped for 80 Lines with Capacity for 100 Lines.

Switchboard Equipment.

Fig. 5 shows the switchboard, equipped with 80 and having capacity for 100 lines. The dimensions of the case are 2 ft. 6 in. by 2 ft. by $7\frac{1}{2}$ in.; thus it occupies little space when fitted on the wall, projecting

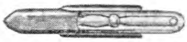


Fig 6.—SWITCHBOARD LAMP. Connections are brought out to metal strips which connect with lamp jack springs when inserted.

Fig. 8.—KEY IN LINE CIRCUIT. When thrown to "operator," connects attendant's telephone to line; when thrown to "line," connects line to speaking condition as in Fig. 4. The key will remain in either position until restored by the attendant.

Fig. 7. — LAMP CAP IMPROVES VISIBILITY OF SIGNAL AND, BY THE COLOUR, INDICATES THE FACILITIES ALLOWED TO THE ASSOCIATED LINE.

(measured over key handles) into the room just a little more than eight inches.

The calling lamps are of the low current consumption switchboard type (Fig. 6) and are inserted into lamp jacks, which are fitted with opal caps (Fig. 7). These opal caps not only improve the visibility of the signal but are supplied in various colours to indicate some facility or restriction.

For example: white caps, fitted on lamp jacks associated with visitors' room telephones, may mean no communication with any station except the main. Red opals (management lines), communication with any station. Green caps (staff lines), communication with other lines bearing similar coloured caps.

Lever type keys (Fig. 8) are employed for switching; those associated with the lines can be thrown in either direction and remain in position until restored. Between the lamps and keys are fitted designation strips carrying number plates suitably engraved to identify the line.

The supervisory or clearing lamp is fitted alone at the top of the switchboard while at the bottom are fitted a "Day and Night Bell" key and a "Speak and Ring" key. These two keys are single-throw; in the normal position the day bell and the attendants' speaking circuit are ready for operation.

The remaining equipment is housed inside the switchboard: three relays (one used as a retardation coil only), a 100-ohm resistance, induction coil, condenser, hand generator, trembler bell and a 3-ampere glass-covered fuse, in the battery circuit.

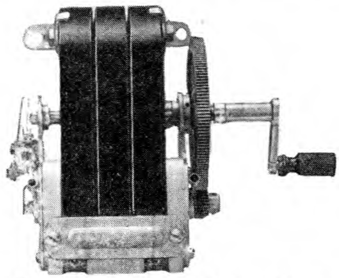


Fig. 9. — HAND GENERATOR WHICH SUPPLIES 75-VOLT 16-CYCLE CURRENT TO WHICH POLARISED RINGERS RESPOND.

The hand generator is fitted with three magnets (Fig. 9) and generates a 75-volt, 16-cycle supply for ringing the polarised ringers on the extension instruments.

The switchboard is hinged to swing out from the backboard when access to the wiring becomes necessary for any reason. The wiring is terminated on screw type terminals so that only a screwdriver is required to connect up new lines to the system. All internal wiring is soldered to tinned connections, and as the only flux used is pure resin, there is no possibility

Fig. 10.—WALL INSTRUMENT.

Fig. 11.—TABLE INSTRUMENT.

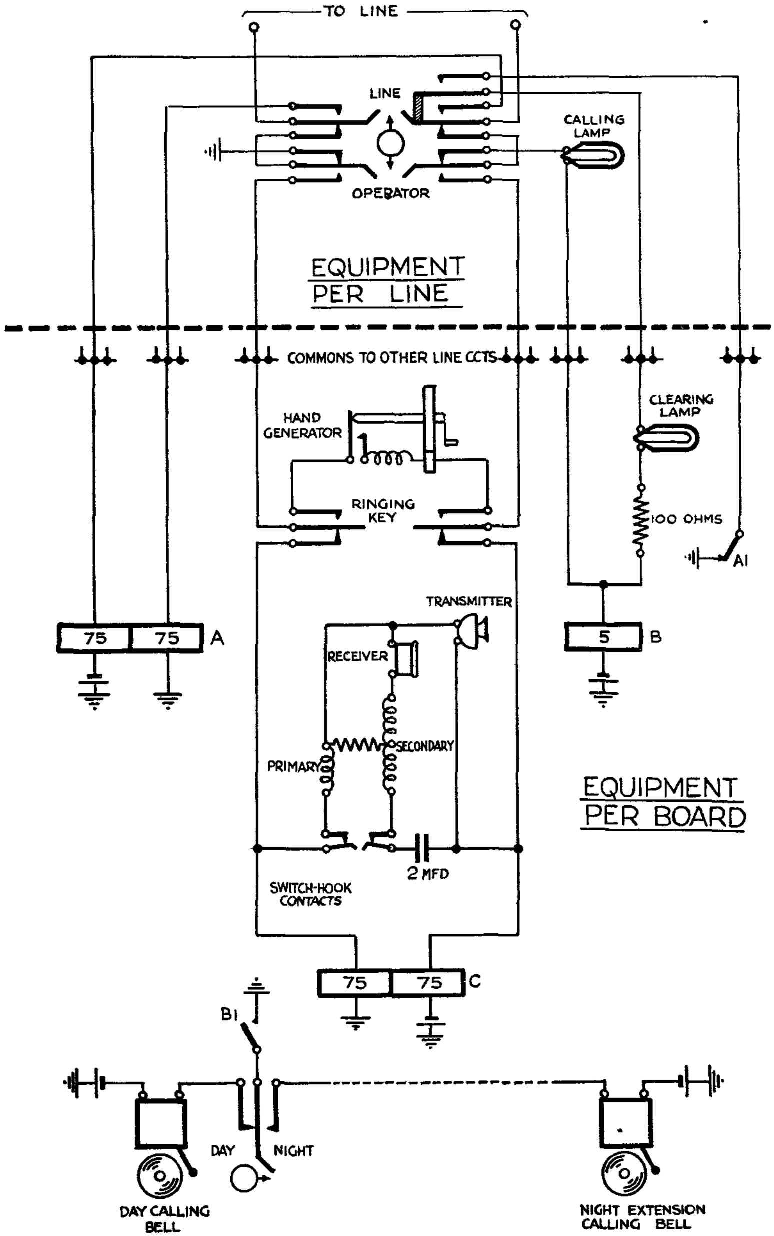


Fig. 12.—FULL CIRCUIT.

receiving a call the key of the calling line is thrown to "operator," extinguishing the calling lamp and disconnecting the call bell. Conversation now takes place between the attendant and the calling station as shown in Fig. 2.

Should the attendant require to call any station, the associated key is thrown to "operator" and the generator operated while holding the ringing key depressed. The action of the ringing key disconnects the attendant's telephone and the feeding coils from the line, switching on the hand generator as in Fig. 3. When the key is released it returns to the normal position, disconnecting the generator and reconnecting the attendant's telephone and the feeding coils to the line.

of bad joints developing through corrosion.

Full Circuit and Method of Operation.

Fig. 12 shows the full circuit, comprising the circuits in Figs. 1-4. On

The throwing of any two keys to "line" brings about the circuit conditions shown in Fig. 4, the glowing of the clearing lamp indicating when the conversation is finished and the receivers have been replaced.

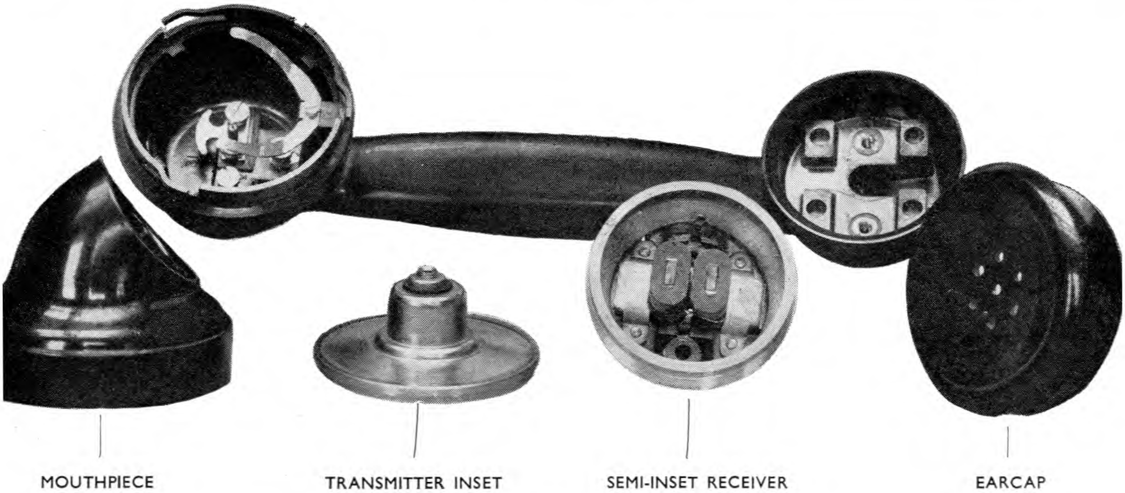


Fig. 13.—MICROTELEPHONE, SHOWING COMPONENT PARTS.

Neophone Instruments.

If telephonic communication is to be relied upon in lieu of natural conversation, speech must be of perfect articulation and good volume. To this end the Neophone instruments are used. Wall and table instruments of this type are shown in Figs. 10 and 11: the design of these instruments is a notable departure in style, presenting a pleasing appearance.

The use of bakelite moulded cases ensures a durability and permanency of finish unequalled by enamelled or lacquered metal. Two colours are standard, viz., black for offices and ivory for bedrooms, but cases may be had in a variety of colours to harmonise with decorative schemes.

The cradle is a point which has received much consideration; it is so designed that however carelessly the micro-telephone is replaced it will assume the correct position for operating the switch springs inside the case, thus obviating false signals so often caused by previous types of switch-hooks.

Transmitter.

The chief improvement in the micro-telephone itself (Fig. 13) has been effected in the transmitter (Fig. 14). The carbon electrodes are immersed in the carbon granules, ensuring that the correct pressure is maintained no matter in what position the instrument be held. The diaphragm has also been the subject of considerable improvement, taking the form of a thin but rigid cone to which is fixed the moving electrode. The lightness of the diaphragm causes it to respond more readily to the speech waves which impinge

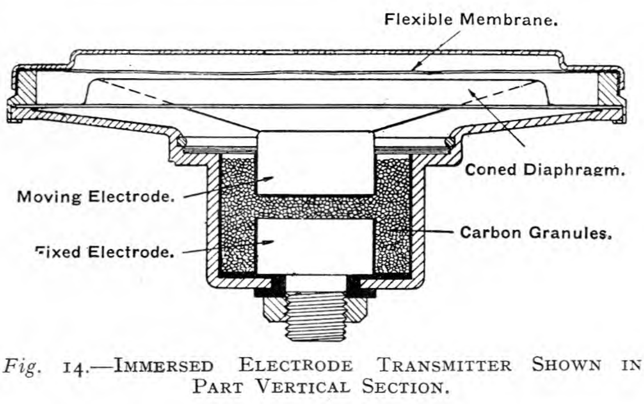


Fig. 14.—IMMERSED ELECTRODE TRANSMITTER SHOWN IN PART VERTICAL SECTION.

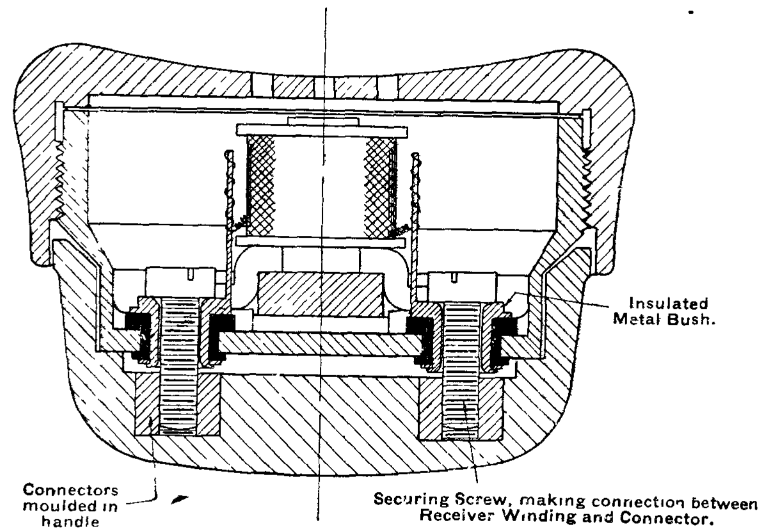


Fig. 15.—VERTICAL SECTION OF SEMI-INSET RECEIVER.

upon it, and this results in superior articulation. No mica diaphragm or rubber-tipped damping springs are necessary.

Receiver (Fig. 15).

The receiver is also of the semi-inset type, being secured in the receptacle by two screws, and is fitted with a Stalloy diaphragm. The earcap has a number of small perforations instead of the usual large central hole.

Side Tone and its Effects.

It will be noticed that, when using a high efficiency transmitter, the speaker's voice is unpleasantly loud in the associated receiver and that any noises in the room are picked up and distract attention from the received speech. This is called side tone.

The effect of side tone is twofold, the speaker subconsciously drops his voice until it sounds natural in his own receiver, thus reducing the volume of speech received at the distant station, and the presence of any noise in the room renders listening to received speech an unnatural strain.

Anti-Side Tone Induction Coil.

To overcome this defect an induction has been designed, which reduces side tone to a reasonable level. To eliminate side tone altogether is undesirable, as the effect of "deadness" causes the user to doubt the efficiency of the instrument and constantly to inquire if his message has been received correctly.

Instrument Circuit.

Fig. 16 shows the circuit of the Neophone instrument: with the receiver on the rest, only bell and condenser are in circuit ready to receive an incoming call. When the receiver is removed the switch springs operate causing current from the central battery to flow through one winding of the induction coil and the transmitter. The arrangement of receiver, induction coil windings, condenser and line may be regarded as an impedance bridge which is practically balanced when the source of current is the local transmitter but unbalanced when current is applied via the line.

Power Supply.

A central supply of twenty volts pressure is required to operate the com-

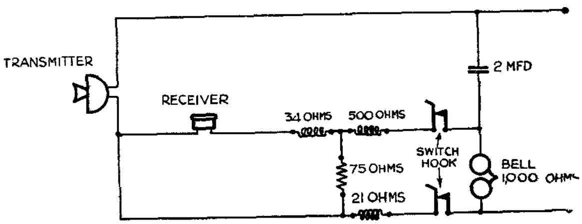


Fig. 16.—CIRCUIT OF TELEPHONE WITH ANTI-SIDE TONE INDUCTION COIL.

With the receiver on the rest, only bell and condenser are in circuit ready to receive an incoming call. When the receiver is removed the switch springs operate, causing current from the central battery to flow through one winding of the induction coil and the transmitter.

plete system for both speaking and signalling. Primary cells may be used for small installations, but for larger equipment a battery of secondary cells or a battery eliminator of the "Transrecter" type is preferable.

Wiring Between Switchboard and Extensions.

Two wires only are required between the switchboard and each extension but for large installations it will be found preferable to run multi-pair cables of appropriate size to junction boxes situated in convenient places for distribution points, and to run pairs from the boxes to the adjacent stations, in accordance with the usual telephone practice.

Simplicity of Operation.

It will be appreciated that to call the attendant involves no more effort than pressing a bell push, while the quality of speech afforded by the instruments eliminates the possibility of misunderstandings and errors.

A skilled telephonist is unnecessary; any of the service staff should be able to operate the switchboard correctly and speedily.

Reliability.

It will be realised from a study of the circuits that there is little possibility of breakdown; all redundant facilities have been ruthlessly pared away leaving only the essentials. The apparatus used throughout is of sound design and robust construction.

First Cost.

The system is economical to install, no selecting devices or speaking batteries being used at the extensions and no multiple cable between stations is required.

The switchboard apparatus has been reduced to the least possible, compatible with the facilities afforded.

Running Costs.

The absence of speaking batteries at the extensions, and plugs and cords at the switchboard, removes those items which experience has shown to be the heaviest in running costs. Indeed, maintenance is practically reduced to periodic visits to the stations to ascertain if any damage has been done by the temporary users.

Ease of Extension.

Equipment for ten lines may be added at any time with little or no detrimental effect to the service enjoyed by existing lines during extension.

Designed by a Famous Firm.

The Neophone system described above has been designed by the well-known telephone engineers, Messrs. Siemens Bros. & Co., Ltd., to whom we are indebted for the loan of several of the illustrations accompanying this article.

ELECTRICITY IN MYSORE

One of the highest waterfalls in the world is to be harnessed to provide electric power for the working of the mines of Mysore. This is the Gersoppa waterfall, a vertical cataract of 960 ft.

Although the undertaking will be an ambitious one, Mysore has had great experience of hydro-electric development. Since the initial installation at Cauvery in 1902 no less than six further installations have been carried out. With the recent completion of the seventh installation, the electrical energy generated amounts to 46,000 h.p. The eighth installation is now being installed to increase still further the total output and to meet the future demands.

The free use of electrical energy for many industrial undertakings has been very marked. There are now many small equipments for pumping from wells for irrigation, fruit gardens and other activities. The demand is not confined to the large cities of Mysore and Bangalore alone, but rural electrification is making rapid progress.

A Buttonhole Microphone

WE are living in what may be termed the "Microphone Age." In the home, entertainment is derived through the medium of the Radio microphone. At the Cinema, the microphone again takes a prominent part in film production. At Greyhound tracks, Speedways, Dance halls, Concert halls, large restaurants and Meeting houses, microphones are always to be found with attendant amplifying equipments and loud speakers. In one large hotel a microphone is used for the purpose of calling cars from a car park. At out-door pageants and ceremonies, the microphone not only enables announcements to be made audible, but also permits the same gathering to be entertained with band music which would otherwise be almost inaudible.

THE IGRANIC BUTTONHOLE MICROPHONE AS WORN FIXED IN THE LAPEL OF THE JACKET.
This is specially suitable for public address, theatre and cinema work, where a speaker or singer wishes to move about whilst addressing or entertaining the audience.

Many microphones used are of the suspended type, usually provided with a floor or table stand, but a recently developed design is the "Igranic" buttonhole microphone, which is specially suitable for public address, theatre and cinema work, where a speaker or singer wishes to move about whilst addressing or entertaining the audience.

Carried in Lapel of Coat.

As this microphone is usually carried in the lapel of the coat, it is out of the direct speech ray, but the voice is transmitted without any variation due to movement of the speaker.

This buttonhole microphone, which is of the transverse current type, is extremely sensitive and capable of responding equally to sound waves of all frequencies, with complete freedom from background noises. The diaphragm is constructed of specially treated mica so that the life of the microphone is practically infinite.

Energising Current from Dry Cells.

The impedance is 450 ohms, and can therefore be used with a coupling transformer, having a primary impedance of from 750 to 1,000 ohms at 100 cycles per second, and a step-up ratio of between 7 to 1 and 30 to 1. It is of course necessary to provide energising current, and this can be supplied from dry cells. The microphone will operate satisfactorily with pressures ranging from 2 to 15 volts.

Control Unit.

It is important that the means of

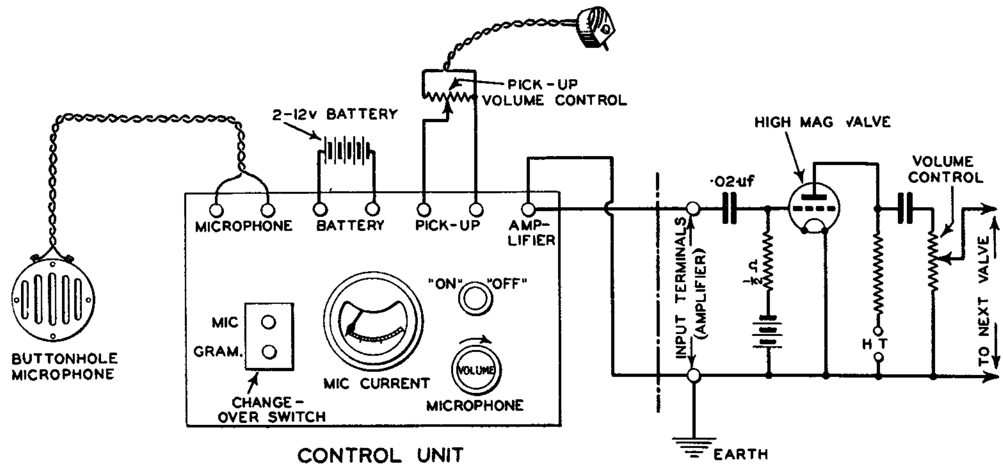


Diagram showing External Connections to Igranic Microphone Control Unit.
Also showing method of connecting source of input circuit of a low frequency amplifier.

coupling the microphone to its associated amplifier should be of the highest order of efficiency so that it will be capable of preserving the true frequency response of the microphone. For this purpose a microphone control unit has been developed, and while its use is not absolutely essential to the good performance of the microphone, it is recommended in all cases where the very best possible results are desired.

The microphone control unit consists essentially of coupling transformer, a milliammeter, a volume control, the necessary control switches and connecting terminals.

The milliammeter serves to indicate the amount of energising current taken by the microphone, the current being controlled by an " on " and " cff " switch.

Pushbutton Switch for Quick Changeover.

A pushbutton switch is provided to effect a quick changeover from microphone to any other associated equipment such as a gramophone pick up, or other sound producing device as required, the necessary terminals being provided for easy connection. The method of connecting up the microphone control unit to the input circuit of a low frequency amplifier is shown in the circuit diagram.

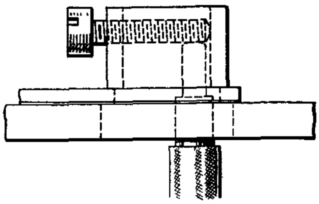
Input Transformer for Coupling Microphone to Amplifier.

If the microphone control unit is not employed it is necessary to provide a suitable input transformer for coupling the microphone to the amplifier. This transformer should have a primary winding having an impedance of approximately 1,500 ohms, at a frequency of 50 cycles and a ratio of the order of 10 to 1 or higher.

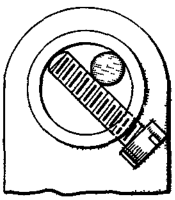
FAULTS IN LIGHTING AND POWER INSTALLATIONS

By H. W. JOHNSON

"FAULTS" which occur on lighting and power installations may be due to bad workmanship, faulty materials, overloading the consuming devices, inefficient maintenance, deterioration of the installation, and unsuitable working conditions.



A BAD CONNECTION BETWEEN A SINGLE WIRE AND A TERMINAL. The wire has been cut off short.



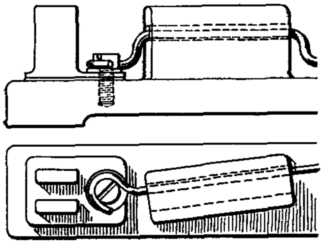
A BAD CONNECTION BETWEEN A SINGLE WIRE AND A TERMINAL.

A large number of these "faults" are constantly recurring on installations, and they may be reduced to a minimum by careful workmanship and an efficient system of maintenance.

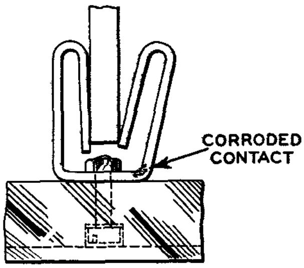
FAULTS ON LIGHTING INSTALLATIONS.

Open Circuit "Faults."

At the terminal connections of switches, the bared ends of the wires are cut off short and cannot be gripped by the binding screws, or if the bared end is long enough, but of small diameter, the end of the binding screw pushes the wire between one side of the terminal entry hole and the side of the screw when it is tightened up.



A FUSE WHICH IS NOT WOUND ROUND THE TERMINAL SCREW IN THE CORRECT DIRECTION AND PLACED UNDER THE WASHER IS LIABLE TO BE PUSHED AWAY FROM THE SCREW, WHEN THE SCREW IS TIGHTENED UP. The result is an "open" or imperfect circuit.



A CORRODED CONTACT OF A FUSE BASE OR SWITCH IS A FREQUENT SOURCE OF HEATED CONNECTIONS AND LOSS OF PRESSURE IN A CIRCUIT.

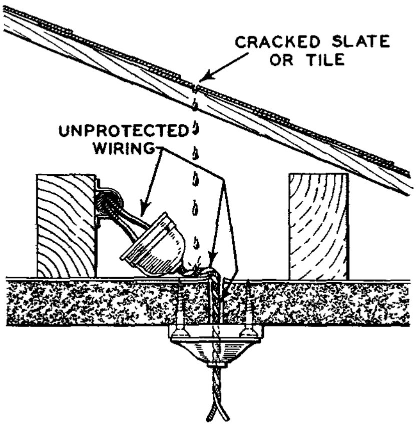
This fault may not have any immediate effect when the installation is new, but in time the wire becomes oxidised, and the lighting on this circuit will be intermittent, until finally the circuit will be "open." Arcing may be set up inside the terminal entry hole, which may have disastrous results.

A fault of this nature may be prevented by taking these precautions:—

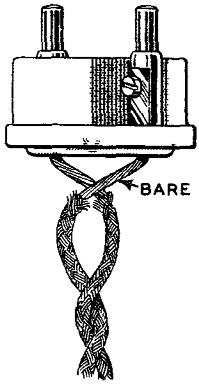
Strip off sufficient insulation from the ends of the wires to allow of the bared ends to pass through to the front of the terminal hole, cutting off any excess wire flush with the terminal. Single wires of small diameter should have sufficient insulation removed from the ends to allow of the bared ends to be bent back so as to form a double wire in the terminal hole. Secure the wires to the terminals with the binding screws before screwing the switch base to the fixing surface, so that connections may be tested by pulling at the connecting wires.

Imperfect Fuse Connection.

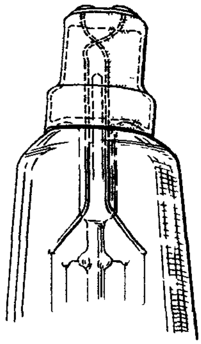
The end of the fuse is not bent round the stem of the binding screw in the direction in which the screw is tightened up, and the wire not gripped between the washer and



Unprotected Wiring in a Roof is Liable to "Drip" and Damage from Vermin, and is a Frequent Source of Fires Starting in the Roofs of Buildings



A Short - Circuit Produced by Careless Wiring of Flexible to a Lampholder.



The Lead - in Wires from the Lamp Filament to the Contact Plates may be "Short - circuited," if the Cement Connection of the Bulb to the Brass Top is Broken.

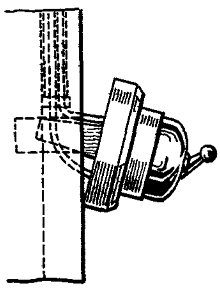
terminal plate. When the screw is tightened up the end of the wire is pushed away from the stem of the screw.

Damaged Fuse.

A soft metal fuse is sometimes cut through by the edge of the washer when the terminal screw is tightened up, and it is always advisable to examine the fuse for this fault, after replacement.

Corroded Fuse or Switch Contact.

Faults of this nature are liable to occur when switches and distributing boards are fixed in damp situations or in close proximity to gas stoves. When the switch is closed, theblade does not make good contact and an open circuit often results. A similar fault will occur if the fuse or switch contacts are not properly adjusted; they should be inspected periodically and adjusted when necessary.



Insecure Fixing of a Switch Due to a Badly Fitted Plug is a Source of Danger.

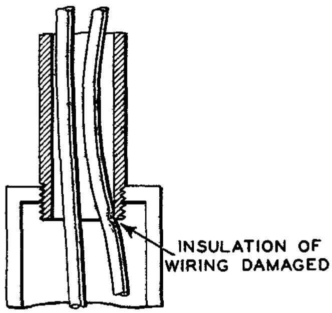
Arcing at Switch Contacts.

A broken spring in the quick make and break action of a switch will cause arcing at the contacts when the switch is operated; this fault is also liable to cause the switch blade to fall into the contacts and complete the circuit when it is not required.

SHORT CIRCUIT FAULTS.

Unprotected Wiring in Roofs.

This fault is a fruitful source of a fire. Unprotected wiring in a roof is liable to attacks from vermin, and may also become soaked with moisture if there is a leaky roof. A short circuit may eventually occur, especially if flexible is taken into the roof. A fault of this description is often not discovered until a fire has been started. If the conduit system of wiring is employed, the conduit should be continuous

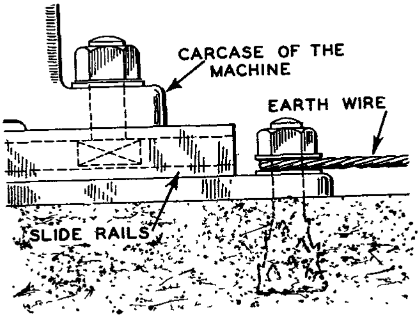


Neglect to Fit Tube Ends on Conduit May Cause the Insulation of the Wiring to be Damaged and an "Earth" at this Point will be Produced.

through to the back of the pateras, fixed at the light position. Under no circumstances should ordinary flexible wire pass through the ceiling into the roof for connection to the circuit wiring. If a ceiling rose cannot be used for making the connection on the ceiling, then a special pateras fitted with porcelain insulated connecting terminals should be secured to the ceiling and be used for making the connection.

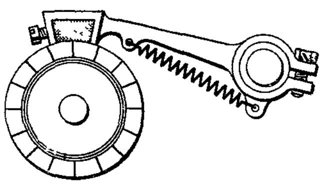
Faulty Flexible Pendants.

When the insulation has been stripped from the ends of the flexible for too great a distance, the bared wires of opposite polarity may come into contact at the back of the porcelain or bakelite interior of the lampholder, and will produce a short circuit. This fault will be prevented if the insulation is not removed beyond the terminals.

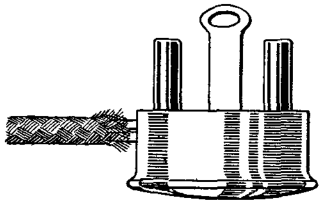


The Earthing Wire is Connected to the Slide Rail Fixing Bolt without Using a Cable Lug to Make the Connection, Also There May be an Imperfect Connection with the Carcase of the Machine if the Slide Rails are Coated with Rust or Oil.

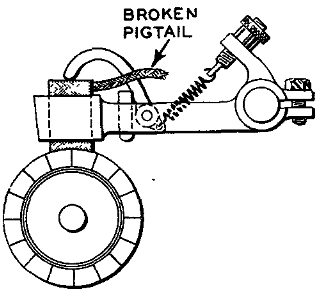
An inefficient cord grip may cause the ends of the flexible to be pulled out of the terminals by the weight of the reflector or shade, and cause a " short " or an open circuit.


Neglecting to Replace a Worn Brush on Finger Type Brush Gear will Cause the Brush Holder to Come in Contact with the Commutator and Produce Serious Flashing, which will Badly Score the Surface of the Commutator and Destroy the Brush Holder.

A broken flexible is often caused by excessive strain and improper treatment when an electric iron, vacuum cleaner, or other portable appliance is connected to a lampholder with an adaptor. Portable appliances should always be connected to the supply through a plug and socket. A short circuit may be caused by the bared ends of the flexible projecting too far above the terminals; stray ends of opposite polarity may easily come into contact with each other.


Frayed Braiding of the Flexible at the Point of Entry to a Plug Top Will Cause the Cores to be Exposed and Subject to Damage which May Eventually be the Cause of a Short Circuit.

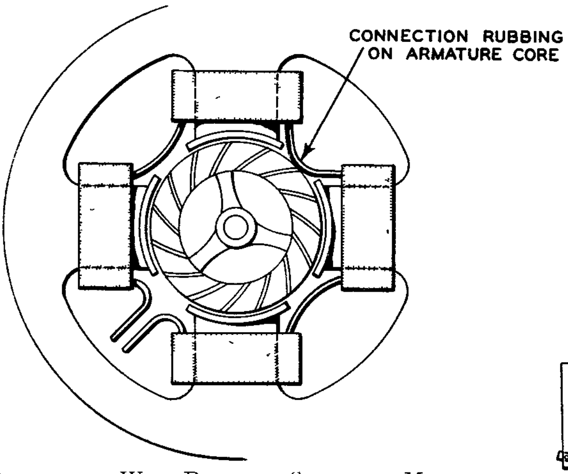
Surface leakage may occur on flexible pendants which are fixed in damp situations if the cotton braiding is not secured by a whipping of thread at the terminal connections so that the rubber insulation separates the braiding from the terminals. A shock may easily be obtained when the flexible is handled if the surface leakage occurs.



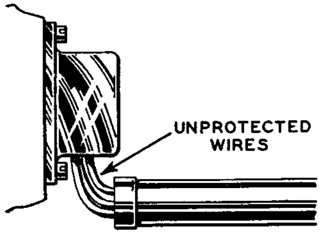
A Broken Brush Pigtail will Cause the Brush to Get Hot and Sparking Between the Brush and Commutator of the Motor will Result.

" Earthed Wiring " on Lighting and Power Circuits.

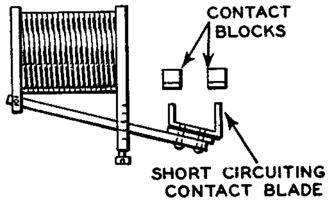
This fault is often due to the insulating covering of the wires being damaged when they are drawn into conduit. Conduit outlets, which are not fitted with bushes, may have sharp edges which penetrate the insulating covering and make contact with the bared wires. The same damage may be done by the



CONNECTING WIRE BETWEEN COILS OF A MOTOR RUBBING ON THE ARMATURE COIL WILL CAUSE AN "EARTH."



UNPROTECTED WIRING AT THE TERMINAL BOX OF A MOTOR SHOULD BE AVOIDED.



A MOTOR WILL NOT BE PROTECTED BY THE RELEASE COIL IF THE CONTACT BLOCKS ARE DIRTY OR CORRODED.
The resistance of the short-circuit path between the blocks and the contact blade is too high to de-energise the no volt release coil.

sharp edges of inspection fittings and metal covers of ceiling rose and switch boxes. Removing the insulation for too great a distance at terminal connection to switches and other accessories may cause the bared wires to come into contact with the metal cases of these accessories. Frequently wiring is "earthed," due to surface leakage at terminal connections, when conduit and metal-cased accessories are fixed in damp positions. Under these circumstances it is advisable to make periodical insulation tests. The surface leakage may be reduced by sealing up all the conduit outlets and cable entrance holes to the accessories immediately after making the terminal connections.

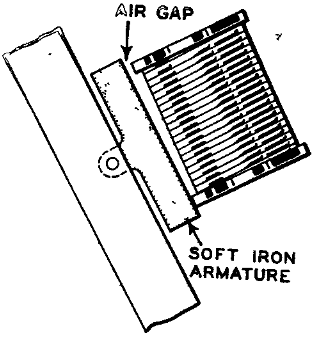
Imperfect Earthing of Metal-sheathed Wiring and Ironclad Switchgear and Accessories.

Neglecting to use a proper earthing clip for the "water main" earth connection and metal sheathing of the wiring, also failing to clean the surface of the water pipe and sheathing, will often produce an imperfect earth. This may allow a high resistance earth on the system. This type of earth is dangerous, as the leakage current is insufficient to melt the fuses, and may be the cause of someone receiving a severe shock. Dirty terminal connections at the terminal boxes and brush gear of motors are frequently the cause of "earths." Periodical cleaning and removal of dirt will prevent this occurring.

A leaky bearing of a motor may produce an accumulation of oil inside the carcase, and any V.I.R. cable connections which are in contact with the oil inside will in a short time be earthed to the carcase, owing to the destructive effect of oil on vulcanised rubber.

Sparking at the Brushes of Motors.

There are several causes which will produce this fault; brushes which do not work freely in the holders, due to dirt, insufficient tension of the brush springs, and "pitted" contact surfaces, are frequently the cause. Neglecting to replace a worn brush will produce serious sparking and severe scoring of the commutator, especially if the brush holder is of the finger type. A worn brush fitted into this type of brush holder will allow the metal edges of the holder to come into



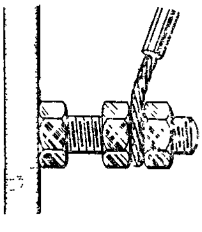
A Motor Starter Arm Cannot be Held Over in the Running Position by the Magnetic Attraction of the no Volt Coil if There is an Imperfect Magnetic Circuit Between the Poles of the Coil and the Soft Iron Armature.

actual contact with the commutator bars, and may cause permanent injury to the commutator. A regular system of maintenance should be instituted to prevent this type of fault.

Commutator Faults.

Short-circuited commutator segments are often caused by the accumulation of copper dust on the mica insulation, especially if the mica has been undercut too deeply. Continual cleaning of the commutator with a piece of carborundum cloth will accelerate this. Under normal circumstances the commutator only requires the application of cloth moistened with paraffin oil to clean it, afterwards moving all traces of the oil with a clean soft cloth when the dirt is removed.

" Flats " on commutators are often developed by continued sparking at the brushes. The only permanent cure for this fault is to skim up the surface of the commutator, taking care to remove all burrs and copper dust before placing the machine in commission again.



The Omission of a Cable Lug when Making Connection Between a Stud and a Cable May Cause Excessive Heat at the Point of Connection and Loss of Power in the Circuit.

A defective micanite V ring is often the cause of an "earthed" commutator. An accumulation of metallic dust on the edges of this ring will earth the commutator, and only strict attention to cleanliness will prevent this fault.

" Earthed " Field Magnet Windings.

Defective insulation of the magnet coils, caused by deterioration after long use and careless assembling of the coils on the magnet poles, is a frequent source of this fault. The defective magnet coil must be removed and reinsulated.

A magnet coil connecting wire which is too long will sometimes come into contact with the rotating armature core, and in time the insulation of this wire will be damaged, causing the bared wire to come into contact with the core.

" Earthed " and Short-circuited Armatures.

Usually deterioration of the insulation of the armature coils and core slots is the cause of this fault, but it is often accelerated by the continuous overloading of the machine. The fault should be located by taking a " bar " to " bar " test for " short-circuited coils," and an insulation resistance test for " earths."

When the fault is due to continuous overloading, the whole of the armature coils may have to be renewed.

Motor Starter Faults.

Dirty and burnt contact studs are caused by an imperfect starter arm contact blade. The spring of this contact blade may have been damaged by the heat produced by the arcing at the contact studs, and a good rubbing contact between the blade and the studs is no longer obtained.

The starter arm remaining in the running position when the motor is stopped may be caused by a weak spring, or insufficient lubrication of arm spindle.

Failure of the no volt release coil to hold the starter arm in the running position may be due to imperfect contact between the soft iron armature of the starter arm and poles of the no volt coil.

Mechanical Faults of Machines.

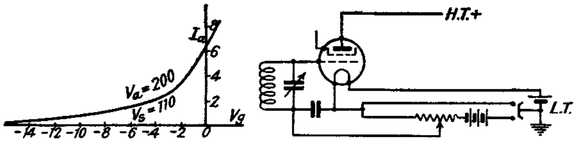
Fracture of the commutator risers is often due to excessive vibration. An unbalanced armature or insecure bolting down to the slide rails may cause this.

A worn bearing bush will often cause the armature core to rub on the pole shoes. Hot bearings may be due to wear, oil rings not working, and dirty or spent oil. The bearings should be cleaned out once a month, and the oil renewed.

Practical Uses of Some Recently Introduced Valves

By " Omicron "

THERE have been such rapid developments in valve design recently that the average amateur has not had time to keep pace with them, and it is thought that a revisionary article would be of interest.

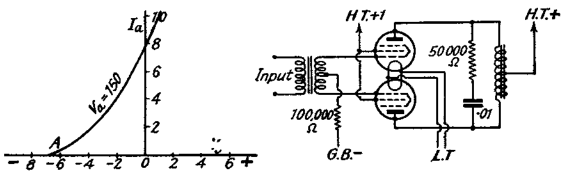


The Variable-mu Valve.
Showing on the left how the control grid is arranged to tail off the anode volts/grid volts curve; and on the right a practical application of this valve

We have now available: Variable-mu valves, Q.P.P. systems, Class B, double diode triodes, single diode tetrodes, H.F. pentodes, and pentagrid valves, all of which have been introduced in this country in recent years.

The Multi-mu Valve.

The first of these, the variable-mu valve, is a normal screened grid, with the control grid arranged to tail off the anode volts/grid volts curve, as in the diagram.

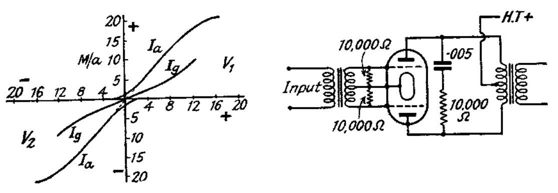


The Quiescent Push-pull System.
The two valves are biased down to the bottom bend in their characteristic as at point A on the left. A typical circuit is shown on the right.

This can be done by several methods, one of which is by tapering the control grid winding, and another by displacing or removing one or two turns. It can be seen from the curve that as the bias is increased, the point of application of the signal is moved along the grid base, and the sensitivity of the valve is reduced by a logarithmic ratio. This, then, becomes an ideal method of volume control, as the sensations to the ear also follow a logarithmic law. There is also the advantage that H.F. overloading and consequent cross modulation is avoided. A circuit is given showing the practical application of this valve.

Q.P.P.

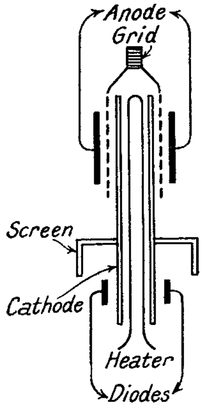
In quiescent push-pull systems the two valves are biased down to the bottom bend in their characteristics (point A). Each valve amplifies one-half cycle, the rest current of the other being extremely low. As the whole of the grid base of one valve is available for the amplification of one-half cycle, the working grid base is doubled, and, therefore, a 9 : 1 or correspondingly high ratio transformer may be used to load up the valves. This system, with two pentodes, can give a reasonably large output sufficient for a moving coil speaker.



Class B—A Development of Quiescent Push-pull.
The curve on the left shows the variation in anode current with grid current. The method of connection is given on the right.

Class B.

This is a development of the Q.P.P. system, but is distinctive in that the grids are driven positive, the anode currents being proportional to



ARRANGEMENT OF ELECTRODES IN A DOUBLE DIODE TRIODE.

the variations in grid signal voltage. As the grid current in this system is of a comparatively high order, it is necessary to utilise an intervalve transformer having a low secondary D.C. resistance, usually not more than 400 ohms. A driver valve is used in conjunction with the special transformer in order that the grids may be fully loaded. The anode (plate to plate) load is convenient, being approximately 8,000 Ω to 14,000 Ω. Both anodes are enclosed within the same bulb, and speech outputs of up to 2 watts or more can be obtained. An Ia/Ig curve is illustrated on previous page, showing the variation in anode current with grid current, and a circuit diagram is given, showing the method of connection.

Double Diode Triodes.

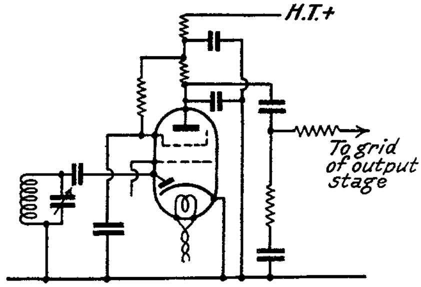
The double diode triode is actually two valves in one, the upper half consisting of an ordinary triode, and the lower half of two small diodes, screened from the triode portion. The uses of this valve are many and varied. The diodes may be used to provide full wave rectification, with the triode as an amplifier, or one diode may be used for half-wave rectification, and the other for delayed and amplified A.V.C. A sketch is given of the arrangement of electrodes within the valve. The method of connections for automatic gain control may be the subject of a later article.

Single Diode Tetrode.

The lower half of this valve consists of a single diode, which may be used for half-wave rectification. The upper half is a tetrode, or screen grid, used as an L.F. amplifier. The valve may be R.C. coupled to the next stage, as in the diagram.

H.F. Pentodes.

L.F. pentodes have, of course, been in use some time, but their necessarily high impedance has been a problem for H.F. stages. High frequency pentodes are a natural development of screen-grid valves, the negative resistance kink in the curve being straightened out by the introduction of a third or suppressor grid. Amplification factors up to 5,000 or more are available, and high stage gains become possible. The grid base may also be

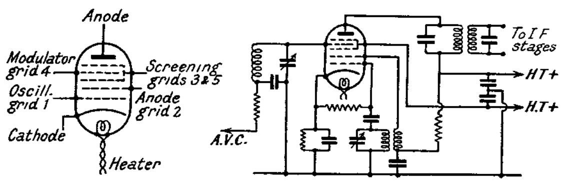


HOW A SINGLE DIODE TETRODE MAY BE RESISTANCE-COUPLED TO THE NEXT STAGE.

made wider, enabling a larger signal to be handled, and the variable-mu characteristic retained, thus facilitating automatic gain control systems.

Pentagrids.

Pentagrids, or five-grid valves, are used as frequency changers in superheterodyne receivers. They have the great advantage that aerial radiation and interaction between tuning circuits is avoided, the mixing being electronic. Within the single envelope the valve electrodes perform the dual function of a triode oscillator and a variable-mu first detector. A diagram of connections is given, and also the electrode layout. The efficiency of this method of frequency changing is equal to the standard methods, whilst the interaction between circuits is avoided.



A PENTAGRID VALVE WHICH IS USED AS A FREQUENCY CHANGER IN SUPERHETERODYNE RECEIVERS.

CABLES USED IN WIRING WORK

THEIR DESCRIPTION AND CLASSIFICATION

By D. WINTON THORPE, A.M.I.E.E.

ALL cables used in wiring installation work have to satisfy three broad conditions. They must carry the current adequately. They must ensure that the current is retained in the conductor and is not allowed to stray into the other conductor or to earth. And, finally, they must, in most cases at least, be protected against mechanical injury. The first requirement is comparatively easily dealt with, since, to all intents and purposes and, so far as the scope of this article is concerned, all conductors are made of copper, which is the best available conducting medium for electricity. The second requirement, that of what is known as insulation, is capable of considerably more discussion; while the third requirement, that of protection against mechanical injury, is again of considerable importance.

The Registered Classifications of the C.M.A.

If, in what follows, I appear to lay rather great stress on the registered classifications of the C.M.A., their standards and their nomenclature, it is because by their co-operative effort they have achieved a unique position in the classification and description of cables; and there can be little dispute as to their reasonable claims to have laid the foundation stone of cable manufacture in this country. Other firms, not members of the Association, may or may not make cables so good in quality as the C.M.A., but they at least have the wisdom in most cases to flatter the Association by claiming equality of standards.

Vulcanised India Rubber.

Of all insulating materials used in circuit cables for wiring work, rubber and its compounds are by far the most important. Now pure rubber, though an admirable insulator, has certain disadvantages when used entirely for the insulating of cables. In the first place it is apt to absorb moisture, which is itself an enemy of insulating properties. In the second place it is not very robust or durable. In fact, therefore, the bulk of the rubber covering forming the insulation of a cable is vulcanised india rubber (hence the initials V.I.R.). Vulcanised india rubber gives a completely waterproof coat and is tougher and more appropriate to its particular use.

What would happen if only Vulcanised India Rubber were used.

If, however, we were to use vulcanised india rubber entirely as the insulation of the copper conductor, certain difficulties would present themselves. The sulphur contained in the vulcanised rubber would tend to set up chemical action between itself and the conductor; in addition, the vulcanised rubber would be apt to contain impurities and imperfections, owing to the process, and also there would be practical difficulties in the way of applying this form of insulation to the wire.

The Solution to the Problem.

Therefore, the solution to the problem has been found in the provision, first of all, of a layer of pure rubber, coated over again with vulcanised india rubber. In the case of what is known as V.I.R. cable we have outside this layer of vulcanised india rubber a spirally wound tape upon which is marked, in the case of all cables manufactured by the C.M.A., and by most other manufacturers, the type and maker. This is most important as the ordinary individual can very rarely tell merely by looking at it what type of cable it may be, or what the quality is. The tape referred to presents these facts in an unequivocal manner. Outside this tape again is the braiding of black or red, or the tough rubber sheath, or the lead sheath.

The difficulties of applying vulcanised india rubber direct to the conductor, which I have dealt with, have been largely overcome in recent years by the chemists and there are now available for use types of cable which, though in many respects similar to the ordinary V.I.R., dealt with above, do not have the layer of pure india rubber next to the conductors, but are insulated throughout with a rubber compound the exact chemical composition of which is immaterial to this article.

Various Types of Rubber-Insulated Cables.

Perhaps we might now turn to the nomenclature adopted by the C.M.A., for various cables, and I think I cannot do better than start by presenting a table of various types of rubber-insulated cables which are manufactured, leaving comment on these cables until later. The space at my disposal is not large enough to treat in detail of the actual specifications to which the various classes of cable are made, but it must be evident to anyone who realises what a large number of cables are available that some standard system of naming the various categories into which they fall must be adopted for the purpose of simple yet definite specification.

1. C.M.A. (Regd.) Cables.
   (*a*) 2,500 Megohm Grade.
   (*b*) 600 Megohm Grade.
2. Nonazo (Regd.) Cables.
   600 Megohm Class.
3. Vicma (Regd.) Cables.
   (*a*) Nominal 2,500 Grade.
   (*b*) 600 Megohm Grade.
4. Vinazo (Regd.) Cables.
   600 Megohm Class.
5. Cables not made by members of the C.M.A., and therefore not officially classified in these categories.

The categories referred to above have been numbered for the sake of easy reference, but it must not necessarily be supposed that the numbering represents the relative order of quality.

C.M.A. (Regd.) Cables.

At the top of the list we have C.M.A. (Regd.) Cables. It is very important—and this has been the subject of litigation—to appreciate the fact that C.M.A. (Regd.) Cables represent an actual standard of quality and are not merely a description of the cables manufactured by members of the Cable Makers Association. This class is divided into two grades known as 2,500 megohm grade and 600 megohm grade, again with emphasis on the use of the word " Grade," for it is only in C.M.A. (Regd.) cables and in the case of No. 3, " Vicma," that the word " Grade " is used in describing the sub-category of insulation resistance into which the cables fall. In other words, the use of the word " Grade " after the megohm reference implies, even though it is not otherwise specifically stated, that the cables are C.M.A. (Regd.) Cables or "Vicma."

" Nonazo."

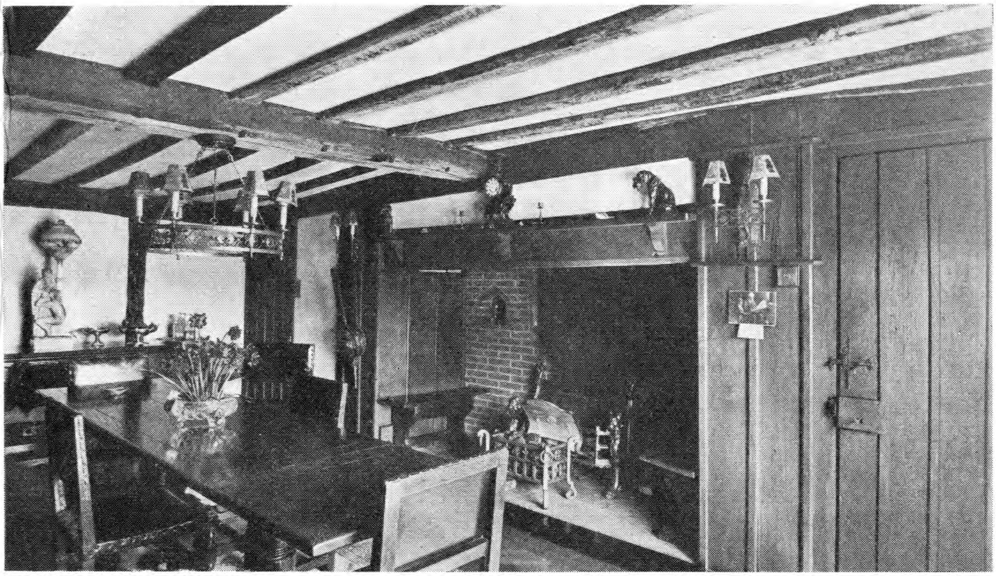
Category No. 2, " Nonazo," which is a registered name given to what used to be termed Non-Association Class, refers to cables which, though manufactured by the same manufacturers as the C.M.A. (Regd.) Cables, are not manufactured to the same high standard or with quite the same degree of perfection of materials.

" Vicma."

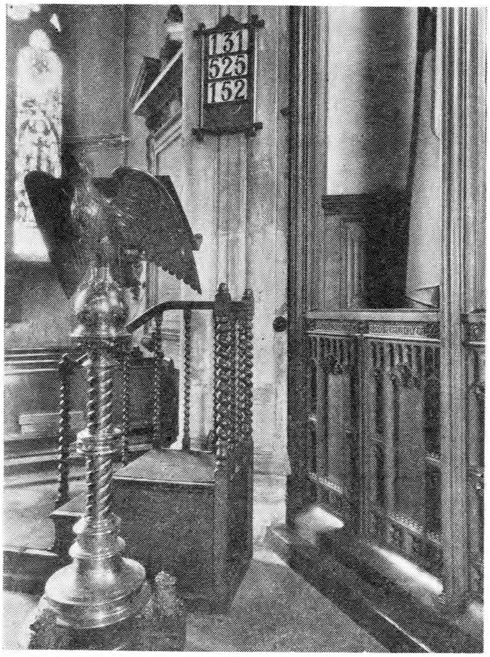
Category No. 3, " Vicma "—it will be noticed that the initials " C.M.A." are brought into this registered name, implying that they are of the highest class and therefore entitled to use the word " Grade " after the insulation, classification—are cables manufactured specially for positions where the use of pure rubber would not be practicable. In conditions where the heat is excessive, such as in the tropics or in a boiler-house, it is found that a compound of rubber is more durable and therefore more generally efficient.

" Vinazo."

Category No. 4, " Vinazo," bears the same relation to " Vicma " as " Nonazo "



AN EXCELLENT EXAMPLE OF INCONSPICUOUS SURFACE WIRING (HENLEY'S WIRING SYSTEM) IN THE DINING-ROOM AT FINCHURST FARM, NEAR GOUDHURST.



SURFACE WIRING NEED NOT BE UNSIGHTLY.

The wiring of a church for electric lighting calls for special consideration. An unsightly appearance of the finished work would not be tolerated, but on the other hand, it is usually not practicable to cut chases in the carved and fluted portions of the structure. These two pictures show what can be done in the way of inconspicuous surface wiring by using the Bondit wiring system (Henley's). On the left is St. Peter's Church, St. Albans, and on the right is Coulsdon Church.

How to Tell the Grade of a V.I.R. Cable.

In the case of vulcanised india rubber cable, there is outside the layer of vulcanised india rubber a spirally wound tape upon which is marked the type and maker. This applies to all cables manufactured by members of the C.M.A. and by most other manufacturers, and enables one to tell at a glance what type of cable it may be, and what the quality is.

does to C.M.A. (Regd.) Cables. It will be noted that it is termed 600 megohm *Class* and not Grade.

Cables not Made by Members of C.M.A.

Finally, we have category 5, which so far as quality goes may more or less repeat the original categories, but is intended to cover all these cables made by manufacturers who are not members of the C.M.A., and who therefore cannot make use of the registered classifications, though they are entitled to manufacture cables to the same specifications. It is found in very many instances that they do at least claim equality by the use of such phrases as "equal to C.M.A. 2,500 megohm grade."

A GUIDE TO THE USE OF THE VARIOUS CABLES.

To arrive at a rough and ready guide as to the use of the various cables in the first four categories (for Category No. 5 must stand on its own legs and more or less follows the lines of cables in 1, 2, 3 and 4) it would be reasonable to make a decision along the following lines:

C.M.A. (Regd.) Cables, of 2,500 megohm grade, that is 1(*a*), are the best cables made. They should be used where there is any special stress of circumstances demanding nothing less than the highest quality or, alternatively, where a customer with money to spend has asked for the best. If a certain amount of saving to the customer's purse is a reasonable consideration, and yet if the quality of the cable is to be definitely good, 1(*b*) 600 megohm Grade C.M.A. should be used.

Points that Determine Choice of Cable.

It is, unfortunately, quite impossible to lay down the law as to the use of C.M.A. cables in terms of localities or types of jobs. The difference between the two grades is such that one's choice must rest on arriving at a nice balance between what the customer can afford and the performance which is required of the cable. One would like to state unequivocally that 2,500 megohm grade should always be used. But so would one like, perhaps, to suggest that the most expensive grade of petrol should always be used in a motor-car. Neither of these two counsels of perfection can exactly be followed.

A Useful Guide.

It is sometimes possible to get some sort of a guide to these matters by what other trades are putting in. In a building where specially expensive bricks are being used, or where the customer is evidently "spreading himself" on the materials that are being used, then 2,500 megohm grade is indicated. But it can be said that in the majority of good reliable wiring installations to-day being carried out, 600 megohm grade is being installed and is at least as good in quality as the rest of the materials used in the composition of the building.

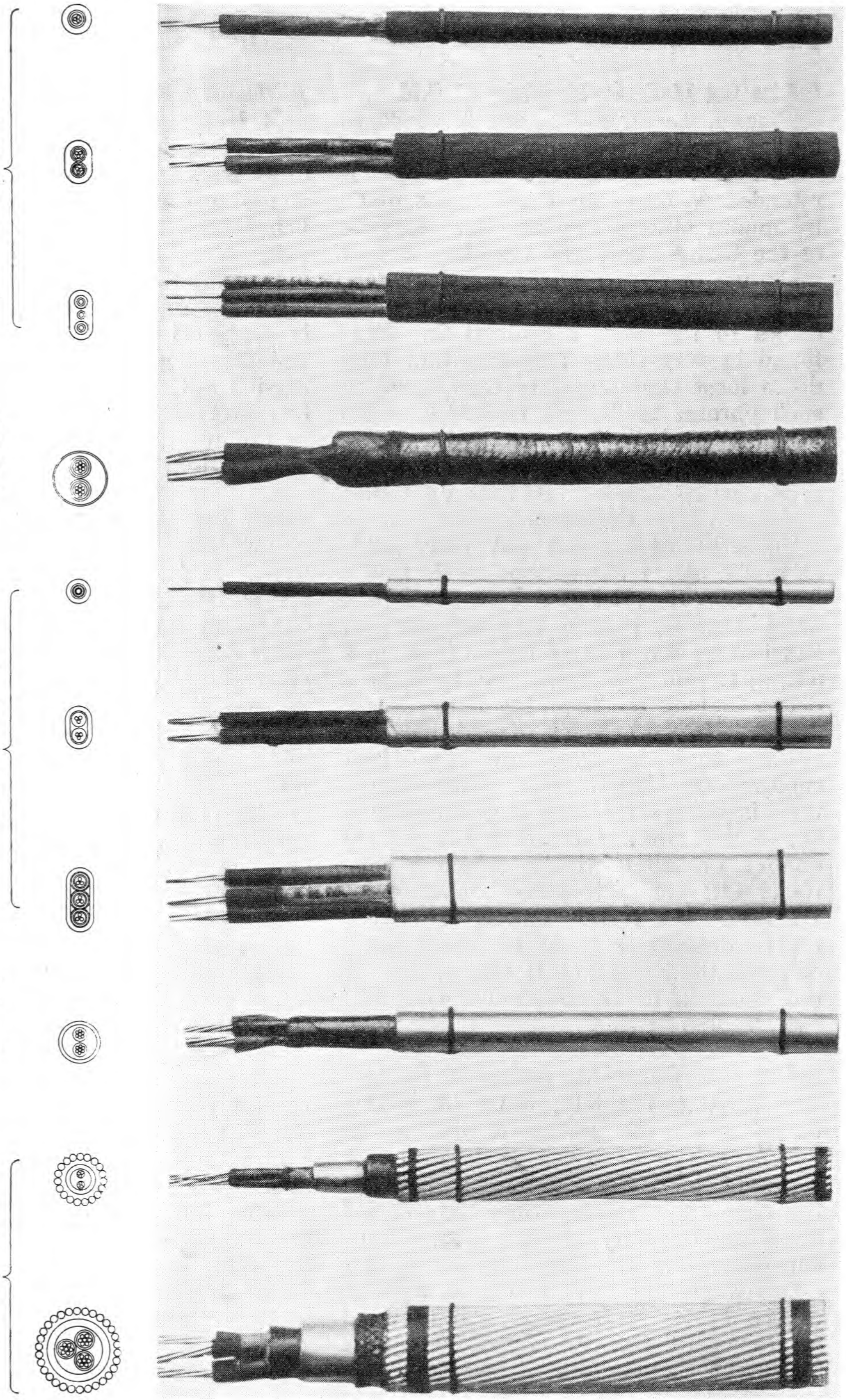
Some Points about "Nonazo."

"Nonazo" is a difficult cable to advise upon. It is, on its own admission, not up to the quality of C.M.A. (Regd.) Cables. Nevertheless it is quite a reliable cable and is so considerably cheaper than the C.M.A. cable that there must be occasions where it is reasonable to use it; particularly is this the case in an installation which is known to be of a temporary character and where length of life is not an important factor. It very often happens in factories or works, and very often in offices, that a good deal of alteration in the wiring is continually being carried out.

Not only is the cable unlikely to be wanted to give a particularly long life bit perhaps more important, it is frequently under what I may term accidental inspection, owing to the fact that alterations are being made. This is a case, I think, where, if money will not run to the more expensive C.M.A. cables, "Nonazo" could be used, but this statement must be qualified by a reminder that "Nonazo" is not as expensive as C.M.A., nor is it as good, and therefore it is quite absurd to install "Nonazo," without realising that its performance will not be as good.

The Use of "Vicma" and "Vinazo."

"Vicma" and "Vinazo" class of cables must come into the same sort of



Single, twin, and three - core. C.T.S. cable, conductors of tinned copper rubber insulated and tough rubber sheathed.

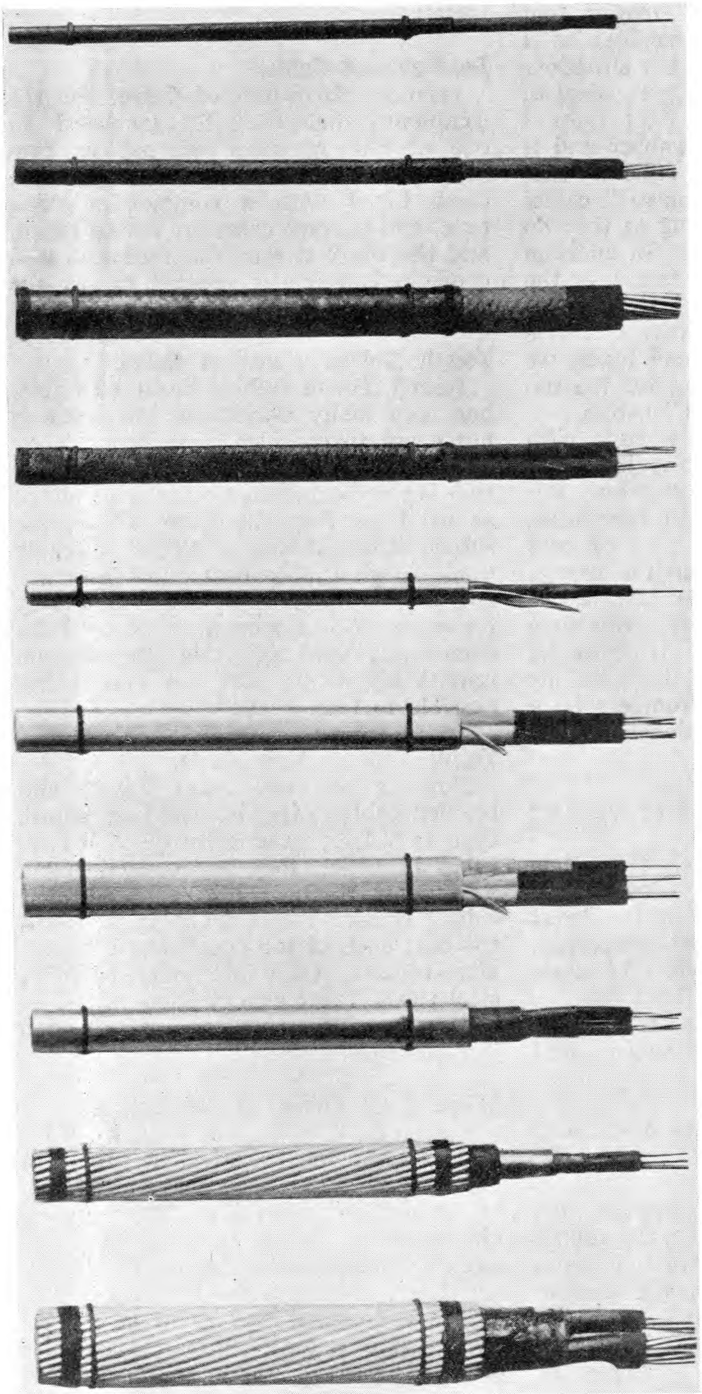
Twin circular rubber insulated taped braided and compounded cable.

Single, twin and three- - core Henley wiring system cables. Tinned copper conductors, rubber insulated cores, lead sheathed.

Twin core circular impregnated paper insulated and lead covered cable.

Twin and three-core impregnated paper insulated lead covered bedded and single wire armoured cables.

Standard Types of Cables.



All single-core rubber insulated taped braided and compounded cables.

Twin flat taped, braided and compounded cable.

Single, twin and three - core Henley's " Bondit " wiring system cables. Tinned copper conductors rubber insulated and lead sheathed with a bonding wire laid under the sheathing, making a continuous bond.

Twin core circular rubber insulated and lead - covered cable.

Twin and three-core rubber, insulated, lead covered and bedded and single-wire armoured cables.

For L.T. Wiring Installation Work.

category, so far as their use is concerned, as C.M.A. and "Nonazo," except that they are particularly applicable, as I have mentioned earlier, in hot situations or situations exposed to a great deal of sunlight. Both heat and light have a deleterious effect on pure rubber and it is to counter this particular difficulty that both "Vicma" and "Vinazo" cables have been evolved containing as they do no pure rubber whatsoever. In addition to light and heat, chemical fumes, or the atmosphere where chemical work is in process, are apt to have a corrosive effect upon rubber, and here again we have a suitable environment for the use of "Vicma" and "Vinazo" cables.

As an example of this I have with success put "Vicma" cables in a tan shop and a chemical laboratory. For the wiring up of motors in factories—particularly where a good deal of heat is to be expected both from the motors and from the general atmosphere of the shop—my personal view is that this class of cable is suitable. But it must be remembered that the actual choice, as referred to above, must ultimately be a matter of balancing conditions and the amount of money available.

Types of Cable from Point of View of Mechanical Protection.

Now for another table, this time showing the types of cable which are available, regarded not from the point of view of their insulating properties, but from the point of view of their external mechanical protection :

1. Rubber (or rubber compound) insulated cables taped and braided.
2. Lead-covered cable.
3. Tough rubber sheathed cable.

Rubber.

The first is composed of little more than what we have been discussing, the rubber or rubber compound insulation, covered with spiral tape upon which the class or grade is marked, and covered overall by braiding, which is treated with a wax compound for the combined purpose of durability and lubrication in the case of drawing the cables through steel tubes which is to-day the normal method of installation.

Lead-covered Cable.

Item 2, Lead-covered Cable, has the conductors independently insulated in one of the manners referred to previously; then the cables are in some cases taped with a common marking tape, and in some cases are not so taped, and the whole is then sheathed in a lead compound which is pressed on to the cable in a semi-molten state.

Tough Rubber Sheathed Cable.

Item 3, Tough Rubber Sheathed Cable, has very many variations, but there is not space to consider them here. They all have one thing in common, however, that is the conductors originally insulated as we have been discussing above, are subsequently coated with a specially made tough rubber compound, designed not for insulating purposes but purely for mechanical protection. Some of the compounds used for this purpose are remarkably tough and are almost impossible to tear.

Taped and Braided Cable.

Now as to their uses: Taped and braided cables, of which the best known type is V.I.R., practically demand steel tubes in which they are carried round a building. Drawn into screwed steel tubing braided cables probably represent the best class of job which can be done. Unfortunately there are other types of steel tubes, but I cannot allow myself to be drawn into the conduit question in this article.

When Steel Tubing is not Possible.

There are, however, occasions when for some reason the use of steel tubing is either not possible or is undesirable. One gets examples of this in some churches, old timbered houses, in extensions to circuits in a building which is already wired and which has also been decorated. Where a frequent and rapid change of temperature is anticipated, the troubles of condensation are inseparable from the use of steel tubes, and it is frequently wise to abandon the steel tube system of wiring in such localities in favour of lead-covered or tough rubber sheathed cable.

It must be remembered here that lead-covered cable, if it is to be used as an addition to an existing installation, does indeed carry on the principle of an earthed sheath and is inclined therefore to be a more logical form of wiring than rubber sheathed cable for such conditions. On the other hand, where there is no question of an existing installation but where the choice must clearly fall between lead-covered and tough rubber sheathed cable it is worth while weighing carefully the claims of tough rubber sheathed cable against lead-covered cable.

Rubber Covered can be Nearly as Inconspicuous as Lead-covered Cable.

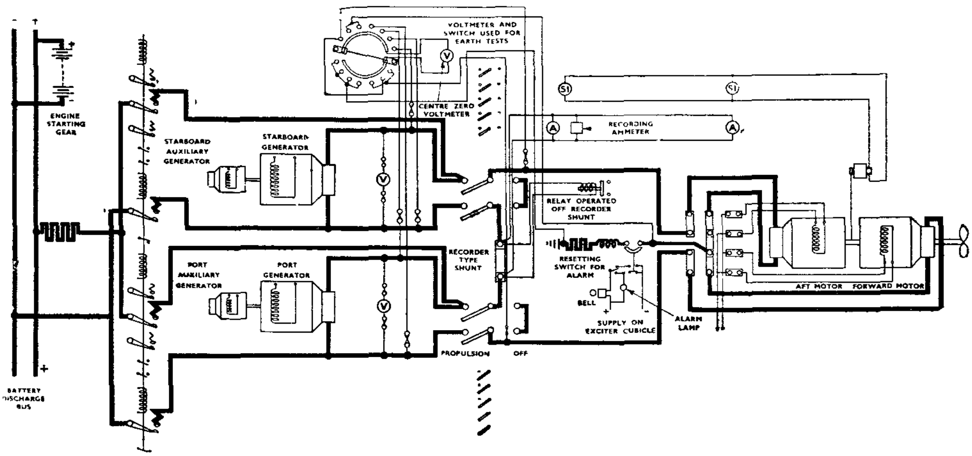
To lay down a hard and fast rule is clearly impossible, but well run rubber-covered cable can be very nearly if not quite as inconspicuous as lead-covered cable ; it is certainly, in my own view at least, less subject to abuse by careless erection. There are certain occasions where the wiring is left free without being made a fixture to the wall or ceiling —such cases are met with sometimes in the wiring up of motors in factories and in the final connection to various forms of electric heaters of the rigid type, etc.

In such conditions lead-covered cable does not offer the best solution ; for lead, though it has a good deal of flexibility, has very little elasticity and it is the elasticity inherent in tough rubber-sheathed cable which is perhaps its greatest protection against rough treatment. One can kick a loose length of tough rubber sheathed cable and it will merely spring away from the foot and return to its normal position unharmed.

If a length of free lead-covered cable is subject to the same abuse it will not return to its original position and it will for the rest of its life bear upon it the bruise or indentation in direct proportion to the strength of the kick.

In conclusion, let me just say this. A cable must be and always will be the *most important* accessory to an electric wiring installation. As such, it deserves the most scrupulous attention on the part of the installing engineer in the choice of cables which he is to use. To say that one cable is very much like another cable is utter rubbish.

AN ELECTRICALLY PROPELLED SHIP



The interesting diagram above shows the propulsion circuit of the "Acklam Cross," which is the first British electrically propelled tug to be built. Power is supplied by two high-speed Diesel engines driving a 200 kW. G.E.C. D.C. generator and a 20 kW. auxiliary generator which are coupled to each engine in tandem.

THE VOLTAGE CONTROL REGULATOR

By R. Harcourt Woodall

IN the past, electric lighting on automobiles, trains, etc., has been carried out by means of what is termed a constant-current dynamo and an accumulator.

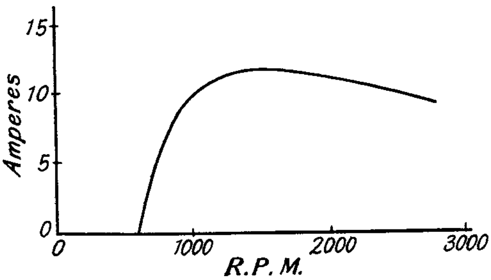


Fig 1.—A Typical Current-speed Curve for Constant Current Dynamo.

Method of Operation of Third Brush Type.

Such a dynamo has been of the third brush type, and its method of operation is as follows. The machine in addition to its main brushes has what is known as a control brush situated on the commutator between these brushes and the field of the generator is connected between this control brush and the main positive brush.

If a battery is connected across the machine terminals, any increase of speed will increase the current flowing. The increase in armature reaction brought about by the drawing of this increased current from the armature reduces the voltage between the third brush and the positive brush, and since the field is connected between these brushes, it follows that the result is a reduction in the field strength or magnetic flux. This is responsible for a fall in voltage, until normal current is again flowing.

Characteristics of this System.

The characteristics of this system are that the total output current, charging current plus external load current will remain reasonably constant over a fair speed range and a typical current-speed curve for a dynamo of this type is given in Fig. 1.

Some Disadvantages.

Now this system has several disadvantages, the chief being that a fully charged accumulator will receive a higher charging current when there is no external load than a discharged battery when full external load is connected. This necessitates the use of a battery of somewhat large capacity, so that overcharging will not readily occur. Also various devices have to be introduced to reduce the dynamo output in cases where, for long periods, the lamps are not employed. Usually a resistance is inserted in the generator field circuit, when the lamp switch is " off " and short-circuit when the switch is " on."

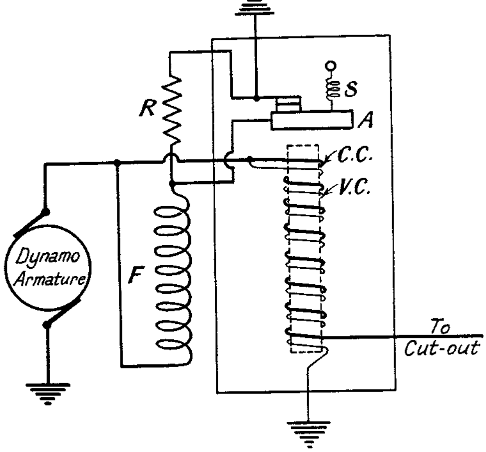


Fig. 2.—Diagram of Constant-voltage System Showing Compensating Coil C.C.

The Constant Voltage System.

In view of the above disadvantages, the constant voltage system is rapidly replacing the constant current system on private automobiles. It has already been used considerably in this country on commercial vehicles notably in C.A.V.-Bosch equipment and also on aircraft.

This consists of an ordinary shunt wound dynamo which works in conjunction with a regulator to produce current at a fixed voltage irrespective of the speed of the dynamo. Briefly, this system comprises a device which automatically inserts resistance into the dynamo field circuit should a rise of voltage occur due to increase of dynamo speed. This, of course, results in a decrease of field current, and therefore of armature voltage, which falls. The resistance is then short-circuited and the process repeated.

How the Regulator Operates.

In order to understand thoroughly the regulator which performs this operation, it will be as well to study carefully Fig. 2.

A coil V.C. on an iron core is energised by connecting it across the dynamo armature terminals and when the voltage across these terminals reaches a certain value, the strength of the magnetism produced is sufficient to attract a soft iron armature A against the spring S. This armature carries a contact which normally engages with another contact, the resistance R in the field circuit being connected across these contacts and therefore short-circuited. The attraction of the armature therefore puts the resistance in circuit, which reduces the field current. The magnetic flux and the terminal voltage are therefore reduced. As the voltage falls, the coil V.C. ceases to produce sufficient magnetism in its core to hold the armature A and it accordingly flies back, the contacts short-circuiting the resistance. This is repeated and the armature vibrates, maintaining a constant voltage across the dynamo terminals.

A Modification for Automobile Work.

The above gives the ideal arrangement and, in certain instances, this scheme has been used on aircraft without a battery in circuit. For automobile work, however, a battery is necessary and a slight modification of the regulator has to be made in order to prevent the overloading of the generator when a totally discharged battery is connected in circuit. To keep a 12-volt battery in a fully charged state requires a pressure of 15-15.5 volts, and this applied to a discharged accumulator with full load " on " would result in an extremely heavy current being taken from the dynamo, which would seriously damage same through overheating.

This is overcome by providing an additional coil C.C., which carries the dynamo output current, and which is wound so that it increases the magnetism produced by V.C. This means that the " points " are separated when the dynamo is generating a lower voltage, as the current is increased.

Normal practice is to adjust the regulator to operate with a voltage of 15 when there is no external load, falling to 13.5 volts with full load.

A COMPACT FORM OF H.T. SWITCHGEAR

A new design of switchgear, known as S.V.D. gear, which has recently been placed on the market by the G.E.C., solves the problem so often encountered by engineers in both municipal and industrial concerns for a compact form of high tension switchgear. It can readily be adapted for ring main service, oil immersed isolating links being provided to isolate either side of the ring main.

Among the many advantages of this class of gear may be mentioned : Safety ; flexibility ; economy in floor space and headroom ; interchangeability of units of the same ratings ; accessibility. S.V.D. units are suitable for use on single or polyphase systems up to 11,000 volts, while oil circuit breakers up to 150,000 kVA. can be accommodated.

Each unit is arranged for floor mounting, and is built up of sheet steel plates fixed to rigid angle-iron framework. The equipment is jig assembled, so that units of the same current capacity, rupturing capacity and voltage are strictly interchangeable. The busbar chambers are arranged at the top of the switchgear, while the oil circuit breakers are located immediately below. Self-contained instrument panels are mounted in front of the busbar chambers, and are provided with hinged front plates to permit ready inspection of the instrument connections.

A Flashing Electric Sign Switch

By H. J. Baldwin

IN the following article details are given for the construction of a drum and contact fingers for a crawling type of flasher round a streamer board and is suitable for four or six circuits totalling 60 to 120 lamps.

The Central Spindle.

A central spindle is mounted on two small plummer block bearings; on this shaft are four fibre cams each set with the major axis at right angles with its neighbour. Immediately above the four cams are the contact arms hinged at one end on a small metal stirrup which in turn is mounted on a fibre or ebonite block or strip. This arm, which is made of laminations of hard copper, comes into contact with a platform bracket mounted on the opposite side of the camshaft. The normal position for the contact blade is resting on the contact platform, where it is firmly held by a small spiral spring. When the camshaft revolves, each of the laminated arms in turn is pushed up, thus causing a break in the circuit.

Fixing the Cams.

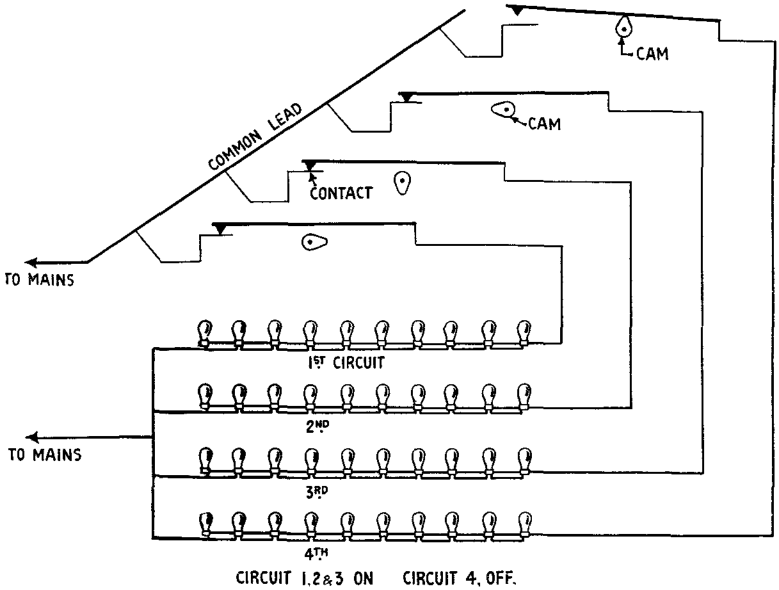
The small sketch shows the method of fixing the cams to the shaft. A square hole is filed in the centre of the fibre into which fits a bush with one end squared; the other end, which projects outwards from the cam, is round and contains a small tapped hole carrying a grubscrew A small hole running one third of the diameter of the spindle is drilled in the shaft to take the point of this set screw.

The Contact Arms.

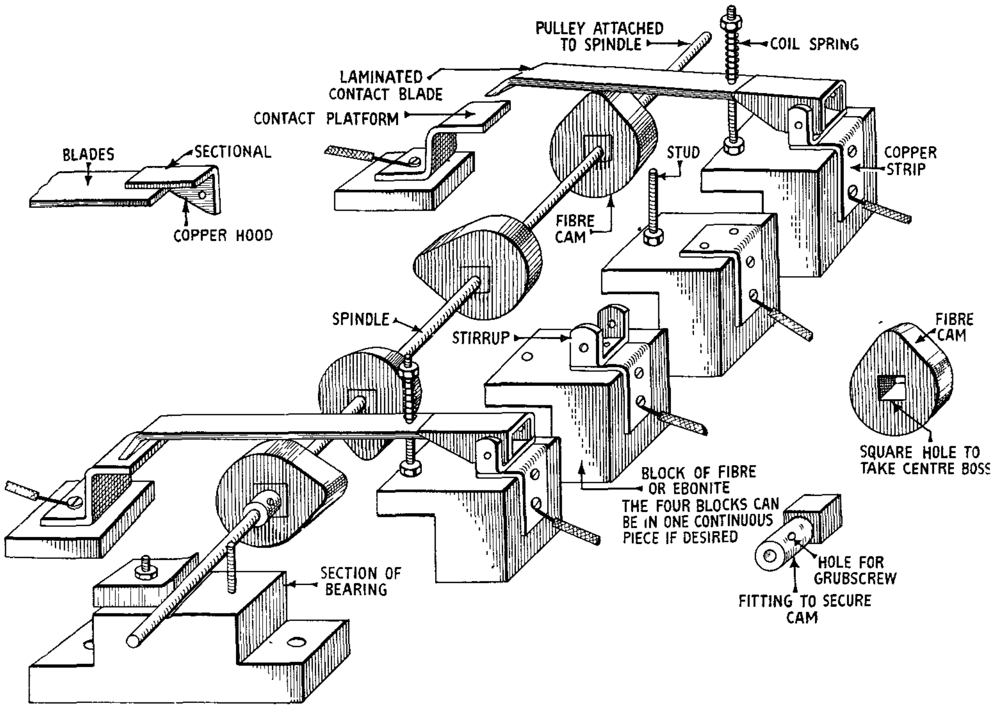
These are made up from two or three thicknesses of hard copper riveted together at one end near to the point where the hooded or cap-shaped end piece is soldered on (see small sketch). The arm is hinged on a pin running through the above-mentioned cap and the holes in the stirrup bracket; it is riveted over on the ends.

The Circuit.

The circuit diagram shows how the four banks of lamps are wired up to the switch. The switch can be designed on similar lines to take six circuits, by substituting six cams and the corresponding contact arms, remembering, however, tha



Circuit Diagram Showing How the Four Banks of Lamps are Wirei Up to the Switch.
The circuit can be designed on similar lines to take six circuits, by substituting six cams and the corresponding contact arms.



Details Showing the Construction of the Cams and Contact Arms.

in this case the angle between the axis of the cams will be 60°.

Driving the Switch.

The shaft carrying the cams must revolve slowly, and it can be driven by a gramophone motor, an electric one for preference. Arrange a fairly large pulley on the spindle and a small one on the motor spindle.

ELECTRICAL REFRIGERATION PLANT IN THE TROPICS

Refrigeration, cold storage or the making of ice are particularly necessary in the tropics, and in the Far East, as elsewhere, the demand for ice has increased rapidly in recent years. At Singapore, where the consumption is about 5,000 tons per month, a large quantity of electrical equipment, including generating plant, switchgear, and motors, ranging up to 180 h.p., has recently been manufactured and supplied by the General Electric Company, Ltd., for use with refrigerating machinery at the Atlas Ice Works, the Malayan Breweries, and the Singapore Municipal Abattoir.

The Plant.

A 400-volt 3-phase 50-cycle A.C. supply for the 50-ton ice plant and also for a previously installed 20-ton plant is obtained from a 280-kW.333 r.p.m. G.E.C. alternator driven by a 420 b.h.p. National oil engine of the vertical 6-cylinder 4-cycle type. The engine and alternator are running continuously at about 80 per cent. of full load. The various engine auxiliaries are driven by Witton motors, the air compressor for starting purposes being coupled to a 10 h.p. slip-ring motor, and the water circulating pump for (cooling the engine cylinders) to a 3 h.p. 1,400 r.p.m. squirrel cage motor with star-delta starter. The various circuits are controlled by a 5-panel G.E.C. switchboard.

THE HIGH-SPEED CIRCUIT BREAKER

By H. W. RICHARDSON, B.Sc., M.I.E.E.

Possibilities of Air Circuit Breakers.

THE result of the almost universal use of alternating current for modern power generation and distribution has led to a tremendous amount of research and experimental work being performed in connection with oil circuit breakers. There is still, however, plenty of scope for the development of air circuit breakers for direct current circuits, particularly in connection with railway electrification. In view of the increasing use of electricity for operating both main line and suburban services which is bound to take place in this country within the next few years, it should prove of interest to consider some of the main features of a modern high-speed circuit breaker as designed for traction purposes.

It should be placed on record that several experiments have been made by more than one prominent engineer in an endeavour to show that oil circuit breakers are suitable for direct current circuits, but so far developments in this direction have not materialised, and there is little reason to suppose that the air break circuit breaker is likely to be supplanted for D.C. purposes.

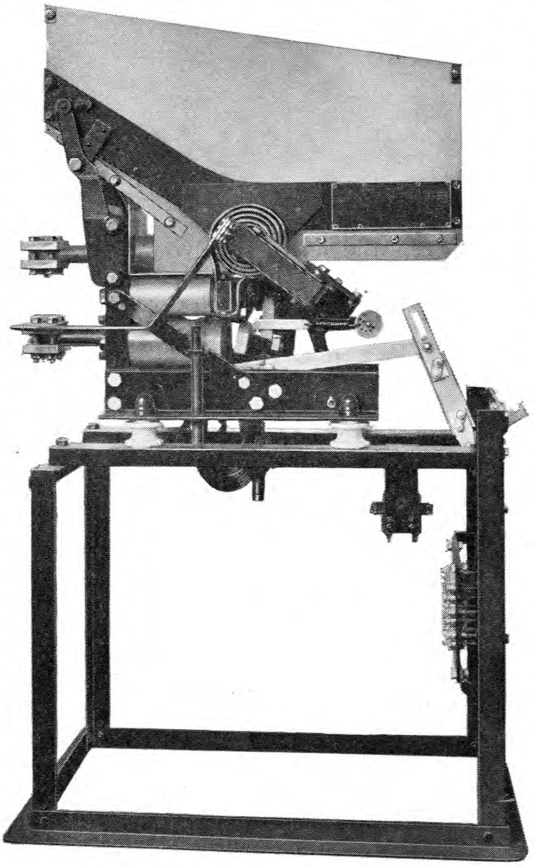


Fig. 1.—GENERAL VIEW OF G.E.C. HIGH-SPEED CIRCUIT BREAKER.

Necessity for the High-speed Breaker.

The need for a high-speed circuit breaker on D.C. systems for clearing heavy overloads on short circuits is obvious. An example of the value of such a device is furnished by the references made to the subject by Mr. F. Lydall in a paper entitled "The Electrification of the Pietermaritzburg-Glencoe section of the South African Railways," read before the Institute of Electrical Engineers on March 29th, 1928. The first summer's working experience on this line showed that a scheme of protection was essential in order to prevent the breakdown on overhead line insulators due to frequent lightning storms.' Momentary high presures, due to lightning discharges in the immediate area, were induced in the overhead line sufficient to cause a flash-over to earth from the live fitting on a pull-off insulator. A 3,000-volt short circuit was thus established, the arc burning out the insulator clamps and allowing the pull-off rod to fall free and hang suspended from the contact line. This rod, which remained alive, fouled and damaged the pantograph of the first locomotive that came along, unless the driver was able to pull up in time, in which case the train was held there until the pull-off arm had been removed.

To guard against this, it was proposed at first to install at frequent intervals some form of lightning arrester which would dissipate the induced charge and thereby obviate the tendency to flash-over; but the solution of the problem was ultimately found in the adoption of high-speed automatic circuit breakers for sectionalising the line at every sub-station. The effect of any flash-over and the subsequent 3,000-volt short circuit was to open the high-speed circuit breaker at each end of the section affected. The arc was thus cut off before it had time to do any serious damage, and the line was made alive again by reclosing the circuit breakers. Any slight damage to the insulators was made good at the first opportunity. In this way the trouble was entirely eliminated.

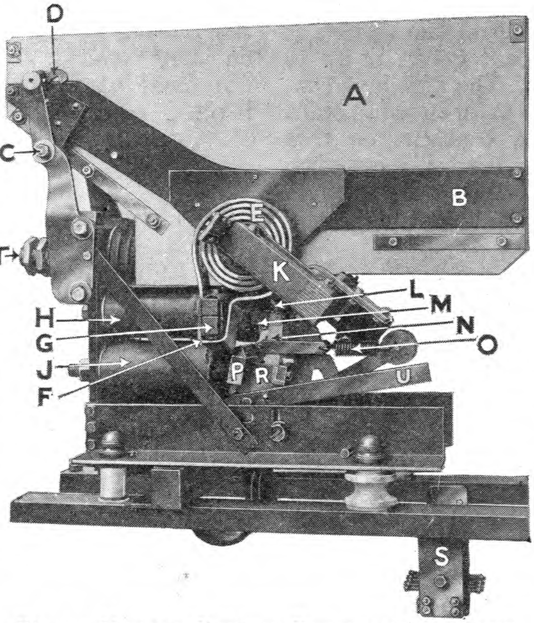


Fig. 2.—VIEW TO EXPLAIN DETAILS OF CONSTRUCTION OF HIGH-SPEED CIRCUIT BREAKER SHOWN IN FIG. 1.

A, arc chute. B, blow-magnet pole extensions. C, pivot for arc chute. D, catch for arc chute. E, blow-magnet winding. F, releasing winding (one turn looped from blow-magnet winding). G, pole pieces (for field created by releasing winding). H, hold-on windings. J, closing coil. K, blow-magnet. L, spring controlling auxiliary contact. M, hold-on armature. N, duralumin switch arm (open position). O, opening springs. P, closing armature. R, pivoted frame carrying P, and also pivot for N. S, frame carrying electrical interlocks. T, positive terminals. U, bar for hand closing—handle removed.

General Requirements.

A high-speed circuit breaker for service of such a nature as that described must naturally be of a thoroughly strong and reliable design, and various of the principal electrical manufacturers of the world have produced an instrument fully capable of meeting the service. It is proposed in this article to describe the high-speed circuit breaker designed and made by The General Electric Co., Ltd., of England, and it is of interest to note that breakers of this type were used with great success on a second section of recently electrified railways in South Africa, namely, that between Capetown and Simonstown.

A general view of this circuit breaker is given in Fig. 1, while its main details of construction may be seen clearly in Figs. 2 and 3; the letter references are given below these illustrations. It will be observed that the essential components correspond to those used in air circuit breakers as used in more general practice, but the general arrangement differs a good deal in detail.

Construction.

Considering the construction and function of the principal parts it should be noted that the moving contact 2 (Fig. 3) is carried at the top of a duralumin arm "N" (Fig. 3) controlled by springs, the parts being so located that the hold-on armature "M" acts as a fulcrum, through which the pull of the springs is transmitted to the contacts in order to hold them together. The auxiliary contacts 3 and 4 (Fig. 3) open an instant later than the main contacts, so that there is no arcing on the main contacts. The fixed auxiliary contact is a plain copper rod, which can be set up many times before it needs replacing. Both main and auxiliary contacts are located in a strong magnetic field provided by a powerful blow-out magnet "K," while the arc is broken in an arc chute "A" (Fig. 2) which is hinged, and can be thrown back and retained by a hooked catch to permit of inspection of the contacts.

The chute carries on its outside surfaces long iron pole pieces "B" (Fig. 2) for the blow-out magnet, and internally it has long-arcing horns which engage with their respective contacts when the chute is in its working position. The magnetic field is so directed that the arc is immediately forced off the auxiliary contacts on to the arcing horns, and the poles of the arc are then kept moving along the horns until the arc is sufficiently extended, and finally broken.

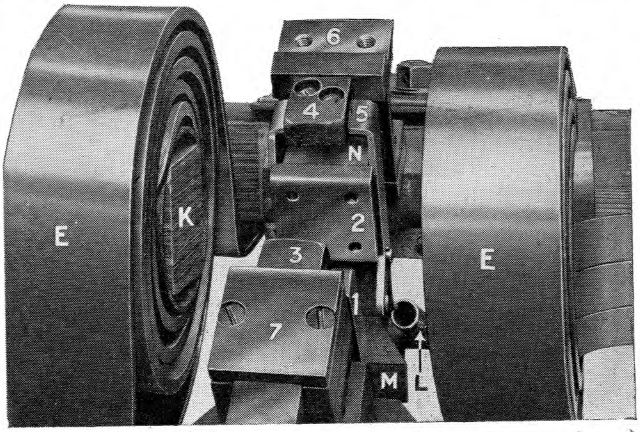


Fig. 3.—View to Explain Detail of Contacts of High-speed Circuit Breaker shown in Fig. 1.

E, blow-magnet windings. K, blow-magnet. L, spring controlling auxiliary contact. M, hold-on armature. N, top of duralumin switch arm. 1, positive (fixed) contact. (Has ball and socket fixing arrangement for quick adjustment.) 2, negative (moving) contact. 3, positive (fixed) auxiliary contact. 4, negative (moving) auxiliary contact. (Note good condition after a series of short circuit tests on 2,000 kW. rotary converter, 1,500 volts, through external resistance of only .0025 ohm.) 5, frame carrying auxiliary contact (4). 6, engaging surface for negative arcing horn. 7, engaging surface for positive arcing horn; also clamp for adjusting (3).

Air Dash-pot.

An air dash-pot is fitted for reducing the mechancial shock on the armature when the contacts close, this allowing the breaker to close and be held firmly on any load below that for which an overload release "F" (Fig. 2) is set.

Overload Release.

This overload release consists of windings carrying the load current, so arranged that they strengthen the field in the cores of the hold-on magnet, but not in its armature. When the load has grown to a predetermined amount it sufficiently saturates the magnet cores, lowering their effective permeability until the magnet hold-on windings are no longer able to maintain sufficient flux in the armature which is thus released.

Should the load current rise suddenly in the releasing windings, the flux which they generate cannot immediately be forced through the hold-on magnet, because of the reaction of its hold-on winding, also because of eddy-current effects in the solid cores of the magnet. Consequently, the armature is immediately robbed of its magnetism, in order to feed that part of the magnetic circuit controlled by the releasing coils. This gives quick action, and discriminates between a slowly increasing overload and the sharp rise that is experienced under short circuit conditions.

As the quick magnetic changes are

restricted to the iron of the armature and the pole pieces, all of which are laminated, and as there is a large air gap in the magnetic circuit controlled by the releasing windings, the armature is released at the moment when the current reaches the critical value for which the release has been adjusted. Adjustment of the release is obtained by varying the current in the hold-on windings by means of an adjustable resistance connected in series. No mechanical alterations are necessary, and a change can be effected by remote control or automatically if desired.

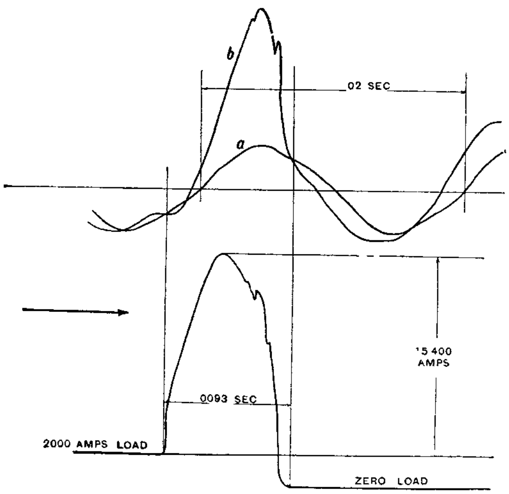


Fig. 4.—Oscillogram of 1,000 kW. Rotary Converter, Short Circuit being Cleared by High-speed Circuit Breaker

Operations.

The breaker may be closed manually, or by means of a closing magnet, this being accomplished in two stages. In the first place, the closing coil "J" (Fig. 2) or handle brings the hold-on armature "M" up to its magnet by means of a closing arm, which engages with the contact arm. The second stage consists of the closing arm being withdrawn, causing the contact arm to pivot on the hold-on armature and the contacts to close. Consequently, if the contacts close on an overload the breaker is free to open in normal fashion.

The circuit breaker is held closed by a hold-on magnet "H" (Fig. 2), which may be excited from the busbars or from the line. When used as a tie feeder breaker a special arrangement is fitted, to enable it to pick up its hold-on current from the side which is alive. Alternatively the hold-on coils may be energised from a battery or other separate source, the consumption being only approximately 25 watts per breaker. When the hold-on armature is released, a duralumin arm pivots on a second fulcrum at its lower end, this lower fulcrum being carried on a pivoted frame "R" (Fig. 3) operated by the closing armature. Strong springs pull the contacts fully open immediately the hold-on armature is released.

The period that elapses before the breaker begins to open varies inversely as the rate at which the current increases, the overload release being designed to discriminate between an overload which increases slowly and the sudden increase resulting from a short circuit. It will, therefore, open much sooner when a short circuit occurs. Although this discrimination is often very valuable, a large number of cases occur where not only is it not required, but must be eliminated as far as possible. A close study of this point has been made and it is now possible to control the degree of discrimination over a very wide range.

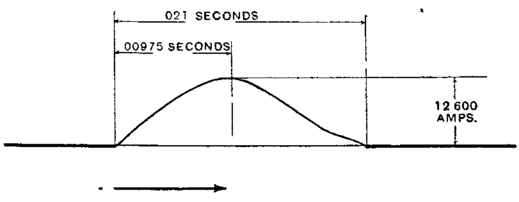


Fig. 5.—Oscillogram of 2,000 kW. Rotary Converter on Traction Load, Short Circuit being Cleared by High-speed Circuit Breaker.

Rating and Performance.

The high-speed circuit breaker as described in the preceding paragraphs is manufactured for capacities up to 4,000 amperes and is particularly suitable for traction circuits with pressures of 600, 1,500 and 3,000 amperes.

Equally it may be used to protect a generator, motor, converting unit, or upon a feeder circuit. Frequently it is installed in a truck, as in Fig. 6, this affording many well-known conveniencies. It is claimed that it clears the worst type of short circuit in approximately 100th second. Some interesting evidence in this connection may be obtained from the oscillograms shown in Figs. 4 and 5. It must particularly be pointed out that the scales of these curves are different for obvious reasons, and the reader should therefore observe carefully the values given which accompany them.

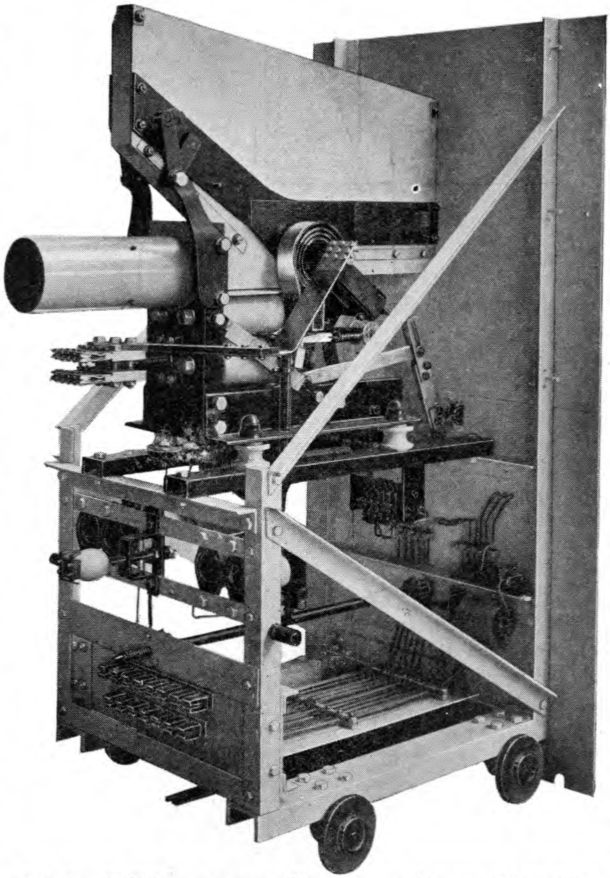


Fig. 6.—G.E.C. 1,500-VOLT HIGH-SPEED CIRCUIT BREAKER MOUNTED IN TRUCK CUBICLE.

In the case of Fig. 4 the oscillogram was obtained from tests on a standard 1,000 kW. 440-volt rotary converter built for ordinary lighting and public supply service. The curves on the top of the diagram are current curves taken from one of the slipring leads and clearly show the relatively small disturbance on the A.C. side of the rotary. Curve "a" is the current wave recorded previous to the occurrence of the short circuit.

From the lower curve (of D.C.) it will be noted that before the short was applied, the rotary was carrying nearly full load, and that when a dead short (resistance of short leads only) was applied the high-speed breaker completely cleared the fault in .0093 sec.

In the case of Fig. 5 the oscillogram was obtained from tests on a 2,000 kW. 1,500-volt traction rotary converter unit (two machines in series).

These rotaries have a comparatively high internal reactance; the growth of current on short circuit is, therefore, relatively slow. In this case the rotary was running light when a short circuit of .0025 ohm resistance was put on. Due to the high internal reactance of the machines and slow growth of current the total time from the beginning of the short to the complete rupturing of the arc is somewhat longer than in the first case.

Probable Developments.

It would seem as if the development of the high-speed breaker for capacities above 4,000 amperes must depend upon suitable methods of artificial cooling. Already considerable experimental work has been undertaken with this end in view.

Electrical Lifting Magnets

By H. E. Hutter, A.Am.I.E.E.

LIFTING magnets first came into general use in the United States about 30 years ago and were soon afterwards introduced into Germany. The earliest magnets in use in this country were constructed by steelworks engineers until the business prospects were realised by several manufacturers.

The introduction of the high-speed electric crane gave a great impulse to the installation of magnets. The time taken to sling an irregular-shaped block of iron or steel to the hook was out of all proportion to the time taken by the crane for the trip when loaded. A crane equipped with a suitable magnet will easily perform 60 to 70 trips per hour.

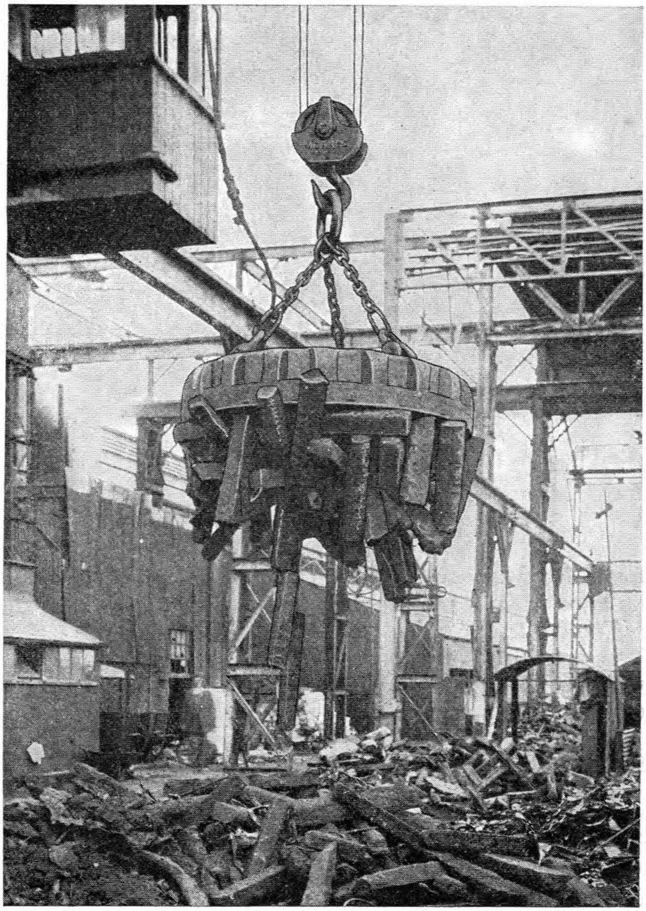
The Three Types of Magnets in General Use.

The largest users of these magnets are steelworks where the amount of magnetic material to be moved is very large. Three types of magnets are in general use:—The circular, suitable for loose material such as scrap, turnings, pig iron, etc.; the rectangular type for slabs and plates, and lastly, the bi-polar, which is ideal for sections such as girders and billets.

The ideal requirements for a lifting magnet are the greatest sustained lifting capacity combined with the minimum deadweight and a reasonable current consumption.

Lifting Capacity is Dependent on Total Magnetic Flux.

With a magnetic shell of the correct proportions, the lifting capacity is dependent on the total magnetic flux which varies as the product of the total of turns and the current, This is not a strict relationship but near enough. The maximum current which a given winding will carry is limited by the temperature rise which the insulation will stand, but as an excessive temperature rise will result in a substantial increase in the coil resistance, the current, when the coil is hot, will be considerably lower than when cold. The



A Circular Magnet Lifting Pig Iron and Heavy Scrap.

CIRCULAR MAGNET LIFTING LIGHT SCRAP AND TURNINGS.

final lifting capacity will therefore be lower than the initial lift.

The designers' objective, therefore, is to obtain a good initial lift which will be sustained as the coil warms up.

Construction of the Circular Type.

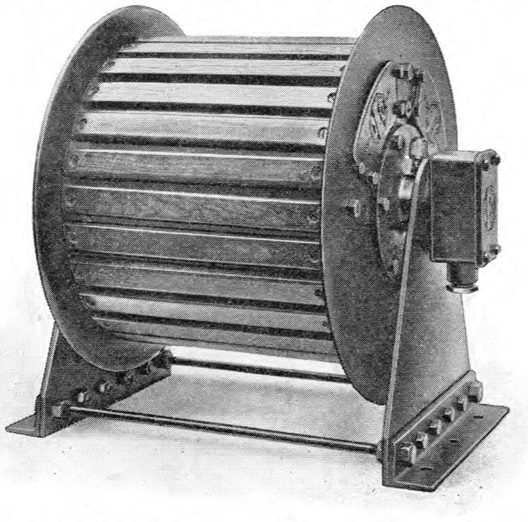
The construction of these magnets is carried out on very similar lines by all makers. The shell is an annular casting of high permeability steel, the outer edge being ribbed for strength; the two poles are also made of this steel. To prevent damage to the coil and magnet face, a bumping plate of non-magnetic steel is used to take the blow received when a heavy block is attracted to the magnet.

The Magnetising Coil.

The magnetising coil is built up of several layers of pancake coils. Each layer is made up of copper strip and asbestos tape, wound on to a mica-insulated former made of metal, and insulation between each layer is of mica plates, the whole coil being impregnated with varnish. After the coil has been placed in position in the shell, the entire unit is filled up with a special compound.

Cable Drums.

The coil leads pass out to a terminal box of substantial construction; from this box a foot or so of cable is taken to a water-tight plug to which the main cable is attached. It will be obvious that this cable will cause obstruction unless some provision is made for winding in the slack, and



SPRING TYPE CABLE DRUM FOR WINDING IN THE SLACK.

this is carried out by means of cable drums as illustrated. These drums are either motor operated, gear-driven or spring controlled.

The magnet is suspended from the crane hook by chains attached to convenient lugs on the magnet shell.

Construction of the Rectangular Type.

The construction of the rectangular type is similar, except that the arrangement of poles is different. As this type lifts from a regular surface, such as a pile of sheets, and the flux distribution is lateral, a lighter construction is satisfactory compared with the circular type. When lifting very long thin sheets there is a decided tendency for them to peel off the magnet, and this can be overcome by using two or more magnets suspended from a spreader beam slung from the crane hook. An experienced operator can lift half a dozen plates at one time, and yet drop them one by one—the use of a series resistance gives the operator a very sensitive touch.

Construction of the Bi-polar Type.

The bi-polar type consists of a central core on which is wound the coil suitably protected by a circular brass shield. Two cast steel poles are bolted to the central core. The suspension bridge is of non-magnetic material to prevent leakage of flux through the suspension chains.

The Magnet Winding.

The winding of a magnet forms a very highly inductive circuit, and should the circuit be opened directly, the voltage rise is liable to disrupt the insulation, and to overcome this risk a non-inductive resistance is connected across the windings at the instant of breaking the circuit.

Controllers.

Controllers of the type met with in tramway work are used. Series resistance steps provide adjustment of lifting power. The design of these controllers has to be very sound from the mechanical point, as the operations may exceed 60 per minute.

The residual magnetism present will often prevent the rapid dropping of the load, and to ensure speed in this operation, a demagnetising step is fitted to the controller whereby the current direction is rapidly reversed.

Lifting Capacity.

The weight which a magnet will lift depends greatly on the permeability of the load to be lifted, and whether it consists of loose material or a solid block. A magnet will lift five to 15 times its own weight of solid block depending on the diameter of the magnet.

Examples of the lifting capacity of typical circular magnets are given in the following table :—

		Average lifting capacity, cwt.			
Dia. in ins.	Weight, lb.	Solid Ingot.	Ball.	Scrap	Pig Iron.
26	730	100	75	$1\frac{1}{2}$	6
36	2,100	170	90	4	10
48	3,900	240	160	10	18
56	5,660	340	180	13	24
66	7,600	440	230	16	30
76	9,000	525	230	20	35

The enormous difference in lifting capacity when lifting a solid ingot and loose turnings and similar scrap is well exemplified by the table. The very poor lifting capacity of turnings is due to the low weight per cubic foot, and the fact that they are usually entwined, and though the top layers may be attracted they are pulled off by the weight of the lower.

The greatest saving in labour occurs when lifting those materials which are so difficult to move with forks. Pig iron can be lifted direct from the beds to the trucks. As an example, 60 tons were lifted in 60 minutes. While the magnetic properties of iron vanish at certain temperatures, materials can be lifted sooner than by hand labour. It is not advisable to lift above a very dull red heat.

We are indebted to the Rapid Magnetting Machine Co. for the loan of the illustrations.

FAULT LOCATION ON RADIO RELAY LINES

By C. W. Watson, A.M.I.R.E.

In previous issues we have dealt with the erection of apparatus for radio relay work. In this article, we deal with the tracing of faults that may develop on radio relay lines

PREVIOUS articles of this series on radio relay systems may have misled many readers into believing that the operation of a radio relay service is a very simple matter, and that once the suitable amplifiers have been installed and the lines erected, the worries of the operator are few. In radio relay service as in anything else, nothing is perfect and by far the greatest consideration of a relay engineer is the maintenance of the overhead equipment, subscribers' installations and the location of faults which are bound to occur.

Measuring Resistance to Earth.

The chief claim of radio relay service over direct reception being reliability, faults must be located promptly to ensure that any interruption of the service is of as short a duration as possible.

On a system with 1,500 subscribers on dual programme and something like 300-400 miles of overhead wires, it is almost a full time job for a man and labourer to keep the lines in order and rectify minor faults which occur. With efficient maintenance it is possible to limit breakdown periods to below .1 per cent. of the total hours of service, or less than 5 hours per year out of the 5,000 hours which may be taken as about the average working of these systems, whilst the majority of these faults should not seriously interfere with the service in general.

An efficient faultsman with the aid of a van or motor cycle and ladders should be able to locate in less than an hour any serious fault on a line supplying say, 250 subscribers, and having a network of 50 miles of wire, whilst some of the minor intermittent faults which can only be traced by placing detectors in the line, may take days to locate, but do not seriously interfere with the service.

Faults.

The commonest faults experienced where bare conductors are used are short circuits on the lines. These occur from various causes, generally a bird flying against one wire and springing it so far that it swings back and twists round the other, shorting in the pair and cutting all installations dead beyond that point, whilst seriously interfering with the quality and volume of the remainder of the line, unless a fuse or other protection device

TESTING LINES TO EARTH WITH A MEGGER INSULATION TESTER.

operates and restricts the affected area. Other short circuits may be caused by aerials being erected and dislocating the wires, aerials falling down and hanging over the lines, or occasionally by a bracket giving way and allowing the wires to become so slack that they twist together with the wind.

Loads.

Heavy loads sometimes occur on the lines and may be caused by the faults above described, which may not be sufficiently serious to form a dead short due to oxidisation of the wires, etc. Loads may also be caused by a pair of wires coming into contact with wet tree branches, may occur internally through a subscriber connecting an unsuitable loudspeaker, by a fault in a volume control, or a fault in the internal wiring.

Malicious Interference.

This is frequently experienced, the lines being often deliberately short circuited by people having a grudge against the relay company or against the subscriber. In other cases the lines have been found deliberately earthed, particularly after dark, presumably by people who are under the impression that this action will minimise interference with their wireless receivers. More serious interference is sometimes experienced, such as an unauthorised person deliberately connecting electric mains to the relay lines or feeding the output of an amplifier to the lines to give the effect of cross-talk and arouse dissatisfaction amongst the subscribers, or even the introduction of a L.F. hum, which might for some time puzzle the relay engineers.

Other problems with which the relay faultsman will be expected to cope are, intermittent disconnections due to faulty nibbing up, etc., earths, intermittent earths, contacts between programmes, or contacts with other lines, contacts or induction with telephone wires, fire alarms, etc., and numerous minor faults which are caused by subscribers carrying out alterations or extensions to their own installations.

Interference with Wireless Receivers.

A general impression amongst the owners of receivers and fostered to a large extent by wireless dealers with little technical knowledge, is that radio relay lines will interfere with the reception of private-set owners and, due to this, the relay operators are often faced with wayleave difficulties and in some cases maliciousness. A little consideration of the elementary principles of tuned circuits will show that except in the case of a faulty or badly designed receiver, interference from L.F. circuits cannot take place. This point does not seem to be generally appreciated by the Post Office Engineering Dept., and complaints referred to them, instead of being rectified at the receiver, are usually passed on to the relay company and take up a fair amount of their time.

Weather Effects on Cables.

Occasionally short circuits and loads are caused by the effect of the weather on the overhead equipment, whilst sometimes the lead or loop may snap for similar reasons. During the heavy snows of last winter, numerous faults were experienced in leading-in cables, caused by the snow freezing fast to the cable and when the thaw commenced the full weight of the ice and snow on the roof had to be supported by the cable, the result being that the insulation was stripped back at the staples which were bearing the strain and short circuits or intermittent shorts resulted.

Methods of Locating Faults.

The location of faults can be greatly facilitated by observation and frequent tests at the relay station, and diagnosis of the general complaints and reports received from subscribers. Every morning the station attendant should make a record of the resistance of each line to earth, the resistance across each pair, and should also test for A.C. and D.C. voltages to earth with the lines disconnected at the jackboard.

Voltage to Earth.

When a voltage to earth is registered on a relay line a contact with some line carrying this voltage will naturally be suspected and a general knowledge of other lines in the locality will probably lead to a fault which may have developed overnight being cleared before the service commences, e.g., a fire alarm system may have a positive potential of about 20 v. to earth, whilst the local Co-operative Society may have a central battery earth return private telephone system, with a negative potential of 6 or 8 volts to earth. A reading given by contact with a G.P.O. line will be readily recognisable according to the system employed in the locality.

Resistance Reading on Dual Programme Service.

A resistance reading should also be taken on dual programme services between No. 1 programme lines and No. 2 programme lines to ensure that contacts between the programmes are remedied as speedily as possible.

Put Test Transmissions on One Programme and Listen for Cross-talk on Opposite Line.

Having made these tests the station attendant should put test transmissions on one programme and listen for cross-talk on the opposite line and vice-versa. These tests occupy only a few moments and should be made at reasonable intervals throughout the day where programme arrangements permit.

Keep a Systematic Record of all Complaints Received.

At the office where complaints are reported a systematic record should be kept and some responsible person should be on the alert for similarity of complaints from any one area, e.g., if a subscriber reports his service as "off" or "intermittent," this may be an inside fault not affecting other subscribers; but should a similar report be received from the same locality a line fault is indicated and a telephone inquiry to a subscriber, preferably at the tail end of the line, will provide further evidence upon which the faultsman can work.

Records of these faults and the findings of the engineers should be preserved and may be filed under the subscribers' numbers, by which means it is easy to detect elusive faults in installations or unauthorised interference.

TESTING WITH TELEPHONES ON A THREE-WAY TEST BOX.

TRACING FAULTS BY TAKING AVOMETER READINGS.

Reception Quiet in One Area and Entirely Off in One Portion.

When a report is received of reception being quiet in a certain area and entirely off in one portion of that area, a short circuit is indicated on the spur of the line which is off, and a check of the outgoing signal current to that line should be taken at the relay station. The faultsman should make a test at the junction of the line and the suspected spur and when the spur is disconnected should receive normal signals on the remainder of the line. He should then follow out the minor branches of that spur taking resistance readings until he comes to the root of the trouble. If protection fuses are installed the spur of the line on which the short occurs should be already cut out by the breakdown of a fuse and the trouble can be located in the same manner. Where an ohm-meter is not available, audible tests may be made with a telephone ear-piece but this method necessitates keeping signals on the affected portion of the line and interferes with the whole of the line until the fault is actually cleared.

Loads.

These are not so easily detected and are only evident at the relay station when the outgoing signal current from an amplifier is found to be greater than is usual for the number of subscribers being fed from that amplifier. When testing for these the linesman should cut a loop in the suspected line or take a fuse out and connect his "Avometer" in series, using the 1.2 amp. A.C. range. A knowledge of the number of speakers on the line and the readings obtained should result in the leakage being found.

A peculiar load is sometimes found and when testing for such a fault the linesman will find that after cutting a certain loop the load is neither forward nor behind him; this usually takes place in a transpositioned line where two earths occur, one affecting each wire, the result being a serious leakage often difficult to find.

Several Earths on Different Lines.

When several earths occur on different lines on dual programme service, the engineers are in for a rough time and for this reason it should be urged that earths, whether appearing to affect the service or not, should be located and remedied immediately they are detected, so that they may not add complications to further faults which may develop. Another "teaser" which may be found when using the "Avometer" as an ohm-meter is experienced when a contact with some line carrying a D.C. voltage occurs. This D.C. voltage if it gets across the line will deflect the meter and upset the deductions of the faultsman. To safeguard against being misled in this manner it is wise to take a voltage reading occasionally.

Intermittent Faults.

Malicious shorting of the lines is usually to be suspected when an intermittent fault clears itself immediately the linesmen appear in a certain street. The best way to locate this is to place fuses on the loops affecting the suspected line, taking note of which fuses blow next time the interference takes place. In this manner the source of the trouble is gradually traced, when steps should be taken to catch the culprit in the act or failing this, make a recurrence impossible. A good plan is to cut the span dead which passes over the suspected premises, feeding the lines another way; the culprit then wonders why his neighbour's relay continues merrily when the lines are short circuited.

Test Boxes.

These should be arranged wherever an important spur branches from the main line. If these boxes contain fuses graded according to the numbers of speakers to be fed through them they are a great help in locating intermittent faults and also serve to restrict the area affected by a fault. By removing the fuses resistance readings and current readings may be taken. If the box is arranged at the eaves or at the gable end, testing is made less dangerous and damage to the roof prevented. Suitable test boxes for this purpose were illustrated in the November issue of this magazine.

The following table of fuses gives the values found by practice to be the most suitable choice from the standard ratings available :—

Table of Fuses.

Loudspeakers.	Carrying Capacity.
1 —10	60 mA.
10 —20	120 ,,
20 —50	250 ,,
50 —100	350 ,,
100—250	500 ,,
250—500	750 ,,
500 upwards	1 amp.

It will be observed from this table that the fuses are not proportionate to the number of loudspeakers to operate through them, but it must be remembered that it is the amplifier which supplies the current which has the fuses to break down and not the number of speakers which operate through same.

Short Circuit.

Internal faults in subscribers' installations are sometimes difficult to locate. Where a short circuit occurs inside, a fuse at the lead-in should blow, and the trouble should be rectified by the serviceman. Contacts between programmes in a subscriber's premises do not, however, break down the fuses, but where this is suspected a D.C. voltage imposed between the two programme lines should blow a fuse in the defective installation; the subscriber then reports his reception faulty in the usual manner, whilst the rest of the service should be unaffected.

Occasionally cases are found where a subscriber has substituted his fuse, especially where these are of the miniature screw type, and one instance is on record where a faultsman, on a cold night round about Christmas, traced a short circuit to a house in which a fairy lamp was gaily flickering in the fuse holder.

Some Humorous Aspects of Radio-relay Faults.

Radio-relay faults are not always to the discredit of the service and at times not without a spark of humour, one example being an occasion when a relay wire came into contact with a bed of Post Office telephone lines and two telephone operators became subscribers the following day; on another occasion when a contact occurred with a Post Office power wire and the relay transmission found its way into the battery room of an automatic exchange affecting every instrument on a 1,500 subscriber exchange and the trunk lines for 40 miles around. This provided a splendid advertisement for the relay service, but it was not until some time later, however, that the Post Office Engineering Dept. appreciated the humorous side of the situation.

Other instances on record are of a Cooperative Telephone Service which inadvertently gave B.B.C. programmes and a fire alarm system which did likewise. The effect of this has been somewhat spoiled since the dual programme working was introduced, the free entertainment being now somewhat mixed.

Perhaps the most baffling problem with which the writer has been faced, is a complaint from three private set owners in one street, who contend that their batteries have required charging more frequently since the radio relay service was introduced.

QUESTIONS AND ANSWERS BY PRACTICAL MEN

Readers are invited to send problems of practical interest. Letters should be addressed to "The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2. Envelopes to be marked "Problem" in the top left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTH'S NEW QUESTIONS

A Question About Power Factors.

On an A.C. system 3,300 v. 3 ph. 50 cycles, there is connected one 70-h.p. induction motor, r.p.m. 720, direct coupled to a D.C. generator, 110 v. 45 kW. Also a transformer kVA. 100, p.v. 3,200/6,400, s.v. 400 50 cycles. Across the induction motor is connected a condenser 35 kVA. 3,300 v.

I obtained the power factor of the system by

READING (1)
No of revs. of meter dis. per kW. = 12.12
No of revs. of meter dis. per sec. = 35

$$\therefore \text{kW.} = \frac{3{,}600}{35} = 104 \text{ kW.}$$

Readings of voltmeter = 3,100.
Readings of ammeter = 24 kVA.

$$= \frac{\sqrt{3} \times 3{,}100 \times 24}{1{,}000} = 128 \text{ kVA.}$$

$$\text{power factor} = \frac{104}{128} = .81.$$

Readings of ammeter to motor = 6 a
Readings of ammeter to transformer = 16 a

READING (2)
No of revs of meter dis. per sec. 44.5

$$\therefore \text{kW.} = \frac{3{,}600}{44\,5} = 81 \text{ kW. approx.}$$

Readings of voltmeter = 3,100.
Readings of ammeter = 20 kVA.

$$= \frac{\sqrt{3} \times 3{,}100 \times 20}{1{,}000} = 107.$$

$$\text{power factor} = \frac{107}{81} = .76$$

Readings of ammeter to motor = 4a .
Readings of ammeter to transformer = 12 a.

How can I obtain the separate power factors of the motor and the transformer? Also if I put a condenser across the secondary terminals of the transformer, what effect will it have on the motor when it is running light load?

H. TARRANT.

The Rapid Cable Calculator.

I was greatly interested in the article published in the June issue, entitled "A Rapid Cable Calculator." I should, therefore, very much appreciate it if you could explain the theory upon which the sliding scales are calibrated.

M. J. S. (W.C.1).

The Metropolitan Vickers Four Panel Board.

Could you oblige me by giving me a description of the Metropolitan Vickers Four Panel board (M. V. type) 600-volt for A.C. work, which has the push button movement?

I should like to know more of its operation than I do at present.

H. E. TURNER (Notts).

Predetermining the Direction of Rotation of Three Phase Induction Motors.

I will be greatly obliged if you will give particulars of the method of predetermining the direction of rotation of three phase induction motors, with star or delta connected stators.

SIGMA.

Constructing an Electrolytic Rectifier.

I was greatly interested in an article appearing in THE PRACTICAL ELECTRICAL ENGINEER, Vol. I. No. 10, *on how to construct an electrolytic rectifier. Would you please inform me how to procure the intermediate tappings, say 60 volts and 100 volts, also what method of smoothing would you suggest? Our current is 130 volts A.C. 30-cycle.*

J. W. W. (Stanfree).

REPLIES TO PREVIOUS QUESTIONS.

Windings for a Small Motor.

Could you please advise me the gauge and number of turns to wind a small motor for 30 volts, 2 amps. D.C.? The particulars are as follows: Armature, $2\frac{1}{2}$ in. diameter, 3 in. long. Fifteen-slot circular about $\frac{3}{8}$ in. diameter. Fifteen-part commutator. Four fields, $2 \times 1\frac{1}{2} \times \frac{1}{2}$ in. each.

A. T. WILSON (Ayr).

Below I submit the winding particulars for the small motor as asked for by Mr. A. T. Wilson, of Ayr, in the November issue of THE PRACTICAL ELECTRICAL ENGINEER.

Armature.—Slots, 15. Commutator sections, 15. Wave wound with 15 coils and 20 turns per coil of .028 in. dia. s.c.c. (gauge 22). The coil span will be from 1 to 4 slot and the commutator pitch will be 1 to 8 sections. As there are two coil sides per slot, the total conductors per slot will be 40. This leaves ample room for insulation and a wedge at the top of the slot.

Fields.—1,200 turns per coil of gauge 28 s.c.c. (.0148 in. dia.). The resistance of each coil will be about 35.6 ohms, and the field current will be about .21 amp.

This motor will run at about 2,000 r.p.m. if the air gap is $\frac{1}{32}$ in., which is a usual gap for such a motor.

S. WOODHOUSE (Leeds).

Trickle Charger for a Model Railway.

I wish to set up a trickle charger in connection with a model railway. The power is obtained from a 12-volt car accumulator of 40 amp.-hour capacity.

It is proposed to use a Westinghouse metal rectifier giving 12 volts 1 amp., as this is the most convenient. However, since one cell when fully charged gives 2.2 volts, six such cells will give 13.2 volts; in other words, the accumulator is never fully charged. Is there any way of getting over this difficulty other than, say, charging three cells at a time from the rectifier?

B. W. HIND (Pinner).

If the model railway has a series wound motor with laminated field and armature, it will run on A.C., and may be run from the mains via a transformer and the rectifier and accumulator need not be used. If it is essential that the accumulator be used, the rectifier will stand the extra 1.2 volts as the current will be low at the end of the charge, due to increased back E.M.F. of the battery. If the correspondent has yet to obtain his transformer and rectifier, perhaps the Westric charger would be best for his purpose, being designed to charge car batteries. W. WATSON.

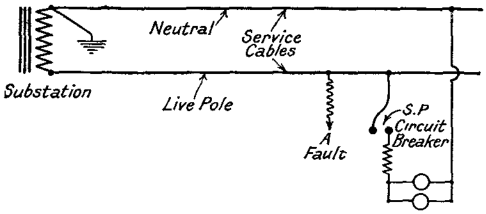
Miniature Circuit Breaker for House Lighting.

Is there any definite regulation prohibiting the use of a miniature circuit breaker on the live leg of an ordinary house-lighting circuit, the neutral being connected direct to a neutral bar? I have in mind a sub-circuit as above, permitting the one control only and therefore dispensing with the usual fuse in either leg and a tumbler switch on the live leg.

The neutral is at earth potential, and provided the neutral wire can easily be disconnected for testing, is there any reason for insisting upon two fuses?

R. W. KANE (Johannesburg).

If your correspondent refers to supply conditions in England, it is essential that a circuit breaker breaks both con-



ductors simultaneously. Assume a layout as above, if the local ground is dry or has a high resistance for any reason, under fault conditions, assuming a fault on the mains to earth at A, it is possible for the neutral to have quite an appreciable voltage to earth, and for the house wiring even with the circuit breaker open to have a dangerous potential to earth. A double pole circuit breaker will definitely render the house-wiring safely dead where open. W. WATSON.

A New Instrument for Radio Servicing

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY MAGAZINE OF ELECTRICAL PROGRESS

VOL. II.—No. 17

JANUARY, 1934

The servicing of radio receivers has been greatly simplified by the new WESTON method of Selective Analysis, described in this issue

1/-

GEORGE NEWNES LTD.

JANUARY, 1934 PRACTICAL ELECTRICAL ENGINEER No. 17

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

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A Profitable Study.

An application of electricity which has up to the present only been developed to a fraction of its full possibilities is that of floodlighting. During the past five years much use has been made of this type of illumination in large cities and in connection with important functions, such as the Aldershot Tattoo. There is, however, no denying the fact that at the present time there is a great possibility of expansion in the use of this special type of lighting. Churches, hotels, theatres and large stores such as are found in moderate-sized towns lend themselves particularly well to this style of treatment. Floodlighting properly applied brings out the architectural beauties of a building in the most striking way.

The installation of floodlighting serves a threefold purpose :—

(*a*) It advertises very effectively premises or other objects to which it is applied.

(*b*) It impresses on the public the fact that electric lighting has much greater possibilities than merely for utility purposes.

(*c*) It provides the enterprising electrical installation engineer with further scope for his activities.

Here are some of the purposes to which floodlighting has been effectively applied during recent months :—

Aerodromes ; bathing pools (open air) ; building construction ; building excavation ; car parks ; colliery yards ; covered baths and swimming pools ; fire brigade and salvage ; flags ; gardens ; hoardings ; loading docks, etc. ; light wells ; memorials, statues, etc. ; outdoor skating, etc. ; pageants, etc. ; parade grounds ; prisons, etc. ; quarrying ; railway yards, etc. ; roadmaking, etc. ; sports (football, bowls, croquet, etc.) : storage yards, etc.; ships' funnels; factories ; theatres; town halls; cinemas ; large stores ; churches.

Naturally, the particular type of floodlamp and the general arrangement of the lighting depend upon the purpose for which the floodlighting is required. There is no reason why the floodlighting on local buildings should not be installed by local electricians. If you are interested in electrical installation work why not approach one or two likely users of floodlighting in your own district ? Remember that your first floodlighting installation will provide a permanent free advertisement for your work.

A most interesting brochure on the subject has just been issued by the General Electric Company, Magnet House, Kingsway. We recommend every reader who is interested in modern applications of electric lighting to apply for one of these, mentioning THE PRACTICAL ELECTRICAL ENGINEER. Ask for publication F6469.

Tariffs.

In our issue of October we expressed the opinion that to secure a wide and rapid adoption of electricity in undeveloped districts the effective price to consumers should be from 0¾d. to 1½d. a unit. We are still of this opinion. The fact remains, however, that at the present time there are enormous differences in the prices charged in different localities. No doubt many of our readers have been asked to explain to their non-electrical friends why it is that in one district electricity costs perhaps 1½d. a unit and in another district 6d. a unit. We, therefore, have asked Mr. Oliver Howarth, M.I.E.E., to explain how these widely differing prices are arrived at. We print his article on page 195, and hope that some at least of our readers will find it useful when answering awkward questions of the kind indicated above. In the meantime, we strongly urge upon those responsible for the prosperity of the electrical industry the importance of reducing the tariffs in those districts where they are unreasonably high, even if this means for a time paying lower dividends to shareholders.

Another Weston Instrument.

The progress which has taken place in electrical engineeering during the past 15 years has been due very largely to the facility with which electrical current, voltage and resistance can be measured. Where exact measurements can be taken accurate calculations can be made enabling results to be foretold. Electrical instruments also enable one to tell immediately where a fault exists. The new Weston Analyser, which is described on page 189, represents the latest application of scientific measurements to radio receivers. By using this instrument it is possible rapidly to take readings in every part of the circuit of a modern receiver with the exception of the input from the aerial circuit. Valve emissions, grid current, L.F. and H.F. transformer output, voltages between various points, can all be read off quickly and accurately.

The servicing of commercial wireless receivers is becoming every day of more importance. These sets have been sold in very large numbers during the past two or three years, and the sales are continuing at an increasing rate. After a year or 18 months in use even the best sets are liable to develop faults. Reception may deteriorate owing to the gradual loss of emission from the valve anodes. Any such deficiency can be demonstrated immediately by the use of this instrument, which entirely eliminates guesswork in the servicing of receivers.

A Novel Application of Electricity.

In an article beginning on page 208 will be found a description of one of the latest applications of electricity in industry, i.e., in connection with the humane slaughtering of animals. It is found that a low-voltage electric current scientifically applied can be used to cause complete unconsciousness in animals which are to be slaughtered. It is not impossible that a somewhat similar method may be used as a substitute for chloroform, ether and other anæsthetics; but before this is applied to human beings it must be shown conclusively that the use of electricity in this way does not produce any permanent injury to the tissues or nerves of the subject.

Another Flashing Electric Sign Switch.

Much interest was shown by readers in the article which appeared in our December issue describing the construction of a switch for controlling a flashing electric sign. This month we publish an improved design suitable for dealing with fairly heavy currents. Full constructional details for this are given in the article which begins on page 216. With the increasing use of electricity as an advertising medium there is a very wide scope for the use of signs and flashers, especially in smaller towns where the development in this direction is as yet comparatively small.

Vehicle-actuated Traffic Signals.

Road signals which are actuated by vehicles passing over a prepared strip of the road in front of the white line are coming more and more into use. Readers will remember that in our issue of July we gave technical details of the Electromatic system. This depended for its operation upon the vehicle depressing a mat in the roadway and completing two electrical contacts. In the Autoflex system, described on page 199, the vehicle passes over a pneumatic mat which sends a puff of air into bellows the rising of which closes the detector contacts. Another feature which distinguishes the Autoflex from other systems is the fact that the whole of the electrical switching is carried out by means of relays. The method used to obtain delayed action in the closing of the relays is particularly interesting. It utilises the fact that a condenser can be discharged as slowly as desired, providing a sufficiently high resistance is used for discharging it, in conjunction with the fact that a neon tube will not allow current to pass until the voltage across the ends of the tube exceeds a certain value. The ingenious adaptations of this principle as embodied in traffic-control systems are well worth serious study, even by engineers who are not directly interested in traffic-control apparatus.

AN INGENIOUS INSTRUMENT FOR SERVICING RADIO RECEIVERS

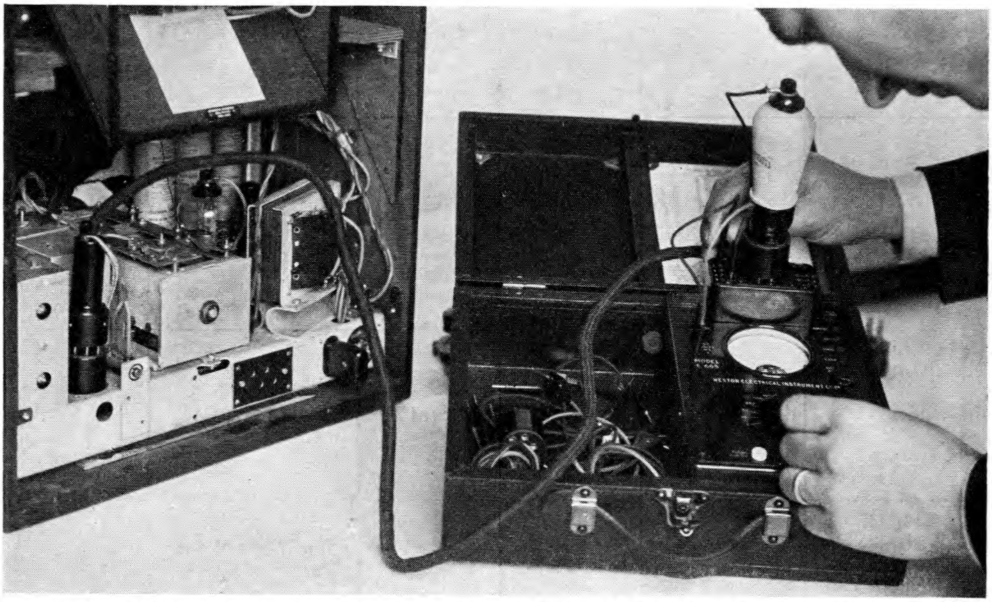


Fig. 1.—USING THE WESTON SET ANALYSER TO TEST VALVE VOLTAGES AND EMISSION.

MODERN commercial radio receivers are as a general rule so carefully designed and well made that normally very little trouble may be expected. At the same time any electrical or wireless dealer who has during the past two or three years sold a large number of commercial sets is certainly liable to be called in to service some of these sets at frequent intervals.

Very often the purchaser of an expensive radiogram or complicated superheterodyne receiver is a man who does not profess to have the slightest knowledge of wireless set construction or maintenance. No radio or electrical engineer who takes his work seriously, likes to feel that he must return a set to the makers for some minor defect to be remedied. It is, therefore, essential for those engaged in this work to have some systematic means of testing the various circuits and components in a receiver.

Most of the larger set makers now issue full technical data relating to each set. A typical table which relates to the Philips' Model 830A is given on page 190.

Here it will be seen that the makers specify certain potentials to be applied to the valve electrodes and the normal values of the currents in the electrode circuits for the correct functioning of the receiver, also various components for different resistance values. The Weston selective Analyser has been specially designed to enable all these values to be verified systematically, accurately and quickly.

In order that the Analyser shall be suitable for use with any commercial type of receiver, adaptors are provided which

VALVE TESTING TABLE (TYPE 830A PHILIPS RECEIVER).

To Measure	Measure Between	Normal Readings	Reading Too High, Examine	Reading Too Low, Examine	Remarks
L2, S4VB (1)					
Plate voltage ..	Plate and cathode ..	160–175 v		S10, S11, C4, R3	
Screen voltage ..	Screen grid and cathode	70–80 v.	R2	R1, C3	
Plate current ..	Plate ..	1 7–2 3 m a.	R6–R7	L2, R6–R7, S10–11 R3, C4	
Grid circuit ..				S7–8–R9	Continuity test remove valve
L3, S4VB (2)					
Plate voltage ..	Plate and cathode ..	160–175 v.		S12, R10	
Screen voltage ..	Screen grid and cathode	70–80 v.		R4, C5, R10	
Plate current ..	Plate	1.7–2.5 m a.	C16	L3, S12, C5, R4, 11 and 10	
Grid circuit ..				R18	Continuity test remove valve
L4 (244V)					
Plate voltage ..	Plate and cathode ..	75–85 v.		R4, C23,C5, S23	
Plate current ..	Anode ..	4.0–6 0 m.a.	C24, C17	L4, R13,R4, C5 S13, C23	
Grid circuit				R13	Continuity test remove valve
L5 (PM24A)					
Plate voltage ..	Plate and filament ..	145–175 v.		S16, S15, C20, C21, L1	
Aux. grid voltage	Screening grid and fil. ..	145–175 v.		L1	
Plate current ..		14–17 m a.	S14, R8, S5	L1, L5, S15–16, C20–C21	
Grid circuit ..				S14, R8, S5	Continuity test remove valve
Heater voltage ..	Across filament	3 9–4 v.	Mains transformer	Mains transformer	

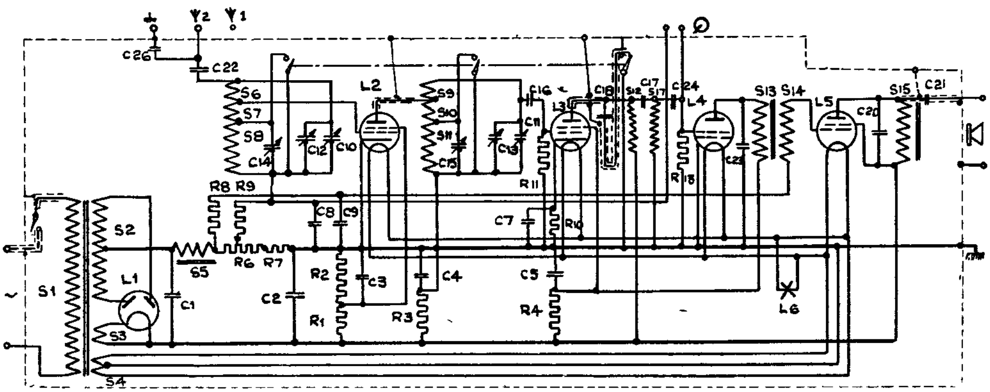


Fig. 2.—THEORETICAL CIRCUIT DIAGRAM OF PHILIPS TYPE 830A.

enable the set to be plugged in to either a 7-pin valve holder, a 5-pin valve holder or a 4-pin valve holder. This covers all requirements likely to be met with.

Radio valves are, however, subject to rapid development and the Weston Electric Instrument Co. will stock adaptors to meet any future requirements in this direction. A complete range of adaptors for American valves are also stocked.

Description of the Instrument.

Briefly the Analyser consists of a sensitive moving-coil instrument provided with resistors and shunts which enable it to be used for giving accurate readings of voltage and current over a very wide range. When used as a voltmeter the instrument has a resistance of 1,000 ohms per volt on all ranges. This is of special importance in the case of measuring eliminator potentials since the voltage regulation on load charges of an eliminator is inherently bad. A rectifying device is, of course, incorporated in order to measure A.C. values.

In addition to the above, a small battery is included. This is used in conjunction with the indicating instrument and a circuit whose constants are specially designed for the measurement of resistance, and for this purpose the instrument is provided with an ohm scale.

Voltage Readings from 5 up to 1,000 Volts.

Considering first the use of the instrument as a voltmeter it will be found that immediately below the instrument dial is a selector switch. For reading voltages this switch must be set to the left of the off position, where a choice of six different scale readings is available from 5 volts to 1,000 volts full scale deflection.

Milliamp. Readings from .1 up to 1,000.

For measurements of current the switch arm must be turned to the right of the centre division, and it will be found that there are similar scale ranges corresponding to 2.5, 5, 50, 100, and 500 milliamps. for the full scale reading.

Either A.C. or D.C. Readings.

Immediately below the switch arm can be seen two press buttons. For reading A.C. voltage or current, the button so marked is depressed and, if desired, it may be locked in position by turning. The other button is depressed and locked in position when the readings desired are direct current.

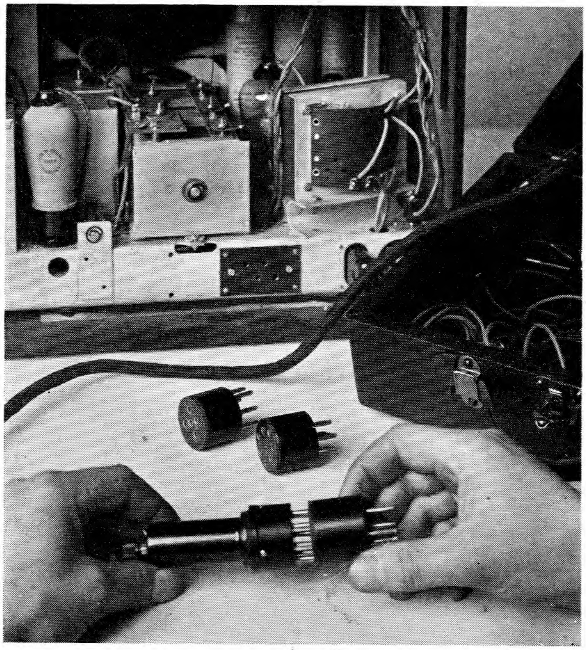


Fig. 3.—As Valves are Made with 4, 5 and 7-Pin Bases, Special Adaptors are Provided to Enable the Set to be Plugged in to Whichever Type of Valve Holder is Being Used.

Measuring Resistance.

When it is desired to use the Analyser for a rapid measurement of resistance, the switch arm is turned fully over to the right on to the division marked "ohms." The D.C. button is depressed

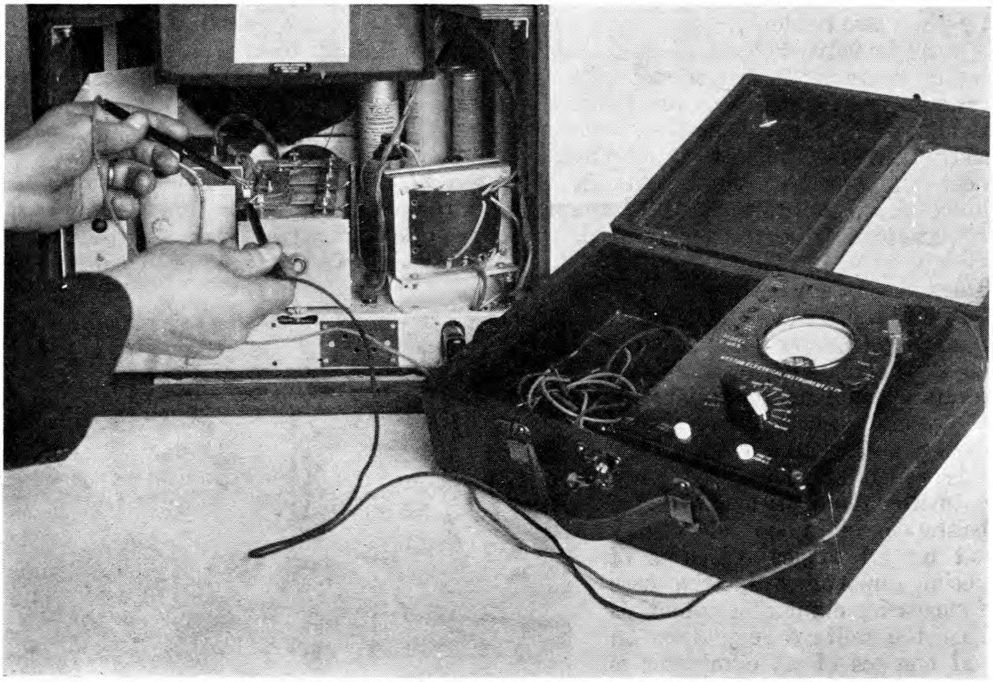


Fig. 4.—TESTING CONDENSERS FOR SHORTING OR BAD INSULATION.

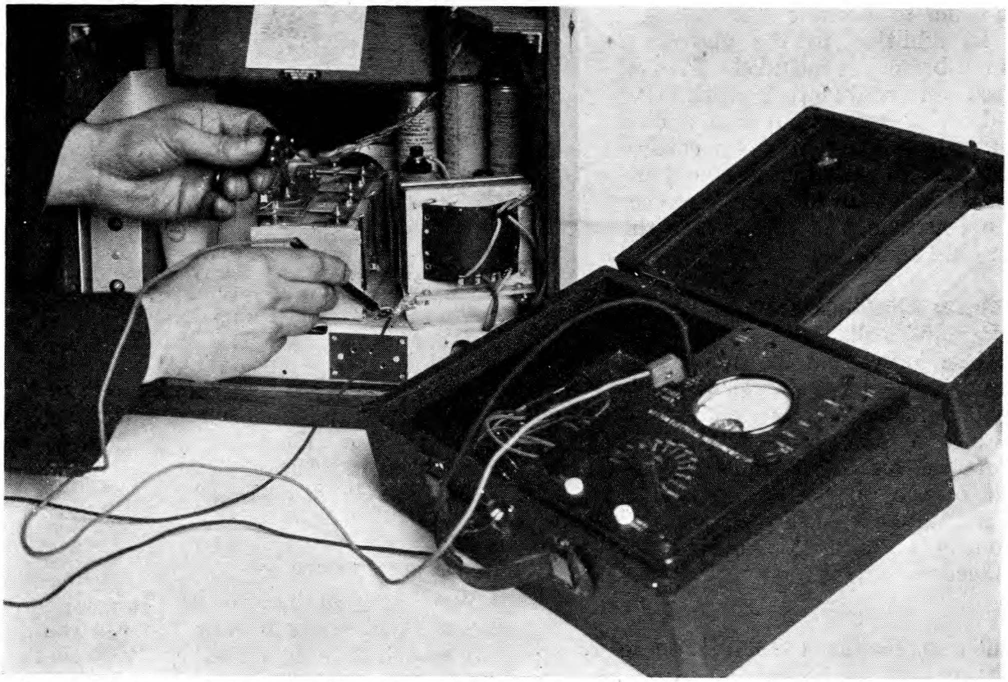


Fig. 5.—MAKING A VOLTAGE TEST ON A LOUDSPEAKER FIELD. NOTE THE EARTH CLIP, THUS LEAVING ONE HAND FREE.

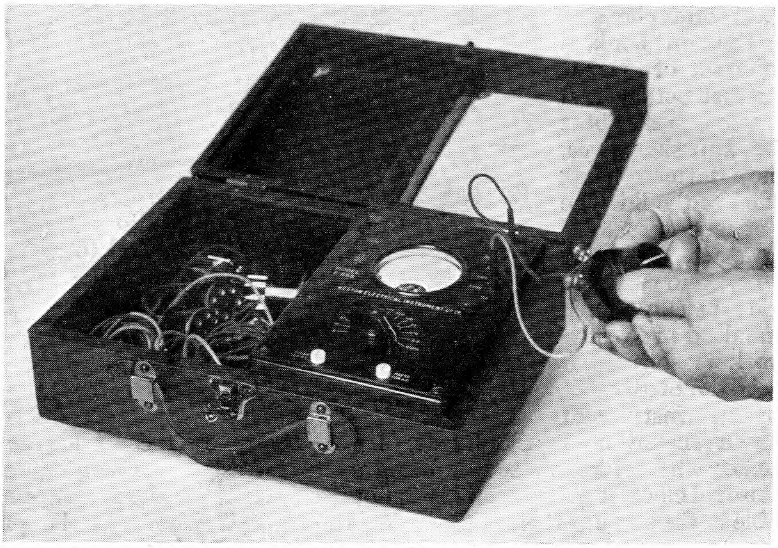


Fig. 6.—Checking the Resistance of a Potentiometer.

and locked in position. The leads are plugged into the small holes provided at the top right-hand side of the instrument, and the other end of the leads are applied direct to the ends of the resistance which it is desired to measure. Immediately, the value of the resistance is indicated on a special scale provided on the instrument dial.

Multiplying Scales for Resistance.

If the test leads are plugged into the first pair of holes, a direct reading of the resistance is obtained. If the first and third holes are used, the scale reading must be multiplied by 10. If the first and fourth holes are used, the scale reading must be multiplied by 100, and by using other pairs which are marked, the scale readings can be multiplied by 50, 100 or 500. This ingenious arrangement enables the resistance scale to be used for giving reasonably accurate readings of any resistance from 1 ohm up to 500,000 ohms. A typical makers' table of ohmic resistance is given on the next page.

Eliminates Guess-work in Set Testing.

It can be readily seen that such an instrument places in the hands of the radio service man a sure method of eliminating all guess-work in the locating of faults in a wireless receiver. In a short space of time this set Analyser can be instrumental in saving many valuable hours which might otherwise be easily wasted by hit-and-miss methods of fault location.

The complete set includes a

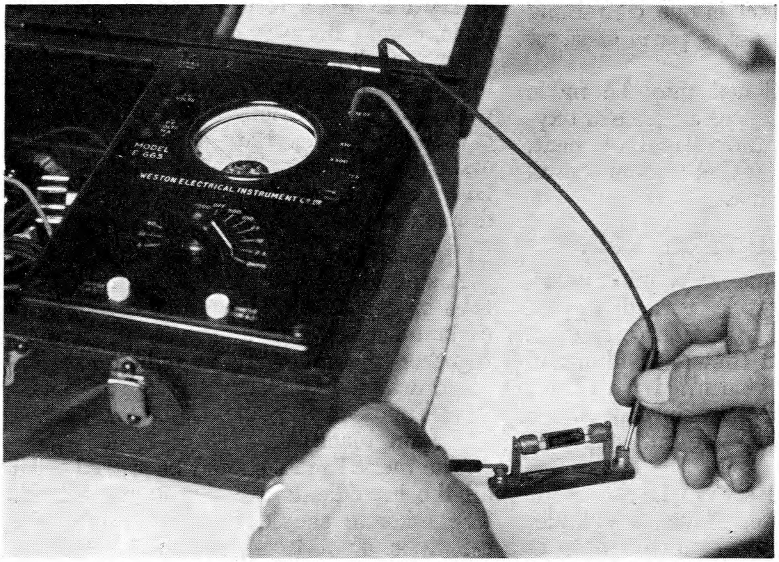


Fig. 7.—Making a Resistance Test on a Grid Leak.

most comprehensive instruction book, a brief set of operating instructions and a valve base chart for British valves, the latter being fixed in the lid. The instrument is very compact, light to carry, and is up to the usually high standard of Weston workmanship.

Undoubtedly it is an instrument which should be in the hands of every dealer who prides himself on being up to date and efficient in his work. It is not possible in the scope of this article to deal fully with the systematic testing of a typical wireless receiver. Nor do we think it would be fair to our readers to attempt to do this, as the actual procedure to be followed varies in the case of each different make. Sufficient information has, however, been given to enable the reader to appreciate the possibilities of this novel and ingenious instrument, and we are content to leave the matter at this. If you are desirous of obtaining further information write to the Weston Electrical Instrument Co., Ltd., Kingston By-pass, Surbiton, Surrey, who will be pleased to send details of this ingenious instrument to any reader of THE PRACTICAL ELECTRICAL ENGINEER.

Ohmic Resistances of Coils Type 830A Philips.

Circuit Designation	Resistance in Ohms	Remarks.
S8, S11 ..	21—23	For designations referred to in col. 1, see circuit diagram Fig. 2.
S6-7, S9-10	3.2—3.3	
S12 ..	31.0—37.0	
S13 ..	340—420	
S14 ..	1,460—1,780	
S15 ..	925—1,135	
S17 ..	129—157	

HINTS AND TIPS FOR THE PRACTICAL MAN

Readers are invited to send brief paragraphs for inclusion in this section. All contributions will be paid for at our usual rates

TO SOLDER NICKEL PARTS.

A suitable grade of solder for joining nickel parts consists of three parts of yellow brass to one part of silver. A cheaper grade of solder is one containing 15 parts of yellow brass, 5 parts of silver and 4 parts of pure zinc.

The solders mentioned may be made with the aid of a blow pipe, furnace or oxy-acetylene flame as the source of heat. When using these nickel-solders borax should be used as a flux.

TURNING HARD FIBRE ROD.

The electrician frequently requires parts, for electrical apparatus, turned in the lathe from fibre rod. In this connection it may be mentioned that hard fibre and also ebonite should be turned with tools similar in shape to those employed for machining brass, but without any top rake.

The cutting speed should be from 600 to 900 ft. per minute. Thus, a cylinder of 2 in. diameter would have to rotate at about 1,600 revolutions per minute.

It will generally be found that tools used for turning hard fibre wear fairly quickly. For this reason many firms concerned with the quantity production of hard fibre parts use diamond-pointed tools, employing a type of black diamond known as "bort"; these coloured diamonds are comparatively cheap compared with the clear variety and they have an exceedingly long life. Moreover, when one of the "points" wears, another may be brought into action by remounting the diamond in its holder.

WAX FOR DRY BATTERIES.

A suitable wax for use in filling up the tops of dry cells and coating the tops of carbon electrodes can be made by heating together the following ingredients:—

Paraffin wax	8 parts.
Pitch	1 part.
Lampblack	1 „

The melted mass should be stirred until all the ingredients are thoroughly mixed. The mixture should be poured into the cell tops or a brush may be used for applying it.

TARIFFS FOR ELECTRICAL ENERGY

By O. HOWARTH, M.I.E.E., M.Am.I.E.E.

THERE are two main factors which govern the price of most commodities: one is the value to the purchaser, the other is the cost of producing and delivering the commodity to the purchaser. If the cost exceeds the value to the prospective purchaser it is useless to embark upon the production of the commodity. The value is not likely to be the same to all prospective purchasers, and therefore the lower the cost the greater the number of purchasers—there is a saturation point, of course, but it is usually remote—and thus the supplier has an incentive to reduce his costs in order to increase his sales.

Why the Price of a Particular Commodity Will Not be the Same in All Places.

Electrical energy is a commodity which can be used for various purposes for which energy is required. The value of the energy to the purchaser is determined by the use to which he puts it, and, as will be shown later, the cost of supplying him with the energy varies with the varying uses—hence the different rates for different purposes. The price must cover the cost of delivery to the place where the purchase is made, and, therefore, the price of a particular commodity will not be the same in all places.

An Analogy.

For instance, the cost of supplying a cup of tea at the top of Snowdon is more than the cost of supplying one in an ordinary city tea shop. Fortunately for the caterer there, its value to the purchaser is greater at the top of Snowdon than in the tea shop.

Electricity Supply Undertakings Have No Monopoly.

There are those who think that electricity supply undertakings have a monopoly and can fix their prices without regard to the above considerations, but a little reflection will show that such is not the case. Supply undertakings have not a monopoly of the supply of energy, only of the supply of *electrical* energy. There are alternative forms of energy available which can be used for the purposes for which electrical energy is used, and the purchaser has his choice.

When a house is built in the average urban district there is usually the choice of electricity, gas, coal and oil for various household purposes, but there is rarely any choice of water supply. Water supply is a real monopoly in urban areas. The builder is compelled to install a water supply, and it must be obtained from the local water supply undertaking. Not so with electricity; ordinary commercial considerations determine whether electricity will be installed or not.

Items that Determine the Cost of Affording a Supply of Electricity.

The total cost of affording a supply of electricity can be divided up into a multitude of items each influenced by various factors. It is not practicable in a short article, nor is it necessary, to enter into a detailed discussion of the various items. A consideration of the effect of the cost of generation, transmission, distribution and administration upon the cost of affording the supply will enable the reason for different prices in different areas and for different purposes to be understood.

The Question of Generation.

Generation is easily dealt with, as the grid tariff represents the cost of generation and is the cost at which an undertaking buys at its station bus bars. The tariffs so far published by the C.E.B. have sliding scales for the kW demand charge which commence at £3. 10s. and come down to £2. 15s. per kW per annum. The kW demand is defined as twice the largest number of units taken during any half-hour in the year of account. It should be noted that this is a higher figure than the average of the monthly or quarterly demands, as a high demand during November or December will increase the cost of electricity purchased from the C.E.B. during the preceding 10 or 11 months. The grid price per unit is of the order of 0.2d.

Cost of Transmitting Depends on Size and Nature of the Area.

The cost of transmitting electrical energy from the point of generation to the various distribution centres will be determined by the size and nature of the area. If small loads have to be transmitted considerable distances the cost per kW of demand will be much more than if large blocks of power can be transmitted to distributing centres within a few miles of the generating station. The kW charge may thus be increased by anything from £1 to £3 per kW, and the iron losses in a multiplicity of transformers continuously energised may be equal to 25 per cent. of the units sold. The price of electricity delivered to the distribution system may therefore be taken as of the order of £4. 10s. per kW of annual maximum demand, plus 0.25d. per unit.

The Cost of the Distribution System.

The cost of the distribution system will vary with the nature of the area. In general it will be a low tension system in urban areas and a mixed high and low tension system in rural and semi-rural areas and in large cities where the load density is high. The cost of space for transformations and of breaking up streets is high in cities and tends to nullify the economic advantage of high load density. An examination of the published records of capital expenditure and number of consumers for a variety of undertakings receiving a bulk supply, and who, therefore, have only the distribution system to provide, shows the capital expenditure upon this item to vary between £20 and £60 per consumer.

Administration Costs.

Each consumer must have his meter read, his account made out, and so on. Various records must be kept and attention given to complaints and enquiries. Office accommodation must be provided. In short, all those items classed under the heading of management or administration must be paid for. An average administration cost for normal undertakings is 25s. per consumer per annum.

The Four Items Combined.

The four items of generation, transmission, distribution and administration can now be combined for consumers fed from the low tension network. Experience has shown that a house having two living-rooms, scullery and three bedrooms uses on the average 130 units per annum for lighting and imposes a demand of 0.05 kW on the peak. This demand is per consumer and incorporates what is known as diversity. That is, it is less than the consumer's actual demand, but is the amount by which he increases the peak load of the undertaking.

A Typical Example.

The cost of generation and transmission is combined in the price of £4. 10s. per kW per annum, plus 0.25d. per unit. The cost of 130 units per annum will be :—

0.05 kW at £4. 10s.	54d.
130 units at 0.25d.	33d.
Total ..	87d.

A cost of 0.66d. per unit.

Administration at 25s. per consumer per annum .. .. 300d.

A cost of 2.3d. per unit.

7½ per cent. for interest and depreciation on distribution capital of £20 per consumer .. 360d.

A cost of 2.77d. per unit.

This amounts to a total cost of 0.66 + 2.3 + 2.77 = 5.73d. per unit.

If the distribution capital is £60 per consumer, the cost of this item will be 8.3d. per unit and the total cost will be increased to 11.26d. per unit. Thus the most important items in the cost of electricity for lighting are the capital and administrative costs. The nature of the area supplied may have such an effect upon the cost per consumer of distribution as to make a difference of 6d. per unit in the cost of affording a supply for lighting.

When the Supply is Used for Power Purposes.

Where the supply is used for purposes other than lighting the cost of the additional supply will depend upon the use, but it is usual to average all domestic uses other than lighting and charge one price. A normal consumption for an electric washboiler is 170 units per annum and the addition to the peak load of the undertaking is 0.15 kW per boiler. Assume there is no addition to the cost per consumer of distribution or of administrative costs. The extra cost to the undertaker of supplying these units will be :—

0.15 kW at £4. 10s.	162d.
170 units at 0.25d.	43d.
Total ..	205d.

A cost of 1.2d. per unit.

If still more extensive use is made of electricity for heating and so on, and 800 units per annum are used in addition to the 130 units for lighting with an addition to the peak load of the undertaking of 0.25 kW, the extra cost of supplying the units will be :—

0.25 kW at £4. 10s.	270d.
800 units at 0.25d.	200d.
Total ..	470d.

A cost of 0.59d. per unit.

Margin Allowed for Voltage Drops Due to Power Appliances.

It must not be overlooked that the addition of washboilers, cookers and radiators, whilst they may only add a fraction of a kilowatt to the maximum load of the undertaking due to the diversity in the times when the various consumers use these appliances, will cause voltage drops in the distribution system due to loading up individual distributors. This will result in an increase in the cost per consumer of the distribution system, and some margin must be allowed over the above cost to cover this.

Prices based on the above costs in the case of the £20 per consumer distribution system might be :—

Lighting	6d. per unit
Domestic power	1d. per unit

Or, alternatively, a two-part tariff with a fixed charge of 13s. 9d. per quarter for a house of the type described with a charge of ¾d. per unit might be charged.

In the case of the £60 per consumer system the charges might be :—

Lighting	1s. per unit
Domestic power	1½d. per unit

Alternatively, a two-part tariff with a fixed charge of 28s. 9d. per quarter for a six-roomed house, with a charge of 1d. for every unit consumed.

The reason for the higher running charge under the two-part tariff and the higher domestic power charge on the £60 per consumer undertaking is to cover the increased distribution charge per consumer which would inevitably result from the increased load.

Electrical Energy Used as Motive Power.

Another use for electrical energy is as motive power. Experience shows that while the use varies over a wide range, the average small motor uses about 4,000 units per annum for every kW which it adds to the peak load of the undertaking. The cost of generation and transmission is :—

1 kW at £4. 10s...	1,080d.
4,000 units at 0.25d.	1,000d.
Total ..	2,080d.

A cost of 0.52d. per unit.

This cost is independent of the number of units provided that the ratio of kW to units remains the same. The cost of supplying a small motor using 500 units per annum from a £20 per consumer distribution system will be :—

Administration at 25s. per consumer per annum .. .. 300d.

A cost of 0.6d. per unit.

7½ per cent. of £20 distribution capital .. .. 360d.

A cost of 0.72d. per unit.

This amounts to a total of $0.52 + 0.6 + 0.72 = 1.84$d. per unit.

If the distribution capital is £60 per consumer the cost per unit will be increased to a total of 3.28d. Obviously, an increase of consumption, although accompanied by an increased kW demand, will effect a reduction in the cost per unit, but the distribution system will have to be strengthened along the route to a power user whose demands are above a certain limit, and, therefore, the total cost will never approach the lower limit of 0.52d. per unit. A sliding scale would be an appropriate charge for this type of load, and in the case of the £20 per consumer undertaking it might commence at 2d. per unit and have a final price of 1d. per unit. In the case of the £60 per consumer undertaking the corresponding prices might be 3½d. and 1¾d. per unit.

Only a broad indication has been given of the way the price of electrical energy is determined.

There are various factors — such as local rates, which may amount to as much as 10 or 15 per cent. of the revenue—which must be taken into consideration when fixing prices, and while the figures given are typical of what obtains in some districts conditions are so varied that they must not be regarded as applicable to all districts. For instance, the aforesaid addition to the C.E.B. price to cover transmission would be much too small in the case of a lightly loaded transmission line to a remote bulk supply undertaking.

COSMIC RAYS

THE power of X-rays to penetrate large thicknesses of wood, flesh, aluminium, etc., is well known.

Cosmic rays, however, are of much greater penetrating power. They can penetrate a thickness of several feet of lead before they are reduced to one-half their original intensity, whereas X-rays would not penetrate 1 inch of lead.

As we ascend above the surface of the earth, cosmic rays become more numerous. This can be shown by balloon ascents, such as that of Professor Piccard. The original experiments on the power of water to absorb these rays were done on Lake Constance, in Switzerland. The intensity of the rays was reduced to one-half of its initial value 40 ft. below the surface of the water.

What Cosmic Rays are.

Cosmic rays are probably very short electromagnetic waves similar to X-rays, ultra-violet light and ordinary light. There are associated with them electrons and other particles moving at a very high speed of an order of 100,000 miles a second.

What Cosmic Rays Can Do.

Occasionally when penetrating matter, e.g., lead, copper, glass, etc., the cosmic ray goes right through an atom and breaks it up into its component parts.

A copper atom has been observed to break up into as many as 26 parts under the influence of cosmic rays. Among these parts we find electrons, protons, alpha particles, and strangest of all a positive electron has been detected.

Where Cosmic Rays Come From.

When scientists had assured themselves that the rays did not come upwards from out of the earth, several theories were advanced as to their origin. The first theory suggests that cosmic rays were electrons moving with enormous velocities. These electrons are produced during thunderstorms.

More recent ideas seem to show that most of the rays come from outside our solar system. It has been suggested that they may be produced by new elements being formed in the depths of space, as a result of all the energy which is radiated as light and heat from the stars.

Fresh Fields to Conquer.

Further research work is required before a definite conclusion can be arrived at, as the subject is comparatively new to science, and the field which it opens out is largely unexplored.

THE "AUTOFLEX" VEHICLE-ACTUATED TRAFFIC CONTROL SYSTEM

By FRANCIS G. TYACK, Grad.I.E.E., City and Guilds Bronze Medallist

It will be remembered that in our issue of July we gave a full description of the Electromatic traffic control system. Below we give an outline of another system, the Autoflex, which has been adapted for use at several important traffic centres

General Remarks on the Autoflex System.

THE use of red, amber and green traffic signals for controlling the traffic on busy cross roads and junctions is so well known as to render it unnecessary to describe these. The Autoflex system provides a means by which the changing of the lights is automatically controlled by the traffic as it approaches the cross roads.

About 70–100 feet before the white line is reached a long strip of rubber mat is let into the roadway so that every vehicle has to cross this. Sections of this rubber mat are shown in Figs. 3 and 4. Notice that the mat is divided into two compartments containing air. Each of these compartments is connected to a small bellows. (See Fig. 2.)

How the Pneumatic Mat Operates.

When a vehicle is approaching the white line in the ordinary way it must pass first over the leading side of the mat. This sends a puff of air down the left-hand air pipe to the left-hand bellows (see Fig. 2) thus closing the contact.

Quick Moving, Slow Moving or Stationary.

If the vehicle is moving quickly the contact is of brief duration, if slowly the contact remains closed for a longer period. If the vehicle comes to rest on the mat the bellows rise and make contact and then fall because the pneumatic system is open to the atmosphere.

Vehicles on Wrong Side of Road.

If, for any reason, a vehicle approaches the mat in the wrong direction, i.e., on

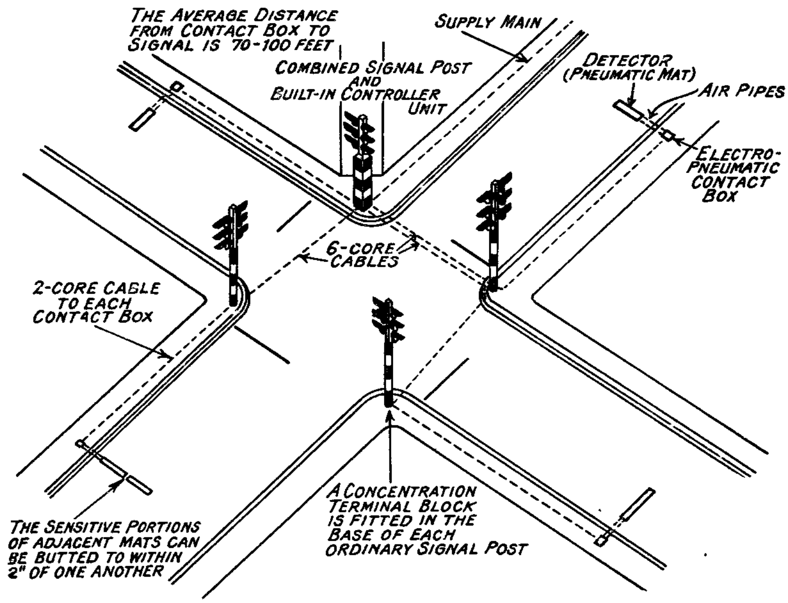


Fig. 1.—LAY-OUT AND CABLING OF A TYPICAL STRAIGHTFORWARD INTERSECTION OF THE "AUTOFLEX" VEHICLE-ACTUATED TRAFFIC CONTROL SYSTEM.

its wrong side of the road when moving away from the white line, the right-hand air channel in the mat is depressed. This causes the right-hand bellows to be raised. The edge of the bellows interlocks with the edge of the left hand bellows carrying the electrical contacts, and the left-hand bellows, therefore,

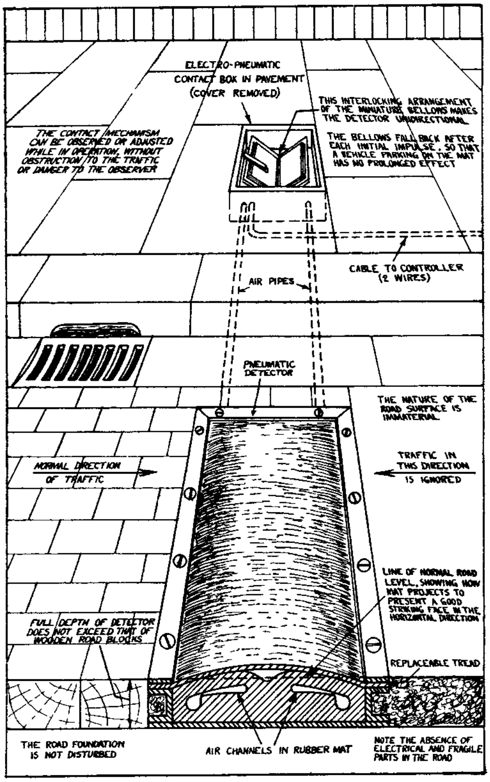


Fig. 2.—Diagram Showing the Pneumatic Detector Used on the "Autoflex" Vehicle-actuated Traffic Control System.

cannot lift when the vehicle passes over the other side of the mat.

The Functions of the Pneumatic Mat Summarized.

From the above it will be seen that the pneumatic detector takes account of the following conditions:—

(*a*) A fast-moving vehicle approach- the white line causes a brief closing of the detector contacts.

(*b*) A slow-moving vehicle passing over the mat causes the contacts to be closed for a longer period. The "closed" period is inversely proportional to the speed.

(*c*) A vehicle brought to rest on the mat causes the contacts to remain closed for a period and then become opened.

(*d*) A vehicle crossing the mat in the wrong direction produces no effect on the detector contacts.

We have now to discover what happens when the detector contacts are closed. Before proceeding to explain this, we must digress for a few moments.

A Few Words about Relays.

The Autoflex system is operated throughout by electrical relays. Every electrical engineer is familiar with the simple type of relay where a small current passed through the coil of an electromagnet causes an armature to be attracted and so closes a second circuit. The principle of the relays used in the Autoflex system is exactly the same, but the point to bear in mind is that most of the relays used have a large number of contacts so that two, three, or more circuits are made or broken when a single relay is operated.

How Delayed Action is Obtained.

It is fairly obvious that as the red, green and amber lights have each to be switched on for certain periods some means must be provided for delaying the action of some of the relays. The method employed for this is ingenious and interesting.

The Neon Tube and Condenser Circuit.

Fig. 6 shows a typical time delay circuit. It will be seen that a neon tube is connected in series with a relay and a condenser across the supply terminals. In parallel with the neon tube and the relay is a charging resistance of 2,000 ohms, and there is also a discharging resistance (variable) which can be connected across the condenser terminals by moving the control contact from left to right.

How it Functions.

Look again at Fig. 6 and see what are the electrical conditions of the circuit.

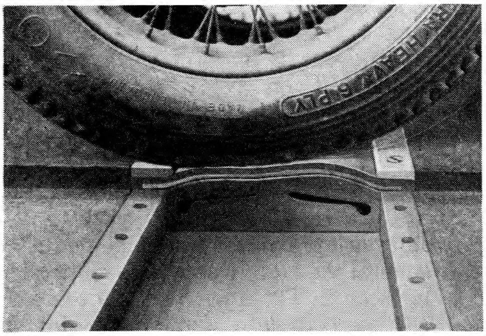


Fig. 3.—View of Pneumatic Mat with Car Wheel Compressing One Air Channel.

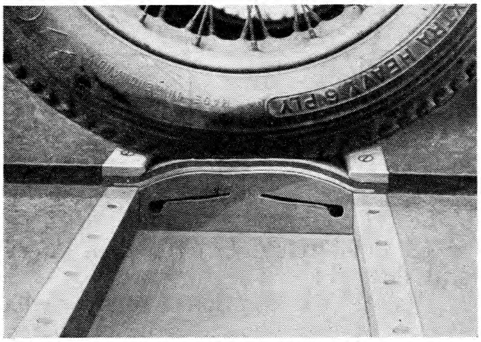


Fig. 4.—View of Pneumatic Mat with Car Wheel on Centre.

The condenser is fully charged through the charging resistance and no current can pass through the neon tube or the timer relay. Now imagine that the control contact is moved over into the other position so that the discharge resistance is placed across the condenser terminals. The condenser will immediately begin to discharge itself through the resistance, and when it is discharged or nearly so, the voltage across the timer relay and the neon tube is sufficient to "strike" the tube. Current will now flow through the neon tube and timer relay which will, therefore, be operated. Obviously, by adjusting the value of the discharge resistance, the time which elapses between the switching over of the control contact and the operation of the timer relay can be varied between very wide limits.

Another Method of Obtaining Delayed Action.

Fig. 7 shows a modification of this circuit. An additional contact has been placed in the neon tube circuit, and the normal position of the control contact is such that the condenser is normally in a discharged condition owing to the position of the upper switch marked "Right of Way Relay Contact."

Notice that the charging resistance in this case is 20,000 ohms.

This Method Allows for the Speed of the Approaching Vehicle.

This is the circuit which takes account of the speed at which a vehicle crosses the detector mat. The right of way relay contact is moved into the charging position for a period inversely proportional to the speed at which the vehicle passes over the mat.

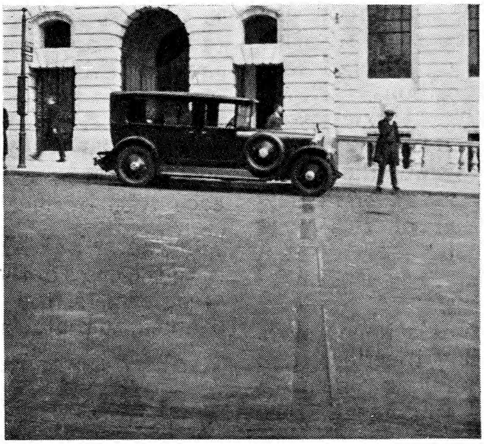


Fig. 5.—A Car Inadvertently Parked on a Detector Outside a Public Building.

This causes a permanent demand for the road concerned when electric detectors are used, but has no effect on the operation of the system when pneumatic detectors are used.

A Slow-moving Vehicle.

In the case of a slow moving or stationary vehicle the condenser has time to become fully charged.

A Fast-moving Vehicle.

In the case of a fast-moving vehicle the condenser is only partially charged. Thus, assuming that the demand relay contact is closed, there are two methods by which a variable delay action can be obtained for the

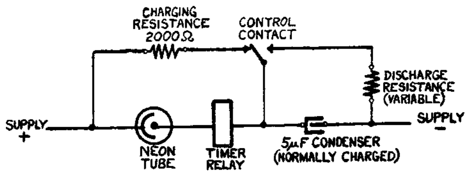


Fig. 6—The Basic Timer Circuit.

speed timer relay, *i.e.*, the time interval will depend:

(*a*) On the duration of time for which the condenser is being charged.

(*b*) The value of the discharge resistance.

Once the principle of these two circuits has been thoroughly grasped, there should be little difficulty in following the operation of the system. There is just one other point.

The "Detached Contact" System of Drawing Circuit Diagrams.

To simplify the reading of the circuit diagrams the circuit arrangements are most conveniently shown by what is known as the detached con act system. In this system each relay is indicated by a rectangle marked RW, DE, LC, etc. A relay marked DE may have associated with it three or more sets of contacts. These contacts are shown separately from the relay and are marked DE1, DE2, DE3, etc. Thus, when relay DE is operated, the contacts DE1, DE2, DE3, etc., are closed or changed over from their normal positions. Relays marked with hatched lines at one end of the rectangle are slow to release. Having grasped all the above points the reader will have no difficulty in understanding the following description of this most ingenious electrical robot.

The Controller Apparatus.

Standard Post Office telephone relays are used for all switching functions, and comprise the only moving members throughout the normal equipment. The movements of the armatures do not exceed $\frac{1}{16}$ in. A typical relay is shown in Fig. 8.

The remainder of the equipment is purely static, and consists of well-known items such as condensers, neon tubes, resistances, and Westinghouse metal rectifiers.

The equipment is as far as possible accommodated on relay set mounting plates of the "jack-in" type, which are now standard for use in automatic telephone exchanges. These facilitate removal and replacement for inspection purposes, and also permit very great flexibility in the circuit arrangements.

A general view of a complete controller can be seen in Fig. 13. This photograph shows the complete equipment for a normal controller. The timing control switches are located in the compartment above the relay set. The switches are graduated in seconds.

No Oiling or Regular Maintenance is Necessary.

From the above description it will be realised that no oiling or regular maintenance is necessary, and that the equipment is capable of operation for long periods without attention.

THE TIMERS.

The basic timer circuit is shown in Fig. 6, and consists essentially of a 5 mfd. condenser in series with a neon tube and a relay, and also a high value resistance which can be connected across the condenser when required.

As already explained, the neon tube is used as it has the peculiar property of acting as an insulator until the impressed E.M.F. is sufficiently high to ionise the gas and enable it to pass current. The ionising potential remains constant for a particular tube, and the supply E.M.F. can be adjusted to suit each tube by means of a potentiometer.

The Amber and Maximum Green Timers.

In the cases of the amber and maximum green timers, the condenser is normally charged, so that a large potential difference

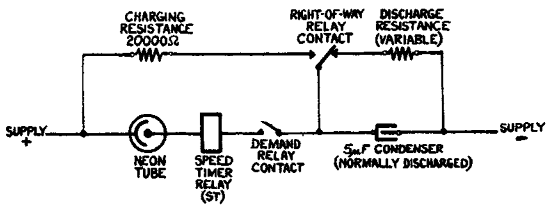


Fig. 7.—The Speed Timer Circuit

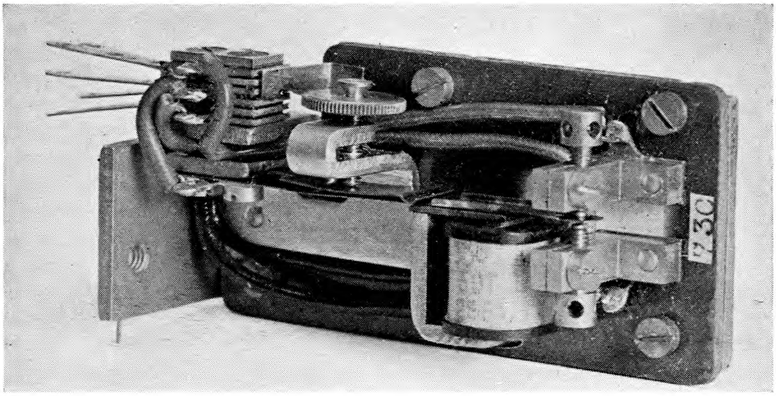


Fig. 8.—The Right-of-way Relay.

This relay is capable of operation and release in the time of 0.5 millisecond (5/10,000 of one second), and so affords extremely accurate repetition of the vehicle impulses.

exists across its plates. When it is desired to measure off a time period the control contact is operated, so commencing the discharge of the condenser and removing the short-circuit across the neon tube and relay.

The potential across the condenser gradually drops and that across the neon tube correspondingly rises, until such a state is reached that the tube "strikes" and passes current, so recharging the condenser and operating the relay.

The relay remains operated during the charging period of the condenser (80 milliseconds) and affects the external circuits in any desired manner. The 5 mfd. condenser discharges to the required striking voltage at the rate of 1 second for each 0.1 megohm of the discharge resistance.

The Speed Timer.

The conditions of operation of the speed timer (see Fig. 7) differ from those applying to the remaining timers inasmuch as variable times, inversely proportional to the vehicle speeds, have to be measured off in place of fixed periods. In this case the condenser is normally discharged, and is charged only during the passage of vehicles across the detectors in the roads having right of way, *i.e.* when relay RW is operated. The neon tube circuit is not completed until the registration of a demand in the road not having right of way, when relay DE operates and locks via its own contact.

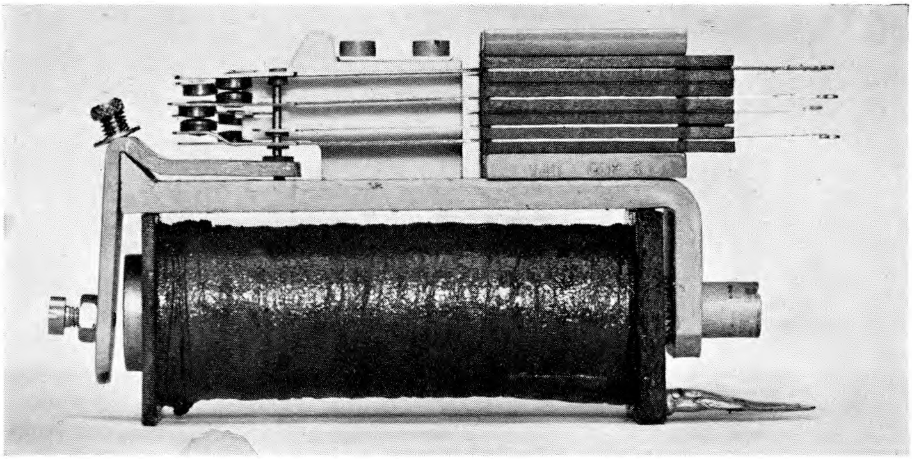


Fig. 9.—Plan View of the Typical Lamp Contactor.
A successive break action is shown on the nearer side.

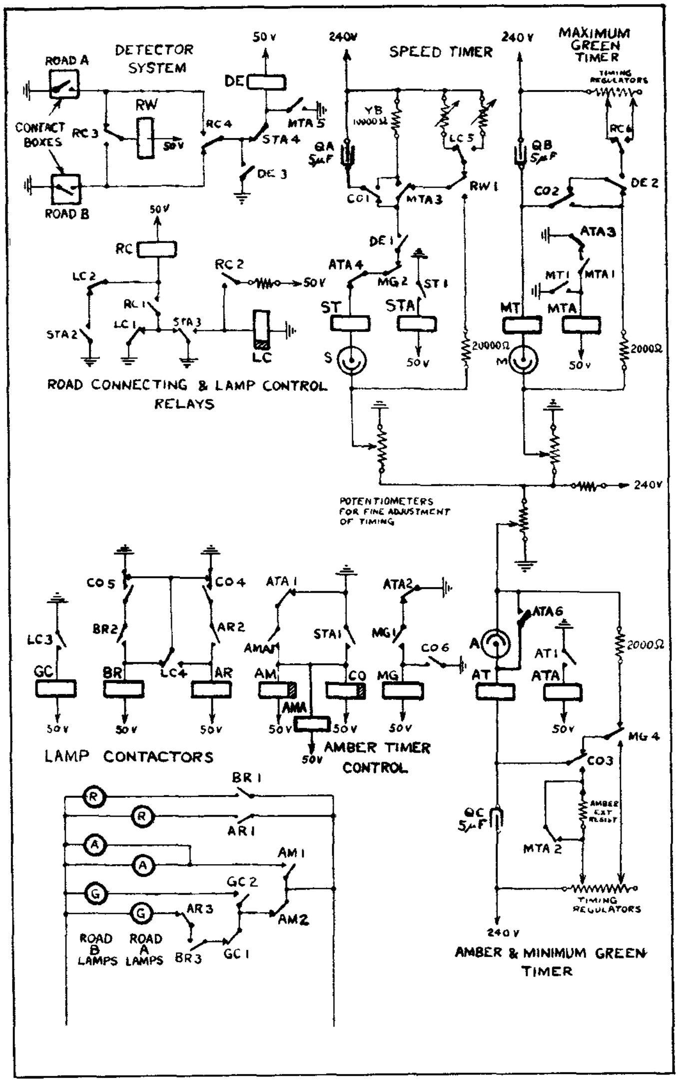


Fig. 10.—Explanatory Diagram Showing the Basic Circuit of the Two-part Cycle Controller.

It can be seen that as the condenser is charged inversely proportionally to the speed of each vehicle a corresponding period must elapse before the potential across the neon tube is sufficient for striking, and this represents the right-of-way period.

Repeating Vehicle Impulses to Speed Timer.

A high-speed relay, capable of operation or release in the remarkably short time of 0.5 millisecond ($\frac{5}{10000}$ of one second), is used to repeat the vehicle impulses to the timer circuit, so that extreme accuracy of impulse reproduction is obtained. There is no distortion due to relay characteristics, and signals from high-speed vehicles are transmitted as accurately as those from low-speed vehicles. The condenser charge periods are correctly graded for all speeds down to 2.5 miles per hour, at which value the maximum right-of-way period is afforded.

An explanatory diagram showing the detector system is given in Fig. 11. The road connecting relay (RC) is associated with the lamp control relay (LC) as explained later, and these two relays ensure the correct phasing of the signal lamps and road relays.

LAMP CONTROL.

Four contactors are equipped in each normal two-part-cycle controller, and are designated in accordance with the lamps controlled, thus:—

" A " Road Red Contactor ..	AR
" B " Road Red Contactor ..	BR
Green Contactor	GC
Amber Contactor	AM

The general arrangement of the contactor contacts is shown in Fig. 10, and it can readily be seen that although all the desired standard indications can be given, dangerous conflicting indications (such as two simultaneous clear indications) are impossible.

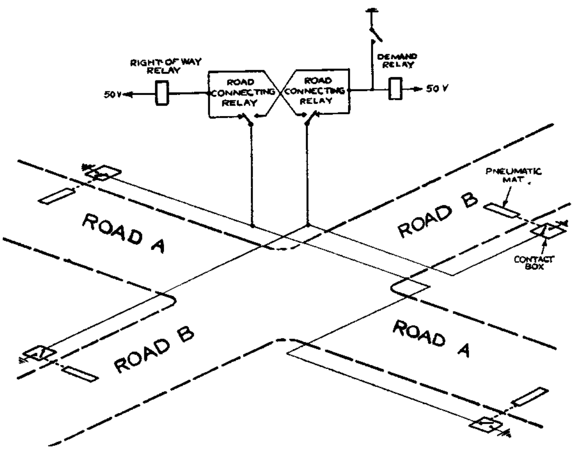


Fig. 11 —CIRCUIT ELEMENTS OF THE DETECTOR SYSTEM.

THE CONTACTORS.

The contactors are of the ame type as the remainder of he relays but are fitted with ıeavy tungsten contacts, each :omprising three springs operating n sequence, as can be seen in ᶠig. 9. By use of these springs ınd a patented spark-quench ırrangement the possibility of prings "freezing" together is nade non-existent, and arcing s completely obviated.

The load is carried by the ırst of the springs to open, and he spark-quench condenser is onnected to the first and second prings. The supply is con- ected to the third spring.

On opening the first two springs the urrent is diverted to the condenser and ecomes reduced as the condenser charges. 'he impedance then enables the circuit) be finally broken with absolute safety. [ormal time lags on the contacts are ıore than sufficient for the charging of ıe condenser.

he Road Connecting and Lamp Control Relays.

The main function of these relays is) ensure that the road relays and signal ımps are correctly connected, *i.e.* they ıust ensure first of all that the road :lays and the lamps have the correct :lationship to one another and, secondly, ıey must control the road relays and ımp contactors so that right of way is ›rrectly given to each of the groups roads as required. The fundamental rcuit is shown in Fig. 10.

Both RC and LC are at normal when ›ad A has the right of way, and ›th are operated when road B has the ghtof way. The requirement is that they should both operate or release, as the case may be, on each operation of the speed-timer relays (ST and STA).

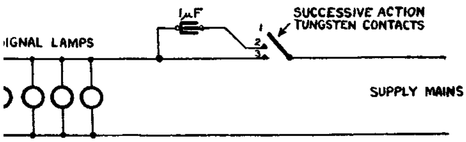


Fig. 12 —THE CONTACTOR SPARK-QUENCH CIRCUIT.

When a change-over to road B is required, STA2 operates RC and STA3 short circuits LC to prevent its immediate operation. RC holds temporarily via RC1 and LC1, and then via RC1 and STA3 at the termination of the speed-timer pulse. LC operates and holds via RC2 when the short circuit is removed by release of STA. LC1 and LC2 open to prevent holding of RC on the occasion of the next pulse from the speed timer.

When a change-over to road A is required, STA3 releases RC, and STA2 has no effect. RC2 releases LC, which does not, however, restore until after the end of the speed-timer pulse, as it is slow to release. RC cannot reoperate at this stage as LC2 is open.

THE CIRCUIT OPERATION DURING A CHANGE-OVER.

Fig. 10 shows the complete circuit conditions applying to a normal controller, but for the sake of clarity all references to special facilities are omitted.

On receipt of a demand DE operates, locking via DE3. DE1 prepares the striking circuit of the speed timer and DE2 commences the discharge of the maximum green timer condenser. If no further vehicles pass along the road having right of way, the speed timer tube

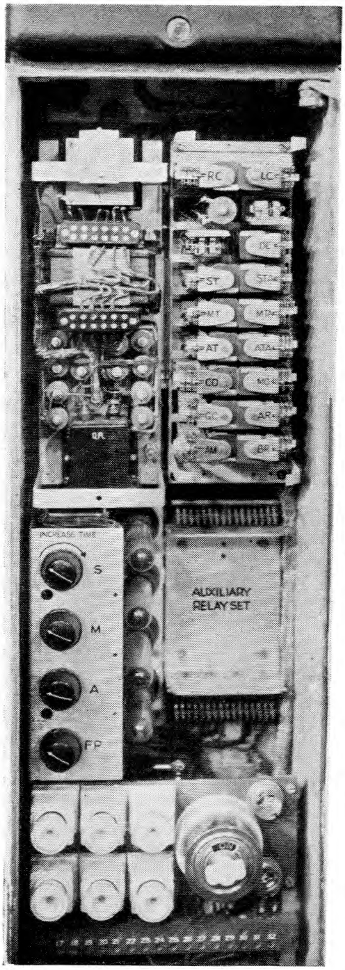


Fig. 13.—A TYPICAL CONTROLLER. The timing control switches are located in the compartment above the relay set.

strikes and relay ST operates. ST1 operates STA. If a constant stream of vehicles passes along so that condenser QA does not discharge, QB discharges in its place and causes operation of tube M and relay MT, so marking the end of the maximum green period. MT1 operates MTA.

If the maximum green timer operates MTA locks via MTA1, MTA2 removes the short-circuit from the amber extension resistance in order to lengthen the amber period by two seconds as it is known that a large amount of traffic still has to leave the intersection, and MTA3 discharges QA (speed timer) rapidly through YB and causes immediate striking of the relevant neon tube, followed by operation of ST and STA as before. MTA5 holds DE operated to register a demand for the return of right of way to the road from which it is taken.

STA2 and 3 reverse the state of RC and LC, as already explained, and STA4 releases DE unless MTA has operated. STA1 operates AMA, AM, and CO, which hold via AMA1 and ATA1.

CO1 disconnects the speed timer from the supply and discharges QA completely in readiness for further use. CO2 recharges QB. CO3 commences the discharge of the amber timer condenser, QC, and CO4 and 5 disconnect LC4 to prevent immediate connection of the red lamps of the road from which right of way is being taken. (These last contacts make before breaking to retain the red contactor of the road about to receive right of way and so give the standard red-with-amber indication.) CO6 operates MG, which holds via MG1. AM connects the amber lamps and disconnects the green lamps.

The Amber Timer Operates.

On the expiration of the amber period the amber timer neon tube and relays AT and ATA operate. ATA1 releases AMA, AM and CO, and AMA1 prevents

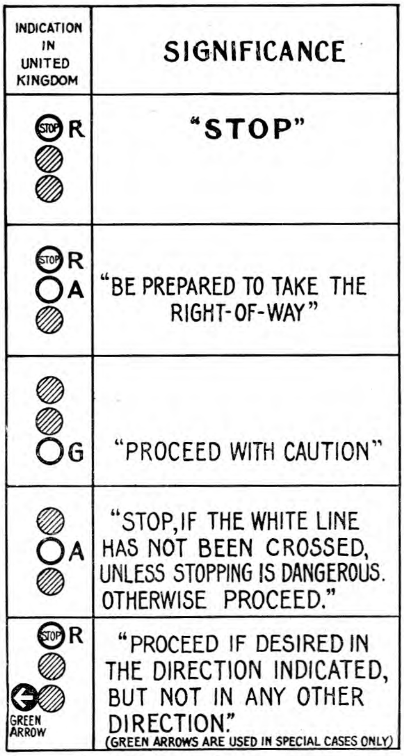


Fig. 14.—THE SIGNAL INDICATIONS GIVEN BY THE "AUTOFLEX" SYSTEM.

Fig. 15.—This Photograph Gives Some Idea of the Traffic Congestion Resulting at the Elephant and Castle Intersection when Traffic is Controlled By Hand Signals.

continued operation of AM and CO after release of ATA. CO is sufficiently slow to release not to restore before the end of the pulse, and at CO6 prevents release of MG. On restoration of CO and ATA, MG holds via MG1 and ATA2 as before.

The release of CO disconnects the red contactor of the road receiving right of way and connects the appropriate red contactor (dependent on LC4) of the road losing right of way. ATA3 releases MTA.

The Minimum Green Period.

A fresh discharge of QC is now commenced via CO3 and MG4 to measure off the "minimum green" period, during which no further change-over can take place.

Resetting the Speed Timer.

On the expiration of the minimum green period AT and ATA operate as before. ATA2 releases MG, which at MG2 prepares the circuit of the speed timer for a fresh demand. ATA4 prevents immediate operation of the speed timer on restoration of MG2, as there would be no locking circuit for CO when STA1 closed until after ATA1 had restored to normal.

Power Supply.

Power is taken from the mains through radio interference suppression equipment and thence to the contactors for illumination of the signal lamps and to a suitable power unit to supply direct current at 50 volts and 240 volts for operation of the relays and neon tubes respectively.

A Transrecter is used in the case of an alternating current supply, and a specially designed dynamotor when the supply is direct current. The average power consumption of a normal controller (apart from the signal lamps) is approximately 20 watts, and at no time does it exceed 40 watts.

Conclusion.

During the stages of development of the "Autoflex" system it was desired to construct a comprehensive working model to demonstrate the capabilities of the system, and for this purpose the "Elephant and Castle" intersection in London was selected.

The model was constructed, and served to demonstrate beyond doubt that the equipment not only operated satisfactorily under such circumstances, but that the traffic flow could be vastly improved by the use of a signalling system such as that proposed.

Signal Indications.

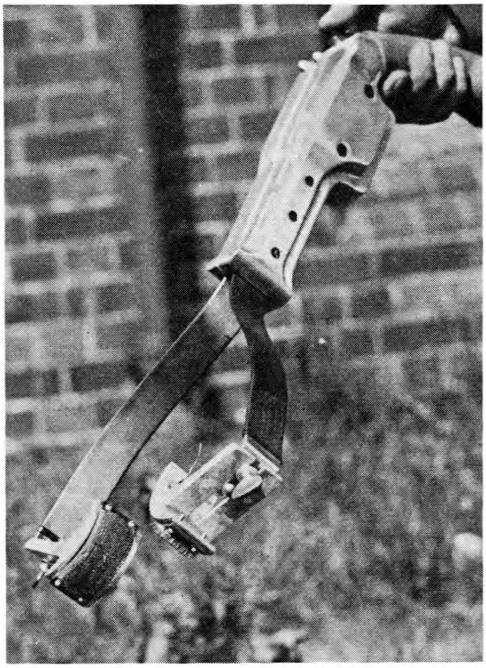
The signal indications described in this article are those standardised for use on road traffic signals in the United Kingdom.

We are indebted to the Siemens and General Electric Railway Signal Company for invaluable assistance in preparing this article and the accompanying illustrations.

ELECTRICITY AS AN ANAESTHETIC

By C. W. Watson, A.M.I.R.E.

ON January 1st, 1934, in almost every part of the country, by-laws will come into operation compelling the stunning of pigs and sheep before slaughter. Similar Regulations have, of course, been in operation for some time in connection with the slaughter of cattle, except for Jewish consumption. The use of electricity as a means of destroying life, e.g., the electric chair, and a fear of death by electrocution as a means of preventing the escape of prisoners is everyday knowledge, but comparatively little interest has been so far shown in the use of electricity for the prevention of pain.



The "Anestygun," a Self-Contained Electrical Stunner Working Directly from the Mains.

Efficient and Economical.

That electricity, properly applied, can be used to produce a state of anaesthesia has now been proved beyond doubt, and as its use is more efficient, economical and less unpleasant than the pole-axe or the humane killer, there is no doubt that this method of stunning animals prior to slaughter will be generally adopted.

Home Office Recommendations.

Recommendations by the Home Office, almost amounting to co-operation in design, have led to very satisfactory precautions being taken to prevent danger to the operator in the use of apparatus for this purpose, but still, butchers are generally hard to convince that the apparatus is perfectly safe to the operator.

In the interests of electrical engineering and the prevention of cruelty to animals, electrical engineers can do much to further this project by studying the apparatus in question and making their recommendations to the interested parties in their districts.

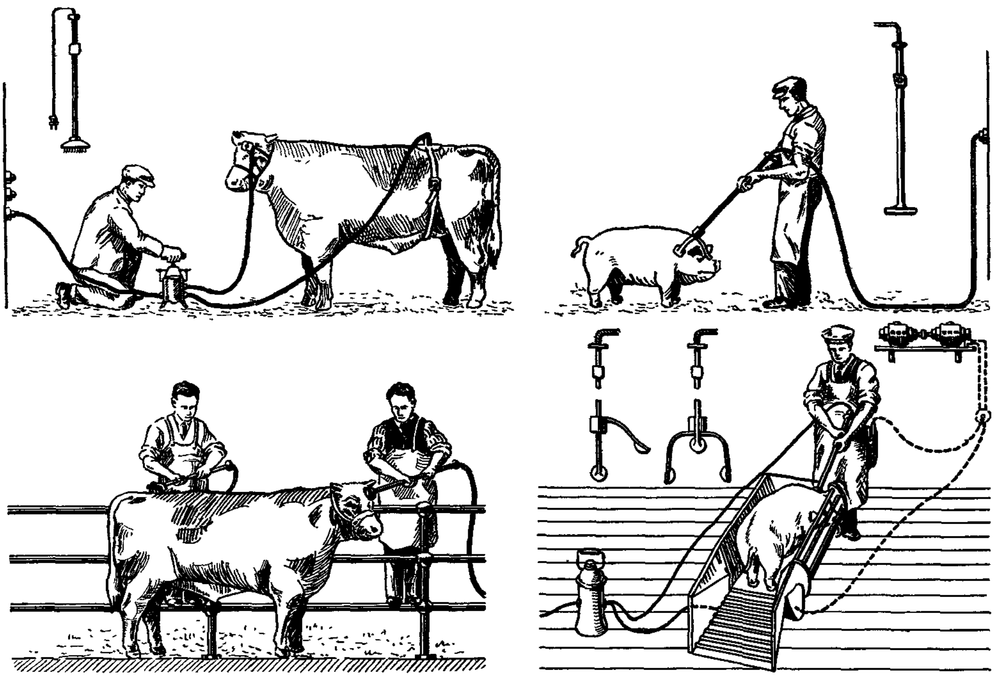
Even 70 years ago the possibilities of electricity as an anaesthetic were to some extent realised, use being made of the current obtained from a galvanic battery, either alone or in combination or conjunction with a powerful induction coil. Nowadays, when alternating current is almost universally available, and with the comparatively recent developments of transformer technique, we have a much better chance in this direction than was the case in the days of galvanic batteries and induction coils.

What Happens When Current is Passed Through the Body.

When a current is passed through the body, and particularly an alternating current, the results are somewhat painful, but when alternating current is properly

SHEEP AFTER TWO SECONDS APPLICATION OF THE "ANESTYGUN."

USING THE " ANESTYGUN " FROM A CAR BY MEANS OF A ROTARY CONVERTER WORKING FROM THE BATTERY.



METHODS OF APPLICATION OF CURRENT TO PIGS AND CATTLE ALL SUBJECT TO BRITISH PATENTS, BUT OBVIOUSLY EXPERIMENTAL.

applied to the brain or spine the sensation experienced is not at all painful, but is, in fact, almost fascinating. If the voltage is gradually built up and the electrodes are arranged so that the current passes through the brain, an uncontrollable twitching is experienced at the eyes, followed by red flashes at the frequency of the supply, which continue to increase until the current is sufficient to produce unconsciousness. This unconsciousness, produced by confusion of the brain and nervous system, is almost akin to mesmerism, not shock.

By careful experiment, apparatus has been designed to give the correct voltage and pass the proper current for stunning animals for slaughter, and instead of gradually increasing the voltage as was done in the case of the experiments, it is now possible to render an animal unconscious immediately the current is applied, whilst a continuation of the current for 2—4 seconds, in the case of sheep, and 8—15 seconds in the case of pigs, is sufficient to ensure that the animal will be unconscious of any pain, although its heart and lungs will function normally until almost the last drop of blood is expended.

Thus, not only are the animals despatched as mercifully as possible, but, due to more complete bleeding, the meat produced is more suitable for human consumption.

The Electrodes.

The electrodes which apply the current to the animal must of necessity be designed to secure consistency in operation, and whilst most of the electrodes available need to be saturated with brine immediately before application, there is one instrument with large dry electrodes and another which works quite well when the electrodes are moistened with clear water.

The " Electrolethaler " Method.

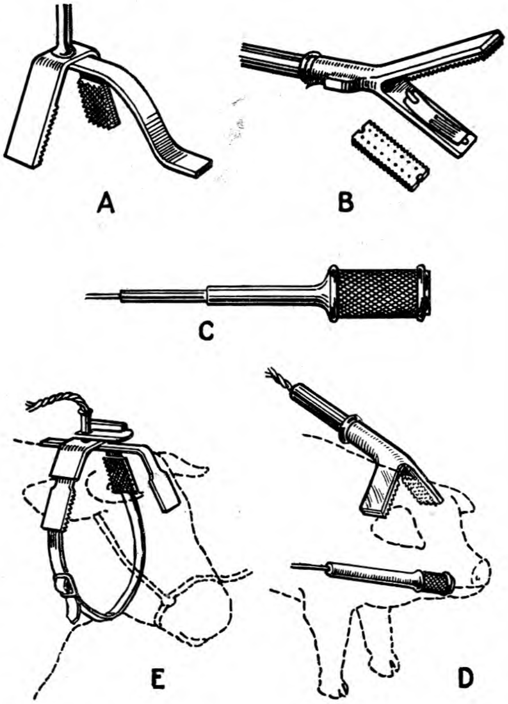
The " Electrolethaler " method employs a pair of tongs or electrodes, and a switch is built into the fulcrum of the tongs in such a manner that the current cannot be switched on until sufficient grip has been obtained on the animal. Another instrument supplied by Messrs. Higgs Bros. also makes use of tongs.

The "Iwel."

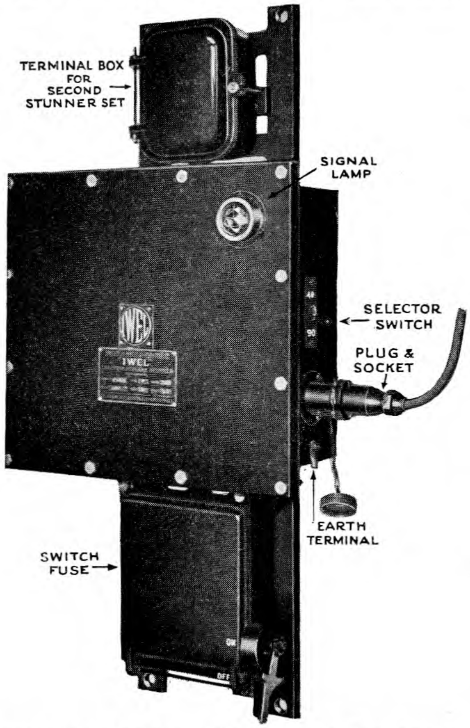
The "Iwel," manufactured by Messrs. Imperial Waste Eliminators, Ltd., is a three-electrode instrument with dry electrodes, operated from a transformer which is housed in a cast-iron box, usually attached to the wall. This box contains a signal lamp and the various protective devices.

The "Anestygun."

A comparatively recent introduction is the "Anestygun," which is a self-contained instrument with the electrodes in the shape of a pair of prongs which are arranged to give even pressure on almost any size of animal. Housed in cavities in the electrodes and projecting through the contact surface are sponges, which, when soaked with water, ensure a good contact. The voltage at the electrodes of electrical stunning apparatus is usually between 70-80 volts A.C. When electrodes carrying this voltage are suitably connected across the head of an animal, the back legs draw up and the front legs extend. The eyes will close and the animal will remain in this condition throughout the period of application. Immediately the current is switched off the muscles will relax, the eyes open, and the corneal reflex will be absent. If left in this condition the animal will, after a period of five to fifteen minutes, according to the length of application, resume its activities without any signs of ill-effect.



ELECTRODE ARRANGEMENTS.
A. "Iwel" three-electrode instrument; B and C. Another form of "Iwel" electrodes; D. Electrodes being applied to a pig; E. Head-gear for electrically stunning cattle.



LATEST MODEL TYPE "T" CURRENT EXCHANGE.
(Industrial Waste Eliminators, Ltd.)

Apparatus May be Used for Surgical Operations.

It will be seen from this that the apparatus may be used for surgical operations, and it is more than probable that an operating surgeon will, in the near future, be able to regulate the condition of a patient by means of a rheostat or other electrical instrument.

LOCATION AND REMEDY OF FAULTS IN A.C. MOTORS

By "TRICIAN"

In the following article are described some of the common troubles experienced with motors of the induction and synchronous types, and the steps to take to remedy these faults

IT is always necessary, where there is running electrical machinery, to employ a man with sound practical knowledge to examine periodically all equipments for mechanical and electrical defects. There is much truth in the old saying, " Prevention is better than cure," and this applies particularly to electrical machinery, as in many cases serious trouble has been experienced through inattention during operation. For instance, motor bearings have seized because clean oil has not been frequently and properly applied, or the belt tension not reduced when the bearings commenced overheating.

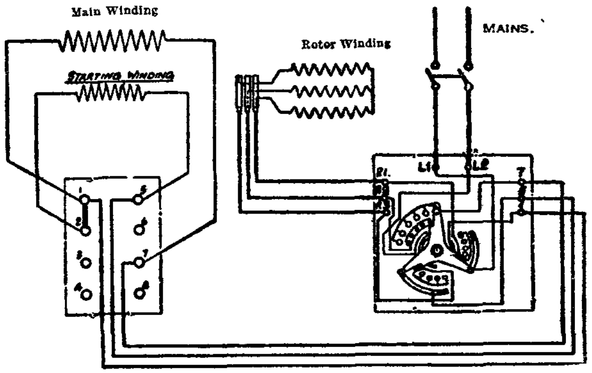


Fig. 1 —SINGLE-PHASE MOTOR WITH WOUND ROTOR AND GRADUATED STARTER.

The supply voltage should also be frequently checked and steps taken to ensure that the line pressure is not unbalanced, as this will reduce the output of the motors and produce unbalanced phase currents.

Some of the troubles experienced with induction motors and synchronous motors are common to both types. These troubles will be dealt with later. It is proposed to describe first of all faults peculiar to each machine.

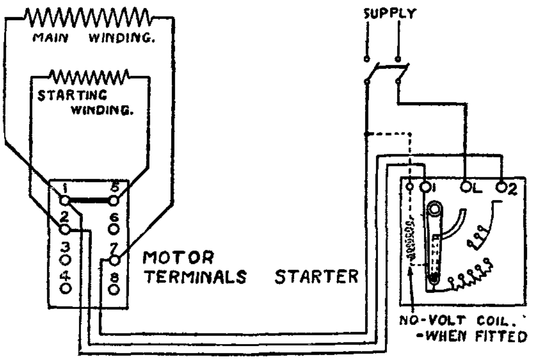


Fig 2 —SINGLE-PHASE MOTOR WITH SHORT-CIRCUITED ROTOR AND GRADUATED STARTER

INDUCTION MOTORS.

Troubles at Starting.

If an induction motor refuses to start, the first and most obvious thing to do is to ascertain that the mains supply has not been cut off, that the fuses or circuit breaker are in order and position, also that the starting switch is in the correct position.

The motor should then be uncoupled from its load and tried for free running, to check that the bearings have not seized.

Squirrel cage motors have a limited starting torque. Therefore, if a motor of this type refuses to start, it should be uncoupled from its load, and tried starting light. If it starts light, the loading should be increased, until the maximum against which it will start is determined.

With a wound rotor, that is a slip ring motor, the trouble may be due to

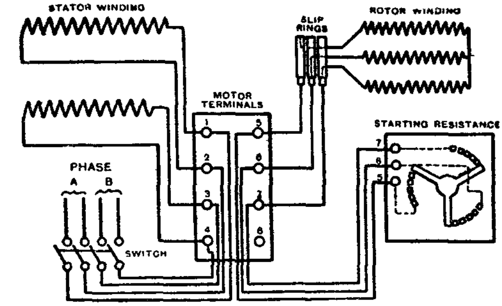


Fig. 3.—Two-phase Motor with Wound Rotor and Starting Resistance (Motor with Internal Slip Rings).

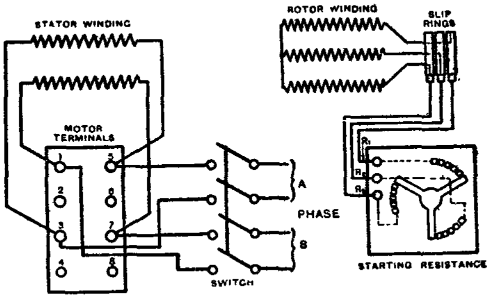


Fig. 4.—Two-phase Motor with Wound Rotor and Starting Resistance (Motor with External Slip Rings).

insufficient starting resistance, or to an open circuit in the rotor.

An overload will cause excessive current at starting, and it is necessary to reduce the load to that for which the motor is rated. A wrongly connected auto-transformer will also cause a very high starting current and the output will be very low, as only a reduced voltage is available.

Fig. 1 shows a connection diagram for a single-phase motor with a wound rotor and graduated starter, while Fig. 2 shows the arrangement for a single-phase motor with short circuited rotor and graduated starter. Connection diagrams showing the arrangement for starting different polyphase slip-ring motors are given in Figs. 3 to 8, while Figs. 9* and 10 are connection diagrams for switching polyphase squirrel cage motors direct on the mains. By means of these diagrams it is possible to trace the connections of the various circuits.

* For auto-transformer starting, the starters are connected in the position occupied by the main switch in Figs. 9 and 10.

Motor Running at Slow Speed.

An induction motor generally runs at about 4 per cent. below synchronism, the difference between synchronism and full load speed being known as "slip." The synchronous speed is calculated by the following formula :—

$$\text{R.P.M.} = \frac{\text{Frequency} \times 120}{\text{No. of poles}}$$

A very heavy load, or high resistance in the rotor circuit (whether in the windings or at the brushes), will cause greater slip.

It is sometimes found that a machine starts up, but will not carry the load. If the usual measures fail to locate the trouble, it is most likely due to magnetic locking between the rotor and stator teeth. When such a fault occurs (which is very unlikely with a machine in service, as all motors are thoroughly tested by

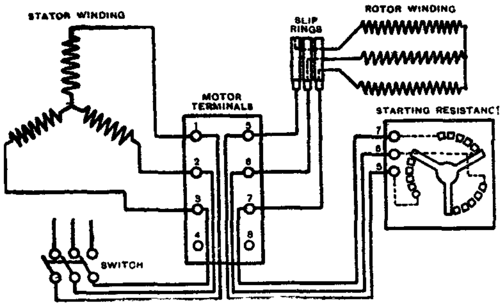


Fig. 5.—Three-phase Motor, Star Wound, with Wound Rotor and Starting Resistance (Internal Slip Rings).

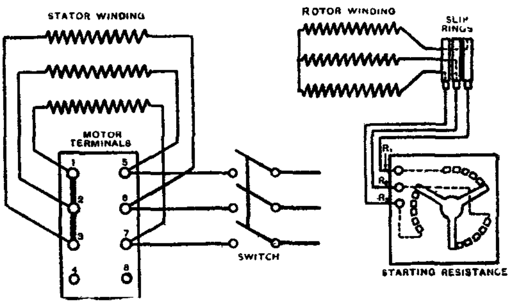


Fig. 6.—Three-phase Motor, Star Wound, with Wound Rotor and Starting Resistance (External Slip Rings).

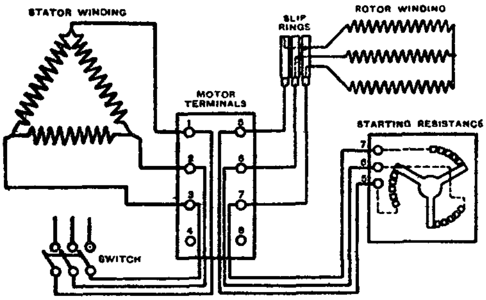


Fig. 7.—THREE-PHASE MOTOR, MESH WOUND, WITH WOUND ROTOR AND STARTING RESISTANCE (INTERNAL SLIP RINGS).

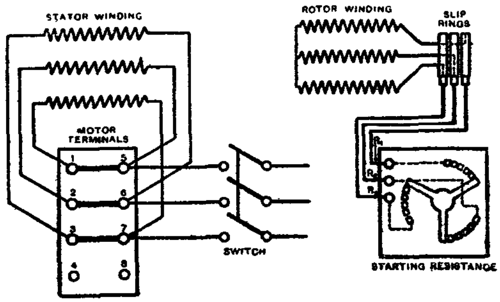


Fig. 8.—THREE-PHASE MOTOR, MESH WOUND, WITH WOUND ROTOR AND STARTING RESISTANCE (EXTERNAL SLIP RINGS).

manufacturers before being sent out), the motor should be returned to the maker as there is no simple remedy. This point will be most useful to engineers engaged on testing, as it is during test that this fault would occur.

The Motor Stops Running.

A motor will stall if it is overloaded beyond what is known as the pull-out torque. The machine will take many times its normal current when this happens, and the windings will burn out if the fuses or the circuit-breaker do not operate immediately.

The torque varies with the square of the voltage, therefore the reason for a motor stopping may be low volts. The starting torque of a machine is very much reduced when it is started under low voltage. If low starting torque is found to be due to this and the mains voltage is correct, the remedy will probably be found in using larger transformers and larger leads to the motor.

Worn bearings will cause the rotor to foul the stator, and when this happens the motor will stop or must be stopped immediately.

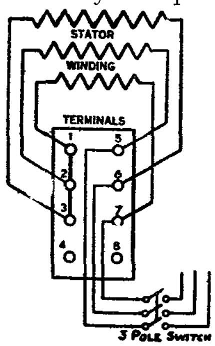


Fig. 9.—THREE-PHASE MOTOR, STAR WOUND, SWITCHING DIRECT ON TO MAINS.

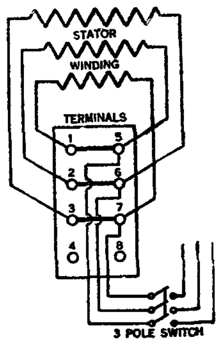


Fig. 10—THREE-PHASE MOTOR, MESH WOUND, SWITCHING DIRECT ON TO MAINS.

SYNCHRONOUS MOTORS.

Starting.

As in the case of the induction motor, the first action to take if a synchronous motor fails to start is to ascertain that the mains supply has not been cut off. If this is not the cause, reduce the load and try starting light. If this does not effect a cure, the next thing to do is to look for open circuits or faulty connections in the auxiliary apparatus; or the fault may be due to incorrect rotor connections which result in unbalanced circuits and consequent failure to start. If there is an open circuit in the machine there will be no current in the affected phase. If the trouble is due to a short circuit the current will be very high. It may be due to earth faults, and if left running the machine will burn out. The motor might run for a short period with a single coil burnt out, but if it is definitely ascertained that the trouble is due to a short-circuit, the machine should be shut down.

Field Troubles.

It is sometimes found that the field of a motor is electrically weak or defective. If this is so, the trouble may be due to one of several faults. The voltage of the exciter should be checked, as it may be incorrect. Another cause of the trouble may be an open circuit in the field itself or in the regulator. If it is found that the fault is not in the direction of any of these causes, it remains to check the polarity of the field coil connections. This is a fault sometimes experienced, and must, of course, be remedied before the motor will operate.

When starting, the field coils of a motor are subjected to a high induced voltage, which may cause the insulation to break down and result in a short circuit. The short circuit will be indicated by overheating and a high reading on the ammeter. The machine will shut down or the armature become badly overheated if there is an interruption of the field during operation.

In the event of the field current being excessive, the polarity of the armature coils should be tested for reversed connections.

Armature Troubles.

A very high armature current is indicated by overheating, and when this occurs the load should be reduced, or less done in the correction of power factor.

The armature connections should be checked when it is found that a motor has an extremely low starting torque. If the armature is slowly rotated, the currents in the armature phases should be about the same, but it does not necessarily indicate that there is a fault if there are unequal currents when the rotor is stationary.

GENERAL.

Trouble Due to the Auto-transformer.

A very high starting current and very low torque with the switch in the running position may be due to the auto-transformer connections being reversed. If a motor will not start, the change-over switch may be faulty, or there may be loose connections or an open circuit in the transformer. A higher tapping should be used, but the ammeter should be very carefully watched when this is done. Wrongly connected transformer windings will considerably reduce the line voltage, perhaps to zero.

Mechanical Faults.

Such defects as worn bearings, bent shaft or insufficient end-play on sleeve bearing machines can cause considerable damage. Reference has already been made to the first-mentioned fault, and it needs little imagination to know what would happen if the rotor shaft was bent.

The amount of end-play allowed for a rotor on sleeve bearing machines varies with the size of the motor, but it should be possible to press the shaft to and fro while the motor is running. Insufficient end-play will cause friction and heating. There should be, of course, no slackness of the rotor in the bearings.

Rotor Short-circuiting Switch.

Care should be taken with wound rotors to ensure that the rotor short-circuiting switch is operating satisfactorily, particularly if the switch is an internal one. When the machine is stopped the switch should automatically return to position. If it opens when the motor is running under load, the machine will probably stop, or at least slow down. This points to overload or a defective short-circuiting mechanism.

In conclusion, the author wishes to thank Messrs. Crompton, Parkinson & Co., Ltd., for the diagrams used in the article.

A USEFUL AMALGAM SOLDER

A useful cold amalgam solder can be made by shaking copper filings and mercury in a vessel containing some dilute sulphuric acid. The amalgam is made into pellets and these are heated until the mercury exudes. After wiping the pellets free from the mercury they are rubbed into a soft paste in a mortar. The surfaces to be united are first treated with a soda amalgam having about 2 per cent. amalgam, and the cold amalgam is then applied to both surfaces. The joint should then remain under pressure for several hours when it will have set firmly.

An Electro-Magnetic Flashing Switch

By H. J. Baldwin

In the December issue we gave details of a simple flashing electric sign switch. The following article deals with an improved form suitable for use on circuits where fairly heavy currents have to be dealt with

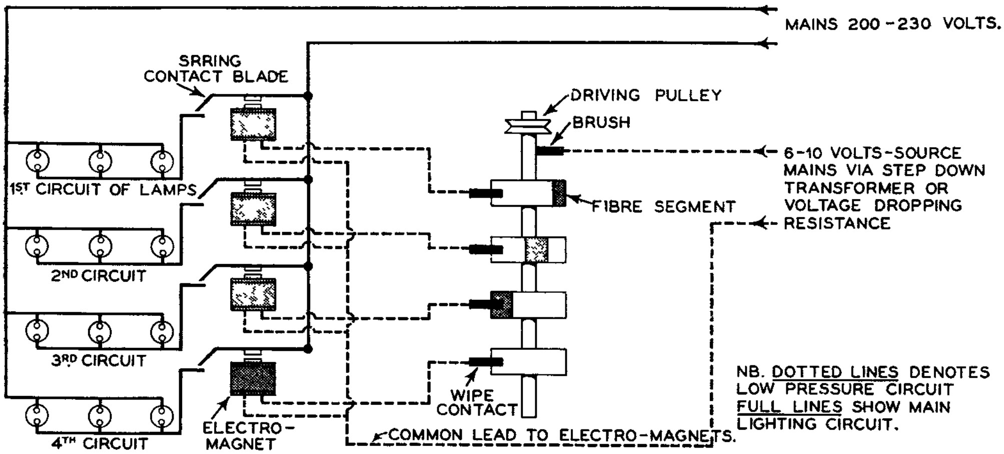


Fig. 1—The Circuit of the Electro-Magnetic Flashing Switch.

THE switch outlined in this article is in unit form so that it can be arranged to operate any number of circuits. Each circuit has a wipe contact and a magnetic circuit breaker; extra contacts and breakers can be added at will while the sequence and time interval between the " make " and "break" is widely variable, since the contact wheels which are carried on a spindle can be locked together in a variety of positions The electro-magnetic breaker operates the main circuit, while the wipe contact is used in a low-pressure circuit. The former is capable of breaking a current of 6-8 amps., which would cause undue sparking and burning on a rubbing contact. The friction between the wipe contacts and the wheels is very much less than that on a camshaft type of switch, thus very little power is needed to drive it.

The Main Circuit Breaker.

The laminated blade is made from two thicknesses of sheet copper, interleaved with two laminations of spring brass. Fig. 3 shows the details of the blade and a simple method of roughly adjusting the strength of the spring to the pull of the magnet by filing away small sectors. A small soft iron armature is riveted at right angles to the blade, which in turn is fixed down at one end to the fibre bridge while the free end rests on a metal platform. Immediately above the blade is an adjusting screw carried on a brass bracket. This permits of fine adjustment so that the magnet gives a sharp pull down when the wipe contact supplies current to the bobbins. The natural spring in the blade causes it to rebound when the magnet is not pulling.

The Magnets.

The shape of the soft iron core can be seen in Fig. 2, the material being rectangular in section. The bobbins have fibre or sheet ebonite ends glued to a central tunnel composed of layers of paper tightly held together by shellac varnish. The tunnel is easily made by winding on four layers of stout paper to a piece of iron strip which has been coated with wax to prevent the paper sticking to it; the wax enables the completed tunnel to be withdrawn easily when the adhesive is dry.

The bobbins are wound with 8 to 10 layers of No. 26 enamelled copper wire; the completed magnets should have a pull of at least 1¼ lb.

The Adjusting Bracket.

This is made from a piece of strip brass and has two screw holes for fixing to the base and one placed centrally in the upper bend. This latter hole should be tapped out 2 B.A. to accommodate an adjusting screw to regulate the distance between the armature and the poles of the magnets. When this screw is so adjusted as to give sharp contact and break, it is locked in position with the nut provided, see Fig. 2.

The Wipe Contact Wheels.

These are made from sections of stout brass rod, a piece is cut out to admit a segment of fibre; note the slope on the sides, see Fig. 3, the piece of fibre is dovetailed into the brass. Around the central hole which takes the spindle are a number of smaller ones according to the number of circuits; twelve such holes will give a large variety of settings. Between each wheel is a spacing washer carrying a locking peg, see Fig. 3, which engages with one of the small holes round the centre of the contact wheel. Thus if 12 holes are bored on each wheel a large number of fine adjustments between the wheels can be arranged; 2, 3, 4, 6 or 12 circuits can be controlled to give breaks at regular intervals, and one or more circuits can be set to flash irregularly by moving the locking peg a hole or two.

The wheels and washers are mounted on a shaft carried on two simple bearings, or small ball bearings if desired. The whole assembly is clamped between two driving collars which are shown in the sketch, see Fig. 3. A hole in the bearing carries a spring brush which makes direct contact with the spindle.

The Wipe Contacts.

The blades are pieces of steel or spring brass carrying a semi-circular wipe contact at the end. The fixed end is fastened to a bracket carrying an adjusting screw for

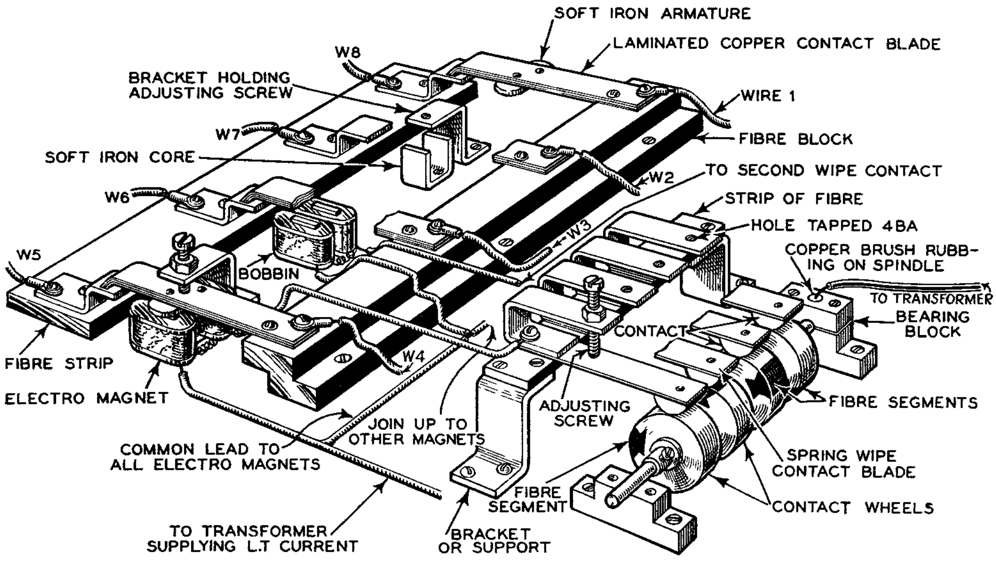


Fig. 2.—PICTORIAL VIEW OF ELECTRO-MAGNETIC FLASHING SWITCH. The whole apparatus is to be mounted on a baseboard

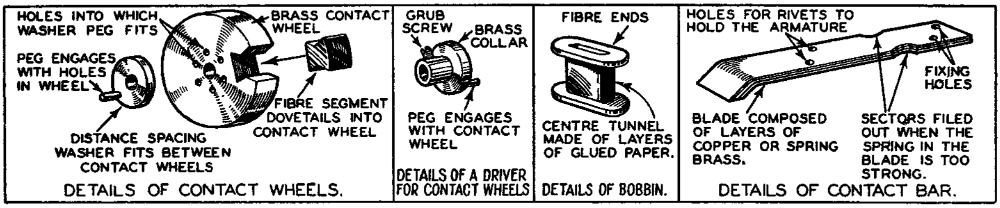


Fig. 3.—SOME CONSTRUCTIONAL DETAILS.
Showing from left to right, details of contact wheel; details of a driver for contact wheels; details of bobbin; and details of contact bar.

varying the pressure on the contact wheels. The bracket and blade assembly is in turn supported on a fibre bridge held firmly in place by two metal supports. The drawing, Fig. 2, shows four wheels and four wipe contacts, but, of course, the number can be varied to suit the individual requirements. The distance between the blades must be the same as the space between the wheels and this is decided by the thickness of the distance washers. A pulley is attached to one end of the shaft to take a small belt from the driving motor which can be a clockwork one, if desired, as the friction of the wipe contacts is very little.

Method of Mounting Up.

The switch is essentially in two parts: first, the main circuit breakers and, secondly, the wipe contacts. The two parts should be mounted up in line one behind the other on a base board, and the whole covered with a ventilated sheet iron shielding box.

Wiring Up.

Fig. 1 shows the method of wiring up. The dark lines show the actual main lamp circuits and breakers, while the dotted lines denote the low-pressure circuit which works the electro-magnets.

Low-pressure Side.

One end of the winding on each set of bobbins is connected to a common lead which goes to the power source while each of the remaining ends is connected to its respective wipe contact. The brush on the spindle is in contact with the other power terminal. The source of power for the low-pressure side may be a step-down transformer, an accumulator or a voltage dropping device on D.C. mains.

The Lamp Circuits.

All lamps are wired in parallel, one end of each set being connected to a common lead while the remaining leads are joined to their respective contact platform. Finally a common lead joins up all the blades and runs to the supply mains.

The Switch in Use.

The switch can be used in several different ways. First, it can control several rows of lamps so that at regular intervals each line will die out for several seconds, the time varying with the speed at which the main shaft turns.

Secondly, a number of lamps surrounding an illuminated sign can be wired so that every fourth lamp (supposing there to be four circuits) is in a common circuit controlled by a breaker. Then every fourth lamp is out at one moment, while a few seconds later the lamps immediately next to these will go out and the previously mentioned lights come on again. This makes the sign appear as though the light is running round the board, while if the sign is a narrow vertical one it can be made to appear as though the balls of light are falling in two cascades.

A Survey of Recent Developments in Short-wave Transmission and Reception

By "Omicron"

PRACTICALLY all oscillators for amateur transmission purposes, apart from crystal oscillators, are based on the simple tuned plate, or tuned grid arrangement. In the circuit given in Fig. 1, in which the plate circuit only is tuned, the value of mutual inductance necessary to sustain oscillations is given by :—

$$M = \frac{C R_a R_i + L_2}{\mu}$$

Where R_a = Resistance in oscillatory circuit
R_i = Valve impedance
μ = Valve amplification factor.

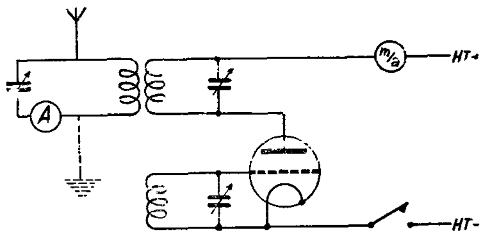


Fig. 2.—How the Circuit in Fig. 1 can be Converted into a Low-powered Transmitter by the Insertion of a Key in the H.T.— Lead and the Addition of Suitable Aerial Coupling.

Once this value of M is reached the valve and its associated circuit will oscillate at a frequency determined by the physical constants of the coil and condenser. It is essential that the coils are connected in the correct phase relationship, otherwise the circuit will not oscillate. The internal capacity of the valve is represented by a dotted condenser and sets a limit to the lowest wavelength which can be obtained.

The insertion of a key in the H.T.— lead and addition of suitable aerial coupling is all that is necessary to convert

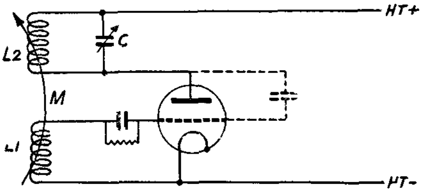


Fig 1.—A Simple Form of Oscillator.

this circuit into a low-powered transmitter (Fig. 2).

The Hartley Oscillator.

This is a development of the simple oscillator system, and it will be noted from the diagram (Fig. 3) that the coil is wound in one continuous length with a centre-tapping taken to H.T.+. This is known as the Hartley circuit, and as the grid and anode coils are now associated with the one common tuned circuit, a far tighter coupling can be obtained.

Push-pull Oscillators.

It has been mentioned that the valve capacity limits the lowest wavelength to which an oscillator will tune. If two condensers are connected in series, the resultant capacity is less than that of the single condenser. This, then, is the principle behind the application of valves in push-pull, as the capacities of the valves are effectively in series with respect to the tuned circuit. The circuit shown in

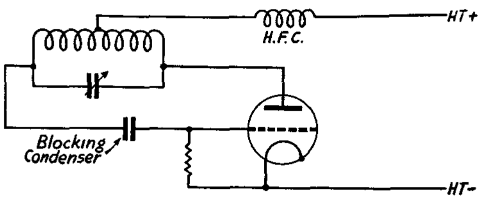


Fig. 3.—The Hartley Oscillator.

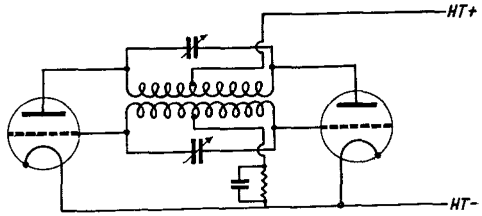


Fig. 4 —A Push-pull Oscillator.
This arrangement gives greater stability than the triode oscillator.

Fig. 4, showing two oscillator valves in push-pull, gives greater stability than the triode oscillator.

The Master Oscillator System.

For large powers the master oscillator system is used. An oscillator, usually a crystal (although a valve can be used), is maintained in oscillation at an accurate frequency. This is then amplified by a series of amplifiers of increasing size.

Modulation may be introduced at low power in this system, and, consequently, good speech quality can be obtained.

Crystal Oscillators.

If an alternating E.M.F. is applied across the two faces of a quartz crystal cut in one of its principal axes, the crystal will vibrate mechanically at a very high frequency. Dielectric changes will be set up and the crystal will oscillate electrically when coupled to a tuned circuit of approximate resonance. The circuit will then be accurately maintained in oscillation at a frequency dependent upon the physical dimensions of the crystal, the necessary feedback being obtained through the valve capacity. For transmitting, the crystal is placed in the grid circuit and the anode circuit tuned nearly to the crystal frequency, the succeeding stages being amplified or frequency doubled as desired. A simple circuit is given in Fig. 5.

Frequency Doublers.

When a pure sine wave is applied to the grid of a valve, and the valve is then overbiased, the wave form is distorted and harmonics are produced. If the anode circuit is now tuned to twice the frequency of the grid circuit, a large proportion of second harmonic will be picked out, and this circuit will now be oscillating at twice the frequency of the grid circuit. This is known as frequency doubling and may only be repeated a certain number of times, after which the doubling efficiency falls off.

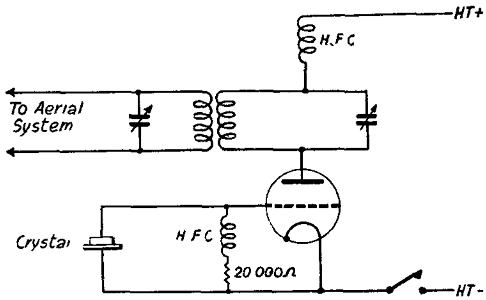


Fig. 5.—A Simple Crystal Oscillator Circuit.

As amateur transmitting bands are in multiples of frequencies a crystal cut to oscillate at the lowest frequency may be made to give harmonics in each of the higher frequency bands.

Neutralised Amplifiers.

In an oscillator-doubler system it will usually be found that the output from the last doubler, although of the desired frequency, is insufficient. A stage of

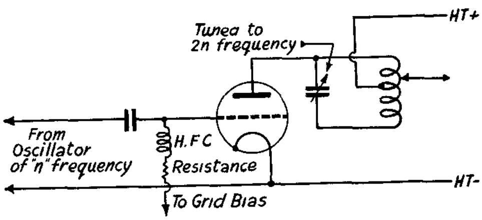


Fig. 6.—A Frequency-doubler Circuit.

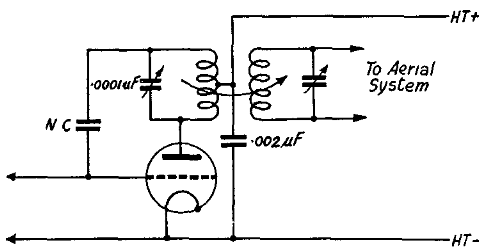
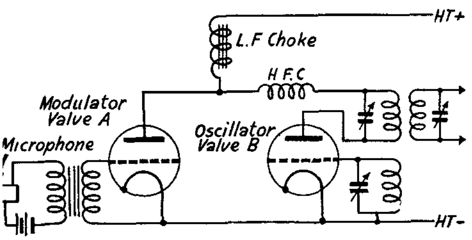


Fig. 7.—Neutralised Amplifier Circuit.



'ig. 8.—How Two Valves are Used in Choke Control.

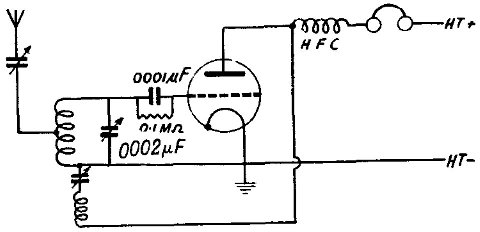


Fig. 9.—Simplest Form of Short-wave Receiver.

›ower amplification is, therefore, added o obtain the required output. Now as he grid of this valve is driven by the .node coil of the last doubler, and as its ›wn anode is tuned to the same frequency, here is a tendency for the circuit to ›scillate of its own accord. This is ›revented by neutralising, and a circuit ; given in Fig. 7 showing the method of onnection to the amplifier.

Iodulation Systems.

There are four systems of modulaion :—

1. Aerial modulation.
2. Absorption control modulation.
3. Grid control modulation.
4. Choke or Heising modulation.

Only the last will be dealt with, as ystems 1 to 3 are not general practice. n choke control two valves are used in the ıanner given schematically in Fig. 8. 3riefly, the anode supply to both valves ; constant, and if the anode current of ne valve is varied, that of the other must ary in sympathy. A rise of current in one alve will result in a decrease in current f the other. In the diagram valve B ; maintained in scillation at the :equency to be :ansmitted, and alve A has the peech frequencies npressed on its rid circuit.

Modulation, i.e., uperimposition of udio frequencies n radio frequencies, s, therefore, btained.

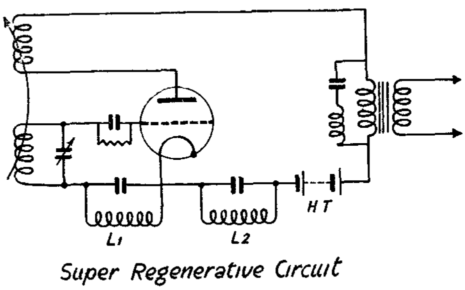


Fig 10—A Super Regenerative Circuit for Short-wave Reception.

Transmitting Valves.

In the simple tuned plate, tuned grid circuit, as shown in Fig. 2, valves of the LS5B or T25D class are usually used. For larger inputs the size of the last valve is only limited by the amount of H.T. available and the power it is required to dissipate. Pentodes are used in the oscillator stages, as the efficiency of the modern pentode greatly exceeds that of the triode. Screened-grid transmitting valves, with their low inter-electrode capacity, are being increasingly used in drive and separator stages, obviating to a large extent the necessity of neutralising. For modulation, valves of the large amplifying type are used, as it is essential that a linear characteristic, or as nearly linear as possible, should be obtained. Valves for magnetron oscillation are now specially made, as the filaments of ordinary valves will not stand up to the work they are called upon to do.

In America an attempt has been made to obtain waves of the ultra-short class by reducing the physical dimensions of the electrodes, but difficulties in standardisation are being experienced, as the geometrical spacing of each individual valve varies.

Reception.

The most simple short-wave receiver consists of a reacting detector as shown in Fig. 9. This type of receiver is favoured on account of the low background and

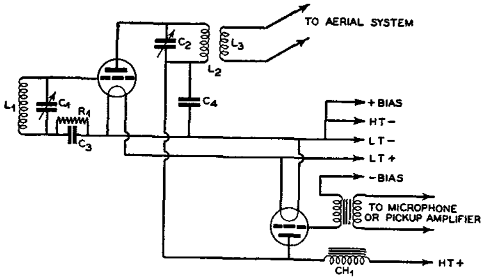


Fig. 11.—SIMPLE T.P T.G. TRANSMITTER FOR LOW POWER WITH CHOKE CONTROL MODULATION

	40 Metres.	20 Metres.
Coils, L_1 =	10 turns	6 turns
L_2 =	8 ,,	4 ,,
L_3 =	5 ,,	3 ,,

3 in diameter spaced 10 or 12 S W.G. bare copper.

Other values, C_1 = .0001 mfd.; C_2 = .0002 mfd.; C_3 = .002 mfd.; C_4 = .005 mfd (mica); R_1 = 10,000 ohms; Ch_1 = 30 Henries at 50 mA.

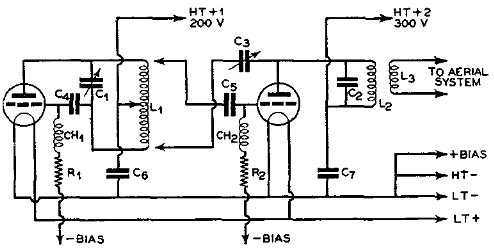


Fig. 12.—MASTER OSCILLATOR POWER AMPLIFIER CIRCUIT FOR LOW POWER.

	40 Metres	20 Metres
Coils, L_1 =	14 turns	8 turns
L_2 =	10 ,,	4 ,,
L_3 =	6 ,,	3 ,,

10 or 12 S.W.G. bare copper spaced.

Other values, C_1 = .00015 mfd.; C_2 = .0002 mfd.; C_3 = .00005 mfd.; C_4 and C_5 = .002 mfd.; C_6 and C_7 = .005 mfd.; R_1 = 10,000 ohms; R_2 = 5,000 ohms; Ch_1 and Ch_2 = 200 turns 32 S.W.G. on 1 in. former.

interference level. Low frequency amplifying stages may, of course, be added.

The Super-heterodyne.

The principle of changing the frequency so that the signal may more easily be amplified is undoubtedly one of the best in present use.

The Super-regenerative Circuit.

For five-metre work this circuit offers great advantages, as the amplification obtained is tremendous. Reaction is allowed to reach a high value and is then quenched just before the valve breaks into self-oscillation. This quenching frequency is supplied by the two coils shown as L_1, L_2 in Fig. 10. The drawbacks to this type of circuit are the distortion of speech frequencies and the difficulty of operating.

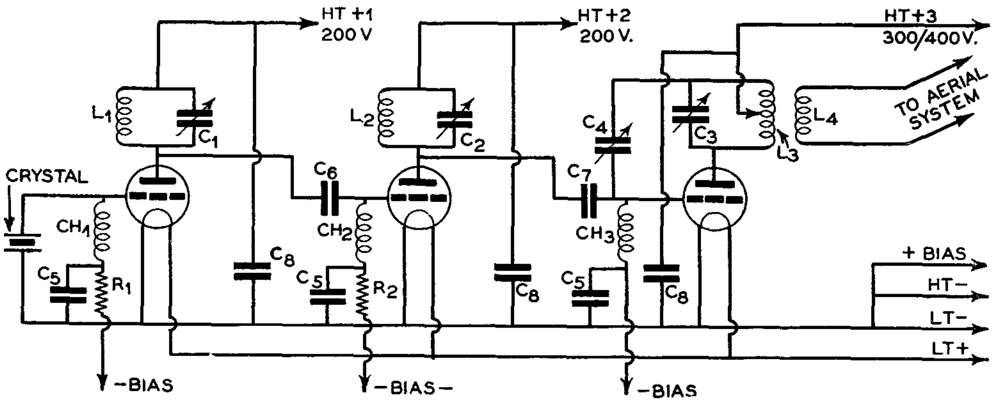


Fig. 13.—COMPLETE CRYSTAL-CONTROLLED TRANSMITTER FOR 40 AND 20 METRES (LOW POWER)

Coils	L_1	L_2	L_3	L_4
40 Metres.	22 turns	10 turns	10 turns	4 turns
20 Metres.	12 ,,	6 ,,	6 ,,	3 ,,

3 in. diameter, 12 S.W.G. bare copper spaced.

Other values, C_1 = .0002 mfd.; C_2 and C_3 = .00015 mfd.; C_4 = .00005 mfd.; C_5 = .05 mfd.; C_6 and C_7 = .002 mfd. (mica); C_8 = .005 mfd. (mica); R_1 = 5,000 ohms; R_2 = 10,000 ohms; Ch_1 and Ch_2 = 200 turns of 26 S.W.G. wound on 1 in. former; Ch_3 = 150 turns of 26 S.W.G. wound on 1 in former. Note that for 40-metre working use 80-metre crystal, and for 20-metre working use a 40-metre crystal.

ELECTRICAL APPARATUS FOR MODERN AIRCRAFT

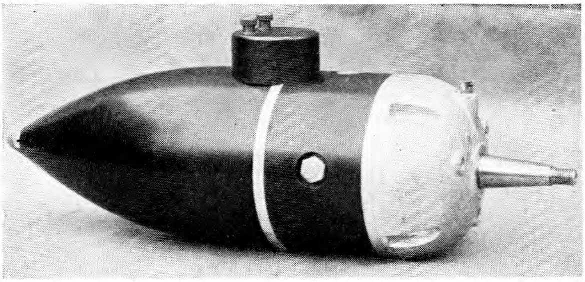
A REVIEW OF PRESENT-DAY EQUIPMENT

By R. HARCOURT WOODALL, A.M.I.E.E.

IN this article it is proposed to deal with the electrical apparatus fitted to modern aircraft, excluding any reference to ignition, which is dealt with fully in another part of this journal.

Nowadays electricity plays an important part in civil and military aviation—modern planes utilise electric lighting, electric starting, electric heating, electricity to provide power for radio, and in all probability in the not very distant future electric heated water urns and hot cupboards will be employed on large passenger-carrying planes.

In no other branch of engineering is apparatus subjected to such close inspection and testing as that demanded in the aircraft industry, and like every other component the electrical ones are each carefully inspected at each stage of their manufacture and finally examined and tested by responsible A.I.D. inspectors. Previous to manufacture, the design and a preliminary sample has been approved by the Airworthiness Department of the Air Ministry after exhaustive tests have been taken.



AN AIR-DRIVEN GENERATOR TO GIVE 150 WATTS AT 12 VOLTS.

Electric Generators.

Except in very few installations on light aircraft operated by battery only, electric current is supplied by a D.C. generator.

Methods of Drive.

The dynamo is either fitted on the wing of the plane and driven by a small airscrew, which is situated in or near the slipstream of the main propeller, or is driven by the engine, sometimes being mounted vertically, sometimes in a horizontal position.

Devices to Ensure Constant Generator Output.

Obviously, if a fixed blade type of windmill is employed the speed of the generator will vary with the speed of the aircraft, which with a dynamo of ordinary characteristics will result in a variation of the voltage across the machine terminals. Such a rise or fall could not be tolerated, so that devices have to be introduced to ensure a constant generator output over a fair speed range.

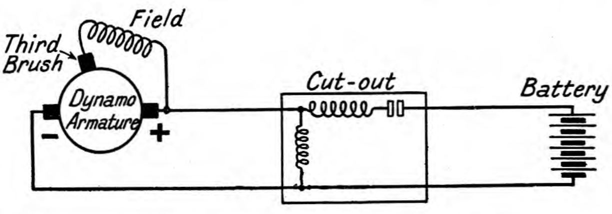
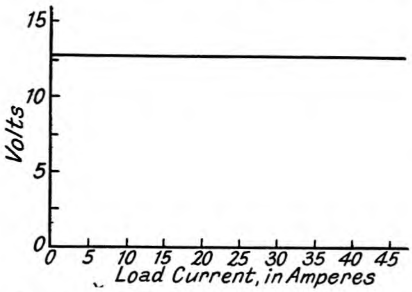


DIAGRAM SHOWING CONNECTIONS OF A SIMPLE THIRD-BRUSH DYNAMO CUT-OUT AND ACCUMULATOR.

Constant Speed Windmill.

In several systems use is



By Suitably Proportioning the Series Turns of a Compound-wound Dynamo, it can be Made to Give a Constant Voltage with Changes of Current from No Load to Full Load. It is then said to be "Level-compounded."

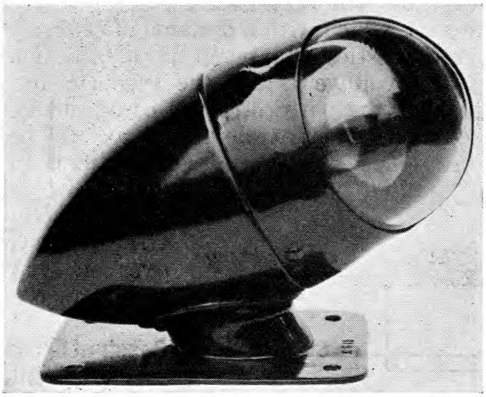
made of what is termed a constant speed windmill. This is a propeller in which the pitch of the blades alters with increase of speed, thereby maintaining a constant generator speed.

Self-regulating Generator.

In others, the generator is designed to be self-regulating and to maintain a constant output although driven at varying speeds.

Constant Current System.

In the Rotax constant current system, a third brush type of generator similar to a car dynamo is employed. In this the field of the dynamo is connected between positive main brush and a third brush situated between the positive and negative brushes, and a constant current

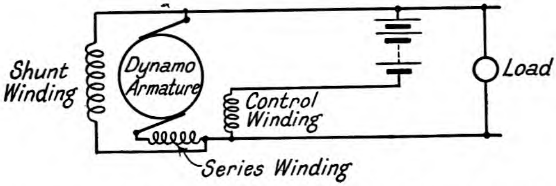


A Navigation Lamp for Wing-tip Mounting. (*Rotax, Ltd.*)

output is maintained due to the distortion of the main field by "armature reaction." A diagram of connections for an air-driven generator of this type and battery is given on the previous page. An automatic cut-out is employed to connect the generator to the battery when the voltage rises to 12 and to disconnect same when the machine is at rest.

How Overcharging of the Battery is Avoided.

To avoid overcharging of the battery during long day flights when the external load is either "off" or very small, a special arrangement of the generator field provides full output from the generator only when navigation lights are "on," a small charging current flowing into the battery when the lamps are switched off.



Patented Regulation System for Engine-driven Dynamo.

The Constant Voltage System.

Another system, known as the constant voltage system, was described on pages 168-169 of the December issue.

One of the drawbacks of this system has been the interference with radio reception on the plane caused by the vibrating contacts, but recently a fully screened type of regulator has been introduced which overcomes this objection. Also the life of the contacts has been considerably increased, their short life being another objection to this system in the past.

It is, however, fairly definite that an effort is being made to dispense with air-driven generators due to the inefficiency of this method of drive, and electric current for the aeroplane of the future will in most cases be derived from an engine-driven generator.

Air-driven Generators Now Provide H.T. and L.T. Current.

It should be mentioned that at the moment the air-driven generator is often used to provide H.T. current for radio transmission and reception as well as L.T. for lighting, etc. In many instances a dual purpose machine is employed, a double-wound armature being used with a common magnetic field.

ENGINE-DRIVEN GENERATORS.

Engine-driven generators can, of course, be of the third brush type or constant voltage type. Another system of regulation has, however, recently been developed by the Air Ministry and has several interesting features.

In this a compound-wound dynamo is employed, the series winding being arranged to give the machine a level compounded characteristic, i.e., with a constant speed the voltage will remain constant over changes of current from no load to full load.

To cope with changes in engine speed a third field winding known as a control field is employed, this being wound so as to oppose the main field. This winding is connected in series with the battery charging circuit and does not carry the main load current. The diagram on the previous page makes this clear. An increase in dynamo speed means an increase of charging current. This, therefore, results in a decrease of the main field and accordingly the terminal voltage falls.

Generally, in order to reduce weight, the generator is driven at about twice engine speed.

The Cut-out.

It is, of course, necessary to employ a cut-out in every system incorporating an accumulator, and this is invariably of the reverse current type similar to the automobile cut-out. Its function is to connect the accumulator in circuit when the generator voltage exceeds the battery voltage and disconnect same when the generator is stationary.

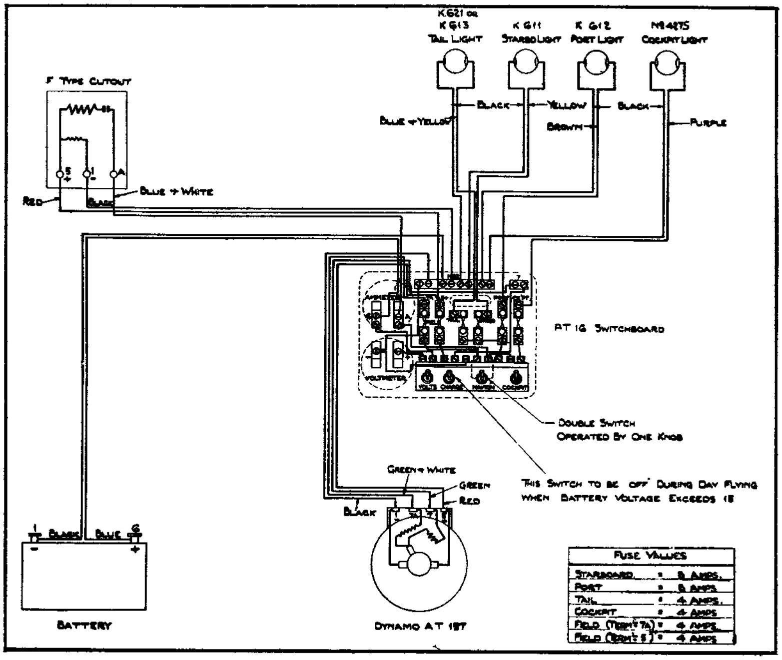
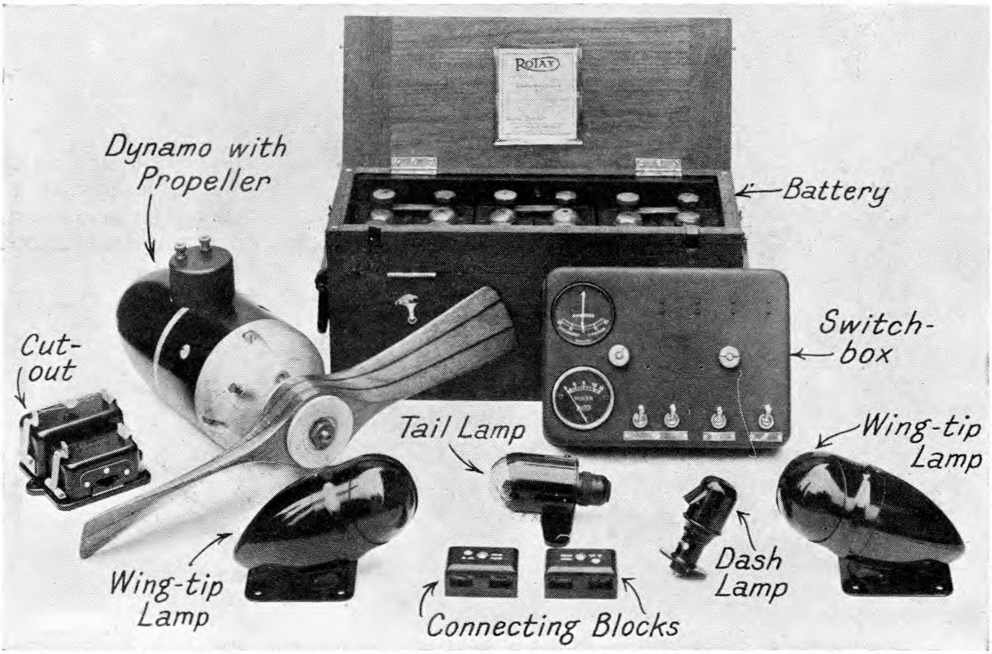


Diagram of Connections of Switchbox Used in the Electrical Equipment on Light Aircraft. (*Rotax, Ltd.*)

Navigation Lamps.

The International Commission for Air Navigation regulations demand that aeroplanes shall carry red and green (port and starboard) lamps, and these are usually fixed on the wing tips. A tail lamp is also a necessary fitment. Recently a central type of navigation lamp has been introduced, this incorporating the three lamps normally employed. Two such lamps have to be employed on each



COMPLETE LIGHTING EQUIPMENT OF A LIGHT AEROPLANE. (*Rotax, Ltd.*)

plane, on top and underneath the wing. A considerable saving is effected in the necessary wiring when a lamp of this type is employed.

Landing Floodlight.

Although not by any means a standard fitment, a fairly large head lamp is often used for landing purposes on unilluminated aerodromes. A bulb of 100 to 200 watts is fitted.

Interior Lamps.

It is essential to illuminate the instruments on the dashboard of an aeroplane, and a lamp with a cowl for the purpose of shielding the direct rays of light from the pilot's eyes is generally used.

Cabin lights are usually of the roof type. A 10-watt bulb is employed.

Switchboxes.

Various types of switchboxes are employed, depending upon the number of lighting and heating points on the craft.

On the previous page is given a diagram of connections for a switchbox fitted to a light aeroplane. It will be seen that in addition to the switches, the box incorporates fuses, in the generator field circuit and in each of the other circuits. A voltmeter and an ammeter, the latter showing the current flowing to the battery, are included.

Electric Starting.

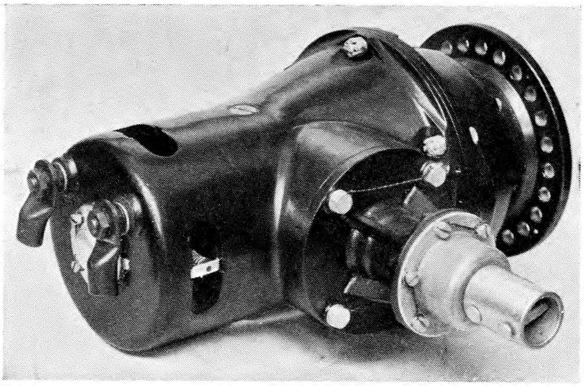
The introduction of an electric motor for starting aircraft engines is comparatively new. It is anticipated, however, that before long it will become a standard fitment.

There are two distinct types of electric starters, namely, the direct cranking electric starter and the electric inertia type.

The former consists of a series-wound D.C. motor operating from 12 volts, which turns the engine through a train of gears.

A torque overload release in the form of a multiplate clutch is a special feature, this preventing damage to the starter should the engine backfire. Engines of different types require different cranking speeds and models which crank the engine at speeds from 8 to 80 r.p.m. are available. A starter suitable for an engine of 2500 cub. in piston displazement is shown in one of the illustrations. The motor takes a current of about 40 amps.

The electric inertia type of starter has as its principle the storage of kinetic energy in a flywheel which is brought up to the high speed of 12,000 r.p.m. by means of an electric motor. The motor is then switched off and the starter jaw, which is driven by the flywheel through sun and planet gearing, is meshed with the crankshaft jaw, the crankshaft momentarily acquiring a high speed of 80 r.p.m. The current taken by this type of starter is independent of the stiffness of the engine, but although the actual current is lower than that taken by the direct cranking type, it takes 30 to 40 seconds to bring the flywheel up to speed. Therefore, it seems that the direct cranking starter is the type most likely to gain favour. In most instances a hand cranking attachment is also fitted so that a start can be effected even if the power supply fails. A torque overload release is also incorporated in starters of this type.



COMBINED HAND AND ELECTRIC DIRECT CRANKING ELECTRIC STARTER. (*Rotax, Ltd.*)

Accumulators.

Aircraft batteries have to be as light as possible and have to be unspillable when placed in any position.

For a lighting load only, the jelly acid type of battery has been found to be suitable.

Starter loads, however, demand a liquid electrolyte battery of the multiplate type and such batteries must be fitted with unspillable vents. The Davis vent is in general use.

Radio Power Plant.

Present-day practice is to use an air-driven dual purpose generator for anode and filament supply of a radio transmitter and receiver, or to use an air or engine-driven generator for L.T. and a rotary transformer for H.T. supply. Such a machine is of the double-wound armature type, the primary being wound for 12 volts and the secondary 500 to 1,200 volts D.C., depending upon the characteristics of the valves in the transmitter. It is essential for a rotary transformer for this work to be highly efficient, and, therefore, field windings are usually dispensed with, a permanent magnet being employed to provide the flux.

For emergency work a dual-purpose hand-driven generator is often carried.

Conclusion.

On government craft, the 12-volt supply is used for heating the pilot's clothing. There are many other electrically operated pieces of apparatus, Holt flares for landing purposes which are electrically ignited, electrical petrol gauges, landing signal lights, etc., a number of which are illustrated.

It may be predicted that before long many of the features mentioned in this article will be standard fitments on all aircraft, electricity thus playing as big a part in the air as it to-day plays on automobiles.

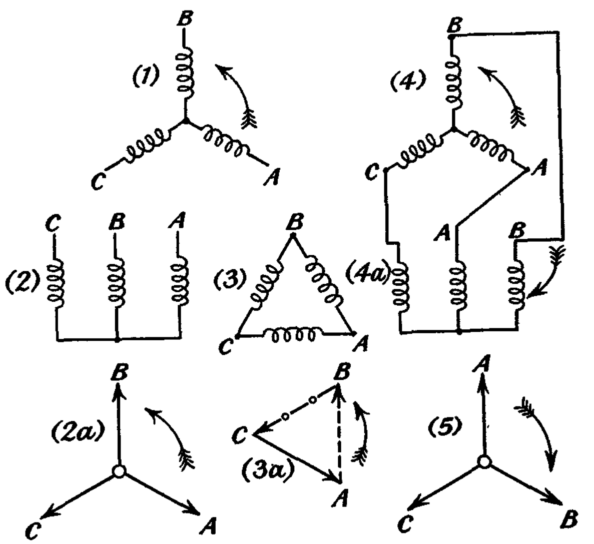
Direction of Rotation of Three-Phase Induction Motors

By W. T. Wardale, A.M.Inst.E.E.

THE direction of rotation of an induction motor, whether wound star or delta, depends on the direction of the phase rotation of the system to which it is connected, and not on its type of stator winding.

The Star-connected System.

Fig. 1 represents the star-connected system with the phases rotating anti-clockwise as shown by the arrow. Fig. 2, is the star-connected winding of a motor stator, and 2*a* the vector for its rotation, working A, B, C, anti-clockwise. Fig. 3 represents a delta-wound stator, and Fig. 3*a* its vector layout for rotation.



Figs. 1–5.—Diagrams of Star and Delta Connected Systems, with Vector Layouts, Referred to in the Text.

Now note that in this case, we set out the first vector representing phase A, in parallel with phase A, in Fig. 2*a*. Phase B comes next, and is set out in parallel with phase B as before, and, being in the same direction lies along the dotted line AB. Phase C is then set out parallel to phase C in Fig. 2*a*, and in the same direction, and so completes the delta as shown by the linked line BC. Thus, the phase rotation is still anti-clockwise, and the motor will still run in the same direction as with a star-wound stator.

Now consider Figs. 4 and 5. Note that the *system* still works anti-clockwise, A, B, C, as before. Two of the leads to the motor stator, 4*a*, are crossed; phase A, supplying the mid-winding on the stator, and phase B the right-hand winding. Below in Fig. 5, is the vector for this rotation. Phase A has now come to the vertical position, with phase B on the right-hand side; as the system still revolves A, B, C, the rotation in the stator must now be *clockwise* in order to follow this sequence, and the motor will run in the reverse direction if two of the lead-in wires to the stator are crossed over.

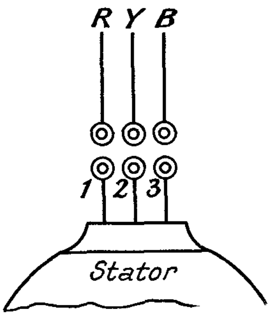


Fig. 6—If Motor Runs in Reverse Direction with Connections R to 1, Y to 2, B to 3, Disconnect R and Y and Connect R to 2 and Y to 1.

An induction motor then, depends for its direction of rotation on the phase rotation in the stator; straight connections make it follow the system rotation; two leads crossed reverse the phase rotation in the stator and so reverse the direction of running. Induction motors often started up by means of a starter which first puts a low voltage on the stator by giving a delta connection from the system, and then brings the motor up to full speed, by throwing it over to a star connection. Please note that the vector layouts show direction only, and are not drawn to scale to show magnitude.

Connecting Induction Motor to System.

To apply the above explanation refer to Fig. 6. Connect line R, representing the red phase, to terminal 1 on the motor; Y, the yellow phase, to 2, and B, the blue phase, to 3. Give the motor a spin up, note the direction of rotation and, if as desired, make the connections permanent. If you require the reverse rotation, disconnect R and Y, connect R to 2, and Y to 1, and the motor will then run reversed. If the motor is built into a machine tool, before spinning it round, bar the tool round to see all is clear.

When the connections have been determined, mark the terminals on the stator, with R, Y and B, and also enamel the motor leads the correct colours. Then when a motor has been taken out for new bearings or similar work, you can put it back, and connect up straightaway. If the motor has been rewound, however, you will have to make another trial.

The reason motor stators cannot be sent out marked with the terminals R, Y and B, is that such motors are mass produced ; whilst some systems work to the standard colours and rotation of phases and some do not. Also there are private plants with their own phase rotation. As the induction motor can be tried and altered inside ten minutes, to prove correct connection for the rotation desired, there is no need to have each motor tried and marked at the works.

CURING NOISY MAINS TRANSFORMERS

It will sometimes be found that certain mains transformers operating from the alternating current supply are much noisier than others in the matter of mains " hum." In most cases the cause of this enhanced hum will be found to be due to the presence of slightly loose core stampings or laminations. These should, of course, be clamped tightly during the manufacturing operations but occasionally, owing to the presence of fine burrs or to particles of dust, one or more of the plates is not firmly clamped, with the result that under the influence of the alternating current it vibrates and thus gives rise to a low-frequency hum.

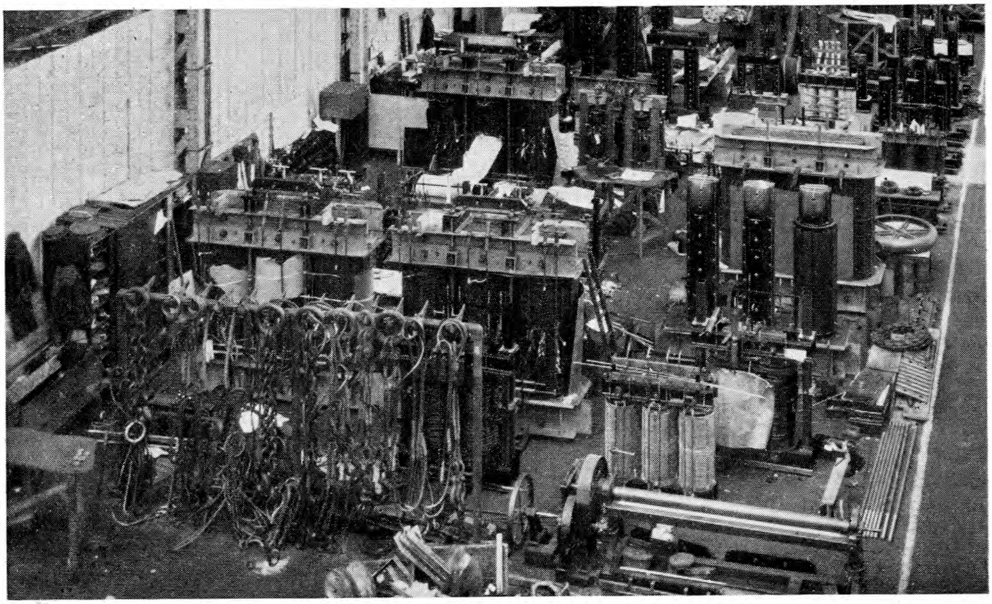
The proper procedure, to effect a permanent cure, would be that of dismantling the transformer, cleaning and reassembling the laminations. This is a lengthy and complicated operation, however, and amounts in practice to the making of a new transformer, after having unwound the primary and secondary coils.

An excellent expedient that does not involve any dismantling of the transformer consists in filling up the interstices between the laminations with shellac varnish.

The transformer should be warmed slightly for this purpose and the heated shellac varnish poured over the laminations.

If, then, the transformer is kept warm the varnish will find its way into the interstices, so that when the transformer is afterwards allowed to cool down the laminations and their varnish will be found to form a solid unit in which there is no possibility of any appreciable mains hum arising. The varnish, apart from acting as a filling medium, also serves as a corrosion protection for the iron laminations.

A Modern Transformer Factory



General View of the Main Transformer Bay.
It is here that transformers up to 60,000 kVA. have been built, and testing transformers with voltages up to one million. (*By courtesy of B.T.H. Co., Ltd.*)

IN any up-to-date manufacturing organisation, one of the chief considerations is the best system for the most expeditious and efficient method of production.

This is not always an easy matter where the articles manufactured cover a wide range of sizes and types, but careful planning can usually ensure that the work flows through from operation to operation in proper sequence without undue delay at any stage.

The following brief description of the B.T.H. transformer factory at Rugby indicates how the desired object can be achieved when manufacturing every class of transformer, from those designed for the largest ratings and the highest voltages yet contemplated down to the small instrument transformers.

With the exception of the tank shop, manufacture is almost entirely confined to one large building, which consists of a main bay with ample annexes, and a gallery.

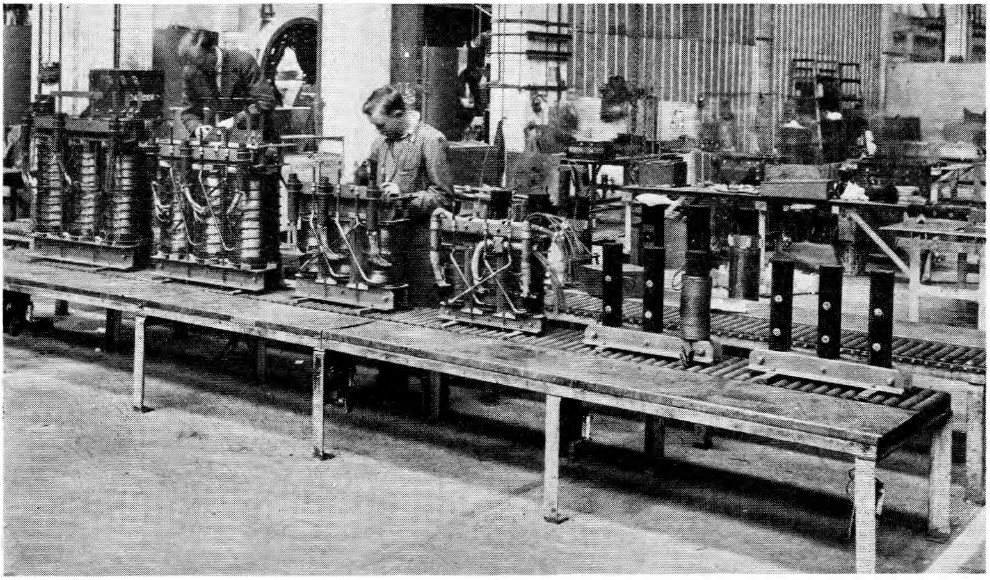
All instrument transformers are manufactured on the gallery, power transformers and distribution transformers being built in the main bay below. Also on the ground floor is a well-equipped machine shop, with machine tools which are in the main primarily adapted for the machining of fabricated structures ; these, of course, play a large part in the make-up of the modern transformer.

The Welding Area.

At the end of the machine shop, but in the main bay, is located the welding area, where large transformer tanks are built. Beyond this area is the heavy winding section. Winding lathes having capacities great enough to pull 50 conductors 0.125-in. × 0.65-in. in parallel are available, as well as smaller machines for high voltage coils. In an annex adjacent to this area is a separate winding area devoted to the coils for distribution transformers.

The Varnish Treating Section.

Completed coils from this area proceed



THE CONVEYOR BENCHES FOR ASSEMBLING DISTRIBUTION TRANSFORMERS.
The conveyor is arranged in the form of a " U." Cores are placed on one leg and then proceed along the conveyor through their various assembly stages.

to the varnish treating section, also located in an annex, where they are vacuum dried and compressed until they are solid, and impregnated with various varnishes.

Core Building Area.

Adjacent to the annex in the main bay is the core building area. Core laminations are given their insulating varnish treatment at a position adjacent to the receiving stores, and are then brought into the transformer factory at this point for assembly. After the cores are built all core bolts are tested at 2,000 volts from a high voltage supply located adjacent to the area.

The Main Assembly.

Beyond this point in the building the main assembly starts. First there are distribution transformers; these are assembled on a roller conveyor arranged in the form of a " U." Cores are placed on one leg of the " U " and then proceed along the conveyor through their various assembly stages. At the base of the " U " a ratiometer is located in order that a preliminary check for ratio can be made before all connections are complete. At the end of the conveyor the assembled core and coils are lifted off and taken into the drying ovens. When dry they are brought back to the same area and placed in their tanks which are then filled with oil. They then proceed by overhead crane to the testing area at the end of the factory.

Power Transformer Assembly Section.

Beyond the distribution transformer section is the power transformer assembly section. Here transformers up to 60,000 kVA. have been built, and testing transformers with voltages up to one million. The special insulations required for transformers are prepared on the gallery above, where, in addition, the conductor for the coils is insulated. This insulation is performed on a special machine which first cleans the conductor and then wraps on paper to the desired number of laps.

Beyond the power transformer assembly area is located the treating section for large transformers. The testing section is located at the lower end of the building.

QUESTIONS AND ANSWERS BY PRACTICAL MEN

Readers are invited to send problems of practical interest. Letters should be addressed to "The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2. Envelopes to be marked "Problem" in the top left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

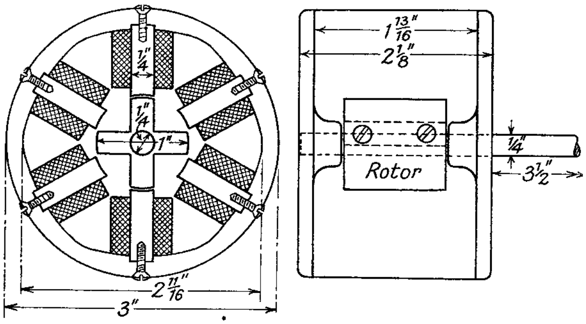
THIS MONTH'S NEW QUESTIONS AND LETTERS

Starting a Small A. C. Motor.

I have a small A.C. motor made by Vickers, Sons & Maxim. The stator has a solid yoke about 3 ins. diameter. There are six pole pieces, giving a bore of 1 in. The rotor consists of a Maltese cross arrangement as in diagram, being built up of (copper plated) iron laminations. I have been informed that the machine is for 220 volts, 50 cycles, single phase.

I wish to know how to start this machine. The motor appears to belong to some gun indicating gear, as its makers are connected with such work, and it has gearing attached to give about a 50-1 reduction. A diagram of starting and running connections would be appreciated. The six coils have two leads each, and are of approximately the same size and wound with approximately the same gauge wire.

H. O. C. (Devon).



THE SMALL A C. MOTOR REFERRED TO BY "H O C"

Auto-starting Transformers.

Referring to the article in THE PRACTICAL ELECTRICAL ENGINEER, *November issue, on "The Installation and Operation of Induction Motors," I should be glad to know if you can give me any information regarding the general design relationships of Auto Starting Transformers.*

Three-phase starters, in some instances, are star connected and in others open delta connected. Is there any advantage in one or the other of the two connections? Also as these transformers are only connected to the line during the starting period, it appears possible for the induction in the core to be made a fairly high figure and as the starting period on even a fairly large motor seldom exceeds 30 seconds, together with a specified limit to the number of starts per hour, no doubt the section of copper can be reduced very greatly.

Could you give me some information on these points, together with some indication of the manner in which the temperature rise can be calculated? E. 61 (Merton Park).

Working Temperatures for Heating Elements.

It is understood that the selection of wire for heating elements is made from wire manufacturers' tables, but the operating temperature of the wire must be known. What are the recommended temperatures for the heating wires in electric fires, toasters, kettles, hot plates, cookers, etc.?

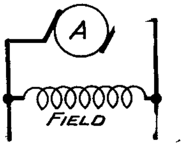
The tables assume a straight wire in air; what correction factors must be applied to spirally wound elements? How are the effects of adjacent heat reflectors and the materials in which the elements may be embedded considered?

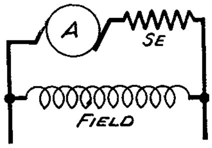
E. A. B. (Sheffield).

Using a Motor Generating Set for Welding.

I have a motor generating set, the particulars of which are :—

Motor.	*Generator.*
G.E.C., No. 21,415.	*G.E.C., No.* 21,414.
H.P., 5.	*Volts*, 60.
Volts, 460.	*Output*, 3.9 *kW.*
Revs., 1,400.	*Revs.*, 1,400
Shunt wound.	*Compound wound.*
	No interpoles.





I want to use same for electric welding. Could you possibly give me particulars as to what I should do regarding same ? I want a load of 80 *amps. Please give the wiring diagram, the correct resistances and S.W.G. of same, as I want to make my own.*

E. C. (Eccleston).

Rewinding Motors.

Of particular interest to me have been the questions and answers, in your correspondence columns, on rewinding motors.

Could you please put me on to a suitable book from which such information regarding rewinding, name plate details and winding space dimensions only being known—can be obtained.

I feel sure it would be much appreciated if you could find space in your paper, of a most useful practical nature, to publish at intervals a list of new literature of practical electrical engineering interest.

H. C. B. SWAN (West Siam).

[ED. NOTE.—We are looking into the point raised in the last paragraph and would value readers' opinions on it.]

Ultra-Violet Lamps.

We should like to endorse the advice given in your editorial paragraph (November issue) that makers of ultra-violet lamps should give full instructions as to the correct methods of using them. We have always borne this in mind from the outset in marketing our popular home model the "Homesun." From the enclosed copy of our instruction book we hope you agree that the directions given are fully sufficient to enable anyone to use this lamp with maximum benefit. This seems to be endorsed by the experience of our users, who probably outnumber all users of other domestic ultra-violet lamps in this country.

Yours faithfully,

D. A. JONES, Director.

THE BRITISH HANOVIA QUARTZ LAMP CO., LTD.

[We quite agree that the directions given in the Instruction Book referred to would enable anyone to obtain the maximum benefit from "Homesun" lamps.—ED.]

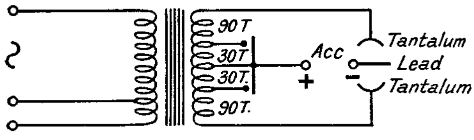
REPLIES TO PREVIOUS QUESTIONS

Electrolytic Battery Charger.

I am constructing the electrolytic battery charger described in the June issue, and should be pleased if you could inform me if this charger could be modified to charge six 10-*volt H.T. accumulator blocks in parallel, the current for each battery being* 0.25 *amp.*

C. C. (Wednesbury).

There is no reason why the charger should not be modified for the purpose outlined above. Tantalum has a breakdown voltage of 25 volts, so that above this value current will start to flow in either direction. The turns of the secondary windings could be increased by $33\frac{1}{3}$ per cent. before approaching the safety limit.

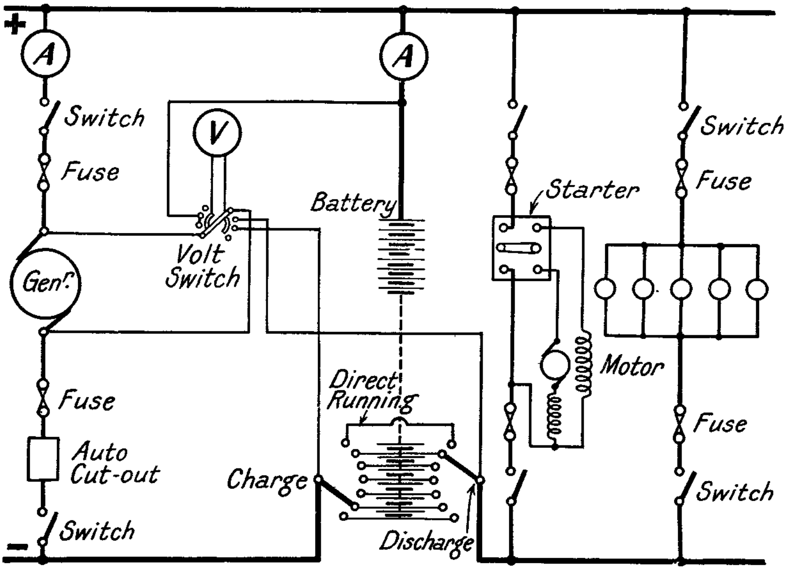


THE ELECTROLYTIC BATTERY CHARGER ARRANGEMENT.

A Private Installation Problem.

I have a 100-135 *volt,* 20 *amp. dynamo with switchboard, which I want to use for lighting and driving a* 7 *h.p. motor. I should like to know the number and size of batteries required, also plan of wiring from dynamo to switchboard, batteries, etc.*

The motor would be required to run for 4 *hours per day, and if any advantage I*



CIRCUIT DIAGRAM FOR PRIVATE GENERATING SET.
The battery recommended is 54 cells type SFG6 Chloride.

could make this 2 hours in the morning, and 2 hours in the afternoon.

The lighting load will not be in use at the same time as motor.

The dynamo can be run for 9 hours per day.

If the 7 h.p. motor is run at full load and if its efficiency is, say, 90 per cent., the input current will be :—

$$\frac{7 \times 746}{100} \times \frac{10}{9} = 58 \text{ amps.}$$

approximately. As it is to run 4 hours per day, the capacity required at the 4-hour rate of discharge of the battery will be 58 × 4 = 232 amp. hours. This corresponds to a battery capacity of 300 ampere hours at the 10-hour discharge rate.

Twenty amperes is just half the normal rate of charge of a 300-amp. hour battery and so the whole of the discharge may be put back at this rate. Allowing for an amp. hour efficiency of 90 per cent. then the total charge required will be 258 amp. hours (i.e., 232 amp. hours plus 1/9) and will, therefore, take nearly 13 hours to complete. This does not, of course, allow for the battery to be used for lighting, and if this is required the battery will have to be larger and the time of charging longer. For a 100-volt circuit it is usual to employ 54 cells, and to fully charge these it will be necessary for the dynamo to give nearly 150 volts towards the end of the charge, but possibly its speed can be raised to obtain this pressure.

A drawing is reproduced showing a typical arrangement of connections for dynamo, battery, motor and control gear.

Advantages of D.C. over A.C. for Marine Purposes.

The principal advantage of D.C. over A.C. for use on ships is that it is much more suitable as a supply for auxiliary purposes where variable speed drives are required. To take a few examples:—Motors driving centrifugal pumps where a predetermined pressure has to be constantly maintained on the pipeline; winch motors which have to lift heavy loads at a slow speed, at the same time being capable of giving a high light-hook speed; motors driving compressors, whose output depends directly on their speed, and needs to be varied as the occasion demands, and so on.

To obtain a variable speed drive with an A.C. motor, a wound rotor is usually fitted, the speed being decreased by inserting resistance in the rotor circuit, with a considerable loss in efficiency.

With a D.C. motor the speed is increased by inserting resistance in the shunt field circuit, or in the case of a heavily compounded winch motor, by diverting some of the current from the series field circuit, by a parallel resistance, with practically no difference between the top and bottom speed efficiencies of the motor.

J. M. B.

How to Install Electric Motors (See page 251)

The PRACTICAL ELECTRICAL ENGINEER

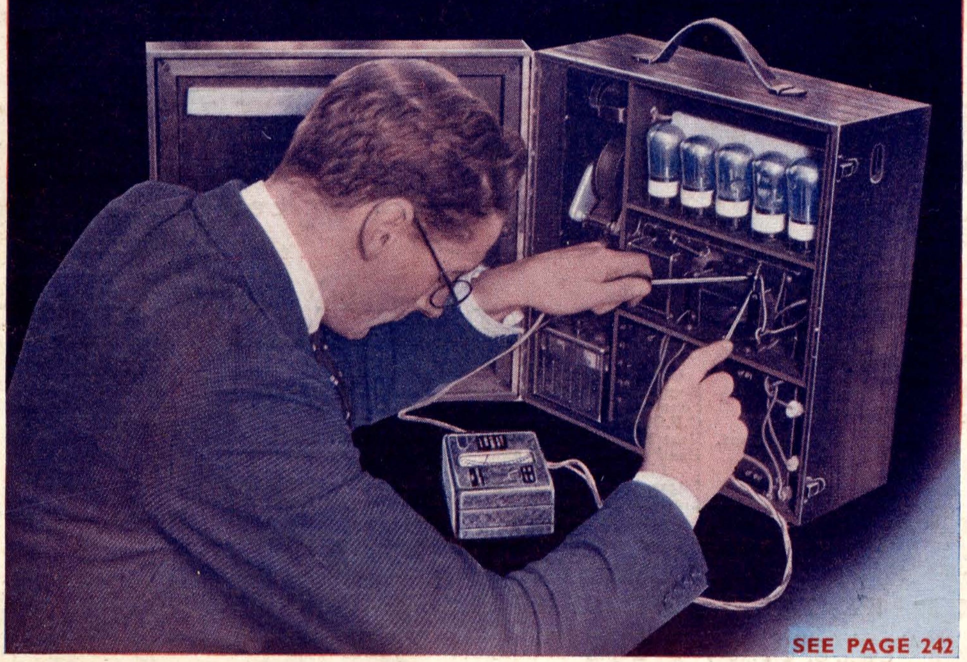
A MONTHLY MAGAZINE OF ELECTRICAL PROGRESS

VOL. II.—No. 18

FEBRUARY, 1934

EASY CIRCUIT TESTING

with the Megger Circuit Tester



SEE PAGE 242

1/-

GEORGE NEWNES LTD.

FEBRUARY, 1934 PRACTICAL ELECTRICAL ENGINEER No. 18

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

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Development in the Electrical Industry.

This month we publish an article dealing with the astounding growth of electricity supply in Wimbledon during the past few years. The results achieved have already been the subject of favourable comments in the general, technical and trade press, but we believe that this is the first time the full story has been told. Readers of the article on pages 237-241 will see that the two important factors of the scheme were :—

(*a*) Gradual reduction of the average price per unit from 4.72d. until the figure now stands at 1.32d.

(*b*) That the supply undertaking installed and maintained a large number of cooking and heating appliances in their consumers' premises, charging low rates for the hire.

We have heard it suggested that the latter action is detrimental to the interests of electrical contractors and installation engineers. The evidence given in our article on this point does not seem to support this suggestion, but any readers who have views on this question are invited to send them along.

Another Case for Co-operation.

In an address to members of the Institute of Landscape Architects at the Royal Horticultural Hall, Mr. R. O. Sutherland, A.R.I.B.A., Architectural Lighting Expert on the Lighting Service Bureau, pointed out a new field for electric lighting which has hardly been explored at all.

He suggested that the artificial illumination of landscapes and gardens should form a factor in the inspiration of the layout and should receive early consideration. Nature fills a garden during the day with her own lights and shadows, and it is open to the horticulturist, the architect and the illuminating engineer to co-operate and form a means of producing equally beautiful effects by night.

An interesting and thoroughly practical idea, which should not be allowed to drop. Readers who require more detailed information on the subject are invited to apply to the Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.

Progress During 1933.

We have received from some of the large electrical manufacturers interesting accounts of the progress they have made during 1933. A list of all the items mentioned would form a fairly comprehensive catalogue of present-day electrical manufactures. The following are some of the more interesting features mentioned :—

The British Thomson-Houston Company.

Further developments in the Mazda Mercra lamp ; hot cathode rectifiers ; thyratrons (which have already been described in our issue of September, 1933); domestic refrigerators and sound reproducing equipment for fair grounds, concert halls, cafés, etc.; cathode ray oscillograph tubes, suitable for low-voltage operation and capable of adaptation for use in connection with television, are also worthy of special mention.

On the heavy engineering side it is interesting to note that plant is still being supplied to the Central Electricity Board.

Special testing transformers for use in making tests on switchgear have been constructed to give voltages from 22,000 volts to 132,000 volts. These transformers are capable of withstanding repeated three-phase short circuits up to a value of 1,000,000 kilovoltamperes. When it is remembered that at unity power factor 1 kVA. equals approximately $1\frac{1}{3}$ h.p., the enormous stresses set up in these short circuit tests can be appreciated.

A new traction motor has been developed having a single-turn armature winding which has proved very satisfactory in service. This motor commutates very heavy currents even on the weakest field strength with complete absence of sparking.

Since the development of the Grid the output of A.C. motors in medium, small and fractional h.p. sizes continues to increase. During the past year the British Thomson-Houston Company supplied a greater number of A.C. machines than ever before.

The conversion of one of the large three-storey buildings of the B.T.-H. Rugby works into a factory for the production of electrical home appliances such as washing machines, cookers and immersion heaters has already been commented on in an earlier issue. We are glad to hear that a large number of appliances of each type have been manufactured during the year.

G.E.C. Progress.

Here again the number of products covered in the annual report of manufacturing activities covers an enormous range. Some of the more notable items are the development of the Osira lamp, the catkin valve, cold cathode discharge tubes, and special lighting equipment for aircraft.

As in the case of the B.T.-H., a heavy demand for alternators has been experienced by this company. During the year geared motor units of a small size have been produced in quantity. Much progress has been made in switchgear design, a small but interesting feature being a liquid immersed rewireable high voltage fuse which can be rewired by the user. This is the first fuse of the type produced in this country embodying such a feature.

Much attention has been devoted to the development of gasfilled lamps for special purposes, such as for use in home talkie equipment, for the lighting of cinema studios and for use in full-size projection apparatus.

Floodlighting and luminous tube lighting have made striking progress during the past year.

Progress in telephone work has been evident in several directions. The range of rural automatic exchange equipments has been extended, while, in general, automatic systems are being ever more widely introduced. Of the large city exchanges completed for the British Post Office, perhaps the most notable is the Kensington equipment, which is one of the largest in Great Britain, providing capacity for 10,000 local subscribers' lines. During the year 50 miles of oil-filled cable have been installed ; the working pressure being from 33,000 to 132,000 volts.

The most important development in connection with measuring instruments is the application of thermionic valve technique to apparatus for measurement and detection.

How the Wireless Valve Received its Name.

At the 24th Annual Exhibition of the Physical Society Sir J. Ambrose Fleming, D.Sc., F.Inst.P., F.R.S., gave a discourse on "The History and Development of the Thermionic Valve." It was fascinating to hear at first hand how the Fleming Valve came to be discovered. It may interest many readers to know that not only did Sir Ambrose make the first rectifying valve, but he also christened it. He selected the word "valve" as a word from the English dictionary, widely understood and expressing exactly the function intended.

The British Industries Fair.

The space booked by electrical exhibitors for this year's British Industries Fair is nearly 50 per cent. greater than that occupied by electrical exhibits in the 1933 Fair.

Exhibits in the electrical section range from domestic appliances to heavy industrial equipment.

On account of the strong electrical interest readers are advised to spare no efforts to pay a visit to the Birmingham section at Castle Bromwich. The Fair opens at Castle Bromwich, Olympia and White City on Monday, February 19th, and closes on Friday, March 2nd.

The Birmingham section of the Fair is open from 10 a.m. to 6 p.m. every day, excepting Sunday, from February 19th to March 2nd.

On payment of an initial charge of 2s. trade buyers receive a badge entitling them to visit the London or Birmingham sections as frequently as they please without further charge. The general public will be admitted, at a charge of 2s., daily after 4.30 p.m. On Saturday, February 24th, and Friday, March 2nd, the Fair will be open to the public all day, i.e., from 9.30 a.m. to 7.30 p.m.

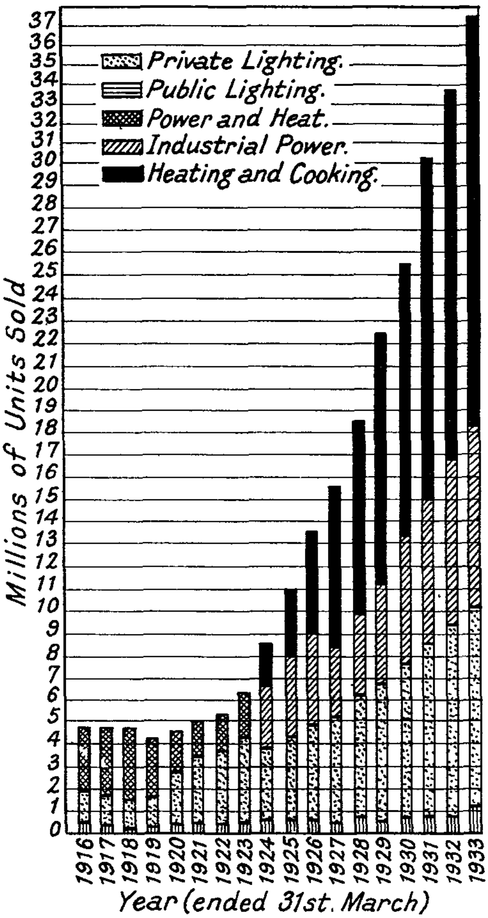
THE WIMBLEDON EXPERIMENT

TWELVE years ago the chairman and members of the Wimbledon Electricity Committee were feeling very gloomy about the prospects of their undertaking. What they saw when they reviewed the results of the previous six years' working is shown in the table. A little simple arithmetic showed that the net results of six years' strenuous effort on the part of the undertaking had resulted in a loss of £11,459. 0s. 11d.

The figures seemed to show very definitely that electricity was being sold too cheaply, especially as the monthly profit and loss account for 1922 indicated that the results for that year were likely to add still further to the losses already incurred.

PROFIT AND LOSS FOR YEARS 1916-1921.

Year.	Results of Year's Working. Loss. £ s. d.	Profit. £ s. d.
1916	2,525 3 5	—
1917	4,220 15 6	—
1918	—	380 6 11
1919	3,023 16 9	—
1920	—	1,629 10 4
1921	3,699 2 6	—



THIS CHART SHOWS HOW THE LOAD ON THE WIMBLEDON STATION HAS INCREASED DURING THE PAST 12 YEARS.

The Price Seemed Too Low.

At that date the number of units sold per year was round about 4,000,000 and the average price per unit for all purposes 4.72d.

For the preceding year the average price had been approximately 4.7d. per unit and the result of the year's working was a loss of £3,700 in round figures. The obvious remedy seemed to be to increase the price by 1d. a unit, bringing the new price up to roughly 5¾d.

It was suggested that though this might lead to a slight diminution in the number of units sold, the net result would be more profit on the year's working. Possibly this would have been the case, but fortunately for Wimbledon consumers in particular and, we think, for the Electrical Industry as a whole, this counsel was not adopted.

A Bold Step—They Made it Lower Still.

The Chief Engineer of the undertaking, Mr. A. E. McKenzie, strongly urged upon his committee the advisability of reducing the price by 1d. a unit; a bold step to take you will agree, but not only had Mr. McKenzie the courage of his convictions, he also enjoyed the confidence of his committee, who sanctioned the suggested decrease in price.

A Tremendous Jump in Profits Resulted.

The results of the enterprising policy of which this price reduction formed the keystone can, without exaggeration, be described as staggering. In 1923—the first year during which the new price was fully operative—*the profits amounted to no less than £28,000.* We do not suggest that a price reduction of this kind is in itself sufficient to turn a languishing undertaking into a flourishing one, but it has been clearly demonstrated in the succeeding years' results of the Wimbledon undertaking that progressive lowering of the tariff charges is one of the most important items necessary to secure prosperity in the industry.

Further price reductions were made in subsequent years until at the present time the average price per unit in Wimbledon is at the low figure of 1.32d.; whilst for certain purposes, e.g., electrical heating and cooking, electrical energy is supplied at the highly attractive figure of .655d. per unit.

A Twelve Years' Test.

The table above shows the actual figures from year to year since the courageous policy outlined above was adopted.

Everyone is Happy.

These results are sufficiently striking to merit the most careful study by everyone who has the welfare of the electrical industry at heart. The Electricity Committee of the Borough of Wimbledon find their satisfaction in the pleasing financial results of each year's working. The ratepayers of Wimbledon are delighted because the Electricity Undertaking contributes a substantial amount each year (for 1933 the figure was round about £11,000) to the rates, and the consumers in the Wimbledon, Merton, Malden and Coombe District experience a glow of satisfaction when they switch on their electric fires and reflect that their electricity charges are lower than those paid by consumers in most other supply areas in the country.

Year.	Average Price Per Unit.	Total Units Sold.	Profit on Year's Working. £ s. d.	Number of Consumers.
1922	4.724d	4,277,808	5,894 1 9	8,867
1923	3.754d.	6,156,683	28,701 19 4	10,654
1924	2.882d.	8,570,130	30,407 12 3	11,804
1925	2.381d.	11,010,062	23,971 8 2	12,969
1926	2.180d.	13,586,008	33,504 14 6	14,399
1927	2.089d.	15,511,438	19,951 4 1	16,029
1928	1.887d.	18,411,699	33,089 14 7	18,081
1929	1.660d.	22,467,621	27,062 16 4	19,779
1930	1.626d.	25,388,075	20,309 13 9	21,702
1931	1.552d.	30,143,349	32,388 13 1	23,602
1932	1.436d.	33,329,843	22,493 16 1	25,949
1933	1.320d.	37,219,138	31,387 9 10	28,122

and whereas at 1922 the Reserve Fund of the undertaking stood at £5,000, to-day it stands at £98,000.

How the Load has been Increased.

A graph, which we reproduce on page 237, shows how this astounding development has taken place. Study it for a moment, and you will see that nearly half the total units sold during 1933 were supplied for the purpose of heating and cooking.

As a matter of fact, during the past year, nearly 19,000,000 units were used by the people in Wimbledon for heating and cooking. *This is not an accident.* The heating and cooking load has not simply grown of its own accord. *The Wimbledon*

Electricity Department, under the able guidance of its Chief Engineer and Manager, Mr. McKenzie, and with the full support and encouragement of the Electricity Committee and Council, caused it to happen.

The Secret Told.

The secret of this very healthy heating and cooking load is simply this :—

The people of Wimbledon have at the present moment in their houses over 25,000 electrical heating and cooking appliances. Here are the actual figures at December 31st, 1933 :—

Electric cookers	4,960
Electric wash boilers ..	1,420
Electric water heaters ..	3,670
Electric irons	5,285
Electric kettles	4,275
Electric fires and radiators	5,600
Total	25,210

It is obvious that with all these appliances in commission in a district where the cost of electrical energy for heating and cooking is less than ¾d. a unit there is bound to be a very big consumption of electrical energy for these purposes.

A Secret within a Secret.

But, anyone who has ever tried to sell electric cookers will ask " How did Mr. McKenzie persuade 5,000 people in Wimbledon to purchase their cookers ? "

The answer is, " He didn't." But, still, he has managed to get these 5,000 cookers into the homes of the people of Wimbledon with their full consent and to their continued satisfaction, and the method he used and is using is ridiculously simple.

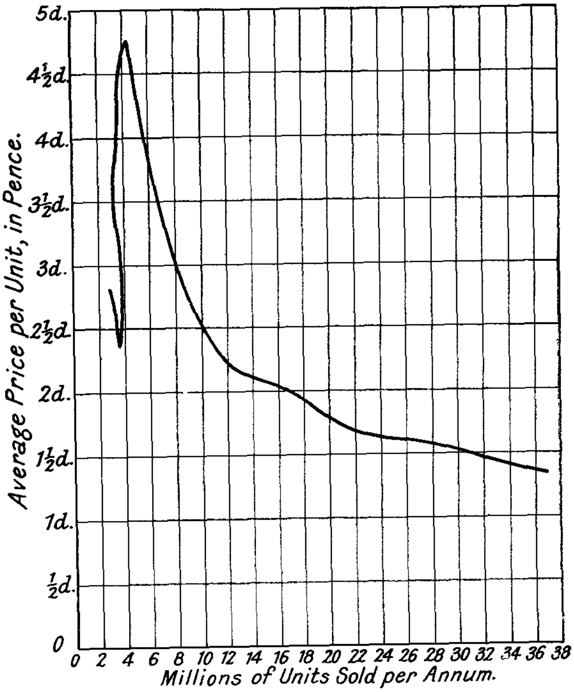
What the Gas Companies Learnt Thirty Years Ago.

He did the same as the gas companies all over the country have been doing for the past 20 or 30 years. He installed electric cookers for a nominal quarterly rent comparable with that charged by a gas company for a gas cooker.

How and Why the Consumer Pays Cheerfully.

It is of particular interest to note that this quarterly charge does not bear any relation to the capital invested in the cooker. If the cooker rents had been fixed in accordance with the strict principles of accountancy they would need to have been two or three times as large as they are at present.

The next question is " Who stands the racket ? " The reply again is simple. The money invested by the Borough in the purchase of electric cookers will be, and is being, paid off out of the yearly profits on the sale of electric current, so the consumer pays just the same with this vital difference —he pays in a manner which is perfectly painless, therefore he pays cheerfully, and he recommends electric cooking to all his



AN INTERESTING GRAPH.

This shows units sold per annum plotted against average price per unit, covering the period 1913-1933. It is interesting to note that when development on scientific lines started (in 1922), these two variable became related by an approximate mathematical laws Previously there seems to be no connection between. the two figures.

friends. A similar system has been adopted in connection with electric wash boilers, water heaters, fires, iron and kettles.

Some Interesting Questions and Answers.

Now we come to another aspect of the subject—Is the system outlined above a good thing for the electricity industry as a whole ? As far as the generating side is concerned we shall simply ask another question, viz. :—

" Is it better to sell, as in 1921, 4,000,000 units at a cost of 4¾d. each, to give a net loss of nearly £3,700, or is it better to sell, as in 1933, 37,000,000 units at an average price of 1.32d. with a profit of £31,000 ? " —and leave the reader to answer it.

The Manufacturer.

From the point of view of the electrical manufacturer there can be no question that he is delighted to supply the extra plant, switchgear, cables, meters, and the 25,000 cookers, wash boilers, water heaters, irons, kettles and fires which have been requisitioned during the past eight or nine years on behalf of the electricity consumers of Wimbledon.

The Installation Engineer.

This leaves us with a third important interest still to consider, viz., the Electrical Installation Engineer and his staff. At first sight it would appear that for an electricity undertaking to supply and install cookers, wash boilers, and other current-consuming devices for a nominal charge is distinctly against the interests of this section of the industry, but let us look at the facts. When this system was started in Wimbledon, i.e., during the years 1922 to 1923, the number of people employed by the Wimbledon Corporation on the distribution and maintenance side was 75. To-day the number of people employed by the Wimbledon Corporation on the distribution and maintenance side is 274.

In 1923 electrical contractors in the Wimbledon district had a clientele of about 9,000 consumers of electricity in their district. To-day this figure is in the region of 29,000.

True, the Wimbledon Corporation install and maintain their own cookers and other apparatus which is hired out, but the field for the sale of all-mains wireless sets, table lamps, electrical refrigerators, toasters, fans, vacuum cleaners, lamps, lamp shades and fittings has been trebled during the progress of the Wimbledon experiment.

Here again we will leave the reader to answer the question for himself. We prefer only to state the facts.

This System is Bound to Come.

The results achieved during the past 10 years at Wimbledon demonstrate conclusively the lines upon which electricity supply can be developed rapidly in this country. It is admitted that Wimbledon is a district which has lent itself to rapid development, but most supply areas possessing equal facilities from this point of view lag far behind this in achievement. Much has been written and more has been spoken in attempts to prove that electricity can never be made available to the general public at less than 2d. or 3d. per unit if the supply undertaking is to show a profit. We think we can carry every reader with us when we say that where they are available, accomplished facts are more convincing than the most elaborate arguments. It is our considered opinion that the system so successfully demonstrated at Wimbledon is bound to come into wide use in other undertakings. There will be opposition, as there is to every forward move, but we believe the sooner this system becomes widely adopted, the better it will be for electrical engineers in all sections of the industry.

A Short Digression.

The Chief Engineers of many other electricity undertakings in this country can bring about a similar development in their own undertakings if they wish to do so. At the present time only about one-third of the 12,000,000 houses in the country are wired for electric supply, whereas 94 out of every 100 houses in Wimbledon, Merton, Malden and Coombes are supplied with electricity. By adopting a similar policy it should be possible to double the number of consumers in the country within the next five years. Wimbledon has shown how it can be done, and providing that *proper incentives are offered to the engineers and managers* responsible for the undertakings, progress should be equally rapid in many other districts.

A Few Words on Emoluments.

It is fairly common knowledge that many chief electrical engineers are underpaid in proportion to the responsibility of their position. Electrical progress, like most other things, cannot be worked out entirely on paper. It can be planned, but in the end the plan must be put into action by a capable engineer who has also commercial ability. To embark on a programme of expansion involves the responsible engineer in a great deal of administrative detail. If the Chief Engineer sees little prospect of personal advancement what inducement is there for him to take up the installing of cookers, water heaters, fires, and other appliances.

"It would," says he, "be a splendid thing for electrical manufacturers, it would probably be very good for the consumers, and also profitable to the undertaking, but as far as I am concerned, it will only mean that my work and worries will be at least doubled or trebled."

On the other hand, we believe that there are very many engineers who are so keenly interested in their work that they would not consider their own side fo the question—but if they do who can blame them?

Therefore, if this rapid development which we all desire is to take place, not only must prices be lowered and heating and cooking appliances be made easily available to consumers, but also the *engineers and managers must have an inducement offered to them.* A small commission on the profits of the undertaking added to the basic salary is a reasonable system, but the exact method of remuneration does not matter. *What does matter is that the men who can develop the industry shall be given a suitable inducement to do so.*

USEFUL TABLE OF CURRENT CONSUMPTION FOR DOMESTIC APPLIANCES

	Rating in Watts.	Units Consumed per Hour.	Hours per Unit.	Current Consumption, Amperes. 100 volts.	110 volts.	200 volts.	210 volts.	220 volts.	230 volts.	240 volts.	250 volts.
Lamps	15	.015	66.6	.15	.136	.075	.0715	.068	.065	.0625	.06
	25	.025	40	.25	.227	.125	.119	.114	.108	.104	.1
	40	.04	25	.4	.36	.2	.19	.18	.174	.167	.16
	60	.06	16.6	.6	.55	.3	.286	.27	.26	.25	.24
	75	.075	13.3	.75	.68	.375	.357	.34	.326	.312	.3
	100	.1	10	1	.91	.5	.475	.455	.435	.415	.4
Irons	200	.2	5	2	1.8	1	.95	.91	.87	.835	.8
	300	.3	3.3	3	2.7	1.5	1.44	1.36	1.3	1.25	1.2
	500	.5	2	5	4.5	2.5	2.38	2.27	2.17	2.08	2
Fires	1,000	1	1	10	9.1	5	4.75	4.55	4.35	4.15	4
	2,000	2	.5	20	18.2	10	9.5	9.1	8.7	8.35	8
	3,000	3	.33	30	27.2	15	14.4	13.6	13	12.5	12
Cookers	4,000	4	.25	40	36.4	20	19	18.2	17.4	16.7	16
	5,000	5	.2	50	45.5	25	23.8	22.7	21.7	20.8	20
	6,000	6	.17	60	54.4	30	28.8	27.2	26	25	24
	7,000	7	.14	70	63.7	35	33.25	31.85	30.45	29.05	28

A New Instrument for Testing Electrical Circuits

HOW TO USE THE MEGGER CIRCUIT-TESTING OHMMETER

By D. Winton Thorpe, A.M.I.E.E.

PROGRESS in science or in any industry must, if it is to be permanent, carry with it progress in the design of instruments, equipment and accessories for testing and maintaining the product of that science. A good battery of accumulators is of no use without a good hydrometer with which to make periodic tests. A good lubricating system on a motor car is of no use without a well-designed, easily operated grease-gun.

In electrical work of every description troubles are liable to arise. Nothing is perfect in this world, unfortunately; and reliable as it is, all electrical apparatus is subject to faults. There is no fault in electrical work which is not comparatively easily and quickly remedied *when it is known what that fault is and where that fault lies.* Diagnosis, then, is by far the largest factor in the remedying of faults, and we may call the tracing out of faults where they actually exist a positive diagnosis; while an equally important adjunct to the proper conduct of electrical maintenance is to be found in what I may term negative diagnosis—establishing the fact that there is no fault.

These facts do perhaps emphasise the increasing importance of any apparatus which helps us in our diagnosis of trouble in electrical circuits.

Fig. 1.—The Megger Circuit-testing Ohmmeter in Use.

Note how the instrument is slung round the neck, leaving the hands free for holding the two testing prongs.

A New Circuit Tester.

Testing out circuits by means of a battery and galvanometer has been the practice ever since electricity started to take its place in our daily life. There is nothing new in applying a voltage to a circuit and watching to see if a galvanometer kicks over. But this really tells us very little about a circuit; true, it does

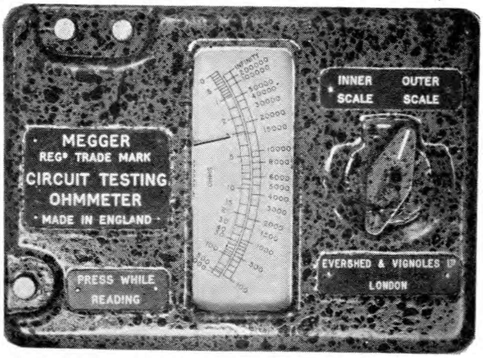


Fig. 2.—THE MEGGER CIRCUIT-TESTING OHMMETER.

tell us whether there is a circuit of sorts, or whether the circuit has been opened by some unexpected break; but, beyond that, we can tell nothing which is of much service to us. The purpose of this article is to discuss a new circuit tester, the "Megger circuit-testing ohmmeter," which has recently made its appearance on the market, and which should prove to the electrician as valuable as the stethoscope is to the doctor.

Does Away with Tedious Calculation.

By means of mathematics and the necessary equipment we can establish practically anything we want about a given circuit. But we have first to apply a known pressure; secondly, to be able to read the current which passes when we apply that pressure; and, thirdly, we have to find the paper, the pencil, the time and the inclination to do a little sum. The instrument in question requires only to be connected to the circuit, when, on the pressure of a button, a direct reading of the resistance of that circuit can be taken from a scale on the instrument. The instrument, fortunately, need not be carried round on a 5-ton lorry, for its weight, to be precise, is 2 lb., and its size that of a small pocket-camera.

How the Pressure is Applied.

The pressure is applied by means of a small $4\frac{1}{2}$-volt flash-lamp battery, and since the instrument has its two coils (pressure and current) wound so as to form a true ohmmeter, any drop in pressure in the battery is compensated for, so that towards the end of the life of the battery, when the voltage starts to drop, the readings still remain accurate, even though the movement of the pointer may become sluggish.

Resistance Readings Up to 200,000 Ohms.

Resistance readings can be taken up to 200,000 ohms—just under a quarter of a megohm—though it is not possible in one instrument to have readings over this complete scale. The same instrument, so far as external appearance, size and weight are concerned, can be fitted with any type of scale to embrace the following ranges:—

1. 0-30 and 0-300.
2. 0-500 and 0-50,000 and infinity.
3. 0-1,000 ohms and 0-200,000 and infinity.

Thus any electrical engineer, knowing what the work is for which, generally speaking, he requires this instrument, can purchase one with the appropriate scale fitted.

The Principle of the Instrument.

Earlier in this article I made reference to the fact that this instrument is based on the principles of the true ohmmeter. What exactly does this mean?

An Essential in Any Instrument Giving Resistance Readings.

If we can apply a given pressure to a circuit, and if we know the exact resistance of that part of the circuit contained in our instrument, we can, by means of an ammeter, establish what current is passing through that circuit and, therefore, what

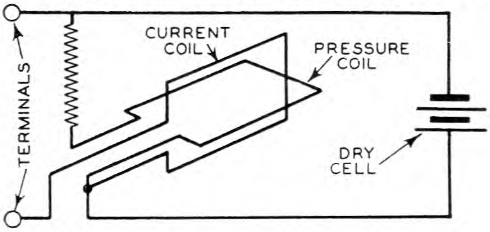
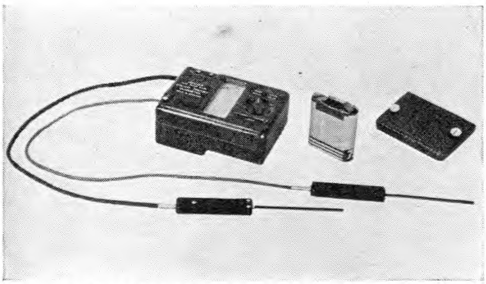


Fig. 3.—THE PRINCIPLE OF THE CIRCUIT-TESTING OHMMETER.

is the resistance of that circuit. It would not be a very difficult matter to arrange that our ammeter instead of reading in amps. should read in terms of ohms. This, however, assumes that the pressure which we apply is exactly known. Any variation in this pressure would immediately give us a false reading on our ammeter, if it were calibrated in terms of resistance. This is a risk which we cannot possibly run if our record of the resistance is to be valuable to us as an exact and precise reading. In the case of the instrument in question, the 4½-volt flash-lamp battery, which provides the source of pressure, can scarcely be relied upon to apply a potential difference across the terminals of 4½ volts exactly from the beginning to the end of its life. Therefore, some compensating principle must be incorporated in the design of the instrument in such a way that a fall in pressure on the part of the dry cells supplying the pressure does not affect the reading on the scale.

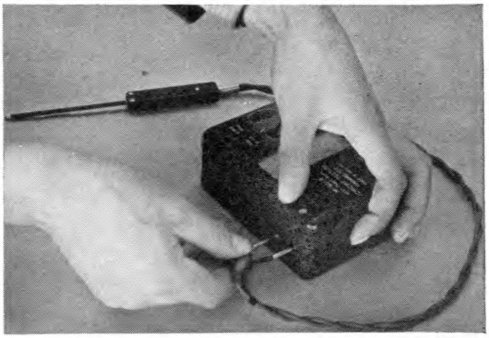
Pressure Coil and Current Coil.

The principle which is applied in the case of the instrument under review consists of two coils known respectively as the pressure coil and the current coil, which are included in circuits connected across the battery in a manner indicated in Fig. 3. The pressure coil, which is in series with a high resistance of fixed value, is connected directly across the battery,



THE CIRCUIT TESTER DISMANTLED.

In the centre is the instrument having the two prongs connected with it; that in the foreground being the switch prong and being connected by a twin flexible with the two normal terminals, while the other is connected to a special terminal under the press button. The battery and the cover can be seen separately on the right.



CONNECTING UP THE TWIN FLEX OF THE SWITCH PRONG TO THE TERMINALS OF THE CIRCUIT TESTER.

so that the current which passes along this circuit is proportional to the voltage of the battery. Between the circuit of which we wish to test the resistance and the battery, the second coil (the current coil, that is) is connected in series, so that the current in this coil is proportional to the pressure generated, and varies inversely with the resistance under test.

What Would Happen if We Try to Test a Circuit Having an Infinite Resistance.

This paragraph becomes a little more lucid if it is read in conjunction with Fig. 3 referred to above. If we were to try to test a circuit having an infinite resistance—in other words, if we were to press the contact button of the instrument without having connected our terminals to any circuit at all, no current would flow between the external terminals, which means that inside our instrument the only flow of current taking place would be through the pressure circuit, and the pressure coil would, therefore, take up a position at right angles to the magnetic flux between the poles of the magnet in the field of which the coil is mounted. At such a position the needle which is attached to the coil will read infinity.

When a Closed Circuit is Connected Across the Terminals.

If now a resistance of some sort, that is to say, a closed circuit with a measurably finite resistance, is connected across the terminals, a current will start to flow

Fig. 6.—Using the Circuit-testing Ohmmeter for Testing the Windings of a Transformer in a Radio Set.

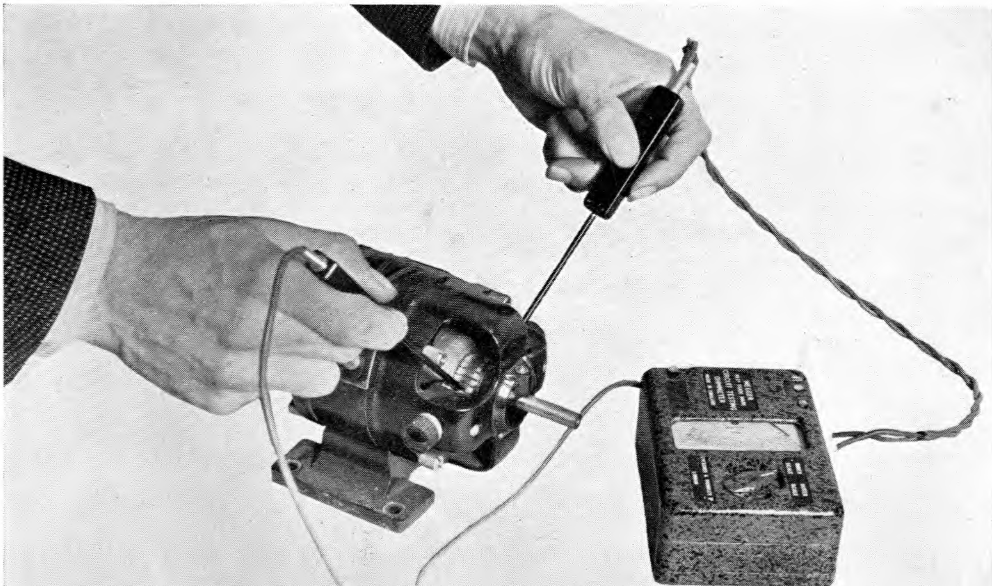


Fig. 7.—Armature Testing.

A test between any two segments of the commutator can be compared with what the resistance of the windings thus brought into circuit should be.

through the current circuit and current coil in addition. This will tend to bring back the pointer from the infinity position which it had taken up when the only influence upon the two coils was that exerted by the pressure coil. In this way the pointer will ultimately come to rest at a position where the forces exerted by the current and pressure coils respectively have reached a state of equilibrium.

This, then, is the principle of the instrument, which is a true ohmmeter; that is to say, that it records the resistance of the circuit under test according to principles which take no account of the actual pressure which is being applied, but only take account of the ratio between the forces exerted by the two coils, the pressure coil and the current coil, since any variation in the actual pressure must affect both the circuits equally and, therefore, both the coils.

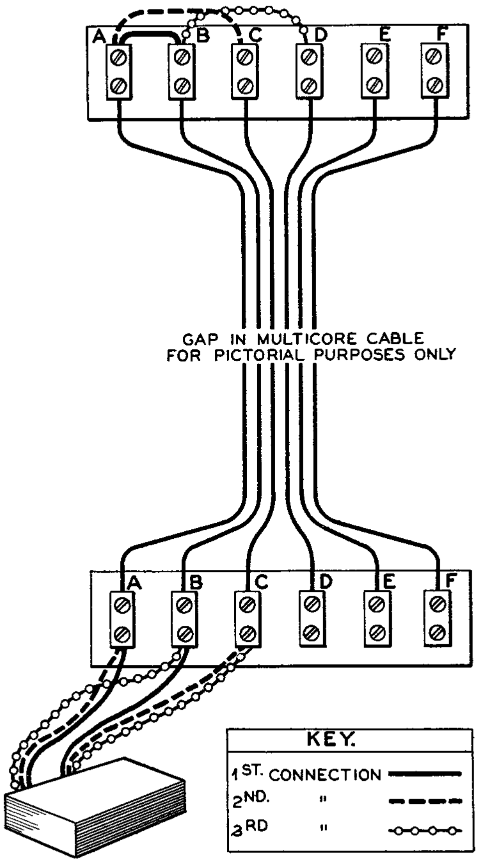


Fig. 8—TESTING OUT THE RESISTANCE OF TELEPHONE CIRCUITS.

Some Practical Uses.

Let us now turn to a consideration of the uses of this instrument.

In the first place, it is reasonable to remember that even in cases where we do not require an exact resistance reading, this instrument will immediately tell us whether we have a closed circuit or not. So, if we only consider it as a more convenient form of the old galvanometer and battery principle of testing, that in itself is something, since the instrument can be carried about as a compact unit, and by making connection to the appropriate terminals will indicate immediately whether there is or is not a conducting path of sorts round the circuit under test.

The Normal Method of Using the Instrument.

The first and what I may term the normal method of using this instrument, is to a certain extent on the lines of the methods of using the Megger insulation tester. That is to say that two terminals at the side of the instrument which are visible in Fig. 2 are respectively connected to two leads. It should be noted that in the case of this instrument the connection is effected by a spring terminal, it being necessary only to depress the button at the top of the terminal which opens an aperture into which the bared end of the lead is inserted; when the pressure is removed from the button the bared end is clipped tight in a metallic contact. Thus, with the instrument having two leads from its two terminals, these are respectively connected to the ends of the circuit.

Now, instead of turning the handle of a generator, as in the case of the Megger insulation and continuity tester, the third button in the other corner of the instrument is depressed. This completes the circuit, and the measurement of the resistance is read directly from scale on

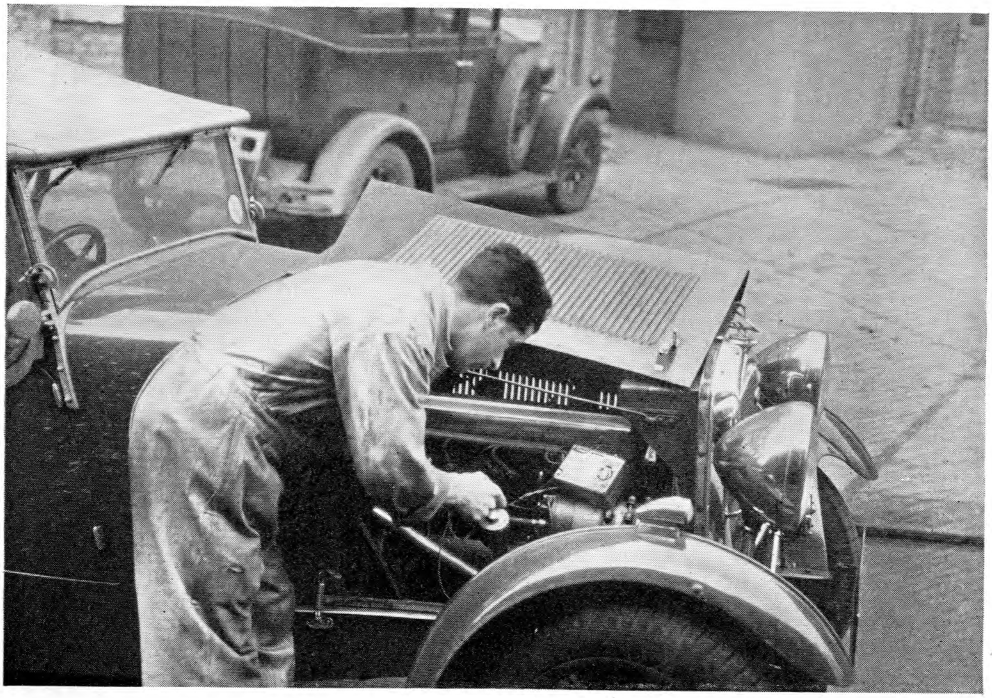


Fig. 9.—Testing the Magneto Windings of a Motor Car.

the top of the instrument. This method of using the instrument has its chief value in the measurement of the resistance of a specific circuit where the resistance perhaps can be altered and where, only one circuit being under test for the moment, an exact resistance is to be achieved. The instrument in this way remains connected to the circuit under test, and as alterations are made to the circuit so the switch button is depressed and the new reading taken until the desired reading is achieved.

Testing Out Domestic Appliances.

In the testing out of domestic appliances, for instance, it may sometimes be convenient to establish what is the actual circuit resistance of the heating element: thus, in the case of a $5\frac{1}{2}$-lb. iron, having a loading of 450 watts, operated on a supply at a pressure of 230 volts, the resistance of this should be 117 ohms, and this can be checked with the instrument in question. Similarly, a 2-pint kettle with a loading of 650 watts, the resistance would be 81 ohms.

Handling the Instrument for Radio and Telephone Work, etc.

Since a great many circuits which should be subjected to tests have small sweated terminals in inaccessible positions, such, for instance, as in the case of a radio set or a telephone junction box, there are provided with this instrument two leads having at their ends long insulated needles with bare metal tips. By connecting these leads on to the appropriate terminals—not, as a matter of fact, the normal terminals used—so as to eliminate the switch contained in the press-button, the needles at the end can be energised with the necessary pressure by the operation of a switch contained in the handle of one of them. The instrument can thus be carried strapped round the operator's neck and hanging like a tray in front of him, leaving his two hands free to hold the insulated needles and insert them in the most inaccessible portions of the anatomy of a complicated electrical device. He can insert them until they are making contact with the respective terminals of the circuit to be tested, and not until he is satisfied that contact is made need he press a switch on one of the handles, and then, glancing down, read from his instrument scale the resistance of the circuit; or, alternatively, whether the circuit is a closed circuit at all.

Testing Out Resistance of Telephone Circuits.

In the case of testing out the resistance of telephone circuits in general and of house telephones in particular, the instrument with the spike connectors will probably be found the most convenient. In order to get the resistance of a telephone line it is necessary to loop the two conductors together at one end of the circuit and then to take the test across the two free ends of this pair of conductors at the other end. The reading thus recorded is a measure of the total resistance of the entire circuit, which, of course, includes the two conductors. Let us assume that conductors A and B in Fig. 8 have been looped together at one end and the test taken across them at the other end fails to produce a reasonably low resistance. Conductors A and B should be disconnected from one another at the far end, and conductor A should be looped, say, with conductor C and another test taken, and subsequently conductor B with conductor C and another test taken. Alternatively, conductor A may be connected to earth and the test taken at the original end between the free end of conductor A and earth, or conductor B may be connected to earth and the test completed in this manner. By either method it is immediately possible to establish on which of the two legs the fault lies.

Armature Testing.

This same instrument with the spikes can conveniently be used for armature testing, as shown in Fig. 7, where a test between any two segments of the commutator can be compared with what the resistance of the windings thus brought into circuit should be.

Fig. 6 shows how the instrument, used in the same manner with the three leads and the two spikes, can conveniently be used to test any individual circuit in a radio set.

Fig. 9 shows yet another use for the instrument, where it is used for testing out the magneto windings of a motor-car.

Testing Resistance of Metallic Sheathing or Conduit.

One rather widely abused section in the Regulations for the Electrical Equipment of Buildings demands that the resistance of the metallic sheathing or conduit of any metal-sheathed wiring installation shall not exceed 2 ohms measured from the most remote part of that sheathing to earth. Here is an immediate and ready means to ascertain whether the resistance of such sheathing does, in fact, come within the provisions of these Regulations or not. Domestic apparatus can be tested to see whether the heating element is showing the correct resistance; motors can be tested; generators can be tested; in fact, there is no piece of electrical apparatus upon which a test of this sort will not provide useful intelligence.

Telephone Work and Weak Current Work.

Most of all, perhaps, its use lies in the direction of telephone work and weak current work in general. It is in this class of work that we have usually a large number of circuits, and circuits operating at low voltages, with the result that the resistance of each circuit is far more important than the exact resistance of a circuit operating under the influence of a higher voltage. Although a good contact in a terminal is a maxim of all good wiring work, such contact is clearly of much greater importance in a circuit operating at 4 volts than in one operating at 230 volts. An inefficient or ineffective contact of any sort on a circuit which should have complete and unblemished continuity is immediately shown up by a reasonably increased resistance as shown on this instrument.

I am indebted to Messrs. Evershed and Vignoles, Ltd., for lending me the illustrations for this article and providing me with facts about the instrument.

HINTS AND TIPS FOR THE PRACTICAL MAN

Readers are invited to send brief paragraphs for inclusion in this section. All contributions will be paid for at our usual rates

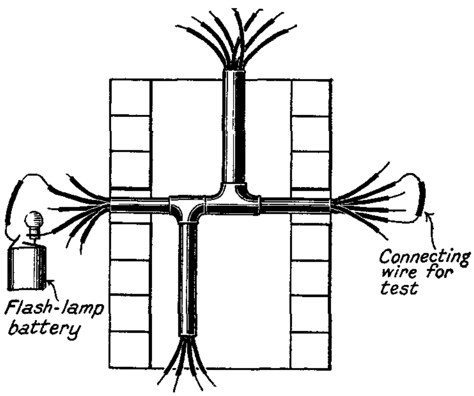
FILLING HOLES IN EBONITE PANELS.

Holes which are not required in ebonite panels should first be plugged with pieces of soft wood, such as deal, cut about $\frac{1}{16}$-in. shorter in length than the thickness of the panel. Drive the plug into the hole so as to leave it $\frac{1}{32}$-in. below the surface at each end. Then level up with melted Chatterton's compound, or pitch; smooth off with a heated knife blade.

AN IMPROVISED CIRCUIT FINDER.

A flash lamp should form a part of every electrician's equipment. Not only is it needed for use in dark corners etc., where meters and fuse boxes generally are, but it also forms a useful circuit finder, when wiring two or three two-way switches on to one block.

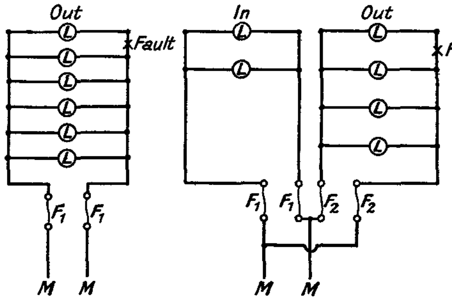
Hold one end of wire on the threaded part of the lamp and the other end on one of the battery terminals; then by placing the centre contact of the bulb on



the other battery contact, it is easy to find out which is which. Don't forget, of course, to make sure the main switch is turned off.

A FUSE HINT.

The practice of running all the current required for a house through one set of fuses may be cheap, but it is not at all practical. The best plan is to place one or two of the lights nearest the fuse box on one set of fuses, so that in the event of a fault developing somewhere, there is at least a light on until the fault is found and remedied. With all the load



on one fuse, any fault cuts everything off until the fault is found, and the fuse replaced. It also pays wherever possible to keep all the plugs or points for appliances with flexible leads on circuits to themselves, as most blow-outs are caused by these.

NICKEL PLATE ADHESION.

The imperviousness and adhesion of nickel plate depends to a predominating extent upon the mode and thoroughness of the preparatory cleansing.

The following process has proved beyond doubt its effectiveness in ensuring a trouble-free finish, and is productive of very satisfactory results with steels.

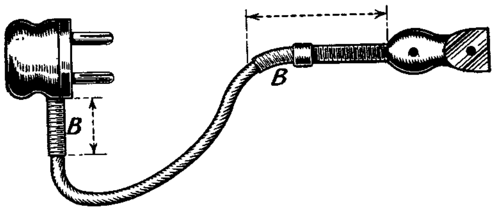
1. Five minutes' immersion of the article as cathode in boiling caustic soda. 4-5 ozs. of soda per gallon of water, and 20-30 amps. per square foot of the article's surface.

2. Rinse in cold water to remove adherent alkali.

3. Two minutes immersion as anode in sulphuric acid at room temperature.
4. Rinse in clean hot water to remove acid and crystalline products adhering to the surface.
5. Pickle in hot weak solution of a hydrochloric acid.
6. Rinse quickly in clean hot water to remove all traces of acid, and transfer mmediately into the plating bath.

WIRING UP ELECTRIC IRONS, CLOCKS, ETC.

When wiring up irons, clocks, kettles, etc., to plugs it is a good plan to use a length of dress cord, such as used on ladies' cycles, to bind the end of the flex where this enters the plug, as shown in



the sketch. This binding increases the life of the flexible enormously, and gives a neater finish.

VASELINE FOR FUSES.

It is a good idea to keep a tin of vaseline handy in the tool bag. A trace of vaseline smeared on fuse contacts makes them far easier to withdraw and replace, and also prevents that green deposit which appears in damp places. Vaseline is also useful for power switches, saving wear on the switch blades.

USING THE ELECTRIC MAINS AS AN AERIAL.

Users of wireless receivers in houses having electric lighting may utilise the lighting circuit as an aerial in a very simple manner.

It is only necessary to connect the aerial terminal of the receiver to one terminal of a fixed condenser of small capacity, namely, from .0003 to .0005 mfd. The other terminal of this fixed condenser should be connected to one of the two lighting leads. In this connection it will generally be found that one of the mains wires gives practically no hum (when A.C. is used), whereas the other wire gives appreciable hum.

The Fixed Condenser.

The fixed condenser should be of the best mica insulation type and it is advisable —but not essential—to fit a fuse between the aerial terminal of the set and the fixed condenser. If for any reason the two sets of tin foil plate of the condenser short-circuited this fuse would protect the coils of the receiver against the effects of the mains current.

Shielded Cables.

It is also an advantage with A.C. sources of mains supply to employ shielded cables for the connection between the aerial terminal and the fixed condenser; the shielding should be earthed.

Although a mains aerial does not give the same results as an outdoor aerial it is an excellent substitute in cases where the latter cannot conveniently be fitted.

MERCURY CUP SWITCHES.

It is generally accepted that in cases where switches must have a constant resistance to their action—as in precision work—the mercury contact type is definitely superior to the others. A well amalgamated copper prong dipping into a cup containing clean mercury gives a fixed and low value for the contact resistance.

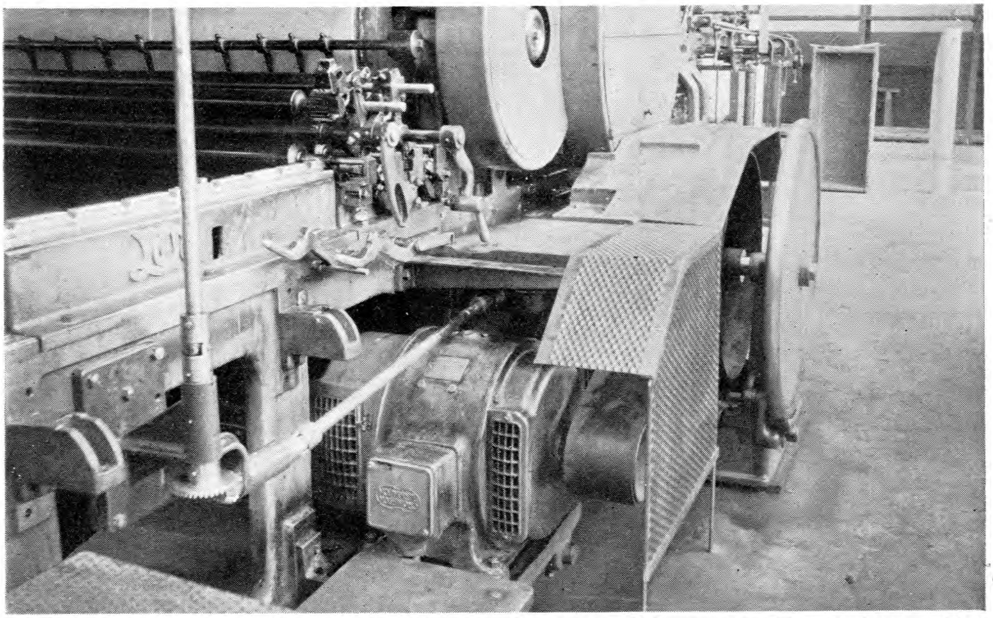
One drawback of this type of switch, however, is that in the course of time the surface of the mercury deteriorates and a film of impurity is formed. This film tends to alter the contact resistance and the switch therefore loses its main advantage over the other types. In practice it is not always convenient to remove and clean the mercury by the usual suction method.

A Good Method of Cleaning the Mercury.

A good method of cleaning the mercury is to employ a piece of filter paper that has been dipped into water. If this moistened paper is moved over the surface of the mercury it will be found that the impurities, owing to some form of capillary attraction, cling to the paper and can therefore be removed with it.

A few applications, using strips of wetted filter paper will generally be found to be sufficient for cleaning the whole of the surface.

INSTALLATION AND OPERATION OF ELECTRIC MOTORS



A D.C. MOTOR DRIVING A MACHINE IN A TOBACCO FACTORY. (*Messrs. Crompton Parkinson, Ltd.*)

NOTES ON D.C. MOTORS.

ALTHOUGH the changeover to standard A.C. 50-cycle supply has greatly increased the use of A.C. motors, there are still districts where D.C. is likely to be used for the next few years, and where, therefore, D.C. motors are required. Also there are many applications for which D.C. is essential.

The installation and operation of A.C. motors was described in a previous article, and in the present article we deal with D.C. motors, as the information will, no doubt, be useful to works and maintenance engineers.

As with A.C. motors, once D.C. machines have been properly installed, their operation requires little skill.

Installation of Motor.

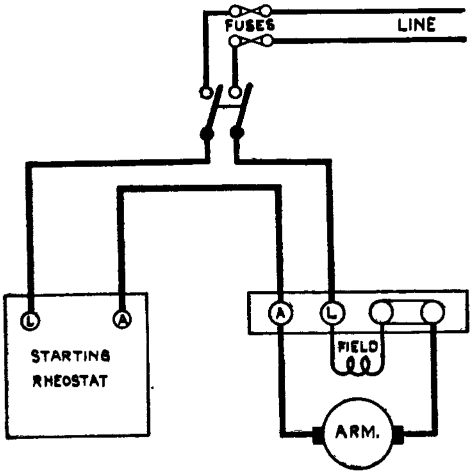
Machines may be obtained for horizontal use, and suitable for mounting on the floor, wall or ceiling with pulley or gear drive, or direct coupling. The motor should be mounted on a rigid foundation and correctly aligned to its drive. For direct coupled and geared drives, horizontal machines are generally supplied with shims in order that the height of the centres may be minutely adjusted.

Belt Drive.

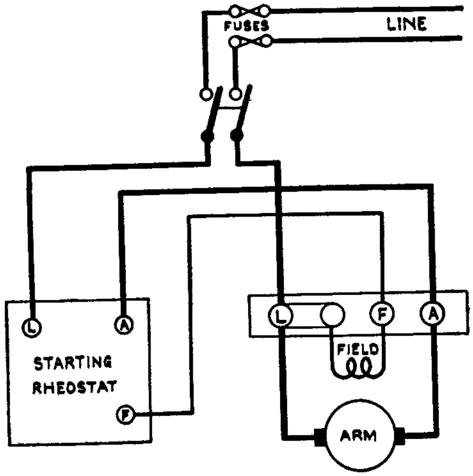
Where a belt drive is used, slide rails should be employed for belt adjustment. Where slide rails are required to suspend a motor from the wall or ceiling, the manufacturer should be informed at the time of ordering, so that suitable rails can be provided.

With open belts the distance between the pulley centres should not be less than $3\frac{1}{2}$ times the diameter of the larger pulley; the speed ratio should not exceed 5 : 1.

If possible, the tight side of the belt should be arranged to come on the underside of the pulley. Take care not to put excessive tension on the belt.



Wiring Diagram for a Series-wound Motor and Starting Rheostat.



Wiring Diagram for a Shunt-wound Motor and Starting Rheostat.

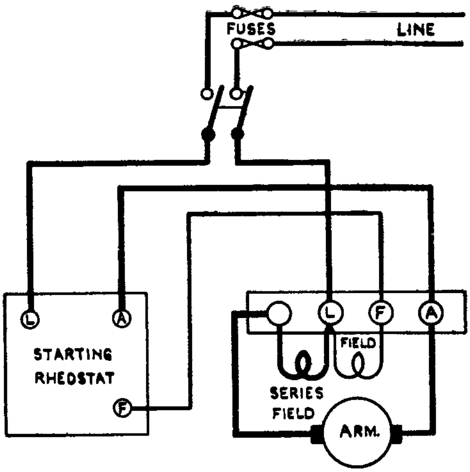
Three examples of D.C. motor drives are shown in the accompanying photograph.

Wiring.

It is usual for the manufacturer to supply a wiring diagram with each machine and the directions given on this should be carefully followed. Wiring diagrams are given for series-, shunt- and compound-wound motors, and show the general arrangement.

Direction of Rotation.

The direction of rotation must be checked before a motor is put into service, because if a motor runs in the opposite direction to that required, and it is connected to whatever equipment it is to drive, there may be disastrous results. Unless specified otherwise, motors are usually supplied for anti-clockwise rotation. An arrow is generally painted on the machine at the commutator end to indicate the direction of rotation.



Wiring Diagram for a Compound-wound Motor and Starting Rheostat.

Starting Up a Motor for the First Time.

A motor which is being started for the first time should be slowly rotated by hand a few times to make sure that the armature is quite free and does not bind. All dirt and foreign matter must be removed, particular attention being paid to the commutator and brushes. The motor must be properly lined up with the machine it is driving, and if a belt is used, see that it runs in the middle of the pulley.

The connections of the motor and starting rheostat should be carefully checked by the diagram.

The bearing oil reservoirs should be filled with high-grade oil, so that there is no danger of the bearings becoming overheated.

Take care that the brushes are making proper contact with the commutator, and that they exert the correct amount of surface pressure.

Starting a Shunt-wound Motor.

When starting a shunt-wound motor for the first time, make sure that the starting rheostat handle is in the "off" position; then, after removing the belt, close the circuit-breaker, afterwards closing the main switch. Before current is passed through its armature, the motor should have a strong field, or acceleration, and consequently the building up of the counter E.M.F. will be delayed on account of the low torque, and the armature winding may be injured by the prolonged starting current. With all but very small motors it is usual to take further precautions against an injurious armature current by connecting a starting rheostat in series with the armature and the supply.

Now Move Rheostat Handle to the First Contact.

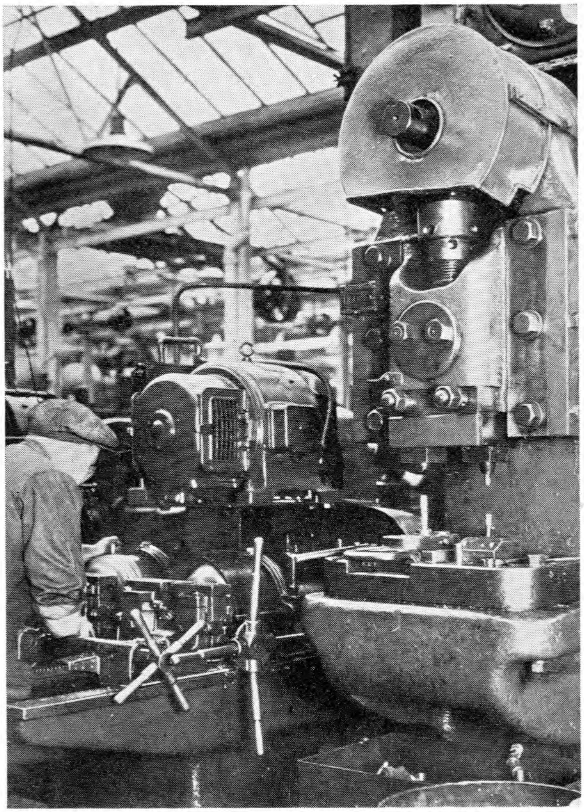
The motor should now be started by moving the rheostat handle to the first contact, and after holding it there for a moment, move it slowly to each successive contact, thus cutting out all resistance. Before moving from one contact to the next, time should be allowed for the motor to build up its speed. In order to make sure that the motor is running properly it should be allowed to run unloaded for a time. If it does not run satisfactorily, open the main switch, thus cutting off the current; do not allow the machine to run without locating the trouble and rectifying it.

When the motor has attained full speed, make sure that the bearings are being lubricated properly, and that no part is becoming overheated.

Take care that the shunt-field circuit of a self-excited or separately excited motor is not opened during operation. If it is, and the machine is lightly loaded, it will tend to "race"; if it is heavily loaded, it will tend to flash over. There is danger of the field coils being punctured if the shunt-field circuit is opened when carrying current and the motor is not operating. Therefore, the field circuit should be broken slowly, if it is necessary to break it.

Starting a Series-wound Motor for the First Time.

In order to prevent too great a rush of current in starting, a starting rheostat must be connected in series between the supply circuit and the motor. Unlike a shunt-wound motor, a series-wound machine operating on a constant potential circuit has a varying field strength and does not run at constant speed. When starting and operating a series-wound motor, the motor should have a fairly heavy load, because if the load were removed the speed of the motor may become so high as to extensively damage the armature.



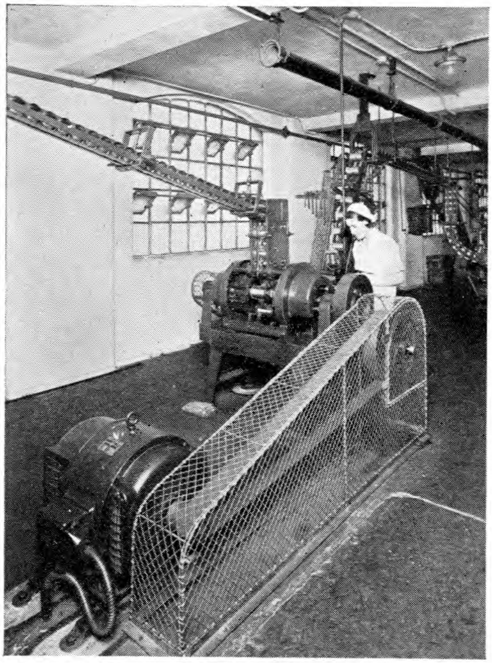
A D.C. MOTOR APPLIED TO A MACHINE TOOL DRIVE AT THE FORD MOTOR WORKS. (*Messrs. Crompton Parkinson, Ltd.*)

Shutting Down the Motor.

The circuit-breaker or main switch should be opened, and the motor allowed to slow down without any assistance. A motor should never be stopped by releasing the lever of the starting rheostat, as by doing this there is danger of burning the rheostat contacts and puncturing the field and armature coil insulation.

The Motor Running with Load.

When the motor has been allowed to run light for a time, and it appears to be operating satisfactorily, it may then be connected to its load. The motor should be started as before, and carefully watched, so that the main switch can be immediately opened if anything appears to be wrong.



A D.C. Motor Driving Can-making Plant in Messrs. Crosse and Blackwell's Pea Canning Factory. (*Messrs. Crompton Parkinson, Ltd.*)

Connect an Ammeter in the Circuit when Load is First Applied.

In order to ascertain that a machine is not overloaded, an ammeter should be connected in the circuit when load is first applied. A motor must never be loaded beyond the rating stamped on its name-plate, or trouble is likely to be encountered.

Inspect Frequently for Loose Connections, Hot Bearings, etc.

During its early days of operation a motor should be inspected frequently for loose connections, hot bearings, etc. The machine must be kept free from water, dust and dirt, and every effort must be made to ensure cleanliness. The bearings should be kept properly lubricated; care must be taken to guard against leakage of oil, and to see that oil does not enter the windings. If any sparking should take place, try wiping the commutator, while rotating, with canvas covered slightly with vaseline.

Such troubles as overheating, sparking, noise and abnormal speed are liable to be encountered with D.C. machines, and it is hoped in a future issue to deal with the location and remedy of these and other faults.

PRACTICAL NOTES ON THE INSTALLATION OF D.C. or A.C. MOTORS.

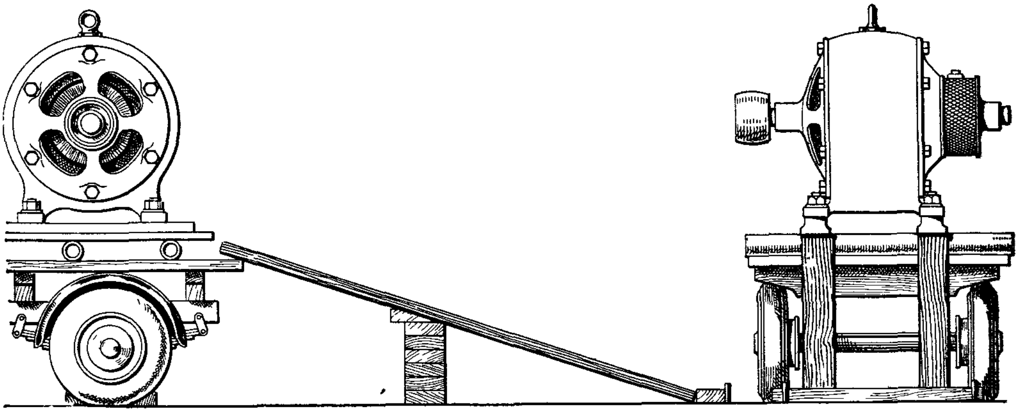
The installing of electric motors requires one to have the ability to handle and fix them safely in their running positions, in addition to the skill and knowledge required to fix and connect the wiring and switchgear to them.

Often a heavy motor has to be fixed in a position where it is impossible to use the ordinary lifting tackle to put it there, or where the foundation which is provided is not good enough to prevent vibration and possible damage to the structure of the building. The motor may have to be taken to pieces in order to get it in the running position owing to its heavy weight and difficult route from the place of unloading, afterwards being assembled again in the running position.

This will call for the ability to remove pulleys, pinions, endplates, armatures, etc., in the safest and speediest manner, without doing damage to the various parts.

Unloading a Heavy Motor from a Lorry.

Make an inclined track from the back of the lorry to the floor with two or more

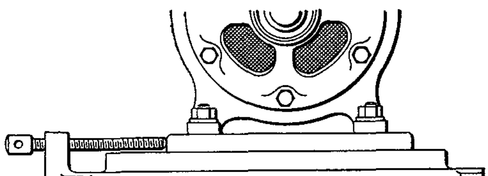


UNLOADING A HEAVY MOTOR FROM A LORRY.
The slide rails are lifted and rollers placed under them, the motor is pushed slowly towards the " deals " and the back roller taken out. The motor is tilted gently until the slide rails rest on the surface of the " deals." Additional wooden packings are placed under the " deals " midway along the track if the motor is very heavy.

9 in. × 4 in. " deals " ; the angle of their inclination to the floor must not exceed 30°, and their ends which rest on the floor should be " scotched " to prevent slipping, also the wheels of the lorry should be similarly " scotched." The projection of the upper edges of the " deals," which rest on the end of the lorry, above the surface of the lorry is measured, and three iron rollers, whose diameters are equal to this projection, are obtained. If the projection is excessive, then wooden packings will have to be placed under the slide rails, so that when the rollers are placed under the rails, the machine can be rolled on to the "deals."

Placing the Rollers Under the Slide Rails.

The ends of the slide rails at the back end of the lorry are lifted with a suitable steel bar, using the bar as lever, with a piece of hard wood for a fulcrum or "heel." Place one of the rollers under the ends of the rails, keeping the fingers clear in the event of the bar slipping; the roller should be at right angles to the inclined track of the " deals." Another lift is made, and the roller is pushed farther under the rails until it is approximately below the centre of the motor, when with a pressure exerted on the end of the motor at the front end of the lorry, another roller may be placed under the end of the rails to occupy the same position as the first roller before it was pushed under the centre of the motor.



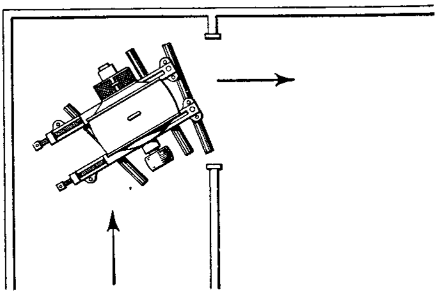
THE MOTOR IS TAKEN TO ITS RUNNING POSITION BY PLACING ROLLERS UNDER THE SLIDE RAILS.
The front roller is placed in position immediately before the back roller is free.

Rolling the Motor on to the " Deals."

Push the motor forward until the edges of the slide rails overlap the ends of the deals. The centre roller will now have moved towards the ends of the rails, and should be taken away. The motor is now on one roller which will have moved under the rails towards the centre of the motor. The motor is again pushed forward, and the end which is towards the " deals " is tilted gently downwards until finally the whole of the rails rest on the surface of the inclined track.

Sliding the Motor to the Ground.

Ease the lower ends of the slide rails by gently lifting them with the bar and at the same time push the motor



The Direction of Travel is Changed by Altering the Inclination or "Cutting" the Front Roller.

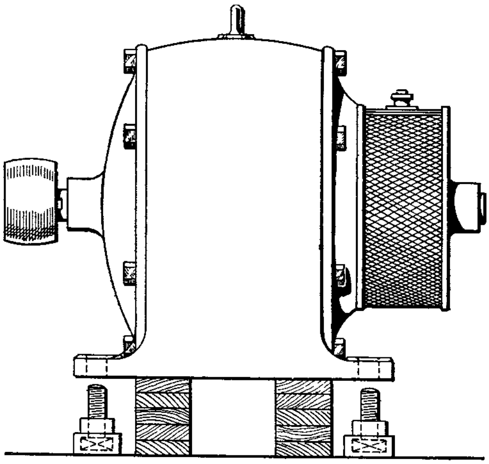
forward carefully. As the rails near the ground, remove the "scotch" from the "deals" and place a roller in position to receive the rails as they come forward, easing them as the motor nears the ground. A second roller is placed in front of the rails and the motor again pushed forward until both rollers are under the rails and the slide rails completely clear of the "deals."

Moving the Motor to the Running Position.

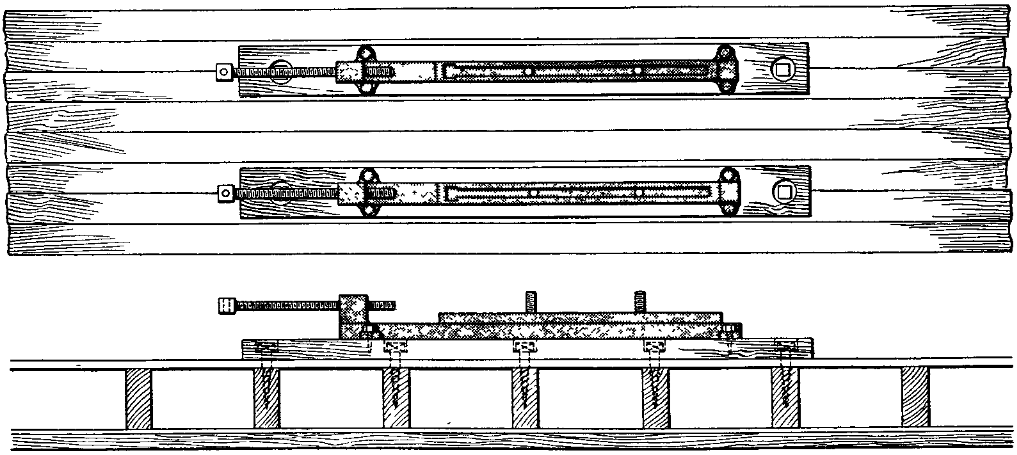
Push the machine forward and as the back roller is on the point of leaving the slide rails, place another roller in the front of the rails. This procedure should be repeated when the back roller is again on the point of leaving the rails. The direction of travel may be altered by placing the front roller at right angles to the new direction which is desired. In the case of a right angle turn, the change in direction of travel should be carried out in about three stages, that is, by successively changing the inclination of the front roller until the direction of travel desired is obtained.

Taking the Motor off the Slide Rails.

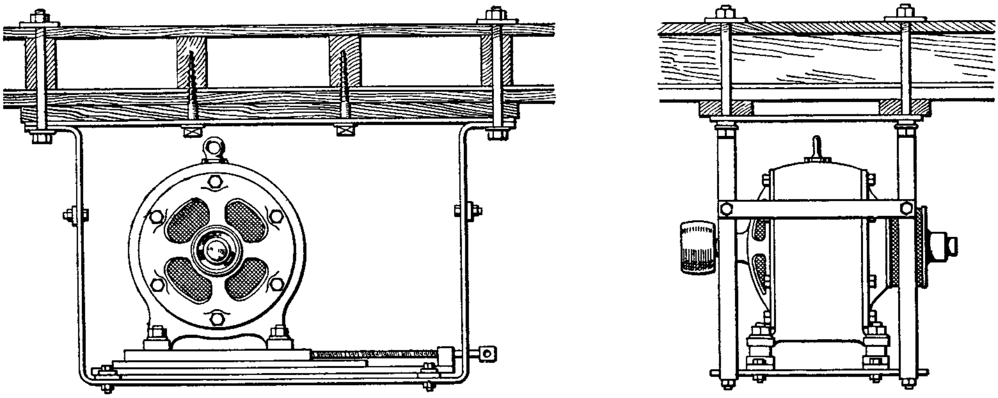
This may be necessary in order to drill



The Motor is Lifted from the Slide Rails and Packed Up Above the Ends of the Bolts, when the Slide Rails are to be Fixed on the Foundation.



A Wooden Floor Foundation is Strengthened and Vibration is Reduced with "Deals" which are Secured to the Floor by Coach Screws Screwed into the Joists. The slide rails are fixed to the "deals."



A MOTOR MAY BE SUSPENDED FROM A CEILING WITH WI OR MILD STEEL HANGERS WHICH ARE BOLTED TO THE JOISTS.
The hangers are stiffened by cross stays.

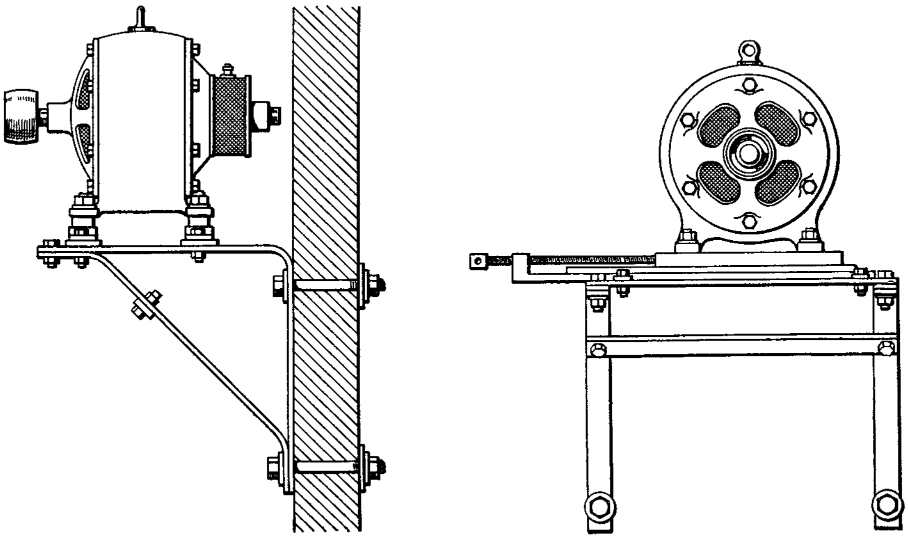
the holes for the foundation bolt holes after the motor has been lined up.

Unscrew the nuts (from the bolts) which hold the motor to the slide rails.

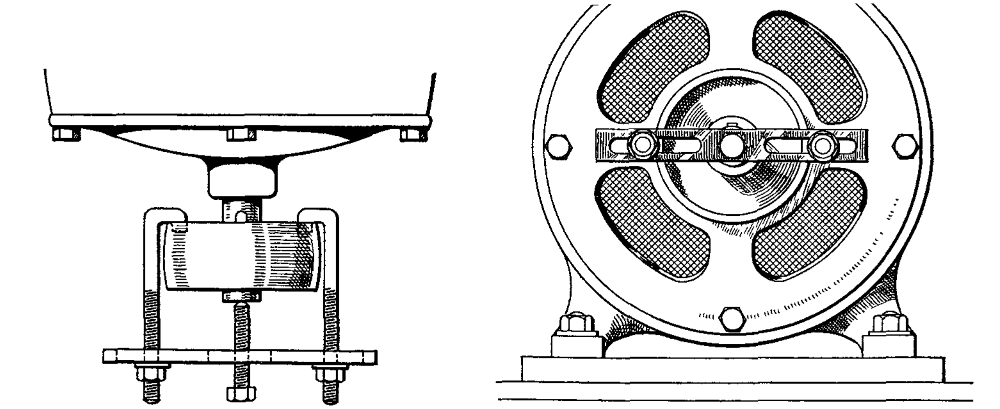
Lift up one side of the motor with the steel bar and place a wooden packing between the bars of the motor and the surface of the floor; repeat this operation with the other side of the motor. The motor must be raised in stages as described adding the wooden packings until the base of the motor is completely clear of the slide rail bolts. The packings should be sound pieces of wood, having perfectly flat surfaces.

Preventing Vibration and Strengthening a Floor Foundation.

When a heavy motor has to be fixed on a floor which is supported by wooden joists it is often necessary to fix the slide rails on 9 in. × 3 in. "deals," which are secured to the surface of the floor. The deals are drilled and recessed, at intervals along their length, with holes to accommodate the stems and heads of 8-in. long



THE MOTOR IS FIXED ON THE WALL BRACKET, WHICH IS BOLTED TO THE WALL.
The bracket is stiffened with a stay.



A Pulley which is Difficult to Remove may be Drawn Off with "Drawing Irons."
The pulley should be tapped as the nuts on the drawing iron stems are screwed up. Place a piece of wood on the edge of the pulley when tapping it with the hammer.

coach screws. The centres of these holes will be equal to the distance between the centres of adjacent joists. Each joist above which the deals will lie, is drilled for a depth of about 3 in. with a hole large enough to allow the coach screw to get a good hold when it is screwed into the joist.

Suspending a Motor from a Ceiling.

When floor space is limited, and the motor is not too heavy, it may be suspended from the ceiling by hangers made of suitable bar iron. Two 9 in. × 3 in. "deals" are secured to the joists with 8-in. long coach screws at intervals. The ends of the "deals" are secured to the joists with bolts which pass through the joists into the floor above. Each bolt is provided with an iron plate about 6 in. square which is drilled and fitted between the surface of the floor and the nut. The hangers, and a bar of iron which is secured to the lower face of each deal with the coach screws, are fixed to the "deals" with the bolts. The hangers are stiffened with cross bars made of flat iron.

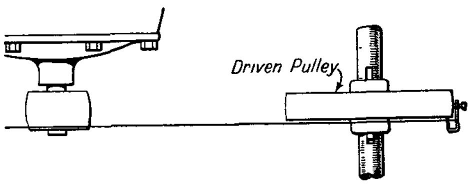
Fixing a Motor to the Side of a Wall.

A wall bracket is made from suitable angle or bar iron, and strengthened with a stay on each leg. The wall is drilled through in two places for 1 in. bolts, and the bracket is secured to the wall with these bolts which are fitted with wall plates about 6 in. long and 3 in. wide. The wall plates are placed between the outer surface of the wall and the nuts. The bearing surface of the bracket is fitted with cross bars to which the slide rails are bolted.

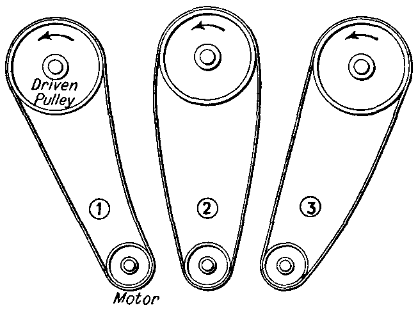
Drawing a Pulley off a Motor Armature Shaft.

Occasionally, when a pulley is very tight on the shaft, it cannot be forced off with a bar, which is placed between the endplate and the boss of the pulley, then it has to be drawn off with "drawing irons."

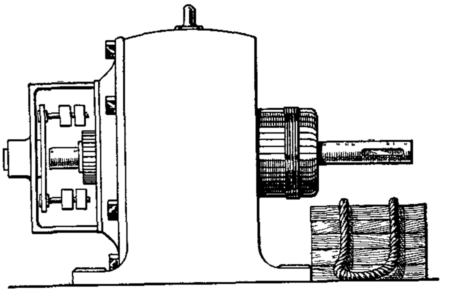
The set screw which holds the pulley to the shaft is removed, and a little paraffin oil is poured into the screw hole. The oil will soften any rust which may be on the shaft and materially assist the operation of drawing off the pulley. The irons are fitted on the pulley, and the nuts on the iron stems are gradually tightened; tap the pulley during the tightening process. Should the pulley show no signs of moving, heat round the boss of the pulley with a blow lamp which will cause the hole in the pulley to expand a little before



Lining Up a Pulley.
One end of the line is clamped to the outer edge of the driven pulley, and the line stretched taut across the edge of the motor pulley. The slide rails are turned until the edge of the motor pulley is parallel to the line.

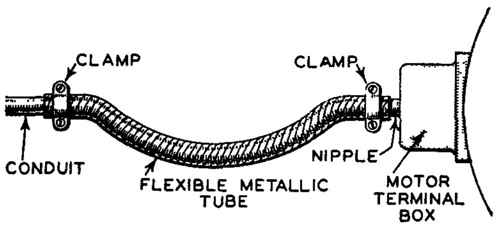


CORRECT AND INCORRECT POSITIONS FOR MOTOR
(1) The correct position of the motor relative to that of the driven pulley to obtain a good drive. (2) A tight belt is required for this drive, and there is an excessive loss of power and possibility of hot bearing. This position should be avoided. (3) The motor position is wrong; this belt will slip and speed of the driven pulley will be reduced when load is increased.



TAKING ARMATURE OUT OF MOTOR CASE.
Flat surfaced wooden packings are built up by the side of the motor case to the required height and a rope sling is placed across the packings. The armature is carefully withdrawn from the case, easing the weight by lifting at the commutator end of the shaft.

the shaft gets hot. This treatment, together with tapping the pulley and tightening the stem nuts, will generally draw the pulley off the shaft. If the key is tapered, a wedge will have to be driven in between the head of the key



MAINTAINING THE ELECTRICAL CONTINUITY OF CONDUIT TO THE TERMINAL BOX OF A MOTOR WHICH IS FIXED ON SLIDE RAILS.
The terminal box is drilled and a conduit nipple fitted to the hole. The end of the conduit is connected to the nipple with flexible metallic tube, the tube being clamped at each of the ends.

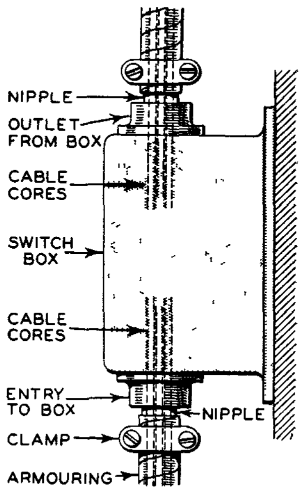
and the boss of the pulley before the drawing operation is commenced.

Lining Up a Motor Pulley.

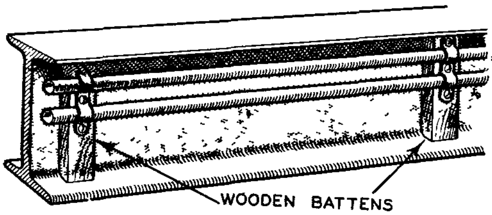
This should be done before the slide rails are bolted to the foundation. One end of a line is clamped to the outer edge of the driven pulley; the line is then stretched so as to pass across the outer edge of the pulley flange or rim. The slide rails are then moved until the rim of the pulley is parallel to the line; allowance should be made for any difference in width between driven pulley and the motor pulley. The crown of the former pulley should be exactly in line with the latter pulley.

Arranging the Slack Side of a Belt to be Uppermost.

Efficient driving of a pulley with a belt and prevention of slipping may only be obtained by having the slack side of the belt uppermost. The direction of rotation of the driven pulley must be known and then the position of the motor, as indicated in the diagram, can be fixed.



MAINTAINING THE ELECTRICAL CONTINUITY OF AN ARMOURED CABLE AT A SWITCH BOX CONNECTION
A nipple is fitted at the inlet and outlet to the box and the armouring of the cable at each place is clamped to the nipple.

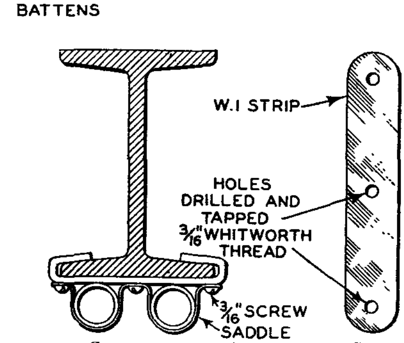


SECURING A RUN OF CONDUIT OR ARMOURED CABLE TO AN H-SECTION IRON GIRDER.
Wooden battens are wedged between the flanges of the girder at intervals along its length, and the conduit or armoured cable is secured to the battens with saddles.

The motor pulley should never be directly underneath or above the driven pulley. Driving in such a case could only be obtained by having a very tight belt and this would probably cause hot bearings and an excessive loss of power.

The Motor Should be Perfectly Level.

The surface of the slide rails to which the motor is bolted must be tested in both directions with a spirit level which is placed on the machined surfaces. Thin steel wedges are driven under the slide rails to obtain correct levelling before the foundation bolts are finally tightened up.

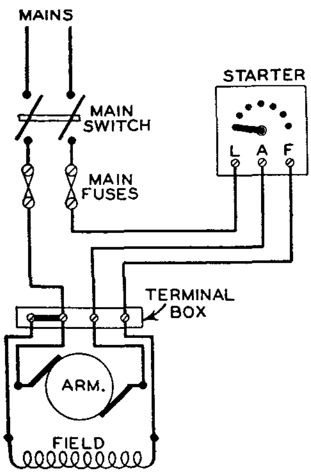


WHEN THE CONDUIT OR ARMOURED CABLE IS RUN ON THE UNDER SURFACE OF THE GIRDER, A NUMBER OF $\frac{1}{8}$ IN. WI STRAPS 1 IN. WIDE AND OF SUITABLE LENGTH ARE DRILLED AND TAPPED.
These straps are placed in position at intervals along the girder and the ends bent over the flanges. The conduit or cable is secured to the straps with round-head short $\frac{3}{16}$ in. screws, which hold the saddles to the straps.

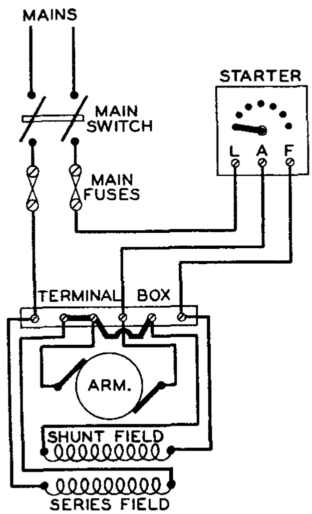
Taking the Armature Out of the Motor Case.

Run the oil from the bearings and remove the pulley, lift the key from the keyway in the motor shaft and specially mark one end of the upper surface, so that it may be replaced correctly. Take the brushes out of the holders. The set screws which hold the endplate to the

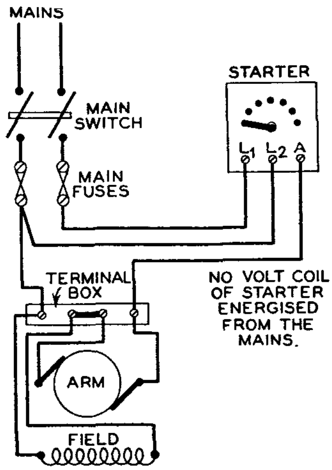
STANDARD CONNECTIONS FOR D.C. MOTORS.



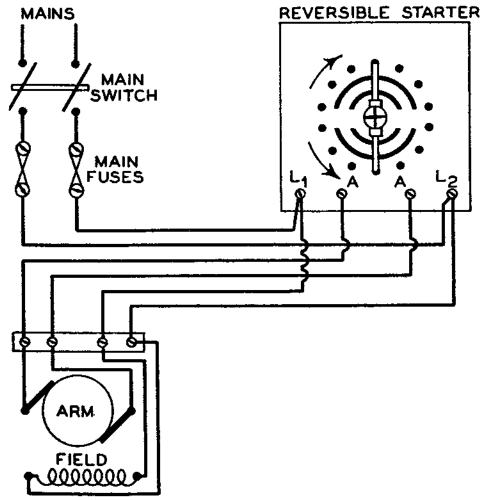
D.C. SHUNT MOTOR.
Reverse direction of motor by changing over the wires from the shunt field at the terminal box.



D.C. COMPOUND MOTOR.
Reverse direction of motor by changing over the brush leads at the terminal box of the motor.

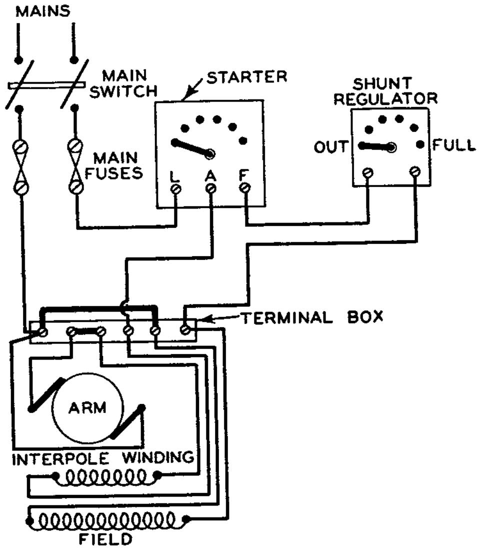


D.C. SERIES MOTOR.
Reverse direction of motor by changing either the brush leads or the wires from the series field at the terminal box of motor.



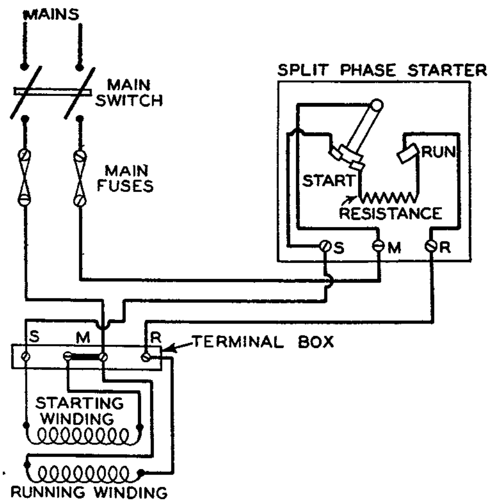
CONNECTIONS FOR D.C. REVERSIBLE SHUNT MOTOR.

The direction of the armature current is reversed by moving the starter arm in the reverse direction.



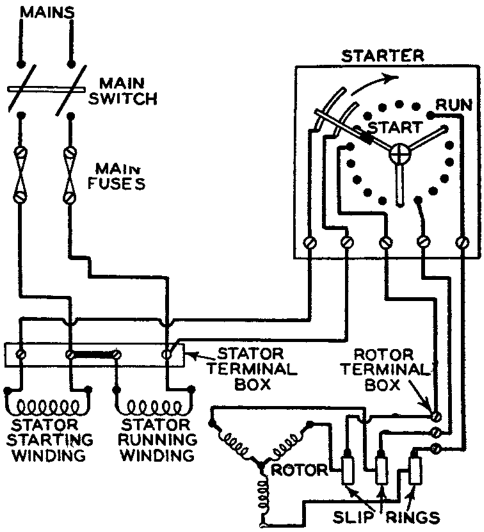
CONNECTIONS FOR D.C. INTERPOLE SHUNT VARIABLE SPEED MOTOR.

The motor should not be started unless the regulator resistance is all cut out.



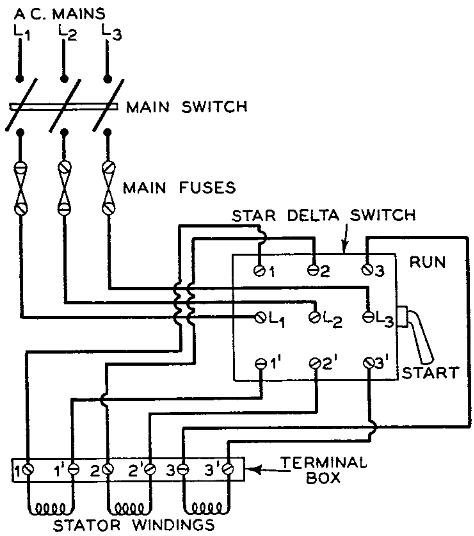
SINGLE-PHASE A.C. MOTOR CONNECTIONS.

The motor is started as a two-phase motor by introducing a starting winding in the circuit. When the motor has run up to speed this winding is cut out of circuit by changing the starter arm from the "start" to the running position. Reverse the direction of motor by changing over either wires from starting or running winding at the terminal box.

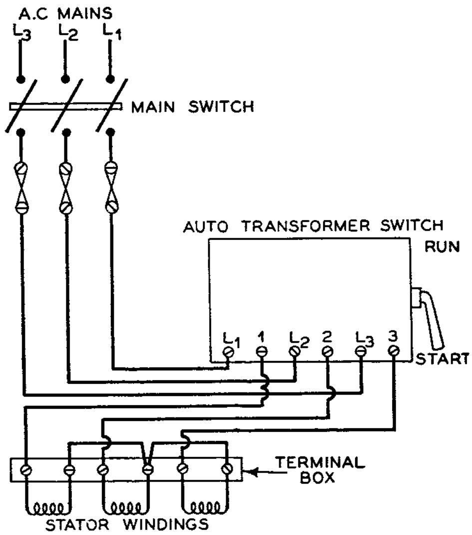


HEYLAND SINGLE-PHASE A.C. MOTOR CONNECTIONS.

On starting the motor the starting and running stator windings are connected in parallel, whilst a resistance is introduced into the rotor circuit. When the motor is run up to speed, the starting winding is cut out of circuit, and the resistance cut out of the rotor circuit.



A.C. Three-phase Squirrel Cage Motor Connections with Star Delta Starter. When the motor is started the star delta switch connects the stator winding in star form, and when the motor is run up to speed the handle of the switch is thrown over to the "run" position, causing the windings to be connected in mesh or delta form.



A.C. Three-phase Squirrel Cage Motor Connections with Auto-transformer Starter. When the motor is started the auto-transformer switch connects the stator windings across the transformer tappings, and when the motor is run up to speed, the handle of the switch is thrown over into the "run" position, causing the stator windings to be connected directly across the mains, and cutting the transformer out of circuit.

The direction of rotation of the motor may be reversed by changing over the leads of any one winding at the terminal box.

motor case at the pulley end of the motor are unscrewed and taken out, and a sharp pull is given to the end of the motor shaft. This will move the endplate from its seating and the plate may then be drawn off the shaft. Give the endplate a rotary motion whilst taking it off the shaft, which has been previously cleaned and smeared with a coating of clean oil.

Build up some wooden packings at the side of the motor case to the height of the lowest part of the armature coil, and if the armature be heavier than can be lifted by one man, lay a rope sling across the packings. The armature is now slowly drawn out of the case so that the core will rest on the sling. When carrying out this operation, the weight may be eased by lifting up at the commutator end of the shaft as it is drawn from the bearing.

The armature is then balanced on the sling, which is securely fixed round the armature core, and the armature removed to a suitable cradle until it is required.

System of Wiring to the Motors and Switchgear.

Generally the system of wiring which should be employed must be fireproof, and mechanically strong. Conduit systems and armoured cable systems comply with these conditions, and in each case the system may be made watertight and gastight by using suitable fittings.

Under certain conditions a lead-covered wiring system or C.T.S. cable system may be used with advantage, for example, where the atmosphere is liable to be charged with acid or alkali fumes, or where the changes of temperature may be varied considerably. Under the latter condition there would be internal condensation produced in a conduit system which was not gastight, and consequently the insulation resistance of the cables may be lowered beyond a safe limit.

Should a lead-covered wiring or C.T.S. cable system be installed, means should be taken to afford additional mechanical protection to the system where it may be liable to damage, and also to give adequate protection against a fire starting in the event of a short circuit occurring on the system.

Determining the Size of the Cables.

Before the wiring system can be erected, the size of the cables to be run to the various motors must be determined.

Examine the name plate of the motor and make a note of the current taken by the motor, the current given will be "full load" current. If only the B.H.P. and supply voltage of the motor is given, the approximate full load current may easily be calculated.

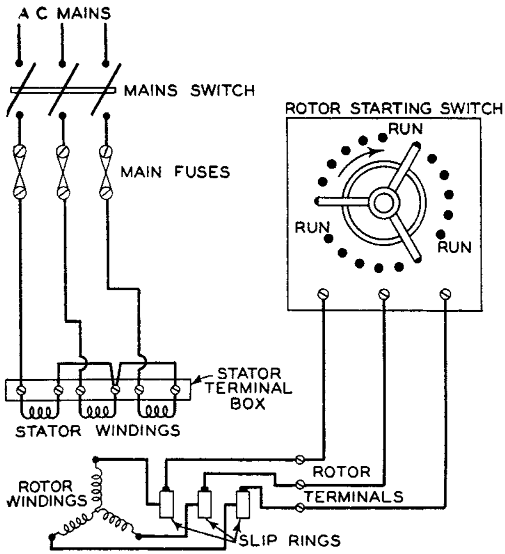
D C. 230 volts.—4 amperes per H.P.
D C. 460 volts.—2 amperes per H P.
A C. single phase 230 volts with Power Factor = .7—6 amperes per H.P.
A.C. single phase 460 volts with Power Factor = .7—3 amperes per H P.
A.C. three phase 400 volts with Power Factor = .85—1 4 amperes per H.P.

In each of the above figures, the efficiency of the motor has been taken at 80 per cent., approximately. This figure will vary; in the case of a small motor the efficiency may come below this figure, whilst in the case of a large motor the efficiency may be considerably in excess of the figure given.

When the full load current of the motor has been determined, reference should be made to Table IV of the Institution of Electrical Engineers' Regulations for the Electrical Equipment of Buildings. The size of the cable to carry a certain current can be obtained from this Table. If the run of the wiring to the motor is abnormal, the pressure drop which will occur may be too much to give efficient results. In such a case, choose a cable having a larger carrying capacity than is required.

Erecting the Wiring System.

The runs must be carefully planned,



A.C. Three-phase Slipring Motor Connections with Rotor Starting Resistance. When the motor is started the rotor windings are connected in circuit with a resistance. When the rotor starting switch is moved over to the run position, the motor speeds up and the resistance is cut out of the circuit. The stator windings are connected to the mains through the main switch.

having due regard to the labour, and the structure of the building. Labour charges become excessive if a large amount of cutting away, drilling holes through walls, etc., is done; also in some cases the structure of the building may be materially weakened.

Where the building is made of reinforced concrete, the fixing surfaces for the wiring system will be mainly on girders, angle iron, stays, etc., and here advantage should be taken by using special clips which may be obtained for use in such cases. Do not attempt to drill the iron or steel work to obtain a fixing unless it is absolutely essential.

If the system is conduit, the whole of the runs should be erected before any of the wiring is drawn in. At convenient points, junction boxes should be fitted to facilitate the drawing-in of the cables.

All outlets must be bushed, and only fittings of the inspection type used.

All junctions between the conduit and distribution boxes, ironclad switchgear and motor terminal boxes should be mechanically and electrically continuous. In the case of terminal box junctions, a flexible metallic tube connection between the end of the conduit and the box should be made, where the position of the motor is liable to be adjusted for purposes of tightening a belt drive. The conduit is secured at intervals along its run with saddles.

When the system employed is an armoured cable one, at all junctions to distributing boxes, switchgear, etc., the armouring must be clamped to the metal cases, in order to preserve the mechanical and electrical continuity of the armouring. Great care should be taken when stripping back the armouring to avoid scratches and cuts, as these often produce a serious wound, owing to the possible dirt and impurities on the surface of steel tape or wire armouring. A pair of stout leather gloves is recommended when handling the armouring.

The Terminal Connections.

The scheme of connections of the cables from the supply to the switchgear and motor will entirely depend upon the nature of the supply, whether D.C. or A.C., and the type of motor. A diagram of standard connections for D.C. and A.C. motors is given. In some cases a special switch control cabinet is supplied. This cabinet or unit generally comprises a main switch fuse, or a main switch fitted with overload and release coils, and a motor starting switch. Makers generally supply a blue print of the connections of this cabinet to the supply mains and the motor. Their scheme of connections should be strictly carried out; if any deviation is desired the advice of the makers should be obtained.

The actual connections of the cables to the terminals should be carefully made; sweating sockets and cable ends should be tinned before the actual sweating is done. The bearing surfaces of the sockets should be cleaned and terminal nuts screwed down tightly. It must be remembered that in some cases heavy currents will be taken by the motors, and an imperfectly sweated cable socket or dirty connection will probably cause a fault.

Summary of Procedure for Starting up the Motor.

It is most important that certain precautions should be taken before the motor is started up, before it is placed into commission. Generally they are:—

1. Examine the bearings and note that the lubrication is satisfactory.
2. Take the belt off the motor pulley, or if the motor is geared, take it out of gear.
3. Turn the armature shaft round by hand, and note if there is any "fouling" or obstruction to turning.
4. Examine the brushes, and note if the brush tension is satisfactory.
5. Check all the terminal connections of the motor and switchgear.
6. Note that the motor starter-arm is in the "off" position and the overload release armature is working freely. Set the scale for the overload current to the proper value.
7. Fuse the main fuse holders with light current fuses.
8. Test the insulation resistance of the circuit. The motor may now be safely started up, and should any fault occur, the light fuse will melt before any damage is done.

ELECTROMAGNETIC VIBRATING SCREENS FOR A.C. SUPPLY

The demand for a vibratory screen that can be plugged into any alternating current supply and requires minimum attention during operation can now be met by the new A.C. Sherwen screen, developed by the G.E.C. The vibrations are obtained by the use of a Westinghouse half-wave metal rectifier connected in series with the vibrator coils. The cyle of operations begins with the rectified half-wave from the rectifier passing to the vibrator coils and drawing forward the armature, which is connected to the screen frame. During the other half-wave of the A.C. cycle, the current is prevented from passing to the coils, thus enabling the springs supporting the armature and live screen frame to accomplish the return stroke. A 50-cycle A.C. supply transmits to the live screen frame a vibration of 3,000 cycles per min.

The Photronic Cell

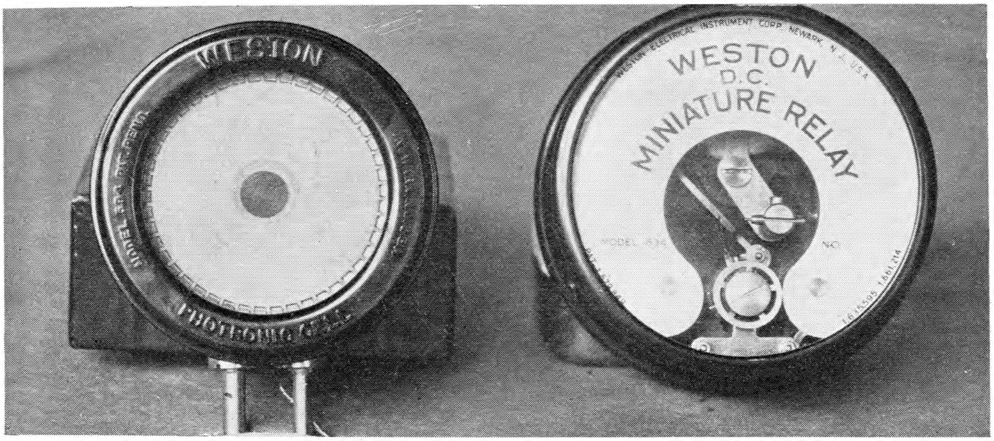


Fig. 1.—The Photronic Cell and Relay.
On the left is the photo-electric cell, showing the large (white) light sensitive surface. The outer serrated ring and the central black spot are the current collecting contacts. The relay is shown on the right, and the moving tongue and fixed contact are readily seen. The movement of the relay is similar to a moving-coil galvanometer.

The Weston Electrical Instrument Co., Ltd., have placed on the market a photo-electric cell which has a large output, and is, for a photo-electric cell, exceptionally strong and simple. This Photronic cell, as it is called, is of the rectifier type, the active element being iron-selenide. It should be noted particularly that it is not a selenium cell, and *on no account must it be connected to a battery*. The sensitivity and output of this cell is remarkably high, being given as 120 micro-amps. per lumen, equivalent to 1.4 micro-amps. per foot candle of light intensity. The light sensitive element is enclosed in a moulded case, about $2\frac{1}{4}$ in. diameter and 1 in. thick, provided with two pin connections; the exposed area of the sensitive element is about $1\frac{1}{2}$ in. diameter, and is protected by a glass disc. This cell contains no material liable to alteration with time, and is not harmed by intense light.

Will Operate a Relay Direct.

Most photo-electric devices require an amplifier of some form before any effective use can be made of the small currents generated. In the case of the Weston Photronic Cell the current given out when the cell is brightly illuminated may be round about 50 micro-amps. The Weston Electrical Instrument Company have, therefore, produced a very sensitive relay which can be operated direct from the Photronic cell. This relay is similar to a moving coil galvanometer, but instead of a pointer the coil carries an arm forming one side of the relay contact. The other contact consists of an adjustable stop.

In use, the cell is connected to terminals 1 and 3 at the back of the relay, while the secondary relay and battery are connected to terminals 2 and 3 as shown in the diagram (Fig. 4).

Operating a Power Relay.

This relay cannot be used for breaking heavy currents, but it can be used for closing the circuit of a second relay which in turn controls a power or lighting circuit. The photographs herewith show the essential parts of the simplest form

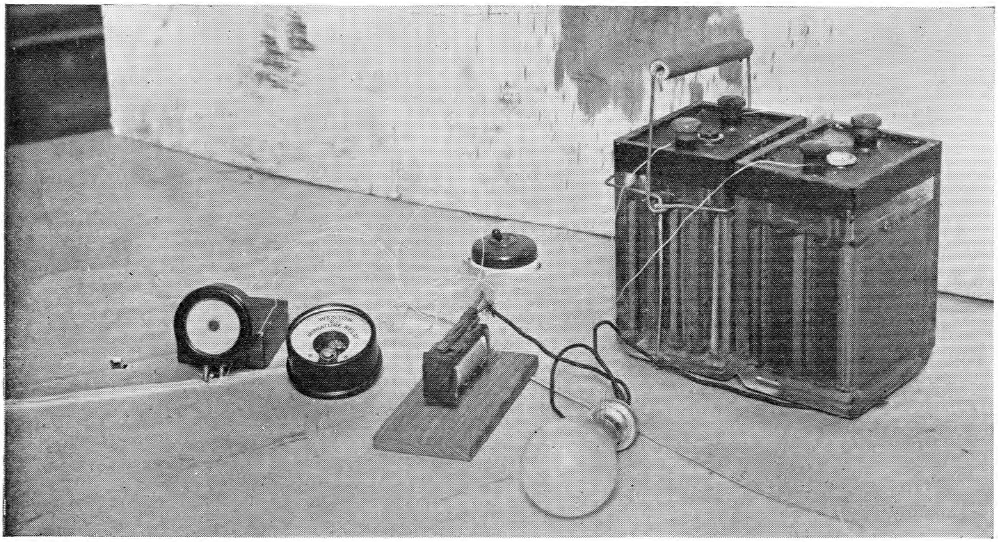


Fig. 2.—PHOTRONIC CELL AND RELAY WORKING A SECONDARY RELAY.

As it generates current, the photronic cell may be used to actuate relays, etc., in a similar manner to a selenium cell, except that no cell battery is required. The cell is not harmed by prolonged or intense illumination, and has no time lag, acting instantly.

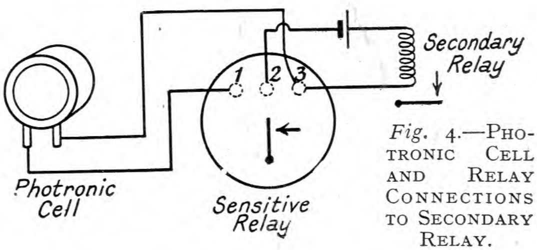


Fig. 4.—PHOTRONIC CELL AND RELAY CONNECTIONS TO SECONDARY RELAY.

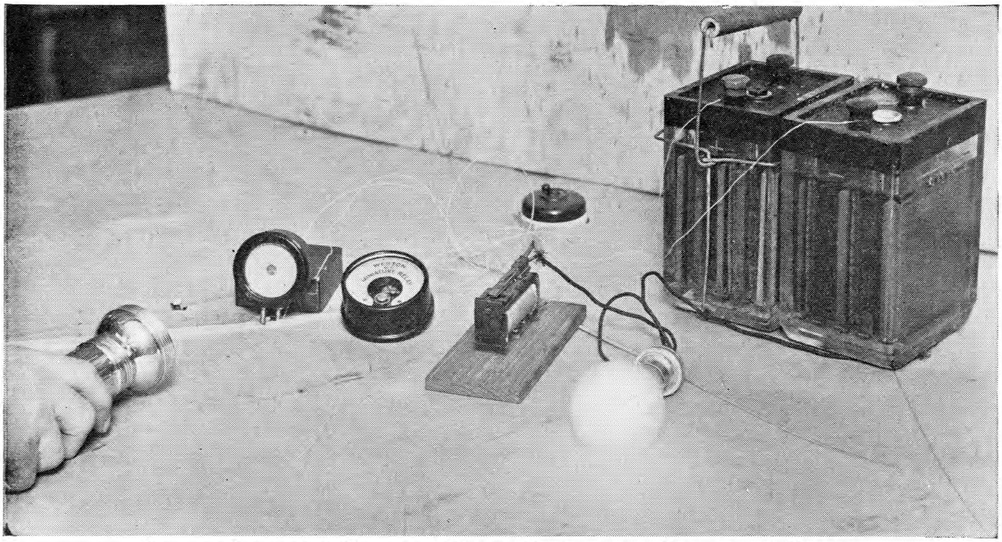


Fig. 3.—PHOTRONIC CELL AND RELAY OPERATING A SECONDARY RELAY.

When light from a pocket torch is directed upon the cell, the current generated is sufficient to actuate the sensitive relay, closing the circuit of the secondary relay, which in turn closes the circuit of an electric lamp, motor, or other apparatus.

of a power relay operated from a Photronic cell through a Weston Sensitive Relay.

No Current Required when Cell is not Functioning.

It is obvious that in certain cases this form of Photo-electric cell possesses advantages over the vacuum type where the amplifying valves must be kept always in operation, even when the Photo-electric cell is not functioning. A Photronic cell is self-operated in the sense that no power supply need be connected in circuit whilst the cell is inoperative. The Photronic cell has already been applied to the following uses :—

The control of street lights.
The control of sign lights.
The control of airways beacons and air field lighting.
The control of lighthouses.
The control of station lighting on transportation systems.
Controlling flood lighting in railroad yards.
Smoke detection.

We have no space here to give full details of the circuits employed in the above applications, but we have arranged with the Weston Electrical Instrument Company that any reader of the PRACTICAL ELECTRICAL ENGINEER who wishes for further information on any specific application can obtain it by applying to the Weston Electrical Instrument Co., Ltd., Kingston By-Pass, Surbiton, Surrey.

ENTERPRISE

Great enterprise is shown by the firm of Ward & Goldstone, Ltd., in their scheme for assisting the electrical dealer in the sale of electric fittings and accessories. The scheme briefly is this :

If a dealer wishes to take up the sale of a new line such as bells and accessories, he can obtain for a very small charge from the above mentioned firm an attractive stand with the following items mounted on it :—

Electric Bell $2\frac{3}{4}$ in. Round Gong.
Electric Bell $2\frac{3}{4}$in. Sheep Gong.
Buzzer.
Bell Transformer.
Pear Push.
Rosette.
Circular Bell Push.
Oblong Push.

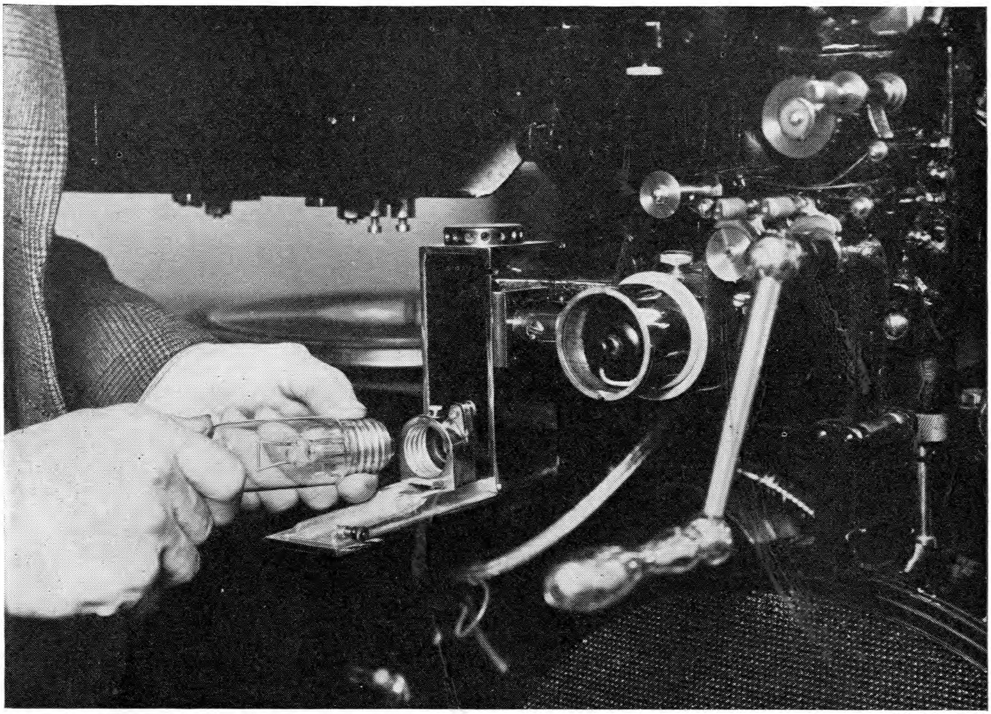
THE DISPLAY STAND FOR BELL ACCESSORIES.

The cost of this is simply the trade price of the items listed above, no charge being made for the display stand on which they are mounted. Bells and accessories can be sold from the stand and re-ordered as required, but we should imagine that before very long dealers who avail themselves of this scheme would be ordering some of the listed accessories in dozens.

A well-thought-out scheme which merits success. Interested readers should apply to Ward & Goldstone, Ltd., Pendleton, Manchester.

INSTALLATION AND ADJUSTMENT OF A SMALL SOUND PROJECTOR

By COLIN N. BENNETT



FITTING AN EXCITER LAMP TO AN IMPERIAL SOUND SYSTEM PROJECTOR.

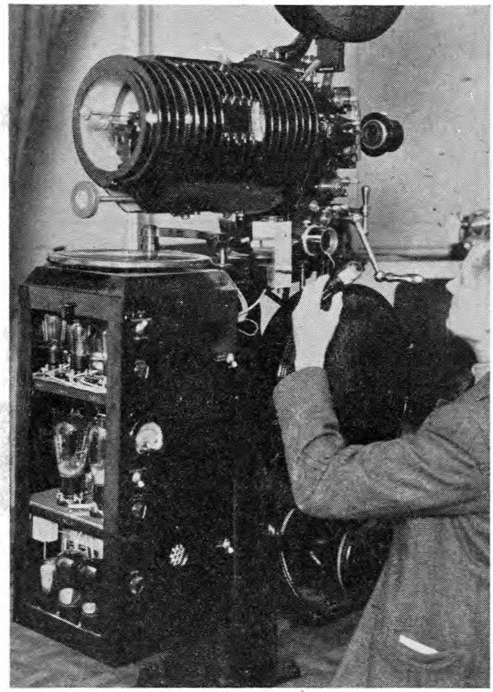
THE time is rapidly drawing near when electrical engineers in even moderate-sized provincial towns may be called upon at short notice by religious, educational and similar bodies to help install talking-picture projection systems. This work is quite straightforward, but is specialised, therefore, a short description of the more important points arising may be of service.

Regulations Regarding Inflammable Films.

At the start there should be noted the vital difference between projector installation in cinemas and that generally to be undertaken for private individuals, religious and lecturing bodies. The difference lies in the inflammability or non-inflammability of the films to be shown. Where inflammable film is to be exhibited it is necessary that the regulations laid down in the year 1923, under the terms of the Cinematograph Act of 1909, be strictly complied with. These regulations are so drastic as to entail major structural work, but, where only non-inflammable film is used, neither the Act nor regulations made under it apply. Film, including sound-film, exhibition becomes as untrammelled by the law as any magic-lantern display. This leaves the contractor free to use his own discretion in the matter of arrangements for the safety and comfort of the audience, and, in taking due precaution against the possibility of fire during a performance, from whatever cause arising.

The Operating Box.

With silent projectors using non-flam film the tendency is rather to take over-much advantage of this freedom, hence



Here we see the General Arrangement of the Projector.

This is a modern type of machine with the practically universal maltese cross intermittent movement for shifting the picture in the gate, frame by frame. The operator is shown replacing the photo-electric cell.

it is fortunate that the sound film machine, if it is to show at its best, really calls for some sort of "operating box" wherein to house it, if only so that the noise of its mechanism shall not mingle with, and spoil, the sound rendering from the loud-speaker. In contriving such an operating box for a sound-film machine, have it lined with asbestos board throughout and let the projection aperture, situate in the front wall of the box at a centring of 4 ft. 6 in., and the viewing aperture, placed handily at eye level to its right-hand side, both be glazed with good *plate* glass. The box should have a self-closing door and a ventilated top sufficiently stout for the "monitor" loud speaker (the small loud speaker which acts as sound guide for the operator) to be fitted firmly upon its underside. In the bad old days of cinematography operating boxes were made ridiculously small, sometimes as little as 4 ft. square inside. This is hopeless from the point of view of efficiency, and the minimum interior measurement of a box for housing a single sound machine should be 6 ft. square.

The sound systems of all modern projectors are arranged to operate at 50 cycles A.C., at currents between 200 and 240, tappings on the transformers being provided accordingly. Motor drive is by constant speed A.C. motors, which in the less complicated systems are of the induction-repulsion type, but for illuminating the picture there is the choice of two systems which are entirely different from each other. They are as follows:—

Incandescent Lamp.

The projector lamp house holds an incandescent electric "focus" lamp, of from 500 to 1,000 watts capacity, optically centred before a mirror. This lamp runs at a voltage round about 30. To feed it A.C. current is taken from the main supply through a step-down transformer and the low-voltage current supply to the lamp is controlled by an ammeter and sliding contact type resistance. Set the lamp once for all to consume its rated current, centre it according to the notes near the end of this article, and henceforward it has merely to be switched on and off when the projector is put in and out of action.

It is, therefore, the simplest illuminant, one adjustment of it being permanent, but its power is limited. The incandescent lamp is suitable where it is not required to project a picture of more than 10 to 12 ft. in diameter, or where there is reason to expect that the machine will be in the hands of a semi-skilled operator. Being comparatively a cold light, and enclosed in its glass bulb, risk of fire from any cause with it is small. It is the light to recommend as "easy way out" where illumination difficulties have arisen. Its weakest point is that at any moment the overrun lamp filament may break down and stop the show till another lamp has been put in its place.

Mirror Arc Lamp.

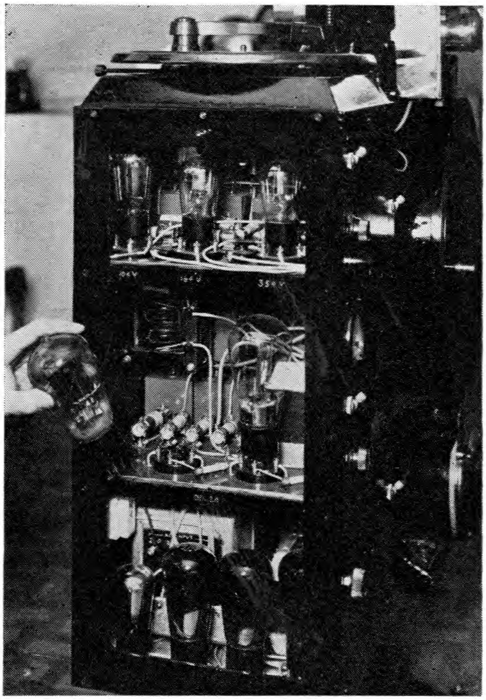
This is an arc struck between carbons held centred before a mirror. It takes D.C., so that where the mains are A.C., a motor generator or rotary converter must be put in. The D.C. side of the motor generator should deliver current at a voltage round about 70 for an ordinary mirror arc, but may deliver at 55 to 60 volts for a high intensity arc taking copper cored, coated, or chemically impregnated carbons. Ship brand "Hilo" carbons are specially made to give high intensity arc light in ordinary hand-feed mirror arc lamps. A 12 to 15 amp. mirror arc lamp will give enough light to illuminate brilliantly a projection screen as large as 16 ft. across. Arcs are invariably used for projector illuminants in cinemas, but they need constant attention, feeding and centring adjustment, and call for skill in their maintenance. From the above it becomes a mere matter of reference to current-carrying capacity tables for the electrical contractor to decide upon the gauge of his D.C. leads for the projection light circuit, making due allowance for voltage drop over their length.

Sound Projection Circuit.

The sound projection circuit calls for quite small A.C. mains current. Most of it is used in heating the filament of the sound head lamp. Though this takes 10 amps. at 10 volts, the wattage is only 100, or, allowing for transforming loss, say $\frac{1}{2}$ amp. at a mains pressure of 220 volts. A 5-amp. fused circuit will, therefore, be ample. Do not bring A.C. and D.C. leads into the operating box close together, or the sound system may pick up hum from the arc. If one set of leads enters the box at its front wall, let the other enter at its back wall. Carry the lighting leads from the controlling resistance and D.P. switch in conduit to the box floor. Here put a terminal box and from it run asbestos-covered flex leads to the projection lamp terminals. For the sound leads arrange a second A.C. terminal box near the amplifier.

Sound Projector Systems.

A sound projector differs from a silent machine in that it makes use of film carrying a photo-electrically impressed



THE INTERNAL CONSTRUCTION OF THE AMPLIFIER.
The circuit is given on page 271. The amplifier is used to build up the original emission current to a value sufficient for the loud-speakers to use.

sound and speech record upon its edge, between the perforations and one side of the picture "frames." There are two systems of sound recording, by variable area, and by variable density, but the same sound reproduction system does equally well for both. These are known indiscriminately as "sound on film" or "sound on edge" systems. Another sound recording system is not done on the film, but on gramophone discs which are played in synchrony with the film during projection. This system is obsolete except for substandard (16-millimetre) film used in " home " projectors.

Description of a Typical Sound Projector.

A typical small and reasonably priced, but very efficient, sound film projector for standard size (35-millimetre) film is shown on page 269. It will be seen to be a modern type of machine with the practically universal Maltese cross intermittent movement for shifting the picture in the gate, frame by frame.

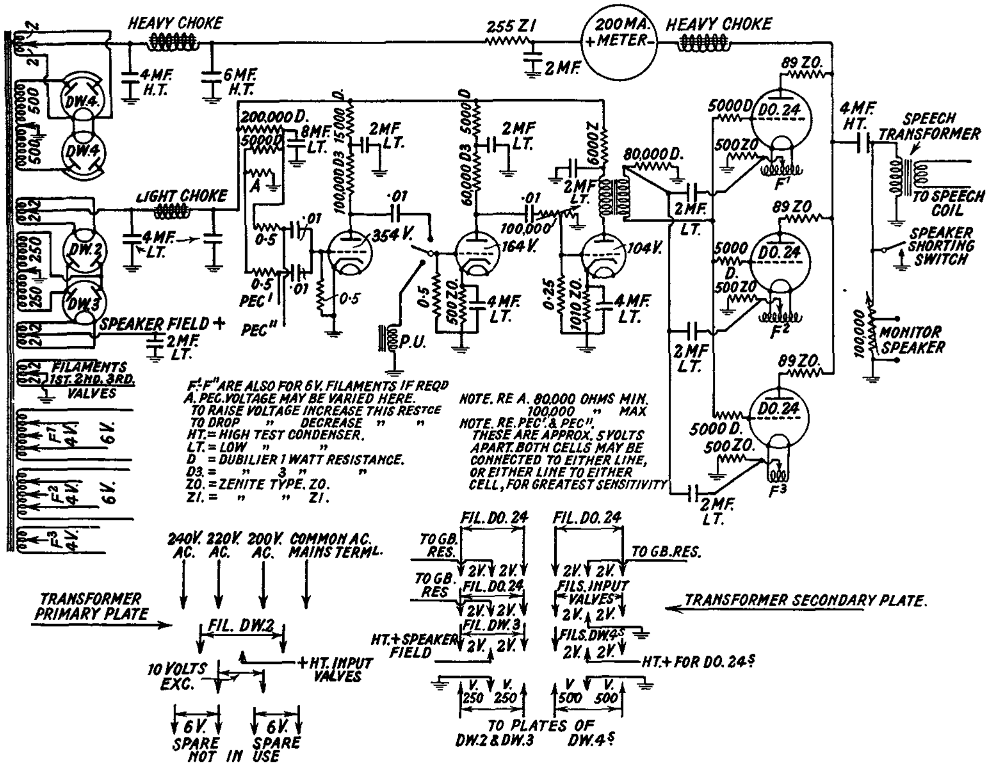
The Sound Head.

At the lower part of the mechanism is its cylindrical-shaped " sound head " to which the film is led after the gate has been entered and left. The sound head contains a G.E.C. photo-electric cell enclosed in a light-tight casing. In this casing there is a small aperture so positioned that the sound record on the film-strip passes directly over it in the course of its travel.

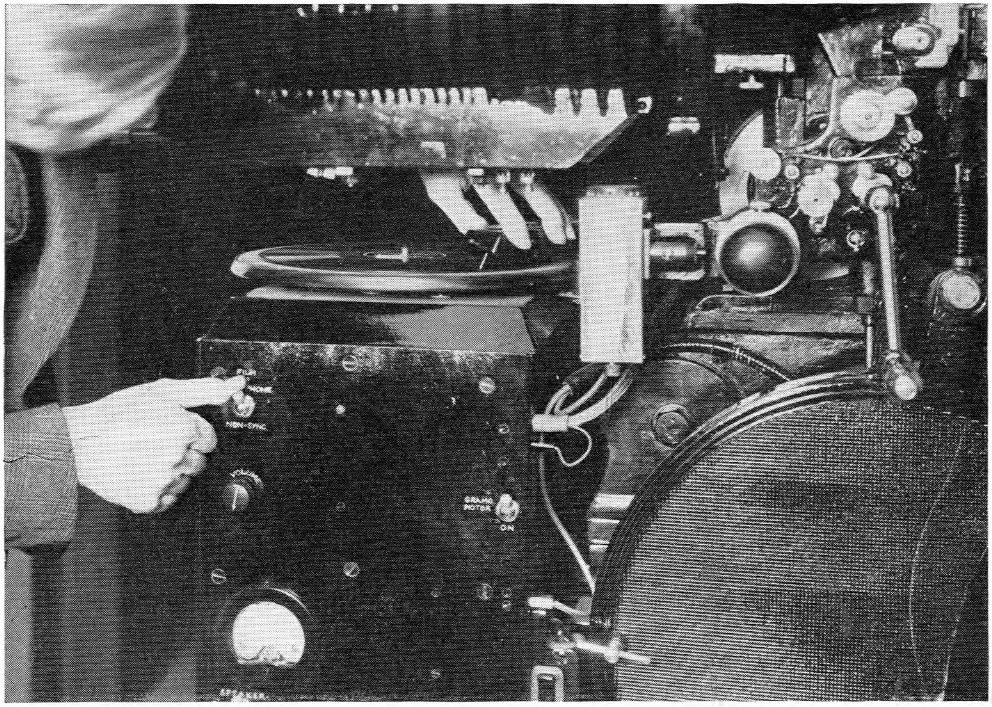
The remainder of the sound system consists of a second casing having inside it a 10-volt, 10-amp. straight filament energising lamp with a condenser to concentrate an image of the filament upon a minute slit, less than one-thousandth of an inch in width, and an objective which focuses the image of the slit upon the film's sound record. Thus, every alteration of light-transmitting value on the film strip's sound record becomes translated into an alteration of the amount of light impinging upon the sensitive cathode of the photo-electric cell. In its turn this causes a variable electron emission within the cell, which, in a modern gas-filled photo-cell may be of the neighbourhood of 20 to 25 micro-amperes per lumen. To make it active the cell has to have an applied voltage of something over 100.

The Multi-Stage Amplifier.

The remainder of the sound system, which may, or may not, be directly



CIRCUIT DIAGRAM OF THE IMPERIAL 50-75-WATT AMPLIFIER.



CHANGING OVER FROM FILM TO NON-SYNCHRONOUS MUSIC.

attached to the projector stand, consists of a multi-stage amplifier to build up the original emission current to a value sufficient for the loudspeakers in use. In such a compact sound projector as the one shown the entire amplifier is contained in the metal housing clipped to the mechanism pedestal.

Here an electrician who undertakes the installation has nothing more difficult to do than to bring his A.C. and (if used) his D.C. leads to the machine, plug the connectors from the machine into their correct marked sockets on the amplifier, run the two-wire leads from amplifier to the monitor within the operating box and the four-wire leads from the amplifier to the main loudspeaker, which should be placed behind, or as nearly as possible behind, the projection screen.

Machine Must be Efficiently Earthed.

The machine as a whole must be efficiently earthed, according to universal practice where inductive A.C. circuits are involved.

Why Four Wires are Taken to the Main Loudspeaker.

The reason why four wires are taken to the main loudspeaker is that, being of the moving coil with separately energised field type, it has both energising circuits and speech circuits, each of which is fed from the amplifier by rectified current. See that the correct transformer tappings are used for the value of the A.C. house mains.

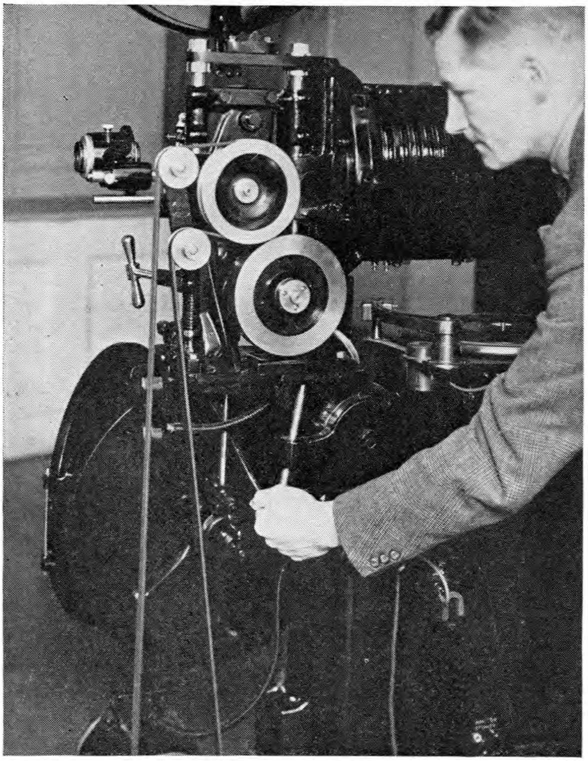
The Amplifier Circuit.

Those conversant with radio circuits will have no difficulty in understanding the amplifier circuit on page 271. Valves used in this case are Mullard, the three first stages using valves Nos. 354, 164 and 104 respectively, while the power output stage uses valve D.O. 24. Rectifying is by valves D.W.2 and D.W.3 (full wave) for the loudspeaker, and two half-wave rectifying valves D.W.4.

Precautions to Take When Arranging a Film Display.

In arranging any film display care must

be taken about placing the projection screen so that stray light from safety lighting does not strike it and ruin the brightness of the projected picture, but with a sound film show, correct positioning of the loudspeaker is of almost equal importance. Sound waves are reflected just as are waves of heat or light. In positioning the speakers in a large cinema many trial and error experiments, often extending to many days, are undertaken. Generally speaking, when arranging a small non-flam sound film exhibition there will be insufficient time to do more than guard against excessive reverberation and echo. Where either shows itself, try to think out the probable course of the sound waves from the speaker mouth, and arrange some sort of padding, either by thick curtains or (better still) glass wool mats, at the point where sound reflection appears to be taking place.



Lining the Projector to the Screen.
Showing also the general arrangement of the back of the projector.

Gramophone Turntable.

Coming back to our illustration of a self-contained sound projector (in this case the Imperial Sound Projector), it will be seen that, supported upon the machine pedestal, in addition to the lamphouse, motion head and amplifier, is a gramophone turntable with its electric motor-drive and pick-up arm. Its controlling switch is built into the amplifier housing and appropriately marked. This gramophone also has its tone arm in electrical connection with the loudspeaker system, but does not run synchronously with the film in the projector feed, as it would do with the obsolete " sound on disc " system of sound film projection. It is technically known as the " non-sync.," the function of it being to allow disc records to be played when film is not being shown, or, alternatively, as a means of providing musical accompaniment during the projection of silent film, when it takes the place of the old-time cinema pianist or orchestra. A " fader " on the amplifier allows of the disc record being faded away to silence and the sound on edge record on the sound film being " faded " in to take its place when the projector is started.

Testing and Starting Up.

Though we do not imagine that the electrician taking a hand in such a sound machine's installation will often be called upon to help with the totally distinct work of "operating," the following notes on testing and starting up may not be out of place.

What to do First.

The first act in starting up a sound system is to put in the main switch on the amplifier. There will be the usual interval of a minute or less while the independently heated valve elements are becoming warm. If, during this time, the speaker current is turned on, the characteristic periodicity hum can be heard, just as with any A.C. wireless set.

Now Test Non-Sync. Circuit.

When the hum dies down, and with the fader knob set for half power, first switch on the non-sync. circuit and gently stroke the point of the gramophone needle; there should be a sound as of artillery from speaker and monitor.

Are the Speakers Energised?

Next switch off the non-sync. and switch on the sound head, wait for a few seconds and flick the corner of an ordinary envelope up and down in the minute light beam just in front of the point where it enters the cell sound housing, and there should be corresponding, but much softer, clicks from the speakers, showing them to be energised.

Now Turn On Projection Focus Lamp.

Now put the fader knob in neutral position, turn on the projection focus lamp, or, if using a mirror arc, strike it, burn a nice crater and centre the mirror so that a clear white circle of light about the size of a penny just overlaps the projector gate aperture. With the projector unthreaded and with hand and automatic cut-offs in the "off" position, and the blades of the rotary-cover shutter clear, this should give a brightly and evenly illuminated screen.

Thread the Film and Fade in the Sound.

Drop the shutters, thread the film, remembering that there must be an interval of 14½ in. between the film picture on the projector gate and the point where the film strip passes over the light beam in the sound system before the photo-cell housing. As soon as the picture is seen on the screen, fade in the sound, enough, but not more than is sufficient. Most inexperienced sound operators put the fader up too loud, so spoiling quality of reproduction, as well as deafening the audience. Obviously, the above is but a skeleton idea of sound picture operation, yet it may help the man who installed the projector to be helpful in emergency.

Arrangement of Projector and Screen.

One way is to use a semi-transparent screen of varnished (or, at a pinch, merely wetted) linen or cotton fabric, place the projector and speaker on one side of it and the audience on the other. The second is to have the operating box and projector at one end of the hall, the screen and speaker at the other, and seat the audience between the two. This second way is strongly recommended, except for halls very long and narrow.

Screen Material for "Front Throw."

Two kinds of special "sound screen" material are made for this. One is thin rubber cloth perforated with minute holes to let the sound waves from the speaker traverse it. Another is an open mesh linen material. For all practical purposes, heavy twill or ordinary sheeting will serve, though the light loss is greater. The speaker goes behind the screen, clear of the light beam. Most efficient of all, for projection purposes, is to use a totally opaque screen, such as a plaster wall, or stretched white distempered hessian, using two parallel connected loudspeakers, one placed on either side of the screen, at about two-thirds of the picture height.

Picture Size and Throw.

Within wide limits a picture of any desired diameter can be given at any desired throw (interval between screen and projector lens) by choosing a lens of the right focal length. Any maker of cinematograph projection lenses will supply, free of charge, a table called a projection chart, giving all necessary figures for making one's choice of the right focal length of lens. As an approximate guide, a 4-in. projection lens will give a picture just over 4 ft. in diameter with an interval, or "throw," of 20 ft. between projector and screen. A 2-in. lens will give a picture of double this size at the same throw. Conversely, an 8-in. lens will give one half the size. Doubling the throw, or projection interval between lens and screen, will double the size of all pictures.

An Important Warning.

Above all things, bear in mind that a standard size projector arranged without the fire safeguards prescribed under the Cinematograph Act Regulations, must positively not be used to show any but strictly non-flam film. Be sure to make this fact clear *in writing* on any estimate or quotation that may be put in for an installation.

How to Connect Meters on A.C.

By J. V. Brittain, B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E.

When installing a motor or other piece of electrical apparatus it is often advisable to put in an ammeter in order to indicate at any particular time what current the machine is taking. This current will give a good indication of the actual load on the motor, and if necessary the ammeter can have its scale marked in H.P. so that the output of the motor can be read off directly in terms of H.P. By this means the machine operator will know how his machine is working.

Also in some cases a voltmeter should be put in to see what pressure is being delivered to the motor, and it will also show whether the load is pulling down the voltage due to volt drop and thus " starving " the motor.

The following diagrams will show how these meters are connected to the mains and also what extra arrangements are necessary in the case of large currents and high pressures. The simple connections for an ammeter and a voltmeter are shown in Fig. 1, which represents a D.C. or single-phase A.C. supply. It should be noticed that the current is actually taken through the meter for the ammeter, but in the case of the voltmeter the meter is connected *across* the mains. This is of course very simple, but there have been cases where an ammeter has been connected across the mains with disastrous results.

FOR THREE-PHASE.

For a three-phase motor it is usually only necessary to measure the current in one line and the pressure or voltage across any two of the lines. This is shown in Fig. 2 in which the current is measured in line L_1 and the pressure across lines L_1 and L_2. It does not matter however which of the lines are taken for these connections.

Connecting the Voltmeter.

For an actual example the connections for an ammeter and a voltmeter for a 400-volt three-phase motor are given in Fig. 3. It is assumed that a main control switch will be used and this is shown as a three-pole switch and fuse. The connections for the voltmeter are taken from the delivery terminals of this switch-fuse, and it should be noted that in the connection to the voltmeter there is a small fuse. The reason for this is that the wiring to the voltmeter will be of small section cable as the meter will only take a fraction of an ampere. The fuses in the switch-fuse will however carry a comparatively large current without " blowing," and thus the wiring to the voltmeter might be dangerously overloaded in the event of any kind of short circuit in the voltmeter circuit. The voltmeter fuse (VMF) prevents the current rising above a very low figure according to the size of the voltmeter.

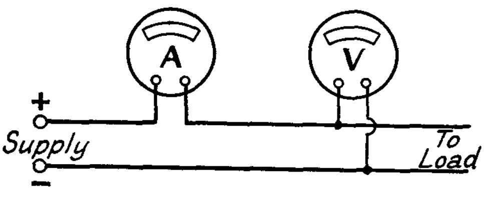


Fig. 1.—How an Ammeter (A) and a Voltmeter (V) are Connected.

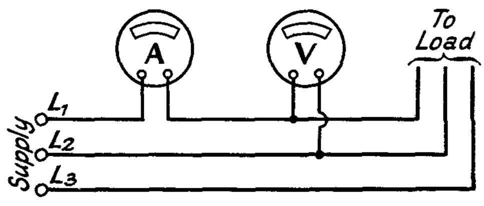


Fig. 2.—Diagram showing Connections for Three-phase.

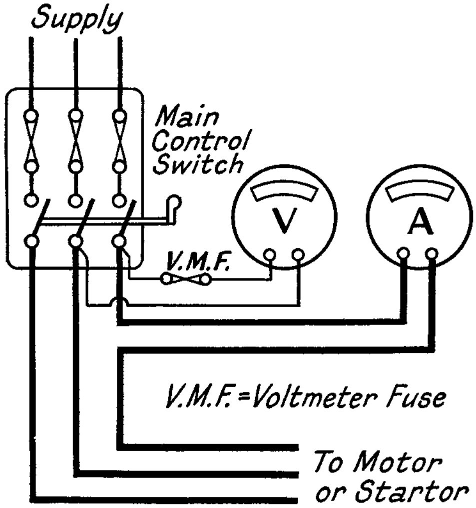


Fig. 3—Actual Connections for Voltmeter and Ammeter on a 400-volt, Three-phase Motor of from 1 to 100 h.p.

Ammeter Connections.

For the ammeter a lead is taken direct from one of the switch terminals to the meter and then the lead to the motor is taken from the other terminal of the meter. These connections will however be quite clear from the diagram. If it is necessary to install an ammeter in an existing circuit this can be done quite easily by removing one of the leads from the main switch and connecting this up again through the meter, as in Fig. 3. This is sometimes done temporarily in order to check the current taken by a motor and, as will be seen, does not involve any complicated wiring. Many of the troubles experienced with motors would be avoided if an ammeter had been in the circuit, as it will, in most cases, give an indication that everything is not in order. Any sudden increase in current should be looked into unless there is some definite reason for it.

As stated, the connections shown so far are for ordinary voltages of 400 volts or thereabouts and for currents which can safely be taken through an ammeter. For larger values we have to use (in the case of an ammeter) a *shunt* or (in the case of a voltmeter) a *series resistance*. By using these only a fraction of the current or the voltage is actually put into the meter. In the smaller sizes these resistances are placed inside the meter case and we do not have to take them into account. As we get to the larger range instruments these resistances have to be placed outside the meters on account of size and heat generated. The connections in this case are shown in Fig. 4, which should be quite clear without any further explanation. In this diagram ES represents the external shunt for the ammeter and ER the external series resistance for the voltmeter.

Connections when Instrument Transformers are Used.

For very high voltages and currents it will be understood that it would be impossible to take direct connections to the meters themselves as they are not designed to withstand voltages of say 6,000 or 11,000 volts. In all cases on E.H.T. systems instrument transformers are used to convert the large currents or pressures to values which can be taken direct to the meters.

The general principles will be seen from Fig. 5 (A), which gives the usual theoretical diagram of a *current transformer*, but the operation will be better understood from Fig. 5 (B). This sketch shows how the actual line current is taken round the primary winding of the transformer. The secondary winding is connected direct to the ammeter and there is thus no direct electrical connection between the line and the ammeter. The transformer will be wound so that the current in the secondary winding is some definite fraction of that in

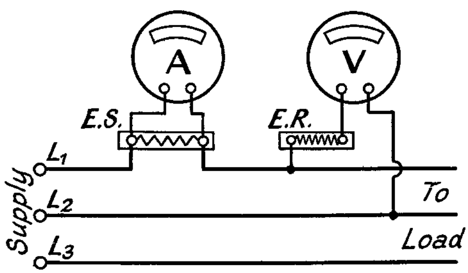
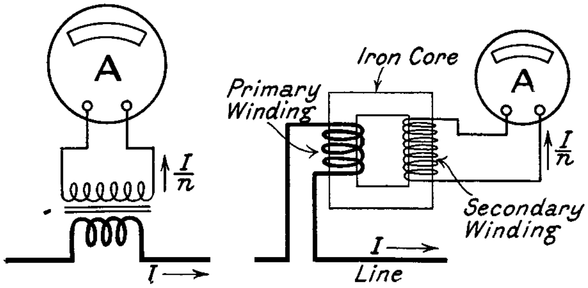


Fig. 4.—Diagram showing Use of External Shunt (ES) and External Resistance (ER) where these are too Large to be Included in the Meter Itself.



Figs. 5A *and* 5B.—HOW A CURRENT TRANSFORMER IS CONNECTED.

$\frac{I}{n}$ is the current in the meter where n = ratio of transformer.

formers are merely a number of turns of wire wound round one of the actual busbar connections. They are of course suitably insulated.

Use of the Potential Transformer.

A similar arrangement is used for the voltmeter circuit which employs a *potential transformer.* The diagram for this transformer is shown in Fig. 6 and the connections should be compared with those of a current transformer as shown in Fig. 5 (A). For a voltmeter the transformer reduces the voltage from that of the line to a value which can be taken direct to the meter. Thus on a 6,600-volt system the pressure would be transformed to 110 volts, which means that the ratio of transformation must be 6,600 to 110 or 60 to 1.

The primary of a potential transformer is connected across two of the lines, as shown in Fig. 6, while the secondary is taken direct to the meter. The primary winding will consist of a large number of turns of fine wire, while the secondary winding will have only a few turns, since the voltage is directly proportional to the number of turns.

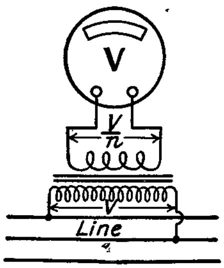


Fig. 6.—HOW A POTENTIAL TRANSFORMER IS USED TO CONNECT A VOLTMETER ON AN E.H.T. SYSTEM.
n = ratio of transformer.

the primary winding, as indicated in the diagrams. By this means, using a 100 to 1 transformer, a meter carrying 5 amps. to give full scale reading can be used to measure currents up to $100 \times 5 = 500$ amps.

If, then, a current transformer is used, the actual line connections are taken to the primary winding of the transformer. The terminals of the primary winding will, on account of the heavy current they carry, be very large, while the secondary terminals which have only to carry a few amperes will be very small. For a current transformer the primary winding consists of a few turns of heavy section, while the secondary will have a larger number of turns of finer wire. The reason for this is that in any transformer the ratio of the currents is the inverse to the ratio of the number of turns on the primary and secondary. For very heavy currents such as those which have to be measured in a large power station the current trans-

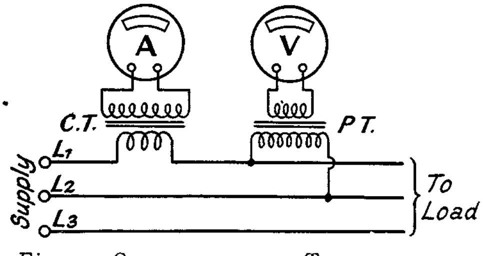


Fig. 7.—CONNECTIONS ON THREE-PHASE FOR METERS USING INSTRUMENT TRANSFORMERS.
CT = current transformer; DT = potential transformer.

It will be understood that the actual construction of a potential transformer is entirely different from that of a current transformer and that they cannot be interchanged.

The actual connections for a three-phase circuit employing both transformers are drawn out in Fig. 7. This shows how the meters are connected with reference to the three lines and will be self-explanatory.

Questions and Answers by Practical Men

Readers are invited to send problems of practical interest. Letters should be addressed to "The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C.2. Envelopes to be marked "Problem" in the top left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTH'S NEW QUESTIONS AND LETTERS

The Metadyne.

Could you give me an explanation of the working, and outline the principles, of the Metadyne, a species of D.C. transformer?

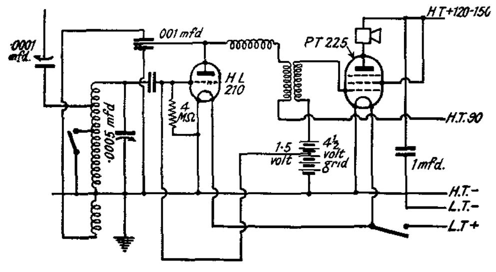
F. C. (Rugby).

We have made inquiries about the Metadyne, and we learn that it is a type of D.C. generator with an additional pair of brushes arranged approximately at right angles to the main brushes. Electrical energy is delivered from the secondary brushes at approximately constant current and varying voltage.

This is, of course, only the barest outline of the idea. An article dealing thoroughly with the Metadyne will be published later.—Ed.

Adding a Screened-grid Valve to a Two-valve Set.

What is the best way to add a screened grid valve to a two-valve transportable set (detector-pentode)? I enclose a sketch of the circuit incorporated in the set. I should like to be able to add this valve without any alteration to the circuit as it is now if possible, as the set works very well, in fact, better than some three or four valve sets. The high tension supply for the set is fed from an eliminator; low tension



from a 2-volt accumulator. I should also like to know the most suitable voltages to apply to this screened-grid valve.

W. Hall (N.W. 1).

Current Limiting Resistance.

I should be much obliged if you would answer the following query. The amplifying system of a public address travelling van relied on a motor-generator set for its operation. The motor had to operate with a P.D. of 25 volts D.C., and when run up to speed took 12 amperes.

As the pressure at our terminals was 210 volts D.C., what should have been the resistance, and what should have been the size of the wire to prevent any serious overheating due to the current of 12 amperes?—

J. R. L. W.

A South Australian Reader's Opinion of the Magazine and of British Electrical Goods.

I think that your magazine is the best on electrical work in the world. In an out-of-the-way place like South Australia we do not get much of a chance of seeing anything very new.

My work is in connection with the tramway system here.

Our one boast in Adelaide is that we have the fastest trolley cars in the Southern Hemisphere. These are a fine piece of work, having remote control and interlocked doors. The bodywork, etc., was made in Australia, but the trucks, motors and controllers were, I believe, imported from the U.S.A., I am sorry to say. I can't understand why this should be so, seeing that one or two of the big electrical manufacturers in Great Britain make such fine equipment. I am afraid if I was *in charge I would always believe in Be British and Buy British, and I would not consider anything else.*

I have an 8-in. lathe, and I tried my hand at making the $\frac{1}{8}$ h.p. motor, particulars of which were given in your September number. It was such a success that I have orders for four more. This type of motor is fairly expensive out here, so I am making a profitable pastime of it.

I was wondering if similar details could be obtained for a $\frac{1}{4}$ and $\frac{1}{2}$ h.p. motors, as these are in great demand.

A. J. HANCOCK (S. Australia).

REPLIES TO PREVIOUS QUESTIONS.

Lifting Magnets.

With reference to the recent article "Lifting Magnets" there are a number of details on which I should appreciate a little further information.

What is the value of "B" usually attained and the pull per square inch?

The lifts for scraps seem to be very low, and that the material is highly magnetic, and the lift is aided by induction from pieces already picked up by the magnet. Are these figures correct? K. T. (Erdington).

The value of "B" will vary according to the steel used for the cores. The usual value is taken from the B/H curve of the steel at a point just on the knee of the curve. The value would be round about 100,000 lines per square inch.

The lifting figures are correct and are those from which the magnets are sold; the actual lifts are a little higher. The pull given by a magnet varies as B^2 and consequently the flux that will pass through a piece of turning is very small, as its section is also small, consequently the pull is small. The greatest trouble, however, is due to the fact that these turnings cling so together, and while the magnet grabs a lot they are so entwined that sheer weight drags a lot off again.

H. H.

The Rapid Cable Calculator.

I was greatly interested in the article published in the June issue, entitled "A Rapid Cable Calculator." I should therefore very much appreciate it if you could explain the theory upon which the sliding scales are calibrated.

M. J. S. (W.C.1).

The scales of the Rapid Cable Calculator described in the June issue are constructed on a logarithmic basis. The user of the slide rule knows that multiplication of two numbers is effected by addition of their logarithms.

Dealing with the upper scale first, if the voltage drop with a given cable of specified length and cross sectional area and carrying a certain current is known from Ohm's law any alteration in any one of these factors will proportionately alter the volt drop.

For example if the current is doubled, then the volt drop will be doubled and can be found at a point along the scale twice the log of the first volt drop.

Similarly with the second scale the length of line to give a certain volt drop with specified current can be doubled if the cross sectional area is also doubled. Here again the required cable section will be found at a point twice the log of the previous sectional area.

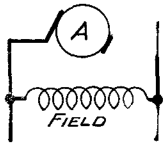
The location of the scales of the calculator under consideration was fixed by trial and error. After the scales were made up a number of calculations were made and the scales fixed in their appropriate positions according to the results of the examples.

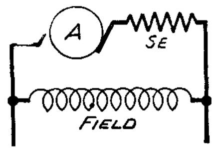
H. E. HUTTER.

Using a Motor Generating Set for Welding.

I have a motor generating set, the particulars of which are :—

Motor.	*Generator.*
G.E.C., No. 21,415.	*G.E.C., No.* 21,414.
H.P., 5.	*Volts,* 60.
Volts, 460.	*Output,* 3.9 *kW.*
Revs., 1,400.	*Revs.,* 1,400
Shunt wound.	*Compound wound.*
	No interpoles.





I want to use same for electric welding. Could you possibly give me particulars as to what I should do regarding same? I want *a load of 80 amps. Please give the wiring diagram, the correct resistances and S.W.G. of same, as I want to make my own.*

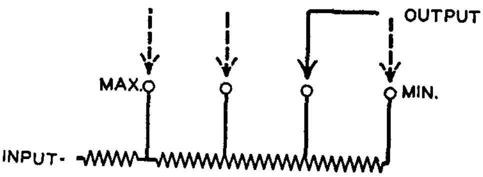
E. C. (Eccleston).

The generator mentioned above is rather on the small side for arc welding, but might be suitable for using 12 gauge and possibly 10 gauge electrodes. In order to do any practical work a variable resistance would be required which should be of the following values:

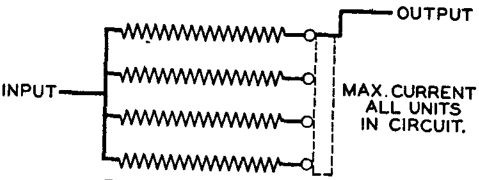
Resistance for 60 volts Constant.
Assume arc volts = 25.
Drop on regulator = 35 v.

Welding Stop No.	Current Amps.	Resistance. Ohms.
1	23	1·5
2	30	1·16
3	40	0·88
4	50	0·7
5	65	0·54
6	80	0·44

Resistances for welding can be either of the series or parallel type. The latter is more efficient for its weight since the whole of the resistance element is in use when carrying the maximum current. The illustrations below show the two types. It may be mentioned that it will probably be easier to make a series regulator as this will not entail any special switchgear. The simplest form would be to use cast iron grid resistances, which could be obtained from the Quasi-Arc Co., Ltd., 15, Grosvenor Gardens, London, S.W.1.



SERIES RESISTANCES.



PARALLEL RESISTANCES.

A Question About Power Factors.

On an A.C. system 3,300 v. 3 ph. 50 cycles, there is connected one 70-h.p. induction motor, r.p.m. 720, direct coupled to a D.C. generator, 110 v. 45 kW. Also a transformer kVA. 100, p.v. 3,200/6,400, s.v. 400 50 cycles. Across the induction motor is connected a condenser 35 kVA. 3,300 v.

How can I obtain the separate power factors of the motor and the transformer? Also if I put a condenser across the secondary terminals of the transformer, what effect will it have on the motor when it is running light load?

H. Tarrant.

With a motor of the power mentioned in the above query the figures given below may be taken as fairly representative of its performance under load conditions.

Load.	Efficiency	Cos. ϕ	kVA.	kW. Input.	Current Amps.	Wattless kVA.
1/1	92%	0.86 lag	60.6	52.2	10.6	31
3/4	88%	0.83 ,,	47.2	39.2	8.27	26.3
1/2	84%	0.78 ,,	33.5	26.1	5.86	21
1/4	70%	0.6 ,,	29.2	13.05	5.1	23.4

With a 35 kVA. condenser in parallel, the resultant motor condenser load will be as follows:—

1/1	52.4 kVA.	.. .. ..	Cos ϕ = 0.995 leading
3/4	39.7 ,,	.. .. ..	,, = 0.986 ,,
1/2	29 ,,	.. .. ..	,, = 0.9 ,,
1/4	16.5 ,,	.. .. ..	,, = 0.79 ,,

It will be seen that by adding the condenser the kVA. input is reduced and the power factor is leading instead of lagging. Assuming that the 100 kVA. transformer is efficient and supplying an average inductive load on the secondary side the power factor of the system as a whole should not tend to be much lower than about 0.9 lagging when the transformer is on half load. This is due to the corrective effect of the combined motor and condenser load at a leading power factor being in parallel with the transformer.

The effect of connecting a condenser across the secondary of the transformer will correct any wattless current taken from the transformer, and will have no effect on the motor. It would, however, improve the system power factor, but hardly seems necessary. A. S. W.

House Wiring Extensions (See page 306)

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY MAGAZINE OF ELECTRICAL PROGRESS

VOL. II.—No. 19

MARCH, 1934

NOTES ON THE OPERATION AND MAINTENANCE OF METAL-CLAD SWITCHGEAR

SEE PAGE 283

1/-

GEORGE NEWNES LTD.

MARCH, 1934 PRACTICAL ELECTRICAL ENGINEER No. 19

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY
OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

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It is gratifying to record that since the publication of our last issue containing the article dealing with the fine results achieved by Mr. A. E. McKenzie at Wimbledon we have received many letters from Chief Engineers all over the country expressing their admiration for this fine achievement. A most interesting point has been raised by Mr. H. Wilson, whose letter appears under the heading "Correspondence" on page 288. Another very interesting communication was received from the engineer of a very large power supply company, and from this we give below an extract :—

I think all practical supply engineers have a great admiration for the work which has been done here, but there is just one little point which I think is sometimes overlooked in connection with Wimbledon and that is this—that they had, for many years, been labouring with an extraordinarily bad generating station and this, to my mind, had a very great effect on the earlier results. This was recognised by the Wimbledon Council and they got Messrs. Sparks and Partners to go into the whole position of the power station for them, with the result that they put in modern and up-to-date plant and with, consequently, a very great improvement in the operating results. Mr. McKenzie was, I believe, associated with this work and went straight from Messrs. Sparks and Partners to take over Wimbledon, with the results which we know.

It would not have been possible to sell cheap units, in my opinion, from the old generating plant and I think this is a practical point which should not be overlooked. Although an increased output always helps a generating station to improve its costs, it still remains a fact that in some of these very old stations, where the coal consumption was very high, the actual coal cost was a great deal more than a halfpenny per unit and could not have been reduced. Under these circumstances, of course, it would have been impossible to sell any portion of the current at a halfpenny per unit or less.

Please do not think I am in any way depreciating the results at Wimbledon, but I think you will find, on looking into it, that the remodelling of the generating station had a very marked effect.

In a few words our correspondent has summarised one of the main reasons why the National Grid was brought into being. Under the Grid Scheme inefficient stations are being, and will be, closed down so that in time it should be a practicable proposition to supply electrical energy at economic rates all over the country, providing that the requisite number of new consumers can be obtained within a reasonable period of time.

The New Television.

For the last six or seven years we have been frequently informed by articles appearing in the newspapers that television is on the eve of becoming a commercial proposition.

In a paper read before the Institution of Electrical Engineers on February 7th, Messrs. L. H. Bedford, M.A., and O. S. Puckle, A.M.I.E.E., gave details of a system which we believe offers better promise of success than any system which has hitherto been put forward. This system operates on what is called the velocity modulation principle. At present it has only been developed for use in transmitting films. The broad principle is as follows :—

At the transmitting end a beam from a cathode ray oscillograph passes through a lens and is brought to a focus on a strip of cinematograph film which is kept moving past the lens at a constant speed of 25 pictures a second. One pair of the control plates in the cathode ray gun cause the ray to sweep out a horizontal line. The light transmitted through the film falls on to a photo-cell and the output from the photo-cell is used to control the speed at which the cathode ray is moving ; thus when the ray encounters a dark portion in the film it is speeded up and when it comes to a transparent portion of the film it slows down. Instead of sweeping out a horizontal line of uniform brightness, the spot sweeps out a line which is sometimes bright and sometimes dark, the dark portions where the spot is moving very rapidly corresponding to the dark parts of the film. At the end of each horizontal line the spot flies back at an enormously high speed ready for the second scanning line. Now the second pair of control plates give it a slight shift downwards and another band is explored or scanned by the next horizontal sweep of the cathode ray. In this way the whole of one picture is scanned by the cathode ray in a fraction of a second, and the following curious effect is obtained :—

A copy of the picture which is being scanned appears on the screen of the cathode ray tube. It can be seen that by suitably tying the control plates of a similar receiving oscillograph in parallel with the control plates of the transmitting oscillograph the same image will appear on the screen of the receiving oscillograph.

The film which is being scanned is moving continuously and to compensate for this a saw-tooth motion is imparted to the scanning beam. This superimposed motion is not transmitted to the receiving cathode ray tube, so that on the screen of the latter we see a succession of still pictures corresponding to successive frames in the original film.

This, in very broad outline, is the principle of the new system, and we have reason for saying that the results achieved are very good indeed.

The authors of the paper acknowledge their indebtedness to Mr. W. R. Bullimore, managing director of Messrs. A. C. Cossor, Ltd., who sanctioned both the experimental work and the publication of the paper. We congratulate the authors on a brilliant achievement.

I.E.E. London Students Section.

We have just received a copy of the second half of the programme for the session 1933-34. Many interesting visits have been arranged, and we notice that meetings for discussing such subjects as selection and layout of electric welding plant, March 6th ; power signalling, April 6th ; train lighting, April 27th, are included in the programme. An address by the President, Mr. P. V. Hunter, C.B.E , will be given at the meeting arranged for March 23rd.

Interested readers are invited to get in touch with the Honorary Secretary, Mr. E. L. Heftermann, Launceston, Heath Drive, Potters Bar, Middlesex.

Works Tour for Readers.

Since publication, on pages 242-250 in our February issue, of the article by Mr. Winton Thorpe on circuit testing, Messrs. Evershed and Vignoles, of Acton Lane Works, London, W.4, inform us that they have had many enquiries from our readers about their new Megger circuit tester. Would readers requiring further information write to the firm asking for pamphlet G.N.033.

A visit to the works of this well-known firm of electrical instrument manufacturers has been arranged for the morning of Saturday, March 24th, in conjunction with THE PRACTICAL ELECTRICAL ENGINEER.

Tickets are limited in number and early application on a postcard is advised. Please address your card to : The Editor, PRACTICAL ELECTRICAL ENGINEER, 8-11, Southampton Street, London, W.C.2, and mark it " Works Visit." The visit will provide opportunity to see the production of all kinds of electrical indicating and recording instruments used in power station practice and elsewhere.

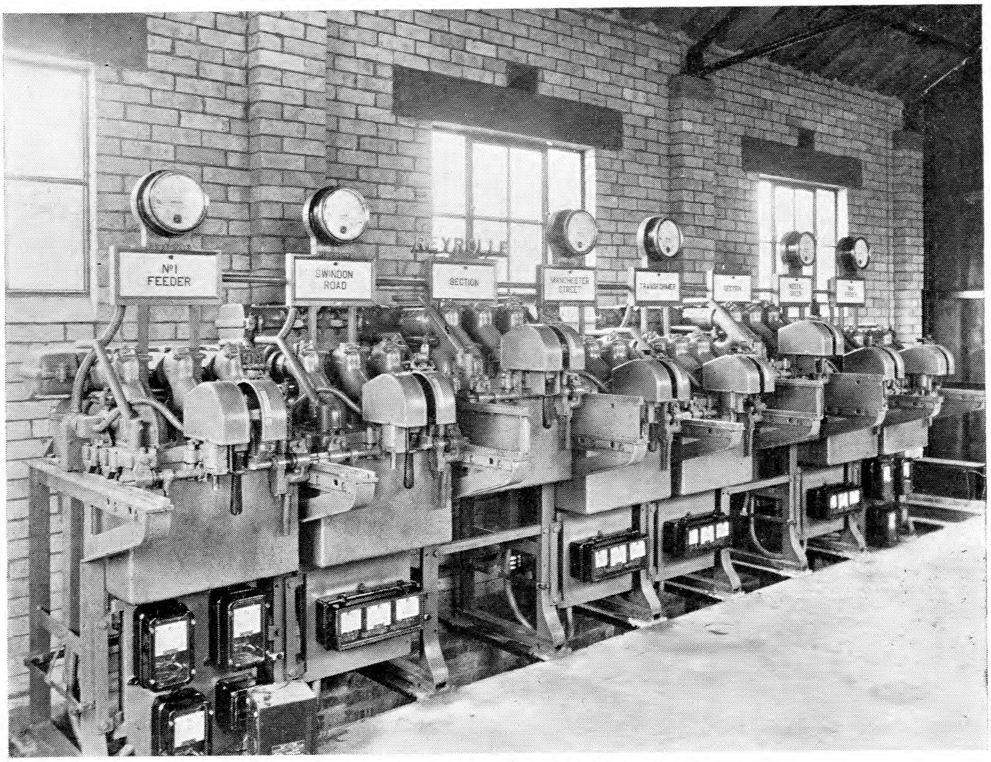
Architects and Electrical Engineers.

The second of a series of conferences for architects arranged by the E.L.M.A. Lighting Service Bureau was held on January 31st, when the subject of church lighting was dealt with in a paper by Mr. H. C. Wheat. A.M.I.E.E. Both the paper and the discussion which it aroused brought out many points of great interest to electrical engineers.

Copies of this paper and also of the paper read at the first conference by Mr. W. J. Jones, M.Sc., M.I.E.E., on " Lighting Principles and Economics," can be obtained by interested readers who apply to the Lighting Service Bureau, 2, Savoy Hill, W.C.2, mentioning THE PRACTICAL ELECTRICAL ENGINEER.

NOTES ON THE OPERATION AND MAINTENANCE OF METAL-CLAD SWITCHGEAR

By "TRICAN."



CHELTENHAM CORPORATION, MARTYN'S SUBSTATION.
An 8-panel, horizontal-draw-out metal-clad switchboard, consisting of single bus-bar direct operated 600 and 300-ampere, 11,000-volt, 3-phase, 50-cycle, oil-immersed circuit breakers.

ALTHOUGH switchgear of the metal-clad type is particularly well protected against external causes of damage, it must not be thought that equipments require no attention whatever during service. Switchgear manufactured by reputed makers is capable of giving satisfactory service for long periods with a minimum of attention, and it is because of this high quality that the few details that require inspection at regular intervals are sometimes overlooked by maintenance engineers.

In order to obtain the very best service attention should be given to certain points, and in the following article these points are described and recommendations made for the operation and maintenance of switchgear for 11,000-volt systems.

The gear selected is that manufactured by Messrs. A. Reyrolle & Co., and complies with the most modern practice.

The information given applies generally to all classes of their horizontal draw-out switchgear, except the pillar type.

Inspection of Circuit Breakers.

All circuit-breakers should be thoroughly examined and overhauled at yearly intervals, but those in very important circuits should be inspected more frequently.

The following paragraphs detail the points to which particular attention should be given.

Inspection of Mechanical Parts—Closing Toggle.

First of all inspect and lubricate with fine oil the various articulated joints between the links of the closing toggle, and all bearings. The oil should be inserted in the oil-holes provided, but first of all take care to remove all dirt and dust which might have collected round the holes, thus preventing ingress of the oil. If the dirt is not removed, grit may be carried on to the bearings.

All surplus oil should be wiped away, and care taken not to lubricate the brass toggle and steel roller engaging the loose-handle mechanism with the circuit-breaker plunger-bar.

Where the circuit-breakers are solenoid-operated, the solenoid plunger should be kept well greased, especially when it is in frequent use.

Operating switches of remote-controlled circuit-breakers should be kept quite clean to ensure satisfactory operation.

Tripping Mechanism.

The tripping mechanism requires lubrication in the same way as the apparatus referred to above.

Take care to ensure that the plungers and plunger-tubes of the over-current and under-voltage (if any) tripping mechanisms are free to slide. If necessary clean out. These plungers actuate a tripping-lever, and this also should be inspected to ensure that it moves freely, and its bearings should be lubricated.

Guide-Rods and Slides.

The brass spindles of the rods and slides for the automatic locking-off doors covering the bus-bar chamber orifices and the current-transformer-chamber orifices must be kept clean and greased. If the turning screws and cheese head screws in the ends of the spindles have worked loose they should be tightened, and if they are stiff when they pass through the brass turning pieces at the extreme ends of the spindles' they should first of all be freed with paraffin and then lubricated.

Racking Mechanism.

Here again, the mechanism requires lubrication, although it is only occasionally that oil need be applied to the bearings of the racking spindle.

It is sometimes necessary through various causes to remove the circuit-breaker from the standards. When this is being replaced, the engineer should take care before attempting to rack the circuit-breaker along to ensure that the right-hand and left-hand pinion wheels engage with corresponding teeth of their respective racks.

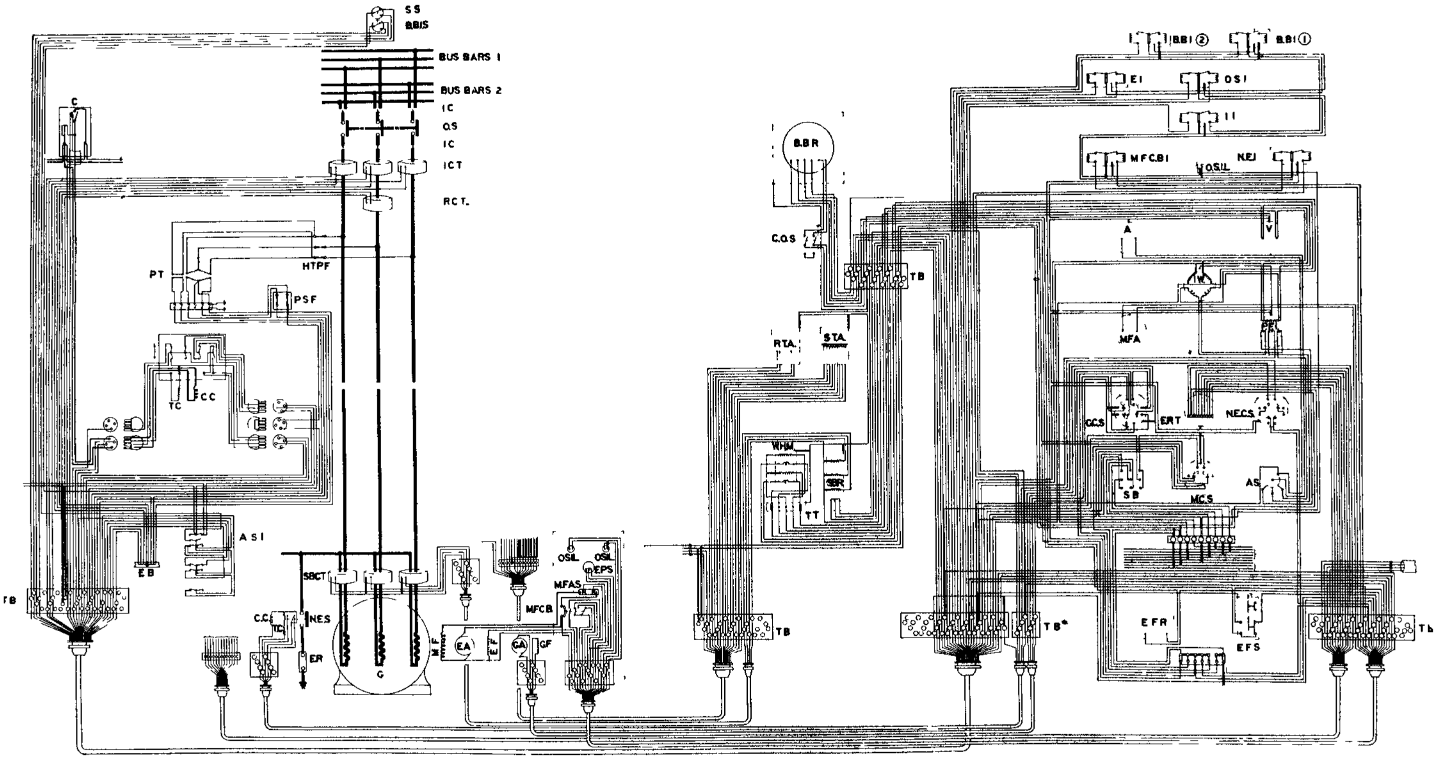
Contacts.

It is very important that the contacts of the circuit-breaker should be carefully inspected and cleaned, and that the brushes should be checked to ensure that they are in correct alignment and making good contact over the whole of their face surface. In order to find out if good contact is being made, feeler gauges should be used.

The main contacts should be particularly examined on each occasion after a circuit-breaker has opened under short circuit conditions, no matter what the nature of the fault. Also, the insulators and auxiliary arcing contacts should be cleaned, the latter replaced if necessary.

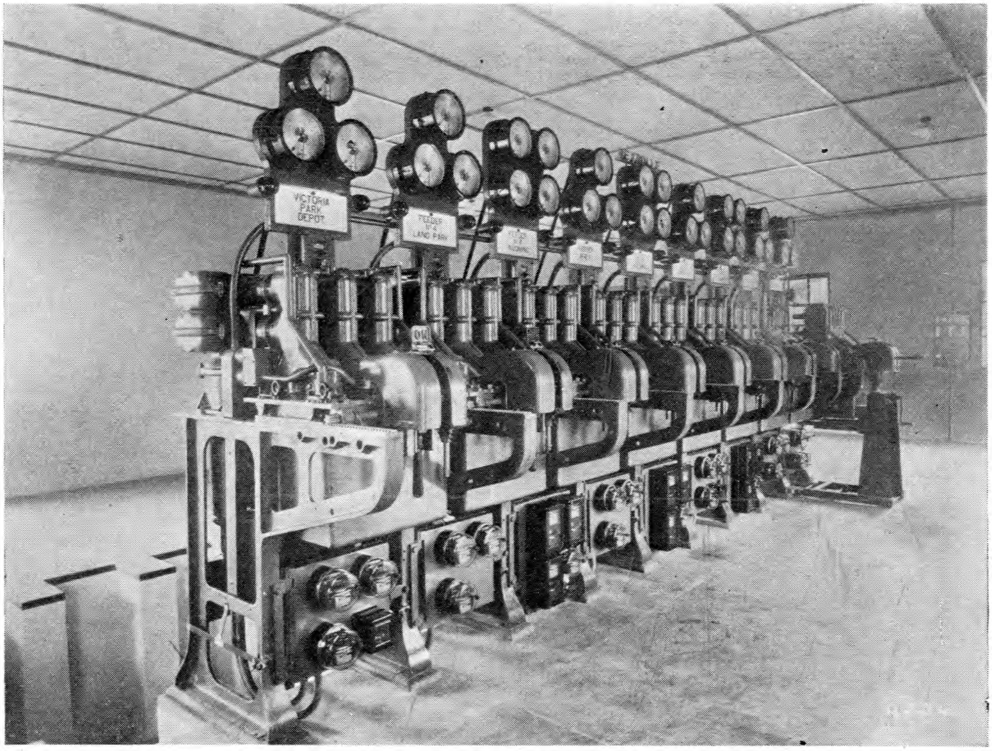
When the multiple finger contacts are fitted to a circuit-breaker which is subject to frequent operation, the screws holding the fingers to the copper blocks should be examined to ensure that they are tight. The steel finger springs should be parallel, so that each contact is quite clear of those on either side of it.

When it is necessary to make an adjustment, the required clearance may be conveniently obtained by placing a sheet of tin between adjacent contacts while tightening up the screws. With the circuit-breaker open, each contact should have some freedom of movement in every direction, and when the breaker is closed, pressure should only be applied to the contacts centrally by means of the rounded bulges on the steel springs.



The Complete Diagrammatic Lay-out of a Typical Single Set of Equipment for one Generator in a Large Modern Power Station.

A., Ammeter; A.S., Ammeter switch; B.B I., Busbar indicator; B.B.I.S., Busbar indicator switch; B.B.R., Automatic voltage regulator; C., Contactor for C.C.; C.C., Closing coil; C.O S, Changeover switch for regulator; E.A., Exciter armature; E.B, Earth bar; E.F., Exciter field; E F.R, Exciter field rheostat; E.F.S., Exciter field switch; E I., Earthing indicator; E.P.S., Emergency push switch; E.R., Earthing resistance; E.R.T., Engine room telegraph; G, Generator; G A, Governor armature; G.C.S., Governor control switch; G.F., Governor field; H.T.P.F, High tension potential fuse; I C., Isolating contacts; I C T., Instrument current transformers; I.I, Isolating indicator; I.W., Indicating wattmeter; M C.S., Main control switch; M.F., Main field; M.F.A., Main field ammeter; M.F.A.S., Main field ammeter shunt; M.F.C.B, Main field circuit-breaker; M.F.C B I., Main field circuit-breaker indicator; N.E.C.S., Neutral earthing control switch; N.E.I., Neutral earthing indicator; N.E S., Neutral earthing switch; O S., Oil switch; O.S.I., Oil switch indicator; O.S.I.L., Oil switch indicating lamps; P.F.I., Power factor indicator; P.S.F., Potential secondary fuses; P.T., Potential transformer; R.C.T., Regulator current transformer; R.T.A., Rotor temperature alarm; S.B., Synchronising base; S B C T., Self-balance current transformer; S.B.R., Self-balance relay; S.S., Synchronising switch; S.T A., Stator temp alarm; T.B, Terminal board; T.C., Trip coil; T.T., Testing terminals for watt-hour meter V., Voltmeter; W.H.M., Watt-hour meter; A S I., Auxiliary switches for indicating.



A 9-PANEL HORIZONTAL-DRAW-OUT METAL-CLAD SWITCHBOARD CONSISTING OF DUPLICATE BUS-BAR, DIRECT-OPERATED, 11,000-VOLT, 3-PHASE OIL IMMERSED CIRCUIT-BREAKERS.

This equipment was made for Brisbane City Council Electricity Department, and is installed in Victoria Park Substation No. 4, Queensland, Australia.

Laminated Brushes.

Adjacent leaves should be in contact over the whole of their length when the circuit-breaker is open, and it is important that the leaves should not be spread during cleaning, or when replacing or removng tanks. The circuit-breaker is liable to overheat if the brushes are kept in this condition, and so, if the brushes have been accidentally spread, they should be returned to the supplier.

A means of ascertaining whether the whole of the brush surfaces are bearing satisfactorily on the contact blocks is to place pieces of tissue paper on the contact surfaces and close the circuit-breaker on them.

When the circuit-breaker is reopened, the impression found on the paper will give the required indication.

Arcing Tips.

If the arcing tips are pitted, they should be filed smooth. Where the pitting is too bad to be remedied by filing, new tips must be fitted. The arrangement of the arcing tips is such that they close the circuit some time before the main contacts close, and open it after the main contacts have separated. It should be noted whether the main and arcing contacts are opening and closing in correct sequence, when a circuit-breaker is being inspected.

Split Circuit-breakers.

Sometimes split conductor protection with split circuit-breakers is used. Where this method is employed it is important that the two splits should be joined together before they are connected to the supply in order to prevent inadvertent tripping when switching in.

This is provided for by ensuring that contact is made on the feeder side of the circuit-breaker earlier than on the bus-bar side, and for this purpose the arcing contacts on the feeder side have considerably more lead than those on the bus-bar side. There is thus only the remotest possibility of inadvertent tripping, but it is well to verify the correctness of the setting during inspection.

Other Details to Watch.

Space does not permit a detailed description of all the mechanical points to which attention should be given.

Before going on to the electrical details, however, we would mention that such components as the brushes or contact arms on the plunger bar should be examined for firmness; the nuts holding the tank to the top plate should be tightened; the plug contacts should be cleaned and smeared with vaseline before the circuit-breaker is racked back to the bus-bars; the orifice insulators should be examined and careful attention paid to the closing of orifices; the locking pins that fix the "in" and "out" positions of the circuit-breaker should be cleaned and lubricated and worked in and out several times; and the auxiliary switches should be examined to make sure that they are in order.

We now go on to the electrical details.

ELECTRICAL DETAILS.

Oil in Circuit-breaker and Voltage Transformer Tanks.

Circuit-breakers on heavy duty, opening under load conditions fairly frequently, should have the oil renewed about every 12 months. Circuit-breakers in substations, however, where they are seldom opened on load, and rarely called upon to break a short-circuit will give satisfactory operation if the oil is allowed to remain unchanged for two years or more. It will thus be seen that the frequency with which the oil is renewed depends to a great extent upon the service a circuit-breaker is called upon to perform.

Suitable oil-testing apparatus such as a Dielectrimeter can be obtained for determining whether the oil should be changed. The results obtained during the test should be in accordance with the requirements of the latest edition of British Standard Specification No. 148, for "Insulating Oils for Electrical Purposes (excluding Cables)."

In carrying out a test on the oil, remove some of the oil from the tank and place in a glass vessel. If the oil is found to be thick and turbid because of sludging, the tank should be emptied and cleaned out, and refilled with fresh oil. The oil should be changed also if it is found that there is water in it, or if it is below standard in dielectric strength. When tanks are being cleaned, rags of hard firm fabric (not fluffy) should be used. Never use cotton waste.

Care should be taken to maintain the oil in the circuit-breaker tanks at the correct level, and it is very important that it should be inspected on each occasion after the circuit-breaker has opened under fault conditions. This should be done because after a heavy short-circuit the oil is likely to be carbonised, and the particles floating about may settle on the insulators with the danger that they may line up and form a path of comparatively low resistance across the insulators. The oil should, therefore, be cleaned or renewed after each heavy short-circuit operation.

The level of the oil in the voltage-transformer tanks should also be checked, and the oil renewed if there are signs of excessive sludging.

Care should also be taken thoroughly to clean the surfaces of all insulators normally under oil, particularly horizontal surfaces, as the effective creepage distance of the insulators is diminished due to the sludge which is likely to accumulate in these places

Check the Continuity of Tripping Circuits.

Routine testing to check the tripping circuits of circuit-breakers should be carried out frequently. In order to test each tripping mechanism raise the armature of each phase of each protective relay on all the panels in rotation. With the equipments being described, relays are provided with a push-button device in order to easily carry out this maintenance operation.

When these routine tests are being

carried out, the following details should be noted :—

(*a*) The trip coil plunger must be perfectly free.

(*b*) The auxiliary switches should be clean and making good contact.

(*c*) The relay contacts must definitely make contact when the armature is up, and definitely break contact when the armature is down.

(*d*) The roller on the circuit-breaker must be perfectly free and must not be lubricated.

(*e*) The tripping batteries must be free from faults, and should be well charged and tested.

(*f*) The secondary wiring must be free from loose connections and other faults; the insulation resistance should be tested by means of a Megger insulation tester.

During these routine tests, see that the relay mechanism is quite free. If there is any sticking, remove the relay lid and examine and clean the working parts. An alarm bell should ring when the relay trips the circuit-breaker.

Unless it is necessary to clean their contact surfaces, the relay contacts should not be disturbed. The contact surfaces may be cleaned by scraping them carefully with the blade of a pocket-knife, or preferably with a magneto file. Take care not to bend the strips that carry the contacts.

When testing the various relay circuits for continuity, the panel should be made dead and the circuit opened at one of the terminals of each relay element. Then apply an independent voltage across the break made in the relay circuit, and raise the voltage until operation takes place. Where operating panels are provided with indicators together with the relays, note whether the indicators and relays operate at the same time.

Test Fuses for Continuity.

Tests for continuity should be carried out on the high voltage transformer fuses and on the low voltage time limit fuses. Faulty operation of the protective gear will perhaps result if there is bad contact at the clips of the time limit fuses.

Indicating Lamps.

Make sure that the indicating lamps are in order; during inspection each lamp on a board should be made to light up in turn.

Under-voltage Releases.

The under-voltage release coils should be tried to see that they trip the switch smartly on a gradually lowering voltage, and also to see that they reset themselves correctly. Any failure to do so is probably due to lack of attention to some mechanical detail previously referred to.

In conclusion the author wishes to thank Messrs. A. Reyrolle & Co., Ltd., for the information incorporated in this article, and also for the illustrations.

CORRESPONDENCE

The Wimbledon Experiment.

I quite agree that the developments made at Wimbledon should be taken as an example by many other towns. The secret of selling electricity is not so much propaganda work, but to make it easy for the customer to use it. To do this you must quote a low running cost, and you must provide apparatus on hire. Given these two things, electricity will sell itself without expert salesmanship. I have only one word of warning, and that is, where an undertaking sells electricity for purposes other than lighting at a low running cost the time is fast approaching when the peak load on such an undertaking will come in the morning instead of the evening, and the "purposes other than lighting" which have been regarded as a sort of bye-product, and have been relieved of all capital charges, will directly influence the peak load and kW. charge paid to the Central Electricity Board, and it is just a question then whether these purposes will be profitable to the supply people at ½d. per unit.

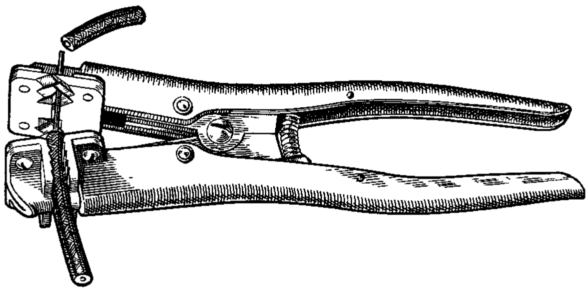
I should be pleased for you to make any use you like of these comments in your paper.

H. WILSON, M.I.E.E.,
Electrical Engineer to the Ashford Urban District Council.

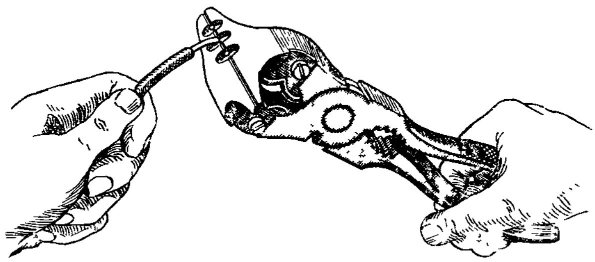
TOOLS FOR ELECTRICAL INSTALLATION WORK

By D. WINTON THORPE, A.M.I.E.E.

A POCKET knife, a screwdriver and a pair of pliers are traditionally considered to be the tool equipment of an electrician. True, that the trade of electrician so far as repair work is concerned is remarkably fortunate in the fact that it is possible for the wireman to cope with most of the work which he may be called upon to deal with with the aid of these three essential implements. The electrician's screwdriver should be long and thin, his pliers should preferably have insulated handles and have side cutters; his knife should not have too sharp an edge on it, or he will find that where he intends to strip the braiding he is cutting into the rubber, and where he intends to strip the rubber he is cutting into the copper conductors.



THE SCRUIT WIRE STRIPPER.



CABLE CUTTING AND STRIPPING NIPPERS.

A Useful Wire Stripper.

There is on the market a wire stripper (illustrated herewith) which is an instrument designed, as its name suggests, for stripping wire. It is made in the form of a pair of pincers which grip the braiding or the insulation, in a miniature vice.

It is not, however, with these three essential implements that I propose to deal, but rather with the tools that are desirable in the interests of efficiency as well as labour saving.

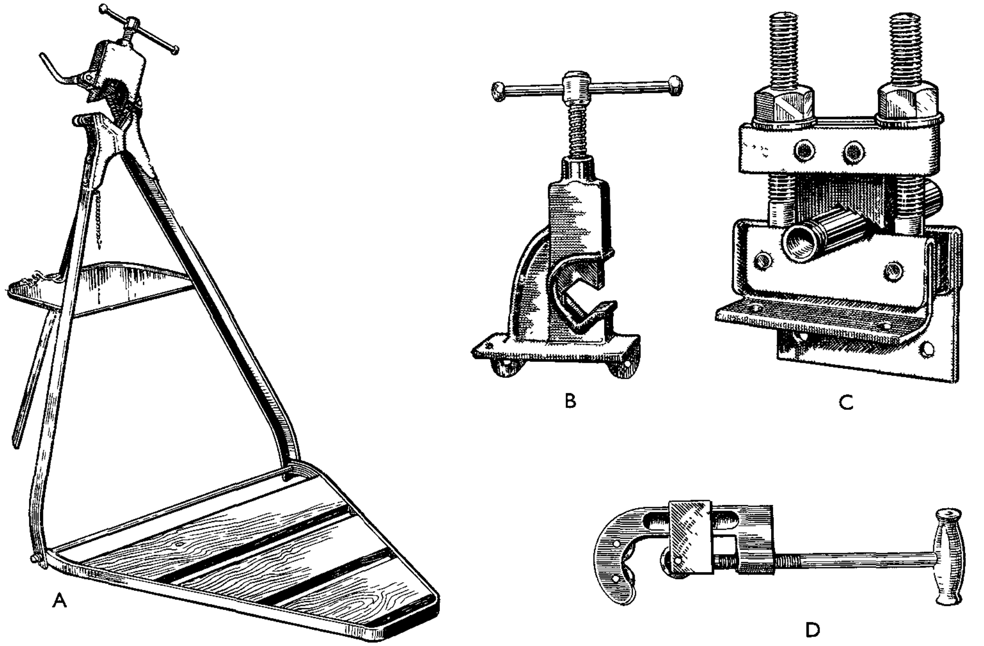
Advantages of an Electric Hammer.

I once calculated, for the purposes of a contract on which I was engaged, that whereas a man would take 12 minutes to make a hole in hollow tile floor for the passage of a conduit if he carried out the work by means of a hand hammer and jumper, it would take him two minutes with an electric hammer and jumper. Now this particular job required 6,000 such holes to be cut; if I can save 10 minutes of a man's time at 1s. 10d. an hour on each hole I should clearly be saving about £90. Since the cost of an electric hammer of this sort was £30, it was quite obvious that the purchase of three such tools would be paid for on this one job alone.

Surface wiring systems require comparatively few tools, but steel conduit systems call for either the exercise of a great deal of ingenuity or, alternatively, for a certain number of tools for their proper erection.

Tools for Cutting Steel Tubing.

Consider: we have a piece of steel tubing 12 ft. in length, and we wish to erect an 8-ft. length from a T to an iron switchbox, and to carry the tube round several corners on its way. First of all we must cut the tube to length,

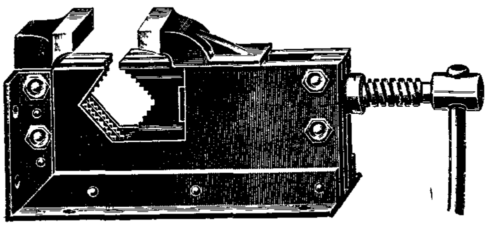


SOME USEFUL TOOLS FOR HOLDING AND CUTTING CONDUIT. (*G.E.C.*)
A, Portable tube vice ; B, Light tube vice ; C, Footprint tube vice ; D, Tube cutters

and for this purpose neither our pocket-knife, our pliers nor our screwdriver is of much use. Clearly we require either a hacksaw, which needs no description, or a wheel tube-cutter. The latter may be bought for about 15s. upwards and the mode of operation can be seen from the illustration here.

Bench and Portable Tube Vices.

But before we can conveniently cut our tube we must have a vice in which to hold it, unless we wish to try the amusing, but not very efficient, experiment of cutting it across our knee. If we have available a solid, well-anchored bench we can buy an ordinary bench vice, to be screwed or bolted to the bench, and which will cost about 12s. 6d. But if the work where we are erecting our tube is away from our own shop or is in some premises where a bench is quite out of the question—and this is likely to be the case in most jobs—then we should certainly consider the purchase of a portable tube vice, which is illustrated herewith. This should cost only something over £2.



COMBINED PARALLEL AND TUBE VICE.

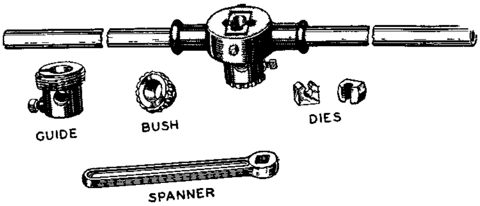
Putting a Thread on the Tubing.

We have then cut our tubing to the required length, but we have still got to put a thread on the end which we have cut, so that it can be screwed into the iron box of the switch. For this purpose we require stocks and dies, which should cost about 10s. for the stocks and for each die the figure varying perhaps from 5s. to 10s., according to the size of the dies required.

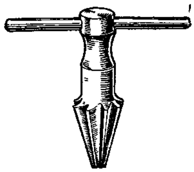
Tap Wrenches.

While on the subject of stocks, although it does not enter into the particular problem which we have in mind at the moment, there are undoubtedly

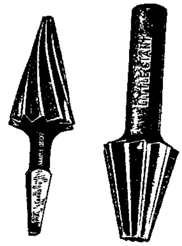
TAP WRENCH



STOCKS AND DIES



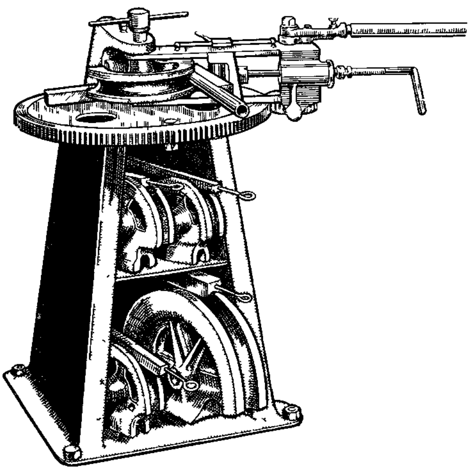
TUBE BURRING REAMER.



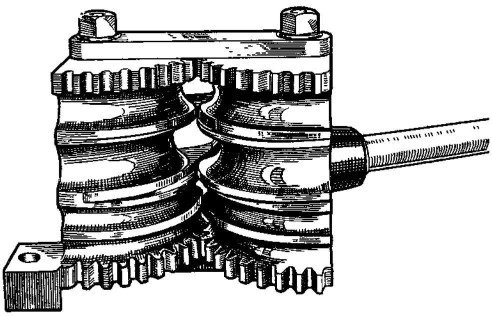
TUBE BURRING REAMERS FOR USE IN VICE

occasions where taps and tap wrenches are desirable. We may be making up some special fitting which requires an internal thread cut in a hole; if we are to consider ourselves well equipped for emergencies of this sort, we should take steps to have in our possession a tapping outfit. In this case a tap wrench will probably cost much the same as the stocks while the price of individual taps is considerably cheaper, starting from a figure as low as 2s. or less.

With the aid of our vice we have, therefore, put a thread on the unthreaded end of our cut conduit (it should be noted that screwed conduit is usually supplied with both ends of each length—about 12 ft. —screwed and one end having on it a socket).



CONDUIT BENDER (*G.E.C.*)
For bending conduit tubing up to 2 in. outside diameter.



BENCH CONDUIT BENDER (*G.E.C.*)
For bending conduit tubing up to $1\frac{1}{4}$ in. outside diameter.

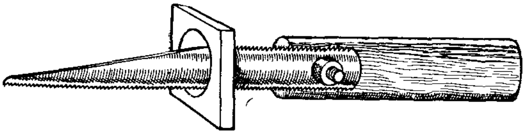
To Remove Burrs from the Inside of the Tube.

At this juncture we have to be most careful that there are no burrs on the inside of the tube which we have cut (also, to be on the safe side, at the end which the manufacturers have cut before delivering the tube to us). For this purpose we require a tube reamer, costing a few shillings only, and illustrated herewith.

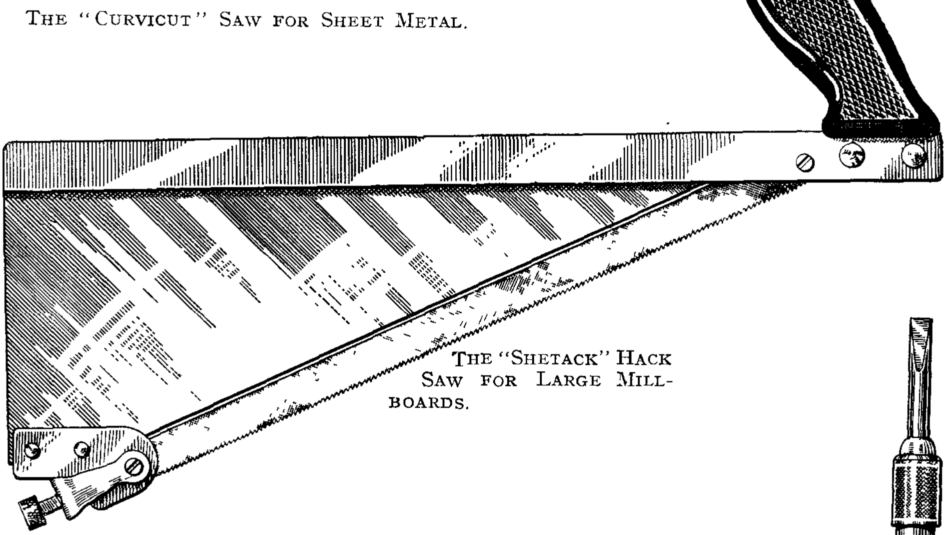
Bending the Tube.

Now comes the question of bending the tube. We have got to bend the tube not into a rough and ready curve, but into an exact curve or set, and possibly in two or three places in its run, so that it falls back neatly against the wall or ceiling. Once again we can, if we like, try setting it across our knee. If we are very strong and don't mind having a bruise on our knee for a bit, this can be accomplished with the lighter forms of tubing.

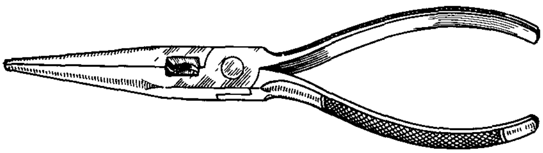
If an old hand were to watch us doing this he would undoubtedly give us a



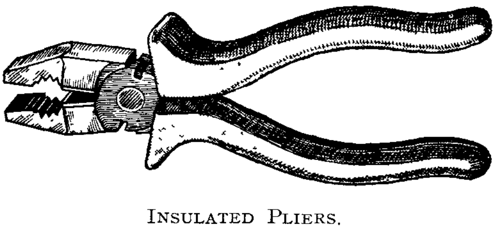
THE "CURVICUT" SAW FOR SHEET METAL.



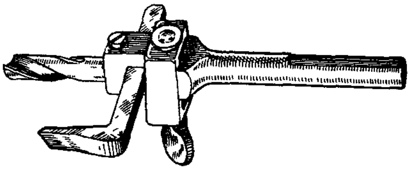
THE "SHETACK" HACK SAW FOR LARGE MILL-BOARDS.



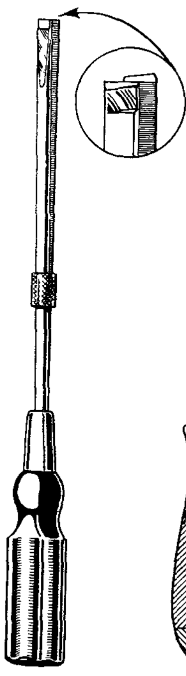
TAPER-NOSED CUTTING PLIERS.



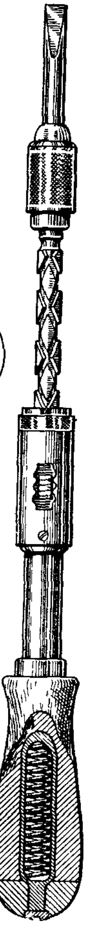
INSULATED PLIERS.



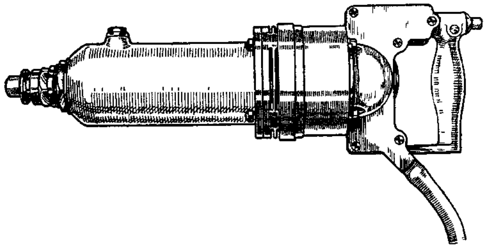
ADJUSTABLE HOLE CUTTER FOR SHEET METAL.



"GRIP" SCREWDRIVER.



"PUSH" OR SPIRAL SCREW-DRIVER



THE KANGO ELECTRIC HAMMER.

useful wrinkle to the effect that we should get a small baulk of timber and drill through it a hole at one end slightly larger than the size of the tube which we wish to bend. He would then show us how we can push the tube through this baulk of timber and, placing the other end of the timber on the ground, get sufficient leverage on the tube to make quite a satisfactory bend.

Mechanical Bender.

There is no doubt that a really skilful electrician, working with a hole in a bit of wood, can make amazingly good and effective bends in the tube. Indeed, it is a system of bending used in a vast number of jobs in progress. It is not a fast method of bending, though, and unless skilfully done is not a particularly efficient method, so that we ought seriously to consider buying a mechanical bender. Now a mechanical bender—a type of which is illustrated herewith—can cost us about £60—but it need not ; it can be purchased for about £6 upwards.

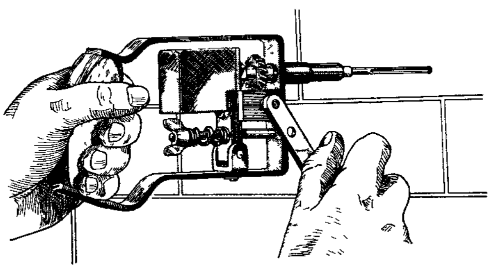
I do not think that any description of the mode of operation which I may make in the text here can possibly help the reader nearly so much as a glance at the illustration, from which it can be quite easily seen how the tube is clamped and brought over a concave roller by means of another concave roller of the same size, so that during the actual process of bending the tube itself, where it is being bent is held in a former which will not permit the tube to lose its cross-sectional shape· Incidentally, however careful a man may be when bending tubes through a hole in a block of wood, there is bound to be a slight, even if hardly perceptible, flattening of the cross-section where he makes his bend. This is clearly not making for efficiency. A mechanical bender, however, produces a clean bend or set without allowing the tube to lose its circular cross-section.

Erecting the Tube in Position.

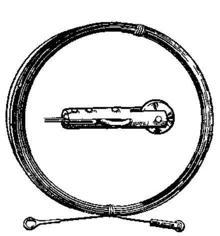
Well, we have made our bend and now we have got to erect our tube into position. We can't tie it up with pieces of string, so we have got to secure it to the wall in some manner ; the way in which this is done is by means of saddles with two screws. But since we cannot put a screw into a brick wall, we must either take a cold chisel and hammer and knock out a chunk of the wall and plug it with wood —the old-fashioned method—or we must take a hammer and steel jumper to jump a small hole, only slightly larger than the size of our screw, insert therein a Rawlplug, and make our saddle and tube a fixture by screwing the saddle into the wall thus plugged.

Kango Electric Hammer.

But here arises the question which I referred to in my opening paragraph. Although the hammer and jumper are perfectly efficient and admirable tools, and though there can be little question that on small jobs it is a much simpler and more economical matter to make the holes in this way, yet there is a very definite point at which pure mathematics will prove that an electric hammer making the holes at a far greater rate repays in the time of the electrician the cost of the hammer. In this connection I am illustrating the Kango hammer, which costs £30, and which requires a certain amount



A USEFUL MECHANICAL HAMMER.



Draw-in Tapes and Wires

of skill in operating, but not nearly so much as one might think.

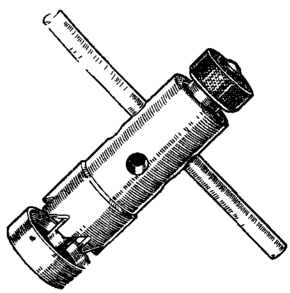
Any number of tools can be fitted to this instrument, which is not only useful for Rawlplugging purposes, but can be used for every sort of chipping, chiseling and cutting. It can with great advantage be used for cutting chases in brick or concrete, for cutting holes in floors, and in many ways be made to save labour on electrical installation work. The manufacturers actually list no fewer than 33 different tools for use with the hammer.

Mechanical Hammer.

If the principle of the automatic hammer is one which is justified by the size of the job, but if the job or likelihood of jobs does not seem to justify the outlay on an electric hammer, there is for the electrician a good compromise in the purely mechanical hammer operated by turning a crank handle which by means of cams delivers a series of blows on the bit, at the same time slowly rotating the bit to ensure a perfect and neat circular hole. Thirty shillings will buy not only the apparatus, but a set of appropriate bits.

Inserting Wires into the Tube.

We have got the tube into position, and we now wish to get our wires in. In this paragraph I must confess that I have to walk very warily, for I am going to refer to that bogey of most consulting engineers, the draw-in tape or draw-in wire. This tool in most quarters is regarded with mingled horror and fear on the part of consulting engineers, as though it were some Loch Ness monster. Many specifications for electric wiring will be found to contain a clause to the effect that no draw-in wire must be used in the introduction of cables into the conduit. The reason for this is obvious. It is that a draw-in wire can be badly abused; it can be used as a means of getting into a tube more wires than the tube should hold and as a means of drawing wires into a tube which is so twisted and bent and flattened that it should contain no wires at all. For this reason its use is forbidden in many specifications. If, however, it is conscientiously and wisely used, it is a very handy tool.



Cooke's Hole Cutter.

It consists of a wire or a steel tape which has flexibility, but a certain amount of rigidity. On to the end of this is fitted a small runner having two little steel wheels. That end of the wire or tape which is carrying this runner is inserted into the end of the tube and pushed forward, the wire or tape being fed in behind it until, rolling along one or other of its little wheels in turn, it emerges at the other end of the tube. The cable to be drawn in is then fastened to the free end of the drawn-in wire which is still protruding from the operator's end of the tube and the draw-in wire is pulled until it has drawn in behind it the cable through the tube. The cost of this draw-in wire is a few shillings only.

Shade Ring Tool

Cooke's Cutters.

Cooke's cutters should form a part of most electricians' equipment. This is an implement for cutting a hole in a steel or iron surface where ordinary drilling or the use of a hammer is out of the question. In using this tool, a small pilot hole is first drilled in the plate, box, tank or other object, after which a centre pin is passed through the hole thus drilled from back to front and the cutter engaged with this pin by means of a thread. The cutter is then screwed down by means of a mill-headed screw until it bears upon the surface of the plate and is then rotated by means of a tommy bar, being perpetually fed down on to the job by means of the mill-headed screw. This tool (which costs from about 20s. per set) is invaluable for cutting holes in water tanks for immersion heaters, holes in draw-in boxes when they are installed in position, and, indeed, for very many jobs within the sphere of operations of the electrician.

Shade Ring Tool.

The shade carrier ring in an electric light fitting is very often in a cramped and almost inaccessible position, particularly where there is a narrow conical or bell-shaped shade. Frequently it is difficult and sometimes impossible to remove and replace this ring without the aid of a shade ring tool, which is a pair of pincers with jaws specially formed to grip the ring.

We are indebted to Messrs. Richard Melhuish (London), Ltd., for the loan of many of the tools illustrated in this article.

OBVIOUS

There are in use to-day thousands of vacuum cleaners and electric irons which are run not from a special plug point, but from a 2-way adaptor fitted into an existing lamp holder. Many of these adaptors are fitted with thumb operated push-bar switches, so that to switch the iron on and off the user has to strain upwards on tip-toe, or else stand on a stool or chair. See Fig. 1.

The simple chain-operated switch shown in Fig. 2 solves this difficulty and affords a quick selling line for the live electrical dealer. A special point about this adaptor, which is known as the " Safeway Adaptor," is that the pull required to operate the switch is extremely light, so that there is no danger of unduly straining the flexible connection between the lamp holder and ceiling rose.

Full particulars of these adaptors can be obtained from The Wenham Lighting Corporation, Ltd., 3 and 4, Henry Street, Gray's Inn Road, London, W.C.1.

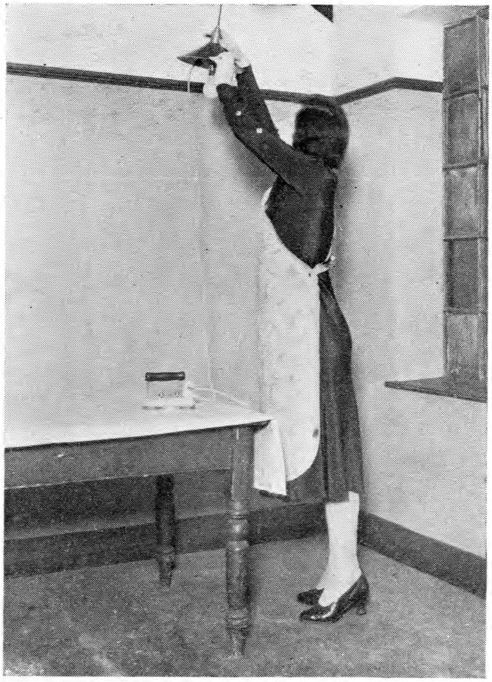


Fig. 1.—THE DIFFICULT WAY.

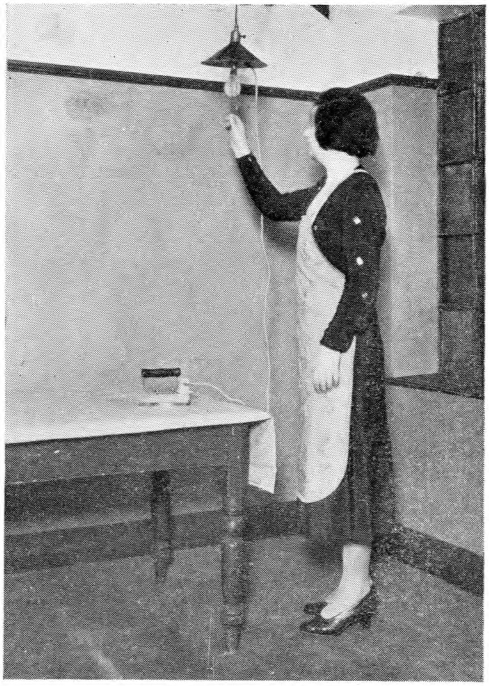


Fig. 2.—THE EASY WAY.

NEON SIGN INSTALLATIONS

IN a most interesting article appearing in the Engineering Supplement of the January issue of the Siemens Magazine Mr. E. A. Beavis gives many interesting practical data.

A Typical Circuit.

Fig. 1 shows the ordinary commercial circuit with fireman's double-pole switch in accordance with the safety regulations.

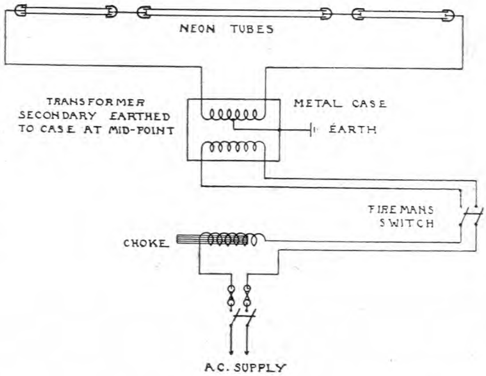


Fig. 1.—AN ORDINARY COMMERCIAL NEON TUBE CIRCUIT.
With fireman's double-pole switch in accordance with the safety regulations.

This switch, which it will be seen is on the primary side of the transformer, should be fixed underneath the sign about 8 feet above street level so that the supply can be cut off from outside in cases of emergency. Notice that the mid point of the secondary winding of the step-up transformer is earthed through the metal case on the transformer. The voltage to earth is

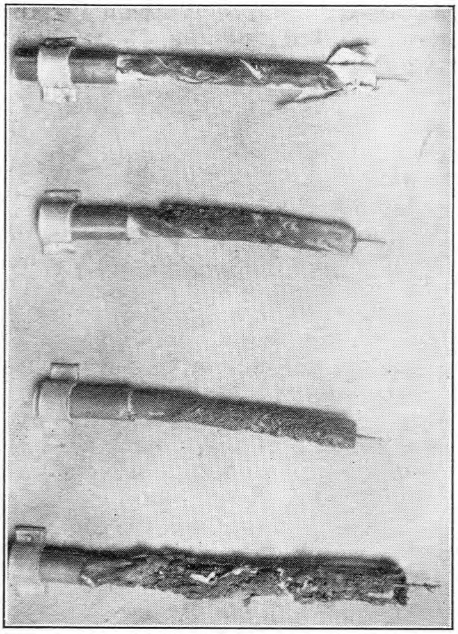


Fig. 2.—PHOTOGRAPH SHOWING CABLE ENDS DAMAGED BY SURFACE LEAKAGE DUE TO MOISTURE.
These show the result of test experiments conducted in the laboratory under excess moisture conditions and with little more than the working voltage. They resemble very closely many of those which have actually been met with in practice.

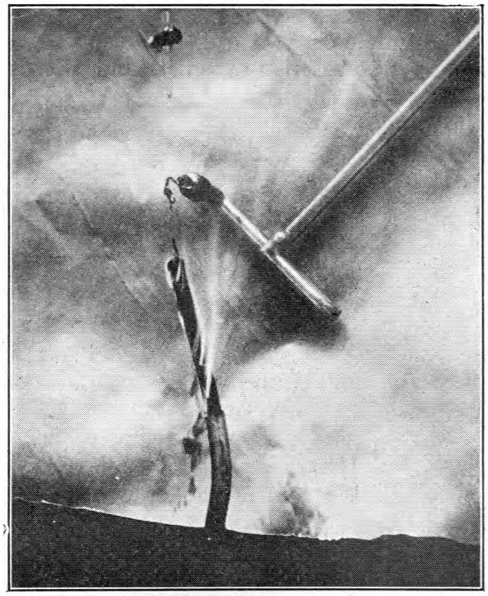


Fig. 3.—A CABLE END ON FIRE DUE TO WATER WHICH HAS BEEN ALLOWED TO DRIP ON THE END, RESULTING IN ACTUALLY BURNING UP UNDER THE LEAKAGE CURRENT PRODUCED.
The only method of definitely avoiding this slow disintregration of the cable end insulation under damp conditions is to cover up the cable termination completely in such a way as not to expose any high-voltage connection to the atmosphere. (See Fig. 4.)

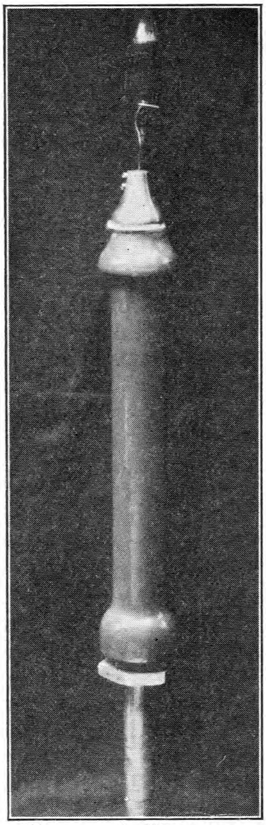


Fig. 4.—A PORCELAIN SEALING END.

thus reduced to half the working voltage of the tubes. The object of this is to minimise dielectric stress on the cables and insulators.

It will be seen that the main supply is led to the transformer primary through a double pole switch, fuse and a choke. The object of this variable choke is to enable the current passing through the tube to be stabilised at the required value so that on the one hand flickering is avoided, and on the other hand the current passing through the tube cannot exceed the safe maximum value.

High Tension Connections to the Tubes.

The working current conveyed through the cables is of the order of 30 milliamperes. It is, therefore, clear that a suitable cable would be a thin conductor protected by very substantial insulation. The usual practice is to use V.I.R. insulated cables with protective lead casing.

The Main Cause of Trouble in Neon Sign Installations.

The majority of troubles experienced with neon sign installations are due to high tension cable faults occurring chiefly where the cables are connected to the tubes. The usual method of making the end connections is to strip the lead sheath back for about six inches from the end of the cable, varnish the exposed insulation and tape over the whole and cover with a bell glass.

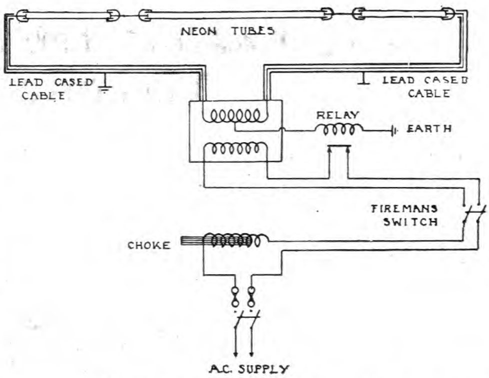


Fig. 5.—NEON TUBE CIRCUIT WITH RELAY CUT-OUT.

A method which has proved more satisfactory is to cover up the cable termination completely in such a way as not to expose any high voltage connection to the atmosphere. This can be done best by using a suitable porcelain fitting as illustrated in Fig. 4.

An Effective Safety Device.

By referring to Fig. 1 it can be seen that should a fault occur on the high tension circuit current will flow to earth. This leakage current, however, cannot in the ordinary way be sufficiently great to cause the main fuses on the primary side to blow. An effective method of protection is given in Fig. 5. It will be seen that a leakage current to earth must flow through a relay. A setting is provided on the relay so that when the leakage current passing through it exceeds a certain amount, a small mercury switch is tilted, thus breaking the circuit in the primary of the transformer.

Readers who are interested should write to Siemens Bros. & Co., Ltd., Woolwich, S.E.18., asking for a copy of the Engineering Supplement to the Siemens Magazine, January 1934, and mentioning the PRACTICAL ELECTRICAL ENGINEER.

An Easily Installed Automatic Telephone System

WE had an opportunity recently of examining an intercommunication telephone system suitable for 2 to 11 lines. This system embodies a basic idea which is sometimes overlooked by manufacturers.

Most British manufacturers today are fully aware of the importance of sound design and good workmanship. The "Shipton" interdial telephone system combines with these two points another very important feature, which is up-to-date appearance.

Fig. 1.—The Desk Type Interdial Instrument.

We hope our readers will pardon us for venturing to point out that this is a feature sometimes overlooked by engineers. The training of an engineer leads him to regard efficiency, economy, and utility as the three factors of major importance with the questions of appearance and fashion relegated to the background. This is perfectly reasonable in the case of many engineering products.

For instance, a turbo alternator, or a rolling mill motor is designed in such a way as to give maximum efficiency, the greatest economy of construction, and maximum utility. The question of appearance cannot be allowed to influence the design to the detriment of any of the three desirable qualities mentioned above.

As soon as an engineering product has to be sold to the non-engineering public other qualities begin to assume greater importance. In the case of motor-car bodywork it is quite obvious that appearance may be of far greater importance than economy of construction. In the case of engine design, silent operation, rapid acceleration and ease of starting have to be given at least equal consideration with mechanical strength and efficiency. But, what has this to do with interdial telephones, you will ask?

Similar in Appearance to Desk Pattern Automatic Telephone.

Just this. In appearance and action the interdial telephone is almost identical with the desk pattern automatic telephone, which has recently been made so familiar to the public by the Post Office Telephone Department. To call up any station on the interdial telephone system the dial on the front of the instrument is pulled round in the same manner as when operating a post office automatic telephone. This selects the required station, and the ringing signal is sent by depressing a button in the centre of the instrument. To answer a call it is merely

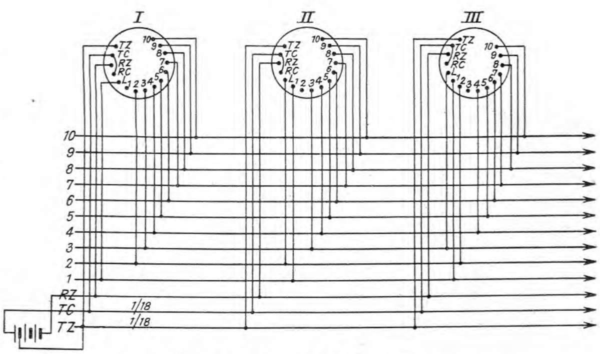
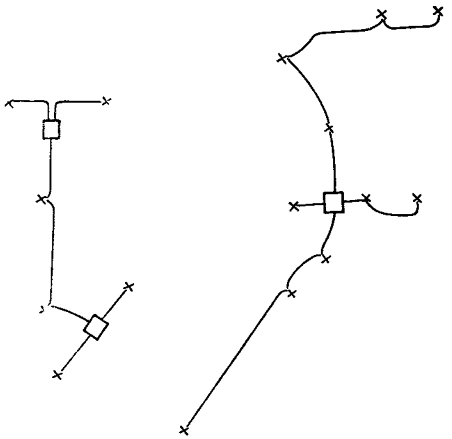


Fig. 2.—A Typical Wiring Diagram. Illustrating a portion of a 10-line system.

necessary to lift telephone from the hook.

Thus, for quite a moderate cost, the user of this type of telephone obtains an instrument which is equal in appearance to that which would be used in a fully automatic system the cost of which might run into a thousand pounds or more, whereas a 10-line installation of the inter-dial system would cost considerably less than one hundred pounds.

In short the system gives a "Rolls Royce" appearance for "Baby Austin" cost. This feature will commend it to many users.



Figs 3 *and* 4.—TYPICAL ARRANGEMENTS FOR A 6-LINE AND 10-LINE SYSTEM.
Note that in the former two 3-way junction boxes are used and in the latter one 4-way junction box

Exceptional Speech Transmission Obtainable with One Dry Cell.

A special feature of this telephone is the exceptional speech transmission obtainable with one dry cell. For ringing purposes two additional cells are usually required. This constitutes the whole of the power; that is to say, three cells only are necessary, fitted in the central position.

Selecting Mechanism.

The selecting mechanism is of a robust nature and consists of materials such as used in the Standard Post Office dial, and consequently long life is ensured in the wear of these components.

Wiring Connections.

The wiring connections are standard with everyday internal telephone practice.

A typical wiring diagram is shown in Fig. 2, which illustrates a portion of a 10-line system. Notice that in this case 13-core cable is used, all the instruments being connected in parallel either by looping in or by the use of junction boxes at selected points.

Figs. 3 and 4 show typical arrangements for a 10-line system and a 6-line system respectively. Notice that in the first case one 4-way junction box is used, whilst in the latter case two 3-way junction boxes are employed. The number and location of the junction boxes depends entirely upon the relative position of the various stations.

In wiring up the instrument note that the terminals TC and RC are bridged.

No Difficulties in Installation.

Some electrical contractors may hesitate to install an intercommunication telephone in an office, works, or factory, preferring to leave this to telephone experts. After examining this particular system we have no hesitation in saying that any electrical man who is familiar with ordinary wiring practice should be able to install and maintain this system.

We suggest that this is a project well worth serious consideration by many of our readers who may be in a position to obtain telephone contracts of this type in their immediate neighbourhood. The makers of the system are prepared to give every facility to reliable contractors who write to "Shipton," c/o the PRACTICAL ELECTRICAL ENGINEER, 8/11, Southampton Street, Strand, W.C. 2.

Controlling Magnetic Apparatus

By H. E. Hutter, A.Am.I.E.E.

THE control of magnetic apparatus such as lifting magnets, magnetic chucks and separators calls for considerable care in the choice of the switchgear if insulation troubles are to be avoided.

In all the apparatus mentioned above the maximum pull per square inch is the ideal aimed at. The pull varies as the square of the lines of force per square inch and consequently a small increase in the value of "B," i.e, lines of force per square inch, will result in a substantial increase in pull. The value of "B" that can be obtained in a magnetic circuit depends on the product of the amperes flowing in the magnetising coil and the number of turns. The current is always kept as low a value as possible and thus to obtain sufficient ampere turns the number of turns will be large.

When an inductive circuit is broken the collapse of the magnetic field caused by the dying away of the magnetising force induces a very high voltage through these lines of force cutting the turns composing the coil. This effect can be seen at the make and break of the electric bell when a small spark can be seen every time the trembler breaks contact with the contact pillar.

It will thus be understood that with a coil consisting of a large number of turns and possibly carrying 100 amperes the induced voltage may rise to several thousand volts with considerable danger to the coil insulation by breakdown unless suitable precautions are taken when breaking the circuit.

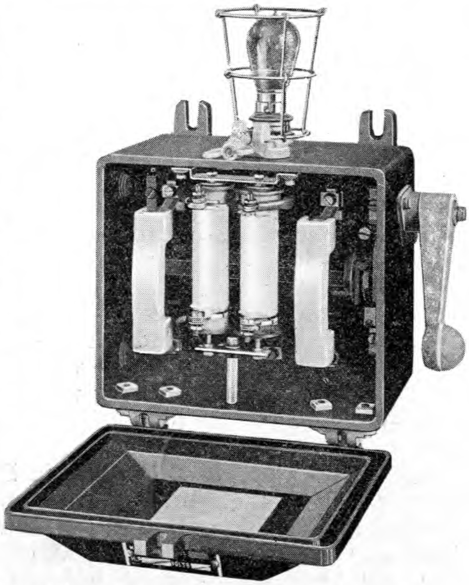


Fig. 1.—A Typical Switch for Small Currents. (*Rapid Magnetting Machine Co., Ltd.*).

The Basic Principle.

The basic principle of this type of control gear is to arrange a non-inductive resistance so that at the instant of opening the supply circuit it is connected across the magnet winding, providing a path for the latter to discharge without any danger of the voltage rising sufficiently to damage the insulation.

Typical Switch for Small Currents.

A typical switch for small currents is illustrated in Fig. 1. The non-inductive resistance units can clearly be seen between the fuses. A drum type movement makes contact with the resistances before actually breaking the supply circuit.

Controllers for Largest Types of Separators and Magnetic Pulleys.

The largest types of separators and magnetic pulleys are equipped with controllers and arranged so that resistance is gradually cut out as the field builds up. To open the circuit the controller handle is moved backwards and thus reinserts the resistance before opening the circuit.

The fact that once a core has been fully magnetised the current can be slightly reduced due to the retentivity of the iron is the basis of the patent potentiometer system of the Rapid Magnetting Machine

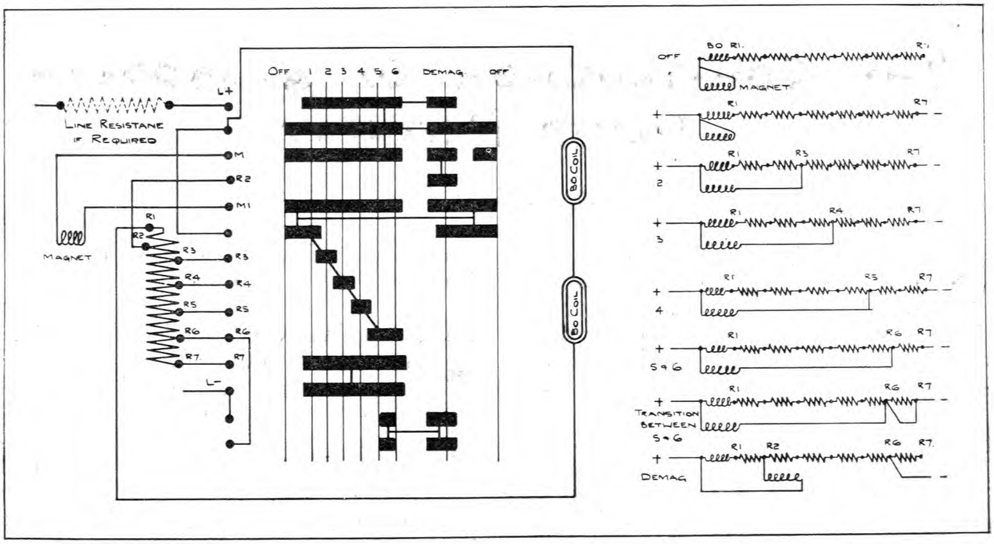


Fig. 2.—TYPICAL DIAGRAM OF CONNECTION AND THE DEVELOPED SCHEME OF CONTROLLER SHOWN IN FIG. 3.

Co. used chiefly for lifting magnets.

The greatest difficulty with lifting magnets is that the space available for the magnetising coil is very limited and to obtain the maximum magnetising force it is necessary to run the coil at the highest economical temperature. The resistance of copper increases with increase in temperature and consequently the magnetising current is cut down as the temperature rises.

With the patent system mentioned, on switching on the controller the resistance is gradually cut out until the full line voltage is on the coil, then a further movement of the controller inserts a section of resistance into circuit again and reduces the line current. The coil is wound for the voltage that will be across it when the resistance is in circuit.

The application of the higher voltage across the coil wound for a lower voltage ensures that the cores are saturated and due to the retentivity of the iron the pull remains the same even with the reduced current.

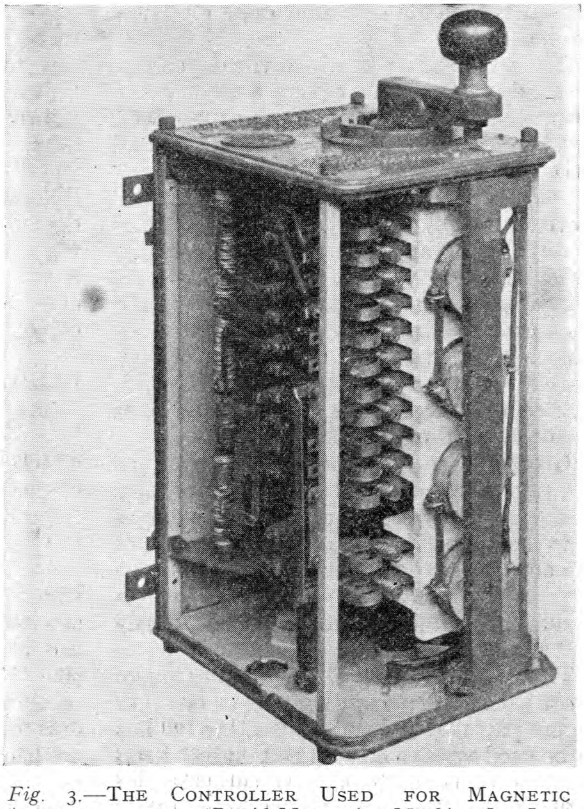


Fig. 3.—THE CONTROLLER USED FOR MAGNETIC APPARATUS. (*Rapid Magnetting Machine Co., Ltd.*)

THE CONSTRUCTION OF A MODERN SILVER REFINERY

By C. C. Downie

SILVER refining to-day is very largely conducted by means of applied electrolytic systems, and little doubt now remains that they represent the most efficient, rapid, and accurate means of recovering the pure metal.

From an experimental point of view, silver is a simple metal to deposit electrolytically, and the same holds good on the large scale, but in consequence of the great monetary value at stake, the deposition of the refined metal must be absolute.

The construction of the electrolytic refinery does not call for any very special skill, but the layout of the plant is usually left in the hands of a first class electrical engineer.

The whole plant in which the deposition is conducted seldom covers a floor space of much more than a hundred square feet, not including the current supply plant and accessories.

Current Supply Plant.

As a general rule, the latter seldom differ materially from the layout of a fairly large plating shop. That is, the construction of the electrical units, or rather the fitting up of motor, bus bars, panels, switch-gear, leads, and cables, is carried out very much on the same lines as for general electroplating practice.

Greater care is necessary, however, as the electrolyte employed is composed of a dilute solution of nitric acid, which is always slightly decomposed as a result of the action of the current.

Insulating Material Has to be Freely Used.

The gases thus evolved readily make short work of any exposed copper or other metal parts, and insulating material has to be used very freely. The building itself is made of concrete, and is composed of two storeys, the bottom floor housing the generator, and the upper floor containing the electrolysis plant.

Floor and Walls Should be Coated with Anti-corrosive Lining.

The floor and walls should be coated with asbestos paint, or other anti-corrosive lining, whilst provision is made to remove all noxious gases by means of a system of electric fans which continuously draw currents of air out of the building. The generator in the bottom flat is practically sealed in, and no corrosive gases can get near it.

The leads from the generator reach the upper floor through a channel, and are directly connected to the panel on which are fitted the switches, ammeters, and voltmeters, etc.

From thence the current is led along bus bars, which are held in suspension by wooden struts, and linked up to the different deposition vats. In the plant described, copper bus bars were used, which it was thought was an error, since aluminium bus bars are practically as effective, and can largely resist the corrosion of the nitric acid gases.

Construction of the Vats.

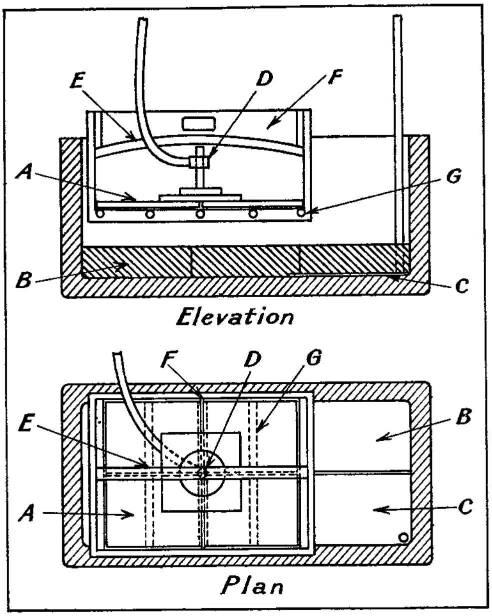
The refining of the silver is prosecuted in a series of eight stoneware vats each of which contains approximately 22 gallons of electrolyte. The charge to be electrolysed consists of what is known as "parting plates." (In the earlier stages of the process, the various materials containing silver and other precious metals are smelted, from which the products obtained are a rich lead alloy, a "matte" and slag. The lead alloy is cleaned by skimming which removes much of the copper and other impurities, after which it is transferred to a cupellation furnace which removes the lead, etc., so that only the "noble" metals remain. These latter comprise silver, gold, platinum, and minute quantities of the rarer metals.)

The Cathode.

The vats are furnished with a set of graphite blocks which are lined along the complete bottom and fitted together by means of a special cement. This represents the cathode for each vat.

The Anode.

The rich silver alloy from the cupellation furnace is cast into anode moulds (made of iron) and the plates from thence are fitted into special open box frames which are placed above the graphite bottom and represent the anode. The sides of the box frame are made of wood, whilst the bottom is composed of a set of thick glass rods, and the space between these rods allows free access to the flow of the electrolyte. A cloth bag is fitted as closely as possible to the bottom and walls of the box, and immediately inside this bag is the set of silver plates representing the anode. As the electrolysis proceeds, the gold and platinum metals remain behind in the form of a dark sludge in this cloth bag.



Design for Silver Electrolysis Vats

A, silver anode parting plates; B, graphite cathode blocks; C, copper plate; D, copper rod; E, wooden bar; F, wooden box frame; G, glass rods.

How Current is Led from Bus Bars.

The current is led from the bus bars to the graphite cathodes by means of a copper plate situated below the blocks, and sealed from the acid. The silver anodes, usually four in number, are placed in position on top of the glass rods in the box, inside the bag, whilst a smaller silver plate (usually one left over from the previous electrolysis) is placed on top of the others.

How the Copper Rod is Held.

The cable from the bus bar is attached to a copper rod specially cast with a small flat circular plate at the immersed end, and a lug at the further extremity. In place of having parts which require screwing into position, the copper rod with attached plate is simply held tightly in position by means of a wooden bar stretched across the tank. In this manner, the setting up of the units for prosecuting the electrolysis is conducted very rapidly. When starting afresh, with the green coloured electrolyte, the cloth which acts as a diaphragm is fixed in position in the wooden box. The four silver anodes are placed in the space, a small anode remnant used to connect the four plates, the copper rod and plate placed on top of the latter, and forced under the wooden bar.

By attaching the cable to the top of the rod all connections are made, as the cathode connection to the carbon blocks is a permanent one.

The whole operation only occupies a few minutes.

Prior to electrolysing the silver plates, they are fully assayed.

Some of these are richer in platinum and palladium than others, and it is necessary to number them and select four for each tank, so that any excess does not interfere with the progress of the electrolysis.

Action of the Current.

Each tank is only about half filled, the electrolyte in each case being only a fraction of an inch above the level of the plates. In this way, the active areas between anode and cathode of the different tanks is considerable. No useful purpose can be served by increasing the volume of the electrolyte, and as bank interest is at stake, no waste of time could be tolerated, and it is, therefore, necessary to connect additional tanks where more electrolysis is required.

Two sets of four tanks are connected in parallel. The electrolysis proceeds without hindrance until the silver anodes have been corroded away, which usually occupies from two to three days.

The bus bars above the tanks have a connecting bar (of copper) which is then unbolted, so that one set of four tanks may be disconnected. The wooden box frames are then raised from these four tanks, and the black gold mud scraped from the cloths, which is then subjected to a further refining process.

How the Silver Deposited on the Graphite Blocks is Removed.

The silver which has been deposited on the graphite blocks as a fine shining crystalline deposit, is removed daily, without interruption to the progress of the electrolysis. This is done by scraping out the white mass with wooden poles, to which are attached leather shoes. The open end of the tank, i.e. that end opposite where the wooden box frame is situated, leaves ample space in which to remove the silver deposit.

How Current is Applied.

Current efficiency, and also the aggregate power consumed, do not come in for the same scrutiny as in other electrolytic plants, as the main feature from an electrical standpoint is to recover the silver deposit as rapidly as possible. Current is applied at fifty amps. per square foot. The resistance set up by different silver plates does not vary very appreciably, but an excess of impurities in the electrolyte, after continued use, tends to raise this, and may be noted by the reading on the voltmeter.

In view of the value of the products, comparatively little regard is paid to the power consumed, but in the construction of the plant, the maximum efficiency is expected on the trial runs.

Best results are secured with a space between anode and cathode of about $1\frac{1}{2}$ in., and using a freshly made electrolyte.

Practical Details.

Most of the remaining points are more of a chemical than an electrical nature, and the construction of the refinery necessitates a training in both sciences. The operating of the plant does not require the services of skilled labour, but the various products have to be fully analysed.

The Electrolyte Solution.

The electrolyte consists of a 0.5 per cent. solution of nitric acid, and the attendant tests this daily in each tank to see that this concentration is maintained. The copper content of the solution tends to rise as the acid content rises. Copper is determined daily, and should not exceed four per cent. of the solution.

More than this amount of copper would be injurious to the quality of the deposit, but too little copper tends to allow the silver to deposit in a too fluffy condition. It is, therefore, necessary to add a small amount of copper to the electrolyte in some instances.

About Half Gallon of Electrolyte Should be Removed Daily.

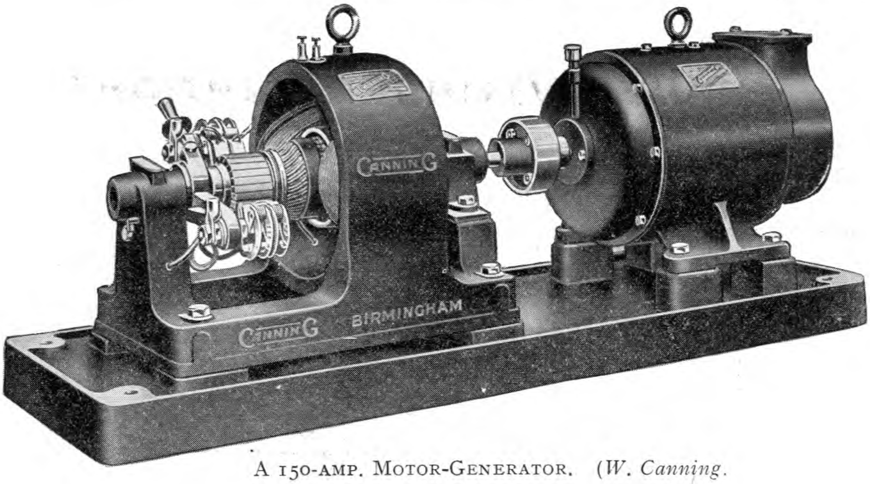
Silver in solution is also tested daily, and should be maintained at three per cent. Instead of working an electrolyte until it is foul with impurities, and then disposing of it, it is customary to remove about half a gallon of the solution daily from each tank.

Instead of replacing this with fresh weak acid which would thus unduly reduce the fixed three per cent. silver content, a solution of silver nitrate is added. This is made by dissolving some 200 ounces of silver deposit in about 2 gallons of dilute nitric acid, and adding it proportionately to the different tanks.

A Summary of the Operations.

To sum up these operations, the attendant's work is as follows :—

The electrolyte is tested daily to see



A 150-AMP. MOTOR-GENERATOR. (*W. Canning.*

that it is maintained at 0.5 per cent. nitric acid, 3 per cent. silver, and up to a maximum of 4 per cent. copper.

Half a gallon of liquor is removed from each electrolyte daily and replaced by an equivalent amount of silver nitrate solution.

The silver deposit is removed daily, without disturbing the electrolysis. Every second or third day, the silver anodes have been dissolved away, in one set of four tanks, which are then disconnected for removal of the gold mud.

The small portions of the electrolyte removed daily are accumulated, the silver precipitated from them by addition of copper scrap, or common salt, and the residue returned to the smelting process. As a general rule, some 20,000 ounces of silver are removed daily, whilst the black gold slimes, removed twice weekly, amount to from 3,000 to 5,000 ounces. The totals recovered from each individual tank are not noted, after the initial trials have been made. The silver deposit and gold anode slimes are dried over an ordinary gas burner system, when they are accurately weighed and removed for disposal.

The Composition of the Products.

As regards the composition of the products, the silver deposit should be represented by at least 99.9 per cent. of silver, the remaining point being made up of moisture, carbon particles which have been scraped off the cathode blocks, and an infinitesimal fraction of gold.

The parting plates used as anodes contain from 80–95 per cent. silver, 5–20 per cent. gold, 0.2–1 per cent. platinum, and 0.1 per cent. palladium.

The gold slimes recovered from the cloth bag after reduction and boiling in sulphuric acid, contain about 94 per cent. gold, 3–4 per cent. platinum, and 0.4 per cent. palladium.

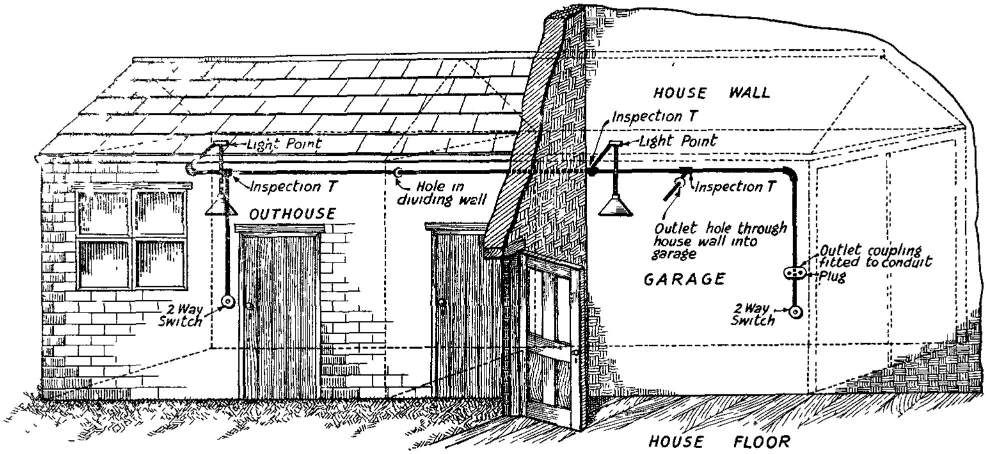
The action of the current causes a slight circulation in the bath, and raises the temperature somewhat, both features being beneficial to the process.

So far as the electrical engineer's work is concerned, except for the cementing of the graphite blocks, and the slightly different system of connecting the anodes and cathodes, the construction scarcely differs from that of an ordinary plating plant. The graphite blocks are embedded in Purimachos cement. The cloth bags prior to use are washed in boiling water to remove any loading contained in the texture. The efficiency of the refinery in practice is represented by about 75 per cent. of the input, but theoretically the ampere efficiency is calculated at about 94 per cent.

House Wiring Extensions

FITTING LIGHTING AND POWER POINTS IN A GARAGE AND OUTHOUSE

By H. W. Johnson



Layout of Conduit in Garage and Outhouse for Lighting Points and Plug for Inspection Lamp.

A MODERN dwelling house should have satisfactory provision made for lighting and power points in the garage and outhouse, and unless the building contractor or the prospective tenant is electrically minded, the electrician is rarely instructed to fix the necessary wiring and accessories for the necessary points, when installing the house wiring.

The Requirements.

The garage should have a central light fitting which has two-way switch control, one switch being fixed at a convenient point in the house and the other switch at the entrance to the garage. Two plug points should be fitted, one to supply an inspection hand lamp, and the other to give a power supply to the radiator.

The outhouse, which may be used for washing, should have a central light fitting which has two-way switch control similar to the garage light fitting, also two plug points to give a power supply to a wash boiler and a washing machine respectively.

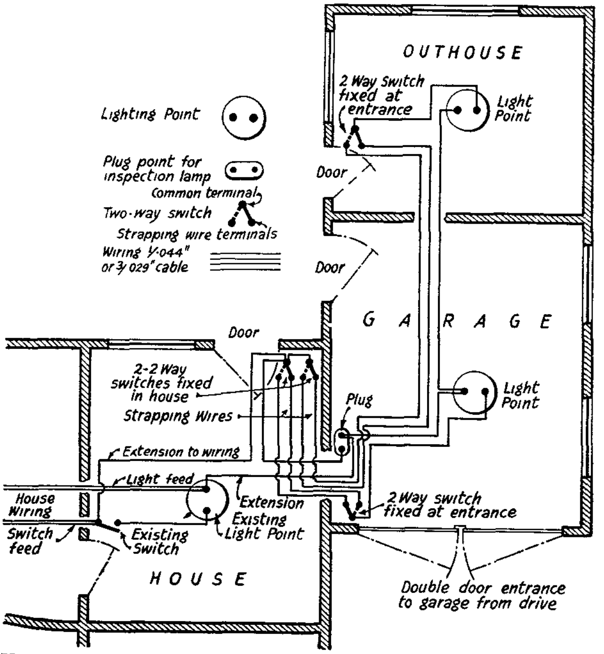
The Supply for the Lighting.

The rules of the Institution of Electrical Engineers state that before an addition is made to an installation care should be taken to ascertain whether the existing wiring, switches, etc., affected by the addition are of sufficient current-carrying capacity for the augmented current which they may have to carry.

Generally the existing wiring, switches, etc., for the house-lighting points have sufficient capacity to carry the small additional current occasioned by the garage and outhouse lighting points.

The Supply for the Power.

The current which will be taken by the power appliances will be considerable, and it is almost certain that a new pair of mains will have to be run from the main switch in the house. In certain circum-



WIRING DIAGRAM SHOWING EXTENSION OF HOUSE WIRING TO THE GARAGE AND OUTHOUSE LIGHTING AND PLUG POINTS.
Note that the lines indicating the wiring do not indicate the actual conduit runs.

stances it will save considerable trouble and disturbance to the structure of the house, due to running this pair of mains, by having a new service brought by the Supply Company's authority into the garage.

If the house service is used, the capacity of the existing main switch must be ascertained, and if insufficient to carry the augmented current occasioned by the power appliances, a new switch having the correct current-carrying capacity will have to be fixed.

Notifying the Supply Authority.

The Supply Company should be notified of the proposed extension to the installation, and full details given to them of the nature and loading of the consuming appliances to be used.

The Connections from the House Wiring for the Lighting.

The terminal connections of the extension from the house wiring will be obtained at the "light feed" connection of the ceiling rose of a light point and "switch feed" connection of the switch controlling this point, nearest to the garage. The "switch feed" connection is the "live" terminal connection to the switch and the "light feed" connection is the connection of the wire from the main to the ceiling rose. Between the "light feed" and the "switch feed" exists the full "mains" voltage.

The Material Required for the Lighting.

$\frac{3}{4}$ inch diam. galvanised conduit. This size of conduit is required on account of the strapping wires connecting the two-way switches in the house to those in the garage and the outhouse.

3/.029 in. or 1/.044 VIR.C.M.A. 600 megohm grade cable.

$\frac{3}{4}$ in. inspection-type galvanised conduit T's.

$\frac{3}{4}$ in. galvanised conduit couplings.

1—$6\frac{1}{2}$ in. × $3\frac{1}{2}$ in. rectangular wooden pateras 1 in. deep.

5—$3\frac{1}{2}$ in. circular wooden pateras 1 in. deep.

4—S P. Bakelite two-way switches

1—5-ampere Wylex fused plug and socket.

$\frac{3}{4}$ in. conduit saddles.

2—H.O -type lampholders for lighting points.

2—Porcelain ceiling roses.

14/.0072 in. workshop circular cored flexible for lighting points.

Preparing for the Conduit Run from the House Light Point.

The trap in the floor immediately above the light point is opened, and the floor board under which the wiring from the light point to the switch runs, is carefully removed. If the wiring is in conduit there will be an inspection T at the corner where the wiring drops from the floor to the switch on the wall below. The floor board from the trap to the wall, through which the conduit to the garage will pass, is also removed.

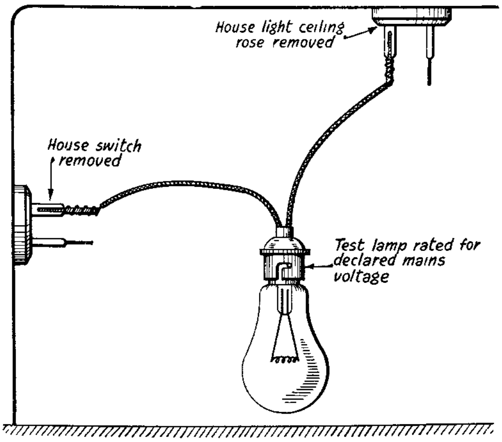
The height of the eaves of the garage above the garage floor is measured, and if this distance is greater than the height of the floor in which the run of conduit will be fixed, a $\frac{3}{4}$-inch diameter hole is drilled through the wall to give an outlet into the garage for the conduit run. When this distance is less, then the hole will be drilled through the wall from the room below at such a height from the floor that he hole gives an outlet into the garage, and a channel is cut in the plaster ¾ inch wide and ¾ inch deep from the hole to the floor from which the conduit will pass.

Should the garage be detached from the house, the conduit will pass through the hole in the wall, and continue overhead outside, and then pass through into the garage through a hole which will have to be drilled through the garage wall. A hole is also drilled through the walls which separate the garage from the outhouse, so that the conduit may be continued from the garage to the outhouse. The floor joists between the trap and the outlet hole to the garage are slotted ¾ inch deep and ¾ inch wide to accommodate the run of conduit.

The position of the two-way switches in the house which will control the garage and outhouse lights is fixed, and a channel ¾ inch deep and ¾ inch wide is cut in the plaster on the wall from this position to the outlet hole to the garage.

The Conduit Runs in the Garage and Outhouse.

Fix the position of the lighting points in the garage and outhouse and their respective switch positions at the doors, also the position of the plug point in the garage. This position could be immediately above the switch position, but



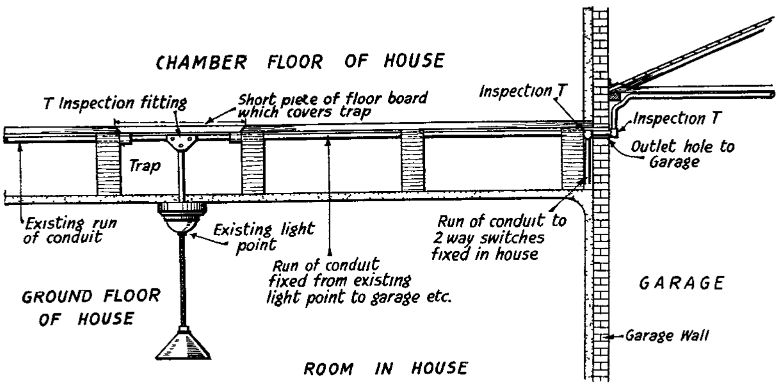
Method of Finding the House Light and Switch Feeds which are Used as the Supply Terminals for the Extension Wiring.
The lamp glows when connected across the light and switch feed.

should not be less than six feet above floor level. The conduit runs to these positions from the outlet hole in the garage are marked off, and, where necessary for fixing the conduit, the walls are drilled and plugged at intervals of about 4 feet.

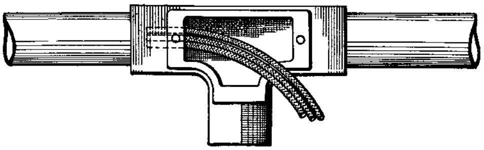
The plugs should be rectangular in shape, 1½ inches wide, ¾ inch thick, and 2½ inches long. Two plugs should be fitted at each of the switch positions and the plug position, to give a secure fixing for the patrasses.

Cutting, Screwing, and Bending the Conduit.

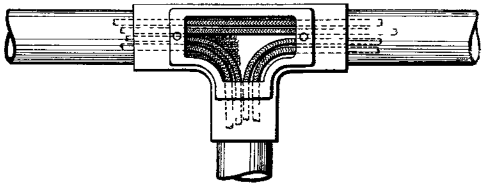
When the conduit is to be fitted it will have to be cut to definite lengths; to be screwed, in order to make joints with the various inspection fittings, and to connect up with other lengths of conduit, also to be bent, when it is desired to change the direction of run.



The Conduit Run From the Trap to the Garage.
The trap is opened by removing the short piece of floor board between the two joists. A T inspection is fitted to the existing house conduit at the outlet to the house lighting point in the trap.



ENTERING CABLES INTO THE CONDUIT AT AN INSPECTION T FITTING.



SHOWING CABLES PASSING THROUGH AN INSPECTION T FITTING.

Conduit should be cut with a metal hack saw blade and all " burrs " removed from the inside edges after the cut is made. A special die, which cuts electrical threads, is fitted in a suitable stock and is used for cutting threads on the conduit. Do not screw the conduit for a greater length than is necessary, and use a liberal amount of oil lubrication when cutting the threads. A $\frac{3}{4}$-inch conduit die cuts 16 threads per inch.

Conduit is bent cold ; the seam of the conduit should always be at right angles to the direction of the bend. The bending operation may be done by placing the conduit over the knee at the point where the bend is required, and a steady pressure applied at the ends of the conduit.

It is better, of course, to use a special conduit bender if one is available.

Running and Fixing the Conduit.

The various parts of the run are measured up, and the conduit cut to these lengths and screwed where the ends are to be joined together, or fitted into the inspection T fittings.

The junction to the existing conduit at the light point in the house is made by fitting an inspection T on the conduit at its outlet to the point. Before this may be done the main switch will have to be turned off and the wiring at the ceiling rose disconnected and drawn back into the trap. The conduit is fixed to the walls, etc., with saddles. An outlet coupling should be fitted in the conduit run to the two-way switch in the garage, where it passes behind the pateras, to which the inspection-lamp plug socket will be fixed.

The Wiring.

The 1/.044 in. V.I.R. cable which is used for the wiring is to be obtained in two colours, red and black, and the wiring is considerably facilitated if both these colours are used.

Measure up the following distances, and cut off from the supply of cable lengths equal to the measured distances, allowing 1 ft. on each length for connection to the fittings and accessories.

(1) Red cable : House switch controlling house light, to the house two-way switch positions, controlling the garage and outhouse lights.

(2) Black cable : House light to lighting plug in the garage.

(3) Red cable : Two-way switch position in house to lighting plug in garage.

(4) Two red cables : Two-way switch position in house to two-way switch in garage. (These two cables are marked at each end for identification.)

(5) Two red cables : Two-way switch position in house to two-way switch in outhouse. (These two cables are marked at each end for identification.)

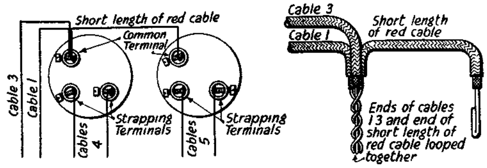
(6) Black cable : Lighting plug in garage to central light in garage.

(7) Black cable : Central light in garage to outhouse light.

(8) Red cable : Two-way switch in garage to central light in garage.

(9) Red cable : Two-way switch in outhouse to outhouse light.

Great care should be taken to avoid " twists " and " kinks " in the various lengths of cable when taking them from the coils. The method to adopt for taking off the various lengths of cable to avoid



THE TERMINAL CONNECTIONS OF THE CABLES TO THE TWO TWO-WAY SWITCHES, FIXED IN THE HOUSE, CONTROLLING THE GARAGE AND OUTHOUSE LIGHTS.

" kinks " and twists is to mount the coils on a rotating drum, and pull the lengths off the coils as required, or to roll the coils across a clean dry floor until the required lengths are run off.

Threading the Wiring into the Conduit.

The most convenient point in the conduit to commence with the wiring is at the inspection T which is fitted in the house floor adjacent to the garage wall.

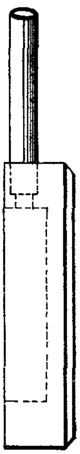
At this point one end of each of the cables 1, 2, 3, 4 (two) and 5 (two) are entered into the conduit.

Cables 1 and 2 are threaded along the main run towards the house switch and light positions respectively, where the supply for the wiring will be obtained. Cable 1 will be guided from the floor run of conduit to the wall run at the inspection T fitted here, and so on to the switch.

Cables 3, 4, 5 and the remaining end of cable 1 will be threaded down the branch run of conduit to the two-way switch positions in the house.

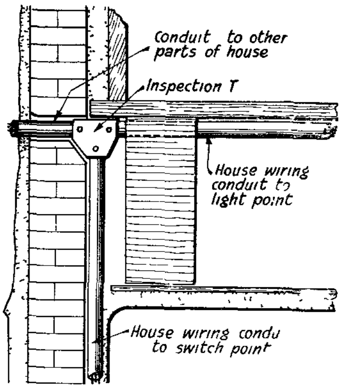
All the various ends are drawn out at their respective positions for about 6 in. to allow for their terminal connections.

The remaining ends of cables 2, 3, 4 and 5 are now threaded through to the inspection T fitted at the outlet hole in the garage, and at this point cables 5 are threaded along the garage run towards the outhouse two-way switch position, whilst cables 2, 3 and 4 are threaded along the conduit run to the lighting plug position. At this point cables 4 and one end of cable 8 are threaded to the two-way garage switch position, which is at the end of this run.



Socketing the End of Conduit Into a Pateras.

From the lighting plug position in the garage, the remaining end of cable 8 and one end of cable 6 are threaded into the conduit and run towards the central light position in the garage. Beyond the inspection T at the outlet hole in the garage, they will keep company with cables 5 until the inspection T is reached, where a short run of conduit branches



Cable 1 is Threaded Through the Existing Run of House Conduit to the House Switch Position for Connection to the House Switch Feed.

off to the light position. At this point one end of cable 7 is threaded into this branch and run along with cables 8 and 6 to the light position.

The remaining end of cable 7 is threaded into the conduit at this inspection T, and run along with cables 5, until they reach the inspection T in the outhouse. Here cables 5 and one end of cable 9 are threaded down the run of conduit to the two-way switch position in the outhouse, and the remaining end of cable 9 and cable 7 threaded to the outhouse light position. The whole of the wiring is now threaded into the conduit and all the covers of the inspection T's may be replaced.

Fixing the Patrasses.

The patrasses are marked off and drilled, for the fixing and cable holes on their faces, and the conduit entry holes at their sides. A $6\frac{1}{2}$-in. by $3\frac{1}{2}$-in. pateras will be used at the two-way switch position in the house. At this position two two-way switches are to be fixed. The ends of the cables are drawn through the holes in the faces of the patrasses and the ends of the conduit socketed into the holes in the sides of the patrasses. A $\frac{3}{4}$ in. diameter hole is drilled rather more than half-way through the side of the pateras and the hole finally completed through the side with a $\frac{5}{8}$-in. twist drill. The end of the conduit is then socketed into the hole. The ledge of wood against which the end of the conduit butts forms a bush and protects the insulation of the cables from being damaged by the edges of the conduit. The patrasses are now firmly fixed in position with suitable wood screws.

"Looping-in" the Ends of the Cables.

The ends of the various cables are cut off to a suitable length to allow of their connection to the accessories, and, in addition, a little slack wire, which may be pushed behind the patrasses when the connections are made.

The insulation is now stripped off from the end of each cable for about 1 in. and the bared ends cleaned where necessary.

The ends are now "looped" together where necessary as indicated in the wiring diagram :—

At the house switch, end of cable 1 to house lighting switch feed.

At the house light, end of cable 2 to house lighting light feed.

At the house two-way switch positions controlling garage and outhouse lights, end of cable 3, to a short piece of red cable, which is used as a feed of the second two-way switch, and the end of cable 1, three ends are joined.

At the garage lighting plug, end of cable 2 to end of cable 6.

At the garage central light fitting, end of cable 6 to end of cable 7.

The various ends must be carefully twisted together so as to make a good "loop-in" connection.

If the colours of the various cables have been adhered to, the identification of the various ends for "looping-in" will be a comparatively simple matter.

Connecting and Fixing the Accessories and Fittings to the Wiring.

The covers are removed from the various accessories, and their terminal screws screwed back to allow of free entry of the bared cables into the terminal holes.

The bared ends must be pushed through the holes so that no bare wires are visible at the back of the accessories. The terminal screws are tightened up to have a good grip on the wires, and any excess lengths of the wires which project beyond the front of the terminals are cut off flush.

Particular care must be observed when making the two-way switch connections.

At the house two-way switch position the common terminal of the two-way switch controlling the central garage light is connected to the "looped-in" ends of cables 1 and 3 and the short piece of red cable. The two strapping terminals of this switch are connected to the ends of cables 4, which have been marked. The common terminal of the two-way switch controlling the outhouse light is connected to the remaining end of the short piece of red cable, whilst the two strapping terminals are connected to the marked ends of cables 5.

At the garage two-way switch the common terminal is connected to the end of cable 8, and the two strapping terminals are connected to the ends of cables 4.

At the two-way switch in the outhouse the common terminal is connected to the end of cable 9, and the two strapping terminals are connected to the ends of cables 5.

Make sure the main switch is turned off before the supply connections at the house switch, and light feeds, are made to the ends of cables 1 and 2 respectively. The lampholder for the garage light is connected to the ceiling rose with a length of workshop flexible wire.

Inspection and Testing of the Extension to the Wiring.

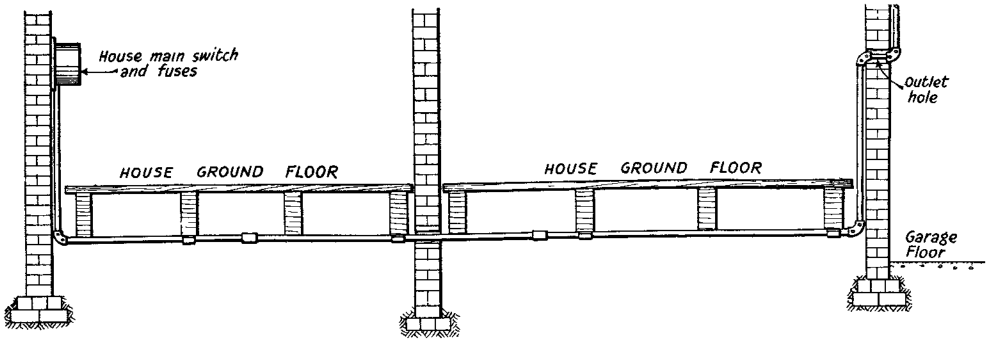
The supply company must be communicated with when all the connections are made and the lamps fitted in their positions. Their inspector will make an inspection of the work which has been done, and an insulation resistance test of the wiring. If the work done and the test obtained is satisfactory the current may then be switched on.

WIRING FOR THE POWER PLUGS.

This part of the work is in reality not an extension to the existing wiring, but an entirely new installation, and must be treated as such.

There are two ways of getting a power supply into the garage and outhouse.

The first method is to run a pair of cables in conduit under the ground floor of the house, from the main fuses in the house to a distribution board, which will be fixed in a suitable position in the garage or



THE RUN OF CONDUIT FROM THE HOUSE MAIN FUSES TO THE GARAGE FOR THE POWER SUPPLY CABLES

outhouse. The second method is to request the supply company to run a pair of service cables from their street mains into the garage or outhouse. This method will generally necessitate the fixing of an extra meter, a main double-pole switch and main fuses in addition to a distribution board.

The distribution board will supply the various plugs with current. A circuit for each plug supplied is run from the various pairs of fuses on the distribution board.

The first method suggested is possibly the less expensive, and will not create an excessive amount of labour, or serious interference with the structure of the building, when the mains are run under the ground floor.

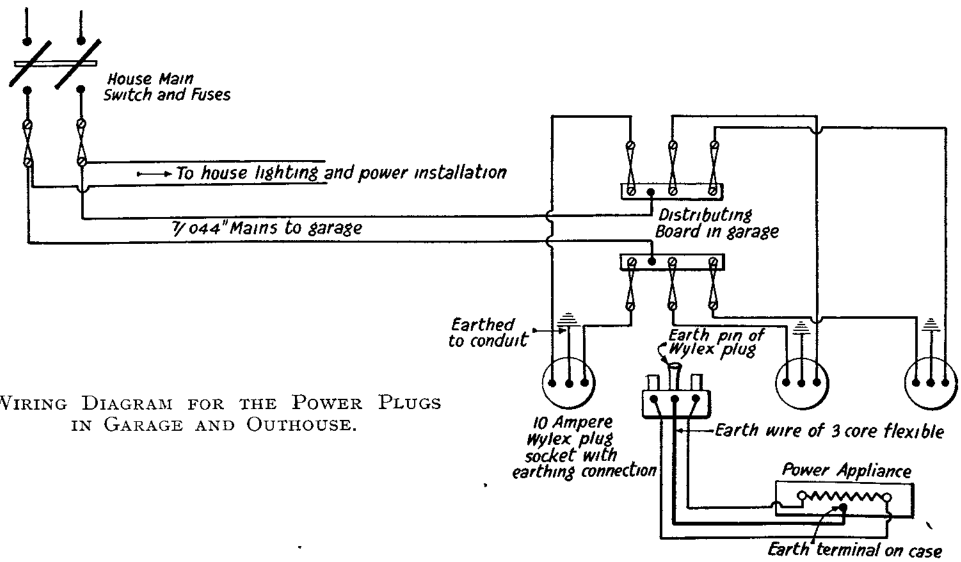
The Size of Cable Required.

The current required by which each of the appliances which are to be used is found from their loading particulars, and the total current for all can then be determined. A cable large enough to carry this total current is then selected for the mains, which will be run from the house main fuses to the distribution board in the garage or outhouse.

For example, if a total current of 25 amperes is required, then a 7/.044-in. cable will be required for the mains.

The Circuit Cables.

Each plug to be supplied will have a pair of cables run to it from the distribution board, and the cables connected



WIRING DIAGRAM FOR THE POWER PLUGS IN GARAGE AND OUTHOUSE.

to a pair of fuses which will protect the circuit. For example, the cables must be large enough to carry the current which the appliance connected to that plug will take.

A radiator for the garage taking 10 amperes will require a 10-ampere Wylex plug or some other form of switch plug, which will be connected to the distributing board with a pair of 3/.036-in. cables.

The Conduit Runs.

Holes should be cut through the ground floor, at a point immediately below the main house fuses, and a point at the house wall adjacent to the garage, also a hole through the house wall adjacent to the garage, just above the hole through the ground floor. The diameter of these holes will depend upon the conduit; if the mains are 7/.044 in. cable, then $\frac{3}{4}$-in. diameter conduit will be required.

The position of the distributing board is fixed; a good position would be about 6 ft. immediately above the outlet hole in the garage.

The conduit runs from the distributing board to the plug positions are marked out, and the walls along the lines of run plugged at intervals for saddles which will secure the conduit to the wall; $\frac{5}{8}$-in. diameter conduit will be suitable for the plug circuits from the distributing board. The plug positions must not be less than 6 ft. above the floor.

Fixing the Conduit.

Admission under the house floor may be obtained through a " trap " which is made by cutting three adjacent floor boards between a convenient pair of floor joists. The conduit is secured to the underneath surfaces of the joists, holes being cut through the dividing walls under the floor, where it is necessary to continue the run from the outlet hole in the floor underneath the main fuses, to the outlet hole in the floor adjacent to the house wall; here the conduit comes up through the floor in readiness for passing through the outlet hole into the garage. Inspection elbows will be fitted at each of these points.

The Wiring.

The various runs are measured up, and the cables cut off to the required lengths; they are then threaded into the conduit runs in a similar manner to those which were threaded for the lighting extension.

Connecting the Distributing Board and Plugs to the Wiring.

The distributing board is fixed in position, and the ends of the conduit runs secured into the sides of the iron case with suitable lock nuts; the ends of the conduit which pass inside the case must be fitted with hard rubber bushes. The ends of the mains are connected to the bus bars with sweating sockets, and each pair of circuit cases connected to a pair of fuses which are opposite to each other.

At each of the plug positions, a socket is connected to the wiring; the end of a short third wire at each position is connected to the earth terminal of the socket, the other end of this wire being secured to the conduit, which has been cleaned at this point, with an earthing clip.

The Connection to the Main House Fuses.

Communicate with the supply company and request them to take out their fuses. The main switch and fuses are then replaced with new ones which will safely carry the augmented current occasioned by the new power load.

The ends of the mains are then looped into the main fuse terminals.

Connecting the Plugs to the Appliances.

The various power appliances are connected to the plugs with suitable lengths of three-core flexible. Make sure that the earthing wires of these flexibles are connected to the correct terminals of the plug and the appliance.

If the distributing board is iron cased, the case is connected to the water main with a 7/.044 wire; make the connection to the case with a sweating socket, and the connection to the water main with an earthing clip. If the distributing board case is made of wood or non-conducting material, the conduit must be earthed to the water main.

Inspection and Testing.

There must be an inspection of the work done and an insulation resistance test of the wiring and appliances by the Supply Company's inspector before the current is switched on.

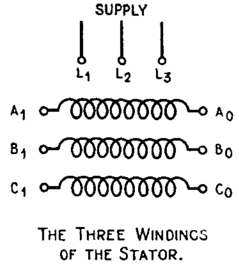
STARTORS FOR THREE-PHASE INDUCTION MOTORS

By J. V. BRITTAIN, B.Sc., A.M.I.E.E., A.M.I.Mech.E.

EXCEPT for small motors, some apparatus is necessary for use in starting up an induction motor in order to prevent the starting current from reaching too high a value. If a motor is switched straight on to the line, the starting current, immediately it is switched on, will be from three to six times the normal current taken by the motor on full load. This is not a serious matter with a small motor developing 1 or 2 h.p., as the normal full load current is only a few amperes.

When Starting Gear is Necessary.

With larger motors, however, this sudden demand for current would upset the supply system, and thus a supply authority usually fixes a limit to the size of motor which can be switched straight on to the supply. This limit varies from 2 h.p. to 10 h.p., but it can be assumed that any motor above 10 h.p. must definitely have proper starting apparatus.



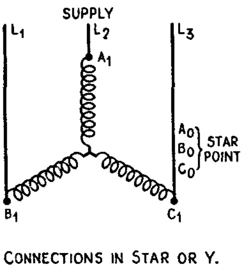
(a)

Fig. 1.—(*a*) THE THREE SEPARATE WINDINGS OF THE STATOR OF A SQUIRREL-CAGE INDUCTION MOTOR.

The methods of connecting the winding terminals with the three supply lines for starting and running are illustrated in Figs. 1 (*b*) and 1 (*c*)

Methods of Starting.

The nature of this starting gear depends on the type of motor employed and the actual service which it renders. This latter point refers particularly to the load against which the motor has to start. In some cases the motor is started without any load at all or with very little load, such as a line shaft; this is, of course, the easiest case to deal with. Next we get the motor which has to start up against a portion of the load and finally the motor which must start up against full load.



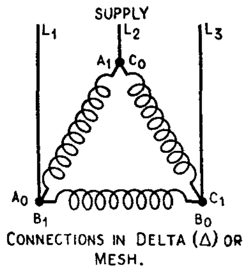
(b)

Fig. 1.—(*b*) "STAR" CONNECTIONS FOR STARTING SQUIRREL-CAGE MOTOR.

STAR-DELTA METHOD OF STARTING FOR SQUIRREL-CAGE MOTOR.

For a drive which can be started up light or with very little load, a *squirrel-cage* motor is used, and is started up by the *star-delta* method. Referring to Fig. 1, the stator of the squirrel-cage motor consists of three windings brought out to six terminals, as shown in Fig. 1 (*a*). The three-phase supply will have three supply wires, as indicated by L_1, L_2 and L_3.

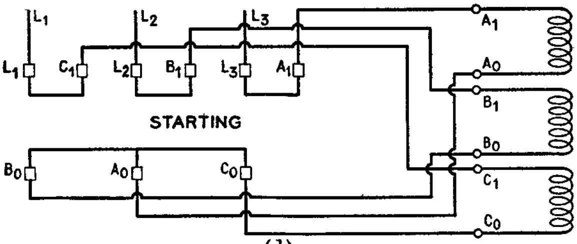
These three windings can be connected up to the supply either in *star* or in *delta*, Figs. 1 (*b*) and 1 (*c*), and when running the machine is arranged in delta, as in (*c*). If, however, the motor is connected in star instead of delta, it will only take one-third as much current in starting. This fact is made use of to give us a starting position, and the connections will be as shown in the theoretical diagram (*b*). The actual manner in which the three windings shown in



(c)

Fig. 1.—(*c*) "DELTA" CONNECTIONS FOR RUNNING SQUIRREL-CAGE MOTOR.

sketch (*a*) can be arranged to form either (*b*) or (*c*) should be thoroughly understood. The letters A_1, B_1, C_1, and A_0, B_0, C_0, will enable the connections to be followed.

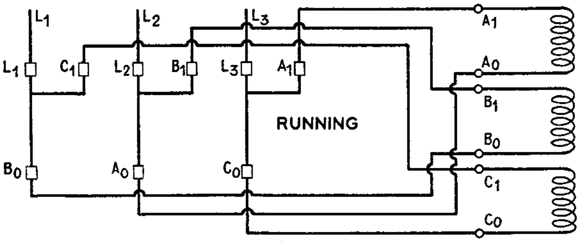


(d)

Fig. 1.—(*d*) STAR-DELTA STARTOR IN STARTING POSITION.

Actual Connections for Starting.

The actual startors used in practice generally have nine terminals, as shown in Fig. 1 (*d*), which shows the connections in the starting position. It will be seen that there are three line terminals, L_1, L_2 and L_3, to which the supply is connected and six motor terminals (one to each end of each of the three windings). For starting, the *star-point* is obtained by short-circuiting the three contacts A_0, B_0 and C_0, while one of the line wires is connected to each of the terminals A_1, B_1 and C_1. If the connections to the three windings on the right of sketch (*d*, are now traced out, it will be found that these windings are in the form shown in sketch (*b*), *i.e.*, in star.

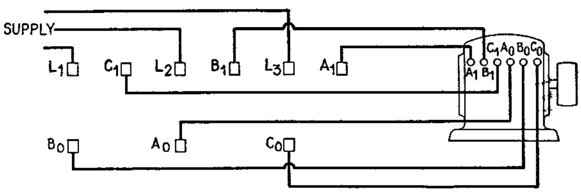


(e)

Fig 1.—(*e*) STAR-DELTA STARTOR IN RUNNING POSITION.

Running Position.

For the running position when the motor is up to speed, the windings have to be in delta, and this is obtained as drawn in diagram (*e*). To form this delta connection the points A_1C_0, B_1A_0 and C_1B_0 are made into three common points, and one line of the supply connected to each.



ACTUAL CONNECTIONS TO MOTOR.
(f)

Fig 1.—(*f*) ACTUAL CONNECTIONS FROM STAR-DELTA STARTOR TO SQUIRREL-CAGE MOTOR.

This forms the delta connection, as will be seen by tracing out the connections.

The actual terminals on the motor may be marked in various ways, but that shown in diagram (*f*) is the usual arrangement, and this diagram gives the actual connections to the motor without showing the switching connections inside the startor. There are thus six wires to be run between the startor and the motor for a star-delta startor.

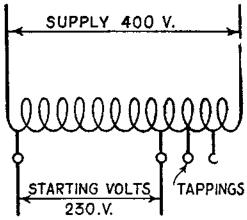
With a squirrel-cage motor there are no connections whatever to the rotor, and the connections shown in diagram (*f*) are all that are necessary.

AUTO-TRANSFORMER METHOD.

Use of an Auto-transformer for Starting Squirrel-cage Motor.

Another method of starting up a squirrel-cage motor is that making use of an *auto-transformer*. The principle of the auto-transformer will be seen by reference to Fig. 2 (*a*), which shows a single-phase winding. If the full supply voltage is connected across the whole of the winding, then any fraction of this voltage can be obtained by tapping off at different points as shown. In the diagram there are three tapping points which would give approximately 60, 70 and 80 per cent. of the full voltage.

By using an auto-transformer it is possible to apply a reduced voltage to the motor for starting and thus limit the starting current by this means. If the supply is 400 volts, this can be reduced to 230 or 240 volts for starting, as shown in sketch (*a*). The provision of two or three tappings allows an adjustment to be made, so that if 60 per cent. of the full voltage does not provide sufficient starting torque the tapping can be altered to 70 per cent., or, if necessary, to 80 per cent. Once this setting is found suitable, it is fixed at that point, and is not variable without opening the case and remaking the connections.



(a)

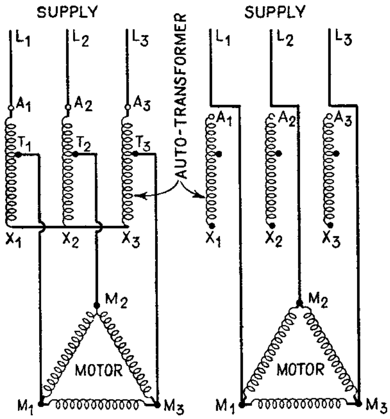
Fig 2.—(*a*) PRINCIPLE OF THE AUTO-TRANSFORMER.

Showing single-phase winding Any fraction of full voltage of supply can be obtained by tapping off at different points, as shown.

The theoretical diagrams for the starting and running positions for a three-phase auto-transformer startor are given in Figs. 2 (*b*) and (*c*). The motor windings are permanently arranged in delta for ordinary voltages and the three leads are taken either to the tappings on the transformer for starting or direct to the supply for the running position.

The actual manner in which these connections are obtained in an actual startor is given in Figs. 2 (*d*) and (*e*). Referring to diagram (*d*), which shows the starting position, it will be seen that the startor is actually a form of four-pole change-over switch. In this arrangement it is connected to the left for starting and then thrown over to the right for running.

The star-point of the auto - transformer is formed by joining X_1, X_2 and X_3, and this is done by the bottom blade of the switch. For starting, the other three contacts join the motor connections M_1, M_2 and M_3 to the tappings T_1, T_2 and T_3. The change-over to the running position disconnects the three contacts forming the star-point of the transformer and puts the motor connections direct on to the supply. The contact D is merely a dummy in this arrangement.



(b) STARTING. **(c)** RUNNING.

Fig 2 —(*b*) THEORETICAL DIAGRAM OF THREE-PHASE AUTO-TRANSFORMER IN STARTING POSITION.

Fig. 2.—(*c*) THEORETICAL DIAGRAM OF THREE-PHASE AUTO-TRANSFORMER IN RUNNING POSITION.

Method of Connecting up Auto-transformer.

The actual connecting up of a startor of this type is fairly simple, since it is only necessary to connect up the supply to the line terminals L_1, L_2 and L_3 and the motor leads to M_1, M_2 and M_3. There will thus be only three leads between the motor and the startor when using the auto-transformer method of starting.

STARTING SLIP-RING MOTOR.

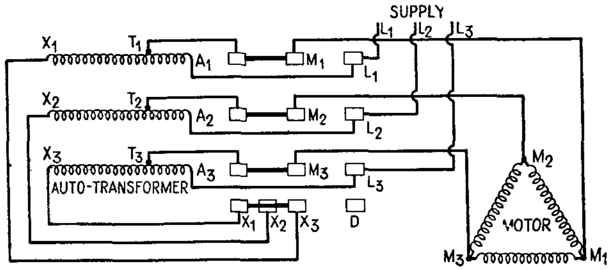
For a motor which is permanently connected to its load and which will have to start up against full load, an induction motor will have to be of the *wound-rotor* type generally referred to as a *slip-ring* motor. In this type of motor the rotor winding is brought out to three slip-rings, which are mounted on the rotor shaft. These slip-rings are for the purpose of inserting resistance in the rotor circuit for starting purposes.

Resistances Inserted in Rotor Circuit for Starting Purposes.

This resistance, which is put in the rotor circuit, prevents the starting current from being excessive and enables the motor to start against a heavy load.

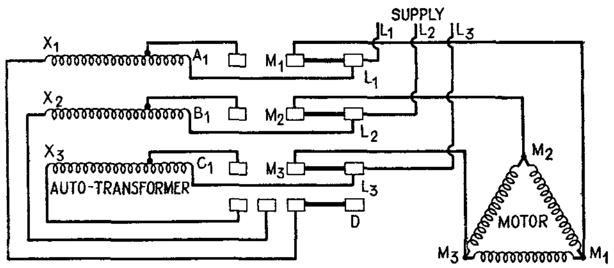
The diagram of connections for this type of motor is given in Fig. 3, and the method of starting is shown diagrammatically at (*a*), (*b*), (*c*) and (*d*). In sketch (*a*) it will be seen that the supply is taken direct to the stator winding, and, as far as actual starting gearing is concerned, there is no control in the circuit except the main control switch, which is not shown in the first four diagrams.

The slip-rings are connected by means of leads from the brushes to three variable resistances which are "starred" at one common point, as indicated. For starting purposes the startor must be in the position giving all the resistance in circuit, as in sketch (*a*). As the motor speeds up the resistances are gradually cut, and an intermediate step is shown in sketch (*b*). Finally, as the motor reaches full speed the last steps of the resistances are cut out and the slip-rings are then practically short-circuited, except for the resistance of the leads from the brushes to the rotor resistances.



(d) STARTING POSITION.

Fig. 2.—(*d*) CONNECTIONS TO ACTUAL AUTO-TRANSFORMER STARTOR—STARTING POSITION.



(e) RUNNING POSITION.

Fig. 2.—(*e*) CONNECTIONS TO ACTUAL AUTO-TRANSFORMER STARTOR—RUNNING POSITION.

Running Position.

The motor is then in the running position, as shown in sketch (*c*). In the case of motors which run for fairly long periods, it is often usual to arrange for the brushes to be lifted and the slip-rings to be short-circuited. This is done by a lever on the end of the motor shaft, and this state of affairs is indicated by sketch (*d*).

The provision of this brush-lifting gear has the advantages of avoiding brush friction, which results in wear of brushes and slip-rings, and of doing away with the losses in the leads to the rotor resistances. Where this refinement is not provided, the connections are left as shown in (*c*).

Actual Connections.

The actual connections which are required in practice are very similar to those given in the theoretical diagrams, and a fuller wiring diagram is given in Fig. 3 (*e*). The stator is connected to the supply by means of the main stator switch, which will have the necessary overload and no volt coils. The rotor is connected by means of the slip-rings to the rotor stator, which consists of the resistances described above.

Faceplate Type of Rotor Startor

The rotor startor drawn in this diagram is that known as a *faceplate* type, and six positions are shown. The process of starting, consists of setting the rotor startor to the start position (that shown in full in the diagram) and then closing the stator switch. The rotor startor is then moved in a clockwise direction until the running position is reached (as shown dotted).

The actual connections will thus consist of three stator leads, M_1, M_2 and M_3, from the stator switch to the stator terminals and three rotor leads from the slip-ring terminals, R_1, R_2 and R_3, to the three terminals, on the rotor startor. Whatever type of rotor startor is used, the connections will be essentially the same, and there should be no difficulty in tracing the terminal connections out.

Reference has been made to the fact that the rotor startor must be set in the "start" position before the main stator

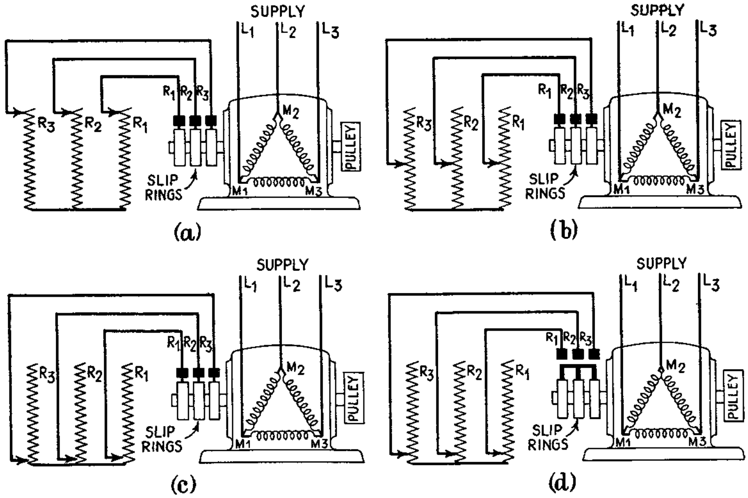


Fig. 3 —STARTING OF SLIP-RING MOTORS.
Theoretical diagrams of connections : (*a*) starting position, (*b*) intermediate position, (*c*) running position, (*d*) with brushes lifted and rings short-circuited.

switch is closed. It will be readily understood that this is essential in order to prevent this excessive starting current which we have to avoid.

Interlocking.

In all modern gear this is made more or less foolproof by interlocking—either mechanical or electrical. This interlocking consists of an arrangement whereby the stator switch cannot be closed unless the rotor startor is in the " start " position.

Cutting Out Resistance Gradually.

In the better types of startors for three-phase slip-ring motors, the actual motion of the contacts which shut out the sections of resistance in the rotor circuit is worked by a worm gear or other form of " slow-motion." This is in order to prevent the resistance being cut out too quickly, which would cause excessive starting current. This process of cutting out the resistance in the rotor circuit of the motor must be done gradually. Modern startors are generally designed so that with ordinary care a smooth start can be obtained without any special skill.

The Liquid Rotor Startor.

A form of rotor startor which gives a very steady start is the " liquid" type in which the resistance takes the form of a solution of common soda in water. The resistance is gradually decreased by lowering plates into the liquid until finally the liquid is short-circuited in the running position. This form is, however, rather bulky and, owing to the gassing of the liquid, is not suitable for all purposes.

Emergency Stopping of Motors.

Emergency pushes can be installed at as many points as required in order to stop the motor in case everything is not in order. The pressing of one of these stop-pushes releases the starting handle in the case of a squirrel-cage motor, and opens the main stator switch in the case of a slip-ring motor. Thus in case of emergency the operator does not have to walk across the room to stop the machine. These stop-pushes short-circuit the no-volt coil on the startor, thus allowing the handle to return automatically to the " off " position.

Automatic Control.

It will be seen from the diagrams that have been given here that startors for three-phase motors can be suitably adapted to automatic control.

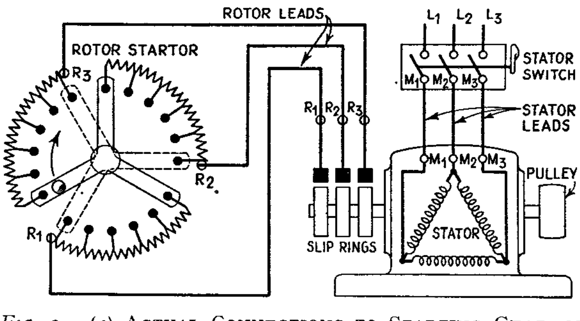


Fig. 3.—(*e*) ACTUAL CONNECTIONS TO STARTING GEAR OF SLIP-RING MOTOR.

THREE WAYS OF JOINING ELECTRIC WIRING

AS every electrical installation engineer knows there are three standard methods of making connections inside the junction boxes which are used on house lighting circuits. These three methods are illustrated in the accompanying series of photographs.

The first method which is probably the most popular is to use single-way, two-way or three-way porcelain connectors. This method is illustrated in the second series of photographs. It involves unscrewing and screwing up a number of tiny screws, but gives a perfectly sound job.

The second method involves the use of special junction boxes containing terminal posts into which the ends of the wires to be connected are inserted. It makes quite a neat job but can only be used provided the special junction boxes are employed.

The third method has been introduced only recently but is rapidly spreading amongst the more up-to-date electrical installation engineers. This method is illustrated in the third series of pictures and depends upon the use of thimble - shaped porcelain connectors known as "Scruits" which screw on to the ends of the two cables which have to be connected. The lower part of the fitting also screws on to the insulation of the cables thus making a water-tight job.

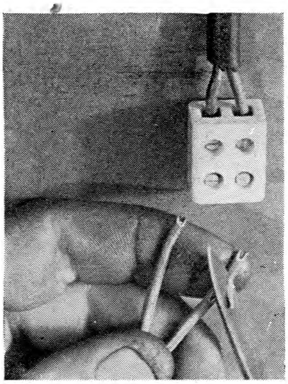


Fig. 1.—A PORCELAIN 2-WAY CONNECTOR.

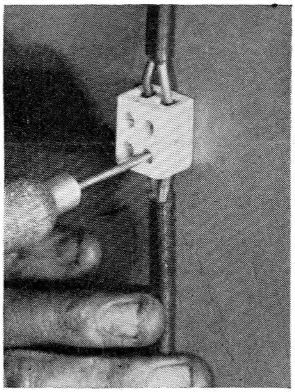


Fig. 2.—THE COMPLETED JOINT. Time taken for stripping wires and completing joint, 4 minutes.

The photographs show three methods. We think our readers may be interested to note the times taken in each case.

To wire up a 4-way junction box with terminal pillars took 12 minutes. To wire up a 4-way junction box using Scruit connectors and correctly bonding the metal sheaths of the cables took 8 minutes.

To join a pair of twin lead-covered cables using a 2-way porcelain connector took exactly 4 minutes. To effect the same joint using Scruit connectors takes under 2 minutes. (These times include removing the lead covering and insulation).

Scruit connectors, which are British made, are obtainable from the G. V. Manufacturing Co., Ltd., Gorst Road, Park Royal, London, N.W. 10, who will be pleased to send samples for test to any reader who sends them a postcard mentioning this Journal.

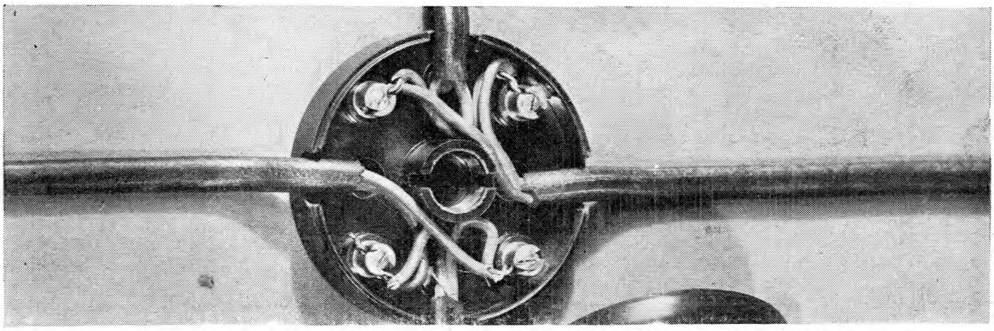
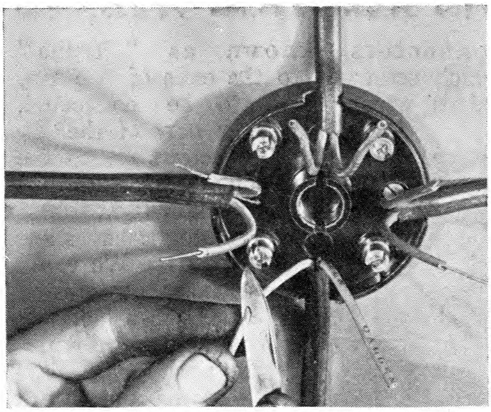


Fig. 3.—THE WYLEX JUNCTION BOX PARTICULARLY SUITED FOR C.T.S. CABLE. Note that the internal connections are made by side of terminal post inside box.



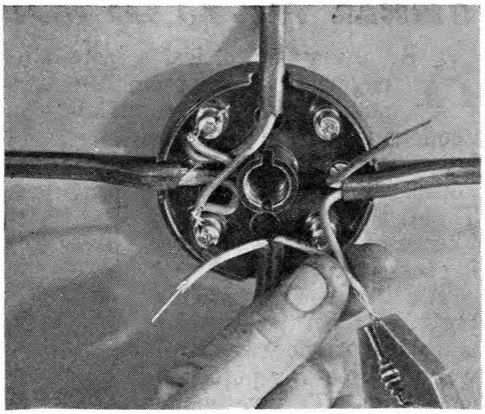


Fig. 4.—WIRING THE WYLEX JUNCTION BOX. *Fig.* 5.—TWISTING THE WIRES TOGETHER.
The time taken for the complete operation shown was 12 mins.

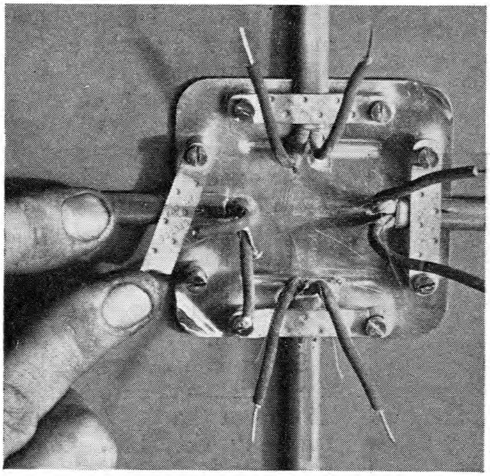


Fig. 6.—THE SCRUIT METHOD.
Bonding the cable sheath.

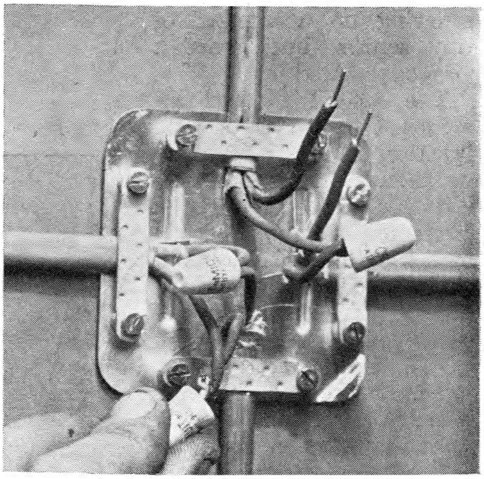


Fig. 7.—THE SCRUIT METHOD.
Making the internal connections.

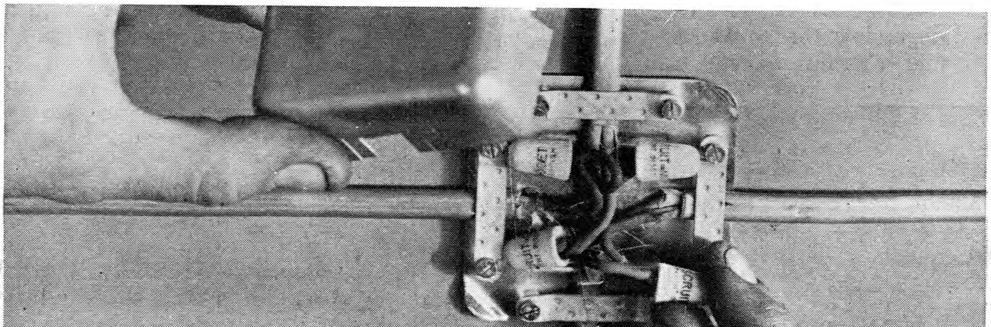


Fig. 8.—A FOUR-WAY JUNCTION BOX WITH SCRUIT CONNECTORS.
The time taken for complete operation, including stripping ends of the cables and bonding, was 8 minutes.

Hints and Tips for the Practical Man

Readers are invited to send brief paragraphs for inclusion in this section. All contributions will be paid for at our usual rates

METHOD OF INSERTING TEST AMMETER IN 3-PHASE MOTOR CIRCUITS WITHOUT STOPPING MOTOR.

Connect ammeter of suitable range across a spare fuse bridge (omitting the fuse wire) and, as quickly as possible draw one of the motor fuses and insert fuse bridge with ammeter in its place; readings can then be taken at leisure. As any 3-phase motor will run single-phase on the two remaining fuses at practically the same speed and at roughly $\sqrt{3}$ times the current per line, this method is quite feasible and very useful to maintenance engineers where no ammeters are permanently connected in motor circuit.

POINTS IN CABLE ERECTION.

Great care should be taken in the bending of cables as too sharp a bend will result in the over-stressing of the insulation on the outside of the bend. For paper and cambric insulated cables the minimum radius of bend should be about 12 times the diameter of the cable, but this should be increased whenever possible. For rubber insulated cables the minimum radius of bend should be six times the diameter.

Terminating.

All paper and cambric insulated cables should have the ends sealed with either compound or oil to prevent leakage of the oil from the cable and moisture entering the insulation. Wax is sometimes used for telephone cables.

Lead-covered, rubber-insulated cables are usually terminated by a clamp gland or a lead wool packing gland to ensure a good contact with the lead sheath of the cable. Plain rubber cables should be taken through an insulating bush.

Wire armouring and steel-tape armouring should be clamped to the gland in such a manner that a continuous earth is established, and the weight of the cable is taken by the armouring.

For single core cables with a lead sheath, it is usual to insulate one end of the cable by means of an insulated gland, so as to prevent any circulating currents in the lead sheath.

Racking.

When cables have a compounded overall serving, it is advisable, where these cables enter or are racked in a warm building, to remove the serving so that any dripping of the compound is prevented. This also prevents the accumulation of dust on the cable.

All plain lead-covered cables should be wrapped round once with lead strip at each clamping point. This prevents the cable clamp damaging the cable.

When cables have a heavy current to carry, the cable racks and fittings should be made of a non-magnetic material so as to prevent any complete magnetic circuit round the cable.

Measuring.

When measuring a length of cable, make sure that a good length is allowed for, at each end of the cable for jointing purposes. If possible, have the required run of cable racked before cutting from the drum, thus preventing any waste due to an inadequate length being cut.

WHEN WIRING UP A MOTOR.

To obtain good continuity right through when wiring up a motor, it is a good idea to solder a nipple on either end of the flexible tube and fix to the motor by locknuts either side of the box, then screw the nipple of the other end into a coupling which would be on the conduit and tighten the joint with a further locknut.

QUESTIONS AND ANSWERS BY PRACTICAL MEN

Readers are invited to send problems of practical interest. Letters should be addressed to " The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2. Envelopes to be marked " Problem " in the top left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTH'S NEW QUESTIONS

An Interesting Problem on Electrically Driven Tools.

I have under my control a small frequency changer supplying a number of portable Hi-cycle grinders.

The input is at 440 v., 3-phase, 50 cycles and the output is at 125 v., 3-phase, 198 cycles. The speed of the set is 3,000 r.p.m. and I have checked this, also the input voltage. As I have not an instrument capable of measuring current and voltage at 198 cycles, I am unable to check the output voltage, which should be 125 v., and the current consumption of the tools.

The tools are supposed to have a free load speed of some 4,000 r.p.m., the full load speed being in the region of 3,900 r.p.m. On checking for speed at the tool, I find that each tool runs on free load at only 2,000 r.p.m. What is the trouble ?

WM. T. MCMILLAN.

Powers of Local Supply Authority.

Can a local supply authority withhold a supply of electricity because a switch has been looped on the wrong side, i.e., you have to switch on in one room to get a light in the next ? Also can they withhold it because the live wire has been connected to the dead side of a switch plug?

ELECTRICIAN (Scunthorpe).

How to Tell the Phases of A.C.

Will you kindly inform me if there is a simple way of telling the phases of A.C. Should there be no marks on the wires so as to be able to connect an A.C. motor ? Also could you please inform me how to wire up a warning lamp on a travelling crane, fitted with three trolley wires on the traverse so that a red light will show when the current is switched on.

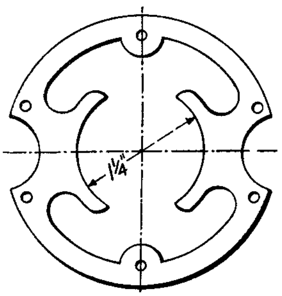
A. G. RYALL (Erdington).

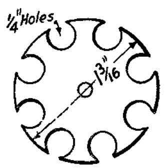
REPLIES TO PREVIOUS QUESTIONS

Rewinding a 220-volt Motor.

I have a small D.C. motor which was wound for 220 v. D.C. What I want to know is the gauge and number of turns, or weight of wire, to rewind it to run off a 6-volt accumulator. The sketch gives the actual sizes of field magnet, and armature.

A. MOSS.
(Hyde.)





Before stripping the armature, make a careful note of the commutator connections, so that you may readily connect up again when rewound with the thicker wire.

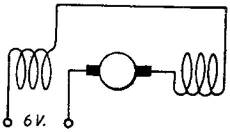
The armature winding consists of 8 coils of 24 S.W.G. double silk-covered wire. Each coil will have 32 turns. The slots are first lined with a single layer of empire cloth, this insulation being sufficient for the low voltage. The commutator probably has 16 segments and in order to avoid a duplex winding, the segments are bridged together in pairs so as to make an 8-part commutator.

Wind the armature coils in the following order :—

Wind round slots 1 and 6, then 6 and 3,

3 and 8, 8 and 5, 5 and 2, 2 and 7, 7 and 4, finally, 4 and 1. Rather less than 2 ounces of wire is required.

The field winding consists of two coils of 130 turns each, of 20 S.W.G. enamel covered wire. Wind the coils on a wooden former, the size of which can readily be determined from one of the old high voltage coils. Half a pound of wire is required for the fields.



Connect the two field coils in series with one another and in series with the armature as shown above.

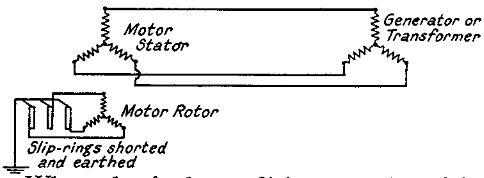
H. E. J. Butler.

A Three-phase Induction Motor Query.

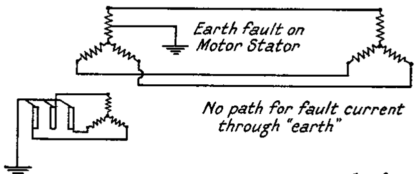
I have a question regarding a three-phase induction motor of the industrial type, with wound rotors and short-circuiting gear. If the "stator" winding of one phase of such a motor developed an "earth," and the supply system was three-phase insulated, what would be the effect on motor when the "rotor" was short-circuited by means of its short-circuiting ring, which is always fitted on motor shaft and not insulated therefrom, which can therefore be considered as "earthed"?

Inducto (Middlesbrough).

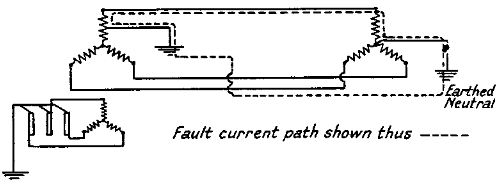
The connections of a three-phase slipring motor, running with its rotor short-circuited by an earthed shorting ring, and of the generator feeding it are shown in Fig. 1. For the sake of clearness, all switchgear and other apparatus connected to the generator has been neglected.



When the fault condition mentioned in the question occurs the connections will be as shown in the second diagram, and it will be seen that an earth on one phase only cannot produce any harmful results, *unless some other point on the primary* (stator) *connections is also earthed.* The mere fact of the rotor windings being earthed through their connections to the sliprings and the short-circuiting ring does not affect the matter at all, because the rotor windings are insulated from the stator windings and the current in the rotor is due to transformer action from the stator, and not to direct connection with the stator voltage. It will therefore be clear that an earth on the stator windings does not close any circuit between stator and rotor, and that unless such a circuit is made a harmful current cannot flow. It must be clearly understood that by circuit we mean a closed connection, in the sense that if we start from any point on the stator windings we can trace out a complete closed loop of connections, via the earth fault and the rotor windings, arriving back at the starting point without crossing any airspace or insulation other than at the fault. This can be seen from the second diagram below.



The danger of a stator earth fault lies in the fact that it is the common practice to earth the "neutral point" or "star point" of the generator or transformer. This earthed neutral is in effect the second earthed point in the faulty system of primary connections, so that a fault current flows, blowing the fuse on the faulty motor phase, or opening the stator circuit breaker, or if neither of these safeguards are present, burning out a portion of the motor windings. The third diagram shows the faulty motor connections in conjunction with an earthed neutral supply and it must be remembered that this



earthing of the neutral is carried out at power station or substation, so that what is apparently an all-insulated three-phase system at the factory is really an earthed neutral system.

Hence the danger of a "stator earth,"

which is due to the intentional earthing of the supply system. No danger arises from the fact that the rotor is earthed.

R. R.

Current Limiting Resistance.

I should be much obliged if you would answer the following query. The amplifying system of a public address travelling van relied on a motor-generator set for its operation. The motor had to operate with a P.D. of 25 volts D.C., and when run up to speed took 12 amperes.

As the pressure at our terminals was 210 volts D.C., what should have been the resistance, and what should have been the size of the wire to prevent any serious overheating due to the current of 12 amperes?—

J. R. L. W.

It is assumed that a starter is used in conjunction with the motor and only a series resistance is required. The value of this resistance is obtained from Ohm's Law, which states that $R = \frac{E}{I}$ where R is the value of the resistance required, E the volts to be dropped across the resistance, and, in this case, equal to $210 - 25 = 185$ volts, and I the current carried.

The value of the resistance thus obtained is 15.4 ohms. A suitable resistance wire to be used in this case would be Ferry, which has a high specific resistance combined with a negligible temperature coefficient. This means that as the wire warms up the resistance does not appreciably alter in value. This is an important point.

To obtain a low temperature rise 11 S.W.G. is suggested, and the length required would be 700 ft. This would be wound on a former 1-in. diameter and opened out into spirals of suitable length bearing in mind the space available in the car.

H. E. HUTTER.

The voltage drop necessary across the series resistance will be the difference between the supply pressure, 210 volts D.C., and the motor P.D., 25 volts D.C. This is 185 volts.

From Ohm's Law resistance equals volts divided by current, it is seen that,

$$R = \frac{185}{12} = 15.4 \text{ ohms.}$$

"Eureka" resistance wire, which has a very low temperature coefficient, could be used. The following data are taken from the maker's catalogue.

Gauge	13
Diameter in inches	0 092
Ohms per foot	0 0341
Ohms per lb.	1.32
Approx. current in amps. with 100° C. rise	12

From these figures it may be calculated that 450 ft. of wire weighing 11.7 lb. would be necessary.

THOS. G. FRANCIS, B.Sc., A.M.I.E.E.

As the motor required 25 volts and was going to be fed from a 210-volt supply, the voltage to drop will be $210 - 25 = 185$ volts. Therefore, as current taken by motor was 12 amps., the value of the resistance will be

$$\frac{185}{12} = 15.4 \text{ ohms approx.}$$

If the temperature rise is to be kept below 200° C., the resistance will have to be wound with approx. 115 yards of 14 S.W.G. "Eureka" wire on a suitable former.

J. S. MASON

[In view of our correspondents' divergent views as to the best size and material of resistance wire to use, we recommend J. R. L. W. to adopt Mr. Francis' figures which will give reliability combined with moderate cost.]

Tuning Coils for the New Wavelengths.

I am about to construct a pair of wireless tuning coils from the article in your March, 1933, issue. The lower waveband winding given in this article is to cover from 230 to 550 metres, but I find that under the new conditions it would be better if this covered from 180 to 500 metres. The size of former I am using is $1\frac{1}{2}$ in. overall diameter. Will you please let me have winding table for these coils to cover new wavebands.

R. G. GILKS. (Leamington Spa.)

The modified table on the next page applies to coils made according to the article referred to above. This new specification, however, is for coils tuning from approximately 180 to 480 metres and 800 to 1,900 metres respectively on the two wavebands when used in conjunction with a good .0005 mfd. variable condenser of low minimum capacity.

It should be stressed that the tuning ranges will considerably be restricted if the condenser has a minimum capacity in excess of some 30 m.mfd., since the ratio of maximum to minimum capacity will then be reduced. The ranges mentioned can be widened slightly by employing a condenser of lower minimum than 30 m.mfd., but there are few such components on the market.

Diameter of former	1¼ in.	1½ in.	2 in	2½ in.	3 in.
Winding A—					
No. of turns ..	75	68	47	41	38
Gauge of wire .	32's	32's	30's	30's	28's
Length of winding	7/8 in.	13/16 in.	11/16 in	5/8 in.	5/8 in.
Winding B—					
No. of turns ..	90	84	75	69	60
Gauge of wire .	36's	36's	36's	36's	36's
Winding C—					
No. of turns .	225	195	153	138	120
Gauge of wire .	36's	36's	36's	36's	36's

Coils made according to the above specification will meet with the requirements of the Lucerne Wave-Plan which came into force on January 16th of this year. FRANK PRESTON.

Starting a Small A.C. Motor.

I have a small A.C. motor made by Vickers, Sons & Maxim. The stator has a solid yoke about 3 ins. diameter. There are six pole pieces, giving a bore of 1 in. The rotor consists of a Maltese cross arrangement, being built up of (copper plated) iron laminations. I have been informed that the machine is for 220 volts, 50 cycles, single phase.

I wish to know how to start this machine. The motor appears to belong to some gun indicating gear, as its makers are connected with such work, and it has gearing attached to give about a 50-1 reduction. A diagram of starting and running connections would be appreciated. The six coils have two leads each, and are of approximately the same size and wound with approximately the same gauge wire.

H. O. C. (Devon.)

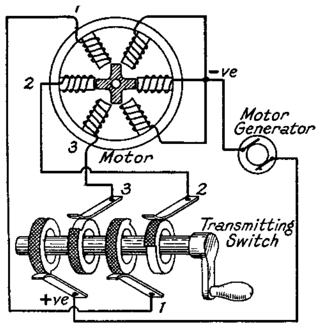
Your correspondent is in error in describing his instrument as an A.C. motor. The instrument is part of the receiver of a "follow the pointer" range transmitter as used in the Navy and Garrisons. In use as above one lead from each coil goes to a common terminal, the other leads being connected to a type of commutator operated by hand. Each contact causes the rotor to revolve one-sixth of revolution.

I have successfully converted one of these instruments to run as an A.C. motor. Coils should be connected in series, so that adjacent coils are opposite polarity.

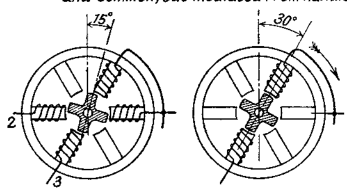
The four-pole rotor should be scrapped and a new one fitted, built up of "stalloy" or soft iron discs to the same width and diameter as original. It will be necessary to reduce the size of bearing spindle to 3/32.

To start as a motor, it is necessary to give spindle a smart twist, or by winding a piece of cord after the style of a spinning top. Very little power is developed, and it is doubtful if it could be put to any practical use. W. H. R.

This motor is not, as your correspondent supposes, a 220-volt. It is a 20-24-volt Vickers step-by-step range receiving motor, used in older ships of the Navy, but now practically obsolete. The motor has to be used in conjunction with a hand-operated transmitter, for which I am enclosing the diagrams, both pictorial and diagrammatic, these, I think, making the operation quite plain.



Note - Shaded portions on transmitter all +ve and common, but insulated from handle



One revolution of transmitter moves armature 90° in 15° steps.

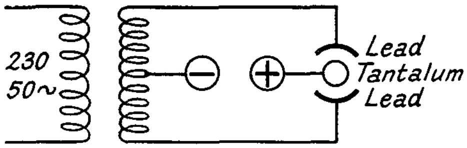
The coils are the same size as H.O.C. mentions, and are joined in pairs in series, a common return for the three pairs, but a separate supply to each.

That I think is all the explanation there is, the remainder of the information can be obtained from the diagrams.

C. W. NEIGHBOUR, A.B.L.T.O.

Electrolytic Battery Charger.

I should be obliged if you would let me know whether the following change in the design of the electrolytic battery charger



described in the June issue would have any effect on the working or output. The modified scheme results in the saving of one strip of tantalum and results in a considerable saving in cost. C. N. MARSTON. (Halifax.)

Unfortunately, your natural desire for economy of tantalum would have disastrous results in the circuit which you have drawn. In a centre-tapped transformer, the maximum potential difference is developed across the extreme ends of the winding, assuming that both are wound in the same direction. Now, as lead has no rectifying properties, it would allow current to flow in both directions from one lead plate to the other alternately.

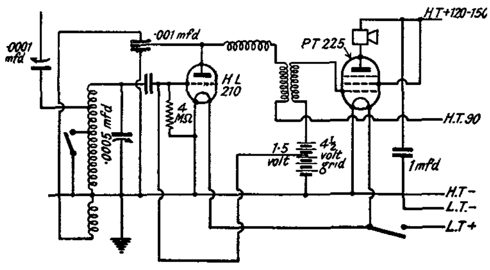
This is not possible under the circuit illustrated and reproduced in your diagram marked "original scheme." Here, the current is forced along the centre tap because a tantalum to tantalum conductivity is not possible without excessive voltage.

If you wish to use one strip of tantalum only, this can be done by employing the charger as a single wave rectifier, which gives us the original scheme less the second tantalum electrode.

WELLINGS W. WHIFFIN.

Adding a Screened-grid Valve to a Two-valve Set.

What is the best way to add a screened grid valve to a two-valve transportable set



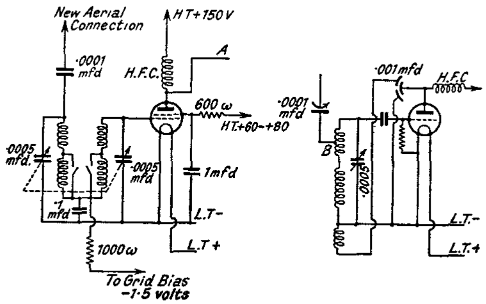
(detector-pentode)? I enclose a sketch of the circuit incorporated in the set. I should like to be able to add this valve without any alteration to the circuit as it is now if possible, as the set works very well, in fact, better than some three or four valve sets. The high tension supply for the set is fed from an eliminator; low tension from a 2-volt accumulator. I should also like to know the most suitable voltages to apply to this screened-grid valve.

W. HALL. (N.W. 1.)

The circuit given below is very suitable to add to the two-valve set above, and requires no alterations to the existing receiver.

It may be made up either as a separate unit or built into the present receiver, depending on the room available. The components required are :—

(i) Band pass coil unit.
(ii) Double-gang .0005 variable condenser.
(iii) Screen-grid H.F. choke.
(iv) 1 mfd. non.-ind. condenser.
(v) 0.1 mfd. non.-ind. condenser.
(vi) .0001 mfd. condenser.
(vii) 1,000 ohm resistance.
(viii) 600 ohm resistance.
(ix) Four-pin valve holder.



The point (*a*) on the circuit diagram should be connected via a .0001 mfd. fixed condenser to the detector circuit at the point (*b*). Thus, if (*a*) is connected to the moving vanes of the existing .0001 variable condenser, and this condenser is kept at a maximum capacity, the same result will be effected.

The voltages applied to the valve should be screen 60-80 volts, plate 150 volts. This circuit will give excellent results and provide ample selectivity for present conditions. ARTHUR T. BURROWS.

Installing Immersion Heaters (see page 389)

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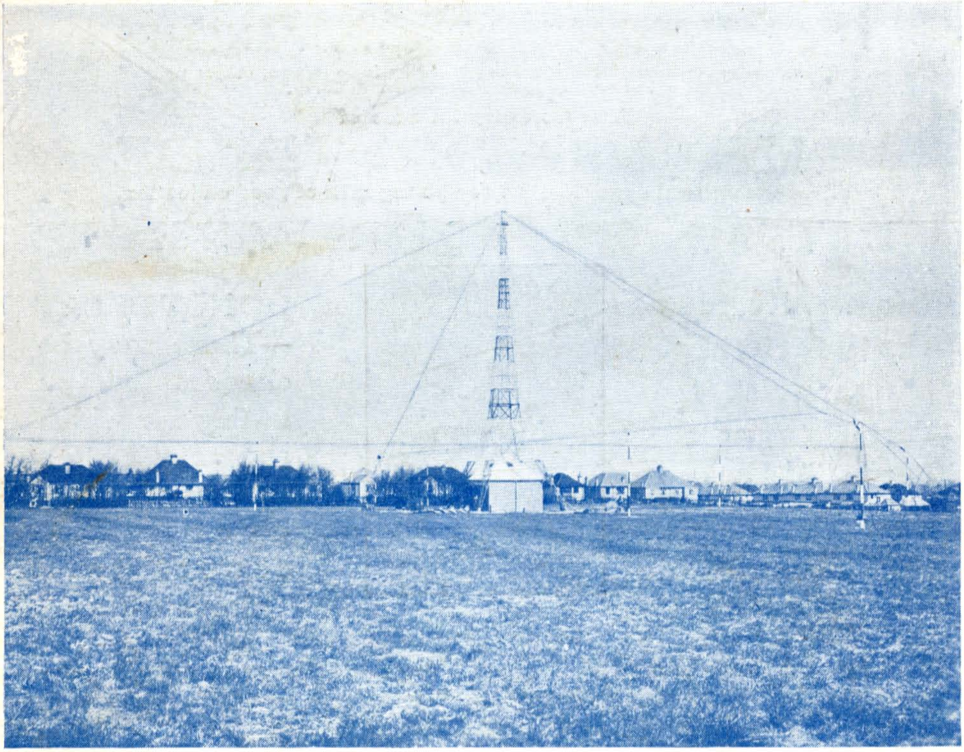
MAY, 1934



THE CROYDON "HOMING" BEACON

An article describing the working of the Croydon Beacon will be found on page 375.

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Our Works Visit.

We must confess that when we announced in our March issue that a Works Visit was being arranged for the morning of Saturday, March 24th, we wondered how many of our readers in the London area would be able and willing to devote the whole of Saturday morning to attending. The response was most gratifying, and we found it a very interesting experience to meet some of the men in the Electrical Industry who support this publication.

The name of Evershed & Vignoles was a guarantee that there would be a great deal of technical interest in the projected visit, but we were surprised at the variety of work done in this well-equipped factory, which it may be remarked has its own power station on the premises.

An Opportunity for an Electrical Power Consultant ?

We did not inquire too closely as to the reason for the existence of this private generating station in the heart of a busy industrial district, but we think that there might be scope here for a super salesman from the E.D.A. or the local Electricity Supply Undertaking or an Electrical Power Consultant, to persuade Messrs. Eversheds to purchase their power in bulk on favourable terms. This is purely an expression of editorial opinion and we trust that it will not cause embarrassment to the people concerned.

The general impression gained from this Works Visit was highly satisfactory. Thoroughness and good workmanship was evident in every department we visited, and junior workers engaged on repetition work had not that driven appearance which one sometimes sees in the course of these visits. Everyone seems to enjoy their work.

Altogether a pleasant and well-spent Saturday morning.

Selling Light by the Million Units.

The above is the striking title of a leaflet issued by the E.L.M.A. It refers to a lecture recently given by Mr. W. J. Jones to the members of the Institute of Engineers-in-Charge. The audience consisted of those engineers directly responsible for the lighting of such institutions as the Royal Exchange, large hospitals, infirmaries, public buildings and factories of every kind.

These are key-men of the utmost importance to the lighting industry, for they represent consumers of the million-units-per-annum class.

We compliment the author of the leaflet on his journalistic flair.

Light and Health.

An adequate appreciation by the medical profession of the hygienic value of good lighting is a factor of equal significance to the lighting industry, in increased business, and to the general public, in increased health. It is, therefore, cheering news to hear that the London School of Hygiene and Tropical Medicine and the Medical Officers of Health Association have both taken advantage of the facilities offered by the Lighting Service Bureau for the study of lighting problems in relation to health.

A study is made by these bodies at the Bureau of modern views of lighting and vision and emphasis is laid on the importance, on health grounds, of improved lighting particularly in relation to slums, schools and public buildings. It is within the powers of a medical officer to condemn inadequate lighting, and this valuable propaganda should tend to raise the standards of lighting where they are at present particularly low. The consequent potential gain to contractors in wiring and equipment business and to the supply authorities in increased load are evident.

Immersion Heaters—Another Opportunity.

It has for some time been recognised that the use of electric immersion heaters in hot water storage tanks provides a very useful load for an Electricity Supply Undertaking, more particularly in that these heaters improve the load factor of an Undertaking, and so facilitate low tariffs. In the next two or three years a great number of immersion heaters will be installed. Therefore, we are glad to include in this issue an article by Mr. E. Chisholm explaining in detail the approved method of installing. Our contributor points out that many Electric Supply Companies carry out the work at a very low cost, and it is noticeable that their electrician is not expected to do the plumbing and the plumber is not expected to wire up the element. It may be remarked, however, that in at least one important Undertaking, the whole of the work is carried out by plumber electricians, i.e., men who are qualified both as plumbers and as electricians. In the circumstances, we have given full details of both sides of the work.

The public will be requiring immersion heaters installed in large numbers in the near future. There is business waiting for the firms and the men who can supply this want.

From the Public's Point of View.

The two-part tariff prepayment meter which has just been put on the market by Messrs. Chamberlain & Hookham, Ltd., has much to commend it. One of its chief features is that it enables consumers who have got into arrears to obtain a further supply of current before the accumulated arrears have been paid off. Another instance of good psychology!

Utilisation of Electricity.

Other articles in this issue of interest in connection with the utilisation side of the industry are "Testing a Completed Wiring Installation," "Care of A.C. Contactor Control Equipment" and "Reversing Electric Motors." Sub-station engineers will be particularly interested in the article beginning on page 401, which gives practical notes on the Care of Rotary Converters.

Questions and Answers.

Each month we notice increasing interest in this section of the magazine. If all questions were published, it would be possible to fill two or three times as many pages as are at present occupied by them. Amongst the letters received this month was one from a reader in Reykjavik. Another was from a reader in South Australia. All letters, whether published or not, receive careful attention, but we must ask readers to forgive a certain amount of delay in replying to queries, especially when the matters have to be referred to experts.

The Croydon Wireless Beacon.

In conformity with our practice of keeping readers in touch with developments in all branches of electrical engineering, we are publishing this month an interesting article explaining the operation of the Directional Wireless Apparatus which is now in use at Croydon, in guiding pilots who wish to land under conditions of poor visibility, owing to mist or fog. This innovation has removed one of the chief hazards associated with commercial flying.

Is it Possible to Sell Electric Fires in Summer ?

We have heard the opinion expressed that it is no use trying to sell electric fires during summer months. On first thoughts this appears to be a perfectly reasonable statement, but is it ?

One of the great advantages of the electric fire is its convenience in that it can be switched on or off at a moment's notice.

If electric fires have any disadvantage it is that they cannot compete with a coal fire for economy if they have to be used from early morning to late at night. Therefore, it would seem that conditions during summer are at least as favourable to the sales of electric fires as in winter. In warm weather it may be only necessary to heat a room for two or three hours a day. To light a coal fire under these conditions is extravagant and troublesome. The electric fire is just the thing.

We should be glad to hear from readers who are interested in this.

HOW THE CROYDON "HOMING" BEACON WORKS

By J. H. A. WHITEHOUSE

These notes and illustrations are published by courtesy of the Air Ministry and Marconi's Wireless Telegraph Co., Ltd.

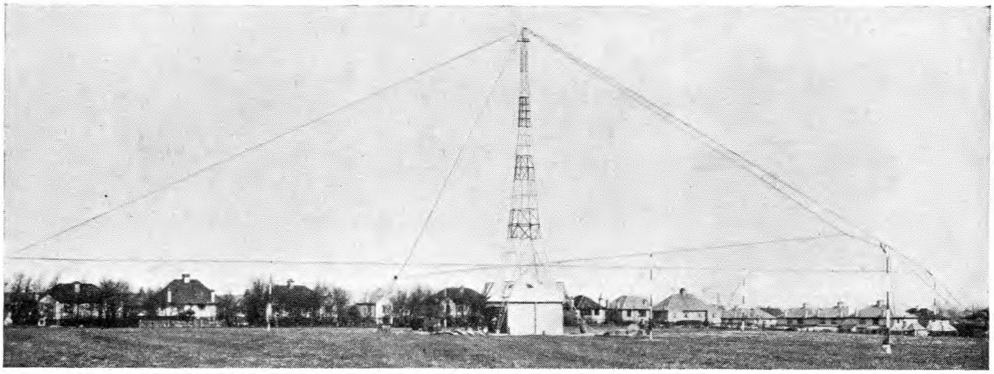


Fig. 1.—THE CROYDON BEACON.

ONE problem is ever present in the aircraft pilot's mind—thick weather. As he sits in his cockpit he is constantly watching the banks of cloud ahead and to the right and left of him, altering course this way and that to make use of clear patches to enable him to fly on to his home aerodrome with certainty. The Croydon beacon gives him that certainty whatever the weather may be. The beacon consists of two highly directional focused wireless beams extending outwards from the aerodrome along which the pilot flies and which guides him right over his landing ground.

How the Pilot Follows the Invisible Beam.

Fig. 2A shows the equipment in the cockpit which enables the pilot to follow the beam and which tells him whether he is accurately on course, or whether he is to the right or the left of it. The actual instrument which the pilot watches is the round indicator dial shown on the right of Fig. 2A and in greater detail in Fig. 2B.

The most important parts of it are the two centre "reeds"; the "too far to the left reed" telling him he is to the left of the wireless beacon beam, and the "too far to the right" reed telling him he is off course to the right.

What the Reeds Do.

The right and left reeds are arranged to vibrate up and down, the amount of vibration depending on how far to the right or left of his course the pilot finds himself. The effect of this vibration is to make the white lines on the ends of the reeds appear wider or narrower as the case may be. Fig. 3 shows what the reeds look like for various positions of the aircraft.

Aircraft No. 1 is too far to the right of the invisible beam or track; the right hand reed therefore vibrates more vigorously and appears wider than the left-hand reed, which is either not moving at all or only very slightly and therefore appears only as a narrow strip on the dial of the indicator.

Aircraft No. 2 is too far to the left of

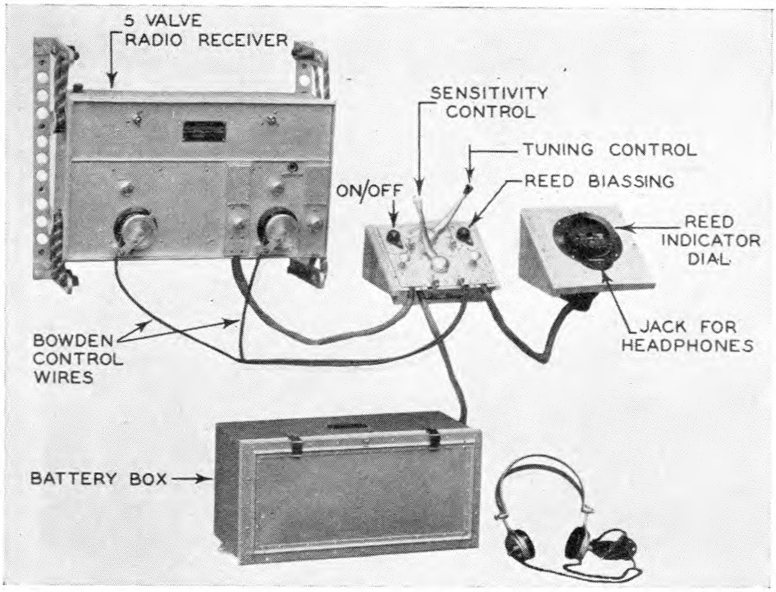


Fig. 2A.—The Equipment in the Cockpit which Enables the Pilot to Follow the Beam.

the beam, so that the left-hand reed now appears wider because it is vibrating more vigorously than the right-hand reed on the dial.

The aircraft in No. 3 position is not so far off course or track as No. 1, so that the difference in size of the ends of the two reeds is not so great.

Aircraft No. 4 is dead on the beam and flying straight down the track on to the aerodrome. In this case the ends of the vibrating reeds appear the same size.

This is the condition the pilot maintains to keep himself on the beam track. If his left reed appears bigger than the right he puts on a little right rudder to correct his course until the two ends of the vibrating reeds are equal in size again. The reeds tell him, too, if he is drifting bodily to the right or left due to a wind across the track he is flying down so that he can fly a course which compensates for the drift due to wind.

If, for instance, he is drifting north-west (Fig. 3) the end of his right reed tends to appear larger and larger, and *vice versa*.

The pilot can, therefore, fly with absolute certainty in the thickest of weather by watching the reeds on his dial to tell him

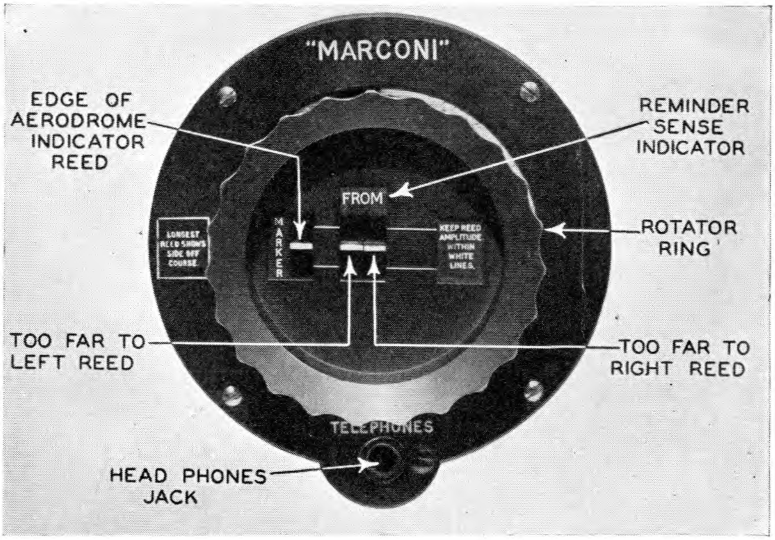


Fig. 2B.—The Actual Instrument which the Pilot Watches.

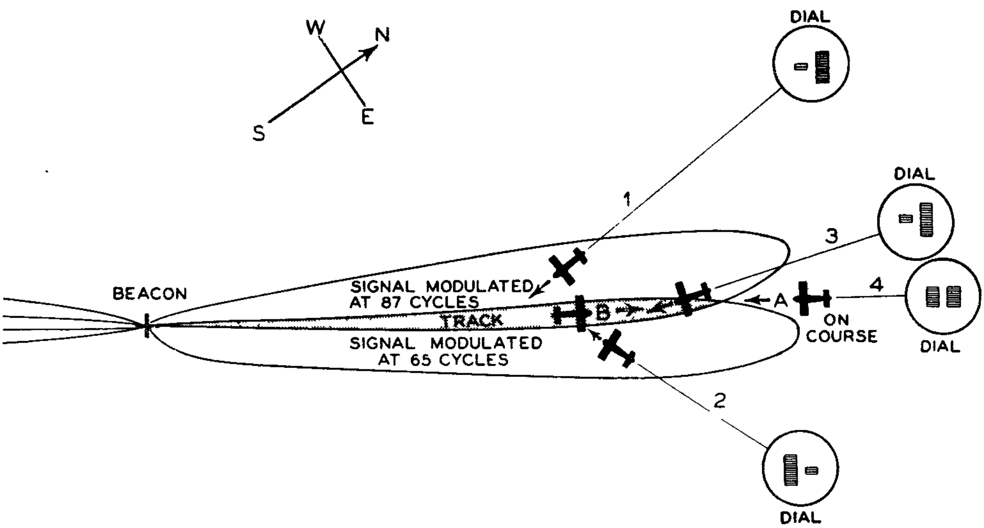


Fig. 3.—True Line Indications for Various " On " and " Off " Course Approaches.

whether he is on the beam, his level indicator and his altometer gyro turn indicator and airspeed indicator to tell him if his nose is up or down (climbing or diving).

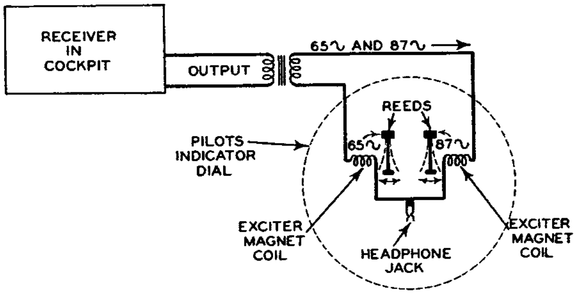


Fig. 4.—The Connections of the Reed Exciter Magnet Coils.

How Collisions are Avoided.

If we look at Fig. 3 it will be seen that both aircraft A and B would, if they watched their indicators, run a serious risk of collision, especially in the narrower part of the track near the beacon. A special " reed bias " control is, however, fitted which adjusts the reeds so that the aircraft each fly a little to the right of the track, thus clearing each other.

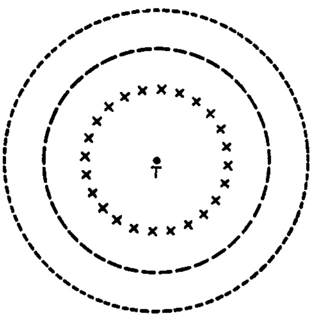


Fig. 5.—A Purely Vertical Aerial Theoretically Radiates a Signal Strength Equally Round the Situation of the Aerial.

How the Pilot's Reeds Work.

The reeds are virtually tuning forks whose size and shape make them vibrate only at a given frequency per second—the larger the fork, for instance, the slower will be its

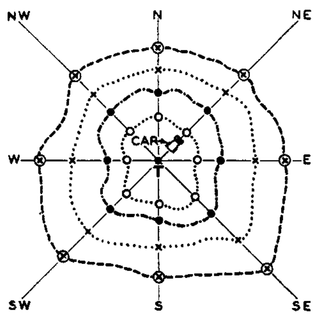
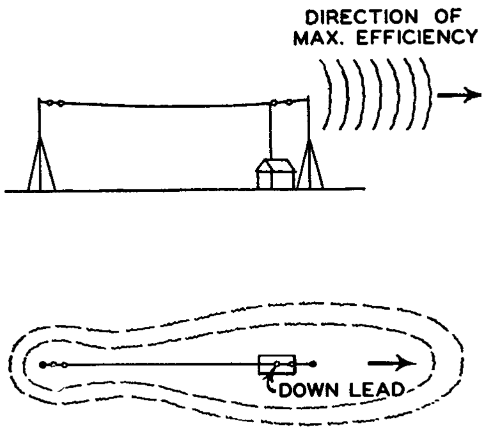


Fig. 6.—How Lines of Equal Signal Strength are Measured.



Figs. 7A *and* 7B.—SHOWING THE DIRECTION IN WHICH AN " INVERTED L " AERIAL IS SPECIALLY EFFECTIVE.

natural speed of vibration, the smaller it is the faster being its natural period of vibration.

The two periods of vibration which have been chosen for the pilot's reeds have for electrical and mechanical convenience a difference of only 22 vibrations per second, one reed vibrating at about 65 per second and the other (the right reed) at about 87 per second.

Fig. 4 shows how the reeds are electrically maintained in vibration and how each reed picks out the vibrations to which it is sympathetic. Near each reed is a magnet through the windings of which flows a current which is composed of two modulated components, one of 87 and the other of 65 vibrations per second. The size and design of each reed prevents that particular reed taking any interest in the period of modulation to which it is not mechanically tuned. The 87 cycle reed is, for instance, not affected by the 65 cycle output from the aircraft receiver nor is the 65 cycle reed affected by the 87 cycle modulation from the receiver.

The two magnet coils are, therefore, in series and they both carry 87 and 65 cycle currents, the reeds automatically sorting out the frequency to which they are mechanically tuned.

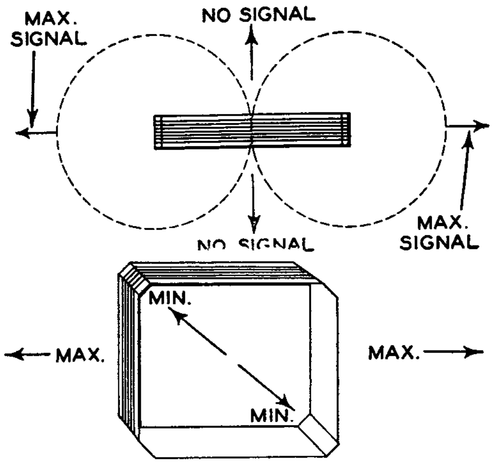
How the Radio Beacon Transmitter Works.

The radio beacon itself is an ingenious combination of two focused wireless beams carefully arranged to be of equal strength and the double modulation of those two beams, at about 65 and 87 cycles per second.

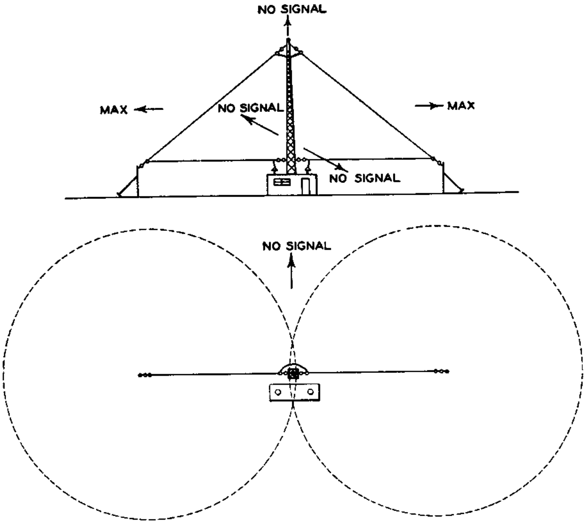
One of the two focused elongated beams of signal intensity is modulated at 65 cycles per second and the other at 87 cycles per second, both are on the same wavelength, so that the receiver on the aircraft has to receive one wavelength only. Fig. 3 shows the area covered by the two beams of signal strength with special reference to the shaded portion which is the area where the two rays are of equal intensity (only a few yards wide at the edge of the aerodrome!).

It will be seen that the shaded portion is actually composed of the over-lap of the two separately focused beams, one modulated at 87 cycles per second, and the other at 65 cycles per second. This is the correct track of the beacon.

The radio receiver in an aircraft flying in this area therefore, receives both the 65 and 87 cycle modulated waves at equal intensity, thus vibrating the reeds on the pilot's dial equally, telling him he is on the correct track. If he is on the right of the track, his receiver aerial is in the signal area of the signals being modulated at 87 cycles per second, so that the output from his receiver will consist chiefly of 87 cycle pulses, so that the right-hand reed on the pilot's dial



Figs. 8A *and* 8B —SHOWING THE VERY MARKED " FIGURE OF 8 " DIRECTIONAL PROPERTIES OF THE FRAME OR LOOP AERIAL.



Figs. 9A *and* 9B.—How the "Figure of 8" Effect Can be Produced by an Arrangement of Two Triangular Transmitter Aerials.

will vibrate more vigorously. If the aircraft is on the left of the track, i.e., in that area covered by the ray modulated at 65 cycles per second, the reverse will be the case and the pilot will ease his rudder to the right to bring himself back into the track again where the signals from the two rays are equal and overlap each other.

How Wireless Transmissions are "Focused."

Every aerial, with the exception of a purely vertical aerial, has in the horizontal plane some special direction in which it is most interested, that is to say, its signals are stronger over a given area in particular directions.

A purely vertical aerial theoretically radiates a signal strength equally round the situation of the aerial (Fig. 5), except for certain aberrations caused by peculiarities of the countryside, and other considerations of a like nature.

How Lines of Equal Signal Strength are Measured.

One method which is employed is to move slowly outwards in a car carrying a calibrated receiver on certain compass bearings measuring periodically the signal radiated from the aerial. All points of equal signal strength are noted and are then plotted out on a map and connected together. Fig. 6 shows the scheme. The car is shown moving out from the transmitter in a north-easterly direction measuring as it goes, and four lines of equal signal strength are shown which combine to form a sort of contour map of the transmission, the lines representing equal signal strengths instead of height above sea level.

It will be noted that there is a slight kink in the north-westerly direction which might be caused by peculiarities of the countryside, such as hills or wooded country or even the electrical "shadow" of one of the masts of the transmitter.

Other Kinds of Aerial.

The fact that it is possible in this way to map out strengths of signal from a transmitter enabled the designers of the Croydon Beacon to produce aerials which would transmit in certain directions only. Figs. 7A and 7B show, for instance, the direction in which an "inverted L"

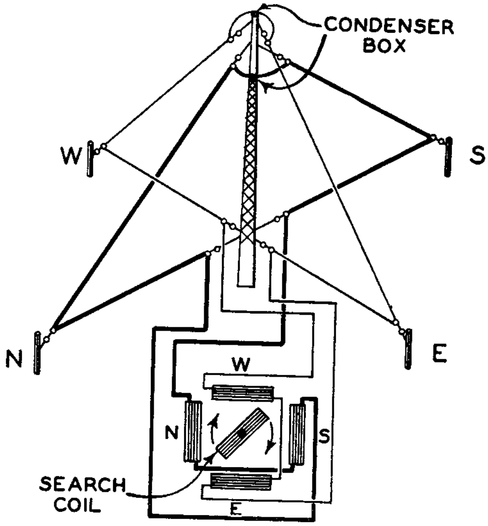


Fig. 10.—How the Two Triangular Loops Fixed at Right Angles to One Another Can be Coupled to a Swinging "Search Coil.

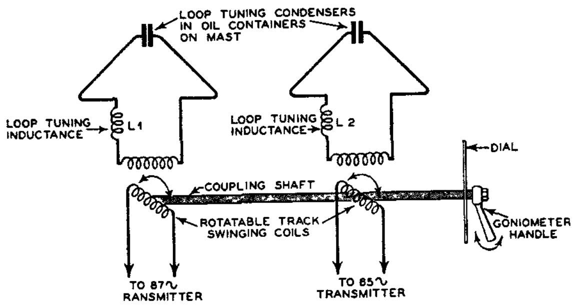


Fig. 11.—The Connections to the Croydon Transmitter of Two Loop Aerials.

the Croydon Beacon itself (Fig. 1), notice that the loops of signal strength shown for the beacon in Fig. 3 are very similar to those shown in Fig. 9, except that they have been focused outwards and considerably elongated.

How the Wireless Beam can be Moved Round Electrically.

If it were physically possible to swing the whole aerial and mast, shown in Fig. 1, the equipment could be made to receive or transmit in any direction.

aerial such as is used by most listeners is specially effective. Notice how it tends to be more efficient in a direction pointing away from the end of the aerial which is not attached to the lead-in wire.

Figs. 8A and 8B are specially important with regard to the Croydon Beacon. They show the very marked "figure of 8" directional properties of the frame or "loop" aerial, such as is used in portable receivers and they demonstrate clearly why a portable set has to be twisted round on its turntable to get the loudest signals from a distant station.

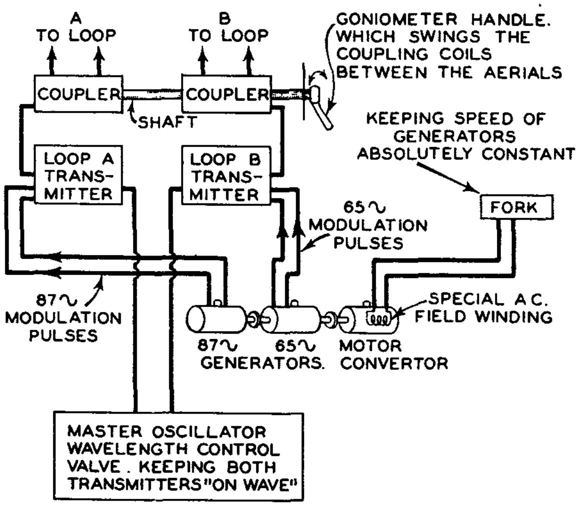


Fig 12 — The Actual Loop Tuning Inductances and Rotatable Coupling "Track Swinging" Coils.

This is clearly not very practical, anyhow from a transmitting point of view, although experimental rotating transmitting beacons are being used which are, however, outside the scope of these present notes. A very neat electrical trick has been developed by Bellini, Adcock and others to make it possible to swing a small tuning coil instead of the complete aerial structure. Fig. 10 shows how the two triangular loops fixed at right angles to one another in Fig. 6 can be coupled to a swinging "search" coil.

Within practical limits, what is true of a receiver is true of a transmitter and a double figure of 8 effect can be produced by an arrangement of two triangular transmitter aerials, shown in Figs. 9A and 9B, and in the photograph of

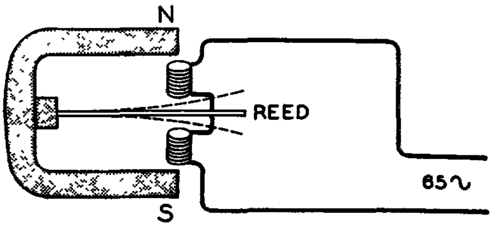


Fig. 13.—Reed Tuned to 43 Cycles per Second, Vibrating in Sympathy with 43-Cycle Pulses from Magnet Coils Fed from Slip Rings.

How the "Search" Coil Works.

Thinking for the moment of the arrangement as a receiver and bearing in mind Fig. 8B, if the signal is coming in on say a north and south line, the current will be strongest in coils " N " and " S " —if on an east and west line in coils " E " and " W."

Taking the case of the " E "—" W " signal, when the search coil is turned until signals are strongest, it will be found to be parallel with the " E "—" W " coils.

The coil is shown in Fig. 11 in a position where it is picking up half from one pair of coils and half from the other pair of coils, that is to say, that the signal is arriving on a north and east bearing and inducing currents into both aerials and their coils. The angular position of the coil, therefore, registers the angle or " bearing " on which the signal is arriving, or in the case of a transmitter, is being sent out. Notice that the direction can be either north-east and/or south-west.

This, however, does not matter when two or, better still, three directional receiving stations are used to plot the position of a ship or aircraft.

How Directional Aerials Can Be Combined.

This can be done by combining the wave directions of two or more different types of aerial and varying the power relations and electrical coupling between them.

How Combined Polar Diagrams Are Used in the Croydon Beacon.

As we have seen in Fig. 3 the Croydon Beacon signal areas have by careful arrangement of the aerials been so elongated and narrowed down that the Beacon is effective as far away as Dungeness!

How the Croydon Beacon Transmitter is Arranged.

The Croydon Homing Beacon is actually a combination of two transmitters each sending out an elongated " figure of 8 " signal from their respective triangular aerials.

Fig. 11 shows the connections at the

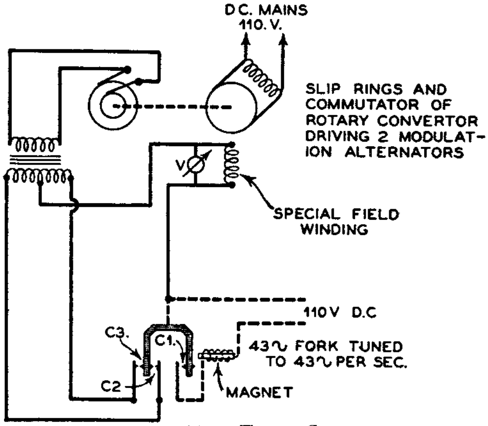


Fig. 14.—THE FORK CIRCUIT.

Croydon transmitter of the two loop aerials. It will be noticed that in addition to the tuning inductances, L1 and L2, each loop is further tuned by two condensers situated in oil containers at the top of the mast and electrically in the apex of each loop. The swinging coupling coils are mounted on a common shaft to which is attached the " goniometer " or " angle " control.

The actual loop tuning inductances and rotatable coupling "track swinging" coils are shown in Fig. 12.

How Both the Croydon Transmissions Are Kept Accurately on the Same Wavelength.

It is most important that the wavelength of both the two loop transmitters of the Croydon Beacon are kept identically the same. Since a common receiver is used on the aircraft, if one loop went slightly off tune the effect would be to weaken its signal relative to the other in the aircraft indicator device. The result would be that even if the aircraft was correctly on the track one reed on the pilot's dial would vibrate less than the other.

For this reason the two separate transmitters are both controlled by the same master or " wavelength control valve."

The Importance of Accurate Modulation.

Even if the wavelength of the two transmitters is kept exact, unless the modulation

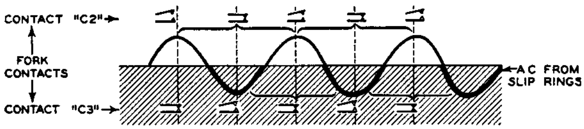


Fig. 15.—THE IDEAL CONDITION FOR THE FORK CIRCUIT.

at either 65 or 87 cycles per second is not kept accurately, the pilot would still get a false reading on his dial reeds. The Croydon Beacon has a special arrangement to keep the 65 and 87 cycles modulation absolutely correct.

The Marconi Company took no risks in this matter and installed a separate rotary alternating current generator of the correct frequency for each loop transmitter. These are mechanically coupled together and to the driving motor convertor.

The speed of the motor driving the two modulation alternators must be kept correct within very fine limits, otherwise the modulation frequencies of the two loops will vary.

How the Beacon Transmitter Modulation is Controlled by a Tuning Fork.

The motor driving the two alternators is not a simple D.C. motor—it might be more accurately described as a D.C. rotary convertor which, in addition to driving two separate alternators, actually generates alternating current itself which is tapped off two special slip rings mounted on the same shaft.

It is this A.C. output which is used to keep the speed of the D.C. motor constant with the assistance of a mechanically tuned vibrating fork.

How the Modulation Control Fork Operates.

Fig. 13 shows the theoretical arrangement of the fork. This fork or reed operates in a similar manner to those installed on the aircraft, that is to say, it vibrates only at the speed which is determined by its physical dimensions and character. Such a fork can be agitated in two ways. One method is by an electrical blow such as the pull of a magnet; if the magnet pulses are timed to correspond with the natural period of the fork or reed, its vibrations will be encouraged and it will be maintaned in vibration, the dimensional amplitude of which will be determined by the strength of the magnet pulses. Alternatively the fork can be kept agitating by connecting it as a simple vibrator by means of a contact on the fork and using D.C.

The dotted portion of Fig. 14 is the D.C. fork exciter circuit, and it will be seen that with the contact (C1) and the magnet it is that of a simple electric bell.

The Fork as an Inverted Rectifier.

There are three contacts on the Croydon Beacon modulation stabiliser fork. As we have seen, one (C1) is that which keeps it in vibration, C2 and C3 are concerned with the stabilisation circuit. In Fig. 14 is shown an auxiliary field winding for the D.C. end of the convertor driving the modulation alternators. If no current flows in this winding it will not affect the speed of the machine—if current flows one way it will speed the machine up and if the other way it will slow it down. The ideal condition is no current in this special winding. This condition is shown in Fig. 15.

The fork is in effect an inverted full wave rectifier which, when operating correctly, cuts off the + and — pulses from the alternator instead of passing current.

If, however, the speed of the rotary convertor alters, the A.C. output from its slip rings becomes out of synchronism with the mechanically fixed frequency of the fork, which, instead of stopping current flow, now allows it to flow in one direction or the other, depending on whether the frequency of the A.C. from the slip rings is ahead of or behind the mechanically fixed fork frequency.

TESTING A COMPLETED WIRING INSTALLATION

By D. WINTON THORPE, A.M.I.E.E.

THE only real test of an electric-wiring installation after it has been erected into position, is the test of a long and trouble-free life. Any tests which we can apply before the installation is put into service, though they may serve to show up and identify certain specific faults, cannot, however good the result, give an unqualified clean bill of health. It is most important to remember this fact. "It can't be wrong, it's just been tested"—a phrase which is not infrequently heard—is, in fact, quite a worthless statement.

Regulations for the Testing of a Completed Wiring Installation.

The testing of a completed wiring installation is the subject of a special section of the Regulations for the Electrical Equipment of Buildings (Sec. 127), and in this Section the Regulations lay down the following tests:—

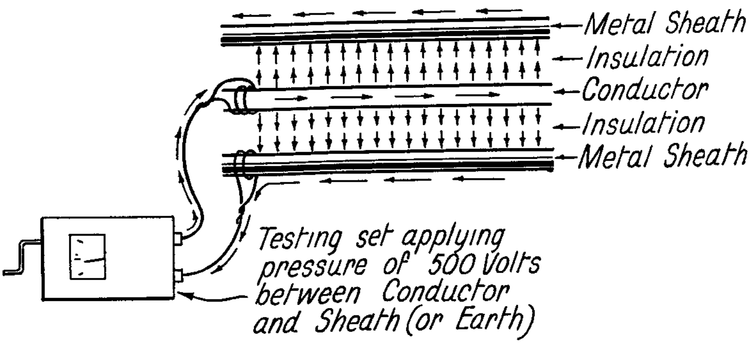
"*The insulation resistance shall be measured by applying between earth and the whole system of conductors or any section thereof, with all fuses in place and all switches on, a direct current pressure of not less than twice the working pressure. Where the supply is derived from a three-wire (alternating or direct current) or polyphase system the neutral of which is connected to earth either direct or through added resistance, the working pressure shall be deemed to be that which is maintained between the outer phase conductors and the neutral.*"

To all intents and purposes, this means that a pressure of about 500 volts must be applied in order to satisfy this Section.

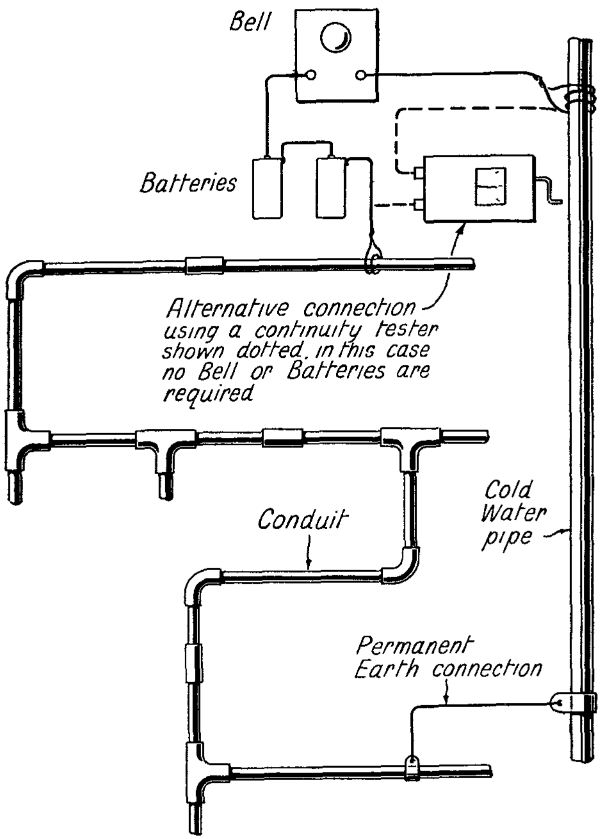
"*The insulation resistance of an installation measured as above shall not be less in megohms than 25 divided by the number of points on the circuits, provided that any installation shall not be required to have an installation resistance greater than 1 megohm; lighting circuits shall be tested with all lamps in place, except in the case of earthed concentric wiring systems; and heating and power circuits, with or without lighting points, may be tested, if desired, with the heating and power appliances disconnected from the circuits, but with the lamps (if any) in place. The insulation resistance between the case or framework and every live part of each individual dynamo, motor, heater, arc lamp, control gear or other appliance shall not be less than that specified in the appropriate British Standard Specification, or where there is no such specification, shall not be less than half a megohm.*"

When Measuring Insulation Resistance Between Conductors and Earth.

The first point to notice is that when



THE PRINCIPLE OF INSULATION TESTING.
Arrows indicate the path of testing current. Small arrows in insulation indicate minute leakage currents which, collectively, indicate the total leakage of current and hence the resistance of the insulation.



THE PRINCIPLE OF CONTINUITY TESTING.
A fault developing in the wiring system may possibly cause the live conductor to come into contact with the metal sheath. There should, therefore, be perfect electrical continuity between each section of sheathing and between the metal frames of all accessories and the sheath. This can be tested either with a 4-volt battery in series with the conduit under test and a bell taking at least 2 amps. for its operation. If connected up as shown and the bell rings, then the resistance of the conduit under test is not greater than 2 ohms. Alternatively, a continuity tester can be used as shown dotted.

the insulation resistance between the conductors and earth is being measured, all fuses must be in place and all switches on, and where lighting circuits are being tested, all lamps must be in position. The purpose of this is to bring into the circuit every conceivable conductor, so that the test actually taken is a test not only of part of the installation, but everything which ultimately will be in service, with the permitted exception of portable appliances.

For instance, it sometimes happens that a lamp contact develops a fault to the cap and from there to the lampholder. If this lampholder were on a bracket fitting connected as it should be to earth, then a test taken without the lamp in position would show no fault, while if the lamp were in position the fault would be identified at the outset.

Calculations.

With regard to the actual calculations it can be seen from this Regulation that any installation having not more than 25 points can be considered to have passed its test if a reading of 1 megohm is obtained. In the case of an installation having 100 points, 250,000 ohms would satisfy the test. In point of fact, these values demanded by the Regulations for the Electrical Equipment of Buildings are very easy standards to achieve. Most engineers, if they secured a test reading of 250,000 ohms on a 100-point installation would not be satisfied unless some special circumstances accounted for this.

Effect of Dampness on Accurate Insulation Testing.

This brings us to what is really one of the chief difficulties of accurate insulation testing.

Damp is one of the chief enemies of insulation. Damp at the same time is one of the most noticeable features of the interiors of new buildings in course of erection. Since a very large number of wiring tests are applied to installations which have just been completed in a building which itself has just been erected, they are applied to an installation which is surrounded with imperfectly dried fabric in a building which has had no heating. If the test is satisfactory under such conditions it may be confidently assumed that a test taken, say, six months later, will be even better. For this reason, if the test does not come up to the required value, but is not far below it, it is sometimes possible to arrange with the supply undertaking to allow the building to dry out a little before taking another test.

It is extremely desirable that, quite apart from the statutory test applied by the supply undertaking, the electrical engineer responsible should take a further insulation test after an installation has been in service for, say, six months. Faults may develop which, for some reason or another, were not apparent at the initial test, and apart from other considerations, a second test of this sort saves money in the long run, since it establishes as soon as possible any faults which may be on the system.

Indeed, the Regulations for the Electrical Equipment of Buildings in a Note state:

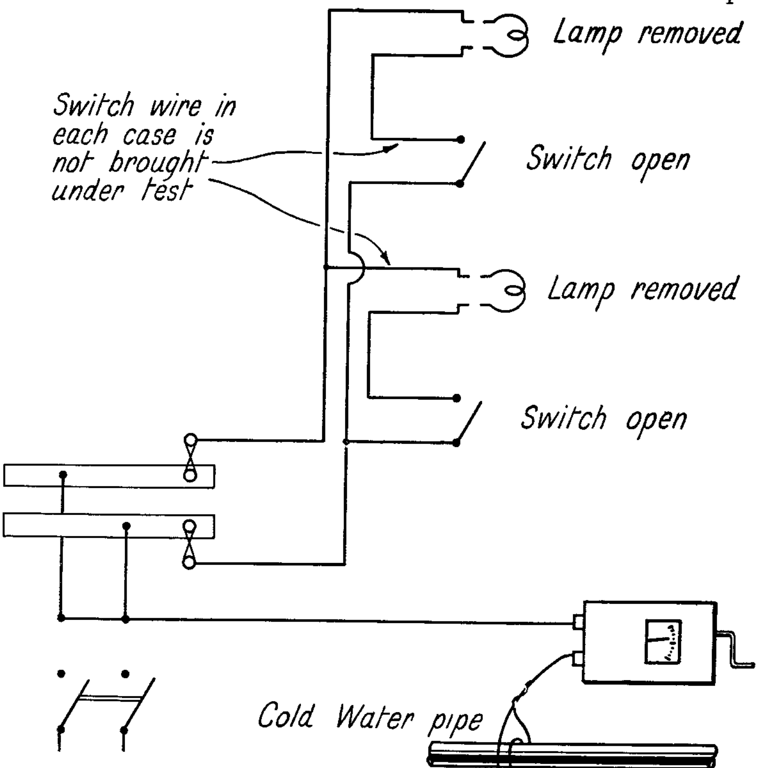
" *The following tests,*" those referred to above, " *are intended to insure that the installation is in a satisfactory state at the time of completion. The value of systematically inspecting and testing apparatus and circuits cannot be too strongly urged, and such periodical tests are essential if the installation is to be maintained in a sound condition and undue deterioration thereof detected . . .*" Now let us just consider the actual principles involved in taking an insulation test.

Test Between all Conductors and Earth.

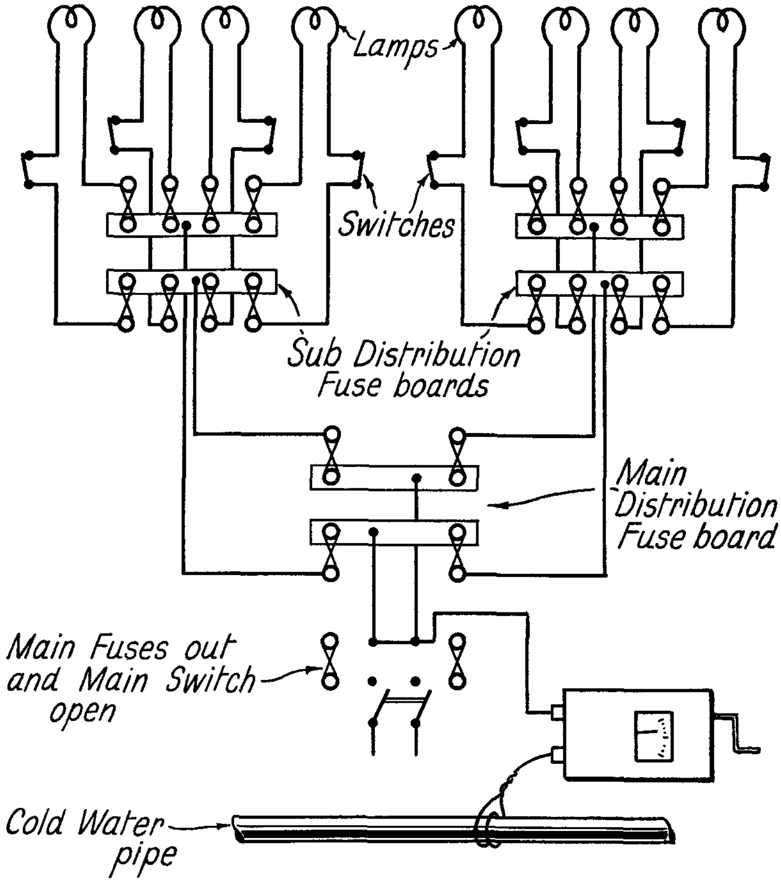
The first and most important test is between all the conductors and earth. Fuses, it should be remembered, must be in position and all switches closed, but this requires a little qualification. If the supply has not yet been connected this injunction can be obeyed to the letter.

Isolating Supply from System While Test is in Progress.

If, however, the supply is already connected, it must be in some way isolated from the system while the test is in progress, and for this purpose the only practical method of applying the test is to remove the two main fuses, and to test the installation from these fuse terminals on the installation or dead side. One terminal of the testing set is connected to the two main conductors (in the case of a three-phase system, three main conductors) collectively, and the other terminal is connected to some known earth, such as a water-pipe. If the test so secured is good, that is to say, is above the minimum insulation resistance per-



THE INCORRECT METHOD OF MAKING AN INSULATION TEST.
Since the switches are open and lamps are removed the switch wires are not brought into the test.



THE TEST BETWEEN ALL CONDUCTORS AND EARTH.
In the case of an installation to which the supply has already been connected, the main fuses should be removed and the main switch opened.

mitted, no further steps need be taken in this connection, though it is wise, and recommended by the Regulations for the Electrical Equipment of Buildings, to take a further test between the conductors, that is to say, having one terminal of the testing set connected with one main conductor, and the other terminal with the other main conductor.

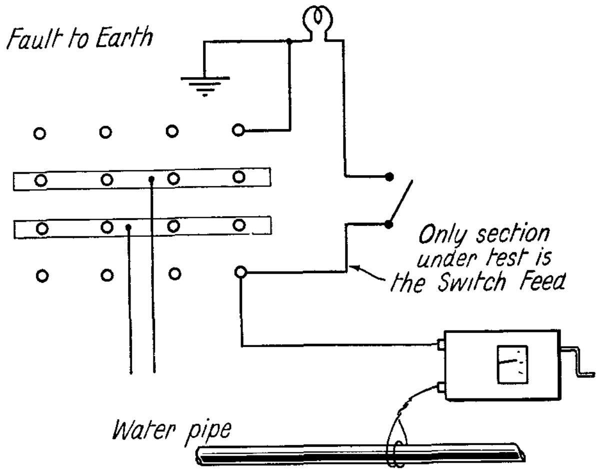
How to Find Where a Fault Lies.

If the test on the first occasion—that between the bunched conductors and earth—is not up to the required standard, it is necessary to start the process of elimination which ultimately will identify the sub-circuit in which the fault lies, and further, in which part of that sub-circuit it lies. For this purpose, the simplest manner (though it should be noted that there are very many combinations which will give the same result) is to remove one pair of fuses from the main distribution board. If the test is taken and the fault remains on, then a second pair should be removed, and so on until the fault clears and the test comes up to standard. It will then be apparent that the last fuses to be removed before the fault was cleared are those controlling the circuit in which the fault lies; that is, assuming that the previous removal of pairs of fuses did not materially affect the test (beyond the slightly increased resistance which will automatically result from throwing off circuits), for one has always to bear in mind the possibility of more than one fault on more than one circuit.

An alternative method, after the initial test on the whole system has shown a fault, is to remove all the fuses from the main distribution board and to connect up each circuit in turn by replacing one pair of fuses at a time, and removing these and replacing them in the next pair for each successive test. This method is longer, but perhaps rather more definite. It is most important when taking these tests to note down every reading taken, whether it is good, bad or indifferent. A record of this sort is very useful for subsequent reference.

What to do When Main Circuit Containing Fault has Been Traced.

Having established which main circuit contains the fault responsible for lowering the general insulation resistance, this main circuit alone should be allowed to remain connected through its pair of fuses with the point of test. Now that we have one sub-distribution board only in the system so far as our test is concerned, our main distribution board is acting merely as a link in connecting our testing set with the sub-distribution board which is the cause of the trouble. Therefore, we apply our successive tests by removing or inserting fuses exactly in the same manner as we applied it in the case of the main distribution fuseboard when we were endeavouring to find which main distribution circuit was at fault. In this case, however, when we identify the location of the trouble we have got down to a sub-circuit. And once again we leave only these sub-circuit fuses in position.



THE FINAL STAGE IN TESTING WHEN FAULT HAS BEEN TRACED TO A SUB-CIRCUIT.

By opening the switch, the fault is cleared, thus proving that the fault must lie on switch wire or black feed. Actually it is in the latter so that the closing of the switch and removal of the lamp will indicate this.

It will be realised that as there is usually a considerable distance between the sub-distribution board and the testing set at the main switch, we shall either require two people to co-operate in the testing, one to alter the position of fuses and one to record the test, or else we may, as we eliminate all but one circuit on a particular board, move our testing set up to a position adjacent to the fuseboard which we are actually testing out.

Tracing the Fault in the Sub-circuit.

Now that we have an individual circuit on which we have established that there is a fault, we must, if we can, establish upon what section of that sub-circuit the fault lies. Each sub-circuit is divided into three well-defined sections in the case of lighting sub-circuits. They are the switch feed, the switch wire, and the black feed. The switch feed is the live wire running to one side of the switch; the switch wire is the wire running from the other side of the switch to one side of the lamp; and the black feed is the neutral or dead wire representing the other leg of the circuit and running to the other terminal of the lamp. Since our switch can open or close the circuit, and since by inserting or removing our lamp we can open or close the circuit at the lampholder, we can isolate any of these three sections. Our method of test, therefore, is now slightly different and we should start by connecting one terminal of our testing set to either of the two wires (black and red) going away from the sub-distribution fuseboard. The sub-distribution fuses, of course, should be out, and it does not really matter to which side we connect our testing set. Let us assume that we have connected it with the red wire, that is to say, the switch feed.

First Test with Lamp in Position and Switch Closed.

First of all, our lamp will be in position and our switch will be closed, since that is the position in which all these accessories are for the general test. Let us test once more to establish the fact definitely that there is a fault on this circuit. Our test reading perhaps shows zero, in other words a complete connection or contact between the conductor (which should be insulated) and earth.

Now Open Switch and Test Again.

Let us now open the switch—turn it off—and take the test again. If this time the fault is cleared and our test is good, we have established the fact by eliminating, as we have done, the switch wire (from switch to lamp) and the black feed (from fuseboard to lamp) we have cleared the fault, therefore the fault must have been on one of those two sections. In this case, we must close the switch and remove the lamp, so that we have now eliminated only the black feed, leaving the switch wire and the switch in circuit. If we take the test again and the fault is cleared we have established that the fault lies in the black feed. If, however, it is not cleared by isolating this last section, we can assume that it lies somewhere in the switch wire.

Beyond this point our testing set is not of any serious use to us, but we have, without interfering with any part of the actual installation, established that the fault which has caused the general failure to come up to the standard required by such test, lies on a section of cable probably not more than 15 to 20 feet in length. The actual finding of this fault is a matter of practical wiring and does not properly come within the scope of this article.

Put into print in this manner, helped out with the diagrams which may make the matter a little clearer, the process of progressive isolation applied in the case of testing a wiring installation may appear to those who have not carried out this work to sound and look rather complicated. If such people will bear in mind, however, that the testing set is nothing more than a generator which is applying a very big voltage to one conductor in order to establish how much leakage this big voltage will cause to another conductor—the earth—and that this fixed principle is unalterable in insulation testing, not only will the methods described herein become clearer, but it will be found possible for each operator of a testing set to work out his own method of applying this principle of progressive isolation—for there are dozens of different practical methods of applying the test, all of which subscribe to precisely the same principle.

In conclusion, it should be emphasised that every supply undertaking in the country has statutory permission to operate as the sole supplier of electricity in a given area, provided that it adheres to certain statutory Regulations in the matter. One of these Regulations ordains that it may not connect the supply to the consumer's premises until it has satisfied itself by test that the state of insulation of the wiring system reaches the standard laid down.

HIGH PERMEABILITY ALLOY

A new "low loss" alloy possessing exceptionally high permeability is known as Mumetal. It has a specific gravity of 8.61. The ultimate strength is 40 tons per sq. in. The yield point is 20 tons per sq. in., and elongation 25 per cent. on 5 ins. The electrical resistivity of Mumetal is 45 microhms per c.c. The magnetic permeability depends upon the heat-treatment, but it has an *initial permeability* up to 24,000 and a maximum value up to 120,000.

The losses are only a fraction of ordinary transformer iron. Mumetal is obtainable in the form of sheets, rod, wire and stampings.

The Installation of Immersion Heaters

By E. Chisholm

HOT water is one of the chief necessities of every modern household. Electricity provides the most up-to-date system, and this article particularly deals with the type of installation which is heated by means of an immersion heater.

From the labour-saving point of view no coal or coke fired systems can be said to be ideal, both necessitating stoking and constant attention to maintain a good supply of hot water.

There are many reasons for the popularity of the immersion heater, one of the chief being the adaptability of the system. The electric heater can be used independently or in conjunction with an existing coal-fired system.

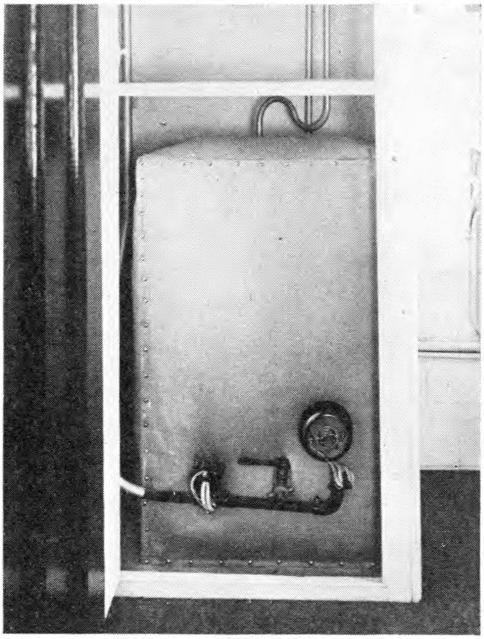


Fig. 1.—A Completed Installation.
The neatness of the lagging is particularly noticeable. Note, too, the "U" bend in the expansion pipe and the adequate earthing arrangements which have been made.

Importance of a Full Understanding of the Subject.

Before proceeding with a description of the installation the attention of the reader is directed to the importance of a full understanding of this subject, and, in fact, it should be stated that whilst the installation is a comparatively simple one, yet this requires the skill of specialists, both with regard to plumbing and the electrical installation.

Many electric supply companies carry out the entire work at a very low cost, and it is noticeable that their electrician is not expected to do the plumbing; vice versa the plumber is not allowed to wire up the immersion heater.

At the same time it is felt that every practical man will wish to be conversant with the fundamentals of this system of water heating, in order to fully appreciate its advantages.

FIRST CONSIDERATION.

Size of Tank in Relation to Most Suitable Loading.

The first consideration is the existing hot water storage tank. If its capacity in gallons is known, the loading of the element can be ascertained from the table given below, compiled by the British Electrical Development Association, Inc.

Table showing Most Suitable Relation Between Capacity and Loading for Thermostatically Controlled Water Heaters Continually Connected to Supply.

Capacity of Tank.	Loading of Element.	Rate of Recuperation for 100° F. Rise.	Number of Baths in Succession.
Gallons.	kW.	Hours.	
20	2.0	3	2
25	2.0	3.75	2
30	2.5	3.6	3
40	3	4	4

Simple Method of Calculating Loading of Element.

On the other hand, it can be very easily calculated, viz. :—

Rectangular Tank.

$$\frac{\text{Height} \times \text{width} \times \text{depth}}{276} \text{ (all in inches)}$$

= capacity in gallons.

Cylindrical Tank.

$$\frac{\text{Dia.} \times \text{dia.} \times .78 \times \text{depth}}{276} \text{ (all in inches)}$$

= capacity in gallons.

Then loading of element (expressed in kw.'s) required to heat water when capacity of tank (gallons) is known

$$= \frac{\text{gallons} \times \text{temperature-rise (°F.)}}{\text{Time in minutes} \times 5.7}$$

In the average size six-roomed house of the present day tanks of 20-25 gallon capacity are usually fixed, and in order that the description may be as simple as possible it is assumed throughout this article that a 2 kw. immersion heater is being fitted in a 25-gallon tank.

It must be remembered when fitting the immersion heater that only the water above the heater will be heated, and it should, therefore, be fixed in a horizontal position.

Typical Installation.

A typical hot-water installation is shown in Fig. 2. This is, of course, a simple case in which the hot-water storage tank (usually situated in the bathroom) is fed from the ball valve controlled cistern in the loft of the house. It will be noted that the cold water enters the storage tank at the bottom.

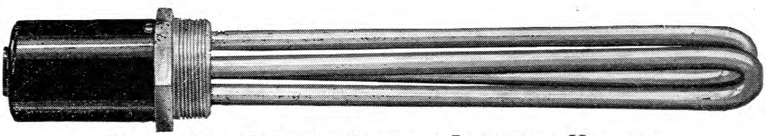


Fig. 3.—THE HOTPOINT TORRIBAR IMMERSION HEATER.

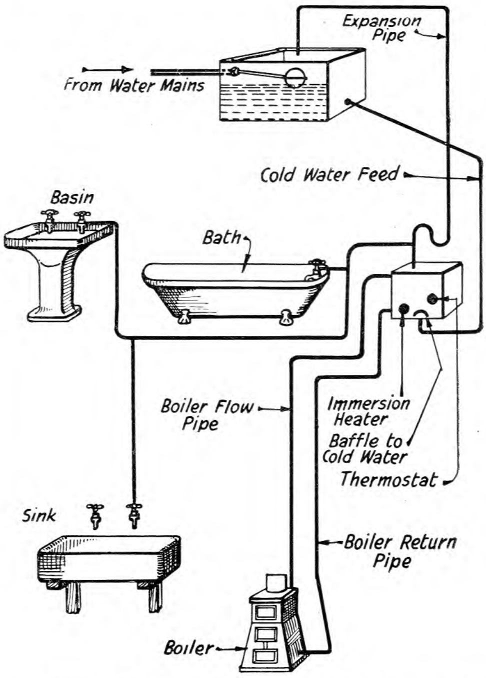


Fig. 2.—A TYPICAL HOT-WATER INSTALLATION. The hot-water storage tank is fed from the ball valve controlled cistern.

Where to Fit a Baffle.

It is sometimes considered necessary to fit a baffle or spreading plate to the cold water inlet inside the tank, to prevent to some extent the incoming cold water mixing with the hot water. The fixing of this baffle is particularly desirable

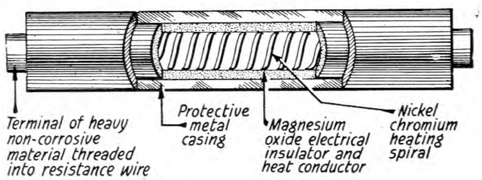


Fig. 4.—SECTIONAL VIEW OF HOTPOINT TORRIBAR IMMERSION HEATER.

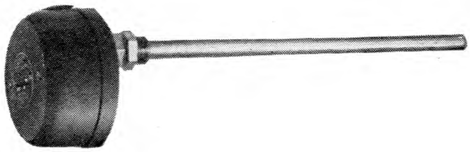


Fig. 5.—THE SATCHWELL THERMOSTAT.

where the immersion heater is being fitted in a ground-floor flat, as in this case the cold-water cistern is usually at such a high level that the " head of water " causes a powerful current of cold water to have a mixing effect on the contents of the hot tank.

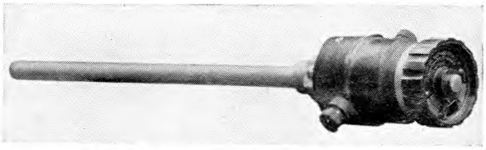


Fig. 6.—The Teddington Type 15 Thermostat.

Hot Water Should be Drawn from the Expansion Pipe.

The hot water is drawn off from the top of the tank, usually from the expansion pipe. This is the pipe which is run vertically from the hot-water tank, its end being bent over the cold-water tank. This pipe acts as the safety valve of a hot-water installation, and will discharge any water or steam into the cold tank should the water in the hot tank boil. (On a good thermostatically controlled installation, however, it is impossible for the water to boil.) It is essential that the pipe is not closed.

The inverted " U " bend shown in the expansion pipe of the sketch will prevent circulation and consequent radiation loss from this pipe. The height of the " U " bend should not be less than 3 inches.

It is essential to examine all installations before conversion, to make quite sure that the feed pipe to the hot taps is taken from the top of the tank or the expansion pipe mentioned above.

What to do if Hot-Water Taps are Fed from the Flow Pipe.

In some cases, hot-water taps are fed from the flow pipe of the boiler, and reference to the sketch will show the reader that it is impossible to draw hot water from this pipe whilst the immersion heater only is in operation.

If taps are found to be connected to the flow pipe they should be disconnected and reconnected to the expansion pipe.

Condition of Tank.

If the tank is not in first-class condition the installation should not be proceeded with.

Position of Tank.

In order that the tank may be efficiently " lagged " with heat insulating material, there should be at least three inches clearance all round the tank.

Description of Immersion Heater and Thermostat.

Fig. 3 shows a very popular type of immersion heater, whilst in Fig. 4 the sectional view is shown. From this it will be seen that the important heating characteristic of this element is the rapid conduction of heat from the helical coil to the copper sheath. The operating temperature of the nickel chromium element is prac-

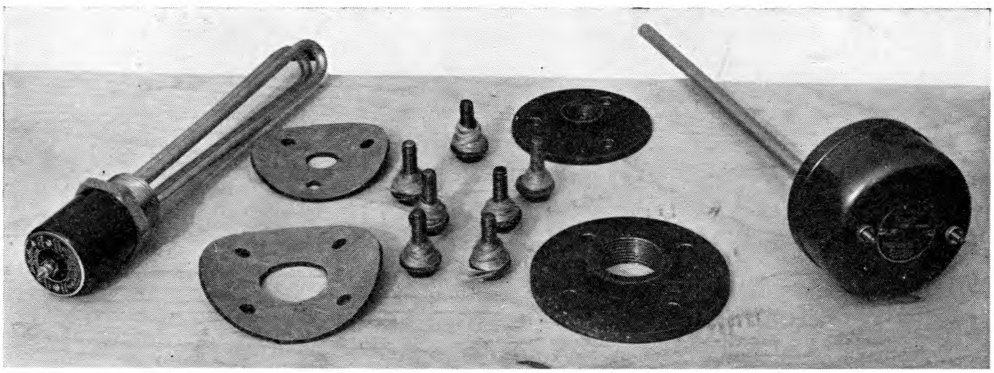


Fig. 7.—The Parts Necessary for an Immersion Heater Installation.

tically the same as that of the sheath constantly immersed in water. Running at this moderate heat, sealed away from air, and thoroughly protected against physical damage, this type of element is practically indestructible.

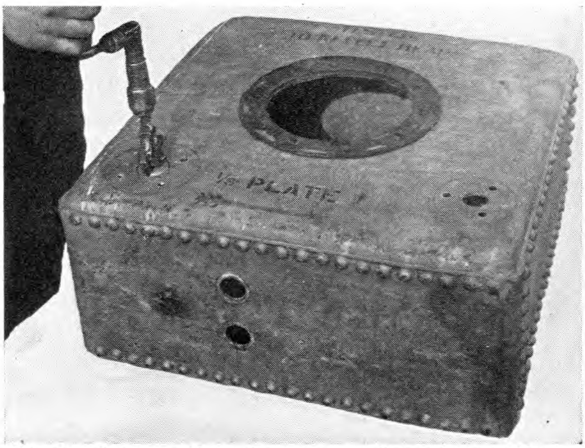


Fig. 8.—Using a Hole Cutter for Cutting the Holes in the Tank.

Figs. 5 and 6 are typical thermostats both being suitable for controlling the immersion heater described above on alternating current supplies.

Space is too limited to deal with the question of thermostatically controlled installations on direct current supplies, as these require the provision of a suitable relay.

Thermostats should always be fitted to immersion heater installations as they make the installation automatic, cutting the current on and off as required.

Briefly, every thermostat comprises a heat sensitive member coupled in some manner to an electrical switch.

Most thermostats make use of the fact that dissimilar metals have different coefficients of expansion. In order that as big a movement as possible may be obtained, one metal is usually chosen for its high coefficient of expansion, whilst the other has a practically negligible coefficient of expansion.

Fig. 9.—An Improved Type Tank Cutter.

The subject of thermostatic control is intensely interesting, but it is possible to give only the briefest description here.

Fig. 7 shows the immersion heater and thermostat with their respective flanges, also the two pieces of rubber insertion which have been cut out to the correct sizes. The fixing bolts for the flanges are also shown wrapped round with plumbers' hemp wool. If this figure is referred to frequently during the following description it will be found of great assistance.

THE ACTUAL INSTALLATION.

The holes for the immersion heater and thermostat may be cut in one of several ways, but it is, of course, necessary to empty the storage tank before commencing the actual installation.

Empty Tank from Draw-off Cock or Plug.

On the ground floor, near the boiler, a draw-off cock or plug is always provided, and it is from this point that the tank should be emptied.

Assuming the tank to be rectangular and flat-sided, two clearing holes are cut, one for the immersion heater and one for the thermostat. The flanges mentioned later should be used as templates. With the aid of a pencil the position and size of the holes may be marked.

Size of Clearing Holes.

For a 2 kw. immersion heater the

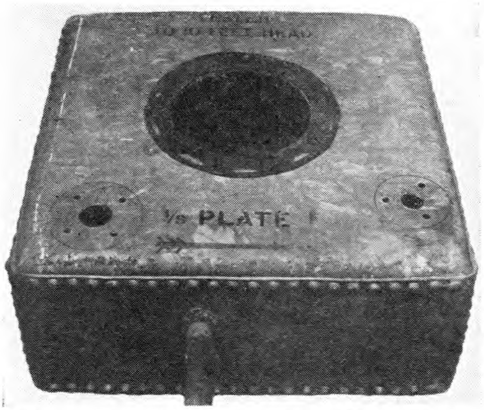


Fig. 10.—The Tank with Both Holes Cut Ready for the Flanges.

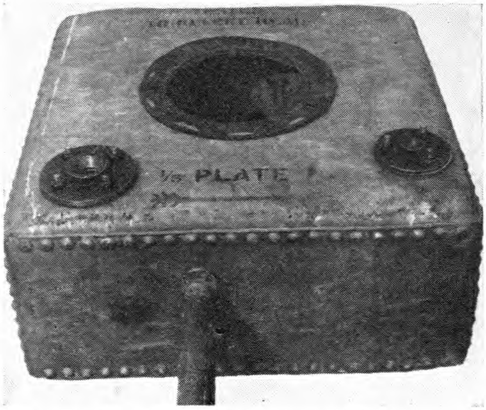


Fig. 11.—The Two Flanges are Here shown Fitted in Position.

standard size of the screwed boss is usually 1¼ in. gas thread. This clearing hole should be drilled as near as possible to the bottom of the tank (not through the bottom as the element has to be mounted horizontally).

The thread on the thermostat housing is ½ in. gas and in this case the clearing hole is drilled in the same face of the tank but in the opposite bottom corner some five inches above the heater hole. Reference to the photographs will make the position of these holes quite clear.

Cutting the Holes with a Tank Cutter.

The simplest method of cutting these holes is by means of a tank cutter (see Fig. 8). This operates in a somewhat similar manner to a carpenter's brace and bit, with the exception that the tank cutter only cuts the outside edge of the circle.

It is necessary to apply plenty of oil or soap water solution whilst the tank cutting is in progress.

What to Do if a Tank Cutter is Not Available.

Another way in which the holes may be cut is that in which a number of small holes are drilled round the circumference of the circle required to be cut. The small holes should be as near together as

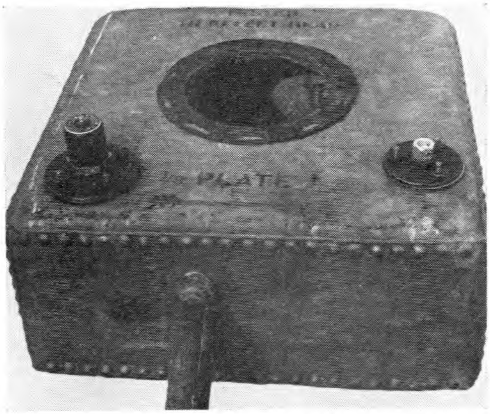


Fig. 12.—The Immersion Heater and Thermostat Sheath Screwed into their Respective Flanges.

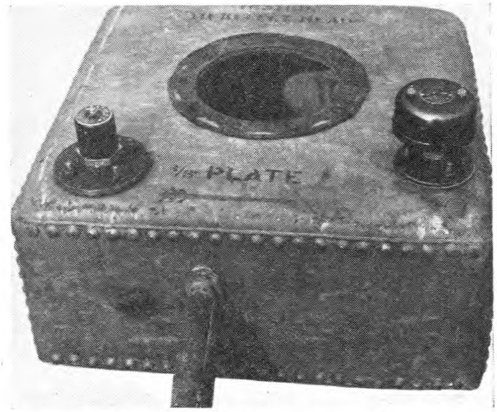


Fig. 13.—Here we see Both Immersion Heater and Thermostat Fitted in Place.

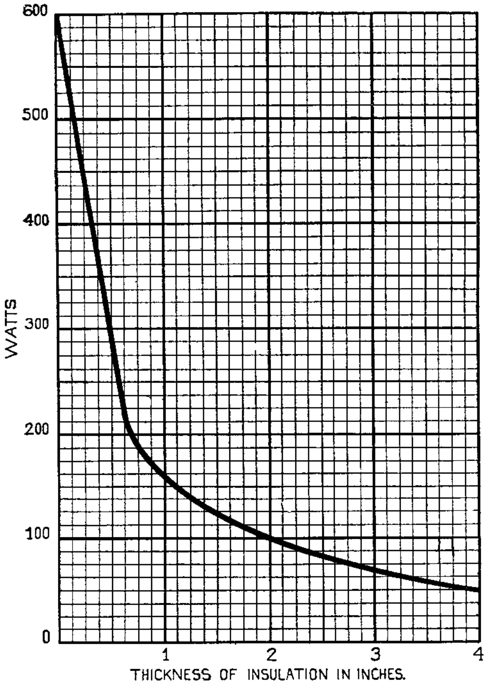


Fig. 14.—GRAPH SHOWING HEAT LOSSES FROM 30-GAL. TANK IN WHICH WATER IS MAINTAINED AT 160° F.

possible and when all of them have been drilled the centre part can be knocked out.

It is necessary to use a file to clean up the hole and remove the burred edges.

An Improved Hole Cutter.

An improved hole cutter is now on the market, and this tool enables the holes to be cut with scarcely any filings or chippings falling into the tank. The description of the operation of this tool is rather long and difficult to understand without demonstration, but Fig. 9 gives some idea of the method of cutting. Fig. 10 shows the work completed.

Remove All Metal Chippings from Inside Tank.

At this stage a very important part of the work has to be undertaken. The reader, will of course, have realised that it is quite impossible to prevent a certain amount of metal from falling into the tank during the cutting operations. It is essential that the manhole cover is now removed and the tank carefully cleaned out so that no trace of metal chippings is left inside. If this work is not done the filings will rust, setting up a chemical action, and in the course of a very short space of time the tank walls will become pitted, rendering the tank useless for further service.

This point is particularly stressed, as unless this work is very carefully carried out there will be a possibility of breakdown and consequent inconvenience.

Next Fit the Flanges to Each of the Holes.

Having cleaned out the tank, flanges should be fitted to each of the holes, rubber insertion being placed between the flange and the tank. The purpose of the flanges is to reinforce the wall of the tank, and it is most necessary that they are fitted in all cases except where the tank is of $\frac{3}{8}$ in. or more in thickness. In such cases a back nut is fitted to the element.

The fixing of the flanges is quite simple. The $1\frac{1}{4}$-in. flange usually has four holes ready for the reception of galvanised $\frac{3}{8}$-in. Whitworth bolts, and the $\frac{1}{2}$-in. flange drilled with three similar holes. Needless to say, washers should be fitted to the bolts, and the nuts tightened up as much as possible in order that there may be no possibility of leakage. (See Fig. 11.)

Fitting the Element and Thermostat.

The element is now screwed into the larger flange, whilst in the case of the thermostat only its detachable sheath is fitted at this stage. It is essential that this sheath is properly fitted (see Fig. 12) before the thermostat is pushed into position and secured by means of the set screw provided (Fig. 13).

In the case of cylindrical tanks, the installation is exactly the same, but, of course, it is necessary for the flanges to be radiused to suit the curvature of the tank wall.

WIRING.

The heater should not be operated from a plug point. All wiring should be permanent and carried out in accordance with the wiring regulations of the Institution of Electrical Engineers. The following table shows the recommended cable sizes for various elements on 110 and 230 volt circuits.

RECOMMENDED CABLE SIZES FOR VARIOUS ELEMENTS ON 110 AND 230-VOLT CIRCUITS.

Loading of Element kW.	Voltage.	Recommended Cable for Wiring.
2	110	7/.036
2.5	110	7/.044
3	110	7/.052
4	110	7/.064
5	110	19/.052
2	230	3/.036
2.5	230	7/.029
3	230	7/.029
4	230	7/.036
5	230	7/.044

One side of the supply should be connected to the heater, the other pole (the "live" side) should be broken through an insulated switch of suitable capacity placed near the immersion heater, the switch being connected to the thermostat, the thermostat to the other side of the heater. No switch or fuse controlling a water heater should be installed within reach from a bath. (See Regulation 100A of the I.E.E. Regulations for the electrical equipment of buildings.)

It is recommended that the wiring in the linen cupboard should be carried out **in** asbestos-sheathed fireproof cable.

The whole installation should, of course, be controlled by a double pole iron clad main switch and fuses placed within 6 ft. of the supply company's service termination.

Earthing.

Do not forget that the metallic covers of the immersion heater and thermostat must be suitably earthed. The earth wire should be connected to the main cold-water service pipe, and all hot-water pipes, secondary cold-water and waste pipes in tha bathroom should be bonded to it.

Efficiency of Installation.

The thermal efficiency in the case of most immersion heater installations is in the neighbourhood of 80-85 per cent. The loss of efficiency is due to radiation loss from the tank and the piping connected to it. This loss may be considerably reduced by lagging the whole of the outside of the tank with a suitable insulating material.

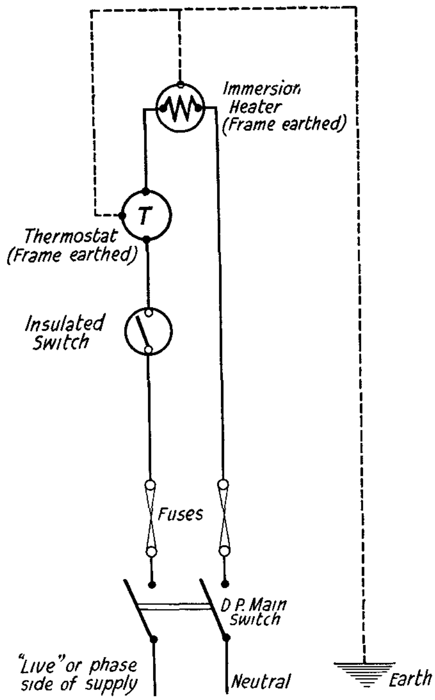


Fig. 15.—THE WIRING FOR A TYPICAL IMMERSION HEATER INSTALLATION.

The simple graph shown in Fig. 14 illustrates the heat losses from a 30-gall. hot-water tank in which the water is maintained at 160° F. It will be seen from this graph that an unlagged tank will radiate 600 watts continuously. With 2 in. of good lagging this loss can be reduced to 100 watts, whilst with 4 in. of insulation the loss is 50 watts only.

Lagging the Tank.

The tank is covered on all sides with a thickness of at least 3 in. of cork wool, a rough framework of wood being made round the tank, and the cork retained in position with suitable canvas.

The reader may consider that this lagging is perhaps an added refinement to the installation. This, however, is not the case. The importance of careful lagging or heat insulation of the hot-water tank cannot be over-emphasised.

Practical Construction of a Small Electric Furnace

By A. G. Arend

PROBABLY one of the most difficult jobs which a practical electrical engineer may be called upon to perform is that of setting up and operating a small electric furnace. The reason for this is not so much the complexity of the work itself, as the difficulty of acquiring reliable practical details, as taken from actual working furnaces.

This will readily be understood since most furnaces on the market to-day are patented, or proprietary articles, and secrecy is naturally observed. No standard work exists on the construction of electric furnaces, although a small library of books has been published on the theory, the method of manipulation, and the extent of performance of these hearths.

At the outset, to fully appreciate the reactions which occur, so as to set up the furnace in the best approved manner, it is desirable to have some knowledge of electro-chemical and electro-metallurgical theory. When this has been gained calculations of the dimensions are comparatively simple. The class of electric furnaces referred to are those employed for the making of different chemical products, which necessitate a high-thermic reduction. These include carbides, cyanides, carborundum, and numerous other compounds.

The preliminary work on all such processes is conducted on a small scale, and hence a type of small hearth has to be used for the various experiments.

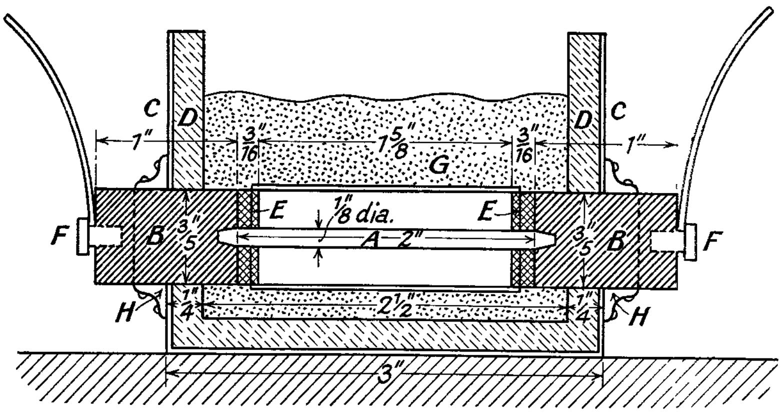
Once a good standard type has been attained this is copied for all future experiments, and the following details are taken from one of these.

The small size of the furnace must not be unduly criticised, as it permits of easy control, and the means of rapid alterations, should it be desired to try out some new experiment, and one on which calculations may be made for large scale operations.

The Carbon Rods.

The carbon rods used as electrodes are taken from arc-lamps, which should be milled by carefully working in a lathe until the desired diameter has been reached. In order to avoid calculations these were milled to exactly $\frac{1}{8}$-inch in thickness. This exposes a surface to the charge which by calculation requires approximately 40 amps. (This is approximately equivalent to 3.800 amps. per square inch).

The same rod is capable of carrying a much greater current density if it should



Constructional Details of Small Electric Furnace
A, carbon rod. B, carbon blocks. C, canister. D, $\frac{1}{4}$-in. fireclay lining. E, asbestos discs. F, terminals. G, powdered charcoal. H, ring mounts.

be required, that is, without alteration. At the temperatures which are required, the voltage necessary to drive a current of one amp. through one square millimetre of carbon rod is approximately 0.4 volt, or slightly less than this figure. Hence the electromotive force which is necessary to overcome the resistance of a carbon rod of $\frac{1}{8}$-in. diameter and 2 in. long at the foregoing density, ranges from 12 to 18 volts.

Why the Use of Smaller Currents is not Advised.

From a purely practical standpoint it is a good plan to operate the small furnace at not less than these figures. Various practical difficulties are liable to arise if smaller currents are used, as the thin carbon rods are readily broken, and become burned through by the oxygen of the metallic oxides which may be present. The presence of excess carbon in the surrounding mixture is not sufficiently active to prevent this oxidation, and this point must not be overlooked. The small carbon rods are, therefore, milled and cut, and the dimensions checked with a micrometer.

The Electrodes are Attached to Small Carbon Blocks.

The difficulty of suitably holding small electrodes has long been appreciated, and for experimental furnace work it is more satisfactory to dispense with these altogether, and revert to the earlier practice of simply directly attaching them to carbon blocks from which the current may be directly led in. These blocks are cut out of solid graphite, and terminals embedded in them, to which the leads are attached. The inner sides of these blocks are insulated with asbestos millboard, which is cut out whilst the latter is wet in the usual manner.

This insulation prevents a passage of current of unknown quantity, and ensures the carbon rod being entirely responsible for leading the current into the mixture to be electrolysed.

Making the Connections.

The small furnace is made up of a canister, which has two discs cut from the sides, to permit of the introduction of the carbon blocks. Ring mounts are screwed on to the outside of the canister to ensure that the blocks are firmly held in position.

When first tried the ring mounts themselves were screwed, so that the blocks could be screwed into position, but this meant that the soft carbon had to be specially handled in a lathe, and the method was abandoned, although it was recognised that such a method allowed of screwing up with greater precision.

Plain ring mounts were attached, the carbon blocks fitted into position, and the inner side of the canister lined with fire-clay. A hole $\frac{1}{8}$-in. in diameter is drilled in the centre of either carbon block, and the carbon rod sandpapered, and then fitted between the two blocks. Two asbestos discs are cut out, each $\frac{3}{16}$-in. in thickness, and pressed into position, " hard-up " against the sides of the blocks.

This totals a thickness of $\frac{3}{8}$-in., which means that the length of the carbon rod as exposed to the mixture for fusion is reduced this much. Starting with a rod 2 in. in length, this means that the effective length of the electrode is $1\frac{5}{8}$ in. in length, or approximately $1\frac{3}{4}$ in. long. It is thus an easy matter to construct a resistance which will be suitable for the currents applied in any experiments, and charges are made out accordingly.

A piece of thin cardboard is cut out, and rolled into the form of a cartridge. The charge to be worked in the furnace is placed in this cartridge, and wrapped round the carbon blocks, so that the carbon electrode exists in the centre of the mass.

Outside the cartridge, the fire-clay lined canister is filled with charcoal powder, which is the final operation prior to working the charge.

The Current.

To get a current of 40 amps. it is necessary to convert any ordinary current available from the main supplies. The use of motor generators can always be resorted to, but this is a costly measure for a small furnace, and a better plan is to make a small improvised generator for the purpose, so that any number of amps.

will be available for those small requirements. The capacity inside the cartridge represents the capacity of the charge.

From experiments done it was found that about 75 per cent. of the amperes were efficient. The voltage which disappeared in overcoming ohmic resistance largely depends on the nature of the charge fused, and varies to some extent. Practically any class of metallic oxide may be reduced in this class of furnace, whilst carbides and different chemical compounds are made with great ease, as the high temperature never fails.

Operating the Furnace.

To operate the small charge the constituents are weighed out in their required proportions, on a balance, with great accuracy. After thoroughly mixing these are packed into the cartridge, and what surplus remains over is also weighed, so that the exact quantity of the charge is obtained.

The space outside the cartridge is then packed with powdered charcoal. The leads are then attached to the terminals, and the current applied.

The time required to fuse the mass, irrespective of its refractory nature, is comparatively short, as a result of the intense heat developed in the small space. When the reactions have been completed, the current is disconnected, and the furnace allowed to cool down. The charcoal powder is then emptied out, and the fritted mass inside the cartridge examined. Even the most refractory of metallic oxides are reduced to the metallic condition by this treatment, and the carbon rod will be found surrounded by a mass of metal of the most infusible character, or, alternatively, by some very difficultly reduced material, as the case may be.

The conditions of the furnace prevent the possibility of an electric arc being formed, and in the absence of any break in the conducting circuit within the charge mixture, the occurrence of electrolytic decomposition is also negatived.

The Water-Turbo Set.

The cheapest way of getting the current is by means of a small direct current dynamo, driven by water power. The dynamo should be "shunt" wound, and be fitted with a laminated cogged drum armature, wound in as large a number of sections as possible in accordance with its size. It should be fitted with adjustable brush gear and lubricators on both bearings, sufficiently large to accommodate the necessary oil, as the speed will not be much under 3,000 revolutions per minute.

The temperatures of the fusions conducted will normally be so high that pyrometers will be of little assistance, and it is better to take a rough estimate from the number of amps. applied. When working in this way a small switchboard is necessary, furnished with an adjustable resistance unit, which allows of a suitable range of amps.

In order to work the small charge on a thoroughly scientific basis, the time that a fixed number of amps. are applied should be noted and the resistance which the mass will set up to the passage of the current. From this the high temperature which will be produced may be calculated, and this can be checked by the time taken to melt refractory materials of known high melting point.

The small water-turbo set is the only expensive item in the whole outfit, and the number of high-temperature experiments which may be conducted is almost unlimited.

Reversing Electric Motors

By C. Hargreaves

It is often necessary to reverse the direction of rotation of electric motors.

The direction of rotation of a direct current motor depends on the direction of the main magnetic field and the direction of the armature currents in the conductors cutting across the field.

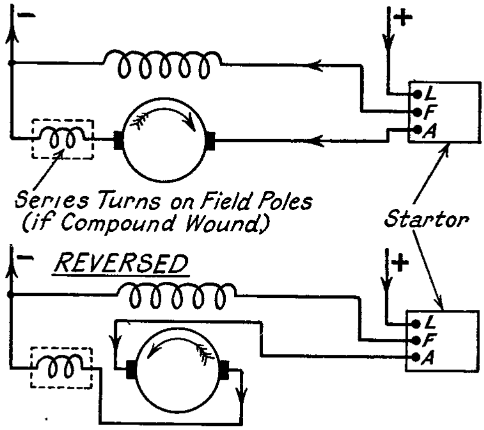


Diagram of Connections for Shunt Wound or Compound Wound Motor, before and after Reversal.

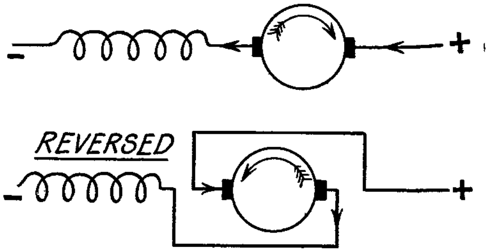
D.C. Motors.

If either of these be changed the motor will run in a reverse direction, therefore we get the law: To reverse the direction of rotation of a D.C. motor, reverse the connections to the field or armature; but not to both. If both connections are reversed the motor will run in the same direction.

Compound Wound Motors.

A compound wound motor has two windings on the main poles; the shunt, a thin wire coil and the series, a thick wire coil carrying the main current.

These coils magnetise the poles in the same direction, so that when reversing rotation by changing the shunt connec-



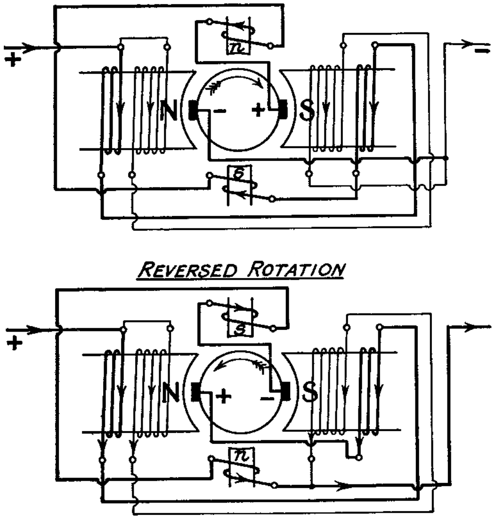
Series Wound Motor Showing Connections before and after Reversal.

tions, care must be taken to change the series connections also.

To avoid mistakes which will result from the neglect of this precaution, it is preferable to reverse the armature connections.

Interpoles.

Interpoles are another snag for the unwary who, after reversing the armature



Connections for Compound Wound Interpole Motor before and after Reversal.

connections, are puzzled to find bad sparking at the brushes.

This is because the interpoles have now the wrong polarity for the direction of rotation.

Treat the interpole coils as part of the armature winding, and all will be well; when armature connections are reversed, reverse the interpole connections also.

A.C. Motors.

In alternating current motors different conditions prevail. The rotation is produced by the stator windings setting up a rotating field which pulls the rotor after it.

To Reverse Rotation of A.C. Motors.

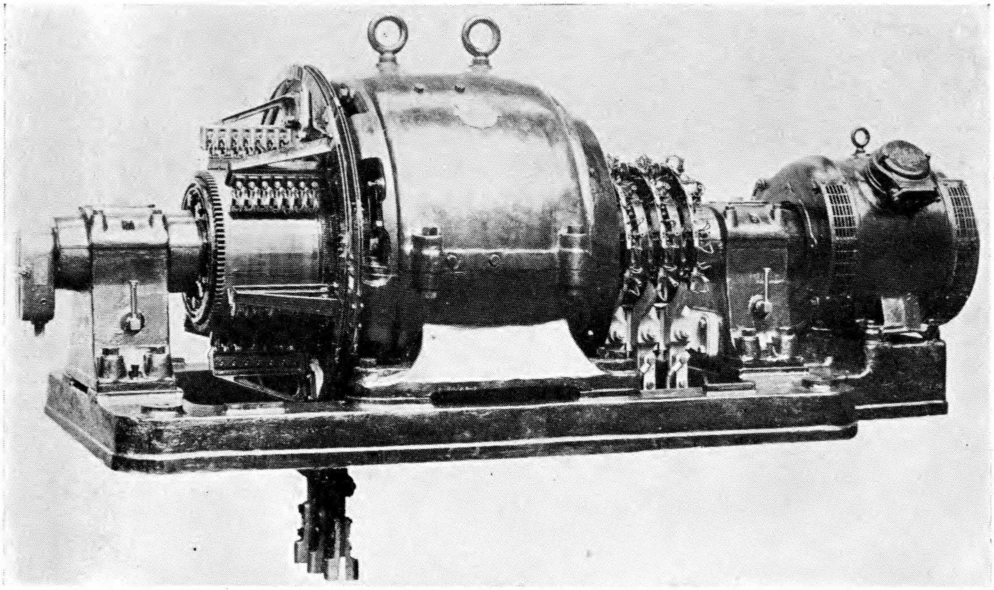
To reverse rotation, the rotation of the magnetic field must be reversed. In a single-phase motor of the split-phase type do this by reversing the connections to the starting winding. To reverse a two-phase 4-wire motor change the connections of one phase only; in a two-phase 3-wire motor change the two outer wires. A 3-phase motor has its rotation reversed by simply interchanging the connections of any two wires.

APPROXIMATE CURRENT TAKEN BY SINGLE PHASE MOTORS OF AVERAGE EFFICIENCY.

H.P. of Motor.	Amperes.			
	200 Volts.	346 Volts.	400 Volts.	500 Volts.
1	7	4	4	3
2	15	8	7	6
3	22	13	11	9
4	29	17	15	12
5	29	17	15	12
6	34	20	17	14
7½	43	25	22	17
10	55	32	28	22
12	66	38	33	27
15	82	48	41	33
20	107	62	54	43
25	134	78	67	54
30	161	93	80	64
35	187	108	94	75
40	214	124	107	86
45	241	139	121	97
50	265	153	132	106
60	317	184	159	127
70	370	214	185	148
75	392	227	196	157
80	418	242	209	167
90	471	272	235	188
100	523	302	262	209
110	575	332	288	230
120	627	363	314	251
130	680	393	340	272
140	732	423	366	293
150	784	453	392	314

(With acknowledgments to "General Information," issued by W. T. Henley's Telegraph Works Copmany Ltd.)

Notes on the Care of Rotary Converters



A 400 kW. Rotary Converter Equipped with Pony Motor. (*Lancashire Dynamo & Crypto, Ltd.*)

It is advisable that maintenance engineers in rotary converter substations should follow a recognised programme in the general care of the machines. There are certain points which require careful and frequent attention, although it depends to a great extent upon the conditions under which the machines operate as to how often they are examined.

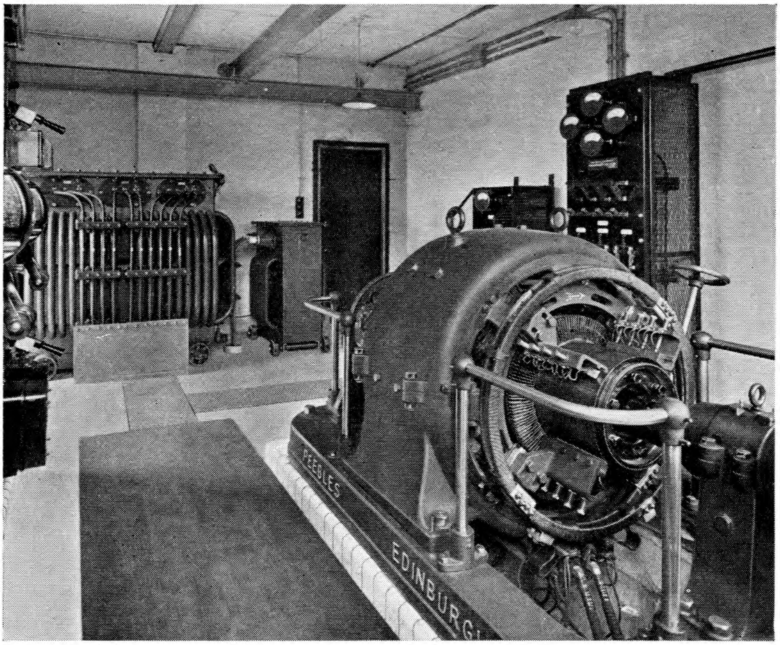
We all know that the inside of a power station or sub-station is kept scrupulously clean, with hardly a spot of dust or dirt to be seen. Rotary converters operating under such conditions require less attention than those installed in buildings where, for instance, extensions are taking place and where the air is dust-laden. Frequent attention must be given to machines operating under these conditions.

No matter what the conditions, however, the fact remains that for a machine to give of its best, it must be regularly examined and maintained in good condition. The object of this article is to point out in a general manner the points requiring the most important attention, and to include particular reference to the location of faults.

We will first of all refer to those details which require the most frequent scrutiny. These points should be attended to every week or two, the machine, of course, being shut down before being inspected.

Details Requiring Frequent Attention.

Dirt and dust have an amazing habit of accumulating, and it will be found that they collect even in the cleanest building, so that it is necessary thoroughly to clean certain parts of the machines every week. The armature of a machine can best be cleaned by blowing it out with compressed air, a small motor-driven compressor being useful for this purpose.



THE D.C. END OF A 150 KW., 3-PHASE, 50-CYCLE ROTARY CONVERTER. (*Messrs. Bruce Peebles & Co., Ltd.*)

The flash screens should be thrown back and the brush brackets thoroughly blown out.

It should be noted that when using compressed air, the air pressure should not be more than say, 25 lb. per sq. inch. A high pressure may tend to lift the insulating wrappings and blow dust inside the coils. It is important that any accumulations of water in the pipe should be blown out before turning the air blast on the machine.

Clean Inside of Brush Boxes.

The attendant should also lift the A.C. brushes from the brush boxes, one at a time, and remove all oil and dirt. The insides of the brush boxes should also be cleaned with a rag dampened with paraffin. Only clean rags should be used for cleaning purposes and on no account should cotton waste be employed.

The slip-ring lubricating brushes must be cleaned, and if necessary, the brush boxes refilled with oil.

We now come to those points which do not require such frequent attention, but which, nevertheless, should be looked after carefully, say, every three or four weeks.

Points to Which Attention Should be Given Every Few Weeks.

Careful attention should be given periodically to the D.C. brushes to ensure that they are kept free from dirt. They must be taken out of the brush holders and cleaned, and the brush boxes should be blown out with compressed air. As all the brushes are bedded to the commutator surface, they must not be reversed when they are put back into the brush holders, but placed in their former positions.

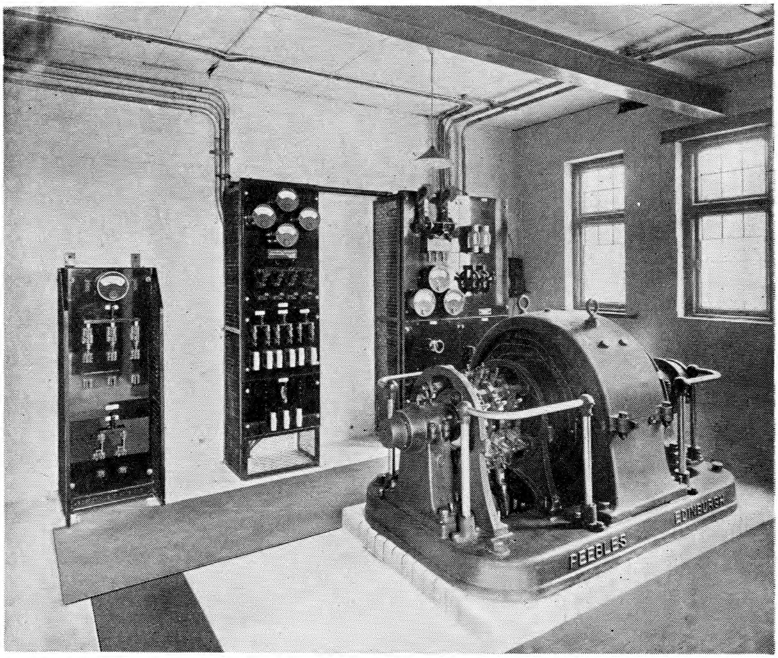
Check Spring Pressure on Brushes.

Check the spring pressure on all the brushes and if necessary adjust to the correct pressure. It is also important that the slots between the commutator segments should be cleaned out so as to remove any foreign matter which might act as a conductor between them.

Attention should also be given to the following :—The A.C. and D.C. current carrying connections should be inspected and joints tightened if necessary ; the clearance between the armature and pole faces should be checked ; if necessary clean the bearings and replenish with oil ; with a rotary converter equipped with an induction regulator, the induction regulator should be inspected ; the operation of the speed-limit device should be watched.

ARMATURE FAULTS.

So far we have described in a general way those points which require attention in order that a rotary converter is maintained in good running condition. Now we will suppose that in spite of the good care that has been bestowed on a machine, it has developed a fault in the armature which must be located before it can be put into operation again. It must be realised that even although the greatest attention is given to an electrical machine, faults will sometimes occur, due perhaps to a short-circuit or breakdown of the insulation or some fault that it is impossible to notice beforehand. As already stated, we will suppose that there is a fault in the armature—the symptoms may indicate a short-circuit, for instance—and the trouble has to be located. This is done by means of a drop-test, and the manner in which this is carried out is explained in the following paragraphs.



THE A.C. END OF A 150 KW. ROTARY CONVERTER. (*Messrs. Bruce Peebles & Co., Ltd.*)

The Drop Test.

First raise the D.C. brushes. Current from a low voltage D.C. supply is then passed through the armature windings, the current entering the armature by connections held on to two adjacent commutator segments. A battery, motor-generator or booster is the best means of obtaining the current, which can be limited if necessary by connecting a small resistance in series.

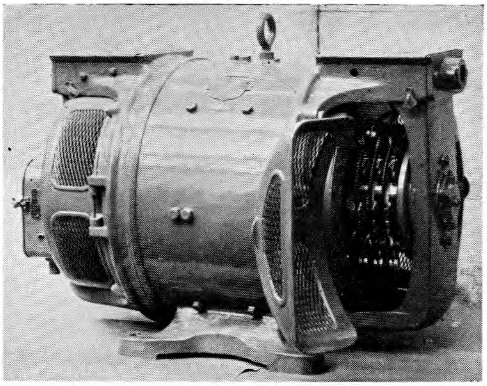
With a certain current flowing, measure the voltage drop across the segments through which the current is passing. Then move each lead to the next segment, and with the same amount of current flowing through the circuit, again measure the voltage drop across the segments. The procedure should be repeated for each adjacent pair of commutator segments.

Instrument to Use.

A milli-voltmeter is the most convenient means of measuring the voltage drop, which is small. In order that the reading is high enough easily to detect any difference in the drop across different pairs of segments, the current should be adjusted to a suitable value.

Difference in Drop.

Across certain segments it will be found that a lower drop occurs than across others. This is due to equaliser and slip-ring tapping connections. The segments should be numbered consecutively to ensure that the low readings occur at equal intervals round the commutator. A very high reading indicates a bad joint, and the source of the fault is located as explained in the following paragraph.



A SMALL 50 KW. ROTARY CONVERTER. (*Lancashire Dynamo & Crypto, Ltd.*)

Location of Fault.

With one voltmeter lead held on the current carrying segment, move the other halfway up the commutator lug connected to the other current carrying segment. If now there is a normal reading on the voltmeter, it indicates that there is a bad joint between the commutator lug and the commutator segment.

With one voltmeter lead held on the current carrying segment, the other should be moved on to the actual armature conductor at the back of the sweated clip, joining the armature conductor to the commutator lug. If now there is a normal reading on the voltmeter, it shows that the connection between the armature conductor and the commutator lug is faulty.

Repeat the test with the voltmeter lead previously moved, now held on a current carrying segment, and the other lead, previously stationary, moved.

It is generally possible to locate bad joints in the connections at the back end of the armature by moving with pliers the clips of those armature conductors which go directly to the commutator segments across which a high reading has been recorded on the milli-voltmeter. Variable readings on the milli-voltmeter will be caused by the movement of a bad joint.

Having described how a drop-test is taken, we will now go on to commutator faults and their prevention.

COMMUTATOR FAULTS.

A commutator that is given proper attention will give very little trouble. The good condition of the commutator of a machine which is running satisfactorily is indicated by its polished surface.

Commutator faults are most likely to occur with a rotary converter which is heavily used. Should it be observed that two or three segments of the commutator are blackened while the remainder are polished, or segments situated at equal points from one another round the commutator are blackened, the cause of the trouble must be located even though there is not much sparking when the machine is on load.

Examine for Roughness.

The commutator should first of all be examined to ensure that there is no roughness and no high or low segments to cause the brushes to lift or make a chattering noise when the machine is running.

Inspect Brush Brackets.

Next, the brush brackets should be inspected to ensure that they are adjusted correctly, and that there are no loose connections in the bus rings connecting the brush brackets.

If it is still impossible to locate the fault, it will be necessary to take an armature drop-test as already described.

Sparking.

It will sometimes be found that sparking is caused through the mica between the segments rising above the commutator surface. If this occurs the mica will have to be cut down, a suitable commutator stone being used for the purpose.

Cleaning up.

On those occasions when it is required to clean up the commutator and slip-rings this should be done with fine carborundum cloth fitted on a curved block; emery cloth should never be used. In the event of the commutator or slip-rings being turned at any time, the greatest care should be taken afterwards to remove all dust with a clean dry cloth. This is important, because of the possibility of metallic dust accumulating in the commutator risers or in the connections leading from the slip-rings to the armature during turning or grinding operations.

A very rough commutator should be polished by grinding rather than by turning.

Care of Brushes.

If it is found necessary to fit new brushes, a careful selection should be made to ensure that the brushes are of the best quality. In fact, it is advisable to approach the rotary converter manufacturer for new ones so that similar brushes to the originals can be supplied. Inferior brushes may cause bad commutation and overheating of the machine.

When new brushes are fitted, they should be carefully bedded to the surface of the commutator. This may be done by drawing sandpaper under each brush in the direction of rotation, first using rough sandpaper, and then finishing with fine. It is essential that before the machine is started, all carbon dust should be removed from the windings, commutator and brushgear.

Badly bedded brushes may do much harm to a commutator, and so in order to ensure that the brushes are properly bedded, the machine should be run without load for a few hours.

Precautions to Take When Starting.

When starting a new machine for the first time, or an old one after being repaired, certain precautions should be taken to prevent trouble occurring. There are several methods of starting rotary converters, such as D.C. starting; induction motor starting when separate synchronising is necessary; induction motor starting self-synchronising, and A.C. starting by means of taps on transformers, but the remarks below are general as it is impossible to refer to each method separately.

Before attempting to start a machine it is always advisable to examine all connections and to check them with the circuit diagram. An insulation resistance test should be carried out on the rotary converter, including switches, cables and rheostats. All switches should be open, and only after the connections are thoroughly understood should any switch be closed. It should be remembered that switches should not be closed slowly.

If the advice given above is carefully followed, there should be no trouble during the starting operation.

Good Maintenance Means Good Service.

It will be appreciated that the foregoing article deals only in a very general way with the care of rotary converters, and there are other points which could be referred to if space permitted. Nevertheless, the author hopes that the information will be of assistance to maintenance engineers whose work involves the care of these machines. It should be remembered that any electrical machine which is operated properly and maintained in good condition by being given regular attention will render far longer satisfactory service than one that is allowed to run month after month without being examined for any possible defects.

The secret of good service is good maintenance.

A HIGH RESISTIVITY ALLOY

A recently introduced electrical alloy, known as *Rhometal*, has the very high resistivity value of 100 microhms per c.c., combined with a magnetic permeability ranging from 80 to 1,500, according to the mechanical and heat treatment. The hysteresis and eddy current losses are very low. This alloy has a specific gravity of 8.2. The ultimate strength is 35 tons per sq. in. The yield point is 20 tons per sq. in., and elongation 25 per cent. on 5 ins.

Rhometal is supplied in standard strip and wire sizes, and as tape and stampings.

An Interesting Morning at Chiswick

Meet Some of Your Fellow Readers.
This photograph was taken immediately after an interesting tour of the works of Evershed & Vignoles, Ltd., Acton Lane Works, Chiswick, on the morning of March 24th, 1934.

It will be remembered that in our March issue we announced that a visit had been arranged for the benefit of readers of the Magazine to take place on the morning of March 24th at the works of Messrs Evershed & Vignoles, Ltd., Acton Lane, Chiswick.

Applications were received from about 30 readers, and the visit proved to be most enjoyable and instructive. The photograph above shows the party immediately after the works tour.

The name of Eversheds is famous throughout the electrical industry in connection with the "Megger" Insulation Tester. Naturally the various processes in the construction of this ubiquitous instrument provided many interesting items for our party of sightseers. Particularly interesting is the method employed to calibrate the scales of the instruments. This will be described in our next issue.

The manufacture of switchboard instruments, including ammeters, voltmeters, and frequency meters, also provided some interesting items.

We were also shown the operation of the Evershed-Midworth Repeater System, which enables the reading of any instrument to be repeated exactly on another dial. This, we understand, is at present being used to indicate at a central control station the power input and output of fifteen power stations connected with the Central Scotland Grid Scheme. We hope to explain the working of this system later, but in passing it may be remarked that only two wires are used between the transmitter and receiver. The power consumed is very small.

In the Marine Department we were intrigued by the Brewerton Course Recorder, which is an instrument to be installed in the chart room of a ship. It operates in conjunction with the gyro-compass and the electrical log, and plots on a chart the course followed.

The visitors included the following :—

Miss K. M. Burgess, A. E. Woollerton, H. E. J. Butler, C. Radford, E. J. Rouse, W. Hall, D. Peel, C. J. G. Austin, S. Gerald Carter, A. H. Handley, H. M. Newman, R. J. Wey, T. J. Hallett, R. J. Meetens, E. Barnett, J. G. Fleming, S. W. Meachem, A. C. Stewart, H. J. Baldwin, E. Browne.

THE CARE OF A.C. CONTACTOR CONTROL EQUIPMENTS

THE satisfactory performance of any electrical equipment depends not only upon its high standard of quality, but also upon the care and attention which it is given during service. It should therefore be the aim of all maintenance engineers to keep in the best of condition the particular apparatus under their charge. The result in the long run will be less trouble to themselves, and less expense to their employers.

Considering the care and maintenance of A.C. contactor control equipments for induction motors it is absolutely essential that the apparatus should be inspected at regular intervals in order to obtain reliability and freedom from breakdown. In the following article we point out the chief points to which attention should be regularly given, and trust that the information will be of assistance to engineers engaged on maintenance work.

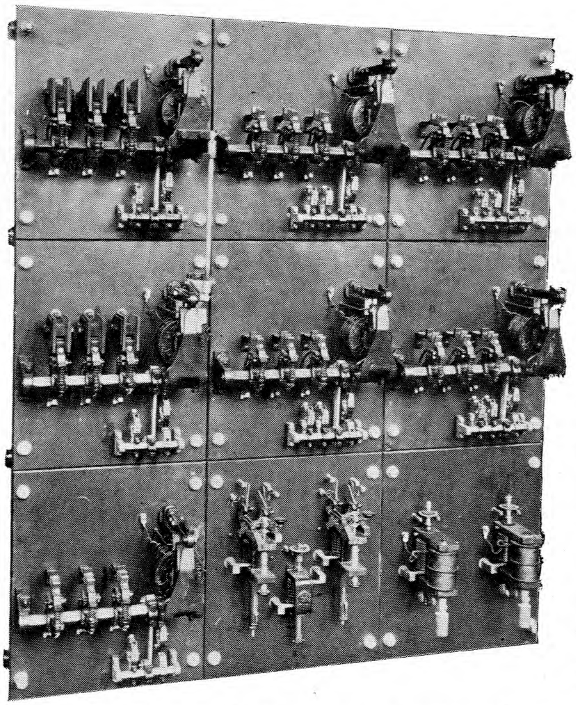


Fig. 1.—A TYPICAL A.C. CONTACTOR CONTROL PANEL. (*B. T. H. Co., Ltd.*)

Points that Should Receive Attention.

Before going on to describe in detail the maintenance of A.C. contactor control equipments, we would point out generally the outstanding features to which the engineer should give careful attention. These are as follows:—No dirt, dust or moisture should be allowed to accumulate on the panel; care should be taken to tighten any connections which may have worked loose, all parts liable to become worn should be regularly examined; there should be free operation of all contactors and relays; the oil in the time-lag dash-pots of the over-current relays (if these are fitted) should be changed if it is dirty, and the dash-pots refilled with suitable oil.

We now go on to point out in greater detail the steps to take in order that the various parts of these equipments should be kept in good working condition.

Examination of Contact Tips.

It will be found after a time when an equipment has been in frequent service that the contact tips of the contactors and interlocks will show signs of wear. When they become worn half-way through, they must be replaced by new ones, as badly worn contact tips are likely to cause trouble.

Badly pitted tips should be smoothed by the use of fine sandpaper.

Badly worn interlock fingers also should be renewed, as bad contact will possibly cause failure.

Weak Contactor Springs.

After long use the contactor and interlock springs may become too weak to function properly and should be changed immediately they are found to be defective. A very simple but satisfactory means of testing finger-pressures is by the spring balance method shown in Fig. 2. It will be seen from this illustration that a piece of paper has been placed between the contact tips and the spring balance attached so that the direction of pull is at right angles. The pull on the balance at the moment the paper is liberated indicates the finger pressure. The correct pressure of the contact springs of A.C. contactor units should be supplied by the makers of each particular equipment to enable comparison to be made with the actual pressure obtained.

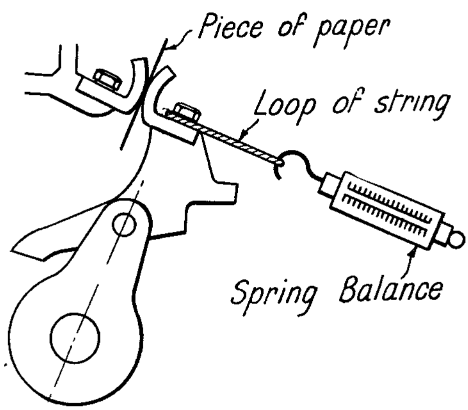


Fig. 2.—How Finger pressures are Tested by Means of a Spring Balance.

Care must be observed when replacing defective parts that they are arranged in their correct positions and that the original assembly is not changed.

Care of Contactors.

The contact tips of the contactors may become roughened by arcing, but this is minimised if they have been designed to close with a combined butting and rolling movement.

Finger-pressures of the contactor should be checked in the manner already described when new arcing tips have been fitted. Fig. 3 shows the necessary clearances between the magnetic faces of a particular equipment, but it will be found that after the equipment has been in service for a long time, these clearances will probably change, and must be re-adjusted. The table below gives typical examples of the clearances for contactors of 75, 150, 300 and 600 amperes continuous rating; this table should be studied in conjunction with Fig. 3.

Contactor Continuous Rating in Amperes.	Clearance in Inches.						
	A.		B.		C.		D.
	Min.	Max.	Min.	Max.	Min.	Max.	Min.
75	$\frac{29}{32}$	$\frac{31}{32}$	$\frac{7}{32}$	$\frac{1}{4}$	.02	.025	$\frac{13}{32}$
150	$1\frac{3}{8}$	$1\frac{15}{32}$	$\frac{1}{2}$	$\frac{19}{32}$	$\frac{1}{32}$	$\frac{3}{64}$	$\frac{15}{32}$
300	$1\frac{13}{16}$	$1\frac{29}{32}$	$\frac{21}{32}$	$\frac{3}{4}$	$\frac{1}{32}$	—	$\frac{17}{32}$
600	$1\frac{15}{16}$	2	$\frac{27}{32}$	$\frac{29}{32}$	$\frac{3}{64}$	$\frac{1}{16}$	$\frac{7}{16}$

To Cure Humming.

It may be found that the contactor makes a humming noise when the coil is energised. The humming may be due to bad connection in the pole-shading device circuit, or it may be because the moving armature is not bedding properly on the top pole-face. The pole-shading device should be examined and all connections checked to ensure that they have not become loose.

If the humming does not now cease, it is probably due to the second cause mentioned above, i.e., the moving armature is not bedding properly on the top pole-face. A test to find out if good contact is being made may be carried out by placing a piece of carbon paper between two sheets of white paper and inserting the whole between the moving armature and the stationary pole before closing the contactor. The part making actual contact (which should be at least 90 per cent. of the full area) will be impressed on the white paper. When it is found that bad contact is being made, the top magnet face should be carefully filed so that the two surfaces will make good contact.

It will perhaps be found that humming occurs with a contactor which has been installed for a long time and has done considerable service. In this case, it is due to the bearings becoming worn, and it will then be necessary to rebush the bearings.

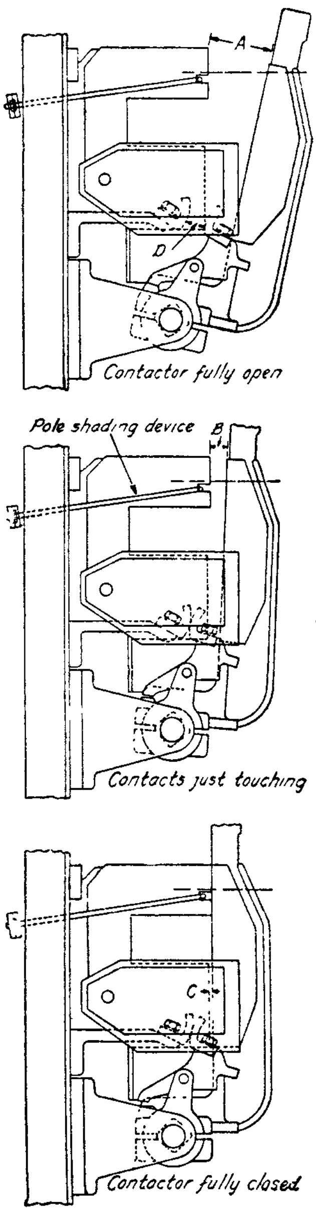


Fig. 3.—Outline of Contactor Units, Showing Clearances. (*B.T.H. Co.*)

RELAYS FOR LIMITING CURRENT.

Before referring to the care of current-limit ("notching") relays it may be of interest to describe the construction and operation of a typical relay.

Construction of Relay.

The relay illustrated in outline in Fig. 4 comprises two soft-iron plungers, arranged so that one (known as the series plunger), which carries an interlock disc, is lifted by the out-of-balance weight of the other. A connecting link between the two plungers is provided by a pivoted brass lever, which is arranged so that when the second plunger (known as the shunt plunger) is lifted by the energising of the relay shunt coil, the series plunger is left unsupported and free to drop under certain conditions.

There are two operating coils with each relay, one a series coil, carrying the full main current (or by using a current transformer a definite fraction thereof), and the other a shunt coil, which is energised under certain conditions with the shunt operating coil (with which it is in series) of the individual contactor under control.

The plunger controlled by the shunt coil is solid, but that operated upon by the series coil is adjustable, being made in two halves, so that the air-gaps between them can be varied by turning up or down the adjusting nut shown in the diagram.

How the Relay Operates.

After the main line circuit has been closed by the oil-switch or stator contactor (whichever is installed), each successive rotor contactor has its operating coil connected in series with the shunt coil of one or other of the two "notching" relays.

The operation of the relay entirely depends upon the fact that although the current flowing through the shunt coil of the relay and the operating coil of the contactor (connected in series with it) is of sufficient value to draw up the relay shunt plunger, it is insufficient to close the contactor.

The lifting of the relay shunt plunger, however, causes the removal of the mechanical support previously given to the series plunger, thus leaving the latter free to drop if the main current flowing through the series coil of the relay is no longer sufficiently great to retain it. In other words, as soon as the main current has decreased to the value for which the relay has been set, the series plunger drops, the disc interlock attached to it bridging two contact posts, thereby short-circuiting the shunt coil of the relay and impressing full voltage upon the operating coil of the contactor, causing the latter to close.

Each " notching" relay operates alternately on one contactor at a time, the correct sequence of operation of each contactor by one of the relays being ensured by the provision of interlocks and interconnections.

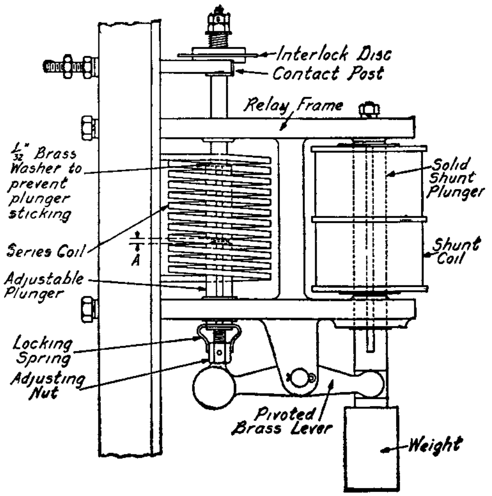


Fig. 4.—Outline Diagram of Current Relay. (*B.T.H. Co.*)

Care of Relays.

Every now and then the current-limit relays should be inspected, and any dirt or pitting removed from the contacts. Badly worn contact tips should be renewed, so should the contact discs if they are so badly pitted that it is impossible to make them smooth.

It should be remembered when altering the settings of current-limit relays, that there is a definite minimum setting of the relay permissible with each contactor equipment, depending upon the load against which the motor has to start. It will be realised that it is necessary to allow a certain margin between the value for which the current-limit relay is set and the maximum current required to start the motor against the heaviest load ; if the margin allowed is too small, a small temporary increase in load may result in the main current exceeding the value for which the relay is set to drop, and under this condition, full voltage cannot be applied to the operating coil of the contactor, the latter, therefore, remaining in the open position. The result would be that the main resistances would become overheated, and the shunt-relay coils and the contactor-operating coils perhaps burnt out.

A margin of about 25 per cent. should be allowed over the current value required to furnish the maximum torque when adjusting the minimum setting of the current-limit relay.

If relays of the type shown in Fig. 4 " notch " up too quickly, the gap shown at " A " should be closed up by turning the adjusting nut slightly; this will cause the plunger in the series coil to hold up at a lower current value. On the other hand, if the relays " notch " up the equipment too slowly, the air gap at " A " should be slightly increased.

MATERIAL FOR TRANSFORMER CORES

A particularly interesting alloy that has recently been introduced, commercially, for low-frequency transformer cores is the nickel-iron product known as Radiometal.

It has a *specific gravity* of 8.26. The *ultimate strength* is 40 tons per sq. in., and *yield point*, 21 tons per sq. in. This alloy is fairly ductile, the elongation being 25 per cent. on a 5-in. specimen.

It has a magnetic permissibility of 1,000-2,000 with small polarising fields, and an electrical resistivity of 40 microhms per c.c.

Two-part Tariff Prepayment Metering

THE extensive use of a two-part tariff for the supply of electricity has called for the production of a prepayment meter to enable supply authorities to extend the use of the two-part tariff to such consumers. Messrs. Chamberlain & Hookham, Ltd., of Solar Works, Birmingham, have recently produced a meter of this type. (Fig. 1).

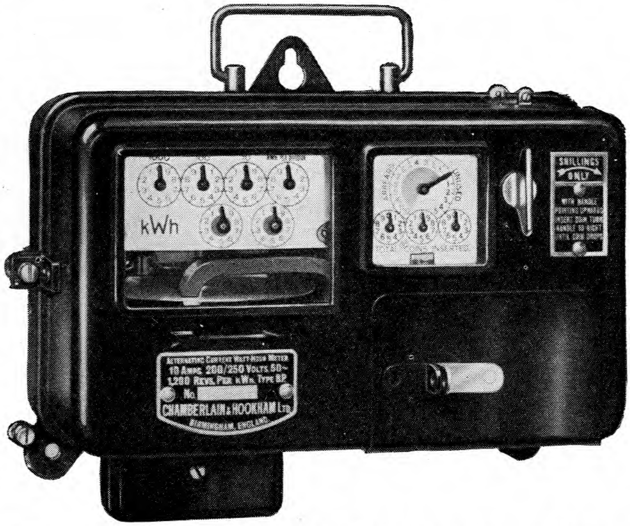


Fig. 1.—Exterior View of the New Prepayment Meter for Two-part Tariffs.

The meter embodies a modification of the well-known Chamberlain & Hookham prepayment meter. The modification consists of the addition of a small synchronous motor which runs continuously and drives the prepayment mechanism (Fig. 2) in the same direction as the meter.

How the Rate at which Motor Drives Mechanism is Determined.

The rate at which the motor drives the mechanism is determined by the standing charge to be collected, suitable gearing being interposed for the purpose. Assuming that the standing charge is one shilling per week and that one shilling has just been inserted in the meter, the switch will be closed and the consumer may take a supply of current if desired.

If Current is not Used.

Should current not be used, the synchronous motor will drive the mechanism for one week, at the end of which time the switch will open the circuit.

On the other hand, if a supply of current is taken, the rate at which the mechanism is run down will be accelerated by the meter in proportion to the consumption, and the switch will open correspondingly earlier.

If, after the opening of the switch, another coin is not immediately inserted in the meter, the motor will continue to run and register arrears against the consumer. Still bearing in mind the previous example, if no coin is inserted in the meter, the arrears will accumulate at the rate of one shilling per week.

In meters of this type hitherto available, no further supply of current can be obtained until the whole of the arrears have been paid off. Strictly speaking, this may be regarded as legitimate, but it is at times very inconvenient. A consumer having accumulated arrears to the extent of, say, three shillings, wishes to obtain a supply of current. Before this can be done, he must find three shillings to pay off the arrears and one additional shilling to prepay for current. Unless he has at least four coins of the right denomination, no current can be obtained.

Emergency Supply of Current can be Obtained without Paying Off Arrears.

To overcome this objection, provision is made in the Chamberlain & Hookham mechanism whereby no matter how much the consumer is in arrears, the insertion of one coin only will provide a limited supply of current, sufficient for an emergency. Thus, the insertion of one shilling when the consumer is in arrears with his payments will provide him with about three - pennyworth of current, and cancel ninepence of the debt.

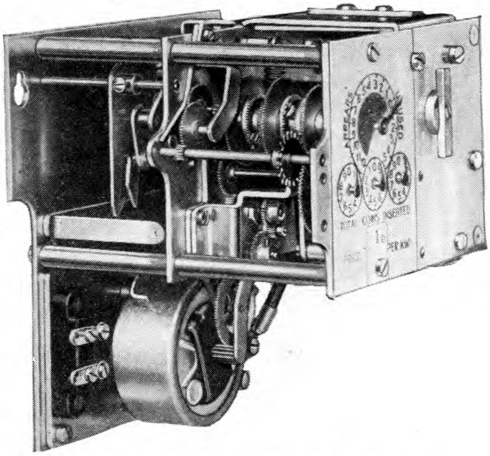


Fig. 2.—The Prepayment Mechanism.

What Happens if Small Amount of Current is not Immediately Used.

This is a convenience which will be greatly appreciated by consumers who may have difficulty in finding a sufficient number of coins to cancel all the arrears. If the small amount of current made available is not immediately made use of, the value is automatically transferred to the cancellation of arrears, and if, twenty-four hours later, current is again required, a further shilling will have to be inserted in the meter.

Credit Advanced on First Coin Inserted Only.

Also a succession of coins inserted will advance credit on the first coin only. Thus, a consumer who is five shillings in arrears can obtain credit to the value of threepence on the first coin he inserts. If five coins are inserted in succession, he will obtain credit to the value of threepence and the balance of four shillings and ninepence will go to pay off arrears, but if the five coins are inserted at intervals, allowing the switch to trip before another coin is put in the meter, the consumer will obtain credit each time.

Arrears Can be Paid Off by Instalments.

The effect of this improved device is that the consumer is enabled to pay off his arrears by instalments instead of being compelled to pay them in a lump sum. In many cases this results in increased revenue, since the consumer is always assured of a limited supply of current for each coin inserted, notwithstanding the fact that he may be in arrears.

We are indebted to the G.E.C. Publicity Department for these interesting details.

A NEW VALVE DEVELOPMENT

" Universal " valves—designed to work on either A.C. or D.C., and almost any voltage—are now an established fact, and mark a startling departure from earlier practice. The complete Mullard range will consist of 11 types.

In external appearance the new valves present almost revolutionary changes. In the first place they are *without pins.* Instead, the bases are fitted with special brass contacts which fit into sunk holders, thus making *positive contact.* The new method has been adopted by the Mullard Company after careful investigation. It was found that much of the trouble experienced in the past has been caused by poor contact between the pins of the valve and the holder, which the new system obviates once and for all, and furthermore, greater clearances between the connections are now possible.

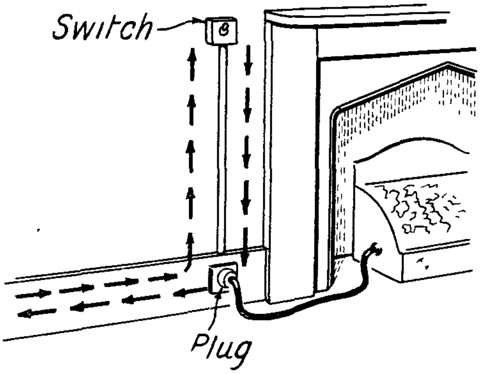
Another improvement which can justly be termed revolutionary is that in all types the grid is taken out to a " thimble " connection at the top of the valve, and connection is made by means of a spring clip.

HINTS AND TIPS FOR THE PRACTICAL MAN

Readers are invited to send brief paragraphs for inclusion in this section. All contributions will be paid for at our usual rates

A HINT WHEN INSTALLING RADIATORS.

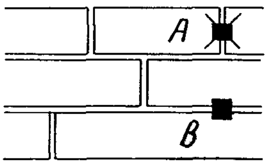
When fixing plugs in skirting boards or any other low level for use with radiators, it is a good idea to suggest a remote switch in circuit with the plug at a convenient

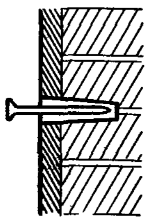


height for an adult to operate ; this avoids the back-breaking method when a live plug only is installed and one has to use the radiator switches every time.

WHEN PLUGGING A WALL.

When cutting out for a plug in a brick wall always try to fix the plug in the horizontal joints (B) of the bricks, and not the vertical joints (A). Slater's laths





make a good plug, being of a handy size, and the wood stands the driving and screwing strain better than other woods. Always allow ample length in the screw you use for a plug.

EASY IDENTIFICATION OF WIRES.

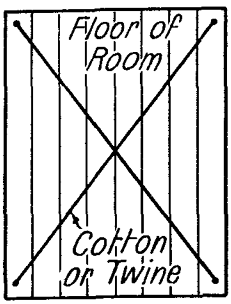
When removing wires from a star Delta starter or other electrical appliance with a number of wires, a number of crocodile clips as sold for connecting wires, with numbers stamped on, or painted in colours, or card numbers fastened to them, will be of assistance if a rough diagram of the terminals are made; at the same time one can send another man on the job with an easy mind.

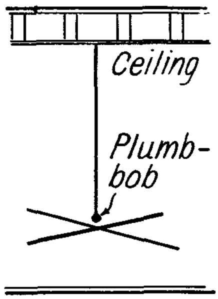
AN UNUSUAL BREAKDOWN.

The following is the result of an actual breakdown. The apparatus consisted of a high-temperature oven with the heating elements in the bottom and the control switches mounted on the side. The connections between the elements and the switches were rubber insulated copper flex in heat-resisting nsulating beads. After breakdown the bottom of the oven was opened for inspection and it was found that one of the connections had fused and the remainder in a very bad condition. On further inspection it was concluded that due to the heat, the sulphur contained in the rubber insulation had vigorously attacked the copper flex until the latter was too small to carry the actual current capacity and had eventually fused.

FINDING THE CENTRE OF A CEILING.

When fixing a lampholder or other fitting in the centre of a ceiling or roof,





the following is a reliable method, and avoids damaging the ceiling. Stretch two lines of cotton or twine from corner to corner, using tacks or drawing-pins to hold the cotton or twine, then with another length of cotton weighted at one end, or with a plumb-bob, hang over the place where the lines cross, and mark the ceiling at the place indicated.

SINGLE STROKE ELECTRIC BELL.

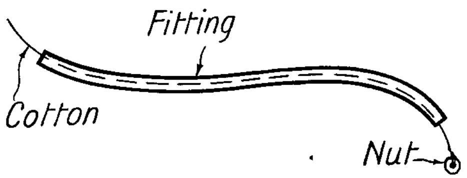
The ordinary trembler bell may easily be converted into a single-stroke bell.

A short wire is connected between the armature end of the magnet coils and the outgoing terminal, so as to short-circuit the make and break contact. Thus, when the bell push is operated the armature is drawn to the pole pieces striking the bell once only. Since the circuit is not broken by the movement, the armature is kept attracted to the magnet until the push is released.

The above conversion will be greatly appreciated in cases where quietude is essential.

WIRING AN AWKWARD FITTING.

An electrician may often have an awkward fitting to wire and much time will be saved if a small nut is tied to a piece



of cotton and dropped into the fitting. The nut can now easily be worked through by tilting the fitting.

A piece of thin string can now be tied to the cotton and pulled through. It is now a simple matter to draw in the wire or flexible.

LEAD FUSES FOR PROTECTING SMALL A.C. MOTORS.

In cases where fractional horsepower motors are used for fans or other steady loads, and where the only protection is a double or, in the case of 3 phase, a triple-pole fuse, it will pay the maintenance engineer to ascertain the normal full load current either by test or from the name-plate, and then to insert lead fuses that will definitely fuse at 50 per cent. over this figure. Lead fuses will withstand the momentary heavier current on starting, but if any heavier current is maintained, it will melt in a few seconds, thus saving motor from a burn-out, if in the case of 3 phase, the motor was single phasing due to bad switch or fuse contacts, etc., or in any single or 3 phase case, where for any reason the motor was drawing a larger current. Only too often fuses are inserted which cannot possibly protect the motor windings, although they may protect the wiring from damage. Lead is specified for the above as it is less rapid than copper of the same capacity, and thus stands the starting current better, also it does not oxidise.

THE ARRANGEMENT OF SLIDE-RAILS.

When installing medium and large-size motors for driving machinery by means of belts or ropes many engineers arrange both slide-rails with the tension screws between the motor and the driven pulley.

It eventually becomes necessary to tighten the belt, and, as a preliminary to this operation, the holding-down bolts are slackened. Owing to the play which exists between the holding-down bolts and the holes in the motor feet and in the slots of the rails, the motor twists round slightly when the bolts are eased, and in order to correct this twist after tightening the belt, it is often necessary to resort to props or packing.

The whole operation is greatly simplified by a slightly different arrangement of the slide-rails. If the slide-rail furthest from the motor pulley is turned completely round—that is, with its tension screw on the opposite side of the motor—it will be found that by tightening one tension screw and slackening the other the belt may be adjusted in tension without the motor skewing and getting out of line.

TO SAVE TIME.

By making a pattern or jig of the wire and screw holes in switches, etc., and using some for marking off switch blocks, etc., one can save many hours on a contract; these patterns are very useful when fixing ironclad fittings to walls, etc., as one does not have to hold heavy parts to mark out the holes. They can be made of three-ply wood.

Questions and Answers by Practical Men

Readers are invited to send problems of practical interest. Letters should be addressed to "The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C.2. Envelopes to be marked "Problem" in the top left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTHS' NEW QUESTIONS

Fitting Up a Sunlight Lamp.

I should be much obliged if you could tell me what precautions should be taken in fitting up a sunlight lamp for domestic use. Can you also tell me what the current consumption is and how long does the actual lamp last before renewal becomes necessary, and whether an old lamp can be used if a longer dosage is given?

J. M. (Greenford).

Electrically Operated Garage Door Opener.

Is there any simple form of electrically operated opener for garage doors? A client of mine who has a garage drive about 30 ft. long has asked me if I can fit some form of door opener which can be operated from the entrance gate or half way down the drive.

T. P. (Torquay).

Fitting an Electric Motor to a Lawnmower.

I should much appreciate it if you could give details for fitting an electric motor to a 12-in. lawnmower. What I want to know is the size of motor to use, the method of drive and suggestions for wiring.

K. L. (Hunstanton).

Transformer for a Luminous Discharge Tube Installation.

Would you kindly inform me as to the factors determining the size and/or number (and voltage) of transformers required to supply a luminous discharge tube installation?

Does the size of tube (i.e., 12/13 or 15/16 mm.) affect the calculations in any way?

E. Copeland (South Tottenham).

Control of Electrically Driven Water Pumps.

I have heard that it is possible to control electrically driven water pumps by means of a pressure gauge and Venner time switch instead of a float switch. I should be much obliged for any information you can give.

E. W. A. (Plymouth).

REPLIES TO PREVIOUS LETTERS

Can an A.C. Machine be Converted for D.C.?

I have a small electric motor which was part of an electrical face-massage machine, but it is for A.C. mains. Can you tell me how to alter it for D.C. mains, 240 volts? It is a two-pole field magnet with a six-pole armature.

Roy G. Brown (Margate).

The small motors used on electrical massage machines are usually made for either A.C. or D.C. mains. So, presuming that correspondent's motor is for 220-240 volts, it can safely be connected to 240 volts D.C. mains. But as it will tend to run at a slightly higher speed, I advise him to wind new field coils, using the same size wire and adding 25 per cent. more turns.

J. Hampton (Bournemouth).

Windings for a $\frac{1}{3}$ h.p. Single-phase Induction Motor.

We have an electric motor, without windings, which seems very similar to the one described in your September, 1933, issue, namely, a squirrel A.C. induction motor (although larger).

We enclose rough details of sizes, etc., and should like to know what windings would be suitable for 200 volts, 50 cycles supply, in order to develop maximum possible power. Can we follow the general directions for winding as in your September article?

We shall be glad to know if you can supply us with full details, number of turns, wire sizes, starting and running windings, etc.

It is intended to use the motor to drive a 4-in. Drummond lathe.

R. C. Base
(Jensen and Base, Wallasey).

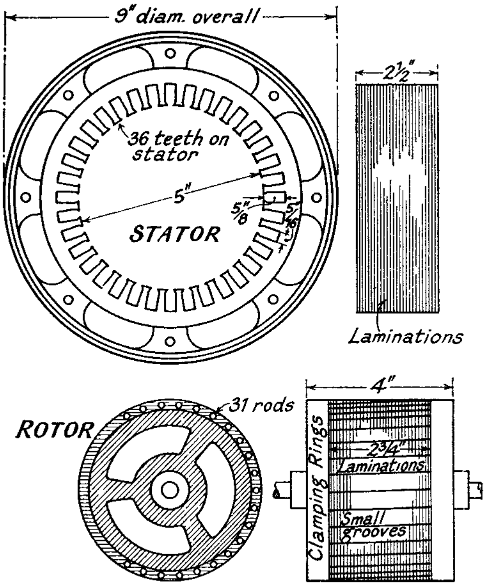
Originally, this motor was wound for 230 volts, 50 cycles, 1,350 r.p.m. and 2.3 amperes at full load.

A motor of this type has two windings: a high inductance low resistance winding for running and a lower inductance higher resistance winding, which is used in conjunction with the running winding only for starting.

The running winding is divided into a four-pole system, in order to retain the original speed. It consists of 24 coils, of 27 turns each, arranged as shown in the development diagram. Although six coils per pole are shown in the diagram, there are actually only four. Each pole has two coils of 54 turns and these are indicated in the diagram as two coils. For example, the two coils in slots 2 and 9 are one double coil.

Wind the running coils first. Start by winding 27 turns round slots 4 and 7 and complete this pole without cutting the wire. Wind all the 160 turns of the first pole in the same direction. Without cutting the wire, continue the winding to the other poles in order, taking care to wind the poles in alternate directions, so that the polarity of the poles will also alternate.

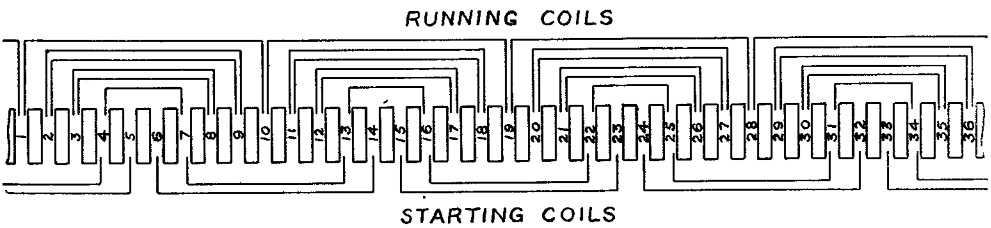
Suppose by starting in slot 4, the first



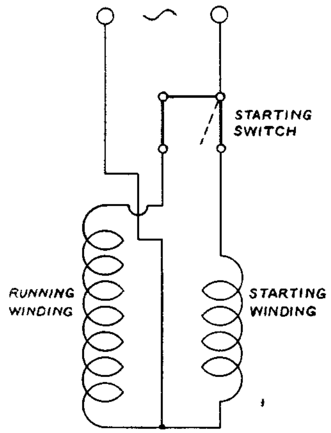
Details of Motor Referred to by Mr. R. C. Base.

coil is wound clockwise, then the winding will finish in slot 10. The wire is then taken to slot 16 and the second pole wound anticlockwise, finishing again in slot 10. From slot 10 the wire is taken to slot 22 and the third pole wound clockwise, to finish in slot 28. From slot 28 the wire is taken to slot 34 and the winding of the fourth pole wound anticlockwise, finishing in slot 28. In order to ensure that the running winding does not cover up the empty slots, required for the starting coils, some dowels or metal rods are placed in these slots while the running coils are being put on.

Before winding the coils, line the slots with .010 in. leatheroid strips. In eight of the slots, the starting coils are wound on top of the running coils. Additional



Details for Winding Running and Starting Coils.



strips of insulation are used in these slots to isolate the two windings from one another. When the winding is finished, the ends of the windings must be bound with string to hold the coils away from the rotor.

The starting coils are wound in a similar manner to the running winding, without cutting the wire, so that all the coils are in series.

The connections of the coils to the starting switch is shown in the above wiring diagram. A special tumbler switch for this purpose is made by Messrs. Lundberg & Sons, Ltd., Sheringham Road, N.7.

PARTICULARS OF WINDINGS.

Running Coils : 24 of 27 turns.
19 S.W.G. D.C.C.
$3\frac{1}{2}$ lb. of wire.
Starting Coils : 8 of 45 turns.
29 S.W.G. D.C.C.
$\frac{1}{4}$ lb. of wire.

To reverse the direction of rotation, reverse the two ends of the running coils.

Startors for Three-phase Induction Motors.

In the above article (March number of your most interesting and helpful magazine) Mr. Brittain states in the paragraph on emergency stopping of motors that "These stop-pushes short circuit *the no-volt coil on the startor." Isn't he making a mistake? I have installed a number of these in the factories in my charge and in every case the push button has* broken *the circuit through the no-volt coil which is connected directly across two phases.*

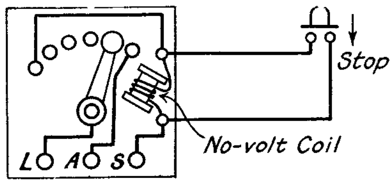
I would be glad if you will make what comment you think necessary in your next issue.

ROBT. BARTLETT (S.E.6).

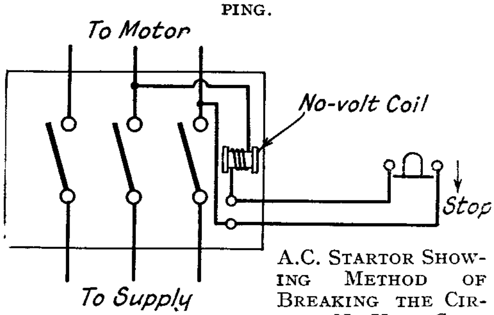
The stop-pushes which are used to stop the motor do not short circuit the no-volt coil, but break the circuit instead. This was an oversight on the part of the author, as to-day the short-circuiting method is very little used.

Originally all startors were made with the no-volt coil in series with the field winding of a D.C. motor and the motor was stopped by short circuiting the no-volt coil. It would have been a serious matter to break the whole field circuit and the handle was returned to " off " by short circuiting the coil.

Later D.C. startors were made with the



OLD D.C. STARTOR SHOWING METHOD OF STOPPING.



A.C. STARTOR SHOWING METHOD OF BREAKING THE CIRCUIT IN THE NO-VOLT COIL.

no-volt coil direct across the supply and, as the correspondent points out, with this type of no-volt coil it would not be possible to short circuit the coil as it is directly across the supply. In this case, therefore, the push button which is used for stopping the motor normally carries the current which flows in the no-volt coil and the motor is stopped by breaking the circuit. This method is generally used for A.C. startors and not the method inadvertently used by the writer in this particular article.

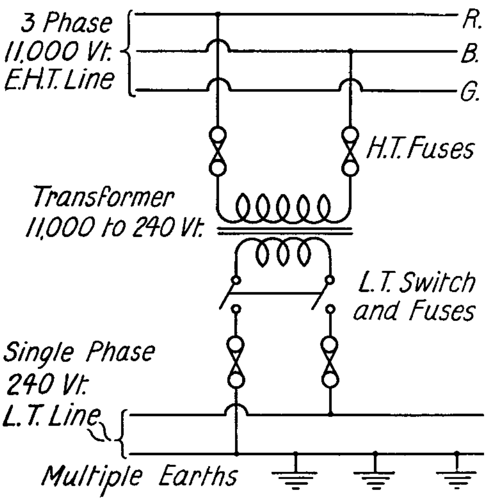
The difference will be seen by referring to above sketch showing the two methods of connecting the no-volt coil. The top diagram shows the method as used in the old type of D.C. startor, while the lower diagram shows the method now used for most startors.

It should be noted that the push buttons used for stopping the motor in case of emergency will be of different types. For one case pressing the button or knob will make contact; whereas in the other case it will break it.

Both systems are to be found in use, but as D.C. is gradually replaced with A.C. and modern type startors are installed the short circuiting type will become obsolete.

Earthing a Single-phase Transformer.

The main transmission system here is



A.C. 11,000 volts, three-phase. In one particular case the three L.H.T. overhead lines are brought to insulators on a terminal pole and two ends taken from the red and blue phases through H.T. fuses to a single-phase transformer. The transformer is wound 11,000 volts in, 240 volts out. The L.T. leads are taken through a pole-mounting switch and meter to the overhead L.T. network, which is single-phase, 240 volts between phases. Multiple point earthing is carried out, i.e., on every second pole, the bottom wire is connected to an earth pipe. This wire, therefore, being equivalent to the earthed neutral of a three-phase, four-wire system.

Does it make any difference which of the L.T. wires from the single-phase transformer is earthed?

JAS. H. PHILLIPS, Junr. (Penstruthal).

It does not make any difference which end of a single-phase transformer L.T. winding is earthed (all the earthed points being, of course, on the same line), as both ends are alternately positive and negative during each cycle and are isolated from any earthed points on the primary side. One line on a L.T. single-phase distribution is earthed in order to definitely tie one line down to earth potential, so that on consumer's premises, where single-pole switches are used and are inserted in the unearthed line (as they should all be), there are no live points when switches are off. There are other and similar reasons for earthing one line.

J. S. MASON (Leeds).

Motor Suitable for a Petrol Electric Vehicle.

I propose building a petrol electric vehicle, and have by me a General Electric motor rated at 60 volts, 70 amps., 1,000 revs.

Would the above be suitable to couple to a 21-60 h.p. petrol engine, 1,000 to 3,000 revs.?

The electric motor was taken from an American accumulator vehicle and I presume is series wound, although the armature leads and four field connections are fitted on top of the casing.

I imagine the motor would be overloaded most of the time, perhaps you can advise me on this point, also recommend some practical manual on the matter.

G. L. F. (Chigwell Row).

The nominal engine output at 21 h.p. is roughly 15½ kW. The input or output of the motor it is proposed to use is, say, 4 kW. at 1,000 r.p.m.

It is not possible, therefore, to use the motor either as driving motor or as generator, since the overloading would be prohibitive both as regards speed and current loading.

THOS. G. FRANCIS (Horrabridge).

Maintenance of Power Transformers (see page 421)

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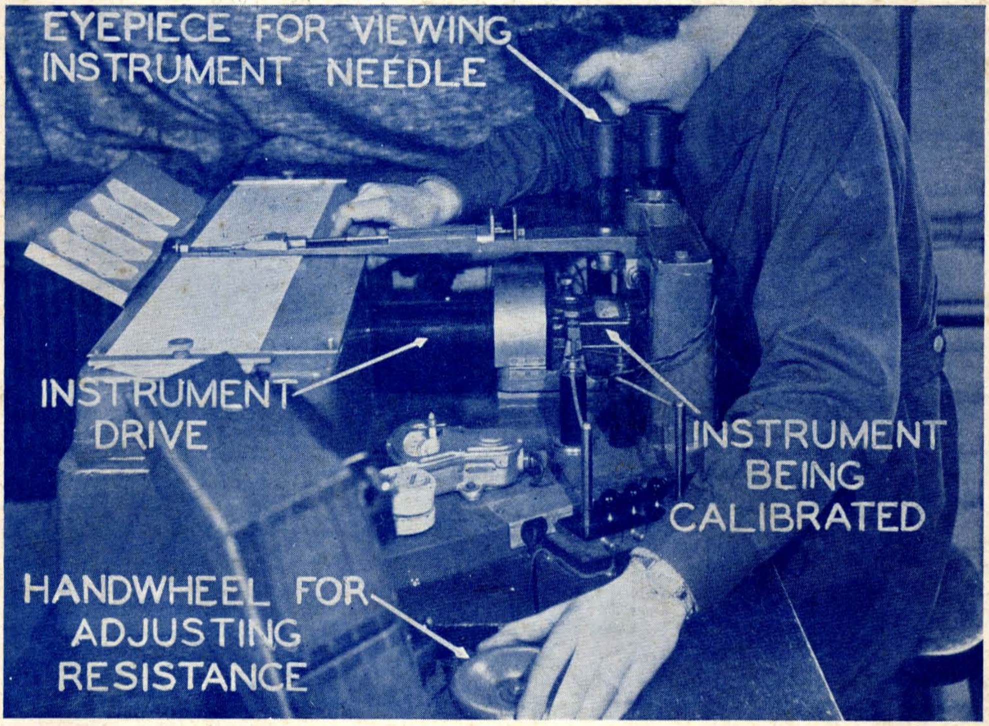
VOL. II.—No. 22

JUNE, 1934



HOW HIGH GRADE INSTRUMENTS ARE CALIBRATED

See article on page 459.

1/-

GEORGE NEWNES LTD.

JUNE, 1934 PRACTICAL ELECTRICAL ENGINEER No. 22

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

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Door Opening by Electrical Means.

Automatic door opening equipment has now given satisfactory service for some years ; more particularly in connection with the Service Departments of up-to-date hotels and restaurants. Regular readers of the Magazine will remember that the Trocadero Restaurant has such apparatus fitted to the doors leading to the servery, so that waiters approaching the doors laden with trays are able to pass through without any inconvenience.

We are indebted to the General Electric Co., Ltd., for the information that the self-opening type of door is now being used for the main vestibules of the cinema and café of the new Regal Cinema, recently opened at Edmonton, by Florida Cinema, Ltd. We congratulate the architect, Mr. Clifford A. Aish, L.R.I.B.A., F.S.I., on his vision and enterprise.

The Regal is one of the largest cinemas in the Kingdom. It has accommodation for over 3,000 people, and is situated on the main London Road to and from the North of England. It has been erected and equipped under the able supervision of the directors, Messrs. A. E. & D. A. Abrahams, both of whom are well-known throughout the cinema world.

The special door opening equipment for the main vestibules and the café, which relies upon the Osram photo-cell for operation, is of an entirely new type and never before employed in a British cinema.

The Equipment.

The equipment consists of the electrical apparatus, which is housed in a pit below the floor level of the door, and the photo-cell equipment by means of which the door opening gear is set into operation.

The gear to open the doors includes a one horse-power driving motor, solenoids, friction rollers, the steel segments which are connected to the doors, door closing springs, etc.

How it Operates.

The operation of the solenoids is under the control of the photo-cell equipment which comprises a double projector lantern with infra-red screens, and a double photo-cell apparatus. Two parallel beams of light are thus thrown on to the photo-cells, the equipment being situated about six feet from the doors to allow sufficient time for the doors to open before the person reaches them after passing through the infra-red rays.

The object of the double ray is to ensure that the doors will open when the rays are cut by a person approaching the doors; while if cut by a person going away from the doors, the mechanism will not operate.

The time during which the doors remain open if only one person is passing is about four seconds, but if several persons pass the invisible ray light, the doors remain open until the last person has passed through.

Little imagination is needed to visualise the possibilities for electrical enterprise which this innovation opens up.

The Home Garage.

Last month we published a query from a

reader who wished to fit some form of garage door opener which could be operated from the gateway of his drive. Already several suggestions have been received from readers. This is a case where photo-electric equipment hardly seems necessary. Probably some simple form of electrical release for the lock combined with a weight- or spring-operated door-opener is all that is needed. An efficient, reliable, and inexpensive mechanism which would be suitable for the purpose would, we believe, be welcomed by many thousands of motorists. Next month we hope to publish an article giving some practical suggestions in this connection.

The Electric Washing Machine.

Another way in which electricity can be utilised to eliminate one of the inconveniences of life is by making it responsible for the weekly wash, which forms such an important item in many households. Excellent machines for this purpose are now available, and we understand from a correspondent who had such a machine installed some months ago, that it is looked upon by his wife as an absolute godsend. Before it was installed he was faced with two alternatives:

(*a*) To engage a woman each week to assist his wife with the work ;

(*b*) To send out the work to the local laundry.

He is paying for the washing machine by instalments, and he estimates that his weekly saving on laundry bills enables him to do this with ease. The way in which this machine was introduced into his household makes an interesting story, but it is too long to be given here.

First-class Salesmanship Needed.

The main point of the story, as we heard it, was that the machine was put in his house on trial almost against his will, but when he had seen it in operation and heard his wife's enthusiastic praise of it he decided to keep it.

In view of the number of homes which now have an electrical supply, and which are still faced with the two alternatives mentioned above, there should be good business in electrical washing machines if the selling side is handled properly.

A Question of Ventilation.

Have you ever noticed on entering a cinema or other crowded public building how the atmosphere seems to meet you as you go through the swing doors ? For a few moments you feel almost suffocated, but very soon you become acclimatised and it is only on leaving the building that you remember what fresh air is like.

Much progress has been made in the science of ventilation, but we believe that there is still great scope for improvement.

A Profitable Study for Electrical Engineers.

How to get the necessary quantity of fresh air into a hall and the corresponding quantity of stale air out of it without creating draughts is a problem which still seems to lack the perfect solution. The perfect solution must be one which does not involve excessive first cost, so that it can be applied to even the smallest cinema without involving too heavy a drain on financial resources. Electricity supplies a cheap and convenient means of handling large volumes of air. A study of ventilation and air conditioning might, we think, be a profitable one to the young electrical engineer who is looking to the future.

An Interesting Experiment.

The latest issue of the London Telephone Directory has inset a circular letter from a non-ring firm of lamp manufacturers. The latter offers to supply gasfilled lamps on three months' approval at prices substantially below ring prices. A business reply postcard accompanies the letter so that people who wish to try these lamps can use the postcard as an order form. The lamps are stated to be British made and are guaranteed for 1,000 hours' burning. As payment does not become due until 90 days after delivery this offer seems likely to prove an attractive one.

The New E.L.M.A. Diploma.

At a recent dinner held at the Howard Hotel Mr. W. J. Jones announced that a new Diploma was being presented by the E.L.M.A. to those members of the electrical industry who attend the full course of lectures on the design and selling of electric light. This should add still further to the popularity of these courses amongst engineers engaged in electrical contracting and installation work.

The course consists of 18 lectures and occupies 5 days. Subjects dealt with include elements of light control, planning factory lighting, planning a commercial lighting installation, how to light a modern shop, salesmanship, and other subjects of equal interest.

The 29th course was concluded on Friday, May 11th. Readers of THE PRACTICAL ELECTRICAL ENGINEER who may wish to consider attending the next course can obtain full particulars of forthcoming lectures by application to the Secretary, Lighting Service Bureau, 2, Savoy Hill, London, W.C. 2.

The Operation and Maintenance of Power Transformers

By E. T. Norris, M.I.E.E., Fellow A.I.E.E.
Chief Designer, Ferranti, Ltd.

When a transformer is new its ability to give uninterrupted service depends upon its design, workmanship and material being suitable for the conditions under which it must work. If the transformer is to give this uninterrupted service for many years, however, some trouble must be taken to prevent the deterioration of the materials used in its construction, and to ensure that the transformer is not used under conditions for which it is not suited. As the modern tendency is to use larger and larger power transformers, correct maintenance becomes increasingly important, not because of increased difficulty, but because the consequences of an unexpected shut down are more serious and widespread, even if extensive damage to the transformer itself is not involved.

Devices for Assisting in the Maintenance of Transformers.

The various devices for assisting in the maintenance of transformers, while regarded as desirable for smaller units, become essential for larger units. These devices fall into three groups, according to the type of duty performed :—

(A) Apparatus to prevent or delay deterioration.

(B) Apparatus to give warning of minor troubles in time to withdraw a transformer from service for overhaul without interrupting the supply, or in time to minimise the damage.

(C) Apparatus and methods required to restore any material to its original condition after deterioration has reached the limits of safety.

Some apparatus will fall into more than one of the above classes, but the various devices will be dealt with in the general order indicated above.

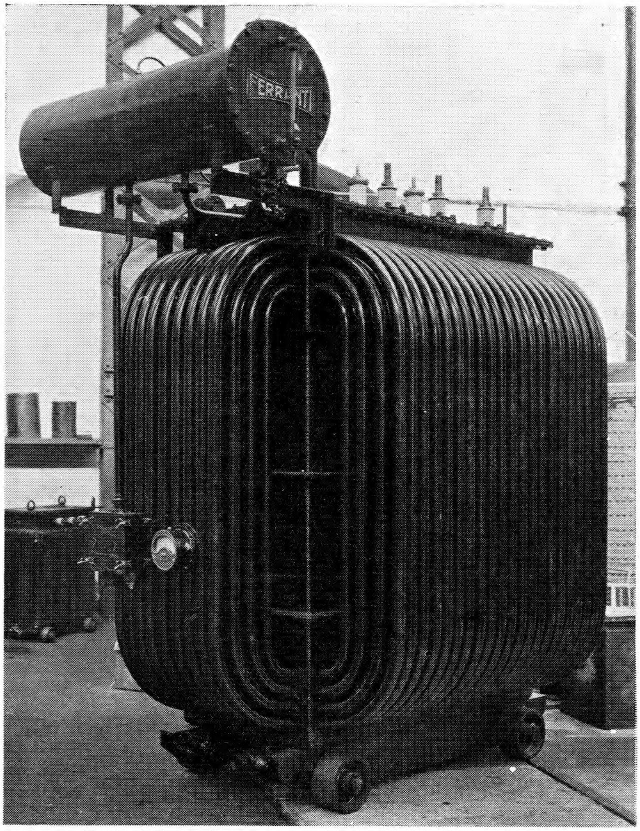


Fig. 1.—View of Transformer Showing Oil Conservator and Breather (*Ferranti, Ltd.*).

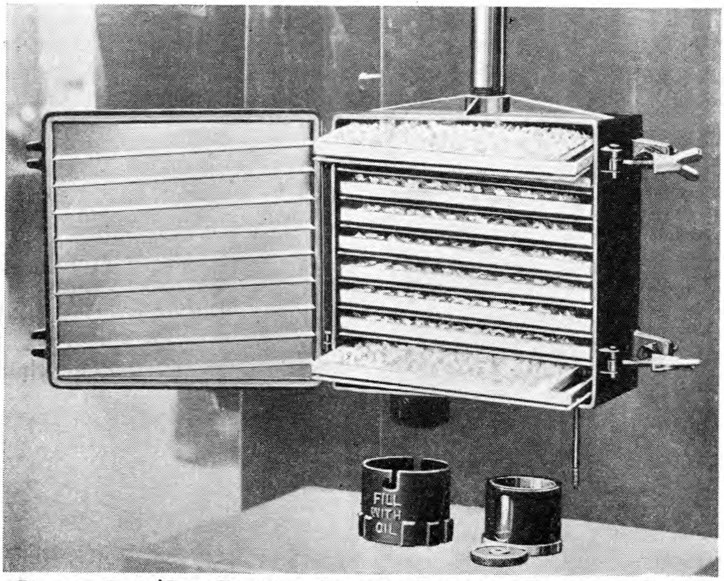


Fig. 2.—The New Pattern Calcium Chloride Breather Shown Open (*Ferranti, Ltd.*).

(1) Oil Conservators (Fig. 1).

As the insulation and oil of a transformer have their insulating properties impaired by the presence of moisture, it is advantageous to restrict the access of air to the oil in the transformer tank. This is done by keeping the main tank completely filled with oil, and connecting this tank to an expansion vessel or conservator placed at the highest point of the oil system, and of sufficient capacity to allow for the change in volume of the oil with change in temperature. As the conservator is connected to the main tank by a single pipe, there is no free circulation of the oil in the conservator, so that there is only a comparatively small surface of cold oil in contact with air. Under these conditions the amount of water absorbed is a minimum, and there can be no condensation of moisture on the inside of the main tank.

(2) Breathers and Oil Seals (Fig. 2).

As a further protection against moisture, the air which enters the conservator is drawn through a "breather," where it passes over a drying agent, generally calcium chloride. In this way only dry air comes in contact with the oil. The breather depends on the calcium chloride for its drying action, and requires inspection every few weeks. When an "oil seal" is provided, the air required for the "breathing" of the transformer is drawn in or expelled against a small head of oil. In this way the external air is kept out of contact with the drying agent, thus reducing the frequency at which it needs replacing. The "breathing" of a transformer is due to oil expansion and contraction caused by variations of load, and also by variations of the surrounding air temperature, so that spare transformers standing idle should also be fitted with conservators and breathers, and inspected together with those actually on load.

(3) Temperature Indicators and Safe Load Indicators.

As a further cause of damage to insulating materials is excessive temperature, the load on a transformer must not at any time exceed the limit set by the safe temperature rise under the existing conditions. The B.S.S. rating is necessarily conservative, and actual conditions are rarely such that the rated load is the maximum which can be carried. If a thermometer reading oil temperatures only is used, advantage cannot be taken of the margin between the rated load and the maximum safe load, since it is the "hottest spot temperature" in the winding which fixes the limit. This temperature cannot be measured directly, but it can, however, be measured indirectly.

How the Winding Temperature Indicator and Safe Load Indicator Work.

The hottest spot temperature differs from the hottest oil temperature by an amount approximately proportional to the square of the load current. If the bulb of a thermometer placed in the hottest oil is surrounded by a heater coil carrying a current proportional to the load current, then the temperature of the bulb will be raised by an amount proportional to the square of the load current. By suitable design of the heater coil for each transformer, the amount by which the temperature of the bulb is raised is made equal to the difference between the hottest spot temperature and the hottest oil temperature, *i.e.*, the thermometer will now read " hottest spot temperature." This is the principle of the winding temperature indicator and safe load indicator. The latter instrument, instead of giving the temperature, is calibrated to read the load on the transformer in terms of the maximum load which could safely be carried under the same conditions (Fig. 3).

Sludge in the Oil.

A further service performed by this instrument where periodic records of its readings are kept qualifies it for inclusion in Class B, as defined above. The formation of sludge in the oil, which interferes with the cooling of the windings, also affects the cooling of the heater coils, so that an increase of the instrument reading without any change in load conditions is a sign of sludge formation.

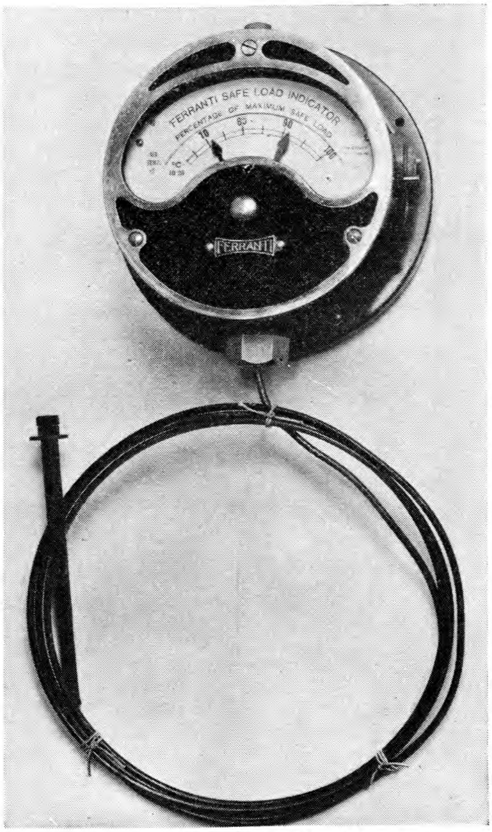


Fig. 3.—SAFE LOAD INDICATOR.

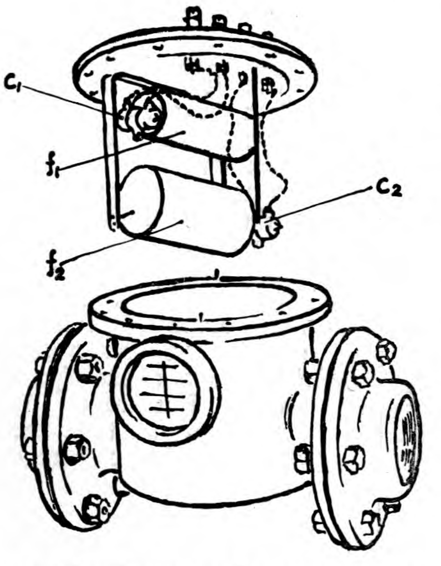


Fig. 4.—THE BUCHHOLZ PROTECTIVE DEVICE. A fault in the transformer will release gases, due to the " cracking " of the oil.

(4) Alarms on Auxiliary Cooling Apparatus.

A transformer depending on auxiliary cooling apparatus for its full B.S.S. rating may be dangerously overheated should there be a failure of the oil-circulating pumps, air blowers or cooling water supply. Where the transformers are in unattended outdoor sub-stations, remote indication at the power station of failure of any auxiliary apparatus by any warning device is a safeguard against damage to the transformer. The installation of duplicate auxiliary apparatus, together with such a warning device, will

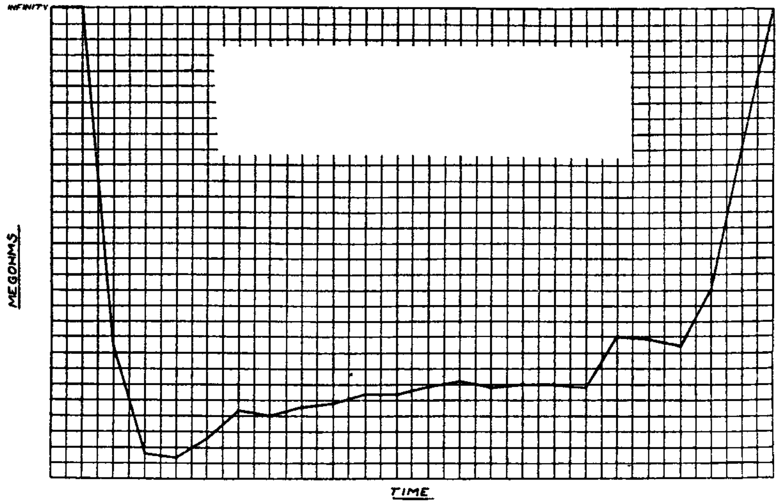


Fig. 5.—Graph Showing Change of Insulation Resistance During Drying-out.

enable the load to be maintained in such cases without the necessity for spare transformers.

(5) Buchholz Protective Device.

This is a gas-operated device which is installed in the pipe between the transformer tank and the conservator. A fault in the transformer will release gases due to the " cracking " of the oil, and the device consists of two floats, f_1 and f_2, each carrying a mercury contact C_1, C_2, operated by tilting of the float (Fig. 4). The upper float is tilted when the oil level in the top of the vessel is lowered by the accumulation of bubbles of gas given off by a minor fault, and operates an alarm. Such minor faults include broken-down core bolt insulation, bad contacts, etc., which would in time develop into serious faults. The lower float is operated by the pressure wave of oil due to a sudden liberation of a large volume of gas due to a serious fault, and operates a tripping device, disconnecting the transformer instantaneously, and minimising the damage. The upper float also gives the alarm if the oil level in the conservator falls, due to leakage, below the minimum safe value.

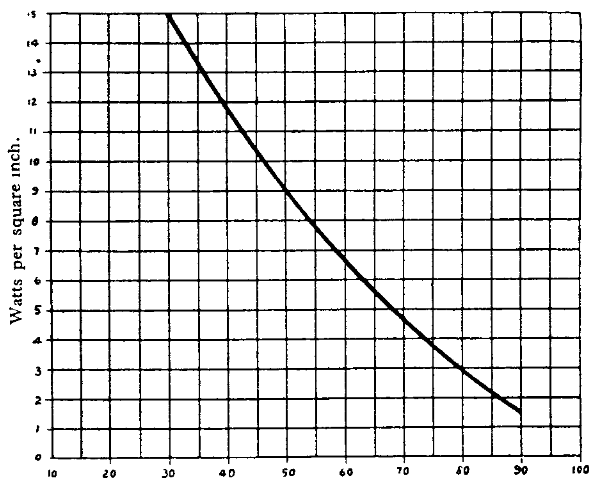


Fig. 6.—Graph Showing Ratio of Watts to Heater Surface for Various Oil Temperatures.

Relief Diaphragm.

This is a safety valve to relieve the tank of high internal pressures due to the gases caused by a fault. It consists of a large diameter pipe fitted to the top of the tank, and rising above normal oil level. The end is sealed by a diaphragm of glass, or a similar material, which is blown out by a high internal pressure, leaving the full bore of the pipe as an outlet. This saves further damage to the tank and oil system, and the consequent loss of oil.

Oil Maintenance.

Testing.—Even with the foregoing devices fitted, naturally cooled transformers should be inspected every 6 or 12 months and artificially cooled transformers every 3 or 6 months. A small quantity of oil should be drawn off from the bottom of the tank and tested.

The method to be adopted in testing oil is detailed in British Standard Specification No. 148—1927, "Insulating Oils for Electrical Purposes," and the oil is passed if two out of three tests, each on a separate filling, give results not lower than the limit fixed. The limit is 30 kV. R.M.S. for 1 minute applied between 13 mm. spheres, with a separation of 4 mm. Fig. 7 shows a standard container and electrodes, while Fig. 8 shows a complete oil-testing equipment.

If, therefore, the first test shows moisture present, a second sample should be tested, and if this confirms the first test, the whole of the oil should be dried by either (*a*) the blotter press, or (*b*) the centrifugal filter.

Filters.

(*a*) *The Blotter Press.*—The oil under pressure is passed through a number of filter papers in a filter press. The papers are specially prepared to fit the filter, and are free from chemicals, foreign substances, colouring matter, etc.

Solid matter and impurities are caught by the paper, while, the capillary attraction between the paper and the water being greater than that between the paper and the oil, the water is retained by the paper, and the oil is freed from moisture.

(*b*) *The Centrifugal Filter.*—By subjecting the oil to centrifugal force it has been found possible to remove water, fibre and solid impurities, with the result that insulating oils can be satisfactorily treated by this process.

The advantages claimed for this method are :—

(1) It can be stopped, cleaned and reassembled in a few minutes.

(2) It completely removes any free water, fibre, sediment, etc.

(3) The separated impurities are shot away from the incoming oil.

Sludge.

Inferior oils have a tendency to form sludge, which is deposited in the oil ducts, gradually restricting the flow of oil. Since the oil, besides serving as an insulator, acts as a medium for the transference of heat from the core and windings to the tank or external cooler, the sludge will cause overheating.

The rate of sludge formation increases with temperature, so that the danger of local overheating is cumulative. An excessive overload for a short time may cause more sludge to form than a normal load for long periods, and although sludge may be removed from the oil by the filtering methods described, it cannot easily be removed from the ducts within the transformer. It is preferable, therefore, to prevent it forming by operating the transformer within the safe limits, as shown by the temperature indicators.

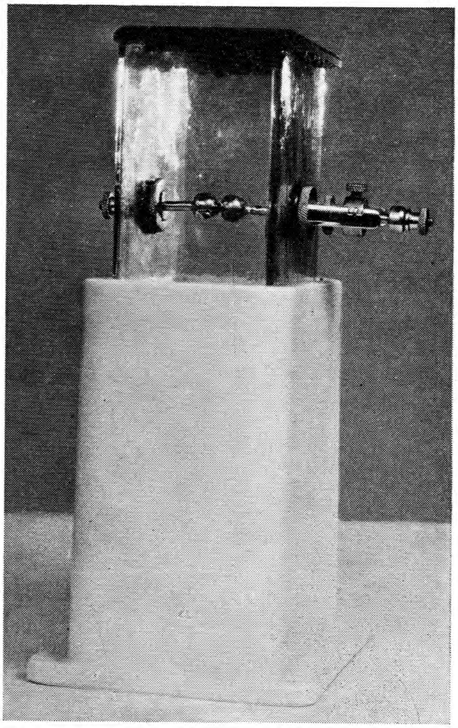


Fig. 7.—STANDARD CONTAINER FOR OIL TESTING.

Drying Out.

The condition of the oil in a transformer may be ascertained in the manner described, but the condition of the transformer insulation is not so easily shown. Although tests with an ohmmeter may show a high value for the insulation resistance of a transformer when cold, the insulation may still be damp. In the course of drying out, by one of the methods given below, the insulation resistance of

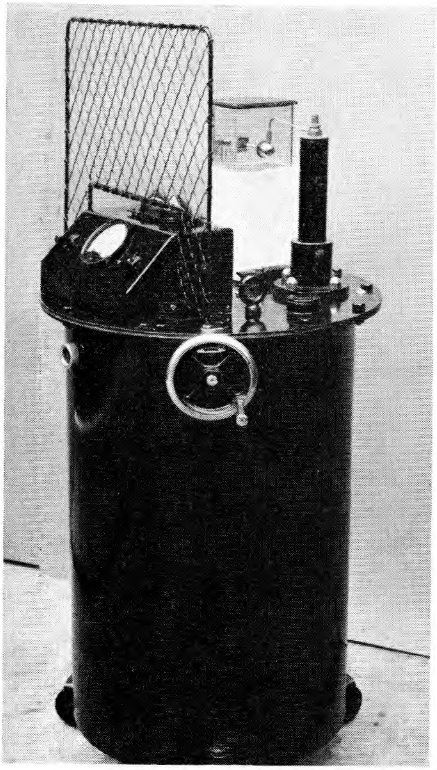


Fig. 8.—Complete Oil-testing Equipment.

a damp transformer will first fall, as shown in Fig. 5. The drying out must be continued until the insulation resistance rises, as at the end of this curve. No general rule can be given for the time taken, and periodic readings of insulation resistance must be plotted till the rising curve shows that drying is complete.

Methods of Drying Out.

(1) *In Air.*—(*a*) The transformer is best dried out by placing it in a drying chamber, raised to a temperature approaching but not exceeding 90° C. (194° F.).

(*b*) As an alternative, a current of hot air is blown through the tank, after withdrawing the oil.

(*c*) The tank itself may serve as a drying chamber by placing suitable resistance units at the bottom, the transformer, without oil, being supported on blocks above the heaters. Care should be taken that the temperature of the parts nearest to the resistance does not exceed 100° C. (212° F.).

(*d*) Where a suitable power supply is available, the transformer may be dried while out of its tank by short-circuiting one winding (usually the low tension) and connecting the supply to the other terminals. The voltage should be about half the impedance voltage at the frequency for which the transformer is designed, so that a circulating current is set up in each winding equal to half the normal load current. This value should be adjusted so that the temperature of the windings never exceeds 90° C. (194° F.).

(2) *In Oil.*—(*a*) The transformer may be dried in oil by using resistance units as in (1) (*c*), but the ratio of the watts consumed in the resistance to the radiating surface of the resistance material must not exceed the values given in Fig. 6, for various oil temperatures, or the oil may be spoiled.

(*b*) The circulating current method, as described under (1) (*d*), may be used with the transformer in oil, but the current required may have to be increased to, say, 25 per cent. above full-load values. It is not possible to give the percentage of full-load current required for all sizes and types of transformers, as a saving can often be effected by restricting the cooling. The object is to maintain a steady temperature not exceeding 90° C. (194° F.), and it is also desirable to circulate the oil through a filter during the process, so that moisture driven off from the windings is not merely absorbed by the oil.

(3) *In Vacuum.*—This method can only be employed for transformers mounted in tanks which have air-tight joints and which are strong enough to withstand atmospheric pressure when evacuated. By this process the transformer is dried uniformly, and it is the best for large high-voltage transformers. It should not,

however, be employed without a previous consultation with the manufacturers.

Installation and Operation.

Many of the points to be borne in mind in the installation and operation of transformers follow directly from the maintenance requirements given above. The location should be chosen so that there are facilities for erection and removal, and sufficient head room for inspection. In addition, where the transformers are of the indoor type, they should be protected from dripping moisture, and ample space for radiation allowed for self-cooled units. In this connection it should be remembered that arrangement for the escape of hot air is as essential as the provision of a sufficient supply of cooling air.

Before putting a transformer into commission, it should be tested for the presence of moisture as described under the routine maintenance tests, and dried out if necessary.

Check Oil Level.

The oil level should be checked before installing and at the periodic inspections. A low oil level, besides depriving a transformer of the protection against moisture given by a conservator, may cause serious damage by uncovering insulation designed to work only under oil. In addition, dangerous overheating will result, even on light loads, if the oil level falls below the outlet to the cooling arrangements of whatever type, as the oil circulation is thereby prevented.

Make Sure all Valves in the Oil-cooling Circuit are Open.

Care should be taken that a transformer is never put on circuit without making sure that all valves in the oil-cooling circuit are open, and that the correct quantities of oil, water or air are circulating. If for any reason the auxiliary apparatus is interrupted, the temperature of the transformer should not be allowed to exceed 90° C. (194° F.).

Finally, the various protective devices and alarms referred to should be tested at regular intervals, as any protective device which is not functioning correctly may, by encouraging a false sense of security, increase instead of diminish any risk of damage.

CALOMIC RESISTANCE ALLOY

Calomic is a resistance alloy containing nickel, iron and chromium in the proportions of 65 : 20 : 15, and is manufactured by Wild Barfield Electric Furnaces, Ltd., North Road, London, N. 7.

This alloy is suitable for resistance and heater elements of various electrical apparatus and it can be used up to temperatures of 1000° C.

It has the following properties :—

A specific resistance of 104 microhms per cube. A wire of 20 S.W.G. has a resistance of 0.491 ohm per foot at 20° C. and 0.54 ohm at 1000° C.

A tensile strength of 54 tons per sq. in.

A melting point of 1400° C.

A specific gravity of 8.2.

The coefficient of thermal expansion is 0.000012 per degree C.

Calomic is supplied in the fully annealed bright condition as wires, rod, sheet or strip. It can also be had in the form of hot rolled sheets and sections of different shape and as castings.

The Installation of Heating Appliances in Laundries

By P. W. Pantry

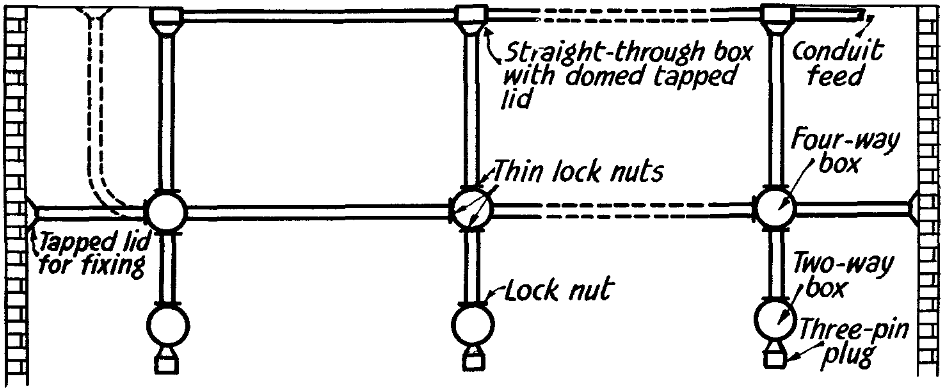


Fig. 1.—The Conduit Lay-out.

In factories or modern electric laundries where a large number of various heating appliances are in use it frequently happens that the wiring for these appliances cannot be fixed direct to a wall or a partition and that it is necessary to install the heating points in the centre of a room or at some distance from any vertical structure.

The following method employing screwed conduit and ironclad fittings throughout will make a very robust and satisfactory job.

A Typical Example.

Assuming, for instance, a bank of 700-watt electric irons for laundry use. Each operative is to remain at the ironing table and therefore requires electrical control of the iron at all times. At the usual supply voltage of 200-250 each iron will take approximately three amperes of current, and 5-ampere switches and plugs will, therefore, be necessary. It is advisable to put no more than two appliances of this rating on one circuit, so that a double-pole 10-ampere distribution board having the requisite number of fuse-ways will suffice.

The Conduit Runs.

The conduit is run from the distribution board across to the first point, Fig. 1, straight-through ironclad joint boxes being used on the ceiling, four-way boxes for the pilot lamp fittings, and straight-through boxes for the switches. Domed tapped lids screwed to the ceiling junction boxes are used to bring the conduit to the four-way boxes. The conduit running between the pilot-lamp boxes does not carry any cables. It is only to give support and permit of correct spacing, and in order to allow easy replacement of the four-way boxes should it become necessary.

Use Straight-through Tapped Boxes.

It is advisable to use straight-through tapped boxes, not the butt end type, so that the conduit length can be screwed into the one box and then screwed back into the next one, a thin lock nut serving to hold the conduit firm. All junction boxes should be locked tightly with thin lock nuts as in Fig. 1. No smaller conduit than $\frac{3}{4}$ in. screwed can be used or it will not be firm enough.

Should there be no pillars or other

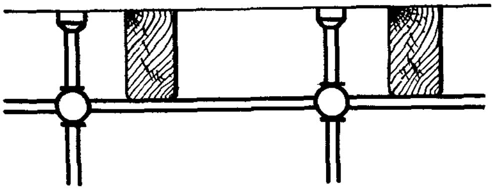


Fig 2.—Conduit Running at Right Angles to Ceiling Joists.

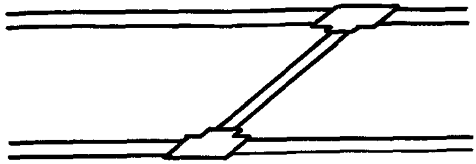


Fig. 3.—Method of Coupling Conduit when Two Lines of Points in Parallel are Installed.

structure within reach of the horizontal supports the conduit must be bent at right angles and fixed to the ceiling, see Fig. 1, dotted portion.

Conduit Runs in Reinforced-concrete Buildings.

In reinforced-concrete buildings it is usually found easier to fit the conduit runs across the joists, Fig. 2. This involves an additional four-way box per point.

What to Do if Ceiling is Very High.

Where the ceiling is so high that the long conduit drops would be impracticable, suitable wooden battens should be fixed between two walls or other supporting structure and the conduit fixed to them in the easiest manner, the circuit branch switches being placed in the nearest convenient position. The amount of bench space allocated to each operative will determine the spacing distance of the points, and it is generally found that a double row of points is required in order to serve both sides of the bench or table. In such a case, the horizontal supporting conduits should be coupled together at every third point in order to ensure better support. Solid tees are used for this, Fig. 3.

The Wiring.

Two points can either be controlled by one 10-ampere branch switch, preferably of the double-pole variety wired to each fuse-way on the distribution board, or each point may have its 5-ampere branch switch, the latter method permitting the repair of one point without cutting off the supply from the second one. Figs. 4 and 5 show the wiring of each method respectively.

The 5-ampere rotary switches should be placed within comfortable arm reach; these switches, as mentioned earlier, are to permit the operative switching the appliance on or off for heat control or other reasons without leaving the table.

In order to prevent the three-core flexible cable from trailing on the work, small galvanized chains suspended from the horizontal conduit supports may be used.

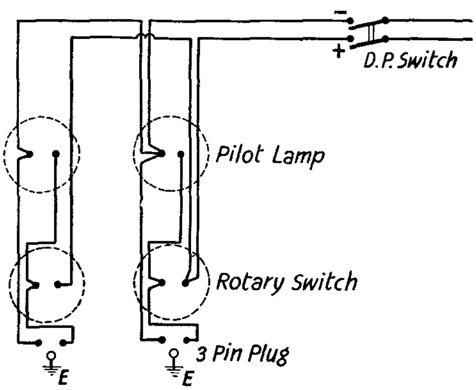


Fig. 4.—Wiring of Two Points off One Circuit Controlled by One 10-Amp. Branch Switch.

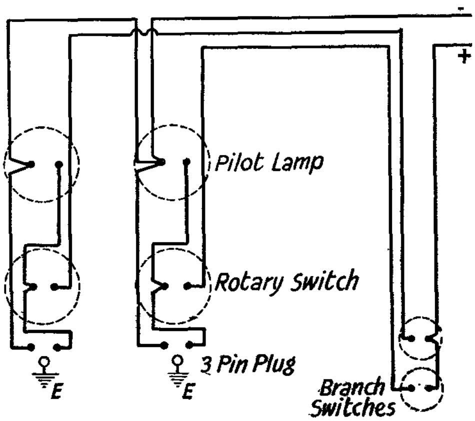


Fig. 5.—Wiring of Two Points, Each Point Controlled by its Own Branch Switch.

Three-pin Type Plugs.

Three-pin type plugs must be used to enable the appliances to be earthed, and they should be $\frac{3}{4}$ in. tapped in order to screw into the ironclad two-way box, "Niphan" metal plugs with their couplings being found most serviceable. Fibre cover lids $\frac{3}{16}$ in. thick should be fitted to the ironclad boxes at the switch and pilot lamp outlets and suitably drilled to accommodate the wiring. B.C. batten lampholders can now be obtained to fit the universal ironclad box, screwing on direct to the box lugs. Red sprayed 10-watt lamps or neon 5-watt lamps will serve for pilot indication. The lamps should be placed 7 to 8 ft. from the floor level.

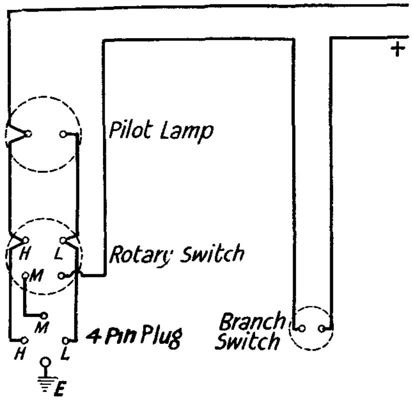


Fig. 6.—Wiring of Appliance with Three-heat Control.
H, high ; M, medium ; L, low.

Other Circuits.

With heavier current-consuming appliances the switches and plugs will naturally be rated accordingly, and with appliances utilising three-heat control, "three-heat and off" rotary switches and four-pin plugs will have to be used. In connection with this it is interesting to note that with the pilot lamp wired as shown in Fig. 6, it glows at its normal brilliance when rotary switch is in the "high" position, about half brilliance in "medium" position, and very dimly in the "low" position. It serves at a glance to indicate to the operative or overseer in which position the rotary switch is placed. Only the ordinary filament lamp will show this; with the neon lamp no glow is given with the switch in the "low" position because the voltage across the lamp is insufficient to allow any current to pass between the electrodes.

Where a switch is fitted on the appliance itself, as an electric drill for example, the rotary switch is not strictly necessary, but a pilot lamp is essential because it indicates that the circuit is alive right to the appliance, and ensures precaution against accidental starting.

Are Pilot Lamps Necessary?

A considerable amount of controversy rages over the question of the use or non-use of pilot lamps and the benefits derived therefrom, but their judicious use invariably results in a saving of current far in excess of that taken by the pilot lamps themselves.

All heating appliances which give no visual indication of their being switched on to the supply, such as irons, heated rollers, cookers, immersion heaters applied to small boilers, tanks, or radiators, not thermostatically controlled, should be fitted with pilot lamps.

The pilot lamp in addition to giving the overseer observation as to which particular appliances are in use, also places a "tell-tale" obligation on the operative who is more likely to switch the current off when leaving the bench or table for mealtimes in the canteen, or when work is finished, than if no pilot lamp was there to indicate that current was being wasted. In addition there is the reduction of fire risks and damage to the appliance due to overheating of the elements.

REMOTE CONTROL OF SUBSTATIONS

WITH SPECIAL REFERENCE TO THE MIDWORTH REPEATER

By H. W. RICHARDSON, B.Sc., M.I.E.E., and W. R. COX, B.E., A.M.I.E.E.

IN electrical distribution and electrical railway systems, substations are used for transforming the pressure at which electricity is supplied, or for converting alternating to direct current.

This equipment must be supervised and controlled, and this may be done either by a local attendant at the substation or by means of remote control equipment, arranged so that the plant and apparatus in the substation may be controlled from some distant point.

Remote control equipment can be divided into two classes :—

(1) Non-selective control ;

(2) Selective control, including supervisory control.

Non-selective Control is, generally speaking, straightforward. To illustrate this type of control take the typical case of a two-unit rotary converter substation in which the E.H.T. and D.C. feeders are hand operated, suitably protected against overload and, in the case of the E.H.T. feeders, also protected against earth and interphase faults. These feeders will normally always be closed, and from the remote point it will only be necessary to start and stop the machines when required, and also to obtain indications of the D.C. busbar voltage and D.C. load at the control point. A valuable addition would be the remote indication of the position of all feeders, but without selective control such luxuries would be expensive. To start or stop the machines it will be necessary to close a contact at the substation for two or three seconds by the operation of a push button at the control station. After this, in the case of starting, the machine in question will be arranged to run up, synchronise, and parallel automatically ; when any machine is running, an automatic voltage regulator will maintain the required pressure on the D.C. bars, and the machine will be automatically protected.

When stopping, a remote controlled contact will trip the machine out and all

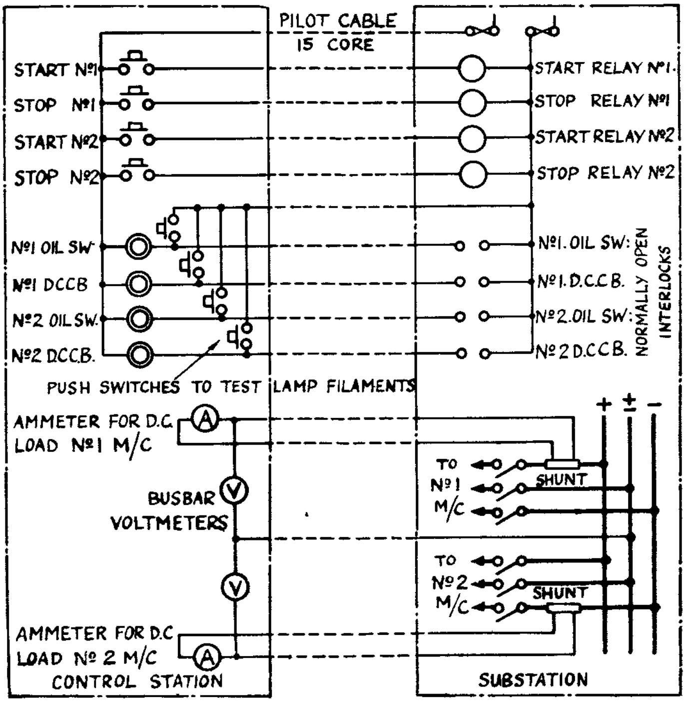


Fig. 1.—DIAGRAM OF NON-SELECTIVE REMOTE CONTROL SCHEME FOR A TWO-UNIT ROTARY CONVERTER SUBSTATION.

gear will be automatically reset for the next start.

To give the control engineer the information he will require to operate the station, the following back indications will be required.

(*a*) Visual indication of the closing of the oil switches to start the rotaries.

(*b*) Visual indication when the machines are actually on load.

(*c*) Remote reading of D.C. busbar pressure.

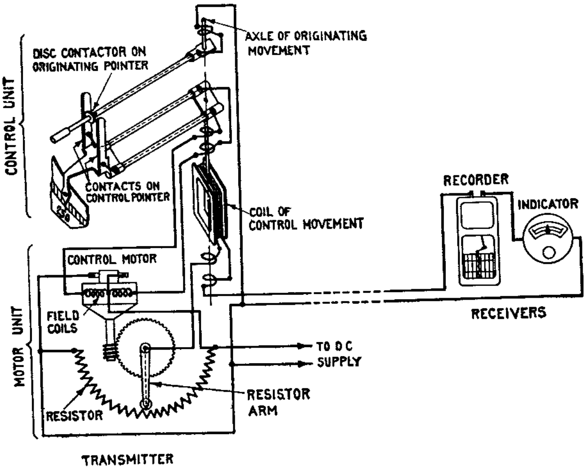


Fig. 2.—Diagram Showing the Association Between the Originating and Control Movements of the Midworth Distant Repeater.

(*d*) Remote reading of load on each machine.

The diagram for the above is shown in Fig. 1.

Selective Control.

As mentioned previously, non-selective systems of control necessarily entail a relatively large number of pilot wires. It is true that by making use of various devices a few pilots can be saved, but to carry out a comparatively large number of operations on very few pilots, selective control must be adopted.

The Midworth Distant Repeater.

As an example of a selective system, it is proposed to study one which is manufactured by Messrs. Evershed & Vignoles. This scheme was first developed for remote metering only, but the fundamental principles used for metering were readily adapted to give remote control facilities.

Principle of System.

The apparatus employed in the Midworth distant repeater system includes a transmitter and one or more receivers—the latter being indicators, recorders, or apparatus used for selective switching or other control work at the distant station.

The transmitter contains an originating movement, giving the indication or movement which it is desired to repeat, associated with a control movement which translates the quantitative information to be transmitted into variations of an electrical current in a series repeater circuit which includes the receivers. The transmitter maintains this current at a constant value for every indication to be transmitted, whatever the variations in the voltage applied to the circuit or in its resistance.

The distant receivers are suitably designed moving-coil milliameters scaled in terms of the information to be transmitted.

The Originating and Control Movements.

Fig. 2 shows diagrammatically the association between the originating and control movements in the transmitter, and the nature of their inter-action. The two movements are in vertical alignment, and are so arranged that a contactor borne by the originating pointer floats between two contacts borne by the control pointer. When the system is in equilibrium the two pointers are parallel and float freely, and the contacts do not touch; but when the originating pointer moves up or down the scale, its contactor touches one of the two control contacts, thereby energising one of two field-coils of a motor which has its armature constantly in circuit. The motor moves a contact arm over a resistor in the repeater circuit, increasing or decreasing the current in that circuit, so that the control pointer follows up the originating pointer.

The motor continues to operate the

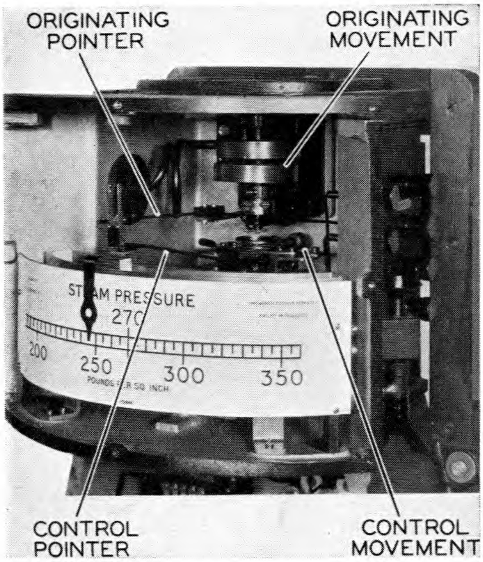


Fig. 3.—MIDWORTH DISTANT REPEATER CONTROL UNIT.

resistor arm, and the current in the repeater circuit continues to change, until the latter reaches a value at which the control pointer overtakes the originating pointer and floats freely parallel with it. When this occurs, the control contactor ceases to touch the originating contact, the field coil circuit is broken, the motor stops, and equilibrium is again established.

The Control Instrument.

The control instrument is itself a milliameter and, being in series with the distant instruments, gives corresponding readings when its pointer is floating freely ; hence, when the control pointer overtakes the originating pointer and floats freely parallel with it, and the distant instruments give the same reading, a reading which corresponds to the new position of the originating pointer.

As the operation of the control mechanism tends always to bring the system to a state of balance with the control and originating pointers parallel and the motor at rest, it is evident that when the state of equilibrium is attained there can be no load on the originating pointer. The originating movement may, therefore, be one having relatively small working forces, and its accuracy is not impaired by its association with the transmitting mechanism.

Three Important Points.

From the above description the following points will be noted.

(1) The remote indication is independent of the voltage of the supply.

(2) The remote indication is independent of the pilot wire resistance and variations in this resistance.

(3) Any number of receiving instruments can be installed in series. These may be recording instruments, indicating instruments or both.

The Transmitter.

As indicated in Fig. 2, the transmitter is made up of two parts, the control unit and the motor unit. These two parts are frequently mounted in a single dust-proof case, but if convenient they can be in separate cases.

The Control Unit.

There are two types of control unit, the " instrument " and the " mechanical,"

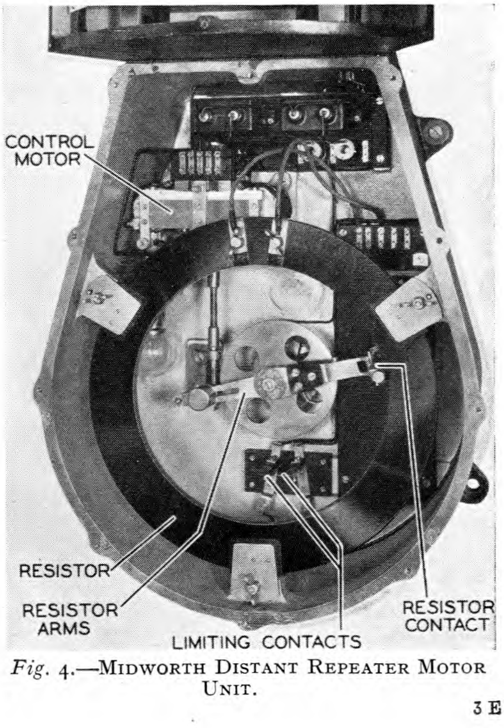


Fig. 4.—MIDWORTH DISTANT REPEATER MOTOR UNIT.

similar in general construction and operating on the same principle, but differing slightly in detail.

In the "instrument" type of transmitter the originating movement is that of some instrument whose indications it is desired to transmit. A typical "instrument" control unit is shown in Fig. 3, the originating movement in this case being a steam pressure gauge. The "mechanical" originating movement, on the other hand, consists of an arm of robust construction, connected by worm gearing to a spindle outside the case, which is in turn coupled to the mechanism whose displacement it is desired to repeat.

A moving-coil milliammeter of the type used in Evershed Recorders is employed as the control movement. It is of robust design and construction and has strong working forces.

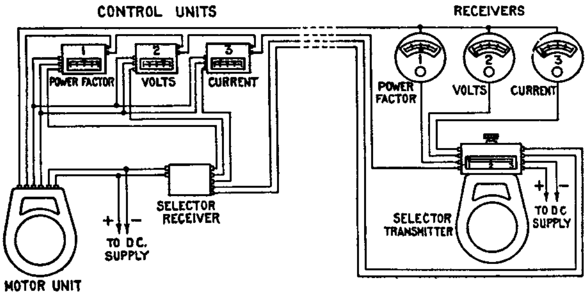


Fig. 5.—Midworth Distant Repeater Selection of Indications.
Showing scheme for reading power factor, voltage and current.

The platinum contacts on the pointers can readily be removed for cleaning or replacement. The full-line voltage is always across these contacts, and prompt operation of the system is, therefore, always ensured. In the "mechanical" control unit, the single disc contact is borne by the pointer of the control movement, and the double contact by that of the originating movement; while in the "instrument" control unit this arrangement is reversed. The method of operation is, however, identical for both types.

Oil damping is provided for both originating and control movements to protect the transmission against too violent fluctuations on the transmitting side, or arising in the repeater circuit through sudden variations in line voltage or resistance. The oil damping trough can easily be filled and emptied without opening the case.

Motor Unit.

The motor unit contains the motor, resistor, resistor arm, and limiting contacts, and is illustrated in Fig. 4. The D.C. motor is of simple design and robust construction. The armature is continuously energised, one or other of two field coil circuits being made or broken by the contacts on the control and originating pointers, as previously described. With this method there is no necessity for a switch in the main motor circuit, and only the very small field current passes through the operating contacts on the originating and control pointers, so that the tendency to spark is reduced to a minimum. Condensers and resistors further eliminate sparking at the contacts. The motor is fitted with a magnetic brake, which is released immediately the field coils are energised, and applied when they are de-energised. This brake effectively prevents the motor from over-running, and the arrangement ensures that the follow-up is accurate and prompt. The operating voltage may be from 50 to 250 volts D.C., 110 volts being recommended. Where A.C. only is available, it must be rectified, and transformed if necessary to a suitable voltage.

The resistor is wound on a flat ring of insulating material, and can readily be removed from the case by undoing two flexible connections and three wing nuts. The resistor contact is a silver roller carried on a spring arm hinged to the rotating arm which is driven by the motor. Since the roller is inclined at a slight angle to the radial line of the arm on which it is carried, it partly rolls, partly slides on the resistor. The effect of this sliding is to keep the surface of the roller and the wire of the resistor clean, so that good electrical contact is ensured. If the resistor or the contactor roller becomes dirty or tarnished, the resistor arm will automatically be caused to oscillate until the dirt

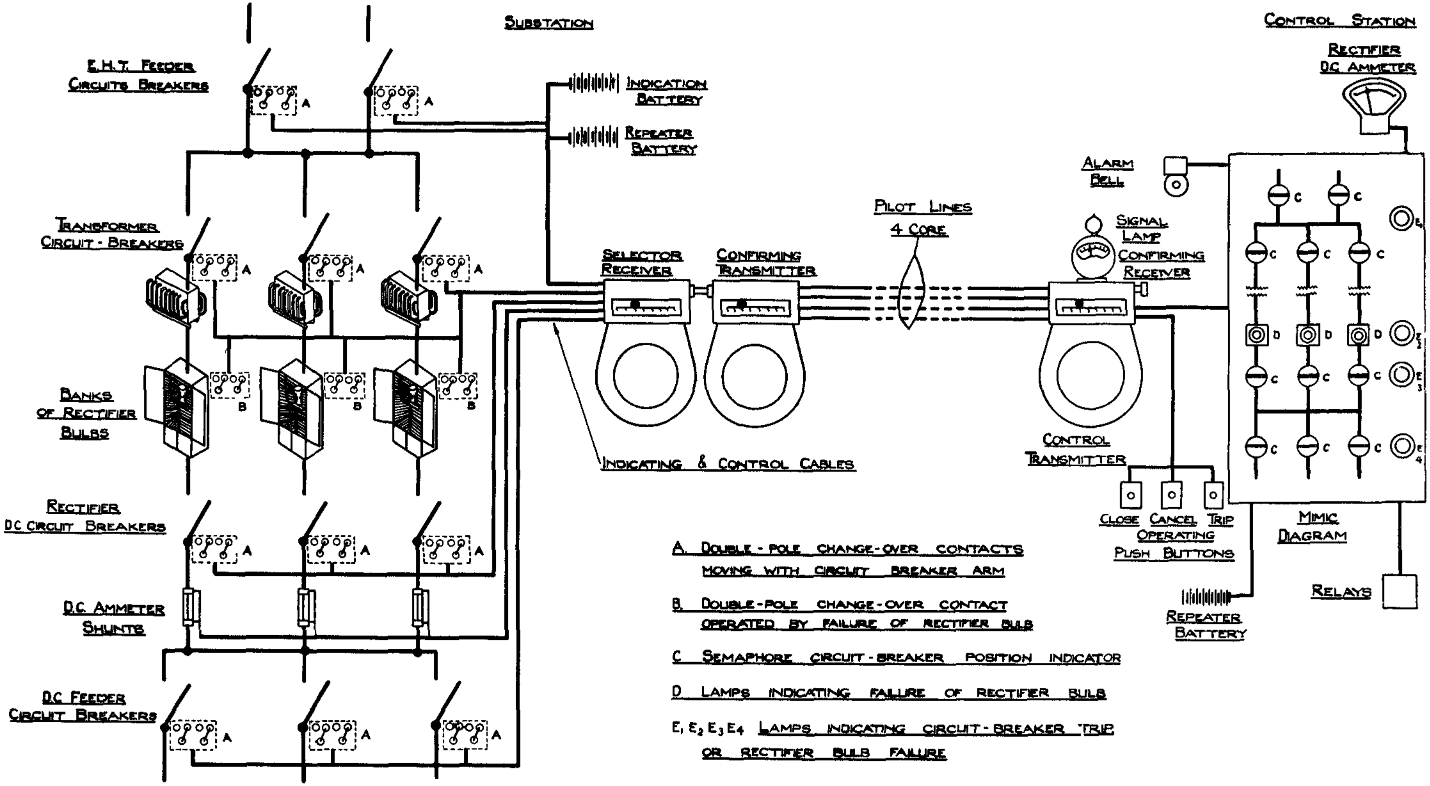


Fig. 6.—DIAGRAM OF TYPICAL EVERSHED-MIDWORTH REMOTE CONTROL SCHEME FOR A THREE-UNIT RECTIFIER SUBSTATION.

The apparatus at the substation is controlled through four pilot lines from the control station, a mim'c diagram being arranged at the latter to show automatically the position of the switches and gear at the substation.

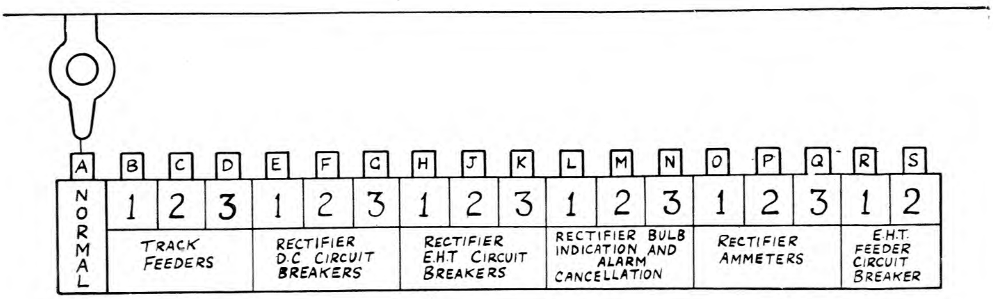


Fig. 7.—SCALE MARKING FOR CONTROL TRANSMITTER.

or oxide has been removed. Hence the resistor is self cleaning.

The two limiting contacts, which come into operation either when the repeater circuit is broken, or when the originating pointer is moved below the zero mark, are shown in the photograph.

Receivers.

The simplest type of receiver is a moving-coil milliammeter which can be of the indicating or recording type, suitably calibrated. Another form, known as a power-driven receiver, is a modified form

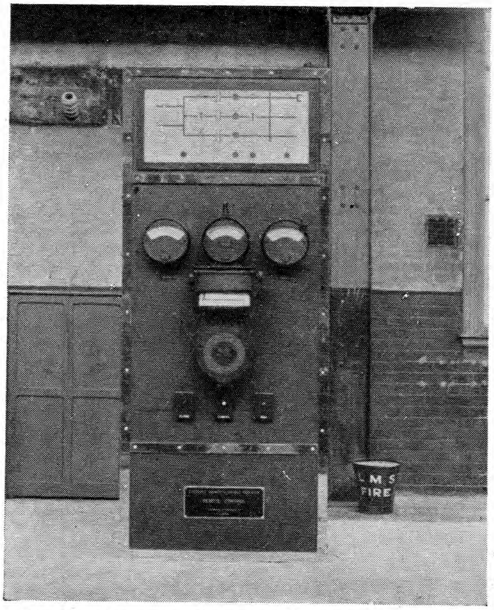


Fig. 8.—TYPICAL CONTROL STATION EQUIPMENT FOR EVERSHED-MIDWORTH REMOTE CONTROL.

of transmitter, in which the pointer is motor driven and can, therefore, be made of any desired size.

Selector Receivers.

As described so far, it will be noted that two pilot wires are required for each indication, and these indications are all continuously recorded. If the distance between the transmitting and receiving stations is great, and the number of indications large, the multiplicity of pilot wires will be expensive. To overcome this difficulty the same system is used for selection or control by making use of a special form of receiver called a selector receiver.

The selector receiver is an adaptation from the power-driven indicator, a switch arm taking the place of the indicator arm. It may be used for the selection of a number of circuits, and if necessary may be combined with a second transmitter to confirm to the originating station that the selection has been carried out, thus showing the control engineer what is happening at the distant station.

By installing a number of control units, one motor unit and one selector receiver at the remote point, and a selector transmitter and a number of receivers at the control point, it will be seen that with four pilot wires only a considerable number of different indications can be received. A diagram of such a scheme for reading power factor, voltage and current is shown at Fig. 5.

Control.

The next step in the development of this scheme is to use the above described method of selection, to select control relays for, say, closing or opening electrically operated oil-circuit breakers, D.C. feeder circuit breakers, etc. When performing such operations, however, it is of the utmost importance that the correct point is selected before attempting to carry out any operation. To ensure that the correct selection is set up the selector receiver is mechanically connected to a confirming transmitter, which, in turn, sends back an independent signal to the control point. If this check-back signal agrees with the signal sent on the selector transmitter, it can safely be assumed that the selector receiver has actually selected the correct point and the operating impulse can then be given, which actually initiates the control operation required. To further ensure that the selector receiver does not move from its correct position, provision is made for locking the selector transmitter and receiver before sending the control signal.

It is obvious that with such a control scheme, meter reading facilities can be combined.

HOW THE SYSTEM IS APPLIED TO A RECTIFIER SUBSTATION.

Finally, a brief description of a complete system as applied to a rectifier substation converting power for traction circuits will give a comprehensive idea of a typical system.

The Equipment.

Fig. 6 shows diagrammatically the equipment supplied. The apparatus at the substation is controlled by the Evershed-Midworth system through four pilot lines from the control station, a mimic diagram being arranged at the latter to show automatically the position of the switches and gear at the substation. The opening and closing of the switches and the other operations required to be carried out at the substation are first selected by means of the control transmitter, this being provided with a scale, shown in Fig. 7, suitably marked and inscribed to indicate the positions corresponding to the various operations required. The actual operation is carried out by press button.

When an operation has to be carried out, the arm of the control transmitter is moved by hand until the pointer is in line with the appropriate mark on the scale, and the attendant then waits a return signal from the substation on the confirming receiver, which shows that the selector receiver at the substation is in the correct position to carry out the operation required. The lock switch on the control transmitter is then turned to the "locked" position, and this ensures that no change in the position of the transmitter or the receiver at the other end can be made, and so mistakes are prevented.

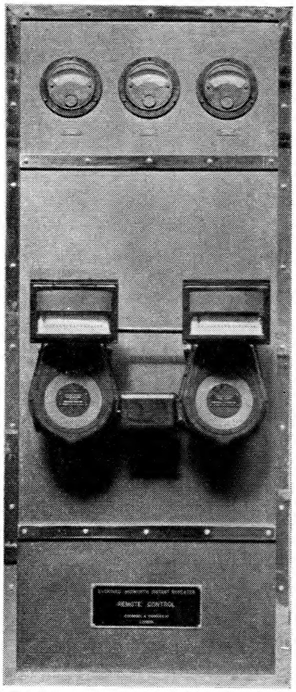


Fig. 9.—TYPICAL SUBSTATION EQUIPMENT FOR EVERSHED-MIDWORTH REMOTE CONTROL.

The lock switch brings into action the circuits to the mimic diagram and this will then automatically give the appropriate indication. If the position selected is one of the circuit breakers, the circuit breaker may be opened or closed by means of the operating press button, and in that case an appropriate semaphore on the mimic diagram gives instantaneous indication as the circuit breaker opens or closes.

After any operation has been carried out, the lock switch is turned to the "free" position, the control transmitter set to the "normal" position, and the lock switch then returned to the "locked" position. In this condition the equipment is ready to receive indications and give alarm in the event of any circuit breaker tripping out or a rectifier bulb failing. A signal lamp is provided to give warning if the transmitter is not left in the " normal " position.

The Operations That Can be Carried Out.

The various operations that can be carried out are as follows :—

Control of Circuit Breakers.

Two E.H.T. circuit-breakers, three transformer circuit breakers, three rectifier D.C. circuit breakers, and three track feeder circuit breakers may be opened or closed by remote control.

Indication of Circuit Breaker Position.

The position of all the above-mentioned circuit breakers is indicated by the semaphore indicators C on the mimic diagram in the control station.

These semaphores will automatically take up the appropriate position as any circuit breaker is opened or closed by the remote control gear.

The semaphores will also automatically set themselves in the appropriate position when the circuit breakers are selected, but not actually controlled by the control transmitter, thus providing a means for checking the condition of the mimic diagram at any time.

Circuit Breaker Alarm.

Any circuit breaker which has been closed by the remote control gear will, upon tripping out on an overload, or from any reason other than opening by means of the remote control gear, cause an alarm bell to ring in the control station, and indicate by means of one of the three lamps, E.1, E.3, or E.4, on the mimic diagram, which particular group of circuit breakers contains the one which has tripped out.

By setting the control transmitter to the group of circuit breakers indicated, the particular circuit breaker which has tripped out will be identified by the corresponding semaphore on the mimic diagram setting itself in the " open " position.

The circuit breaker may now either be reclosed by means of the remote control gear, or left in the open position, and the alarm cancelled by pressing the " cancel " control button.

Rectifier Bulb Failure.

Closure of any one of the three relays, provided as a part of the rectifier equipment, and arranged to close in the event of a bulb failing, will cause the alarm bell in the control station to ring, and the fact that one of the rectifier bulbs has failed will be indicated by the lighting of the lamp E.2 on the mimic diagram.

By setting the control transmitter to the positions corresponding to the three rectifiers, the particular bank containing the defective bulb will be indicated by the lighting of the appropriate one of the three lamps D on the mimic diagram.

Having located the defective rectifier bank, the alarm and signal may be cancelled by pressing a " cancelling " button provided for the purpose.

When starting up a rectifier bank, failure of ignition is also indicated by the signal lamps D, so that a rectifier bank may not be put on load if one of the bulbs has failed to ignite.

Indication of D.C. Load.

The D.C. current output from any one of the three rectifier banks may be indicated by selection on a moving-coil indicator at the control station. To obtain this indication the control transmitter is set to the appropriate position, thereby causing the moving-coil indicator to be connected to the particular ammeter shunt necessary to transmit the measurement required.

A 3-Ampere Battery Charger for A.C. Mains

By H. E. J. Butler

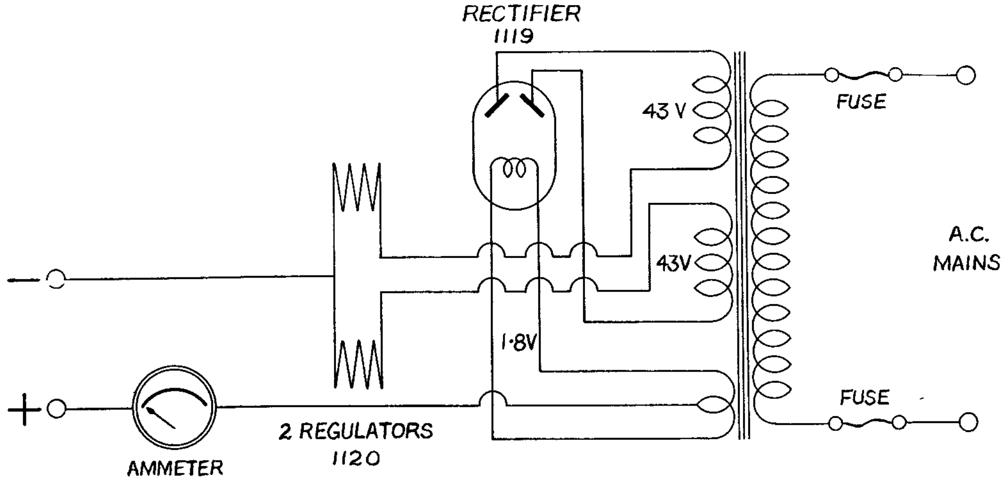


Fig. 1.—The Circuit of the 3-ampere Battery Charger Using a Philips Rectifier and Regulator Lamps.
The ammeter is not essential, but if used must be a special moving coil instrument.

THIS battery charger has an oxide cathode type of rectifier with two regulator lamps, which maintain the charging current at approximately 3 amperes, for any number of cells between 2 and 12. No rheostat is therefore necessary, because the regulator lamps automatically absorb the excess voltage when less than 12 two-volt cells are placed on charge. A rheostat would be necessary to reduce the charging current below 3 amperes.

The total cost of the materials, including the rectifier and lamps, is about £3.

Transformer.

The transformer for working this rectifier has two secondary windings; one of 43 + 43 volts for the anode supply and a second of 1.8 volts 5.5 amperes for heating the cathode. For the construction of the transformer the following materials are required:—

No. 28 Stalloy T-U stampings (see Fig. 2)	1 gross.
Enamel covered wire for primary (see Table)	1¾ lb.
No. 16 S.W.G. double silk-covered wire for secondaries	3½ lb.
Bakelite cheeks for bobbin, 4½ × 3¾ × 3/32 inch	2
Bakelite cheeks for bobbin, 4½ × 3¾ × 3/32 inch	2
Bakelite strips for bobbin, 3 × 2⅛ × 1/32 inch	2
Bakelite strips for bobbin, 3 × 1⅜ × 1/32 inch	2
Cast aluminium clamps	1 pair.

Primary Windings.

The primary coil must be wound to suit the supply, but the secondary windings are the same irrespective of the mains voltage. The following table gives the data for 50-60 cycle supplies.

Mains Voltage.	S.W.G. Enamel.	Turns.
100	19	320
110	20	352
120	20	384
200	22	640
210	22	672
220	22	704
230	22	736
240	22	768
250	23	800

Arrangement of Windings.

Fig. 3 shows the arrangement of the transformer coils on the core. The primary is sandwiched between the two halves of the 86-volt secondary winding. This method of winding the coils is to be preferred to the single coil method, in which the secondary is wound on top of the primary. In the latter method it is difficult to equalise the two halves of the secondary, because the outside 43-volt coil must contain more wire than the inner half.

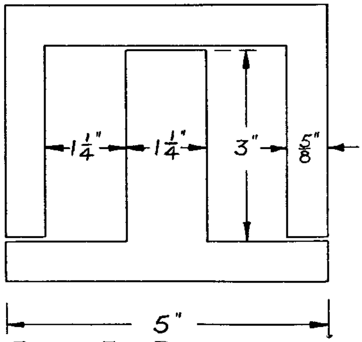


Fig. 2.—The Dimensions of the Stampings Used for the Rectifier Transformer.

The primary coil is wound on a temporary wooden former, so that its thickness is ¾ in. Every other layer of the primary is covered with insulating paper during winding. The 200-240-volt windings will have about 30 layers. A cheek of $\frac{1}{32}$-in. bakelite is placed on each side of the primary to insulate it from the secondary.

The Secondaries.

Each of the two 43-volt coils are 1 in. wide. There is enough space on top of these coils for the cathode winding. This is tapped in the centre, so that 3½ turns are wound on top of each of the 43-volt coils.

The 86-volt windings consist of 138 + 138 turns of the 16 S.W.G. double silk-covered wire. The 1.8 volt winding has 7 turns of the same wire.

Transformer Connections.

Care must be taken to connect up the ends of the two 43-volt coils in the correct sense. The two coils must be wound in opposite directions, the two starting ends are connected to the regulator lamps and the two outside ends are wired to the rectifier anodes.

Rectifier and Regulator Fittings.

The rectifier has a standard valve base, so that any valve holder of generous construction is suitable for this. The regulator lamps have a standard screw cap, and two batten type screw holders are required for these. The rectifier is a Philips No. 1119, and the regulator lamps are Philips No. 1120.

Adjusting the Cathode Voltage.

It is important, in the interest of the life of the rectifier valve, to have exactly 1.8 volts across the cathode pins. If an A.C. voltmeter is available, this may be adjusted by removing a fraction of a turn from the transformer winding, or by introducing a suitable length of 16 S.W.G. bare eureka resistance wire into the leads to the cathode pins. Measure the cathode voltage while the valve is fully loaded, i.e., charging a battery at 3 amperes.

The cathode of the rectifier valve should be allowed to heat up before current is passed through the valve. This is done by switching on the transformer primary a minute or so before connecting the battery to the charging terminals.

We understand that the firm of Messrs F. C. Heayberd & Co., 10, Finsbury Street, E.C.2, are prepared to quote any reader of this magazine for the complete transformer built in accordance with the details given above.

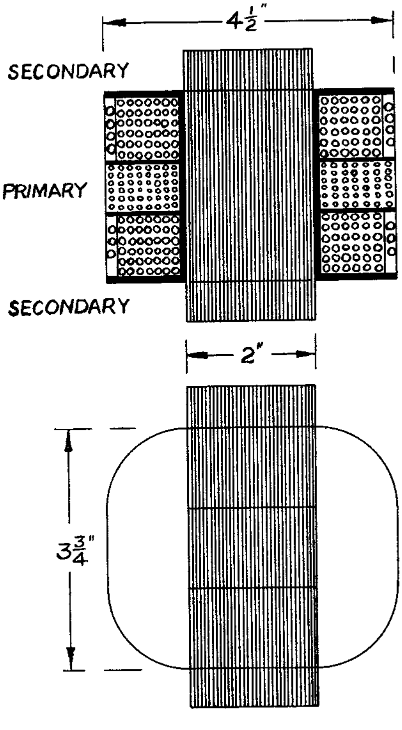


Fig. 3.—The Arrangement of the Bobbin and Coils on the Transformer.

POWER FACTOR AND ITS IMPROVEMENT

WITH SPECIAL REFERENCE TO THE USE OF STATIC CONDENSERS

By N. H. BENTLEY

IT is fairly safe to assume that every electrical engineer knows at least in a general way what is meant by power factor in an alternating current circuit.

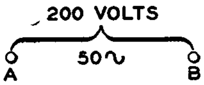


Fig. 1.—THE TERMINALS OF A 200-VOLT, 50-CYCLE A.C. SUPPLY.
At one instant A is 282 volts positive to B. $\frac{1}{100}$ of a sec. later B is 282 volts positive to A.

A 200-volt, 50-cycle A.C. Supply.

Fig. 1 shows the terminals A and B of a 200-volt, 50-cycle A.C. supply. The voltage measured between A and B at one instant may be 282 volts, A being positive. 1/100th of a second later the voltage is 282 in the opposite direction, i.e., A being the negative; 1/100th of a second later still, that is, 1/50th of a second after our first measurement, the voltage is again 282 volts, with A the positive. During 1/50th of a second the voltage varies between these two extreme values.

If we now connect to A and B a non-inductive load such as a lamp or fire, the current flowing *at any instant* is directly proportional to the voltage *at that instant.* In other words, the current variations keep exactly in step with the voltage variations. Thus, the power being drawn from the supply at any instant is equal to:

Voltage × current or

$$\text{Voltage} \times \frac{\text{Voltage}}{\text{Resistance}}$$

i.e., Voltage² ÷ Resistance of circuit.

During 1/50th of a second the resistance, of course, remains constant and the voltage varies from +282 volts to −282 volts. The average power is equal to the average value of:—

$$\text{Voltage}^2 \div \text{Resistance.}$$

Now alternating current voltmeters show not the average value of the voltage during a period and not the maximum value of the voltage, but a reading which is equal to the square root of the average value of the square of the voltage (this sounds complicated, but is really quite simple if you read it slowly).

An A.C. ammeter also gives us a corresponding reading for the current.

For convenience we refer to these as the root mean square values. From the above it can be seen that in a non-inductive alternating current circuit there are two ways of finding the power which is being used:—

(1) We can multiply the R.M.S. voltage by the R.M.S. current. This will give the power in watts.

(2) We can divide the square of the R.M.S. voltage by the resistance of the circuit in ohms. This will give the same result.

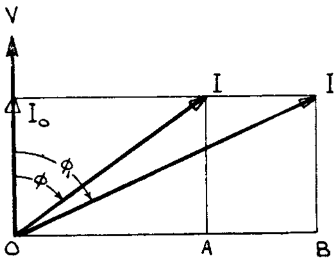


Fig. 2.—VECTOR DIAGRAM SHOWING VOLTAGE AND CURRENT CONDITIONS IN AN A.C. CIRCUIT CONTAINING INDUCTIVE REACTANCE.

The power factor is the ratio of true power to apparent power.

Apparent power in circuit = VI.

True power = VX in-phase component of I = VI_0 = VI cos ϕ.

Hence power factor =

$$\frac{\text{true power}}{\text{apparent power}} = \frac{VI\cos\phi}{VI} = \cos\phi$$

For a given power I_0 is constant, so that if the current lags behind V by a greater angle ϕ_1, its magnitude, represented by OI_1, must be greater. Thus, for equal transmitted power, the current is inversely proportional to the power factor.

What Happens in an Inductive Circuit.

If, instead of connecting a fire to the supply terminals, we connect the windings of, say, an electromagnet, what would happen? The effect of the magnet wind-

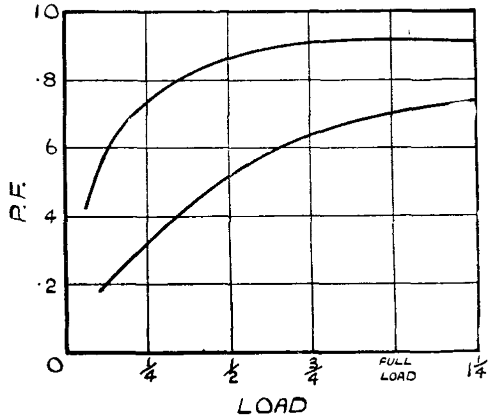


Fig. 3.—SHOWING THE EFFECT OF SPEED RATING OF AN INDUCTION MOTOR ON THE AVEFAGE POWER FACTOR.

Top curve, high-speed motor ; bottom curve, low-speed motor.

ings is to retard the growth of the current in the circuit. Inductance in a circuit produces electrical inertia, and owing to this the current attains its maximum value a fraction of a second later than the voltage. In the same way the current reaches its minimum value a fraction of a second later than minimum voltage.

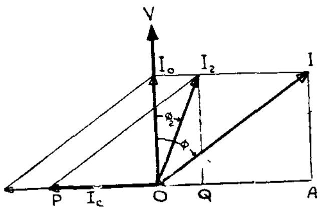


Fig. 4.—VECTOR DIAGRAM OF CONDENSER IN INDUCTIVE CIRCUIT.

If we had a voltmeter and an ammeter connected in circuit as before, these instruments would give us the R.M.S. values of the voltage and current respectively. If, however, we could use instead of these ordinary instruments, a voltmeter and an ammeter which would show us at a given instant the *actual* values of the current and the voltage, we should find that, whereas in the case of the electric fire circuit the voltage and current reached their maximum values at the same instant, in the case of the electromagnet the voltage would be at its maximum perhaps 1/200th of a second before the current reached its maximum. We should also notice that instead of current and voltage always having positive values at the same time and always having negative values at the same time (so that their product was always a positive quantity), in the case of the electromagnet circuit *the current readings would at some instants be negative when the voltage readings were positive, and vice versa.*

Now negative power in a circuit really means that power is being pumped back into the supply mains. Our quick-reading ammeter and voltmeter do not take any account of this, nor do our ordinary A.C. ammeters and voltmeters, but it is quite obvious that if we multiplied together the ammeter and voltmeter readings (R.M.S. values) this would not give us a true estimate of the power being taken from the supply circuit.

How True Power can be Measured in an A.C. Circuit.

This true power can best be measured by means of a wattmeter which automatically multiplies together the *instantaneous* values of the current and voltage and gives an average reading, which represents the true power being consumed in the circuit. The ratio of this true power, obtained by a wattmeter reading, to the apparent power obtained by multiplying the voltmeter and ammeter readings, is called the power factor of the circuit.

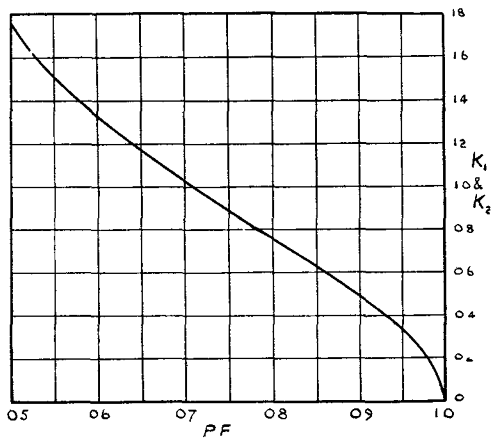


Fig. 5.—CURVE FOR THE DETERMINATION OF CONDENSER kVA.

Power Factor Without Trigonometry.

To give readers a clearer picture of what happens, we have compiled the table below, which shows the relation between power factor and time lag on a 50-cycle supply :—

TIME LAG AND POWER FACTOR.

Power Factor of Circuit ..	1.0	.95	.90	.85	.80	.75	.5	.25	0
Maximum Current Lags behind Maximum Voltage by ..	.0000 sec.	.0010 sec.	.0014 sec.	.0017 sec.	.0019 sec.	.0022 sec.	.0033 sec.	.0042 sec.	.0050 sec.
Angular Displacement on Vector Diagram	0°	18°	25°	31½°	35½°	40½°	60°	75½°	90°

Why a Condenser can be Used for Improving the Power Factor.

Just as introducing *inductance* into an alternating current circuit causes the current to reach its maximum value a little *later than* the voltage, if we introduce capacity into an alternating current circuit this causes the current to attain its maximum value a fraction of a second *earlier than* the voltage. It is, therefore, obvious that by adding a suitable condenser to an inductive circuit the time lag can be reduced any desired amount.

Three Methods of Power Factor Improvement.

There are three distinct types of apparatus available for the improvement of low lagging power factors. These are :—

(1) The synchronous motor or rotary condenser.

(2) The phase advancer.

(3) The static condenser.

Of these (1) and (2) are rotary machines, whilst the static condenser is a simple piece of apparatus possessing no moving parts.

It is the purpose of this article to deal mainly with the aspect of power factor improvement by means of the static condenser.

The Static Condenser.

Unlike the first two types of power factor improvement apparatus, the static condenser possesses no moving parts. It is simply a condenser in the fundamental sense of the term, connected across the supply as near as is practicable to the source of lagging current.

Effect of Connecting a Condenser in an A.C. Circuit.

The effect of connecting a condenser in an A.C. circuit will now be considered.

The current taken by a condenser in an A.C. circuit due to a voltage V across it is given by

$I_c = \omega CV$. Where I_c = current in amperes.
C = condenser capacity in farads.
$\omega = 2\pi \times$ frequency.

The current leads the voltage by 90°, and in Fig. 4 we see the relative positions of the vectors V and I_c in graphical form. The vectors comprising Fig. 2 have been added to this diagram, a study of which will show that the lagging wattless current represented by OA in Fig. 4 can be balanced out to a greater or less extent by the leading wattless current I_c. For instance, if the current taken by the condenser be represented by OP, the resultant wattless current taken by the whole circuit will be OA − OP = OQ, which gives a total current I_2 flowing in the circuit. This current has obviously a much higher power factor than I, and its magnitude OI_2 is less than OI. If the capacitative current I_c is made equal to OA, the wattless components in the circuit entirely balance out, and the current flowing is I at unity power factor.

Condensers for power factor correction are usually rated in kVA. By this means it is easy to determine the size of condenser required to compensate for a given wattless load.

The kVA. of a condenser is given by the equation

$$S = \frac{VI}{1000}$$

$$\text{or } S = \frac{\omega CV^2}{10^9}$$

where C is in microfarads and S is the condenser kVA.

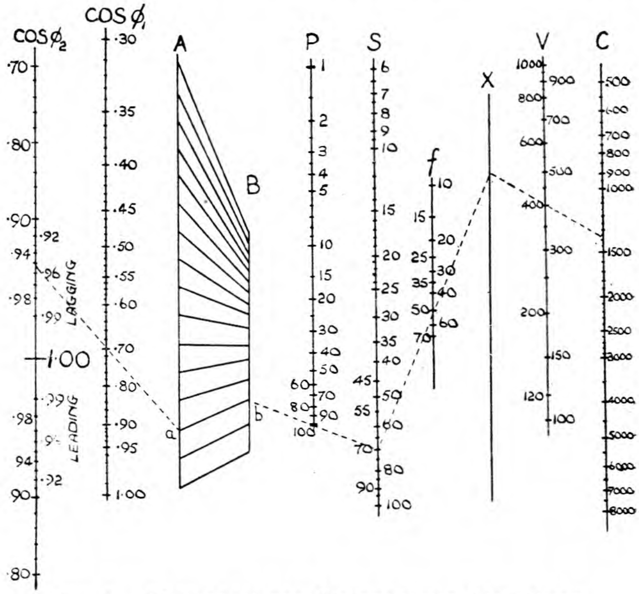


Fig. 6.—NOMOGRAM FOR DETERMINING CONDENSER KVA. AND CAPACITY DIRECTLY

Determination of Condenser Rating.

The condenser kVA. required to correct a given kilowatt load from a low P.F. to a higher one can be calculated from the constant of the circuit with the aid of the vector diagram in Fig. 4, but these calculations may be avoided by the use of one of the methods illustrated in Figs. 5 and 6. By the use of Fig. 5 the required condenser kVA. may be determined. The nomogram reproduced in Fig. 6 can likewise be used to find the condenser kVA., and this figure can also be extended to determine the capacitance required at the particular voltage and frequency of the circuit.

In order to illustrate the use of these diagrams in the calculation of condenser size, a specific example will be worked out. Take, for instance, the case where 100 kW. are being transmitted at 400 volts, 50 cycles. The existing power factor is 0.70 and it is desired to improve this to 0.95. *Method* (1)—see Fig. 5.

Factor K_1 corresponding to $\cos\varphi = 0.70 = 1.02$

Factor K_2 corresponding to $\cos\varphi = 0.95 = 0.32$

Factor $K_1 - K_2 = 0.70$

kVA. of condenser required $= 0.70 \times 100 = 70$ kVA.

Substituting in equation, to find the capacity in microfarads

$$70 = \frac{2\pi \times 50 \times 400^2 \times C}{10^9}$$

$$\text{or } C = \frac{70 \times 10^9}{2\pi \times 50 \times 400^2} = 1390\ \mu F.$$

Method (2)—see Fig. 6.

On the scale marked $\cos\varphi_2$ (i.e. desired P.F.) and the scale marked $\cos\varphi$ (i.e. initial P.F.) find the points corresponding to 0.95 and 0.70 respectively. Join these and produce the line to cut scale A at *a*. Continue from this point in the general direction indicated by the converging lines until scale B is reached at point *b*. Join *b* to 100 on the scale marked P (i.e. load kilowatts) and produce to cut scale S (consider kVA.) at some point. The point of

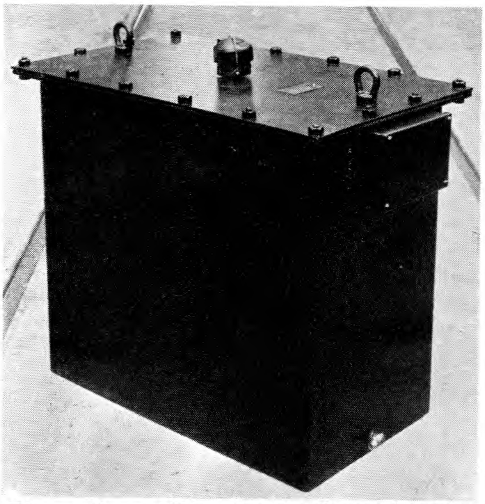


Fig. 7.—A 15 KVA. 400-VOLT STATIC CONDENSER.

intersection of scale S gives the condenser kVA. required and we see that a 70 kVA. condenser is required in this instance.

If desired the procedure can be extended to find the capacity in microfarads. Join the point 70 on scale S to 50 on scale *f* (cycles per second) and produce to line X. From the intersection of X take a line through 400 on scale V (line voltage), produce to scale C, and read off the capacity, 1390 microfarads, on this scale.

Economic Limit of P.F. Improvement.

It will be noticed that the final power factor in the example worked out is 0.95, not unity. It is seldom an economic proposition to correct the P.F. of an installation to unity as may be indicated by an extension of the above specific case. On working the calculation out for $\cos \varphi_2 = 1$, it is seen that the condenser kVA. required is 102, an increase of 36 per cent. in condenser size. The current, however, would only be 5 per cent. less than that flowing at $\cos \varphi_2 = 0.95$. As a general rule, therefore, the higher limit of power factor correction is usually fixed at 0.95 lagging.

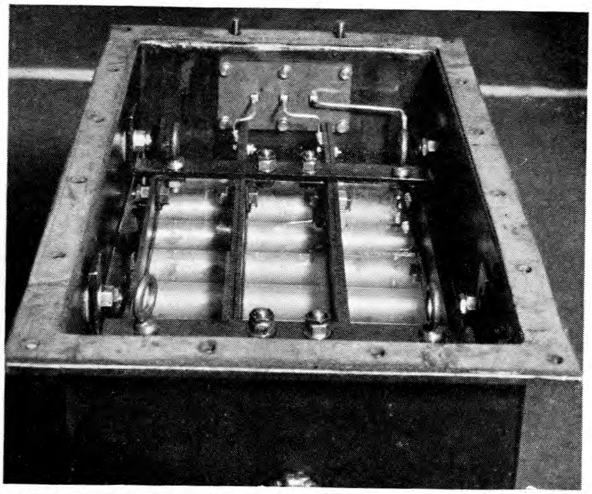


Fig. 8.—Another View of the Condenser Shown in Fig. 7 With Cover Removed to Show Arrangement of Units.

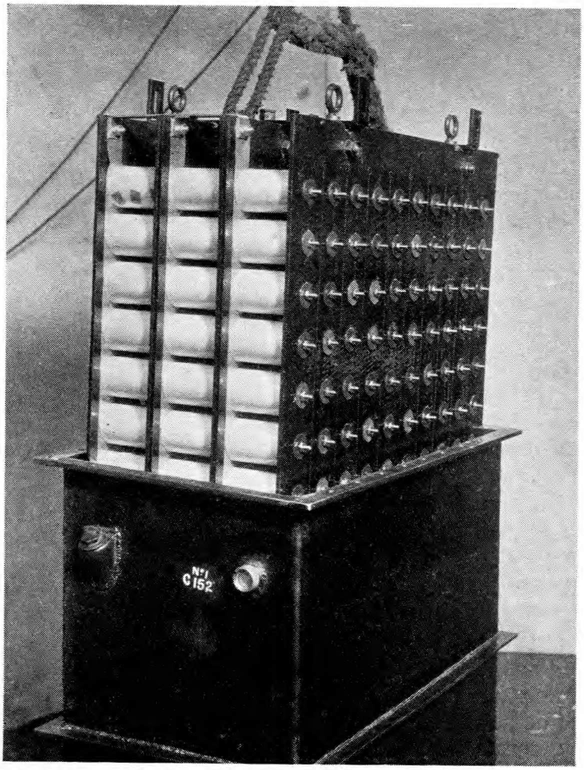


Fig. 9.—25 kVA. Static Condenser Showing Construction.

Construction of Static Condensers.

In order to obtain the high capacity necessary for a normal sized static condenser, small condenser units are connected in parallel. Fig. 7 shows the exterior of a 15 kVA. condenser for 400 volts 3 phase working at 50 cycles, whilst a view of the same condenser with the lid removed is given in Fig. 8. The latter photograph indicates how the units are arranged in three phases, all the units in each phase being

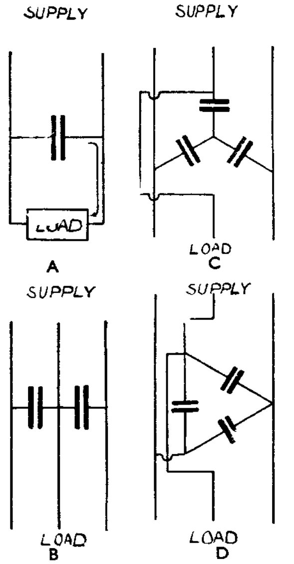


Fig. 10.—CONNECTIONS OF STATIC CONDENSERS.
(*a*) Single phase; (*b*) Two phase; (*c*) Three phase, star connection; (*d*) Three phase, delta connection.

connected in parallel. Fig. 9 also illustrates this point, the photograph being of a 25 kVA. condenser in this case. The whole assembly is immersed in a tank of oil which serves the dual purpose of impregnating and of cooling the units as in the case of a naturally cooled transformer.

Connection of Static Condensers.

Condensers can be arranged so as to be suitable for single, two or three phase systems as in Fig. 10. Three phase condensers may be connected either in star or in delta connection, the actual connections used being a matter of design depending on the dielectric and the voltage. It can be proved that with delta connection the capacitance required is only one-third of that required with star connection, but since the voltage per phase is only $\frac{1}{\sqrt{3}}$ times as much as that in delta connections, the dielectric in the former arrangement can be made thinner and thus the cost per kVA. remains constant whatever the connection.

Situation of the Condenser.

Since the installation of a static condenser has the effect of decreasing the current taken from the supply but not that actually flowing round the condenser-motor circuit, the position of the former should theoretically be as near as possible to the motor. By connecting the condenser directly across the motor terminals it is possible to use a smaller gauge of feeder owing to the small current taken from the supply. Unfortunately, the relatively high cost per kVA. of corrective apparatus in small sizes makes it desirable to group small motors together with a moderate sized static condenser, whose cost would be much less than a number of small condensers of the same aggregate kVA. If the motive power in a works is, therefore, in the form of a large number of small induction motors together with a few large motors, it is the rule in a comprehensive power factor improvement scheme to group the smaller motors with a single condenser and apply individual correction to the larger machines.

Typical Power Factor Improvement Schemes.

Installations which usually work at a fairly low power factor are those where the load is constantly varying, and which may be called upon to take a heavy peak load from time to time. It is obvious that plants of this nature will have to be fairly liberally designed and that during most of their operating time they will be working at a load very much less than their maximum rating. The normal power factor is, therefore, low. An example of this type of works is a rolling mill producing steel and other metal sections, and a typical power supply lay-out for a plant of this sort is reproduced in Fig. 11.

The power supply to the plant we will assume is taken from the Supply Company's mains at 6,600 volts 50 cycles

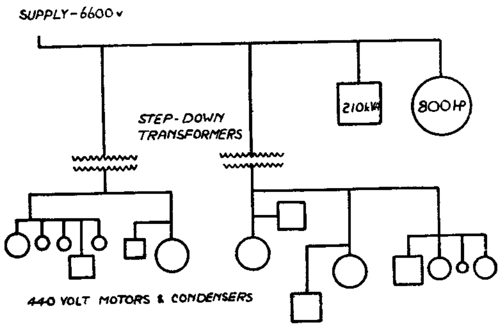


Fig. 11.—TYPICAL SCHEME OF POWER FACTOR IMPROVEMENT AS APPLIED TO A LARGE ROLLING MILL.
The motors are represented by circles and the static condensers by squares.

3 phase. The motors in use are one large 800 h.p. machine running directly off the 6,600 volt supply and driving the main rolling plant, and also a number of small

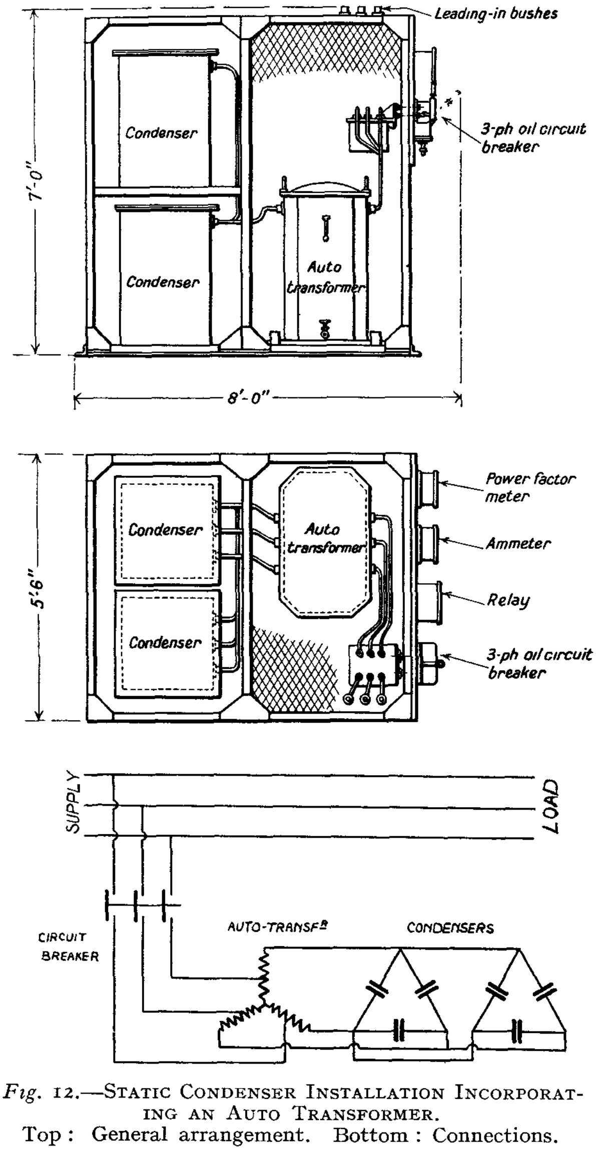


Fig. 12.—STATIC CONDENSER INSTALLATION INCORPORATING AN AUTO TRANSFORMER.
Top: General arrangement. Bottom: Connections.

slip ring and squirrel cage induction motors. We will take the case of a total load of 440 volt motors amounting to 250 h.p., this being divided between two 6,600/440 volt transformers. The size of motor in use varies from 5 to 50 h.p.

Tests indicate that the average power factor of the 800 h.p. motor is 0.75 and that the average kW. taken is 375. The smaller motors consume 150 kW. at a power factor of 0.7.

Correcting Overall Power Factor to 0.95.

Suppose that it is desired to correct the overall power factor of the installation to 0.95. Taking the 800 h.p. motor first, the condenser kVA. required would be 210 as determined from Figs. 5 or 6. This condenser would be connected across the 6,600 volt feeder close to the large motor and would raise the power factor of the motor load to 0.95. This condenser would be of the high tension type, consisting of a number of units in series to withstand the high line voltage. In appearance and size, however, it would be similar to a low tension condenser of like kVA. except, of course, for the larger terminal insulators required.

Low Voltage Motors.

Dealing now with the low voltage motors, both individual and group connection would be applied. Motors of 20 h.p. and over, of which there would certainly be a number in a works of this size, would, in general, have condensers directly connected across their terminals whilst smaller machines would be grouped together. The exact lay-out of the corrective plant will, of course, depend to a large extent on the geographical lay-out of the motors, but the total condenser kVA. required to correct the P.F. of the 440-volt motors to 0.95 is 105.

A typical scheme of power factor improvement as applied to the above works has been shown diagrammatically in Fig. 11.

Electrically Driven Textile Factory.

An entirely different type of load from

the last example is afforded by the electrically driven textile factory. In this case the load is usually very steady, so that the motors are loaded at a figure closely approaching their rated capacity. The overall power factor is thus comparatively good. All the same, it is necessary, where preferential tariffs are in operation, to ensure that the load on the transformers and feeders is kept as low as possible.

The method of P.F. improvement that is actually installed will depend entirely on the type of mill. In a spinning mill, for instance, the tendency is to install a small motor to drive each spinning frame, and here power factor correction by means of separate static condensers would most profitably be employed.

In a weaving shed using electric power, it is usual to drive the looms together in groups, the power being transmitted from a few large motors by means of line shafting. Since weaving is essentially a constant speed operation it would appear that auto-synchronous motors would be the best form of drive to adopt in a new factory, although if the electric drive is already in existence a static condenser for each induction motor should be fitted.

Use of Auto Transformers.

We have already seen that

$$S = \frac{\omega CV^2}{10^9}$$

or that the capacitance is inversely proportional to the square of the voltage for any given frequency. In other words, if the voltage is increased to twice its original value, the capacitance of the condenser need only be one quarter of its original value. This fact is often made use of, and an auto transformer is used to step up the voltage to any convenient figure. In this way it is very often possible to produce an installation which is appreciably cheaper than a directly connected condenser of the same kVA. Connections and lay-out of a typical three-phase condenser with auto transformer are shown in Fig. 12.

Saving Effected by P.F. Correction.

It has been mentioned that tariffs are in operation with a view to penalising plants working at a low power factor. It is usually possible by the installation of corrective apparatus to write off the capital cost of the condenser in a very short period, say, 1—3 years, according to the terms of the tariff. A considerable annual saving can, therefore, be effected.

Comparison of Corrective Methods.

The total sphere of power factor correction is in practice divided between the three methods available, but it is inevitable that a certain amount of overlapping occurs. The rotary condenser is often employed for improving the voltage regulation of long overhead lines. In this case it is connected at the receiving end of the line, and is often of very large capacity. Equipments have been constructed in America of 15,000 kVA. rating.

Phase advancers can be used on medium and large sized induction motors, but their relatively high cost per kVA. rules out the possibility of their use for small motors. It is probable that the scope offered by medium and large motor power factor correction is shared by the phase advancer in its various forms and the synchronous condenser, whilst for small and medium installations the static condenser is by far the best method to use.

Static condensers can be supplied to give capacitative loads of 1—250 kVA. They have the advantage of low first cost, especially in the smaller sizes where they compare most favourably with any other method of P.F. improvement. Static condensers are most suitable for installation in inaccessible positions as they require no attention as is the case with rotary machines. The losses in the latter may become relatively serious in small installations since they are of the order of 10—15 times those occurring in static condensers which have efficiencies of $97\frac{1}{2}$—$98\frac{1}{2}$ per cent.

It will thus be seen that the choice of the method of power factor improvement will depend upon the nature of the load whose power factor is to be corrected, and before any decision is made as to the particular type of apparatus to be installed in any case, it is necessary to be in possession of all the factors bearing on the scheme under consideration.

INSTALLING A COUNTRY HOUSE ELECTRICITY GENERATING PLANT

By H. W. JOHNSON

THE plant which is usually installed consists of a shunt wound dynamo driven by a paraffin or petrol engine. The engine may be directly coupled to the dynamo or may drive it through a belt. A battery of accumulators is run in conjunction with the dynamo. During the daytime the dynamo is run to supply the installation and to charge the battery. In the evening the dynamo is shut down and the battery is discharged to supply the installation until the following morning when the dynamo is started up again.

The installation is fed through a switchboard which is fitted with a battery charge and discharge switch. This switch regulates the charging circuit, and adjusts the battery voltage when the battery is discharging.

The switchboard is also fitted with main switches and fuses for the dynamo and installation, instruments to record the output current of the dynamo, the discharge current of the battery, and the voltage of the supply to the installation. In addition a battery automatic cut-out is fitted which makes the operation of charging the battery automatic and foolproof, thus preventing the battery "motoring" the dynamo at any time.

The Housing for the Plant.

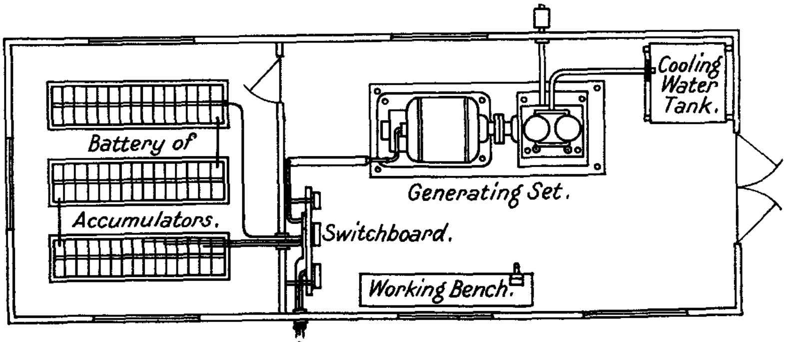
A suitable building large enough to accommodate the plant should be erected within a reasonable distance of the house, but far enough away to prevent the noise which the running plant will make becoming an annoyance to the occupants of the house.

The building should be of brick or stone preferably, well ventilated, and have a concrete floor of sufficient thickness, so as to secure a good foundation for the engine and dynamo. A part of the building should be partitioned off (to accommodate the battery) so as to exclude the acid and gas fumes from the remainder of the plant; this portion of the building must be well ventilated.

Layout of the Plant.

The overall dimensions of the engine and dynamo bed plate, and the iron frame of the switchboard are obtained from the blue prints and the floor space of that portion of the building which will house this part of the plant is allotted, having regard to the following desirable conditions:—

1. Ease of starting and stopping the engine.
2. Convenient position of cooling water tank to engine cylinder jacket connections.
3. Dynamo easy of access for cleaning and overhaul.



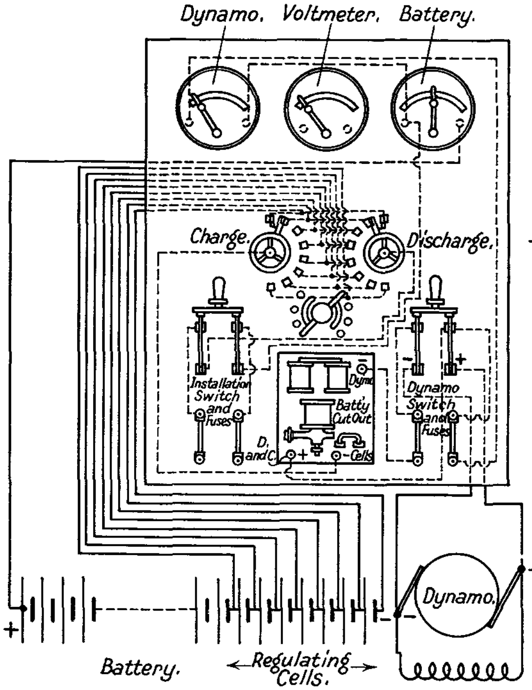
GENERAL ARRANGEMENT OF THE PLANT.
Showing plan of the building.

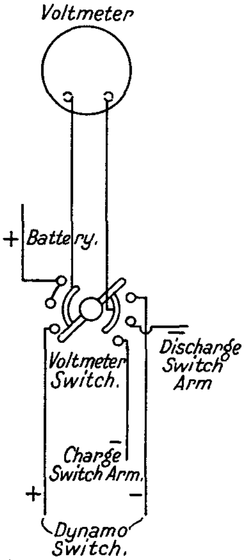
4. Convenient cable connections from the dynamo to the switchboard.

5. Convenient cable connections from the battery through the partition to the switchboard.

6. All cable runs are not exposed to heat from the engine.

7. Suitable outlet for engine exhaust to reduce annoyance from fumes to a minimum.





The Switchboard Voltmeter Connections

THE CONNECTIONS OF THE BATTERY AND DYNAMO TO THE SWITCHBOARD. To avoid confusion in reading the switchboard connections the switchboard voltmeter connections are made on a separate diagram.

8. Convenience in handling the plant when erecting, and dismantling when overhaul and repairs are necessary.

A space should be reserved for a working bench where plenty of light is available and room in front of it for working at the bench.

The floor space of that portion of the building which will house the battery is allotted for the accumulator stands. The stands should be situated and spaced so that individual accumulators are easy of access for "topping up" and testing, also for removal, when required, without interfering with operation of adjacent cells.

Preparing the Foundation and Fixing Bolt Holes for Engine and Dynamo Bedplate.

Make a template of the bedplate and from it mark on the floor the outline of the bed at the portion which has been fixed. Break up this portion of the floor so that the concrete mixture which will form the foundation will make a solid union with the floor. The broken portion of the floor is boxed round to a height which is determined by the depth of the foundation. This may be calculated from the practice that the weight of the foundation should be approximately equal to the weight of the plant on it, and that one cubic foot of concrete mixture is from 120 to 150 lbs. depending upon the mixture. The spaces which the bedplate fixing bolts will occupy in the foundation are now boxed round to the height the foundation will be above the floor. The boxed-in space is filled in with the concrete mixture and the surface made level.

Fixing the Bedplate to the Foundation.

When the concrete is hard, remove the boxing from the bolt holes and place the fixing bolts in their positions. Fill in these holes to the level of the foundation with liquid cement and, while this cement is still liquid, lower the bedplate into position, guiding the ends of the fixing bolts through the holes in the bedplate. A spirit level is placed on the machined upper faces of the bedplate, and steel wedges driven between the foundation and the lower edge of the bedplate at required places until it is level. The washers and nuts are screwed on the bolts and tightened up.

A skimming of liquid cement is poured round the inner edges of the boxing so as to cover the exposed lower edges of the bedplate, and when it is hard, the boxing round the sides of the foundation is removed.

When a belt drive is used the dynamo pulley will be lined up to the engine pulley before the dynamo bed is fixed in position on its foundation.

Fixing the Switchboard.

The iron frame of the switchboard is held in position alongside the partition wall, allowing sufficient space between the back of the switchboard and the wall for a gangway to facilitate the making and inspection of the connections to the switchboard.

The position of the feet of the frame is marked on the floor, also the distance between the frame and the wall measured for making the iron stays which will hold the frame to the wall.

The holes for the feet fixing bolts are drilled and the fixing bolts cemented in to the floor.

Two iron stays are made and drilled for fixing to the wall and the frame.

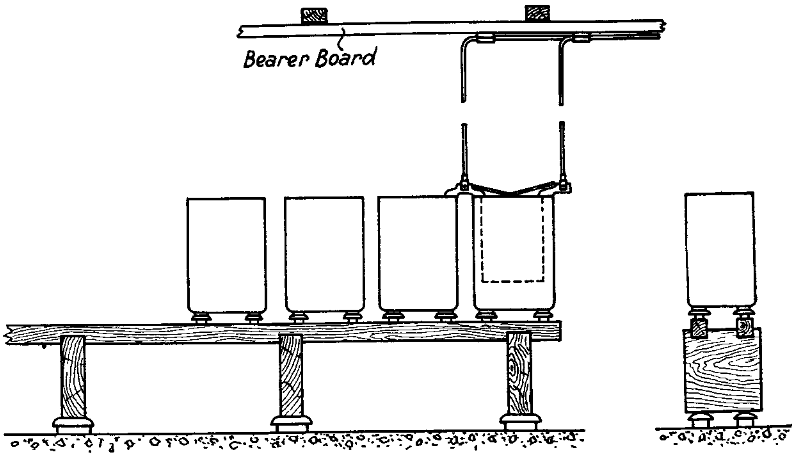
The wall is marked off and drilled for the bolts which will secure the stays to the wall; the bolts are fixed into position and cemented in.

The iron frame is drilled in two places for the bolts which secure it to the stays.

Before the switchboard is fixed in position holes are drilled through the partition wall for the passage of the cables from the battery to their connections on the switchboard, also any cleats required on the wall for the cables from the dynamo are secured in position. The switchboard may then be secured in position.

The Cable Run from the Dynamo to the Switchboard.

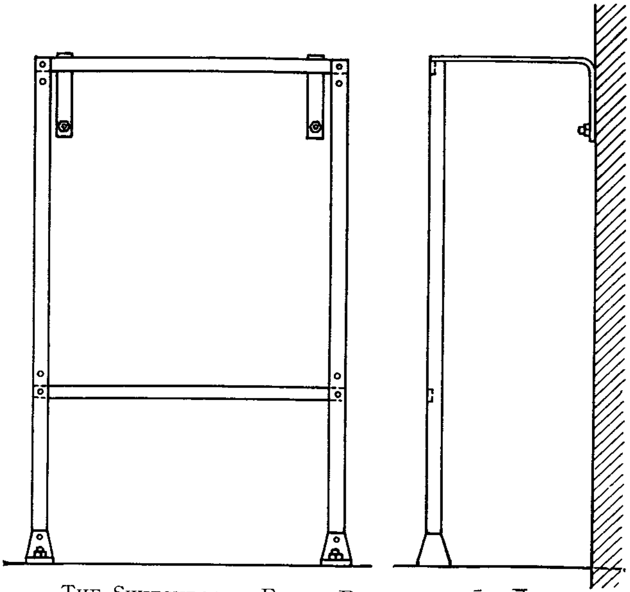
A trench wide and deep enough to accommodate a length of conduit is cut in the floor between the dynamo and the partition wall. The conduit is placed in the trench, and inspection elbows are fitted on the ends of the conduit at the outlet to the dynamo and the partition wall. A fish wire is left in the conduit to allow of the cables being drawn through it. The conduit is cemented over. If this method is not desired, the cables from the dynamo may be taken from the terminal box in a vertical direction to the roof of the building and across the roof to drop down the partition wall to the back of the switchboard. The cables are secured at suitable intervals with cleats.



THE ACCUMULATOR STANDS.
The accumulators are placed on single tier stands and insulated from them with glass insulators. The cable connections to the switchboard are taken vertically up to the roof, and along the roof to the partition wall which is drilled for admission of the cables to the back of the switchboard.

The Accumulator Stands.

These should be made of pitch pine and



THE SWITCHBOARD FRAME BOLTED TO THE FLOOR.
The frame is bolted to the floor and stayed to the wall with ragged bolts. A gangway of sufficient width between the wall and the switchboard is allowed to facilitate the connections to the board.

given a coat of shellac varnish. They are placed in position on the floor and the accumulators spaced on them. A glass insulator is placed underneath each corner of every accumulator. The terminal lugs are so arranged that the positive lug of one accumulator is adjacent to the negative lug of the next.

Connecting the Accumulators.

All terminal lugs are carefully cleaned and lead covered nuts and bolts used to make the connections. Each connection should be thinly coated with vaseline.

Cable connections are made with lead covered lugs and the cables given a coat of anti-sulphuric enamel. The cables are run along a bearer board which is run horizontally overhead, this board is fixed to the lower edges of the roof struts.

The cables are held in position with porcelain cleats, the heads of the screws being given a coat of anti-sulphuric enamel.

Making the Connection to the Switchboard.

Particular care must be taken to connect the cables to the correct terminals on the switchboard so that the proper polarity is obtained. The connections should be made with sweating sockets and kept neatly packed behind the board. It is a good thing to label the cables for future identification.

Test the working of the switches and the contacts made by the switch blades. A little clock oil should be placed on all spindles and bearings of moving parts of the battery cut-out.

The Pipe Connections to the Engine.

These are made between the water cooling tank and the jacket of the engine, flanged joints made with suitable packing, and screwed joints with white lead to ensure watertight connection. The exhaust pipe should be covered with heat insulating material. The petrol tank is fixed in a suitable position where it is accessible and safe from fire.

Preparing to Put the Plant into Commission.

Fill the dynamo bearings with lubricating oil and examine the lubrication system of the engine and the water circulating system. Leave all switches open on the switchboard and turn the engine round. Having ascertained all is clear, start the engine and run it at a low speed for a few minutes; feel the various bearings and note that the oil rings are working. Increase the speed of the engine gradually until normal speed is obtained. Test the dynamo for correct polarity at the switchboard with a moving coil voltmeter.

The engine should be given a no load run for two hours.

Fill up each accumulator with electrolyte solution to the correct level,

Close the dynamo switch and run the engine; carefully increase the speed and note the action of the battery cut-out. When this completes the battery charging circuit, adjust the engine speed until the correct charging rate is obtained.

REWINDING A SMALL LAP WOUND MOTOR

By J. ROWCROFT

THE particular type of motor to which this article refers is the universal type, from $\frac{1}{40}$ to $\frac{1}{20}$ h.p.

Try the Motor Before Dismantling.

Before dismantling one should try the motor by connecting it across the mains in series with a lamp or other high resistance to avoid blowing the fuses in the event of the motor being burnt out. Even if the windings are in very poor condition, the motor will tend to revolve, and this will give the correct direction of rotation, which should be noted. This preliminary test is necessary in view of the fact that many of these motors have no arrow indicating the direction of rotation ; moreover, the arrow, if present, is sometimes misleading, as the direction of rotation may have been reversed at some time or other.

Dismantling the Motor.

After making a note of this, and the position of the end plates relative to the carcase, the machine may be dismantled.

First Take Out Brushes.

First, unscrew the brush caps and take out the brushes, otherwise the brushes may be broken when withdrawing the armature.

Next the Back End Plate.

Next, remove the screws of the back end plate and tap with a wooden mallet, or a small lead mallet, the armature spindle at the front end. Do not use brute force, as the end plates are rather fragile; so is the armature spindle, and if due care is not taken, a broken end plate or a damaged shaft will result. It is sometimes necessary to use a thin wedge to move the end plate off its register.

Now Withdraw Armature.

The armature, complete with back end plate, is now withdrawn from the carcase. If the machine is of the plain-bearing type, the back end plate can easily be taken off the armature spindle ; if, however, the machine has ball bearings, the end plate is held in one hand whilst the spindle is tapped with a small wooden or lead mallet. If the bearing is very obstinate, heat the end plate over the gas flame for a few minutes, when it will be quite easy to withdraw.

Testing the Armature.

The armature should now be tested. First, test it to earth on 1,000 volts; if O.K., test the armature for voltage drop between the segments. This is done by means of sending a constant direct current through the windings and measuring the voltage drop between each segment. A sketch of this arrangement, which can be made in the shop, is given in Fig. 1. The reading of the voltmeter should be the same across each consecutive pair of commutator segments.

Open Circuited.

If the winding is open circuited at some point the needle will go right over to its stop.

Short Circuited.

If there is a short circuited coil the meter reading will be much less than normal.

What to Do Before Removing Old Winding.

Assuming the winding to be faulty and requiring rewinding, proceed as follows: Count the number of core slots and commutator segments. Note the position of the commutator connections relative to the core, the number of coils per slot, turns per coil, gauge of wire, and coil span. All these details should be noted on a record card or book kept specially for the purpose. Also the maker's name, the voltage of the machine, the speed, the output, the direction of rotation as already determined, and, if the machine is A.C., the frequency should be noted.

How to Remove the Old Winding.

The old winding can now be removed, care being taken not to damage the core slots or spread the laminations. The best way is to saw through the winding at each end of the core and then push the wires out of the slots from each end; the end portions of the winding are quite easy to remove.

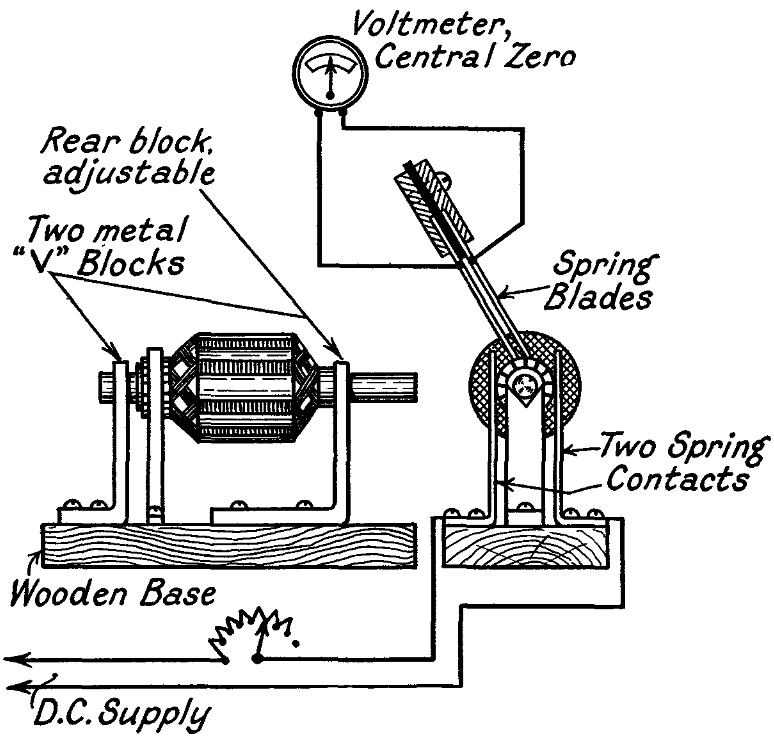


Fig. 1.—The Volts Drop Test.
Arrangement for sending a constant direct current through the windings and measuring the voltage drop between each segment. Any variations in the readings indicate a defect in the armature winding.

Next Remove the Commutator.

Next remove the commutator. A small press is necessary for this as if the correct method is not adopted the commutator will be damaged beyond repair, and in any case no winding shop is complete without a small press.

Test the Commutator.

Thoroughly test the commutator by applying 1,000 volts to earth and 250 volts between the segments. If the commutator breaks down it is best to send the commutator to the commutator manufacturers for a new one, which can be had per return at small cost.

It is advisable to replace commutators made of bakelite, as these will crack or track to earth when the machine has been in service a short time.

Now Clean the Core Slots.

The core slots must now be cleaned ready for the insulation. Scrape out all the old insulation; if this is very difficult to manage, burn the insulation out by means of putting the core over the gas flame, but don't let the core get too hot.

Insulating Core Slots and Spindle.

The insulating of the core slots and spindle can now be proceeded with. Wind several layers of Empire tape over the spindle at both ends and close to the core.

Now Cut Strips of Leatheroid and Empire Cloth.

Next measure the length of the core, and cut strips of .006 to .010 thick leatheroid, the width of the strips being $\frac{1}{8}$ to $\frac{1}{4}$ in. longer than the core. Cut also strips of Empire cloth the same width. Place a sample piece of leatheroid in a slot, and adjust the length until the radial

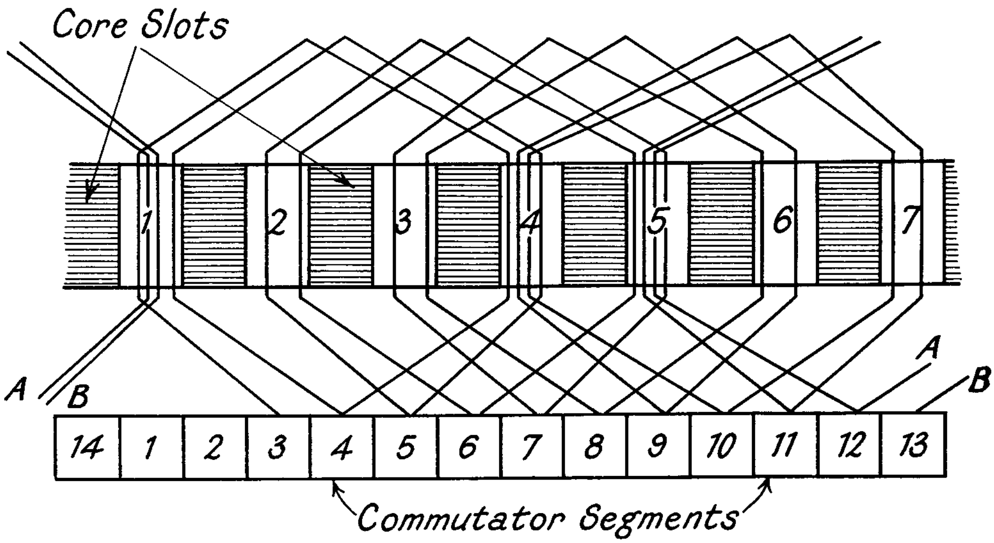


Fig. 2.—The Winding is not Complete until there are 4 Coil-sides in Each Slot as Shown at 1, 4 and 5.

edges project about $\frac{3}{16}$ in. above the core. The leatheroid and Empire cloth can now be cut into lengths as sample, and with the leatheroid on the outside, place one of each in each slot.

Lap Winding.

The armature is now ready for winding. Assuming the winding to be lap, which is by far the most common in these very small machines, by referring to Fig. 2 the winding will be easy to follow. It will be seen that there are as many coils as commutator segments, and that the ends of each coil are connected to adjacent commutator segments. The winding shown has two coils per slot; the coils are shown with only one turn each for the sake of clearness. The wave or series winding is much more complicated and cannot adequately be described in this article.

Best Wire to Use.

The choice of wire must now be made. Enamelled silk covering is the best, but double silk covering can be used if enamelled silk is difficult to obtain. Don't use a cheap brand of wire; the easiest way to make endless trouble is to use inferior wire.

How to Start Winding.

Start the winding by wrapping the free end of the wire round the commutator end of the spindle, and lead the wire into No. 1 slot and back again into the slot determined by the coil span. The coil span is usually one less than half the total number of slots in a two-pole machine. Thus, if the number of slots is 13, the coil span is six, and one coil would have one side in slot No. 1 and the other side in slot No. 7. Wind the correct number of turns, keeping the turns close together and the wire free from kinks.

What to Do When First Coil is Completed.

When one coil is completed, and assuming two coils per slot, which is very common practice, make a loop in the wire and twist the sides of the loop together, then place a length of insulating tubing over the loop as far as it will go. It is advisable to have two different colours of tubing, or as many different colours as there are coils per slot. Then, without breaking the wire, carry on with the next coil, and when complete push a length of tubing over the loop of a different colour from the first.

When the first two coils are completed

move on to the next slots without breaking the wire, and so on round the armature. Take care to see that the slot insulation is in the right position; the insulation should project $\frac{1}{16}$ in. to $\frac{1}{8}$ in. beyond the laminations.

Where to Place Additional Insulation.

As the winding proceeds, place additional insulation between the top and bottom coils at the points where the coils cross each other, as here there is considerable potential difference, and unless this precaution is taken there is a danger of the winding breaking down at these points.

Keep the Wire Fairly Tight.

Keep the wire fairly tight all the time, and press the ends down frequently, as if the ends bulge to a greater diameter than the core it will be impossible to get the armature into the carcase without damage to the winding.

Finishing Off the Winding.

When the winding is complete the two ends should be twisted together as they go to a common commutator segment. It is advisable to count the number of ends; these should be equal to the number of commutator segments.

Test Ends for Continuity.

Now apply a low voltage to the two ends, say, 6 or 12 volts; this is for continuity, for it is possible to break the wire especially if it is very fine, without knowing, since the insulation will hold the two ends together. If the wire is broken it is necessary to start all over again.

Now Test to Earth.

After testing for continuity test to earth on 1,000 volts. Assuming the tests to be O.K., the winding is ready for connecting to the commutator. Place a washer of presspahn over the commutator end of the shaft and press on the commutator. Next fill up the space between the winding and the commutator with cotton tape to the height of the commutator risers.

All is now ready for connecting up. The angle at which the commutator connections are brought out depends on the brush position relative to the poles and the direction of rotation of the armature.

Correct Angle for Commutator Connections.

If the brushes are in a line with the poles, the commutator connections will be at about 45° to the axis of the armature. If the brushes are at 90° to the poles the commutator connections will be practically in line with the axis of the armature.

An Important Point to Watch.

The point to watch is that the sides of the coils are in the neutral zone of the fields when undergoing commutation, that is, when the segments to which they are connected are bridged by the brushes. It is as well to check this point before connecting up, as the previous winding may not have been quite correct from this standpoint, especially if the direction of rotation has been reversed.

Regarding the angle of connections with reference to direction of rotation, the commutator connections ought to be advanced in the direction of rotation by about 10° to 20°; this is equivalent to moving the brushes backward by an equal amount.

Where to Start Connecting Up.

Start connecting up where the winding started, connecting the loops of wire (after removing the covering of the ends) in the same order as they were made, on to consecutive commutator segments. Use a resin, not spirit, flux and a well tinned iron when soldering and avoid shorting the segments with solder.

Testing after Connecting.

The armature should then be tested to earth, and tested for high and low resistance coils in the manner already described. A low reading may be caused by foreign matter being lodged between the segments. It is best to pick out these surface shorts with a pointed tool.

How to Detect a Reversed Connection.

A reversed connection is indicated by a reversed reading on the V'meter scale. The binding at the front end should now be put on, and the last coil at the back end tied down tight to the shaft. The slot wedges should also be put into position.

Drying Out the Armature.

Next dry out the armature by placing it in the oven for an hour or so at a temperature of about 80°C, and after thoroughly impregnating it with insulating varnish, bake the armature again for several hours at a temperature of 85°C.

Make Sure the Commutator is Dead True.

When the armature is cool turn up the commutator in the lathe, using a Tungsten Vanadium or other high-grade tool, or better still grind the commutator surface with a grinding attachment. It is of vital importance that the commutator is dead true with the bearings, as a commutator out of truth by as little as .0005 in. will cause severe sparking at the brushes.

Now Undercut the Commutator.

The commutator should now be undercut, the micas being sawn away to a depth of .020 to .030 in. The commutator can now be polished and the core cleaned off. This completes the work on the armature.

THE FIELD WINDINGS.

The field windings should be tested for earths on 1,000 volts, and their resistance compared, this is easily done by sending a constant direct current through them and measuring the voltage drop across each coil, the readings should be equal and the needle perfectly steady. If either of these tests prove faulty insulation, take the windings out, after first making a note of the connections.

Winding New Field Coils.

Make a wooden former that will fit the coils, the chucks of the former being removable. The number of turns and gauge should be taken and, using enamelled wire, wind new coils as necessary, taking care to push insulating tubing well on to the make-offs, or leads, and, after removing the coil off the former, bind it with cotton tape tightly, fastening down the end with thread.

Inserting New Field Coils.

Next form the coils to the right shape so that they clear the armature, and after drying varnish and bake as with the armature. The field coils should now be placed in position and the leads reconnected.

How to Check the Connections.

To check the connections short circuit the brush boxes, and send a small direct current through the whole set of coils, they ought to alternatively attract and repel the North Pole of a small magnet.

Reassembling the Motor.

The machine can now be assembled; mount the back-end plate on the armature spindle, and put the armature in the carcase; the front end plate has never been removed, in fact there is often no front end plate in these small machines, the carcase being in the form of a cup.

The armature should go into its correct position without trouble, but if it does not do not use force, find the cause and remedy it. Screw up the back end plate, the armature should spin round by twisting the shaft with finger and thunb, if there is any tightness at all, take apart, remove the cause and reassemble.

Now Test For Four Hours at Full Load.

After replacing the brushes the machine is ready for testing. Run it at full load for four hours, and test it finally to earth on 1,000 volts.

There are very few adjustments one can make if the machine does not run correctly. The brush spring tension can be altered, an increase in tension usually reduces sparking. If the machine runs satisfactorily without sparking and with an efficiency of from 55 to 75 per cent. without excessive heating, and passes a final flash test of 1,000 volts to earth for one minute the machine may be released to the customer.

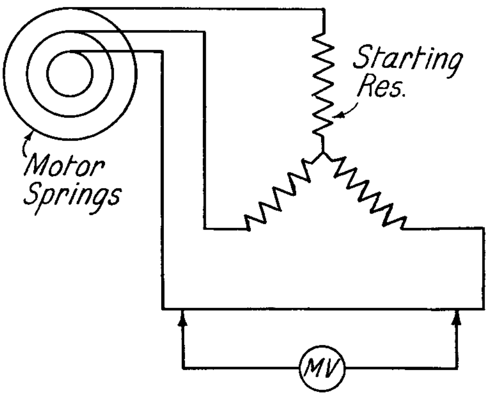
HINTS AND TIPS FOR THE PRACTICAL MAN

Readers are invited to send brief paragraphs for inclusion in this section. All contributions will be paid for at our usual rates

MEASURING SLIP.

Induction Motor.

The amount of slip gives a useful guide as to the amount of torque developed by the motor. When running light the rotor revolves at very nearly the synchronous speed of stator, but as load comes on the difference becomes wider and wider. To measure the slip in a slip ring induction motor, a galvanometer and stopwatch are required. A millivoltmeter will do instead of a galvanometer. The meter is connected across two points in one of the leads to the starting resistance as shown below.



The meter will indicate the passage of a current in the lead, and at the low rotor frequency it is possible to count the swings of the needle as it responds to first a pos. and then a neg. current in the lead. Count the number of periods in a definite time, say 20 secs., a period being a complete throw of the needle from one point back to that point again. Suppose the supply frequency is 50 and that the stator has 6 poles, then the stator field revolves at 1,000 r.p.m.

If r_1 = stator speed and r_2 = rotor speed

$$\text{Slip per cent.} = \frac{r_1 - r_2}{r_1} \times 100. \quad (1)$$

If 40 periods are counted in 20 secs., then rotor frequency $= \frac{40}{20} = 2.$

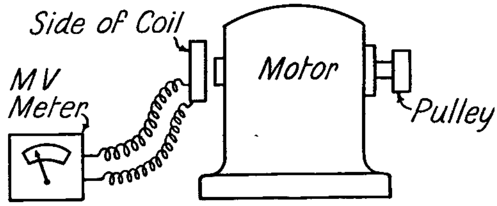
$$\text{Also slip per cent.} = \frac{\text{rotor frequency}}{\text{stator frequency}} \times 100$$

$$= \frac{2}{50} \times 100 = 4 \text{ per cent.}$$

Hence as the field revolves at 1,000 r.p.m. the rotor speed equals = 960 r.p.m.

Squirrel Cage Motor.

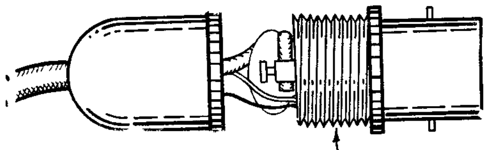
To measure the slip in a squirrel cage motor, a coil of say 6 in. dia. of a great number of turns of fine wire should be constructed, each end of the coil being connected to a millivoltmeter.



The coil is held at one end of the motor in a vertical plane and concentric with the rotor, as illustrated, when the rotor periods may be counted as before.

LOOSE BAYONET-CAP ADAPTORS.

The bayonet-cap adaptors as used on flexible leads often cause trouble through the cap turning without the base when taking it out of the lampholder; a drop of shellac varnish or Seccotine on the threads will cure this trouble.



Apply shellac varnish or Seccotine here.

SAFETY PRECAUTIONS.

It is a good idea when working over an open transformer, to attach spanners and other tools to some fixed object by lengths of tape, in order that they shall not fall into the tank. In addition, no loose articles should be carried in the workmen's overall pockets lest these also should fall into the tank.

HOW HIGH GRADE INSTRUMENTS ARE CALIBRATED

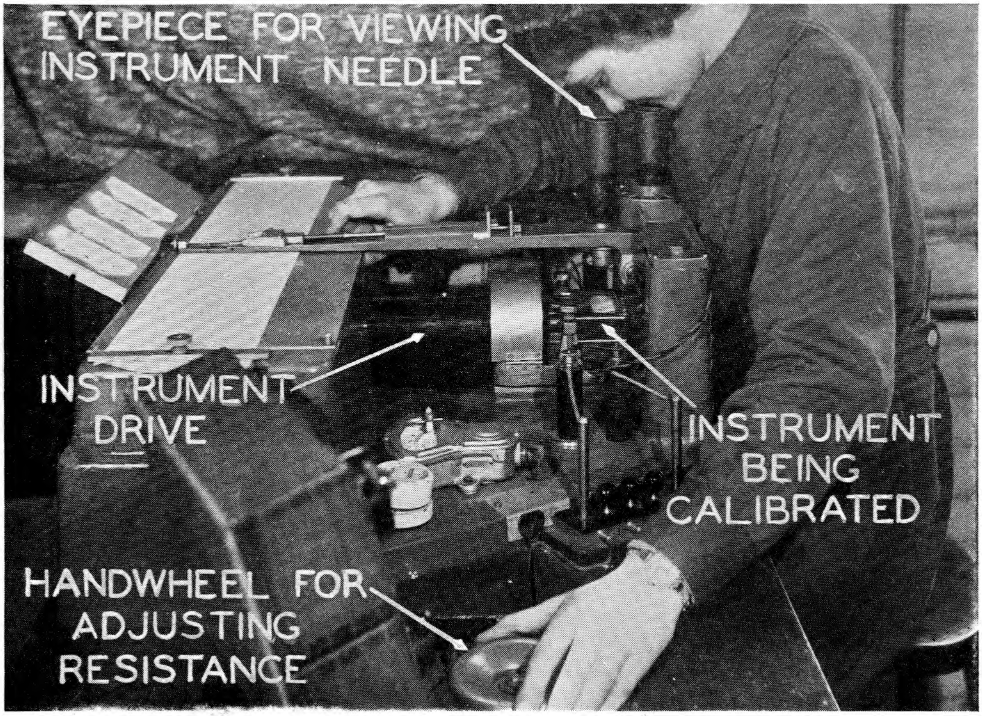


Fig. 1.—CHECKING THE ANGLE OF ARC ON INSTRUMENT AND ON CALIBRATOR CHART.

MOST readers of these pages will have occasion from time to time to use the Megger Insulation Resistance Tester. It was, we believe, the pioneer of its kind in that it was the first instrument which gave a direct reading of resistance, and although many years have elapsed since it was first placed on the market, it still forms an indispensable part of the equipment of every up-to-date insulation engineer.

Because of its robustness and general utility, one is rather apt to form the opinion that readings obtained by this instrument can only be of an approximate nature. That this is not the case is conclusively proved by the method adopted in calibrating the scales of these instruments. The method of calibration is illustrated in the series of photographs shown on this and the following pages.

Why Each Instrument is Calibrated Separately.

Although thousands of Megger and Wee Megger Testing Sets are manufactured every year, the scale of each instrument is individually calibrated. This is because even with the most careful control and standardised methods of manufacture, slight variations in the magnetic qualities of the steel used in the instrument would give rise to small inaccuracies if a standard scale were used.

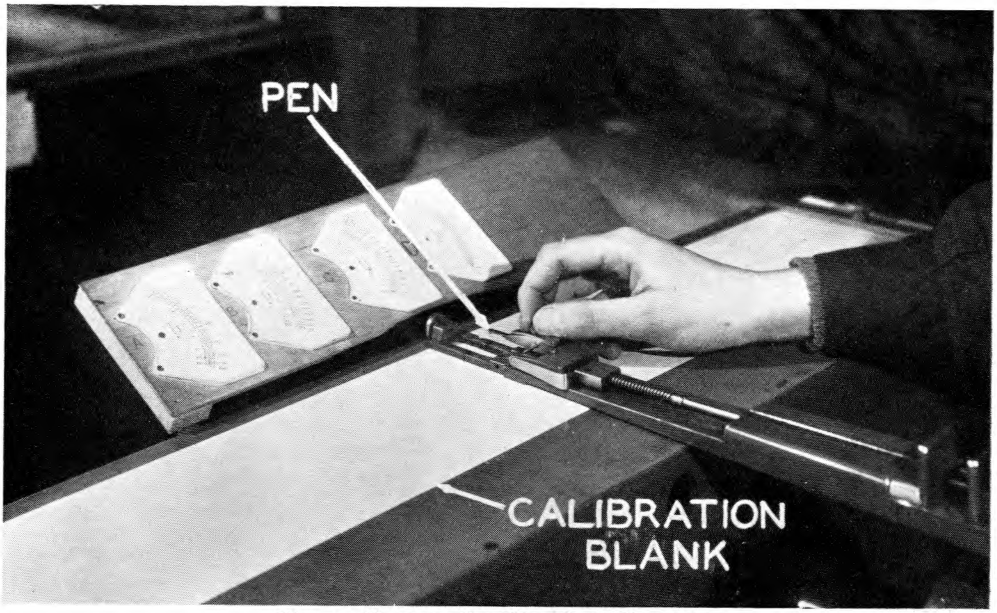


Fig. 2.—Placing Ink Pen Into Position.

The Calibrating Bench.

This is illustrated in Figs. 1 and 2. The instrument to be calibrated is placed on the bench and the generator spindle is coupled to a motor. Leads from the instrument are taken to plugs connected to a resistance box. The latter is provided with a hand wheel which enables the resistance to be adjusted to the exact values required on the scale of the instrument. Immediately above the instrument there is a pivoted lever provided with an eyepiece and carrying at its outer end a small inking pen. A large calibration blank, of five to eight times the linear dimensions of the instrument scale, is fixed on the bench underneath the pen arm.

Fig. 3.—Calibrator Chart Half Finished. Operator Checking Line on Dial of Instrument Through Eyepiece, and Adjusting Known Resistance With Left Hand.

Calibrating the Scale.

The driving motor is now switched on and the resistance is set to the highest scale reading required, e.g., infinity. The needle of the megger immediately takes up the position corresponding to this reading. The operator now moves the large pivoted lever so that the instrument needle comes in the centre of the eyepiece (see Fig. 2). She then makes a short line with the inking pen on the large calibrating blank.

The hand wheel is now used to set the resistance to

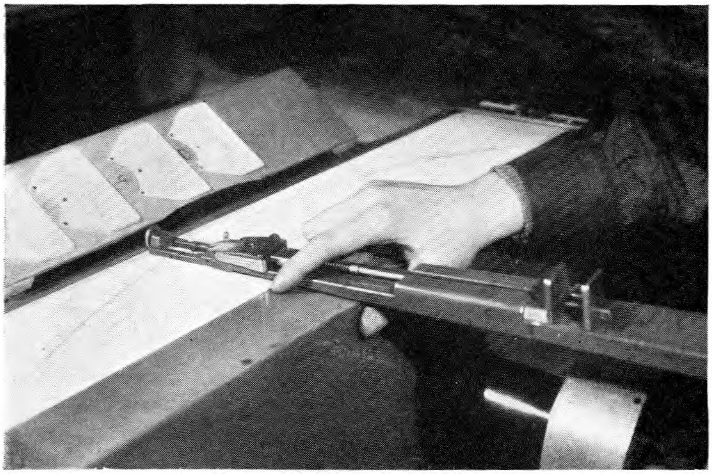


Fig. 4.—Close-up View of Calibrator Chart Half Finished.

by means of a marvellously accurate pantograph mechanism, the markings from the large chart are transferred on to a small scale plate which can be clearly seen on the left of Fig. 8, and in the centre of Fig. 9. The necessary lettering is added on the scale by the pantograph. Metal plates having the lettering recessed in their surface about eight times full size are used to guide the operating point of the pantograph (see Fig. 8). As each letter is traced out a tiny inking pen traces the letter with uncanny precision on to the instrument scale.

the next highest value in megohms required; this depends on the type of instrument and may be as high as 10,000 megohms or as low as 20 megohms for the small tester illustrated. The sighting operation is repeated and a fresh mark made on the calibration blank.

This process is repeated until we have a large calibration chart which corresponds exactly to the actual performance of the instrument which is being calibrated.

The instrument and calibration chart are now taken to another bench where,

We are indebted to Messrs. Evershed and Vignoles, Ltd., for giving our photographer facilities to take the interesting series of works photographs which illustrate this article.

Historical Note.

It is now more than 40 years since Mr. Evershed introduced his portable ohmmeter and hand generator for the

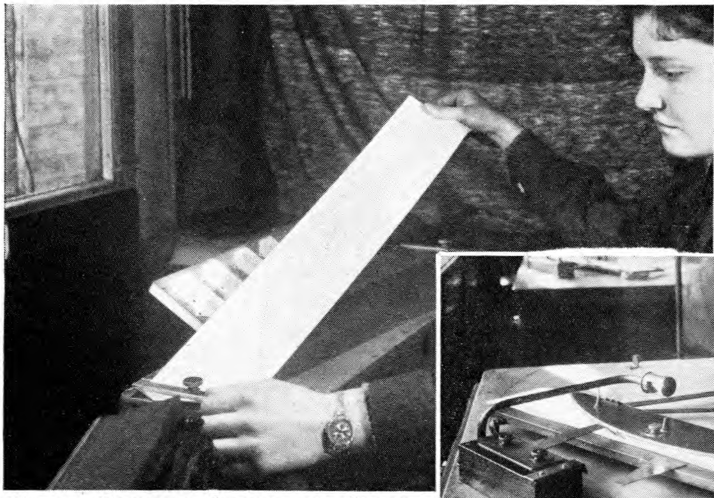


Fig. 5.—Finished Calibrated Chart Which is Marked with Instrument No., Date and Temperature, Operator's Signature.

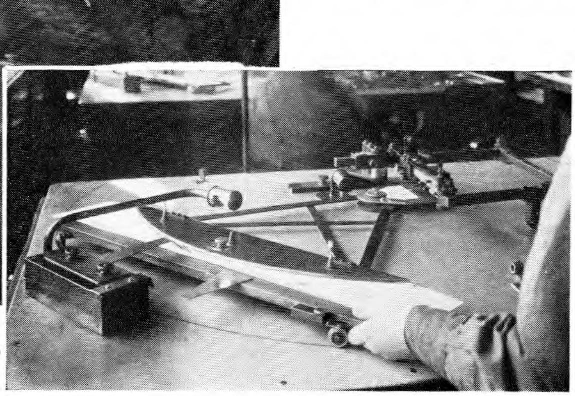


Fig. 6 (Below).—Turning Calibrated Chart on Pantograph to Reproduce Marking on Scale of Instrument.

rapid and convenient testing of insulation resistance. The first big improvement was made in 1903.

The testing set was an immediate success due to the recognition by electrical engineers all over the world of the value of measuring and recording the insulation resistance of apparatus.

With the experience gained, and as the result of research during the forty years which have elapsed since the set was introduced, the instrument has been improved and modified to give greater facilities to the user.

The first major improvements were the combination of the ohmmeter and generator in one case in conjunction with the compensation of the ohmmeter for stray magnetic fields, the fitting of a special guard system to eliminate errors due to surface leakage when very high resistances were under test, and the careful designing of the generator to give a steady voltage when the handle was turned above the slipping speed of the constant speed clutch.

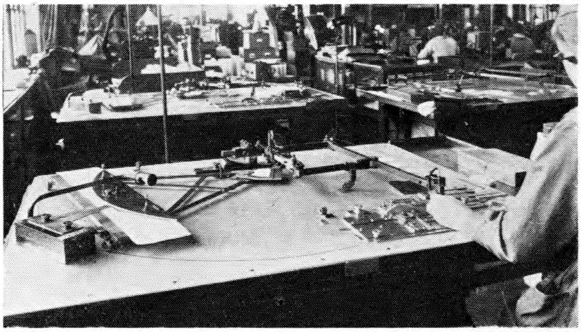


Fig. 7.—Pantograph Machine for Reducing Enlarged Calibrator Chart Down to Scale of Instrument.

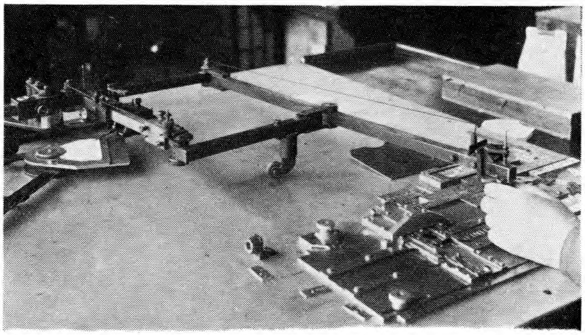


Fig. 8.—Close-up of Operator Running Pantograph Over Die-sunk Lettering, and Reproduced to Size on Scale.

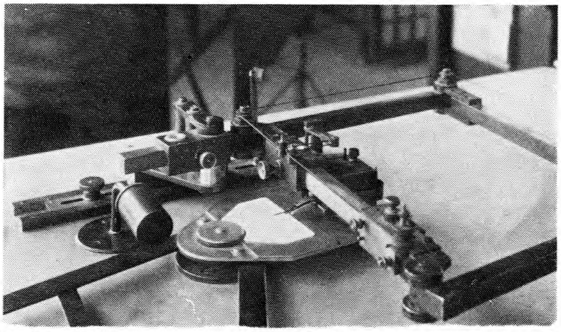


Fig. 9.—Close-up of Pen and Scale of Instrument on Pantograph.

Why Each Instrument Scale is Specially Calibrated.

Although the above-mentioned improvements provide reasonable uniformity of performance, it can be appreciated that slight variations in the insulating properties of the materials used and in the magnetic qualities of the steel are largely beyond the control of the manufacturer. Any slight variations of this kind are taken care of automatically by means of the calibration process described in the preceding pages.

Range of Instruments.

The ranges now available extend from a set with a testing pressure of 2,500 volts reading up to 10,000 megohms, to a set working at a pressure of 100 volts and reading from 0 to 10 megohms.

QUESTIONS AND ANSWERS BY PRACTICAL MEN

Readers are invited to send problems of practical interest. Letters should be addressed to " The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2. Envelopes to be marked " Problem " in the top left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTH'S NEW QUESTIONS

Details for a Small Induction Motor.

Can you please give me building details for a very small single-phase self-starting induction motor to work at 250 volts 40 cycles.

It will only have an extremely small load with which to deal; the main point is for it to keep a steady speed.

F. N. MILBURN (Craghead).

Equipment for a Telephone Line.

What size of wire should be used for a telephone line 220 miles long connecting 2 magneto-type P.B. X's with 2,500-ohm drops and five-bar generators? Would loading coils, telephone repeaters or other special apparatus be necessary, and if so, of what type? The lines are to be erected on existing wooden crossarms, on glass insulators spaced 12 in. apart, and it is desired to use MacIntyre joints or some form of connector not requiring soldering.

This line would run through tropical wooded country with a heavy rainfall.

L. H. (Puerto Mexico Ver).

Meter Rent.

Could you inform me as to whether a Supply Company has any right to charge meter rent to their consumers? In one case I know of they do not charge, and in another case they do.

B. A. BUTS (Plaistow).

Flashing Electric Sign Switch.

I want to fix a crawling type of flasher round a streamer board. Can you tell me how to construct a drum and contact fingers suitable for four to six circuits totalling 60 to 120 lamps?

WILLIAM MARTIN (Notts).

An Address Wanted.

I should be grateful if you could supply me with the address of the English agents for Helios violet-ray instruments, or any firm who repair these instruments.

T. GLEDSTONE (Morecambe).

A Pilot Lamp Problem.

I have under my care a number of electric cookers. Attached to the control board is a pilot light; the lamps used are Philips' 15-watt neon lamps.

I have had several calls to these cookers with the report that the consumer could not get any part of the cooker to work but the light was on.

Upon investigation I found one fuse in the consumer's main switch had blown. Sometimes it was the positive fuse, sometimes it was negative, and it occurs on both A.C. and D.C.

Could you please offer any suggestions as to why the lamp should light with the fuse blown? It does not give full light, but appears to be in series with something.

W. SMITH (Ashton).

A Small Washing Machine.

I am continually being asked for accessories of certain makes, and sometimes it is rather difficult to obtain the addresses of the lesser-known firms. At present I am trying to locate the makers of a small type washing machine, the retail price of which is somewhere in the region of £13 or £14.

Can you please help me?

E. HODKINSON (Wheelton).

The Fescol Process.

I should be much obliged if you could give any information concerning the electro deposition of nickel and chromium by the Fescol Process for the repair of worn machine parts.

D. F. M. (Lockerbie).

REPLIES TO PREVIOUS LETTERS

Two Talking Picture Apparatus Queries.

Would it be possible to run a fan in a cinema operating box? The fan has got brushes for A.C. or D.C. Do you think the talking would pick it up if it was well earthed. We have two Kalee No. 7 projectors, and there is a lot of vibration on the talking of the one projector. We have packed the sound head and the motor on rubber and tightened all the nuts and bolts, but it has not stopped all the vibration. Could you please advise me what to do?

W. BROWN (Upton-on-Severn).

A fan or any similar motor may be run in the operating box without any risk of introducing noise into the talkie apparatus, provided it is not placed immediately adjacent to the soundhead or amplifier.

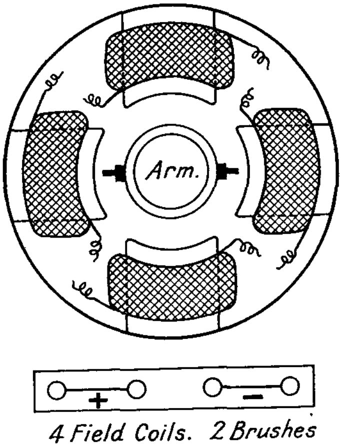
It is impossible to advise definitely *re* vibration trouble, as there are so many possible causes, but would suggest trying the effect of mounting the P.E. cell itself on rubber. It would also be advisable to check the soundhead sprockets and soundgate for excessive wear.

A. T. S.

Reconnecting a 50-volt Dynamo.

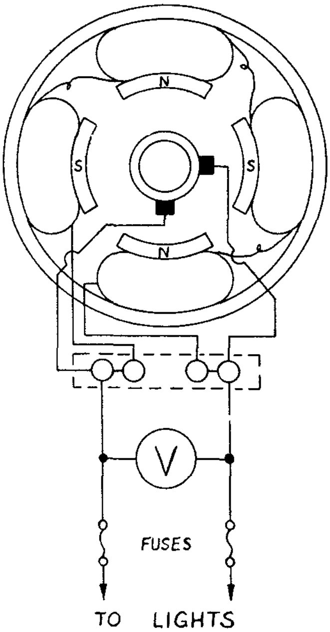
I have a small 50-volt dynamo. The only name on it is " Pullman " and it is not wired up. I enclose a rough sketch of dynamo. I should be very pleased if you could inform me how to wire same; also, is there any particular way for the field coils to be put on? I want to work about five lights direct.

D. J. HILLIAR (Marlborough)



SKETCH OF DYNAMO REFERRED TO BY MR. HILLIAR.

When a 4-pole dynamo has only two brushes, they must be at right-angles. The querist's sketch shows the two brushes opposite to one another. It is probable that the brushes have been moved when the machine was dismantled. The machine will not work like this, because the opposite brushes will have the same polarity, that is to say, they will be both positive or both negative.



METHOD OF CONNECTING UP.

The field coils are connected in series, as shown in the diagram, so that the opposite poles of the field are of the same polarity. After connecting them up, their relative polarity can be tested by means of a battery and a pocket compass. Connect the battery (12 volts is sufficient) to the dynamo terminals with the armature removed. Now bring the compass needle near to each pole, in turn, and so determine whether the polarity is correct. Do not approach the compass needle too quickly to the poles, or the polarity of the needle itself may be reversed.

In order to run lights directly off the dynamo, without a storage battery, the engine must be fitted with an efficient governor, to keep the speed of the machine constant. A voltmeter is also necessary. The output voltage of the dynamo is regulated by adjusting the speed of the engine, in place of the usual shunt rheostat.

If the dynamo fails to generate when it is first tried, reverse the direction of rotation and make sure by means of the pocket compass, that the residual magnetism of the field poles has not been destroyed by driving in the wrong direction. If it is not convenient to reverse the direction of rotation, change over the two field connections to the terminal block.

Lightning Protection for Transmission Lines (see page 483)

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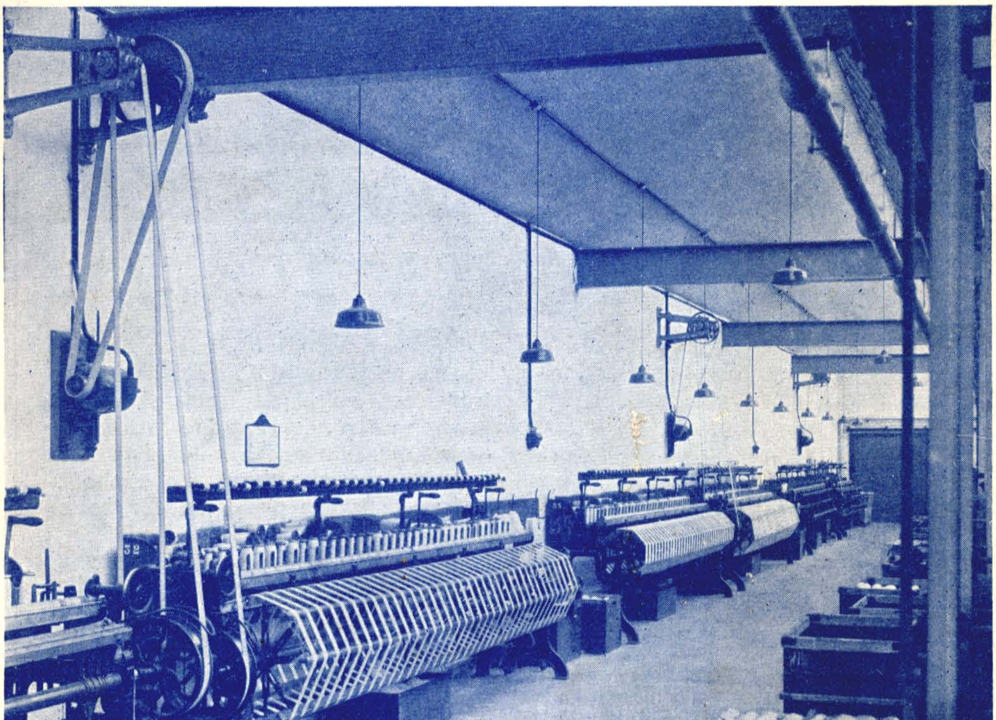

INSTALLING INDUCTION MOTORS

by ROBERT RAWLINSON, A.M.I.E.E.

See article on page 467.

1/-

GEORGE NEWNES LTD.

JULY, 1934 PRACTICAL ELECTRICAL ENGINEER No. 23

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

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Improvement in Gas-filled Lamps.

A new type of electric lamp is to be introduced very shortly. It is known as the Coiled-Coil Filament Lamp, and is the result of research work on the part of lamp companies associated with E.L.M.A.

All our readers are familiar with the construction of the ordinary gas-filled lamp in which a spiral of very fine wire is used as the filament. In the new lamp the spiral filament is coiled upon itself and it has been found that this arrangement enables greater efficiency to be obtained, more especially in the smaller sizes of lamps. Given the principle of spiralising the filament in order to minimise the loss of heat by conduction and convection, the adoption of the coiled-coil principle is a fairly obvious step. It can be appreciated, however, that considerable difficulties of manufacture have had to be overcome before such a system could be brought into every-day use, and the new lamp represents a triumph of research applied to a manufacturing problem.

It is easy to see that the adoption of this new type of lamp may have far-reaching effects in all branches of the electric lamp industry.

Modern Lighting Systems for Works and Factories.

When the Osira high-pressure electric discharge mercury lamp was discovered by the G.E.C. Research Laboratories and introduced as a commercial article for street lighting just over a year ago (see our issue of June, 1933), enthusiasts were anxious immediately to take advantage of this high-efficiency medium for all kinds of purposes without considering its suitability.

The G.E.C. was reluctant to encourage such enthusiasts to use these lamps in circumstances where disappointment might ensue, and, therefore, set itself immediately to explore all possibilities with a view to determining under what circumstances it was possible, honestly, to recommend Osira Lighting.

Three principal factors had to be considered. Firstly, the rating of the lamp from the lighting point of view made it too bright for ordinary industrial work except in cases where ample suspension height was available.

The second factor was the question of flicker. This is not pronounced when adjacent fittings are connected to different phases of the mains supply, but under usual conditions it makes rapidly moving machinery appear to slow up, thereby making the lamp unsuitable for use where such machinery is in operation.

The third consideration was the colour of the light, but in this respect there was nothing to indicate that, except in circumstances where special colour detection was required, the light from the Osira lamp would be any less suitable than that from ordinary incandescent lamps.

The G.E.C. is now definitely in a position to recommend Osira lamps for industrial lighting, under conditions premised above, namely, that there is ample height, no fast-moving machinery, and strict colour discrimination is not involved in any processes.

Works managers and engineers interested in the problem of relighting their premises would be well advised to consider the possibilities of this highly efficient system.

A New Photo-cell Application.

We are informed by the General Electric

Company, Ltd., that they are placing on the market a special device for installing at the entrance to a garage or service station for providing an immediate indication when a car approaches. The well-known combination of a beam of light, Osram photo-electric cell and a suitable amplifier are used. When a car is driven up in front of the establishment it automatically interrupts the light and causes a bell to ring in the office. The apparatus may also be arranged to switch on the lights in the establishment.

Here is an excellent opportunity for more business for the enterprising electrical contractor. The General Electric Company will be pleased to supply details of this device to any readers of the PRACTICAL ELECTRICAL ENGINEER who may be interested.

A Smoke-Detection Equipment.

We have also received from the same source particulars of a photo-cell equipment for smoke detection in factory chimneys. A noteworthy feature is that, unlike some older systems, this does not suffer from "sooting up" of the apparatus by the smoke. The actual installation of this equipment is a simple matter and can be carried out by any average mechanic.

Working to Music.

The use of a powerful gramophone amplifier in a factory to drown the noise of the machinery seems at first sight rather a drastic remedy. However, this novel idea has been introduced successfully in the workshops of Messrs. J. B. Brooks & Co., Ltd., of Birmingham, the well-known manufacturers of cycle saddles, "Antler" leather goods and steel equipments. The music is provided from gramophone records by means of a 10-watt amplifying equipment installed by the British Thomson-Houston Company, Ltd.

The results of this interesting experiment have been very satisfactory and have led to the creation of a still happier atmosphere amongst the employees with a corresponding improvement in production. Other firms will no doubt follow the lead of Messrs. J. B. Brooks & Co., with the same beneficial results.

Electric Mains Rediffusion.

Readers of the Magazine are already familiar with the system of relaying radio by which the programmes are received at a central point and redistributed to subscribers by means of special wires carried from house to house. The British Insulated Cables, Ltd., Prescot, Lancs, working in collaboration with Captain P. P. Eckersley, have now perfected a system which enables this rediffusion to be carried out over the ordinary electric light mains. Several programmes can be sent over the same pair of wires and each subscriber is provided with a loudspeaker and a selector which are incorporated in the same case. By turning the selector switch any one of three programmes can be picked up. A successful demonstration was given on Monday, 28th May, at St. George's Hall, Liverpool, before visitors to the I.M.E.A. Convention, the mains of the Liverpool Corporation being used for the purpose. We wish this new enterprise every success.

Radio Firm Builds Another Five-storey Factory.

We are glad to be able to announce that owing to the phenomenal increase in the demand for Cossor products a further factory is being built by them at Highbury, London. When completed the factory will provide work for over 1,000 workers.

A New Idea for the Electrical Warming of Buildings.

We are informed by Messrs. J. H. Taylor & Co. that they are introducing a new system of electrical warming of buildings which they describe as the "Health-Ray" Heat-Wiring System. Instead of using heating elements working at a fairly high temperature, they propose to use a great length of heating wire running at a temperature very little in excess of the surrounding air, so that the heating effect is equally distributed in all parts of the building.

The exclusive licence for the manufacture and sale of the system in Great Britain has been granted to Messrs. Johnson & Phillips, Ltd., Charlton, London, S.E. 7, who have published a catalogue, No. HR-1, fully describing the system and the methods of installation. The patent rights for the British Dominions, Colonies and foreign countries are available to manufacturers and others desirous of acquiring such rights.

The system can be installed by all competent electrical installation contractors.

A Time-saving Screwdriver.

We have received from the Burgess Products Company, Bush House, London, W.C. 2, an efficient screwdriver fitted with a flashlamp bulb in the handle. This can be switched on to illuminate the heads of screws in dark and inaccessible places.

INSTALLING INDUCTION MOTORS

By ROBERT RAWLINSON, A.M.I.E.E.

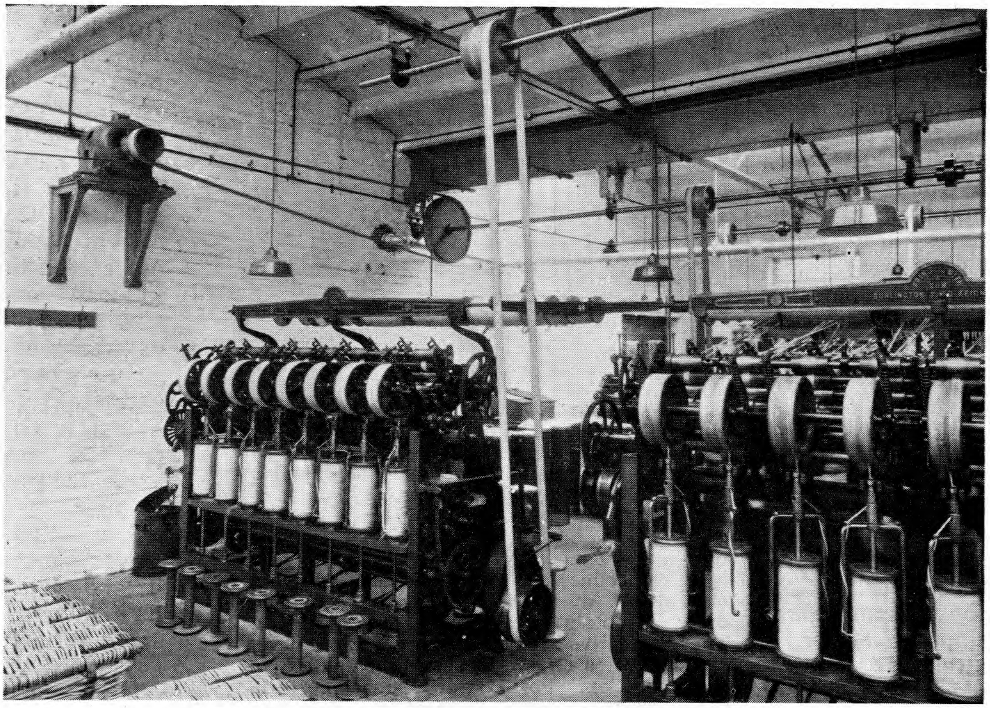


Fig. 1.—INDUCTION MOTOR DRIVE IN A TEXTILE MILL.
The motor can be seen mounted upon wall brackets in the top left-hand corner of the illustration. Note the long centres of the belt drives to the lineshafting, and the use of ball bearings in the lineshaft hangers. Both these points make for steady drives and easy starting, and the ball bearings eliminate the oil leakage which often takes place with ordinary sleeve bearings, and which frequently stains the product. The induction motor is fitted with a double-width pulley and drives two lines of shafting, one on either side. This arrangement is worth noting. (*Metropolitan-Vickers.*)

WHEN a new induction motor is received from the makers it must first be carefully unpacked and examined to see if any parts are broken or missing, and to check that the goods sent agree with the items shown on the advice note. Special attention should be paid to such details as cable fittings, foundation bolts, slide-rail bolts and pulleys or couplings, gears and pinions, etc., while careful search should be made for the diagram of connections and instruction book or card. These latter are often supplied in an envelope tied to the motor eyebolt, but some makers cast or paste the diagram inside the terminal box lid, while very often no instruction book or card is issued. In case of any discrepancies or breakages the suppliers must be communicated with at once, and if no diagram has been supplied the manufacturer should be requested to supply one before installation is started.

The Correct Starter.

We must next make sure that the starter is of the correct type and size. Comparison of motor and starter nameplates will confirm the size question, while the type of starter will depend upon the kind of motor to be controlled. For a squirrel - cage motor, a direct, star-delta, or auto-transformer starter will be in order, while a slip-ring machine will require either a combined stator and rotor starter, a stator circuit-breaker with a rotor controller and bank of resistances, or a stator circuit-breaker and a liquid controller for the rotor circuit.

Test Motor Before Installing.

Presuming that the starter is found to be correct we may proceed, and the next operation should be to test the motor. Before the manufacturer ships a motor it always has a running test, so that we need not concern ourselves with this, being content to test the insulation only since after being tested and passed at the makers' works the motor may have been stored for a considerable time, allowing the insulation to absorb moisture from the atmosphere. In order to be sure that the motor is fit for connecting on the supply circuit it must be "meggered," and the insulation resistance as measured by a 500-volt instrument should not be less than :—

$$\frac{\text{Nameplate Voltage}}{1{,}000 + \text{Horsepower}}$$

If the Insulation Resistance is Low.

If the test discloses a figure lower than given by the above formula the motor must be dried out. To effect this it must either :—

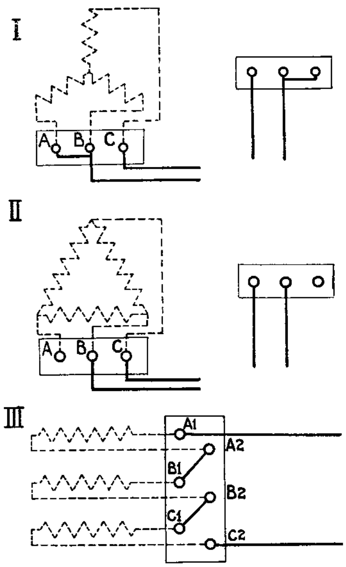


Fig. 2.—Connections for Drying-out.
When the windings are star connected, the arrangement shown in Diagram I should be employed, and the current should be adjusted to the full load amps. as stamped on the nameplate. For delta connections, II applies, the current being limited to 60 per cent. of the nameplate value, however. In both of these cases the connections should be changed every eight hours during the drying-out period in order to obtain even heating on all phases. The alternative connections are given above, and the three circuits should be employed in strict rotation. For star-delta machines use the connections given in III and keep the current at 60 per cent. nameplate value, or less. There is no need for alteration of connections in III.

1. Be placed in an oven or other warm place the temperature of which does not exceed 90° C. (194° F.).
2. Have a current from a low voltage source (preferably A.C.) passed through its windings. This current should not exceed the full-load current stamped on the motor nameplate, and the rotor should be clamped and prevented from revolving.
3. Have heaters placed around it (and within it if large) so as to raise its temperature; this method is most applicable to T.E. machines.

The connections for the second method, using D.C. or single-phase A.C., are shown in the figure, and when method three is used care should be taken that the heaters cannot scorch any insulation, and, of course, all ventilation and inspection openings must be covered to minimise loss of heat.

"Megger" Daily During Drying.

The motor must be tested for insulation resistance at daily intervals during drying out, and when it is found that three successive insulation readings have practically the same value the drying out may be considered complete. Providing the final insulation reading values agree with the figure obtained by the method

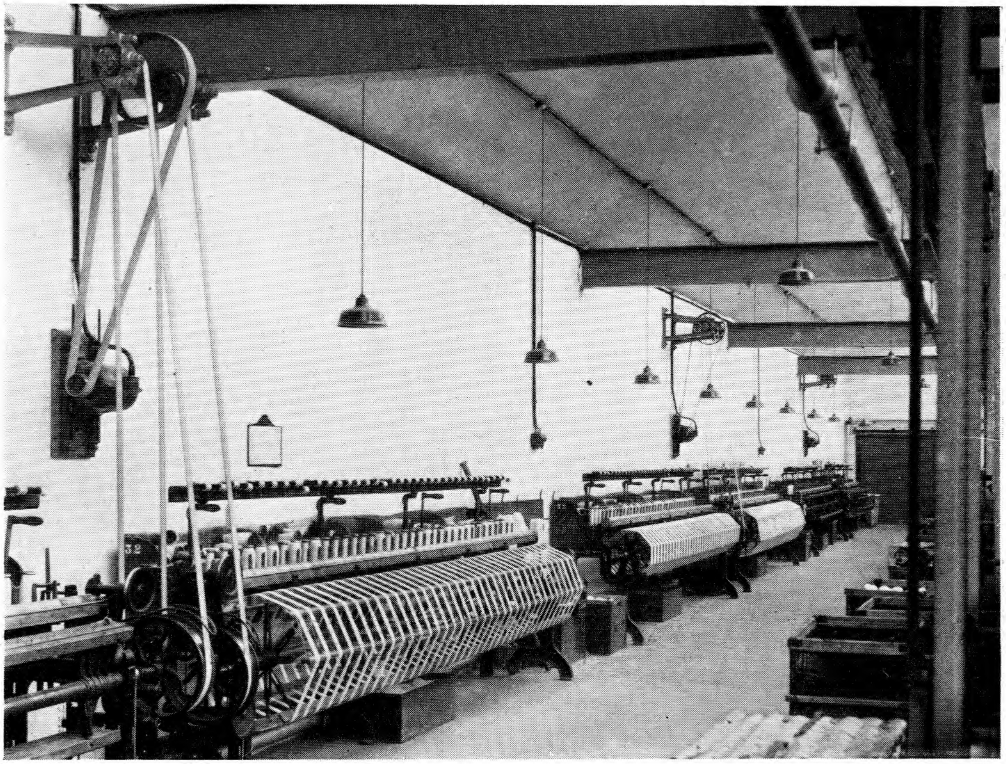


Fig. 3.—WALL-MOUNTED MOTORS.
In this arrangement, each motor drives a pair of machines through a countershaft, and valuable floor space is saved by mounting the motors in this manner. Note how the countershaft is arranged, and observe the neat layout of the wiring with the starter between each group of driven machines. On the motor at the left-hand side of this illustration the flexible tubing to allow movement on the sliderails can be seen, and just above the belt to the countershaft it is possible to see the separate earth wire. (*Metropolitan-Vickers.*)

mentioned above the motor may be installed without fear ; if the readings are below this, however, the manufacturer should be communicated with.

Notes on Drying Out.

During drying out care must be taken that the insulation is not damaged by excessive temperature, so that for method one we would ensure that the temperature of the oven never rises above 90° C. (194° F.), while when using a low voltage current (method II), we would place a thermometer on the windings and see that its reading never exceeded 70° C. (158° F.). When putting heaters (or carbon lamps) in a motor we must be sure that the heating elements are not too close to insulation. The best way is to put a fair number of small heaters in the motor rather than only one or two large ones. In addition to the heaters a thermometer should be placed inside the enclosing covers and the degree of heating must be regulated so that the thermometer never registers more than the 90° C. mentioned above.

Drying out, once started, must be maintained continuously until the insulation resistance is correct and has remained constant as mentioned before ; if the heating is interrupted and the motor allowed to cool down moisture may be reabsorbed and all the previous drying out rendered worthless. In taking the daily insulation readings one must not be deceived by sudden increases in the

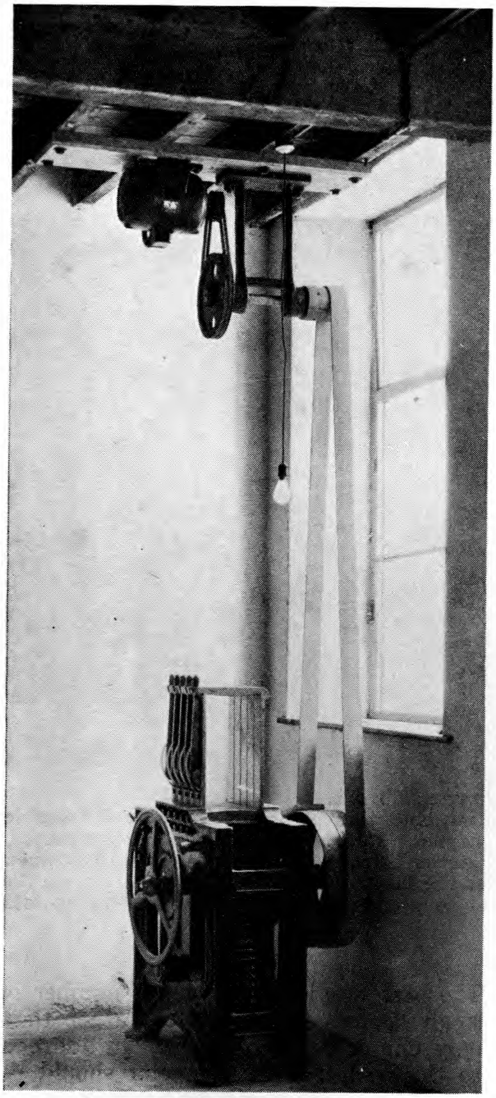


Fig. 4.—A SHAPED BELT DRIVE.

In this small drive the motor supplies power to the countershaft through a shaped belt drive consisting of two belts running in grooved pulleys. By this means a very compact arrangement is obtained and a considerable speed reduction ratio is secured. The inverted mounting of the motor is to be noted, and it should be observed that the driving side of the fast and loose pulley arrangement is on the inside next to the machine bearing. When fast and loose pulleys are used this must always apply. (*Metropolitan-Vickers.*)

insulation value during the early stages of the drying out; these are often caused by the drying out of the surface moisture only. To be quite sure three consecutive readings should have almost the same value.

Installing the Motor.

When we are sure that the motor is in order we may proceed with the installation. The location of the motor will have been fixed before it is delivered, and the motor will be of the type best suited to work under the conditions of the location if the manufacturer has been informed of any adverse features of environment at the time of ordering. It is now possible to supply motors to work under almost any bad condition, and users should always acquaint the maker of the service conditions under which motors are expected to operate.

The ideal location for a motor would be cool, clean and dry, and if any of these conditions are not fulfilled standard machines must be protected. For instance, if dripping water is present it is a good plan to erect a canopy over the motor, while dirty locations may be mitigated to a certain extent by erecting screens around the machine. A hot location is more difficult to deal with, but every effort should be made to prevent hot air from being drawn into the motor. Screens may be erected against radiation from furnaces, for instance, and cool air may be conveyed to the motor through trunkings if necessary.

Protection of the motor will be well repaid by trouble-free service, and the manufacturers should be consulted in doubtful cases. All protecting screens must be arranged so that the ventilation of the motor is not obstructed in any way, and a motor must never, under any circumstances, be completely enclosed by a box or cover; if this is done it is practically certain that the machine will be damaged by anything approaching its full load, even if applied for only a few minutes.

The Foundation.

After injurious service conditions nothing is so harmful to an electric motor as vibration, and the first step in eliminating this source of trouble is to provide good solid foundations. Most industrial motors have concrete foundations, and when

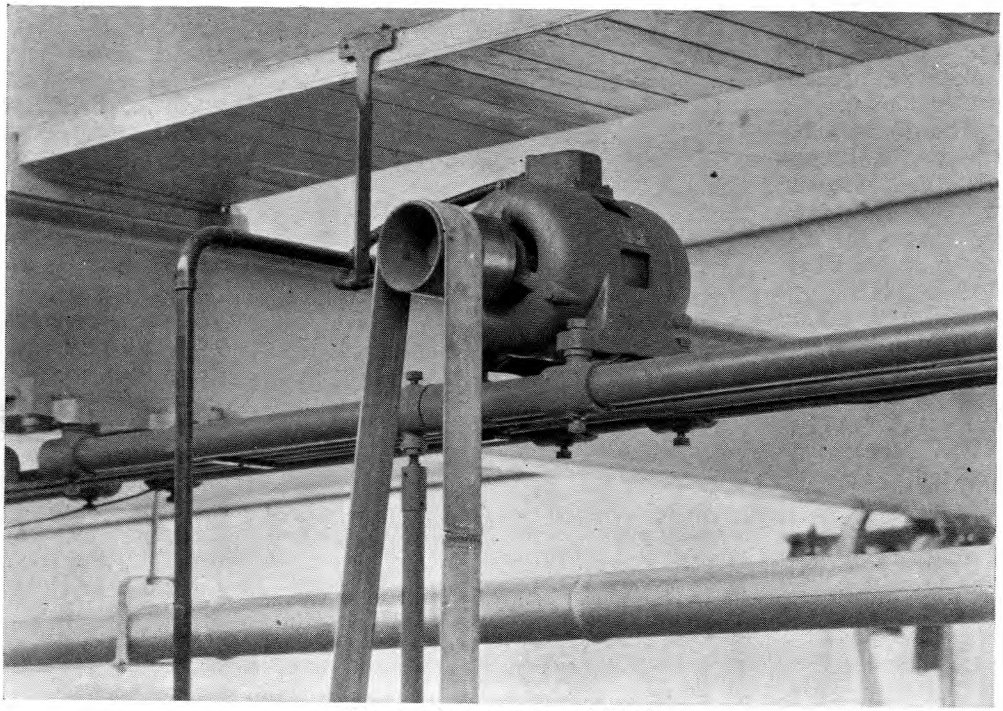


Fig. 5.—Supporting a Motor.

The motor here shown is carried upon tubular cross-members which are, in turn, attached to the building girder work. The simplicity of the motor supports should be noted, and the method of arranging for the motor foundation bolts is worth noting. (*Metropolitan-Vickers.*)

making these care should be taken to sink the concrete block to a good depth, and to use a well-tried cement mixture. Average depths vary from about six inches for ten horsepower to some two feet for 100 h.p. motors, while the mixture usually employed consists of a 1/3/6 blend of cement, sharp sand, and broken stones in the proportions named, by volume. For the grouting in it is usual to employ one part cement and two parts sand mixed thinly enough to pour.

When a motor is mounted on girders or structural steelwork care must be taken that the support is sufficiently strong to bear the motor weight as well as the loads due to the power to be transmitted. Each case must be considered on its merits of course, but stays and bracings may always be added to strengthen the girders at the motor foundations.

The Drive Arrangements.

It has been said that vibration is a cause of many breakdowns and there can be no question that in most cases of bad vibration the trouble can be traced to the drive. Either it is badly aligned or incorrectly adjusted, and in some cases it is definitely unsuitable for the work or machine to be driven. The points to watch are briefly set out below.

Belt Drives.

Most common of industrial drives, the belt is efficient, simple and durable, and although it has its limitations it has a wide sphere of use. In installing a belt drive the driven pulley should never be more than six times the diameter of the motor pulley, unless it is intended to use an idler pulley to increase the belt contact arc on the smaller pulley. This idler or jockey pulley is fitted close to small pulley, on the slack side of the belt, and by its use a drive otherwise impossible is quite good practice. For belt drives the

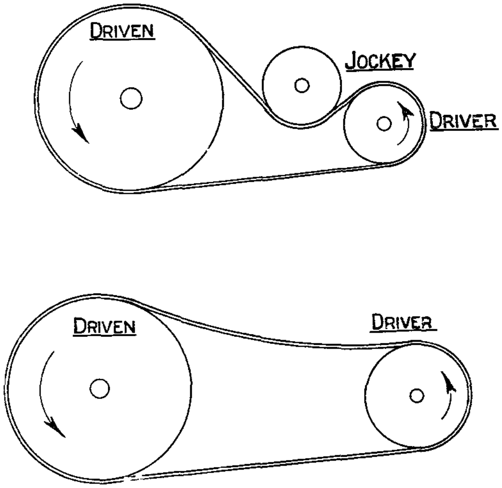


Fig. 6.—BELT DRIVES.
The upper diagram shows the application of a jockey pulley on the slack slide of the belt in order to increase the arc of contact on the small driving pulley; this method is often of service when the centre-distance is small. The lower sketch shows a plain belt drive. Note that the slack side of the belt should always be on the top as shown.

motor should always be mounted upon slide rails unless a jockey pulley is used.

The distance between the centres of the pulleys should not be less than four times the diameter of the larger one, although smaller centres may be used in conjunction with the idler pulley mentioned above. Vertical drives must be avoided at all costs, since they are invariably troublesome. The belt used must be flexible and the joint should be free, smooth, and as flexible as possible, and the belt tension must be adjusted so that the load is transmitted without slip, while on the other hand the belt must not be so tight as to be board hard when stationary. A good belt drive runs without flapping on the slack side, and is quiet and smooth at all loads. The belt speed should not exceed about 4,500 feet per minute, if good belt life and sweetness of running is to be ensured, so that the smallest permissible size of motor pulley will be :—

$$\frac{17200}{RPM} \text{ inches.}$$

This minimum pulley size must be approved by the motor maker, because too small a pulley may result in a broken motor shaft or bearing trouble; and while discussing pulleys it should be noted that those with crowned faces are preferred practice, except in special cases. All pulleys should be well balanced.

When fitting the belt it must not be forced on to the pulleys; the motor must be moved along the slide rails so that the belt can be placed on both pulleys and then the motor can be moved back so as to obtain the belt tension required. The slack side of the belt should be on top, and the correct width of belt can be calculated easily from the tables given in belt makers' catalogues, while the same source will give information as to the jointing methods available. Many belt makers offer jointless or factory jointed belts, and these have much to recommend them on the score of smoothness, flexibility, quietness and increased life. It will be understood, of course, that the pulleys must be at least 1 inch wider than the belt, for drives of anything over 10 h.p.

Rope and Shaped Belt Drives.

The drive may be transmitted by ropes or shaped belts, the first mentioned method often being used for very large powers in the textile trades, while the shaped belt (Texrope, Whittle, etc.) has a very useful sphere in smooth drives at short centres. The sizes of ropes and belts, together with particulars as to pulley diameters and drive data generally, is best obtained from the rope or belt makers who have compiled very complete lists and are always willing to give advice on these highly specialised drives. Let it be said here, however, that drives of these types will often repay consideration in cases where gears seem to be necessary.

Chain Drives.

The chain is a belt which cannot slip, and the modern chain is silent, efficient, compact and durable, besides being of reasonable first cost. Here again the specialist chain drive makers may be consulted with advantage (they have branches almost everywhere), but the following brief notes may be of assistance. Good practice makes the centre distance about 45 chain pitches, although smaller centres can often be employed, while the normal maximum ratio should not exceed about 6.3. This figure can be increased to about a 7 ratio in some cases. Chain covers should be used, and means provided for efficient lubrication of both wheels and chain.

Gears.

Gear drives are positive, very compact, and, properly installed, most efficient and quiet. Badly fitted gears are noisy, dangerous, and troublesome. The motor shaft must be properly proportioned for a gear drive and the motor maker must be consulted regarding the minimum pinion diameter. All gears must be machine cut, and it is good practice to use a rawhide, paper, or special composition pinion on the motor shaft. The ratio of gear drives should not exceed six to one, while the pitch line speed of the gears should be kept down to 1,000 feet per minute or less if possible. Spur gears are the ones most commonly used, if it is proposed to employ any other type the motor maker *must* be consulted, since some types of gear require special provision for thrust or other stresses in the motor bearing. Gear driving is a specialised matter and a gear maker may be consulted with advantage.

Direct Coupled Drives.

This arrangement is commonly employed where the speeds of motor and driven shaft are the same. Either rigid or flexible couplings are permissible, although the latter type will allow for some slight malalignment. There is little to say regarding couplings—the correct size will be put forward by any millwright's supplier on quoting the horsepower and speed, while as regards the type much depends on the users' preferences. The all-metal types are very durable, although some of the other types will give equally excellent service. If the driven shaft has end play, the motor makers should be asked to provide a motor with an equal amount of end play; while at the same time the order for the coupling must state that end play will be present and the amount should be specified. If this end-play question is neglected, trouble with both motor bearings and flexible coupling is liable to ensue.

Aligning the Drive.

True alignment is of the greatest importance; neglect in this respect leads to belts and ropes running off and breaking, to broken chains and gears, and, in the case of direct coupled drives, to broken or bent motor shafts and damaged bearings. In addition to all this trouble, bad alignment sets up noise and vibration, and leads to excessive wear of all parts of both motor and drive.

The method of ensuring correct alignment will be clear from the figures which should be used in conjunction with the following notes. For belt, rope, chain and straight gear drives, the one method of aligning applies equally, and in order to appreciate the full significance of the methods to be used it must be remembered that for two shafts to be aligned correctly they must be exactly parallel to each other. This definition does not apply to direct coupled drives, of course, since in these cases alignment does not exist unless the centre lines of both shafts coincide. When aligning belt or rope pulleys, gears, or chain wheels, it is essential that the centre lines of driven and driving members should lie on the same line. The illustrations will make all these points clear.

Aligning Belts, Ropes, Chains and Gears.

First check that the shafts are parallel by measuring the distance between them, at two points as far apart as possible. For instance, in the case of a motor driving a lineshaft, we would measure the distance from the motor shaft centre line to the lineshaft, first at the free end of the motor, and then at the pulley end, taking care, of course, that the measurements are made at right angles to the motor shaft. Rather than measure from the motor shaft centre it is a good plan to use the bolts in the motor feet in conjunction with cords or wires, as shown in

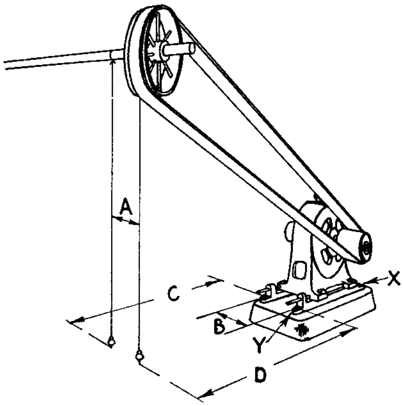


Fig. 7.—Aligning a Belt Drive.

When lining up by means of plumb-lines, as shown, the lines should be fixed to the upper shaft so that the plumb-bobs hang at the same level as the motor foundation bolts, and they should be separated by a distance (A) which equals the dimension between these foundation bolts (B). For true alignment between the shafts the distances C and D must then be equal. Note that the measurement of C or D must be made on a line at right angles to the motor shaft. The easiest way to ensure this is to measure along a straight edge which is laid across the centres of the foundation bolts of each sliderail, i.e., bolts X and Y. In other words, the plumb-bob, bolt X, and bolt Y must lie on a straight line.

the illustration; this method avoids the doubt that the measurements have not been made along a line at right angles to the motor centre line. If the measured distances are equal, the shafts are in line; if the measurements are not the same, the position of the motor must be adjusted until this condition is attained. A steel rule or tape should be employed in making the measurements, since tapes or strings are liable to stretch and give misleading results.

If the shafts are separated by some considerable distance so that the use of direct measurement is prohibited, by difference of the two levels, for instance, it is common practice to employ two plumb lines suspended from the higher shaft, and to mark the positions taken up by the plumb bobs at the level of the lower shaft. The distance between these markings and the centre of the second shaft are measured as before, and equality denotes alignment. If the lineshaft is the highest, the plumb-lines are fixed to it separated by a distance equal to the length of the distance between the motor holding-down bolts; while if the motor is highest, the plumb-lines would be attached to its fixing bolts. The illustrations make this clear.

For Level Shafts.

When the shafts are on the same level, but a considerable distance apart, it is usual to align by means of the pulleys, in conjunction with a lining-up cord or wire. In this method a cord is employed which is stretched between the shafts a few inches from the edges of the pulleys, the cord being so arranged that its points of support are some little distance beyond the *outer* edges of the pulleys, while a careful test is made to ensure that the cord is at right angles to one of the shafts (either one will do). When all is set up correctly, measurements are taken from the cord to the pulleys—in the case of pulleys of equal

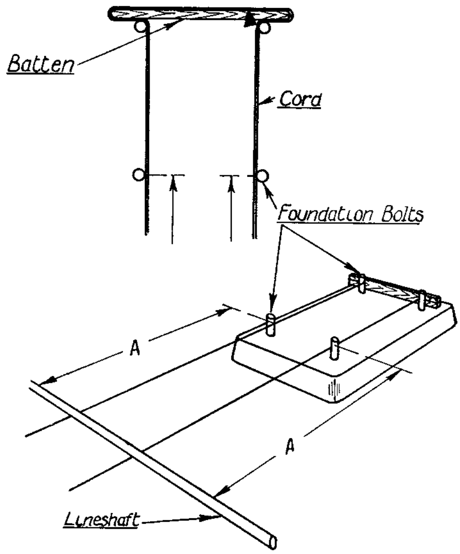


Fig. 8.—Using a Lining-up Cord.

The cord (or wire) is stretched tightly between the motor foundations and supports some distance beyond the lineshaft. The sketch shows a very convenient method of using the cord, and illustrates that contact between the near side foundation bolts and the lining-up cord must be obtained. The two distances A must then be equal for true alignment. This method, and the arrangement shown in Fig. 7, are used in combination when the levels are different.

width the measurements being taken from cord to pulley edges, as shown in the sketch; while, when the driving and driven pulleys are of different width, the dimensions from the pulley centre-line to the cord is employed, instead of measuring to the pulley edge. For exact alignment all four measurements must be equal.

A similar method is used to line up drives the centre distances of which do not exceed about twenty feet or so. In this case, however, a rigid wooden or steel straight-edge is used, and it is so placed that it makes contact with the edges of both driving and driven pulleys at two places on each pulley, i.e., four contacts in all. The position of motor and pulleys is adjusted until these four contacts take place, and the drive is then aligned.

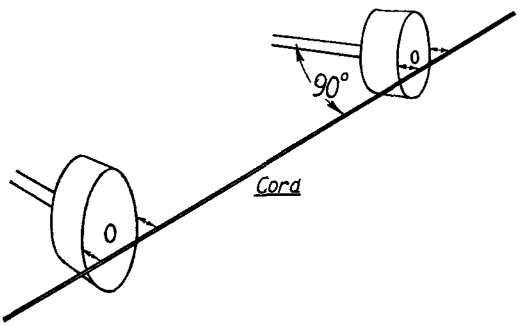


Fig. 9.—Aligning Pulleys. (I.)
The cord is stretched at right angles to one of the shafts and in a position a few inches from the edge of the pulley. The position of the second shaft and of the pulley upon it is then adjusted, so that the four dimensions shown arrowed are equal, and the pulleys are then truly aligned. If the pulleys are of different widths the measurements are made from the cord to the centre of the pulley face in each case.

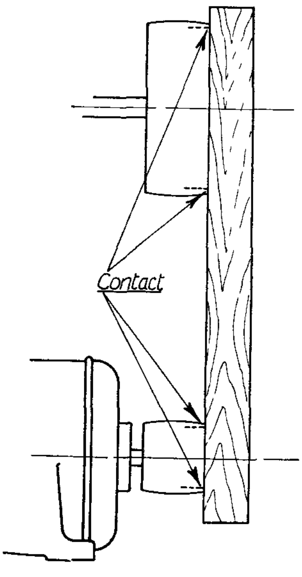


Fig. 10.—Aligning Pulleys. (II.)
The straightedge is placed so as to make contact with both pulleys at two points at opposite ends of a diameter in each case, i.e., four contacts in all, and when the relative positions of motor and driven pulley have been adjusted to bring this about the drive is aligned. If the pulley faces are unequal the cord method (I) should be used and the centres of the pulleys aligned.

Aligning Chains and Gears.

Chain drives are dealt with exactly as for belts and ropes, as also are gears, noting that while small misalignments will probably not give rise to trouble in belt or rope drives, anything appreciably short of perfection in the lining-up of chains or gears will quickly lead to break-down. Note also that chain or gear drives must be fitted at the correct centre distance as recommended by the designer, and that it is essential that pinions or wheels run perfectly truly on their shafts.

Aligning Direct Coupled Drives.

For either rigid or flexible couplings the usual method of lining-up is to place a straightedge across the coupling flanges at four places 90° apart. If the straightedge makes full contact with the whole length of the coupling flange, as shown in the drawing, the machines are in line, but if full contact is not secured, the position of one machine must be altered until it is. Neither machine must be rotated while the lining-up is being adjusted, but when one set of four straightedge applications at 90° shows true alignment, *one only* of the shafts should be turned through half a revolution and a second four trials should be taken at the same positions as the first ones. If this second series shows lack of alignment, bent shafts, untrue couplings, or a twist in one or both coupling flanges should be looked for, and when the error is found it must be corrected before the lining-up can proceed.

As a check on this method in the case of rigidly coupled drives it is usual to measure the distance between the couplings at four points a quarter of a circle apart, before pulling up the coupling bolts. The measurement should be done with a feeler gauge, and the couplings must not be turned while the clearances are being taken. As before, equal measurements denote alignment.

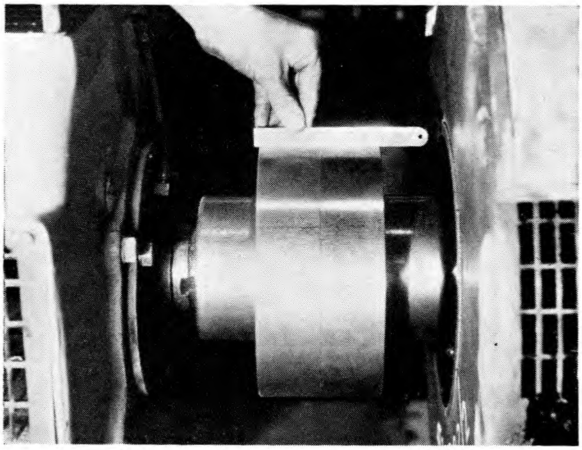


Fig. 11.—ALIGNING COUPLINGS. (I.)
A rigid type of coupling is here shown, and the fitter is holding a straightedge in contact with the outer flanges to ensure that the alignment is correct by observing that the straightedge makes full contact with the whole width of *both* flanges. (*Metropolitan-Vickers.*)

Final Notes on Lining-up.

After lining-up any drive always turn it over slowly, by hand if possible, feeling for any increase of resistance or jerkiness; if impossible to turn by hand use the motor (but at a very low speed to start), and watch the ammeter. Any increase in current indicates a tight spot in the drive, which must be eliminated before putting the drive into service. A final check on lining-up should always be made after the foundation bolts are tightened up, since slight misalignments are often the result of the last pulling up of the holding-down bolts.

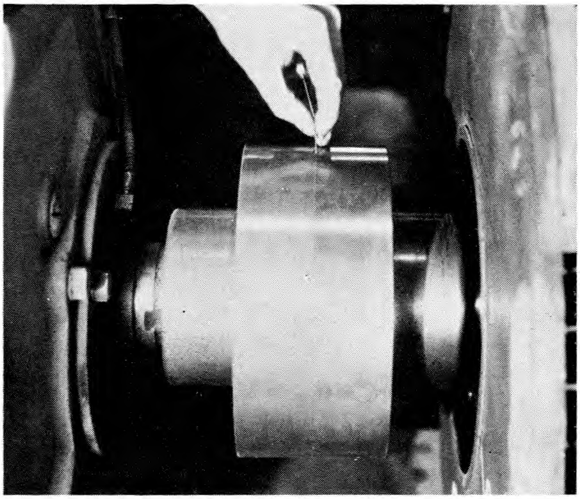


Fig. 13.—ALIGNING COUPLINGS. (III.)
With rigid couplings the straightedge method of aligning is checked by measuring the distance between the coupling halves with a feeler gauge before finally pulling up the coupling bolts. This illustration shows the measurement being taken; to denote true alignment four such measurements at 90° to each other must be equal. (*Metropolitan-Vickers.*)

Wiring up.

This will easily be accomplished by following the wiring diagrams supplied with motor

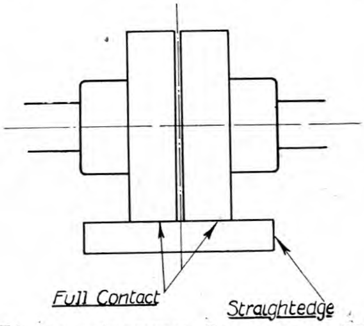


Fig. 12.—ALIGNING COUPLINGS. (II.)
The flexible coupling is also aligned by ensuring that a straightedge makes full contact with both flanges. As explained in the text this test for alignment must be made at four points each a quarter of a circle apart; during these four tests neither shaft must be rotated.

and starter, so that we need only draw attention to such matters as ensuring that the cable size is adequate (use any good wire table or cable-makers' catalogue), and that joints in cables are avoided wherever possible, while unavoidable joints must be efficiently soldered and insulated. Cable ends should also be soldered into suitable sockets for attachment to the motor terminals, while the correct type of cable fittings should be employed to suit the kind of cable in use. These cable fittings are supplied by all the motor makers arranged for attachment to the machine terminal box, and they comprise sealing chambers, trifurcating boxes, plumbing-cones for lead-covered cables, and armour clamps. These details are employed in various combinations to suit the cable, while in the case of conduit wired machines an adaptor plate is supplied for the terminal box; this adaptor plate may be drilled and tapped for the conduit as required.

In view of these facts it is advisable to order the cable fittings with the motor, although they can usually be supplied from stock if this has been overlooked.

Earthing.

For reasons of safety it is essential that the motor frame be earthed, and a terminal and cable socket is usually provided on the motor frame or foot for this purpose. A stout earthing wire should be soldered into this cable socket and run to the nearest earthing point. Sometimes the cable armouring or conduit is used for earthing, precautions being taken to ensure continuity of the earth circuit right through to the actual earthing point. When this is done, the earth wire from the motor should be securely attached to the conduit or cable armour, which must be thoroughly cleaned down to the bare metal to ensure an efficient connection.

It is not usually sufficiently safe to allow the conduit or cable armour to make the earth connection at the motor terminal box, since many manufacturers use packings of cord, etc., to obtain a joint between the adaptor plate and the motor terminal box. Under these conditions it is possible for the packing to form a break in the earth circuit, so that a separate earth wire from the motor frame to the continuous earthed circuit should always be employed. In this connection it must be noted that " flexible conduit " cannot be considered a good earthing conductor, and that the earth wire must be carried back beyond the flexible portion to the solid conduit, or to some other continuously earthed circuit.

To be efficient, reliable, and safe, an earthing circuit should have low resistance (flexible conduit sometimes has considerable resistance) and be absolutely continuous. It must never be broken by switches, and in some few cases it may be found advisable to run a special earthing main, designed to give the low resistance necessary. Failure to earth a motor effectively may lead to shocks or even fatal accidents in case of insulation breakdown.

Starting Up.

Having reached this stage we are ready to start up and carry the load. Before doing this, however, check over the connections with the help of the diagrams,

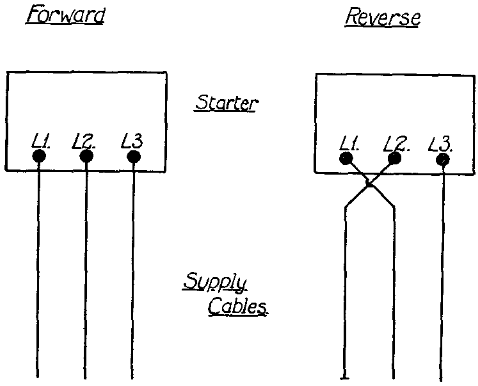


Fig. 14.—Reversing Rotation.
To change the direction in which a three-phase induction motor runs it is only necessary to change over two of the *supply* cables, as shown in this diagram. There is no need to alter any connections in the motor terminal box.

examine the earth wire, pull the belt round to ensure that it is free, see that the starter (if of the oil-immersed type) is filled to the correct level with suitable oil, and ensure that any overload dashpots fitted are filled with oil of correct grade. Overloads should be set to trip at about one and a half to one and three-quarters time full load current as stamped on the motor nameplate. If all these points are in order start up slowly, giving the motor a few seconds on each step to accelerate, and when up to full load speed observe that the vibration is not excessive and that the drive is running sweetly.

When starting up a slipring motor with brush lifting and short circuiting gear be quite sure that the brush lever is in the " start " position before closing the main switch, and as soon as full speed is reached move the handle smartly to the " run " position.

If the Motor will not Start.

If, upon attempting to start the motor, it is found that it fails to revolve or will not accelerate beyond a low speed, the starting handle must be returned to the " off " position immediately, otherwise the windings may be damaged. Before attempting to start up again a careful inspection should be made on the following points :—

(1) Are connections correct to diagrams?

(2) Is the voltage reaching the starter ? Make sure that no section main switch is open, and that there are no fuses drawn on the motor circuit.

(3) Are all terminals tight ? Make sure there are no bad contacts in either cabling or control circuits.

(4) If a brushgear handle is fitted is this in the " start " position ?

(5) Is the line voltage dropping excessively when the starter is operated ? A 400-volt line which falls to 360 volts or less when starting up may make starting impossible.

(6) Try starting more slowly if none of the above points appears to apply.

If all these matters are found to be correct, or have been corrected, remove belt or chain and try starting up light. If the motor gets away satisfactorily, replace the driving arrangement and try again. If the machine starts and runs up to full speed without any trouble load may be applied to the driven machines, while if it is found that the motor still refuses to start although all connections, etc., are in order then the manufacturers should be consulted.

If Motor Refuses to Take Load.

In this event make sure :—

(1) That overload trips are correctly set and any time lags suitably adjusted.

(2) That the load applied is not too large ; motors must not be called upon to carry more than about 50 per cent. overload, and this must not be applied for any length of time. Observe the ammeter reading, currents in excess of 120 per cent. full load nameplate current must not be allowed for more than a few seconds, while currents greater than 150 per cent. full load current may indicate a load too heavy for the motor to pull in any case.

(3) That the drive is free in all positions and is not sticking or stiff.

If, after all these points have been checked, the motor still refuses to start or carry the load, consult its manufacturers.

To Reverse Rotation.

If the motor runs in the wrong direction change over two of the incoming cables to the starter or stator circuit-breaker, this change of connections is shown in the sketch.

Conclusion.

The above notes are not intended to be exhaustive, they are set down simply to point out matters which are not usually dealt with in makers' lists, instruction booklets and cards, or standard handbooks. The more usual " snags " which are encountered in the installation of any type of electrical machine are pointed out, while the points to be watched in maintaining induction motors in good working order will be the subject of a later article.

MARKING DISTRIBUTION BOARDS

Distribution boards should be marked so that the neutral and the live bus-bars can be seen at a glance.

This can be found by connecting a test lamp between the iron frame of the fuse-board, or the conduit, and each bus-bar in turn. The lamp will glow when in contact with the live bar.

The advantage of being able to distinguish the live side is helpful when renewing blown fuses, as it often gives an idea of the trouble which caused the fuse to blow.

A fuse which blows " clean out " on the live side only, invariably points to an earth fault, and it is advisable to see that all the branch switches are off before replacing such a fuse in case the scattered metal should burn the fingers.

A 400-WATT PROJECTOR LAMP TRANSFORMER

By H. E. J. Butler

Although this transformer is primarily intended for the operation of low voltage cinema projector lamps, it can be utilised for any other purpose by choosing a suitable secondary winding.

Materials Required.

The following materials are required for the construction of the transformer:—

No. 35 stampings (see Fig. 2), 9 doz. pairs.

Cast aluminium alloy clamps, 1 pair.

¼-in. Whitworth thread, 3⅛ in. long, 2 pieces.

¼-in. Whitworth thread, 4¾ in. long, 2 pieces.

¼-in. Whitworth nuts, 12.

¼-in. washers, 8.

½-in. wide Empire tape, 20 yds.

Wire for primary (see tables), 4 lbs.

Wire for secondary (see tables), 4 lbs.

Ebonite or bakelite strips, 6½ × 1¾ × ¼-in., 2.

2 B.A. terminals and sistoflex sleeving for primary tappings, as required.

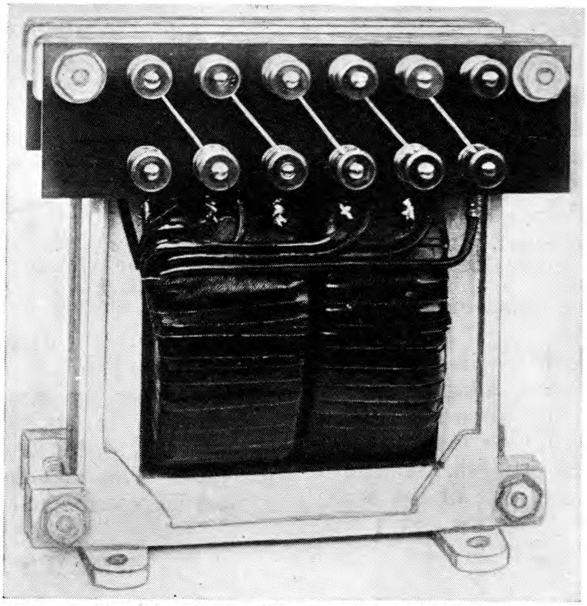


Fig. 1.—The Finished Transformer with a 200-250-volt Primary Winding.

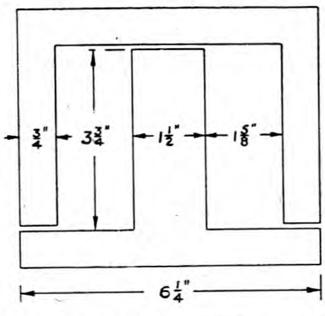


Fig. 2.—The Dimensions of the Stampings Used for the Transformer.

9 dozen pairs are required to make the square core.

The stampings and suitable cast clamps are obtainable from the Lumen Electric Co., 9, Scarisbrook Avenue, Litherland, Seaforth, Lancs. The approximate cost of the materials is £1. 8s.

Arrangement of Windings.

If the secondary voltage required lies between 25 and 120 volts, round wire is used for the secondary coil. The primary and secondary windings are wound as separate coils and assembled side by side on the stampings as shown in Figs. 1 and 3.

For voltages below 25, it is necessary to use cotton-braided copper strip for the secondary, because an equivalent round wire is not only difficult to wind, but is extravagant for space. With the strip-wound secondary, it is not possible to adopt the side-by-side coil construction, on account of the difficulty of making the strip conform to the small squares of the first layers and the waste of

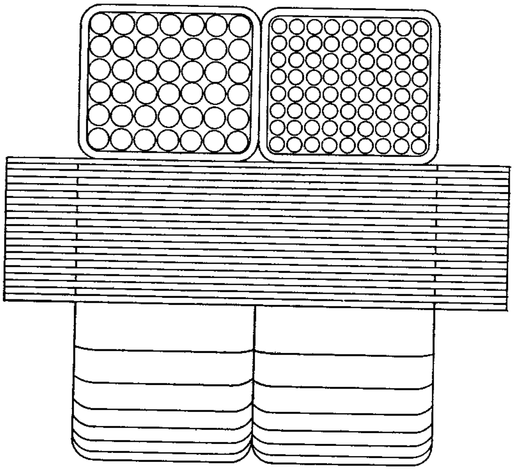


Fig. 3.—THE ARRANGEMENT OF THE COILS ON THE STALLOY CORE, FOR THE SIDE BY SIDE TYPE OF CONSTRUCTION, WHICH IS ADOPTED FOR 25-120-VOLT SECONDARIES.

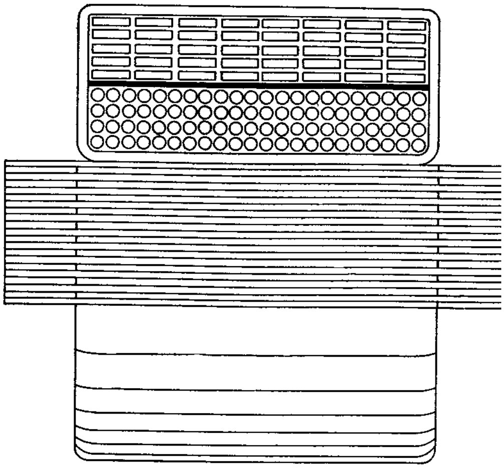


Fig. 4.—THE ARRANGEMENT OF THE WINDINGS FOR THE STRIP WOUND SECONDARIES, WHICH ARE USED FOR VOLTAGES BELOW 25.

space, which is inevitable in a short coil.

The form of winding adopted for the strip wound secondary shown in Fig. 4. The primary is wound on first, then insulated with a strip of $\frac{1}{32}$-in. bakelite or paxolin. The starting size of the secondary is now about 3 × 3 ins., with well-rounded corners, which makes the winding of the strip reasonably easy.

The Former.

A temporary wooden former is required for winding the coils. The method of constructing the coils is to wind the wire on this former, remove it and tie up with thread, then insulate it with Empire tape. The impregnation and baking, which is necessary for a cotton-covered winding, is carried out before taping up.

The former for the side-by-side coil construction is shown in Fig. 5. An allowance of $\frac{3}{32}$-in. all round is made for the tape. This may seem too much, but it must be remembered that the tape piles

WINDING DATA.

PRIMARY WINDINGS (50-60 CYCLES).

Volts.	S.W.G. Enamel.	Turns.
250	19	875
240	19	840
230	19	805
220	19	770
210	19	735
200	19	700
130	17	455
120	17	420
110	17	385
100	17	350

WINDING DATA.

SECONDARY WINDINGS. 120-25 volts.

Volts.	Amps.	S.W.G.	Turns.
120	3.3	18 enam.	440
110	3.6	17 enam.	405
100	4	17 enam.	367
75	5.3	16 D.C.C.	275
60	6.7	15 D.C.C.	220
50	8	14 D.C.C.	184
40	10	13 T.C.C.	147
30	13.5	12 T.C.C.	110
25	16	11 T.C.C.	92

SECONDARY WINDINGS. 20-6 volts.

Volts.	Amps.	Braided Strip Copper Section.	Turns.	Yards of Wire.
20	20	.050 × .200 ins.	73	31
18	22.2	.050 × .250 ins.	66	28
12	33.3	.060 × .300 ins.	44	19
10	40	.060 × .360 ins.	37	16
9	44.5	.070 × .350 ins.	33	15
8	50	.070 × .420 ins.	29	12
7	57	.080 × .400 ins.	26	11
6	67	.080 × .480 ins.	22	10

up rather on the inside corners, and the full amount of stampings must be accommodated without fear of the last few cutting into the tape.

Quarter-inch plywood was used throughout for the former shown in Fig. 5. The two cheeks measure $4\frac{3}{4} \times 4\frac{3}{4}$ ins. outside, with $1\frac{11}{16}$ square hole. The hole is thus $\frac{3}{16}$ bigger than the core. The winding space between the cheeks is $1\frac{3}{4}$ in. The square tubular core of the former consists of four strips of the $\frac{1}{4}$-in. plywood. Two narrower strips are wedged tightly between the two wider ones, which obviates gluing and enables the core to be released with the least possible chance of disturbing the winding. The core strips of the former are made to project $\frac{1}{8}$-in. beyond the wood cheeks, so that they can be pressed in or out of position easily. Thus, the wider strips measure $2\frac{1}{2} \times 1\frac{11}{32}$ in., and the narrower, or wedging strips, $2\frac{1}{2} \times 1\frac{7}{32}$ in.

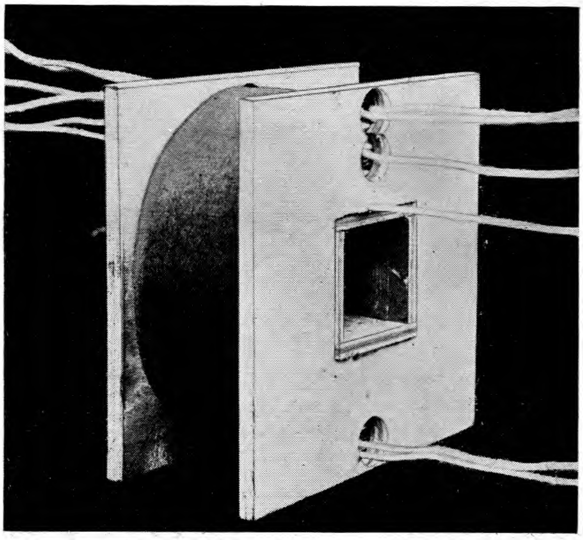


Fig. 5.—A Wound Secondary Coil.
Showing the method of making the tappings and the construction of the wooden former. Note that the final layer is covered before the former is removed from the coil.

Some $\frac{5}{8}$-in. holes are bored in the cheeks to permit the tapping leads to be brought out as shown in Fig. 5.

Former for Strip Secondary.

For a strip-wound secondary, the former is constructed in the same way, but it is longer. The winding length inside the cheeks is $3\frac{9}{16}$ in. Therefore, the wood strips for the square core will be $4\frac{5}{16} \times 1\frac{11}{16}$ and $4\frac{5}{16} \times 1\frac{7}{32}$ in., two off each. It will be necessary to cut a suitable sized slot in one of the former cheeks to take the starting end of the strip.

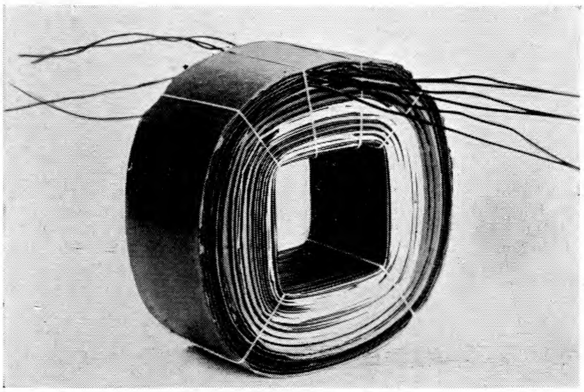


Fig. 6.—A 200-250-volt Primary Winding After Removal from the Former.
The coil is tied with thread before binding with tape, to prevent the end turns from moving while the tape is being wound on.

Winding the Primary.

The primary windings are divided into two classes, according to the mains voltage, 19 S.W.G. for 200-250 volts and 17 S.W.G. for 100-130 volts. Enamel-covered wire is used for either. An untaped 200-250-volt primary coil is shown in Fig. 6. The first part of the winding consists of 700 turns of 19 S.W.G. wire. This takes just 19 layers if evenly wound. Insulating paper is used to cover each layer during winding. Each of the five 10-volt sections occupy one layer of 35 turns. It is advisable to use something more substantial than paper between the 10-volt coils, so as to give ample protection to the leading-out wires. The material used for the coil shown in Fig. 6 was six mil. presspahn. The tapping points may be simply looped out, but it is more useful to treat each section of the coil as an independent winding. This necessitates 12 terminals as shown in Fig. 8. If the primary winding is treated in this way it enables any of the spare 10-volt sections to be utilised as may be required.

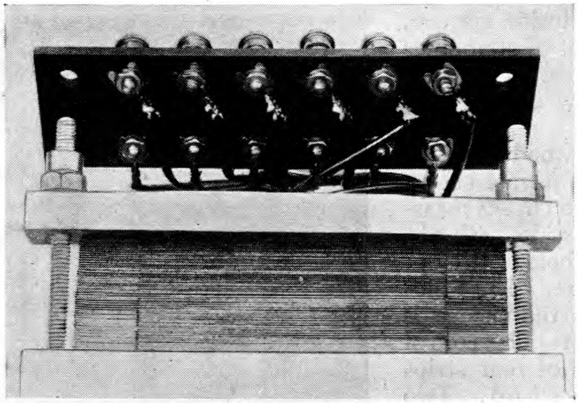


Fig. 7.—THE ACTUAL PRIMARY CONNECTIONS AT THE BACK OF THE TERMINAL BLOCK. Note the use of spade connecters.

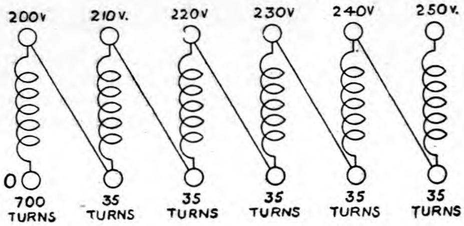


Fig. 8.—THE CONNECTIONS OF THE SIX SECTIONS OF THE 200-250-VOLT PRIMARY TO THE TERMINAL BLOCK.

Connecting the Primary.

Although the ends of the windings can be sorted out after the coil is removed from the former, it is safer to label the ends, as they are wound, with stamp paper.

In Fig. 8 all the starting ends of the six sections are connected to the bottom row of terminals and the finishing ends to the top row. The whole winding is connected in series, for full voltage operation, by means of the oblique links, as shown in Figs. 1 and 8.

For 100-130 volts there are only four sections to the primary and only eight terminals. The 17 S.W.G. wire winds 27-28 turns per layer, which makes 13 layers for the 350 turns. The 10-volt sections do not work out so nicely as those of the 200-250-volt primary. The 35 turns of 17 S.W.G. occupy about $1\frac{1}{4}$ layers, so that this must be spread out over two layers, because tappings cannot be taken in the middle of a layer. There is sufficient room on the core to accommodate six layers on top of the 100-volt section.

The primary can, of course, be wound for a fixed voltage, if so desired. It simplifies the construction, but does not make the transformer of such universal application.

Removing the Coil.

When a coil has been wound, the narrower strips of the former core are prised inwards and the four strips removed. Straighten out the coil leads and lift off the cheeks carefully. The coil is now tied with thread in about six places, as shown in Fig. 6. This prevents the end turns from being disturbed during the taping operation. If the winding is a cotton-covered one, it is baked and impregnated at this stage. A coil of this size must be dried for at least two hours at 200° F. before impregnation with insulating varnish.

Holding the Former.

The former can be held in a small 4-jaw lathe chuck for the purpose of winding on the wire. It should be gripped inside the square hole so as to make the square tube hold the cheeks firmly. If a lathe is not available, the former can be pressed on to a round pole, which has been shaved down to fit tightly.

Lightning Protection for Transmission Lines

By W. A. Coates, M.I.E.E., Fel.A.I.E.E.

It is common knowledge that the potential behind a lightning stroke is computed in millions of volts. The current is extremely small, the power involved having been assessed by the foremost authorities as in the region of 2,000 or 3,000 kW. That which appears to the eye as a single stroke is, in fact, a succession of sparks between cloud and cloud or earth, each lasting one or two micro-seconds (millionths of a second).

Until lately, it has been thought that electrical apparatus, and especially overhead transmission lines, could be subjected to dangerous over-voltages by induction from lightning striking in the vicinity. The invention of an instrument known as the recording klydonograph has permitted quite accurate observations to be made, which confirm the theory held previously by a minority, that except on low voltage lines, real trouble is always associated with a direct strike.

What Happens When Line is Struck by Lightning.

The fact that a transmission line is struck by lightning does not mean that the line therefore acquires a potential of millions of volts. Most of that enormous pressure is used in breaking down the air between cloud and line. The impressed voltage between the line and earth varies very widely. It may easily be high enough to break down the insulation of even the highest voltage equipments, although, as may be expected, the more highly insulated gear suffers least from lightning troubles.

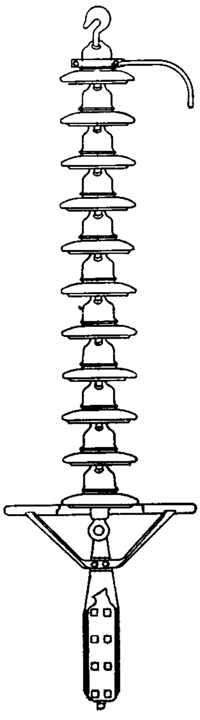


Fig. 1.—Straining Insulator, Showing Arcing Horn and Ring Lightning Arrester.

Notice the position of the arcing devices, to ensure that the arc caused by lightning strikes clear of the porcelain.

Character of Lightning.

The lightning travels along the circuit in both directions, until it can discharge to earth, over or through the insulation, or the air.

In practice, lightning waves do not travel far along transmission lines. A considerable loss of the energy would occur in the form of corona discharge from the wires themselves, in any case, added to which the breakdown of a few insulators is usually sufficient to reduce the over-voltage to harmless proportions. Insulator breakdown is rare beyond a quarter of a mile from the place at which lightning strikes, and the travelling wave has disappeared at two or three miles distant.

The Breakdown of Insulators.

The insulators which are used out of doors, either to support transmission lines, or as inlet bushings on transformers and switches, must, of course, withstand the effects of rain, dust, etc., without breaking down. This is accomplished by fitting them with suitably shaped porcelain rain sheds. If the voltage is increased deliberately until flash-over occurs, it is found that the pressure necessary varies both with the surface condition of the porcelain and with the source from which the voltage is derived.

As a rule, insulators are rated by their

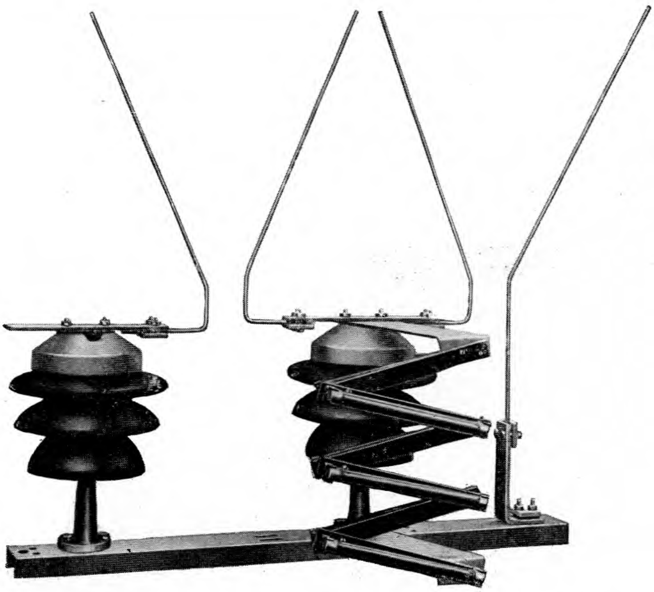


Fig. 2.—Single-phase Unit 37 kV. Horn Type Lightning Arrester, with Compound Limiting Resistance and Supplementary Gap to Earth. (*Metropolitan-Vickers Co.*)

flash-over values at 50 cycles only. The ratio between working voltage between phases, dry flash-over, and wet flash-over is subject to rather wide variation, according to the probable climatic and atmospheric conditions, and the users' opinions. The following table gives the standard minimum values for line insulators. It is quite common practice to use insulators with flash-over values 25 per cent. or more in excess of these figures.

50 Cycle Flash-over Values (kV.; r.m.s.)

Working kV. ..	6.6	11	22	33	66	110	132
Dry F/O. kV. ..	44	53	74	95	160	255	300
Wet F/O. kV. ..	23	32	53	74	137	220	265
Safety Factor ..	6.0	5.0	4.2	3.9	3.6	3.5	3.5

An insulator is stressed normally only to system voltage divided by $\sqrt{3}$, and it is this value, divided into the wet flash-over, which gives the safety factor.

Testing insulators with artificial " lightning," from an impulse generator, it is found that flash-over does not occur until a voltage much greater than the peak value of the dry flash-over. The impulse flash-over value varies only slightly with changes in the shape of the voltage wave, and is not affected by whether the insulator is wet or dry. The ratio between impulse flash-over and peak voltage for dry flash-over, is known as the " impulse ratio," and is usually of the order of 1.5 to 1.7.

LIGHTNING ARRESTERS.

Arcing Horns and Rings.

Under working conditions, an arc started by lightning, over the surface of an insulator, may form the channel for heavy currents to pass to earth, from the system generators. The intense local heating shatters the rain sheds, and renders the insulators incapable of withstanding even the system voltage. In order to provide a safety valve, an alternative path for discharge is needed. This takes the form of arcing horns or rings, as shown in Fig. 1. Such fittings do not greatly affect the impulse ratio, but since the electrode spacing is less, the breakdown voltages under all circumstances are reduced by about 20 per cent. to 35 per cent. from those of the insulator alone.

By positioning the arcing devices a proper distance away, it is possible to ensure that the arc strikes clear of the porcelain. Rings are to be preferred, since a wind will tend to carry the arc round to the lee side. On the other hand, the use of rings in switchgear installations usually involves placing insulators wider apart than when horns only are employed.

Arcing horns or rings offer protection to individual insulators only, and not to the system. A power arc once started between them, cannot be relied upon to be self-clearing, and the automatic oil circuit breakers on the affected circuit will almost certainly operate first.

It is sometimes urged that on a transmission system in which the insulators have arcing devices, a few units adjacent to the stations should have shorter gaps, so as to encourage breakdown there, rather than in less accessible parts of the line. Because of the comparatively short

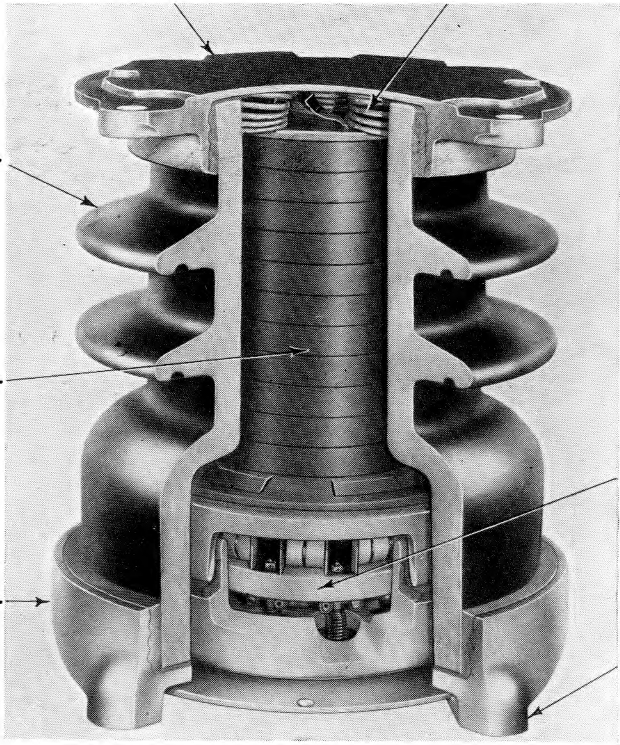


Fig. 3.—One of the Units from which Thyrite Arresters are Made, Showing Method of Assembly. (*B.T.H. Co.*)

distance, a steep-fronted wave will travel without attenuation and reduction in amplitude, this argument is fallacious. The practice is correct in some degree, however, since within the area of an outdoor station, it may be assumed that a travelling wave will have the same characteristics at all points. Hence a wider gap on the arcing devices associated with bushings and other insulators expensive to replace, has some point. It is necessary to check the impulse breakdown values for each different type of insulator and bushing used, as the breakdown of the arcing devices may be affected differently by the electric fields of the adjacent insulators.

Wherever the circuit characteristics (i.e. the ratio of resistance, reactance and capacity) change, as at line terminations, junctions between overhead lines and cables, or at a transformer, steep fronted travelling waves may be reflected back. It is possible for impulse voltages to be nearly doubled at such points, which are, therefore, the most critical in their liability to breakdown.

Importance of Protecting Transformers.

Arcing devices fitted to the insulators in a station will not protect completely the transformers, because of that small, but quite definite, time interval before spark-over occurs. The wave front may have reached the transformer winding and there doubled before there is a sufficient number of relief paths open. The high capital value of transformers, and even of switch bushings often justifies the expenditure of considerable sums on lightning protection in their neighbourhood.

Horn Arresters.

Ante-dating insulator arcing devices by many years, the horn type of lightning arrester is still quite widely used for the protection of the less important installations. It takes name from the peculiar arrangement of conductors shown in Fig. 2. An arc which strikes across the narrow gap at the bottom, will be automatically self-clearing, lengthening as it rises up the horns, due to air convection and a magnetic blow-out effect, and finally rupturing, provided the current is not over about 20 amps. A series resistance, which may be water, oil immersed metal, or one of the graphitic compounds is used. As a rule it is of such value as to limit the current to 10 amps., with normal voltage to earth across it.

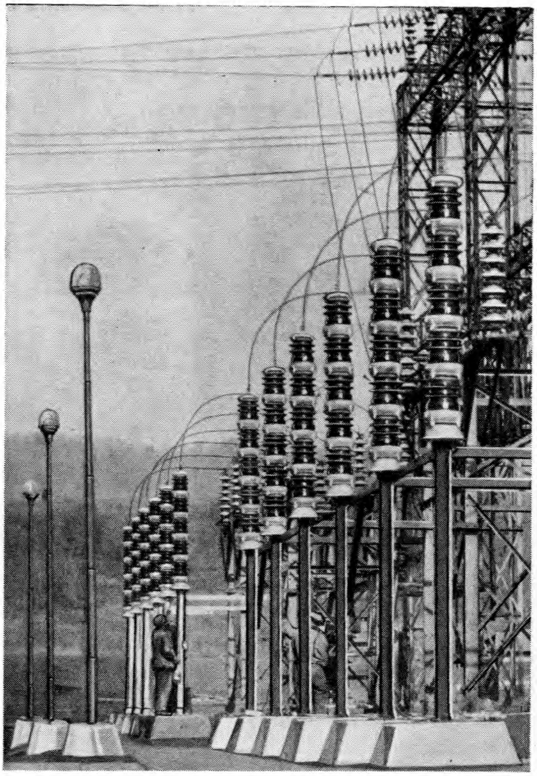


Fig. 4.—Installation of 66 kV. Thyrite Arresters—Neutral Earthed System. (*B.T.H. Co.*)

Unless big spheres are used to form the breakdown gap, horns will have an impulse ratio as high as 2.0 dry, or possibly 2.8 wet. Spheres of sufficient size would have unity ratio dry, and about 2.0 wet. To be effective, therefore, the horn gap must be set to break down at a lower 50-cycle value than will the insulators in the neighbourhood.

The presence of a series resistance in the earth path is a very serious objection, since it imposes a limit to the relief which can be afforded against lightning, as well as to the generator current which follows. In fact, this and all other types of arrester with low discharge capacity, must be regarded as useless against a close-up lightning stroke, since a great part of the superimposed energy is left on the line. Only a certain proportion of potentially dangerous travelling waves can be bypassed to earth with safety to the arrester.

Choke Coils.

To assist in protecting transformer windings, small choke coils are sometimes inserted directly in series between them and the line, with the lightning arrester connected on the line side, adjacent. These coils have only a very small inductance, since their purpose is to cause to build up, and reflect back to the arrester, only high frequency switching surges or very steep fronted impulses. In modern practice, such coils are usually omitted, since they may themselves be the cause of some trouble.

An early arrangement, which aimed at giving improved protection, used several choke coils in series, with a horn gap arrester connected to earth between each pair. This certainly would achieve its object in some measure, just as it has been demonstrated practically that lightning causes no trouble on distribution lines where many small capacity arresters are concentrated within a limited area. The space occupied by arrangements of this sort is practically prohibitive. To-day, where good lightning protection is needed, use is made of one of types developed in America, which country suffers much more serious lightning storms than we do.

Electrolytic Arrester.

The discovery that a film of aluminium hydroxide, formed electrolytically on an aluminium vessel, had a very definite electric strength, led to the development of this, the first arrester with a big discharge capacity. A number of aluminium trays were stacked, with the bottom of one nesting inside the next lower. Electrolyte in each tray completed a circuit through the stack which was connected to the line through a horn gap. Any voltage big enough to jump the gap also punctured the films which had formed on the tray surfaces. When the voltage dropped below a critical value, the punctured films were reformed by electrolytic action. Thus the device was self-sealing, yet could pass to earth currents fifty or a hundred times as great as the simple horn gap arrester.

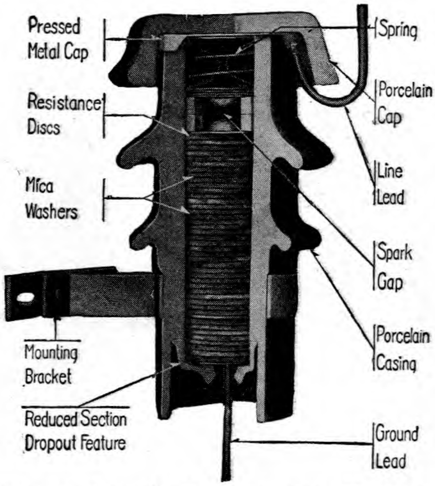


Fig. 5.—Section Through 7.5 kV. Autovalve Arrester for Bracket Mounting. (*Metropolitan-Vickers Co.*)

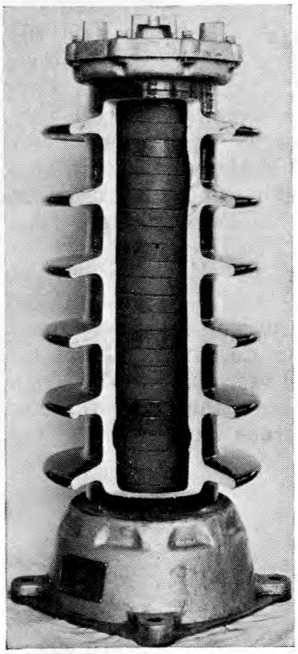


Fig. 6.—Component Block Unit of High Voltage Auto-valve Arrester, with Porcelain Casing Cut Away. (*Westinghouse Elec. and Mfg. Co.*)

Arresters of this type are still giving good service, 15 and 20 years after installation, but the constant care needed for maintenance, especially in hot weather, led to other designs being sought.

Oxide Film Arrester.

This was the first successful rival of the electrolytic type. It was assembled of units each of which comprised a porcelain ring, over the sides of which was spun a steel plate. The inner faces of these plates carried a film of insulating varnish, and the space between was filled with a conducting oxide of lead. As in the electrolytic type, an excessive voltage punctured the varnish films, and permitted current to flow to earth. The heat due to the passage of current, reduced the filling to insulating lead peroxide, which sealed the punctures almost as they formed.

This type of arrester needed little maintenance, but in action gradually deteriorated in discharge capacity. It also is now superseded by those following.

Thyrite Arrester.

Thyrite is

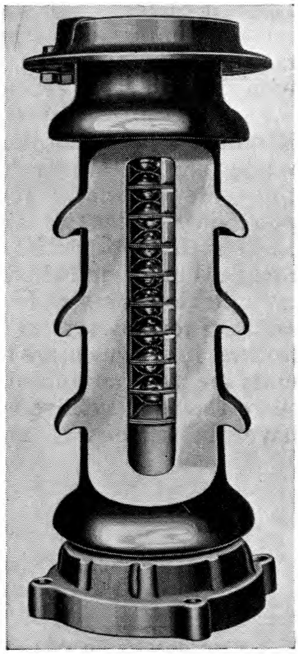


Fig. 7.—Spark Gap Unit Used for High Voltage Auto-valve Arrester, with Porcelain Casing Cut Away. (*Westinghouse Elec. and Mfg. Co.*)

the name given to a material of a ceramic nature, which has some graphitic admixture. It has the unusual and useful property of being substantially an insulator at a relatively low voltage, and becoming a good conductor as the voltage increases. As the resistance is a function of voltage only, the shape of the voltage wave has no significance, i.e. the impulse ratio is unity, and the material has no dielectric time lag, a disadvantage with the film types previously mentioned.

In practical construction, the material is moulded into flat discs, the faces of which are metal sprayed. Several of these are assembled together within a porcelain housing, as shown in Fig. 3. Each such unit has its own series gap. Standard units are bolted one to the other in suitable number to form lightning arresters for any system voltage. Special features in design ensure that when several units are thus assembled, the series gaps share the total voltage equally, and thus have the same arc quenching duty to perform after the arrester has discharged, and the voltage has dropped to normal.

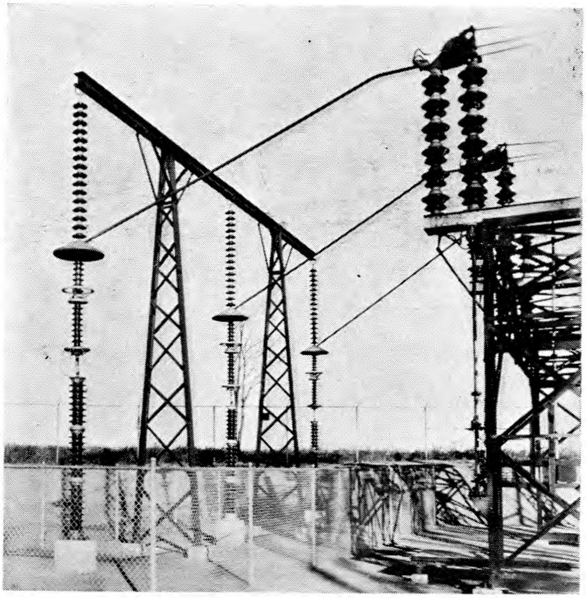


Fig. 8.—INSTALLATION OF 220 KV. AUTO-VALVE LIGHTNING ARRESTER. (*Westinghouse Elec. and Mfg. Co.*)

Auto-valve Arrester.

Although it works in a different way, this arrester also is built of units of semiconductive ceramic material. In this case, the method of manufacture produces numerous minute pores throughout the block. With voltages exceeding a certain limit, electric discharges occur through all these minute paths in parallel. Such discharges have the characteristic common to all arcs, that they cannot be maintained below a definite critical voltage. That is, they act as voltage valves, and are automatically self-sealing. The discharge rates obtainable with this arrester are of the same order as with the Thyrite type.

The practical arrangement is very much as in the previous design, save that the series gaps are all assembled into a single unit, mounted above the stack of units containing the porous blocks.

STREET LIGHTING EQUIPMENT

A new catalogue of G.E.C. street lighting equipment suitable for gasfilled lamps and also Osira electric discharge lamps, has just been issued. Up-to-date notes and characteristics of the various lamps and street lighting equipment are given. The catalogue is replete throughout with technical information, graphs and curves of the various types of lamps, lanterns, reflectors and street lighting equipment manufactured by the Company.

Rewinding Heating Elements

By F. H. Haywood

THE use of electricity for heating and cooking purposes is rapidly developing in all parts of the country, and whilst the modern manufactured radiators, kettles, irons, etc., are very reliable if used properly, yet they do sometimes burn out.

Elements can, of course, be obtained from the manufacturer, but for the small undertakings in particular who are responsible for the maintenance of a variety of apparatus of different makes, loading, and perhaps even voltage, the stocking of such spares entails the use of money which could otherwise have been spent. It is only necessary to purchase a few pounds of different gauge resistance wires and tapes, and we are capable of repairing practically any piece of apparatus immediately.

Rewinding Radiator Bars.

First, concerning the rewinding of radiator bars, the importance of even spacing of the spiral and of not disturbing the oxidised coating of the wire cannot be over-emphasised. Let us consider the usual 3 kW. radiator with three elements consuming 1 kW. each or 4 amps. on, say, 250 volts.

We thus require first of all a spiral capable of carrying 4 amps. and having a hot resistance of 62.5 ohms. Manufacturers of resistance wires will supply tables giving the current-carrying capacities of different grades of wires and also the resistance at varying temperatures. It is thus a simple matter to select a suitable wire for the purpose.

If no tables are available, or if it is desired to use some old wire (old stock), then the hot resistance per foot can be readily obtained by winding up a sample element of known length (of say 3 ft.) and measuring it by ammeter and voltmeter as shown in the sketch.

The current is brought up to the required value either by cutting out resistance or altering the transformer tapping (see Fig. 1). Some idea of the carrying capacity of the wire can also be gathered from the above by noting the spacing and colour of the heated spiral.

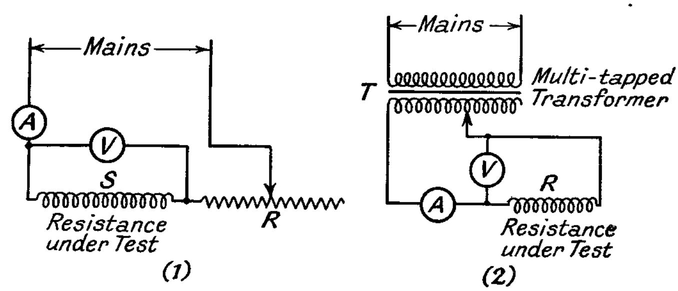


Fig. 1.—Two Methods of Finding the Resistance of Wire. The current is brought up to the required value by cutting out resistance (1) or altering the transformer tapping (2).

Winding the Spiral.

Assuming we know the resistance of the wire per foot, it is an easy matter to calculate the length of wire required, which should be carefully measured off, allowing a little extra for leads. The spiral can next be wound on a suitable wire fixed in a lathe, carefully avoiding the wire running back along the spiral and so damaging the oxidised coating. With a little practice the winding of a perfect spiral is only the work of a few minutes.

Transferring the Wound Spiral to the Porcelain Bar.

With regard to transferring the wound spiral on to the porcelain bar, a few points can be watched which will ensure that a satisfactory repair is effected. In order to make a good terminal connection, clean the ends of the wire with emery cloth.

We will take a typical bar in which the

spiral is to lie in four grooves as shown in Fig. 2. The spiral can be accurately divided up by driving two nails into the bench a convenient distance apart and stretching the spiral between them.

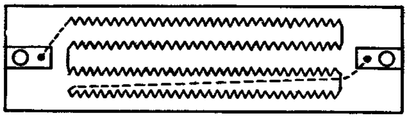


Fig. 2.—TYPICAL RADIATOR BAR, WITH SPIRAL LYING IN FOUR GROOVES. Fig. 3 shows a convenient method of marking out the spiral to fit the bar.

An Example.

For example, the unstretched spiral may measure $13\frac{5}{8}$ ins. In order to divide up, drive the nails 16 ins. apart and mark off in 4-in. sections with a knife blade, just opening the spiral slightly at these points (see Fig. 3).

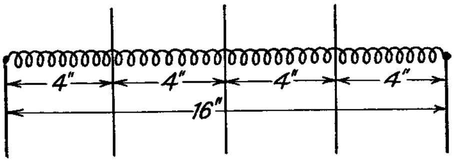


Fig. 3.—METHOD OF DIVIDING UP SPIRAL TO FIT RADIATOR BAR IN FIG. 2. Stretch the spiral between two nails at convenient distance apart and mark off the four sections required. Open out the spiral at these points.

What to do if Grooves are of Unequal Length.

If the grooves in the bar are of unequal length, as in the case of bowl-fire elements, the above method would be complicated. Wind the element with string to find the length required and then stretch the spiral out to this length and continue. Probably the string will be a bit shorter than required, but this can easily be compensated for by stretching the spiral slightly when winding.

Mica Wound Element.

With regard to mica wound elements, as used in irons, kettles, and immersion heaters, the main point is to have good conduction from the element itself in order to keep the temperature of the wire down. Inevitably follows the necessity of having the element in good contact with the surface which it is to heat and of using thin but good quality mica on which to wind the wire. This is particularly important in the case of appliances in which heat is only conducted from one side of the element, such as irons and kettles of the non-immersion type.

INSPECTING DISTRIBUTION BOARDS

Generally the periodical inspection of low-pressure sub-distribution boards has to be carried out with the supply switched on and the sub-circuits in use. Where only a lighting or heating load is connected, it is good practice to withdraw each fuse on the neutral or "dead" pole of the fuseboard in order to ascertain that no direct earth fault has developed on the dead side of the circuit.

If such a fault has occurred, it will be indicated by the circuit remaining unbroken when the fuse is removed, also the arc which takes place when a fuse is normally withdrawn will be absent. If only a partial earth exists, there will be a considerable volt drop across the circuit, which will be indicated (in the case of lighting circuits) by a reduction in brightness of the lamps; also the arc obtained when withdrawing the fuse will be very small.

If such an earth is discovered, especially if it be a direct to earth fault, it should be removed as soon as possible, because, should an earth also develop on the "live" side of the same circuit (which does occasionally happen) the sub-circuit fuses will invariably blow with such violence as to split the fuse-carriers and bases, in addition to blobbing up the contact fingers and making a renewal immediately necessary. The fuse in the main distribution board feeding the sub-board will also blow on the dead side.

A fault of this nature on a sub-circuit carrying only 5 amps. will pass sufficient current to earth to blow a 50 amp. main fuse.

How to Obtain Single-phase from a Three-phase Supply

By J. V. Brittain, B.Sc., A.M.I.Mech.E., A.M.I.E.E.

NOW that three-phase alternating current is standardised as the method of generating and supplying electrical energy it is necessary in certain instances to obtain single-phase supplies from three-phase.

For Small Loads.

For small loads this is a fairly simple matter as by using the 4-wire system of distribution three single-phase loads can be obtained. With this method, however, we must have *three* loads and these loads must be roughly balanced (i.e. they must be approximately equal). On this account it is used for supplying lighting, heating, cooking, etc., but it is not suitable for medium and large loads which require single-phase.

For Medium and Large Loads.

If, for instance, we require single or two phase for an electric furnace some system of transformation is essential. Another instance where the problem arises is when a number of consumers are supplied with single-phase by means of a 3-wire system. It may be much cheaper to convert the three-phase into single-phase than to alter all the distribution equipment so that it is suitable for three-phase.

It may, therefore, be of interest to review the various methods of obtaining a single-phase supply and in particular to explain the "Scott" method of converting from three-phase to two-phase which will give us two independent single-phase supplies.

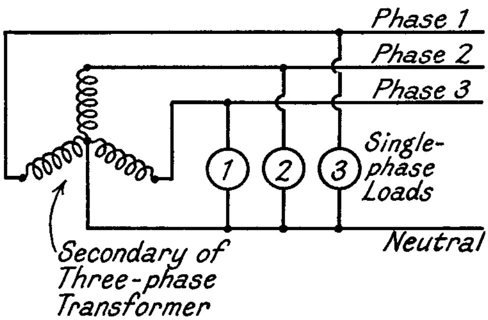


Fig. 1.—4-wire Method of Supplying Single-phase Loads from 3-phase.
This is the standard method of supplying energy for lighting, heating, etc.

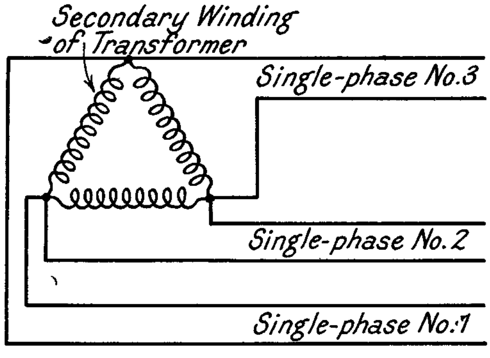


Fig. 2.—Method of Obtaining Three Single-phase Supplies from the Delta-connected Secondary of a Transformer.
As with Fig. 1, three separate loads are necessary.

The 4-wire System—Star-connected Secondary.

The 4-wire system is given in Fig. 1, where the star-connected secondary winding of a transformer enables three single-phase loads at 230 volts to be taken from it. If these three loads are equal there will be no current in the neutral, but if they are not equal the neutral will carry the out-of-balance current. It is, of course, impossible to have the three loads exactly balanced, but as long as the differences are not too great this does not matter. Normally, there are a large number of small loads on each phase and these are arranged to balance up fairly well.

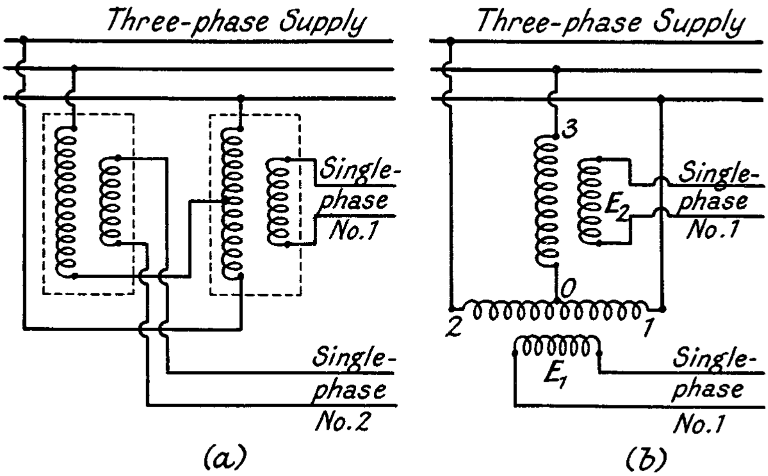


Fig. 3.—" Scott " System of Transforming 3-phase to Single or Two-phase.
Diagram (*a*) shows how the two single-phase transformers are connected. Diagram (*b*) is the theoretical diagram.

Why There Must Be Three More or Less Equal Loads.

On account of voltage regulation, one or even two large single-phase loads by themselves cannot be supplied by this method. The fact that there is no current in the third phase throws the load out of balance, so that unless three more or less equal loads can be found some other method must be used.

Delta-connected Secondary.

The same difficulty occurs with a delta-connected secondary, as shown in Fig. 2. As will be seen, this again requires three separate loads which must be approximately equal. This system is, however, more suitable for supplying large single-phase currents at low voltages.

The " Scott " System of Transformer Connections.

The " Scott " system of transformer connections was introduced by Dr. C. F. Scott some time ago and has been in use to a limited extent since its introduction. It is, however, coming much more into prominence and it appears likely that the system may be adopted in a large majority of cases where single-phase is required. The general principle will be seen by reference to Fig. 3, which shows the actual connections.

The Connections.

Two single-phase transformers are used for this method of transformation and the actual connections are as shown in Fig. 3A, while the theoretical diagram of connections is given in Fig. 3B. By comparing the two diagrams it will be seen that the two primary windings are connected to form a " tee " by connecting the end of one primary to the centre of the other. The two secondary windings will then each give a single-phase supply.

Number of Turns on Primaries Must Be Different.

A simplified vector diagram is given in Fig. 4 where OV_{12} OV_{23} and OV_{31} represent the three line voltages of the three-phase supply. The two secondary voltages are given by OE_1 and OE_2. The voltage OE_1 will be produced by OV_{12} while OE_2 will be due to OV_{31}. There is, however, a phase difference between OE_2 and OV_{31} of 30° and thus the voltage value of OV_{31}

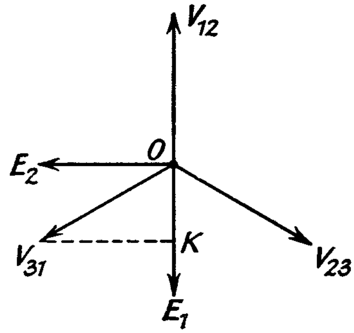


Fig. 4.—Approximate Vector Diagram for Scott Transformation.
V_{12}, V_{23} and V_{31} = 3-phase supply. E_1 and E_2 = single-phase supplies.

for our purpose is KV_{31} which is equal to $\frac{\sqrt{3}}{2} \times OV_{31}$. This means that the number of turns on the winding 03 must be less than on winding 21, the actual ratio being $\frac{\sqrt{3}}{2}$ or 0.866 to 1.

An Example.

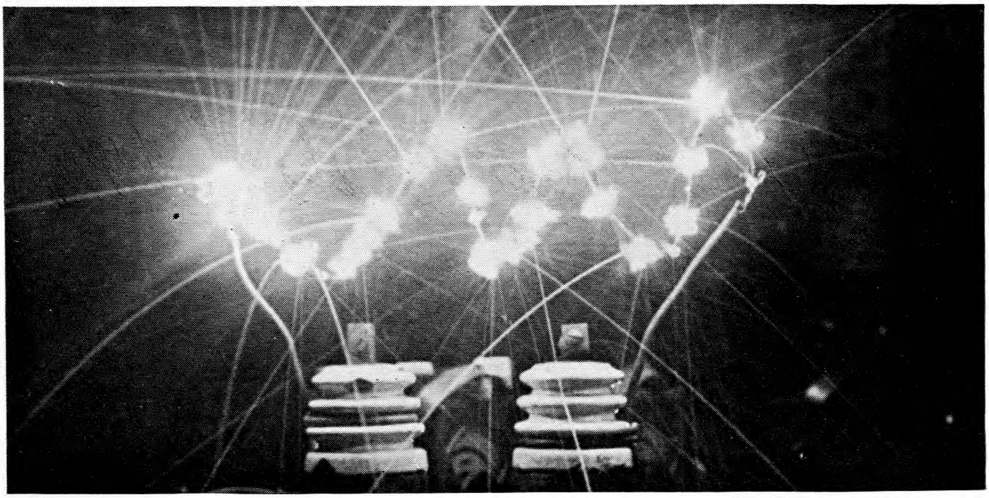
Thus transformers for the "Scott" system have to be specially designed with the same numbers of turns on the secondary but differing for the primaries. Taking as an example a 3-phase H.T. supply from which we require two 230-volt single-phase supplies, one transformer would have to be wound with the ratio of, say, 6000/230 whereas the other would have to be 6000 × 0.866/230 = 5196/230. Also the number of turns on the secondary must be the same, so that it is the primaries which would differ in the ratio of 6000 to 5196.

How Normal Two-phase can be Obtained.

The two single-phase supplies are, as shown in the vector diagram (Fig. 4), at 90° and thus they can be combined to give a normal two-phase supply should this be required. Two-phase is often used for electric furnaces and as these are likely to be used to a larger extent in the future the "Scott" system may become better known than it is at present.

It is also rapidly gaining favour for distribution purposes particularly in rural districts. Where consumers are very scattered a single-phase 3-wire supply is often more economical than a three-phase 4-wire and "Scott" transformers are now being used to give this single-phase supply.

A STRIKING DEMONSTRATION



The accompanying photograph was taken to give a practical demonstration of the action of a high-tension fuse blowing and to show the reason for placing such fuses in tubes and packing each end with french chalk or some such substance.

This immediately damps any arcing and keeps the metal enclosed.

Two wires were joined to the terminals and set about 15 ins. apart and the fuse wire set in zig-zag fashion across them.

When the current was applied the wire melted in several places, but the arc was maintained across each gap until practically all the wire was melted and molten metal was thrown in all directions, the white lines on the photograph indicating the paths of the metal.

The photograph was taken on an Ilford hypersensitive-backed plate and given five seconds exposure in the ordinary electric lights and the current then switched on, at f 8.

Practical Construction of a Copper Bullion Refinery

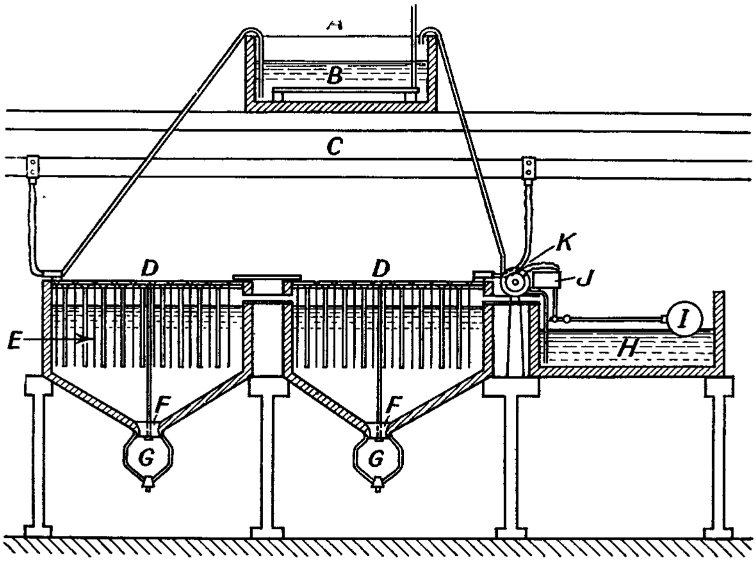
By C. C. Downie

THE majority of the world's copper is nowadays made by the electrolytic method. Refining by smelting has been more or less abandoned because of the slight loss sustained, due to the small proportion of precious metals present which cannot be recovered. Copper is thus mostly obtained by the electrolytic method, but it is doubtful if any authentic practical information has dealt with the plant employed for the work. The following details are taken from the plant in use to-day.

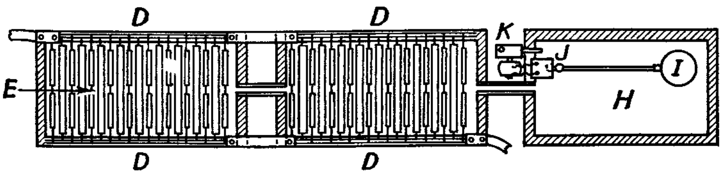
Setting up the Plant.

The object of working this particular class of plant is to recover the copper in the purest possible condition obtainable, and also reclaim any small amount of precious constituents which may be present. The plant consists of a series of stoneware troughs which are lined with lead to prevent any chipping of the glazed surface by careless handling of the cathodes or anodes.

These troughs are usually set up a few feet from the level of the floor, so that the anode deposit which accumulates at the bottom may be removed with ease. The troughs have an average capacity of 65 gallons. A storage tank is constructed at the side of the troughs to collect the surplus electrolyte. A pipeline connects this to another similar tank situated overhead wherein the electrolyte is heated. That is, in setting up the



Elevation of Electrolytic Copper Bullion Refinery.



Plan of Troughs and Storage Tank.

Fig. 1.—Elevation and Plan of Electrolytic Copper Bullion Refinery.

A, Overhead storage tank; B, Steam coil; C, Bus bars; D, Copper strips; E, Anodes and cathodes; F, Rubber bung; G, Glass bottle for collecting anode deposit (gold, platinum, silver, etc.); H, Storage tank; I, Ball cistern; J, Mercury switch; K, Centrifugal pump and motor.

initial layout, a wooden construction has to be made to house these in their proper position and alignment. The troughs and storage tank are maintained at the same level, so that the electrolyte flows from one to the other by a connecting chute.

The troughs are rectangular in shape with the bottoms made conically, so that all deposit accumulates at one point.

Specially made glass bottles are fitted at this point, which are sealed by closely fitting rubber bungs. Whilst the electrolysis is in progress the bottles remain empty.

A lead rod is attached to the respective bungs which protrudes above the level of the troughs. When the electrolysis has been completed, the bungs are removed from the necks of the bottles by raising the rods, whereby the accumulated anode deposit flows therein, together with some accompanying electrolyte.

The Generator and Bus Bars.

The generator, switch gear, panels, and cables are set up on the same lines as that of constructing a large plating shop.

Space economy is one of the features of the layout, and it is customary to have the motor-generator housed in a basement below the electrolysis floor. The leads from the generator are connected through the floor to the panels situated beside the electrolysis troughs, and on which are attached the ammeters, voltmeters, etc. From thence the connections are made to the bus bars. The latter are arranged above the troughs, and so fitted that a large number of troughs may be linked up if desired.

Copper bus bars were used, although aluminium was recognised as being better suited to resist corrosive influences.

As the overhead storage tank has to be connected to the storage tank which is level with the troughs, care has to be taken in fitting up the bus bars that proper spacing is allowed.

The overhead tank has to be fed with surplus electrolyte, and also steam to heat it, and these pipes have to be arranged so that they do not interfere with the bus bars. This is not of the same account with small electrolysis plants, but is of importance in the construction of large plants, as is readily observed where repairs have to be made on short notice.

The Electrolysis Troughs.

The electrolysis troughs are fed with an electrolyte consisting of 16 per cent. copper sulphate and 10 per cent. sulphuric acid.

The electrolyte flows continuously to the storage tank, and when a predetermined level of liquor has filled the latter, a ball-cistern arrangement which is connected to the tank operates a mercury switch. This in turn connects the current to the motor of a small centrifugal pump which raises the surplus electrolyte from the storage tank to the one above. The ball-cistern, mercury switch, and small centrifugal pump thus work automatically and continuously night and day, and require little or no attention once they have been set to meet the desired level of liquor.

The overhead storage tank simply consists of a lead-lined wooden tank which is heated by a steam coil. The heat must be such that the temperature of the electrolyte in the troughs is maintained at 50° C. The electrolyte should be bright green or bluish-green in colour. When the copper electrolysed is unduly impure, and particularly if it contains appreciable quantities of tin and antimony, the electrolyte will become cloudy and opaque.

Polarisation losses would be sustained if too much of these impurities were present, and they are expected to be chiefly removed during the initial skimming of the copper before it has been cast into anodes.

Casting Anodes and Cutting Cathodes.

The preparation of anodes and cathodes is done on the same lines as that adopted for large copper refineries. All scrap copper can be melted up and cast into anode moulds and used for this process. Where the work consists of recovering precious metals, more care is accorded to selecting the scrap, and it is principally composed of old rings, brooches, watch-cases, pendants, etc., etc. These are melted in plumbago crucibles in pit-fires and poured into flat-shaped iron moulds. At the moment when the molten copper is solidifying in the mould, two small bent copper wire hooks are inserted, and are thus fused to the top of the ingots. In this way the cast anode is ready for directly hanging from the copper bars which stretch across the electrolysis troughs. The cathodes are cut from sheet copper, and the work is usually left in the hands of some local sheet-metal worker. These are usually 1½ ft. in length, 1 ft. broad, and about $\frac{1}{16}$ in. thickness. Too thin cathodes are liable to bend out of shape, or become affected by the passage of the flowing electrolyte, otherwise much thinner metal could be employed.

Such troubles would lead to high resistance losses.

The cathodes are cut out, and the tops bent over so that they may be slung from copper bars which alternate with those used in the troughs for the anodes.

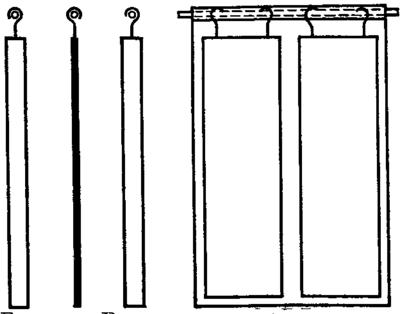


Fig. 2.—Position of Anodes and Cathodes During Electrolysis.

System of Closely Connecting Anodes and Cathodes.

The cast copper anodes and the cathodes cut from sheet copper are hung from their respective copper bars which are placed across the troughs. These latter connect with copper strips running along the sides of the troughs, and which are insulated.

That is, it is customary to have a large number of anodes connected in parallel alternating with a large number of cathodes similarly connected. The cast anodes are slightly less than 6 ins. in breadth, and about ½ in. in thickness. The square area of the anodes is thus slightly less than that of the cathode sheets. As the electrolysis progresses, the anodes get corroded to a thin shell, whilst the cathode in turn increases in thickness from $\frac{1}{16}$ in. to about ½ in. The space which exists between the anodes and cathodes does not change.

This is arranged at the commencement of the electrolysis at about 1½ ins. Should either anode or cathode become bent, or their position shifted, the resulting refined copper will be furnished as a crudely made slab.

Calculating the Current Required.

The current is applied at 10 amps. per square foot. As there are only 1½ inches between each anode and cathode, a very considerable number of electrodes can be introduced to each trough.

The amount of amperage required from the motor generator is thus calculated by multiplying the square area in feet by ten.

The maintenance of the temperature of the electrolyte at 50° C. simplifies calculations. The loss in contacts amounts to about 20 per cent. of the total voltage employed. In large copper refineries this is worked out in detail. (The drop from bus bar to anode rod, from anode rod to anode hook, from hook to anode, from anode to cathode, from cathode to cathode rod, and thus back to the bus bar.) The resistivity of the primary electrolyte usually averages about 2.5 ohms. The electrolyte is not allowed to become impoverished in copper, and crystals of copper sulphate are added when necessary to maintain the desired 4 per cent. copper or alternatively 16 per cent. copper sulphate. Using the foregoing resistivity, the voltage works out at about 0.4 volt, by calculation, but in practice this amounts to a much greater figure. The calculations are extensive when done in complete detail, and the figures are checked by readings from the ammeters and voltmeters.

Working the Process.

When commencing operations, the electrolyte is prepared from copper sulphate crystals and sulphuric acid. This is allowed to heat up and flow through the troughs until the temperature has reached 50° C. The anodes and cathodes are hung in position, and the current applied. When it is known that a minute proportion of silver is present in the copper, a fraction of one per cent. of hydrochloric acid is added, which causes it to separate out as silver chloride. Minute proportions of gold and platinum do not require this treatment since, being insoluble, they deposit as the electrolysis proceeds. The anodes become slowly corroded, and the cathodes correspondingly increase in thickness. As the electrolyte is caused to flow by the automatic ball-cistern and mercury switch connection to the pump, the plant works continuously, and practically without the need for attention.

Removing Impurities from the Electrolyte.

Anodes which are rapidly corroded are replaced by fresh ones, and as the electrolyte is continually flowing this does not adversely affect the corresponding cathode immediately opposite.

When the week's work has been completed, the current is disconnected. All precious metals present, including gold, silver and platinum, irrespective of how slight in quantity, have now accumulated into the conical bottom of the troughs.

The rubber bung which is fitted to the neck of the bottle situated beneath the trough is now withdrawn, whereby the deposit is collected. The bung is then replaced and the deposit emptied from below. These anode slimes may contain anything up to 20 per cent. silver and 15 per cent. gold, depending on the class of copper which has been electrolysed. Other classes of copper scrap will yield only trifling quantities of these metals, but their value is so considerable that it is always a paying proposition to recover them as far as possible. The anode slimes are washed in water and transferred to a smelting furnace to recover the metal values.

Current Losses due to Resistances Set Up.

The current losses due to the resistances set up are comparatively small, despite the fact that a variable amount of anode slime is caused to deposit. This latter is small in weight, and the principal resistances more accrue from the presence of tin and antimony. This reflects on the total amount of current consumed. Polarisation losses are reduced to a minimum by the circulation and heating of the electrolyte. The weight of copper deposited almost coincides with the theoretical figure per ampere per square foot. Rich silver bullion and copper which contains more than two per cent. of silver is not so suitable for this process, as the resistances set up are too considerable, and there is a tendency for slime to deposit on the surfaces of the electrodes.

This eventually leads to the current action being materially retarded, and in extreme cases stopping the working of the process.

The primary object of the process is, therefore, the refining of copper, whilst the recovery of the precious constituents ranks more in the nature of a subsidiary process. It is, however, widely used by the smelters of precious metals, who made great use of it during the recent "gold rush."

The Refined Copper.

The cathodes are removed from the electrolysis troughs and washed in hot water, with the assistance of steel brushes.

The surfaces are sometimes a little rough, and nodules appear where undue resistances have arisen. The metal represents the purest form of copper placed on the market, and is widely employed for all classes of electric goods.

The cathodes, being unwieldy in shape, are seldom disposed of in this condition, but are melted up in plumbago crucibles, and made into bars and ingots, etc.

Composition of the Products.

Electrolytic Copper.

	Per cent.
Copper	99.90
Nickel	0.010
Arsenic	0.001—0.006
Antimony	0.005
Iron	0.002
Oxygen	0.030—0.075
Silver	Up to 1 ounce per ton of copper.

Anode Slimes.

	Per cent.
Silver	3—20
Gold	6—15
Platinum	0.01—0.6
Tin	5—15
Lead	8—10
Zinc	10—15
Copper	4— 6
Insoluble	5— 7
Iron	0.3—0.5

Automatic Operation of Mercury Arc Rectifiers

By H. W. Richardson, B.Sc., M.I.E.E., and W. R. Cox, B.E., A.M.I.E.E.

The mercury arc rectifier being a static piece of apparatus is admirably suited for operation in unattended sub-stations; in fact, a manually operated equipment of this type is not often found in practice.

A detailed description of the starting and paralleling sequence will be given for the glass bulb type of equipment, but as the equipment for a steel tank rectifier is very similar, it will not be dealt with in detail.

The Starting and Paralleling of Glass Bulb Rectifiers.

The whole sequence is very simple as no synchronising is necessary, and since the equipment cannot take a reverse current from the D.C. busbars, a very much simplified form of paralleling can be used.

A typical sequence of events is given below and the diagram, Fig. 1, should be referred to when reading the description.

(*a*) Close E.H.T. circuit breaker and start cooling fan.

(*b*) Strike ignition arc.

(*c*) Excitation anodes pick up.

(*d*) Close D.C. circuit breaker.

(*e*) Adjust D.C. voltage.

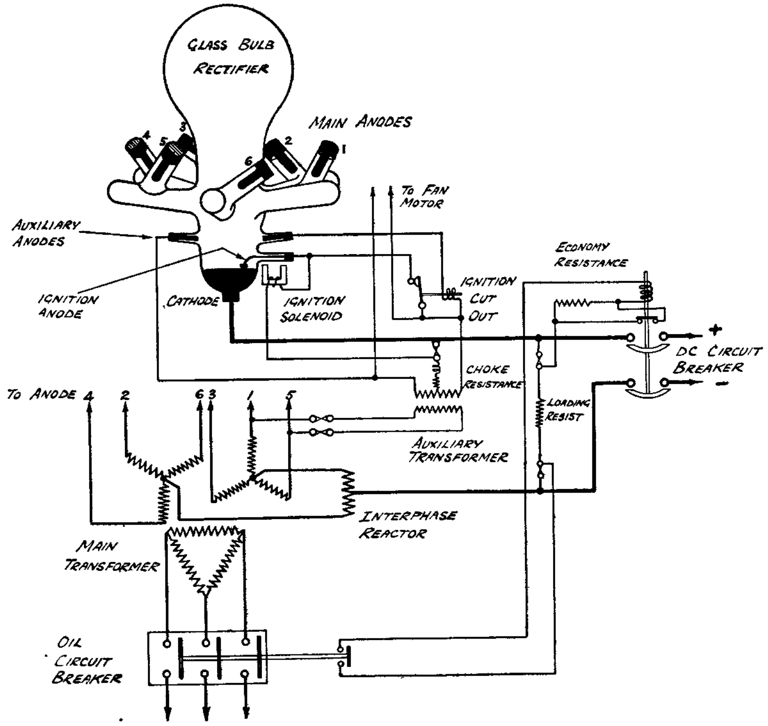


Fig. 1.—Simplified Diagram for Control of a Glass Bulb Rectifier.

Closing the E.H.T. Circuit Breaker.

As in the case of nearly all automatic converting equipments, the closing of the E.H.T. circuit breaker is the key operation which initiates the whole of the automatic starting sequence, and as explained for rotating converters the oil circuit breaker may be closed by :—

(1) Hand operation.

(2) Some form of remote control equipment.

(3) A voltage relay or time switch, etc. (self control).

In all cases, the closing of the E.H.T. breaker energises the main and auxiliary transformers and energises the main and excitation anodes. The fan for cooling the glass bulb is driven by a motor directly connected to the auxiliary transformer. This fan, therefore, starts up as soon as the oil-circuit breaker closes.

Striking Ignition Arc and Starting Excitation Anodes.

The fact that the auxiliary transformer is energised, excites the ignition solenoid which dips the ignition anode into the cathode pool. This operation short circuits the ignition solenoid and thus allows the return spring to withdraw the ignition anode from the cathode pool. As the ignition anode leaves the mercury of the cathode the ignition arc will occur and enable the auxiliary anodes to pick up and start rectifying. It will be noted that as the single ignition anode is energised from a single-phase transformer, the anode may be withdrawn from the cathode pool at a moment when the cathode pool is positive with respect to the ignition anode. In such cases no ignition arc will occur, but the gear is so arranged that the ignition anode will be repeatedly dipped into and withdrawn from the cathode pool until an arc does occur. Including any " misfires " mentioned above, the gear seldom takes more than about two seconds to start and frequently starts more quickly, so that the arrangement is quite satisfactory.

Directly the excitation anodes have picked up, the excitation anode load relay will become energised and contacts on this relay disconnect the ignition circuit.

The excitation anodes are left in service all the time the rectifier is on load, and it will be noted that if they should cease to operate for any reason the excitation anode load relay will become de-energised and immediately cause automatic starting again.

D.C. Circuit Breaker Closes.

In order to simplify small equipments, the D.C. circuit breaker is frequently left closed at all times, so that directly the excitation anodes start operation the rectifier will be ready for load. This is possible since the valve action of the rectifier does not allow the flow of a reverse current when the equipment is shut down.

Sometimes, however, it may be thought advisable to open the D.C. breaker when the rectifier is shut down.

In such cases, the D.C. circuit breaker closing solenoid will be connected between the cathode and the neutral point of the main transformer, and will thus become energised to close the breaker as soon as the excitation anodes start operation and enable the main anodes to operate.

Adjustment of D.C. Voltage.

If the rectifier is supplying a traction load, the plant will generally be arranged to operate at a fixed D.C. voltage, provision only being made for varying this voltage at infrequent intervals by means of an " off load " tapping switch on the main transformer. In such cases, the rectifier will pick up its load directly the D.C. breaker closes and no further operation will be necessary.

If, however, the equipment is supplying a lighting and industrial power supply, some means of maintaining an exact D.C. voltage will be necessary, also to prevent any flicker in the lights when paralleling means must be provided to pick up the load gradually.

Induction Regulation Method of Varying D.C. Voltage.

There are several means available for varying the D.C. voltage and for the purposes of this description it is assumed that an induction regulator is used. The induction regulator will be designed to vary the voltage over the whole working range and the rotor will be motor driven.

Interlocks are provided on the oil switch to run the induction regulator to the position for minimum voltage when the plant is shut down. When the D.C. breaker closes, therefore, the voltage on the D.C. side of the rectifier will in general be lower than the busbar voltage, and when paralleling the rectifier will not pick up any load.

The D.C. voltage is controlled by a voltage regulating relay, which is put into service by an interlock on the D.C. circuit breaker, so that directly the rectifier is paralleled the voltage regulating relay will start correcting the busbar voltage by raising the rectifier voltage, and in so doing the rectifier will gradually pick up load.

While the rectifier is in service the voltage regulating relay operates to maintain the correct D.C. voltage on the busbars.

Shutting Down.

All that it is necessary to do when shutting down is to trip the main E.H.T. oil switch, when the main and auxiliary transformers will de-energise and the main and excitation arcs will be extinguished, the fan will shut down and an interlock will open the D.C. breaker. A further interlock will run the induction regulator to the minimum voltage position.

Protective Devices for Glass Bulb Mercury Arc Rectifiers.

The simplicity of the glass-bulb equipment means that only a few protective devices are necessary to ensure that the plant is properly safeguarded from damage due to faults on the A.C. or D.C. networks or on the converting equipment itself.

Overload.

Both the E.H.T. oil-circuit breaker and the D.C. circuit breaker are fitted with overload devices, which are arranged to shut down and lock out the plant until the station has been visited.

Earth Leakage.

A relay is fitted to shut down and lock out the plant if an earth fault should develop on the main transformer.

Main Anode Fuses.

Fuses are sometimes fitted to the main anode leads.

Failure of Fan.

To prevent the glass bulb becoming overheated and permanently damaged by the failure of the fan motor, a simple type of air flow relay is fitted in the air stream from the fan, and its contacts are arranged to shut down the plant if the air stream fails.

Auxiliary Fuses.

The auxiliary circuits for ignition, excitation, etc., are protected by fuses.

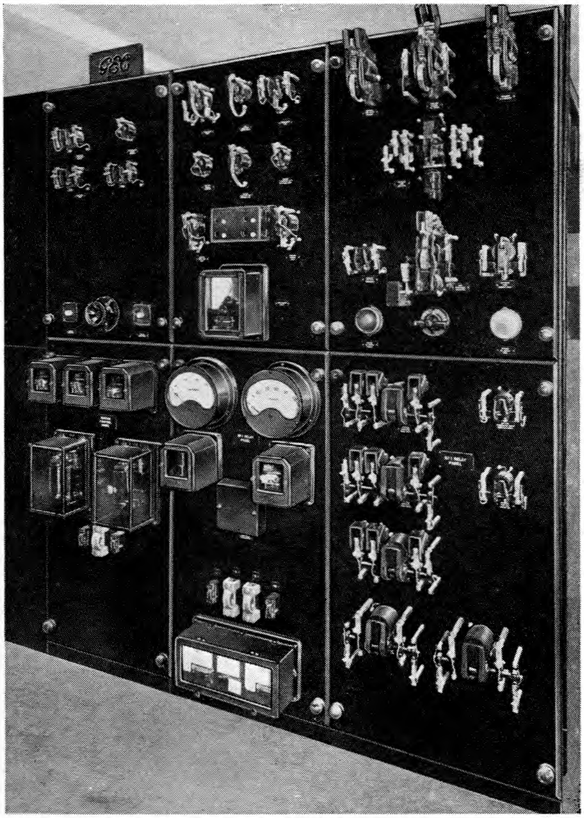


Fig. 2.—Typical Control and Relay Panel for Steel-Tank Mercury Arc Rectifier.

The Starting and Paralleling of Steel-Tank Rectifiers.

Slightly more auxiliary equipment is necessary for a steel-tank rectifier than is required for a glass-bulb rectifier. In the first place, the vacuum is not permanently sealed off and, therefore, vacuum pumping equipment is required, also due to the larger size of units it is generally necessary to water cool the vacuum chamber.

The diffusion pump is nearly always operated continuously, whether the plant is on load or not, but there are various ways of controlling the rotary box-pump, the three commonest being :—

(*a*) To run the rotary box-pump whenever the rectifier is on load and shut it down when the rectifier is off load.

(*b*) To run the box-pump for a short time—say, ten minutes every six or eight hours, whether the plant is on load or not.

(*c*) To fit a contact-making pressure gauge to the interstage reservoir which starts up and shuts down the box-pump according to the pressure in this vessel. All these schemes are quite satisfactory, and it is difficult to say which is the best.

Whatever the water system adopted, it must be started up before the plant is put on load, and this is usually accomplished by an interlock on the main oil switch which closes a contactor, which in turn starts the water pump or opens the valve to the water service. When a closed water system is used, the fan for the water cooler is frequently controlled independently from the water pump by means of a contact-making thermostat in the water system. By this means the rectifier is more easily maintained at its correct working temperature, also on light loads and in cold weather there is a considerable saving in auxiliary power.

Protective Devices for Steel-Tank Mercury Arc Rectifiers.

The protective devices necessary for a steel-tank rectifier are rather more numerous than those required for a glass-bulb rectifier.

A.C. Overload and Earth Leakage protection is the same as for a glass-bulb equipment.

D.C. Overload Protection is frequently omitted, especially on traction plant, but on the D.C. side of the rectifier it is advisable to install a reverse current high-speed circuit breaker in the cathode lead. This breaker is only required when " back fires " occur. A " back fire " is a rare occurrence, but when one does occur, there is a severe short circuit not only on the transformer, but on the D.C. side of the plant, and the flow of D.C. current is from cathode to anode. The function of the reverse current high-speed circuit breaker is to interrupt rapidly the D.C. component of this short in order to minimise any damage it may cause in the rectifier, and also to minimise the disturbance caused on the D.C. network.

Vacuum Failure.

In order to prevent the plant from starting up when there is a poor vacuum in the rectifier and to shut it down should a poor vacuum develop during operation, a vacuum relay is fitted. The operation of this relay will in the first case prevent starting on a demand and in the second case will shut down the rectifier.

Failure of Diffusion Pump Heater.

Should the supply of current to the diffusion pump heater fail for any reason, a current-operated relay in this circuit shuts down the plant or prevents starting.

Failure of Cooling Water for Diffusion Pump.

Should the supply of water for the diffusion pump fail, a water flow relay operates to cut off the supply of power to the diffusion pump heater.

Some manufacturers have developed a thermo-syphon cooled diffusion pump, operating on a closed water system, in which case the above protective feature is not necessary.

Failure of Main Water Cooling System.

Should the main water cooling system fail, the operation of a water flow relay shuts down the plant.

Over Temperature of the Rectifier.

The anode plate of a rectifier is probably the first part of any rectifier which will become overheated by continued overloading. An over temperature relay is, therefore, fitted on or near this plate to shut down the rectifier if the anode plate becomes overheated.

Auxiliary Fuses.

Auxiliary circuits for ignition, excitation, etc., are as in the case of the glass-bulb rectifier generally protected by fuses.

METHODS OF TESTING MAGNETIC MATERIALS

By B. G. CHURCHER, M.I.E.E.

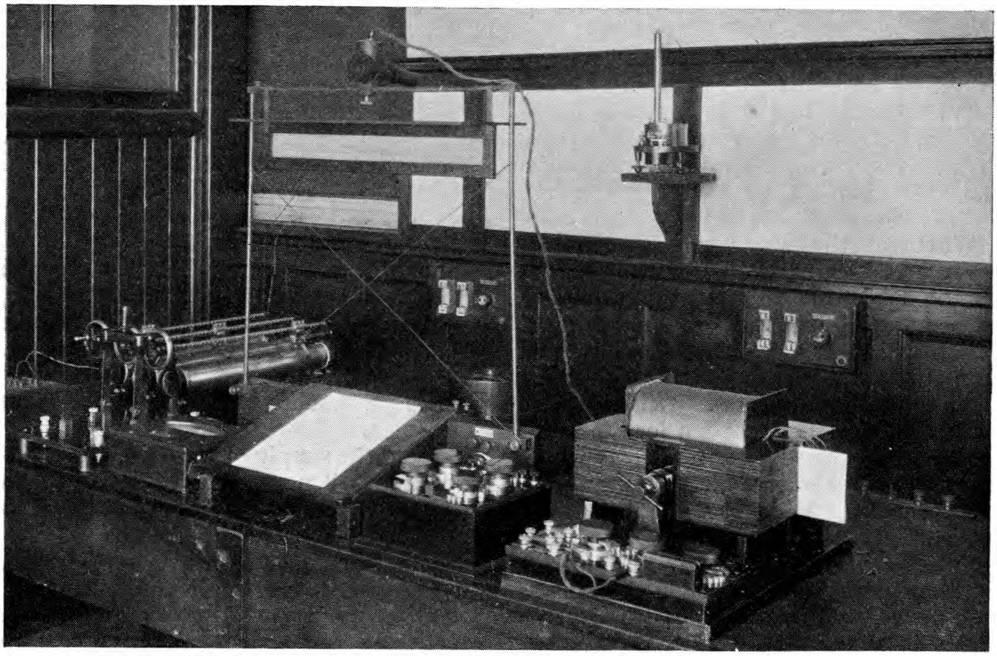


Fig. 1.—APPARATUS FOR TESTING MAGNETIC MATERIALS UNDER STEADY MAGNETISATION, USING SEARCH COILS.

THE importance of magnetic materials in all branches of electrical engineering and the great variety and quantity of materials used creates a need for trustworthy methods of ascertaining their properties. Magnetic materials are used under both steady and alternating magnetisation, and appropriate instruments are required for examining materials under these conditions.

Materials intended for use under alternating magnetisation are made in sheet form so that cores built from the material, such as armature and transformer cores, are laminated. Materials for use under steady magnetisation are usually in the form of rods or bars. Large objects such as forgings or castings are tested by machining off a sample bar of convenient dimensions.

TESTING UNDER STEADY MAGNETISATION.

Properties to be Tested—The Permeability.

If a material is needed simply to carry a steady magnetic flux, the property we require to know is the relation between H, the applied magnetic field, and B, the resulting flux density. The ratio B/H is, of course, the permeability.

The Remanence and Coercivity.

In the case of materials that are required to sustain a steady magnetic flux in addition to carrying it, we have to measure two other quantities. These are the remanence, which is the flux density (B rem.) remaining after the application and removal of the magnetising field, and the coercivity, which is the reverse magnetising field (Hc) required to bring the remanent flux to zero.

Shape of the Test Specimen.

It is most important in all magnetic testing to ensure that the specimen is uniformly magnetised, otherwise B and H values have no definite meaning. The simplest form of specimen to use is a uniform ring. For solid materials this may be either circular or rectangular in section. In the case of sheet material, the specimen is built up from ring punchings, and will therefore be of rectangular section.

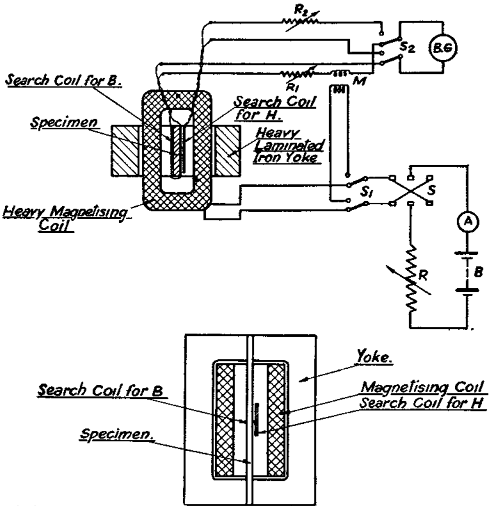


Fig. 2.—How Search Coils are Arranged in Apparatus for Testing Materials Under Steady Magnetisation.

One Method of Testing.

If the ring is wound uniformly over its circumference with a magnetising winding, the applied magnetic field, H, may be directly calculated from the turns per centimetre of circumference and the current. The flux density, B, is measured by a search coil wound closely over the specimen and connected to a suitably calibrated ballistic galvanometer. On reversing the magnetising field by reversing the current, a throw is obtained from which the flux, and hence the flux density, may be calculated.

A Less Laborious Method.

Now it is evident that to make up a ring specimen and to wind on a magnetising winding by hand every time we wish to make a test is a very laborious process, especially if we wish to go to high magnetising fields, which require a great weight of copper. It would be much more satisfactory if the specimen could consist of a machined straight bar or a bundle of strips, the magnetic circuit being completed by an iron yoke and if the magnetising winding consisted of a permanent coil. In using such a method we must ensure that errors do not arise owing to the magnetic reluctance of joints between yoke and specimen and due to the magnetising field not being applied uniformly over a uniform magnetic circuit.

A satisfactory way of dealing with these difficulties has been found in the use of search coils to measure H as well as B. By this means it is possible to carry out the measurement over a short length of the specimen over which uniformity of magnetisation may be secured without difficulty and the effects of joints and yoke eliminated.

Arrangement of Apparatus.

Fig. 2 shows how the search coils are arranged in the apparatus. The specimen, assumed to be a bar of rectangular section or bundle of strips, is placed inside a heavy magnetising coil, the magnetic circuit being completed by a yoke. A battery of accumulators B provides the current supply through an ammeter A, a rheostat R and a reversing switch S to the magnetising coil. Alternatively, the battery can supply current to a mutual inductance M, the use of which will be explained later.

For measuring B, a coil of a few turns is wound closely over the specimen near the centre of its length. It can be shown that H is equal to the flux density in air at the surface of the specimen. We can therefore measure H by placing a thin search coil wound on a strip of non-magnetic material as close as possible to

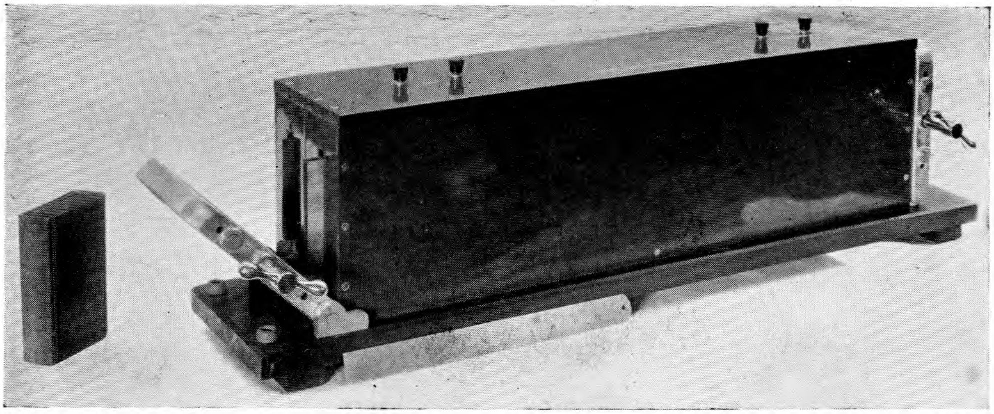


Fig. 3.—Apparatus for Measuring Energy Losses in Samples of Sheet Magnetic Materials Under Alternating Magnetisation.

the side of the specimen. A switch S_2 is arranged so that either the B or H coils may be connected through adjustable resistances R_1 and R_2 to the ballistic galvanometer BG. Fig. 1 shows the actual apparatus.

How to Make a Test.

A test is taken in the following manner. The magnetising current is adjusted and the galvanometer connected to the B coil by means of S_2. The current is then suddenly reversed by S. This reverses the flux in the specimen, which causes a momentary current to flow through BG which is proportional to the flux reversed. By noting the deflection of BG, the flux, and hence B, can be deduced.

The H coil is then connected to BG by throwing over S_2 and the same value of magnetising current again suddenly reversed, the BG deflection being again noted. From this the value of H acting at the central part of the specimen can be deduced. The process is repeated for increasing values of current until a complete B—H curve is obtained.

The H coils are easily calibrated by being placed in a field of known strength set up in a solenoid. The field is reversed and the galvanometer deflection noted. The calibration for the B measurement is obtained by injecting a voltage corresponding to a known flux change into the galvanometer circuit by means of M.

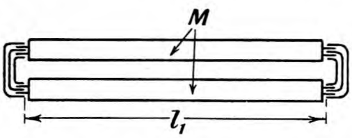


Fig. 4.—How Specimen Strips of Steel Are Inserted Into the Two Coils.

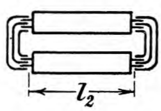


Fig. 5.—Arrangement for Measuring Total End Losses.

The remanence and coercivity of magnet steels may readily be obtained by a slight modification of the connections. The apparatus shown in Fig. 1 is capable of testing either bar or strip specimens at magnetising fields from H = 0.1 to H = 2,500, the latter being sufficient to saturate nearly all materials.

TESTING UNDER ALTERNATING MAGNETISATION.

Measuring Energy Losses.

It is well known that when a magnetic material is magnetised in an alternating field a loss of energy occurs, partly due to hysteresis and partly due to eddy currents. An accurate knowledge of these effects is necessary in the design of many types of electromagnetic apparatus, such as generators, motors, transformers and so forth, so that means of measuring the energy losses in samples of sheet magnetic materials is of considerable importance. Fig. 3 shows an apparatus for this purpose.

Sixteen strips of steel, 4 inches wide by 30 inches long, are cut to form a specimen, and eight are inserted in each of the two long coils shown in Fig. 4. The magnetic circuit is completed by interleaving at the ends U-shaped pieces of low energy loss material. These are seen in Fig. 3.

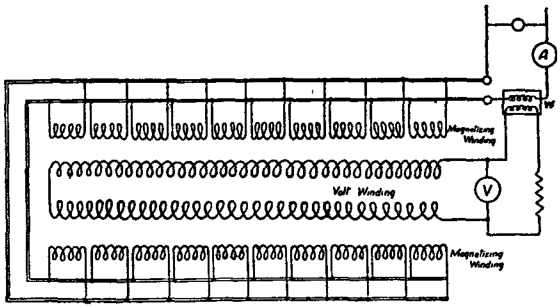


Fig. 6.—CONNECTIONS FOR MAGNETISING SPECIMENS FOR TESTING UNDER ALTERNATING MAGNETISATION.

The Test.

The specimen is magnetised by passing an alternating current through the magnetising winding, the connections of which are shown in Fig. 6. It will be noticed that this winding consists of several identical coils connected in parallel. By this means a very uniform magnetisation of the specimen is secured over its entire length.

A separate volt winding enables the flux density in the specimen to be measured with a voltmeter, and also supplies the pressure coil circuit of a wattmeter which measures the total loss in the magnetic circuit. The volt winding also has the effect of eliminating the copper losses in the magnetising winding from the wattmeter readings. Since the wattmeter reading includes the losses in the U-shaped end pieces and in the joints, the latter losses must be subtracted to arrive at the loss in the specimen.

The total end loss can be ascertained once for all by carrying out a measurement on a full length specimen and then, by means of a set of short coils, on a specimen of shorter length cut from the first specimen, as indicated in Fig. 5. A simple calculation then gives the end loss, and the figure may be used for tests on subsequent specimens of the same general type of steel.

Reducing Effects of Distortion.

A point of importance in all energy-loss measurements is the use of a sine wave of flux rather than a distorted wave. This is secured by using a generator specially designed to give an accurately sine-shaped voltage wave under all conditions of load, and by keeping the impedance of the magnetising winding of the apparatus low. In cases where it is impracticable to avoid a certain amount of distortion, a rectifying voltmeter giving the average value of the voltage rather than the R.M.S. value is used. It can be proved that whatever the wave shape may be, the maximum value of the flux density in the specimen may be obtained from the average voltage, and in this way the effects of distortion are greatly reduced.

METHOD OF OBTAINING AVERAGE POWER FACTOR

Many supply companies now install K.V.A. hour meters in addition to K.W. hour (Unit) meter on large consumer premises and the maintenance engineer can readily obtain the average P.F. As P.F. is equal to $\frac{\text{true watts}}{\text{apparent watts}}$ in any instance, it follows, that by taking the reading of both meters over any determined period and dividing the units consumed by the K.V.A. hours, the result will be the average power factor of the whole plant during the period the readings were taken.

Electro-magnetic Clutches

By H. E. Hutter, A.Am.I.E.E.

The electro-magnetic clutch, like all other clutches, is used for connecting and disconnecting machines from the driving force. Unlike the mechanical type clutch, in the magnetic certain definite disadvantages are not present, and this compensates for the slightly higher price usually demanded.

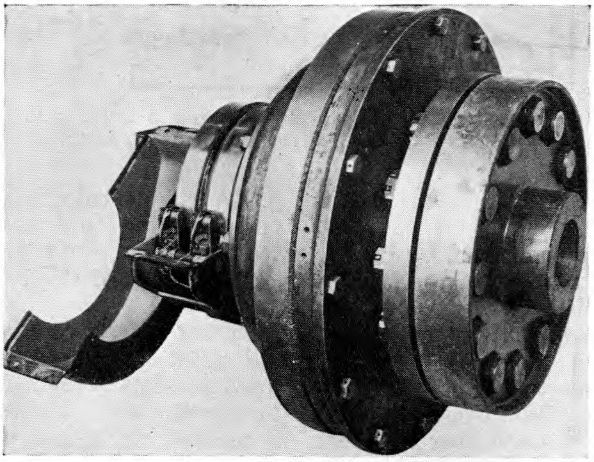


Fig. 1.—A Special Clutch Combined with a Coupling. This is used to couple a centrifugal pump to one side of a 660 h.p. synchronous motor, and, to ensure that the shafts are in line, an essential feature with this type of clutch, a flexible coupling is incorporated in the clutch. The left-hand side of the flexible coupling, which also supports the spring plate, is mounted on ball and roller bearings inside the clutch body. The complete coupling and spring plate are stationary when the motor is running at half load. The clutch takes 11 amps. at 26 volts to energise it, and this current is taken from the motor exciter.

Uses for Magnetic Clutches.

A magnetic clutch can be installed on any drive where reliability of operation is required. The usual mechanical clutch has a number of operating rods and other wearing parts which are dispensed with.

Some typical drives are large synchronous motors driving the main shafting in mills. In this case, the load will possess a very high value of inertia and the motor started up light and the clutch switched on when full speed has been obtained.

The two-speed capstan illustrated is an instance where the light control possible with a clutch is a great advantage, yet at the same time the conditions are very onerous and the little maintenance required with the magnetic clutch is a great advantage.

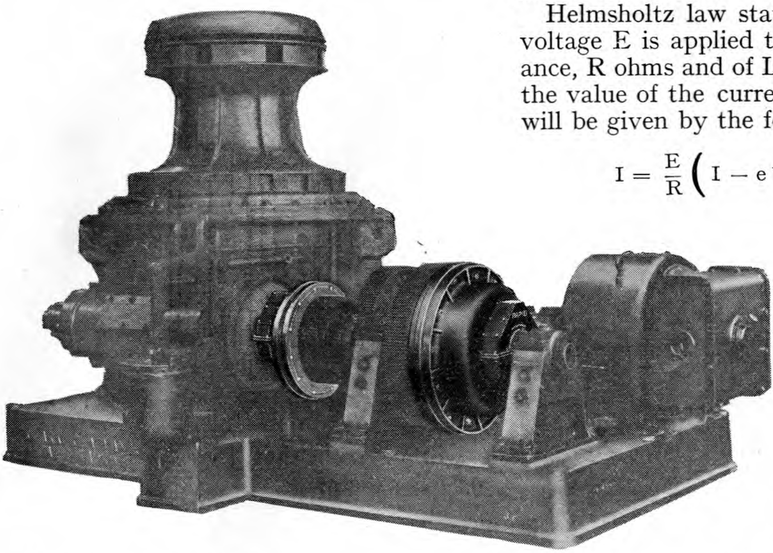
Many types of machine driven from independent motors are fitted with clutches of the magnetic type; push-button control being fitted no mechanical effort is required for engagement. Large power presses in which the clutch would be built into the fly-wheel, forging machines, paper mill drives, rolling mills, especially on the screw-down gear where operation is every few seconds and push-button control is essential are but a few instances. In fact, these clutches can be used in practically every instance where a clutch of some type is needed.

Principle of Operation.

The principle of operation is very simple. The clutch is made in two sections, a magnetising coil mounted in one section provides the pull on the friction linings; current is supplied to this coil by means of two slip rings mounted on the same section as coil.

Advantages of the Absence of Operating Levers.

The direct magnetic action results in



MOTOR-DRIVEN CAPSTAN THE TWO SPEEDS OF WHICH ARE SELECTED BY MAGNETIC CLUTCHES.
The largest clutch is for slow speed and consequently greater torque.

the elimination of all toggles and levers, with consequent reduction in parts liable to wear and get out of order. Again, the absence of all operating levers enables the clutch to be mounted in situations where, while it would be impossible to mount operating rods, the running of two wires is all that is required, Operation by means of apparatus such as float controls or pressure regulators is an easy matter.

Load is Always Picked Up with Smooth Action.

The magnetic clutch always picks up its load with a very smooth action, it being impossible to grab the load. The fact that the winding of the coil has a high value of inductance, being composed of many turns wound on a core built up of high permeability steel, the magnetic flux does not rise to its maximum value as soon as the current is switched on, but takes a definite time varying from a fraction of a second in small clutches to several seconds in the largest.

Helmsholtz Law.

Helmsholtz law states that if a steady voltage E is applied to a circuit of resistance, R ohms and of L henries inductance, the value of the current I after t seconds will be given by the formula :—

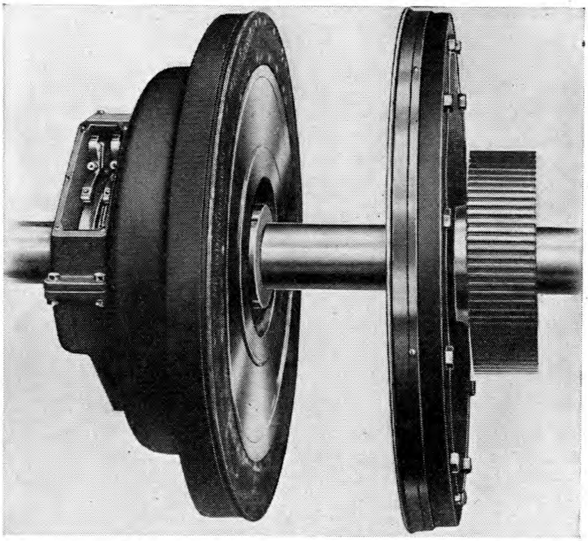
$$I = \frac{E}{R}\left(I - e^{-\frac{RT}{L}}\right) \text{ amps.}$$

e being the base of Naperian logarithms.

As the current does not, therefore, rise to its maximum at once, the magnetic pull will be gradually applied to the friction linings with the result that a gradual acceleration will take place.

Formula for Determining Time Taken to Reach Given Speed.

The time taken to run a given load up to speed when driven by a clutch capable of transmitting a specified torque can be calculated from the formula.



MAGNETIC CLUTCH, SHOWING ARMATURE PINION, FRICTION LINING AND COLLECTOR GEAR.

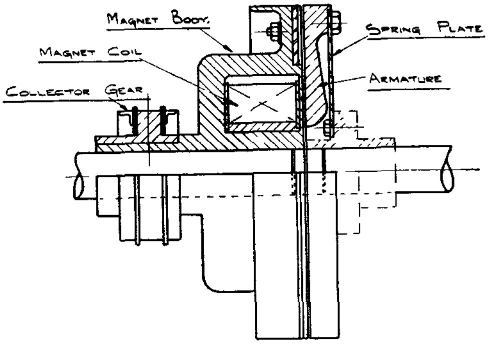


Fig. 4.—SECTION OF MAGNETIC CLUTCH.

Time in secs. to reach given speed $= \frac{0.00326\ W\ n\ K^2}{F\ R}$

Where W = weight of flywheel or mass in lbs.
K^2 = Radius of gyration in feet squared.
n = Required speed in revolutions per minute.
F = Friction force of clutch in lbs.
R = Mean radius of clutch in feet.

The magnet of each size of clutch exerts a definite pull on the armature which, in turn, creates a fixed pressure in lbs. per square inch on the friction lining. The linings are usually of the bonded asbestos type having a co-efficient of friction of 0.4.

Capacity of a Magnetic Clutch.

The capacity of a magnetic clutch is usually given as a certain value in ft.-lbs. of torque which it will withstand without slipping. The basic formula is

$$\text{Lbs.-ft. torque} = \frac{\text{H.P.} \times 5250}{\text{R.P.M.}}$$

It will thus be seen that the power transmitted is directly proportional to the speed, consequently an alternative basis for rating is to state the horse-power per 100 r.p.m.

Selecting a Magnetic Clutch.

The selection of a magnetic clutch is simple from the following table. Assume, for example, that it is desired to transmit 73 h.p. at 430 r.p.m. with peak loads of 110 h.p. As the peak load is the limiting value this must be taken as the basis of selection. The h.p. per 100 r.p.m. will thus be 17, a factor of safety of 25 per cent. must be allowed to ensure that no slip occurs when under load. This gives a h.p. per 100 r.p.m. of 21, and from the table

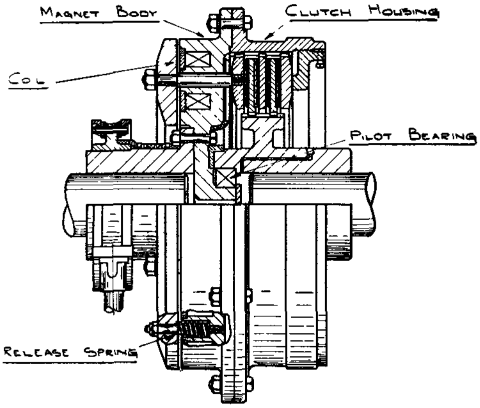


Fig. 5.—SECTION OF 4-DISC CLUTCH.

it will be seen that the nearest size is 20 inches diameter.

Table of Capacities.

The following is a typical table of capacities for which we are indebted to the Rapid Magnetting Machine Co., Ltd.

Diameter in inches.	H.P. at 100 r.p.m.	Pull out torque ft.-lbs.
6	0.3	16
8	0.86	45
10	1.72	90
12	3.05	160
16	11.8	620
20	28.6	1,500
24	51.5	2,700
28	86.0	4,500
32	124	6,500
36	175	9,200
40	221.0	11,600
44	316.0	16,600
48	396	20,800

A Typical Clutch.

A typical clutch is illustrated in section in Fig. 4 and shows the position of the magnetising coil and friction linings. The steel portion of the armature which is attracted to the coil is mounted upon a spring disc which serves the double purpose of transmitting the power and also ensures that the armature will definitely leave the magnet when the current is switched off.

Collector Rings.

Provision is made for taking the current into the coil through two collector rings, as shown in Fig. 3.

Questions and Answers by Practical Men

Readers are invited to send problems of practical interest. Letters should be addressed to " The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2. Envelopes to be marked " Problem " in the top left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTH'S NEW QUESTIONS

Installing Overhead Insulated Conductor Distribution Lines.

In an overhead distribution scheme, consisting of insulated conductors carried on tubular steel supports, how should the conductor be bound to the insulators at the intermediate supports and made off at the terminal supports ? When erecting the conductors, what is the best method of pulling them to tension ? Should an ordinary draw vice be used on the insulated conductor ? Should the conductor be tensioned off between two terminal supports, before being bound in to the insulators on intermediate supports, or is it necessary to pull up each span length separately ?

How can the size, diameter, of tubular steel poles be found to suit different conditions ?

" OVERHEAD " (Middlesbrough).

Generator Calculations.

Can you please give me a formula to calculate :

The rate of change of current in amps. per sec. in a 6 kW., 200 v., 4-pole generator, running at 694 r.p.m. The number of commutator segments is 160 and the brush just covers 2 segments and 1 mica.

Could you recommend me a book of formulæ dealing with electric generators and motors, etc.?

THOMAS MARKS (Cornwall).

Details for D.C. Dynamo.

Can you give me details for making a 4-pole D.C. dynamo, about 100 v. 5 amps., suitable for use with a 3″ bore × 4″ stroke horizontal gas engine (petrol driven)?

W. H. HOWELL (Farnborough).

Action of Rotary Converter Shunt Winding.

I am concerned with the operation of some B.T.H. rotary converters. The machines in question are 1,000 kW., 4-pole, 6-phase (diametrical), and operate on a 25-cycles, 6,600-volt system. They are of the self-synchronising type, with pony-motor in series with rotary, during the starting up period. They supply traction load (600-650 volt D.C.), and are compounded and also fitted with interpoles.

The interpole poles, in addition to their normal series turns, also carry a compensating coil which is placed above the ordinary series turns.

These 4 compensating coils (one to each interpole) are all joined in series and connected as a shunt winding across the terminals of the machine, no rheostat being in circuit with them.

I would much appreciate an explanation of the action of this winding.

The rotaries referred to are not of the synchronous booster type, nor do they possess any induction regulators or external reactances.

" SYNCHRONOUS " (London).

A Question re Neon Advertising Signs.

I have often seen in shop windows a neon tube of circular shape in which the luminous discharge appears to revolve in wave-form manner. Whilst being acquainted with the fundamental facts of neon tube lighting, so far I have been unable to account for this real or apparent motion. I should be greatly obliged if you can answer this problem.

J. CLANCHY (Southampton).

REPLIES TO PREVIOUS QUESTIONS

A Pilot Lamp Problem.

I have under my care a number of electric cookers. Attached to the control board is a pilot light; the lamps used are Philips' 15-watt neon lamps.

I have had several calls to these cookers with the report that the consumer could not get any part of the cooker to work but the light was on.

Upon investigation I found one fuse in the consumer's main switch had blown. Sometimes it was the positive fuse, sometimes it was negative, and it occurs on both A.C. and D.C.

Could you please offer any suggestions as to why the lamp should light with the fuse blown? It does not give full light, but appears to be in series with something.

W. Smith (Ashton).

The explanation of the problem lies in the very small amount of current required to strike a glow in a neon tube of the type mentioned. In the cases which your reader has experienced, this minute current was most probably leaking across the fused particles on the fuse bridges, or possibly the fuse bridges were slightly damp. This would occur whichever pole had fused, or even if both had fused.

I myself have experienced a similar thing when testing with a neon lamp on a 400 volt A.C. circuit in which the fuse bridges were in position, but without any wire across. The lamp glowed brightly although no shock was evident on touching the apparently live ends. This was found to be due to damp on the fuse bridges, these being new and never having had wire in, and the lamp failed to glow when the bridges were withdrawn from the box.

J. S. Mason (Leeds).

Equipment for a Telephone Line.

What size of wire should be used for a telephone line 220 miles long connecting 2 magneto-type P.B. X's with 2,500 ohm drops and five-bar generators? Would loading coils, telephone repeaters or other special apparatus be necessary, and if so, of what type? The lines are to be erected on existing wooden crossarms, on glass insulators spaced 12 in. apart, and it is desired to use MacIntyre joints or some form of connector not requiring soldering.

This line would run through tropical wooded country with a heavy rainfall.

L. H. (Puerto Mexico Ver).

The line should consist of 150 lb. copper. This is the largest size conductor with which unsoldered sleeve joints can be satisfactorily employed. 100 lb. copper tapes and binders will be suitable for binding in. The loop resistance of the circuit would be approx. 4,000 Ω. The route would probably require strengthening, and if the wires are run on the "twist" system with lighter gauge wires there is a liability to contact faults.

The conductors should be terminated at intervals, preferably on double groove insulators, as this speeds up fault localisation. If the wires are run straight, double J or "cow-horn" insulator spindles should be fitted to allow the insertion of transposition crosses.

Loading will be required, the spacing and inductance depending on the cut-off frequency desired and on the standard of insulation resistance which can be maintained. The cut off frequency at $>10{,}000$ MΩ per mile is given by $f_c = \frac{1}{\pi d\sqrt{CL}}$. The natural inductance of the line will be approx. 5 milli-henries per mile loop. Probably 44 m.h. at 10,000 yds. with half section terminations would be satisfactory.

Since repeaters will be necessary it is advisable to consult the leading makers. As only one pair is under consideration a mechanical repeater might be feasible, or it is possible that thermionic repeaters could be built locally. A useful type is the two-wire duplex employing hybrid transformers and balancing networks. The permissible gain of these repeaters and, therefore, their distance apart will depend on how constant the line impedance can be maintained, since singing is set up when line and network become unmatched. Owing to the inefficiency of repeaters at 17 cycles per sec., signalling must be accomplished by using 500 cycles interrupted 17 times per sec., which at the distant end will operate a tuned relay controlling the calling relay.

G. S. Edwards (Amersham).

Meter Rent.

Could you inform me as to whether a Supply Company have any right to charge meter rent to their consumers? In one case I know of they do not charge, and in another case they do.

B. A. Buts (Plaistow).

Legally, no supply authority can force a consumer to pay a meter rent, or to use any particular type of meter. The supply, if metered, must be measured by a meter approved by the Board of Trade; this meter may be provided by either the supply authority or the consumer.

This gives the consumer the right to say that he considers that only a certain type of meter is sufficiently accurate and reliable and that he insists on that make of meter being used to measure his consumption; but in such a case he must provide the meter himself.

Thus the legal position prevents the consumer being made to use a type of meter which he considers is seriously faulty, and it protects the supply authority from the antics of a cantankerous consumer, by requiring that if such a consumer feels he must have a certain meter, then he must pay for his fad himself.

In effect, what the supply authority really say to the consumer is something as follows: "A meter must be provided to ascertain your consumption. We find that the XYZ meter is an accurate and reliable instrument and reasonable in price; as we buy these meters by the thousand we can purchase very much more cheaply than yourself; and, if you agree, we will hire you a meter at a rent based on our low purchase price, and will keep it in adjustment and repair. If, of course, you prefer to buy a meter of your own you are free to do so, but in that case you must pay for the adjustment and repair of the meter yourself."

Naturally, the consumer takes the supply authority's offer.

In some towns in order to encourage supplies being taken, the supply authority will forgo the meter rent for all normal consumers.

"Meter."

A consumer may either provide the necessary meters or hire them from the Supply Authority; the choice rests with the consumer as the following extracts from "The Electricity (Supply) Act 1899" show:—

Section 49.

The amount of electrical energy supplied to any ordinary consumer is to be ascertained by an appropriate certified meter. The consumer may provide his own meter, or he may require the Undertakers to provide the meter on sale or hire.

Section 54.

Every consumer shall at all times at his own expense keep all meters belonging to him in proper order for correctly registering the value of the energy used.

Section 55.

The Undertakers may let for hire any meter for ascertaining the value of the energy used, for such remuneration in money as may be agreed upon between the Hirer and the Undertakers.

Section 56.

The Undertakers shall, unless the agreement for hire otherwise provides, at all times, at their own expense, keep all meters let for hire by them to any consumer, in proper working order for correctly registering the value of energy used.

Practically all Supply Authorities originally charged meter rent; some on reducing their price per unit also reduced their meter rent until no meter rent is charged, the meter being hired to the consumer free. Meter rent may and can be reintroduced at any time.

R. J. S. Curtis (Birmingham).

Electrically Operated Garage Door Opener.

Is there any simple form of electrically operated opener for garage doors? A client of mine who has a garage drive about 30 ft. long has asked me if I can fit some form of door opener which can be operated from the entrance gate or half way down the drive.

T. P. (Torquay).

A sound method is to fit springs to the doors, so that they push them open when a catch is released; fit the catch so that it holds both the doors, and is operated by an electro-magnet or solenoid connected to the power supply by "push" switches fixed in convenient positions. See Figs. 1 and 2.

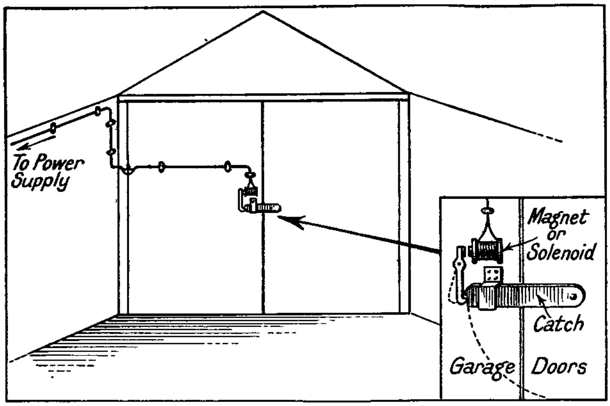


Fig. 1.—The Garage Door Opener.
Showing method of fitting the electro-magnet or solenoid.

Another way would be to open the doors by force of gravity, by fitting a counter-weight, i.e. a weight just heavy enough to pull the doors open when the catch is released.

H. E.

The Fescol Process.

I should be much obliged if you could give any information concerning the electro deposition of nickel and chromium by the Fescol Process for the repair of worn machine parts.

D. F. M. (Lockerbie).

The Fescol process is a patented process for obtaining heavy deposits of nickel, chromium, etc. The process is carried out by Fescol, Ltd., 101, Grosvenor Road, London, S.W. 1.

By means of this process, worn parts or machine-shop scrap can be salvaged. For this purpose nickel is deposited to such a thickness that the part may be machined after deposition to the original size. An exceptional degree of adhesion is obtained between the deposit and the base metal.

Tests carried out by the National Physical Laboratory have shown that when nickel deposit is sheared off the break does not occur at the nickel/steel joint, but that the steel breaks away and remains adhering to the deposit. Nickel deposits of any thickness can be obtained by this process.

Experience has shown that parts repaired by Fescolizing with nickel often gives better service than a new part.

Chromium is not usually used for the restoration of worn parts as the maximum commercial deposit is approximately .008 in. Chromium, as deposited by the Fescol process, has a Brinell hardness number of 800/1000, and is generally applied to new parts where an exceptionally hard-bearing surface is required.

This process should not be confused with ordinary electro-plating practice, where only thin films of metal are deposited. Electro-plated deposits are often non-adherent and useless for engineering purposes.

The Fescol process also has the advantage of being a cold one, and at no time during treatment does the part reach a higher temperature than 180° F. As a result of this no distortion or alteration of the structure of the base metal can take place.

In addition to nickel and chromium, copper, cadmium (for rust-proofing) and lead are also deposited by this process.

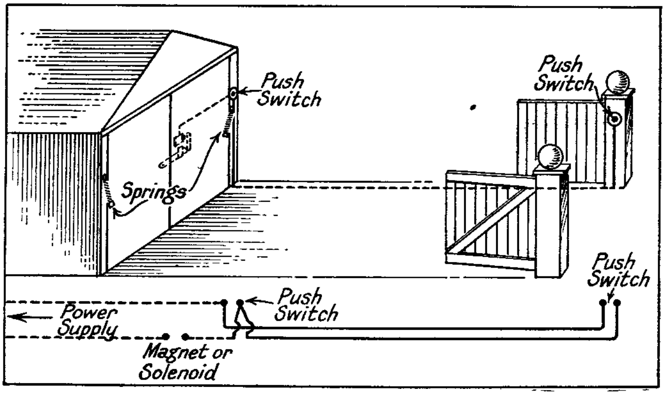


Fig. 2.—The Garage Door Opener.
Showing arrangement of push switches.

Winding Small Motor Armatures (see page 542)

The PRACTICAL ELECTRICAL ENGINEER

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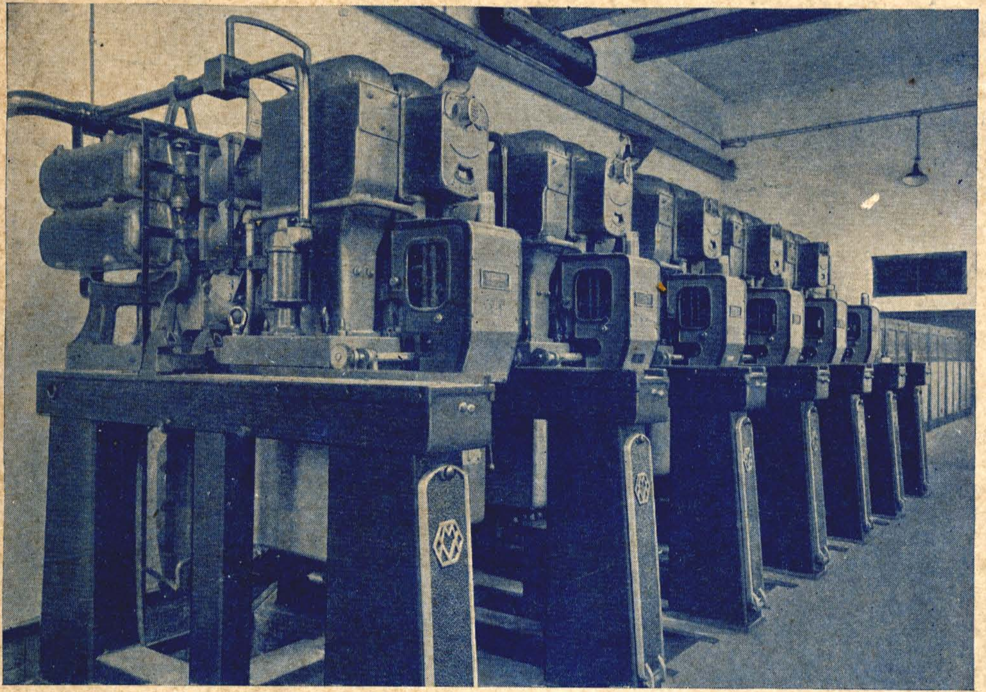
VOL. II.—No. 24

AUGUST, 1934



METAL-CLAD SWITCHGEAR

See article by Mr. W. A. Coates, M.I.E.E., on page 520

INDEX TO VOLUME II

Included in this Issue

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AUGUST, 1934

PRACTICAL ELECTRICAL ENGINEER

No. 24

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

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As reported elsewhere in this issue, Sir William Ray in his recent address to members of the Electrical Contractors Association at the Buxton Conference pointed out that it was essential for the rapid development of the Electrical Industry for the Electrical Contractor to work in co-operation with Municipal Undertakings. Many contractors have a grievance that wiring installation is being undertaken by the Municipal authorities in their own areas.

If Municipal Wiring Were Made Illegal.

Let us suppose for a moment that an amendment to the Electricity Supply Act was brought into being, rendering it illegal for Supply Authorities to compete in this way with electrical contractors. What would be the result?

Undoubtedly there would be an immediate influx in skilled and unskilled men into the wiring and contracting side of the Electrical Industry. Mushroom companies would spring up all over the country and for a few years, whilst the development was in progress, there might be reasonable prosperity, although price cutting might keep profits down to somewhere near vanishing point.

Looking Ahead.

After four or five years, when the bulk of potential consumers premises had been wired, the contractor would find himself in competition with perhaps double the present number of firms in his own district. Under the existing conditions no such influx need be feared, and even those contractors who operate in districts where they have to compete with the Municipal Undertaking will find that their clientèle, or at least their potential clientèle, is increasing year by year.

A Large Grid Controlled Rectifier.

A grid controlled mercury arc rectifier rated at 16,500 kW., 500 volts, 30,000 amps. is now in course of manufacture by the A.E.G. for installation in a large dye works at Bitterfelt, Germany. This is claimed to be the largest unit of its type yet designed. Note the enormous current output which, assuming a working current density of 1,000 amps. per square inch, would require cables approximately 6¼ in. diameter core to carry it.

Can Supply Undertakings Supply Wireless?

Last month we gave a brief reference to a new system of relaying broadcast programmes using electricity supply mains. A Bill has now been presented to the House of Commons by Mr. W. S. Liddall, M.P. for Lincoln, under which it is sought to confer the necessary Powers on Authorised Electricity Undertakers whereby they will be empowered to make arrangements for the relaying of wireless programmes over their electricity supply systems, and it is hoped that the requisite Powers will be conferred by Parliament next Session. The object of the Bill, now presented, is to remove the doubt which exists as to the Powers of the authorised undertakers to permit the use of their electricity supply systems for the transmission of wireless programmes. It is claimed that this new system of listening will entirely eliminate annoyance due to electrical interference.

Iron-selenium-platinum Photo Electric Cell.

We understand that the National Physical Laboratory have recently developed a new type of photo-electric cell consisting of an iron plate coated with selenium covered with finely divided platinum. The new cell is stated to be very suitable for use in electrical photometers and similar apparatus.

Electricity in Ship Propulsion.

The use of electricity for ship propulsion is becoming more and more important. On Monday, July 2nd, the Diesel-electric vessel "Loch Nevis" was put into service on the Mallaig-Portree route. There is a tendency amongst shipowners to replace obsolete vessels by electrically driven vessels. The problems of electrical control on ship installation are entirely different from those met with in land practice and we are, therefore, dealing with this subject in the present issue in an article beginning on page 532 entitled "D.C. Equipment of Electric Ship Propulsion." We hope to follow this by further articles covering different aspects of the problem. All these articles are written by one of the leading authorities on this specialised branch of electrical work.

A Non-Magnetic Watch for Electrical Men.

We have received from Messrs A. Arnold & Co., of 122, St. John Street, Clerkenwell Road, London, E.C. 1, one of their appointment alarm watches for test and review. This watch, which is suitable for desk or pocket use, has an alarm hand which can be set at any desired time. A tiny bell inside the watch rings an alarm at the predetermined time. This watch serves the double purpose of an alarm clock by night and an appointment alarm watch by day, and should be useful to busy electrical engineers; the action is unaffected by magnetic fields. Messrs. Arnold will be pleased to send further particulars on to any reader on receipt of a postcard at the address given above.

Designing an Electric Wiring Installation.

In view of the increasing importance of installation work the article which begins on page 515, and which is written by Mr. Winton Thorpe who has specialised on this class of work, is of particular value not only to men already engaged on the contracting side of the Industry, but also to those who may have occasion at some later date to turn their activities in this direction.

Electric Welding Has Come to Stay.

We have previously referred to the growing use of electric welding in all kinds of engineering, constructional and repair work. The article beginning on page 527 gives an interesting survey of the possibilities of arc welding and much practical information regarding the methods which should be employed to get the best results.

Readers engaged in engineering works of any kind will find that the time spent in perusing this article is well spent. Some of the largest engineering firms in the country are using fabricated (i.e. welded) steel construction for machine parts which formerly could only be made from expensive castings. Move with the times, and apply the latest and best practice to your own engineering problems.

Our Second Volume.

This issue completes the second volume of the Magazine and in response to requests we have devoted some space in the present issue to a complete Index of Nos. 13 to 24. For the convenience of many readers who wish to have their volumes bound into permanent form for reference, Messrs. A. W. Bain & Co. are making a special offer which is announced elsewhere in this issue.

Have You Kept Your Back Numbers ?

We have been surprised at the number of occasions during the past few months where new readers have asked for information on a specific subject and we have been able to refer them to back numbers containing an article giving precisely the information. In view of the very large amount of valuable information contained in the present volume *we advise all readers to have their sets bound without delay.* The bound volume will make a handsome as well as a useful addition to the technical section of your library. If you send issues Nos. 13 to 24 to Messrs. A. W. Bain & Co., Ltd., 17, Bishops Road, London, E. 2, together with your name and address and a postal order for 5/6 they will complete the work in first class style and at very moderate cost and return the volume to you carriage paid. If you have one or two issues missing from your set enclose an extra shilling for each missing part and your set will be made up by the binders.

Questions and Answers by Practical Men.

We still continue to receive every month many more questions than we can possibly find space to answer in our editorial columns, and it is evident that this is one of the most popular features of the Magazine. Several readers have suggested that we should have a more frequent publication at a lower price. This question is receiving very careful consideration. If you have any practical problems connected with any branch of Electrical Engineering we shall be pleased to hear from you. Address your queries to :—

The Editor,
"THE PRACTICAL ELECTRICAL ENGINEER,"
8/11, Southampton Street,
Strand, W.C.2.

Designing an Electric Wiring Installation

By D. Winton Thorpe, A.M.I.E.E.

THE purpose of this article is to examine the initial stages to be passed through when an electrical wiring installation is born. The affair may be approached in so many different ways that the only possible method of treating it here is to assume one particular method and to follow it through on those lines.

The First Consideration—What is the Load Going to Be?

Before we can stir a finger, we must be in a position to know what form the service will take; in general this means, to-day, whether it is to be single-phase or three-phase service. This in turn cannot be ascertained until we are in a position to let the supply authority know what the load will be. The load on any wiring installation is determined by the customer's or the architect's requirements.

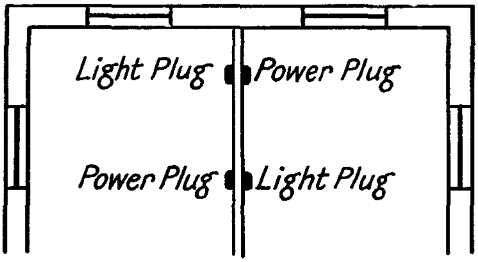


Fig. 1.—A Bad Arrangement of Points. If circumstances permit, let the light plugs be back to back and also the power plugs.

What Points Are Required?

Therefore, the first step must be to get a set of plans of the building, if such are available, and to ask our customer or our architect to mark on those plans exactly what outlets for the use of electricity he requires. Maybe he has few ideas on the subject and asks us to mark on the plans what we think should be there. Now whether the customer, the architect or we ourselves should take this work in hand, three questions must be applied at every turn—what is necessary, what is desirable, and what is perhaps a pleasant luxury?

We must get right out of our minds—and more important still, right out of the mind of our customer or architect—that lighting points represent the only form of outlet for electricity. While writing this article I have just glanced at a plan which lies on my drawing-board. It is a plan of some fairly typical London flats, and I find that each flat contains the following outlets: Lighting points, lighting plugs (5 amp.), heating points, heating plug points, cooker points, radio points, refrigerator points, bell points, intercommunicating telephone points, clock points, post office telephone points (tubing only), and there is little doubt that at this stage of the proceedings something may have been forgotten. All these possibilities then must be prominent in the mind of the electrical engineer and must be brought into prominence in the mind of the customer and his architect.

Placing the Points in the Best Positions.

Having by some means or another finally settled what allowance of outlets of this sort each room in our building requires, it then again becomes our job, in combination with the customer's or architect's views, to put them into positions which at once satisfy the requirements of the customer and make for the most economical wiring lay-out. As an example of what is perhaps a rather elementary fault, but one which is nevertheless made quite frequently, due to carelessness in the initial stages, I have given here a little sketch (Fig. 1) showing two rooms divided by a comparatively thin partition, in which a 5-amp. plug on one side of the partition backs on to a 15-amp. plug on the other side and vice versa. If the requirements of the room permitted—and in most cases it will be found that they do—how much better to apply our knowledge of wiring practice and see that the two 5-amp. plugs are back to back, thereby allowing them to be served with at least one run of tube and possibly with one pair of cables only, looped from plug to plug.

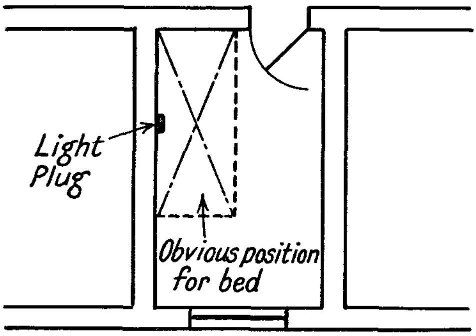


Fig. 2.—AN ABSURD PLACE TO PUT A LIGHT PLUG.

There is only one reasonable place for the bed and the plug should be adjacent *but not underneath it.*

Anticipate the Position of the Furniture.

Again, in another sketch (Fig. 2), I show a little bedroom in which there is only one possible position for the bed, yet the plug intended to serve the reading lamp has been placed in such a position that when the bed is in the room it will be quite inaccessible. It may be argued that to forecast the position of furniture is not our function so much as that of the customer. This may be so, nevertheless with our daily experience of installing 5-amp. plugs, we are in a better position to anticipate such matters than the customer who may only have his house wired once in his lifetime.

Here again is a bedroom (Fig. 3) in which we may normally anticipate that the dressing-table will be placed in or adjacent to the big bay window, yet we have omitted to provide either a ceiling point over the dressing-table or a plug point from which a light may be taken for the dressing-table. It may be that it is very reprehensible of our architect not to have thought of this himself. But we can materially increase our reputation in his eyes if we think of these little things for him.

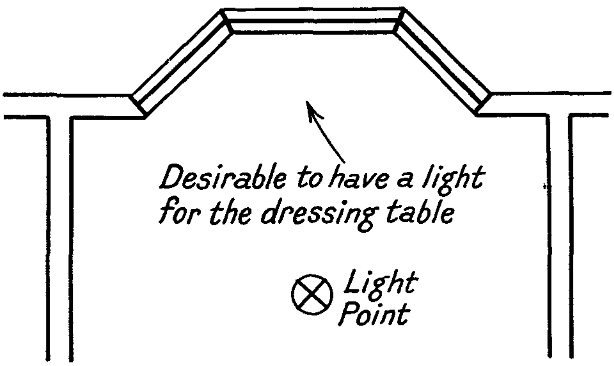


Fig. 3.—A BEDROOM WITH A BAY WINDOW USUALLY REQUIRES A LIGHT IN THE WINDOW FOR THE DRESSING TABLE.

How to Make a Schedule of Points.

Finally then we have established agreement between all the parties—the customer, the architect and ourselves—as to what points are necessary and where they are to be placed. Now we can make a schedule of points. There are various methods of doing this, but by far the best to my mind and probably by far the most commonly used is that of tabulating the rooms in column form as shown (Fig. 4). Here we have noted against each room how many ceiling points it has, how many bracket points it has, how many switches, how many, in fact, of each type of outlet or accessory. At each floor we can make a total brought forward to be added to the total of the next floor, so that finally we have a grand total showing precisely how many points we have in each category.

Estimating the Total Connected Load.

Either by allowing an average loading per lighting point, such as say 60 watts per point, or alternatively, and in greater detail, by adding a final column to our table so that opposite each room is shown the loading for that room, we can arrive at the total load for each floor and the total load for the entire building.

This is what is known as the "connected load."

How to Estimate the Actual Maximum Load.

It is, however, almost inconceivable that every lighting point, every 5-amp. plug, every 15-amp. plug and indeed every form of outlet in a building will be used up to its full capacity at a given time. Therefore the "connected load" which by now we have established, though it is a step in the right direction, must not be confused with the actual maximum load which we anticipate.

To begin with, a 5-amp. plug is rated, as its name suggests, at 5 amp.; it is served with wiring which will carry 5 amp., and it is probably connected to a standard lamp having a 60-watt lamp which takes about a quarter of an ampere; so that even assuming such a preposterous state of affairs as all the 5-amp. plugs being in use at the same time, they would not be in use to the tune of 5 amp. each, but merely a quarter of an ampere. On the other hand, some of these 5-amp. plugs may be connected to electric irons taking over 1 amp. but probably under 2 amp. The 15-amp. plugs may some of them, at times, be connected to a 3-kW. fire with all bars burning and taking, therefore, something very near 15 amp.; others, on the contrary, may be connected with nothing for the time being; while yet others may have a 2 kW. or a 1 kW. fire, taking 10 or 5 amp. only.

A Practical Example.

Therefore we have got to establish what in our opinion is likely to be the maximum load and this is best established by showing it as a proportion of the connected load; this proportion or ratio is usually known as the "diversity factor," and is usually written as a percentage. Thus, at the moment, I am concerned with a large private house which has a connected load of 90 kW.; assuming a diversity factor of 60 per cent. and presenting these two facts to the supply undertaking, they will probably give me a service capable of carrying 54 kW.

At this stage, therefore, we have really established what we want in the way of load and, armed with these facts, the supply undertaking is in a position to tell us what form of service it will give.

Balancing a Three-phase Service.

To-day in any building taking a substantial amount of electricity, it is the usual—though not invariable—practice of the supply undertaking to give a three-phase service. They will further ask that the load be balanced between these three phases, so that possessed of the information that the service is to be three-phase, we must once more have recourse to our plans and divide our outlets in such a manner that the load is approximately even if divided into three parts. This process usually involves a good deal of "trial and error" work, since at a first cast it is usually found that there is a certain amount of out-of-balance which sometimes is not quite so easily rectified as one might imagine, bearing in mind that the phases must be kept distinct, so far as concerns the various outlets which they serve. When the balance has been finally achieved the circuit now becomes to all intents and purposes an independent two-wire service and can be treated as such from the distribution point of view.

Planning the Distribution.

Between the points at which the single-phase service is taken from the three-phase busbars and the points at which the electricity is actually used by the consumer, there must come a certain amount of control gear including switches and fuses. The actual quantity and position of such switches and fuses which are to be installed are once again purely a matter of intelligent anticipation of the needs of the consumer.

Some Examples.

If, for instance, we are concerned with a two-wire service to a village hall, having nothing but lighting as a load, all that we require is one main switch fuse and a small sub-distribution fuseboard dividing the total load into two or possibly three subcircuits.

If, on the other hand, we have perhaps

Page 2.

POSITION Bottom Floor Cont.	Index No.	FITTINGS No.	Type	Power	Position of Switches.	Switches 1-way.	Switches 2-way.	5-amp switch plugs	15-amp. switch plugs.	Synchro-nous Clocks.	Telephones.	Gongs.	Bells.	Bell Pushes.	REMARKS.
Finishing	D1	10	G.	200	Door	4			1						
Office	06	1	H.	100	"	1					1				
Attaching	D2	10	G.	200	"	4			1						
Office	07	1	H.	100	"	1		1							
Bottom Stock	D3	6	EV.	60	"	2									
Lasting	D4	10	G.	200	"	4			1						
Office	08	1	H.	100	"	1		1			1				
Last Store	T4	2	D	150	"	1									
Stairs	09	1	PB	60	Top and Foot		2								
Staff	T5	2	H.	100	Door	2		1							
Cloaks	010	1	P	60	"	1									
W.C.	011	1	P	40	"	1									
Leather Finishing	D5	10	WR	150	"	4									
Tan Shop	D6	12	WR	150	"	4					1				
Boiler Room	014	1	P	100	"	1		1							
Finish Making	015	1	D	100	"	1			1						
Finished Leather Store	016	1	D	100	"	1									

Fig. 4.—A Typical Schedule of Points.

some almshouses, it is clearly desirable that each set of rooms should be controllable by a separate main switch and fuse, however small this may be; though beyond this main switch and fuse, if each set consists of one or at the most two rooms, we need not further subdivide our system into subcircuits, but can leave the fuse of the switchfuse as the only protection required for the circuit.

In the case of a block of offices, we have to try to anticipate the form of division which is likely to take place in the matter of tenants, and make certain that each part of each floor which is liable to be let off as a separate entity has its own independent control gear, whether that control gear is actually placed in the section of the offices in question or on some common switchboard, say in the basement.

Fuseboards—

Fuseboards, it must be remembered, serve two purposes: the first and obviously most important purpose is that of providing protection for individual circuits against overloading due to short circuits or other causes. The second purpose, not so fundamental but nevertheless of great practical utility, is that of providing a simple and convenient means of breaking up one main circuit into several subcircuits. Sometimes the addition of a distribution fuseboard which is not strictly speaking necessary from the point of view of protection of the cables may be extremely desirable and economical on the ground of offering this convenience of splitting up the main circuit, and further, for making it possible for any subcircuit or group of subcircuits to be isolated by the simple process of drawing the fuse or fuses. Though, in order to avoid confusion, it should be added that, having split up the main circuit into subcircuits, the fuses then become necessary.

—and Where to Place Them.

From the electrical point of view it must be remembered that it doesn't much matter where we place our distribution fuseboards. Provided that we have properly calculated the size of the cable necessary to carry the respective circuit currents we can suit ourselves—or, to be more precise, our customer—as to whether, for instance, the fuseboard controlling the subcircuits serving the East wing of the bedrooms is situated in the cellar or in the East wing. From the point of view of the cost of installation we are interested parties; but if, for the sake of argument, the cost is not being considered so much as convenience, then the fuseboard can go anywhere. It is a common mistake to think that the final distribution fuseboard serving subcircuits must be geographically adjacent to the area which it serves. Very frequently it is far more convenient and, in the long run, therefore, more economical to arrange for this distribution fuseboard to be placed with others serving different areas at some common point in the building. Wherever they are placed, however, it is as well to bear in mind that they may have to be used, and that, therefore, while they should be kept as inconspicuous as possible, they should not be placed in inaccessible positions. When a fuse does blow it is irritating enough at the best of times to have to go down and reload the fuse-carrier. If to this is added the task of balancing a step-ladder on the top of a packing case and holding a guttering candle in one hand, the householder may with some reason curse the lack of intelligence of the electrical engineer who caused this trouble by placing the fuseboard in such an inaccessible position.

Two-way and Intermediate Switching.

Two-way and intermediate switching. that is to say the control of one lighting point from more than one switch, is a matter which up to a point should be anticipated by the engineer, and if the customer or the architect has not mentioned the matter he should point out that perhaps it would be convenient if the last person to bed in the evening could switch off the light on the landing below and switch on the light to the landing above as he proceeds up the stairs.

All these details connected with the design of an electrical installation must be settled before the work begins; they should indeed be settled before the contractor is asked to give his price, for if they are not, confusion and uncertainty result. Some decisive lay-out should be agreed upon, even if it is modified at a later date; but that an electrical contractor should be asked to tender for a wiring installation in which these details have not been settled is as unreasonable as for a motor dealer to be expected to quote a price for " a motor car."

WHY EARTH WIRES SHOULD NOT BE STRANDED

Readers may have noticed in some specifications that the earthing of such items as motor frames, switch casings, etc., must be carried out with solid and not with *stranded* conductors. This is not always specified, but it is becoming more usual.

The reason is that with a stranded conductor a large proportion of the strands can become broken and although there is a path to earth it will not be of sufficient cross-section to carry the leakage current in case of a fault. If only one strand is left it will still give a good test, but would be of no use if a serious fault occurred.

Supposing a 7-strand cable is used and all the strands but one corrode away or are broken, the one remaining strand would possibly be burnt out if a fault occurred and the earth would then be useless. Earth connections are much more liable to damage than the circuit wires as they are generally unprotected, and are often taken into damp situations in order to get a good earth.

Where a solid earth conductor is required, either a round single strand wire should be used or strip copper of flat section similar to a bus-bar. In a sub-station a strip of copper is often fixed round the building and the earth connections are made to this strip.

METAL-CLAD SWITCHGEAR FOR HIGH VOLTAGE DISTRIBUTION

By W. A. COATES, M.I.E.E., Fellow A.I.E.E.

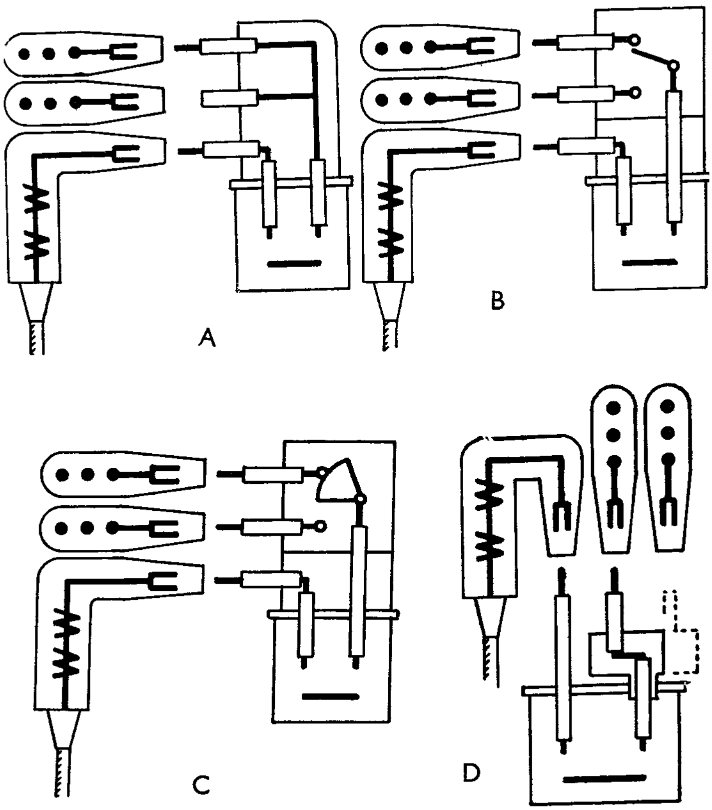
THE term " metal-clad," is applied to all those various designs of switchgear in which the component parts are completely enclosed, each in its own standardised earthed metal casing.

The space between the live parts and the casings is filled with bitumastic compound, heavy oil, or some similar dielectric, which serves at once to supplement the insulation applied to the conductors, and by excluding air and moisture, to keep dimensions to a minimum.

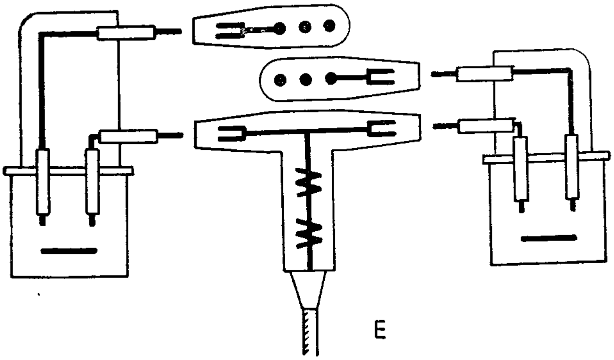
Common to all, is a circuit breaker readily isolated and completely removable for maintenance. There are many methods of isolation, and of selection between busbars, when these are duplicated. Fig. 1 summarises them in a diagrammatic manner.

Conductor Capacity.

Enclosure in a filled casing makes it more difficult for heat to get away from the conductors, the current density in which must always be lower than would be possible in air. When heavy currents are to be carried, a great deal depends upon the relative location of conductors and casing. In Fig. 2 is shown such a heavy current busbar unit, in which the bars are divided, so as to get the surfaces close to the outer metal. For the same reason, the casing is recessed between bars. In more extreme instances, it is necessary to resort to hollow busbars, the central portion of massive conductors being practically useless. It may be thought that the temperature of the conductor is unimportant, provided the outer casing does not become excessively hot. This is not so, because the insulating values of the filling compound, taping around joints, and micarta spacing pieces all decrease rapidly as their temperatures increase.



Figs. 1A TO 1D.—DIAGRAMMATIC REPRESENTATION OF THE STANDARD METHODS OF ISOLATION AND OF BUSBAR SELECTION WITH METAL CLAD SWITCHGEAR. (See also Figs. 1E to 1J.)



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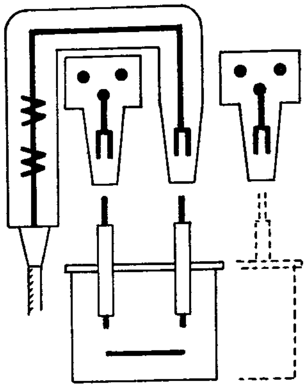

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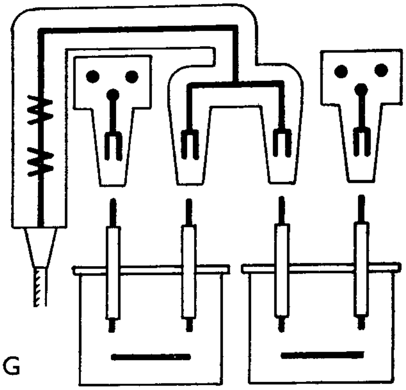

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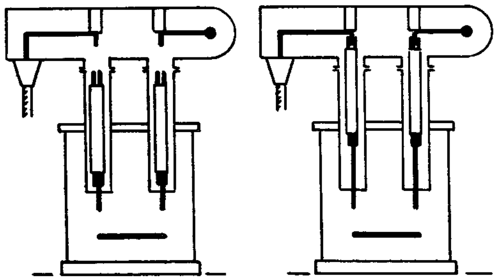

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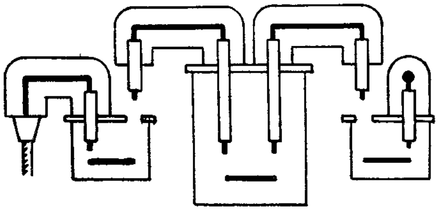

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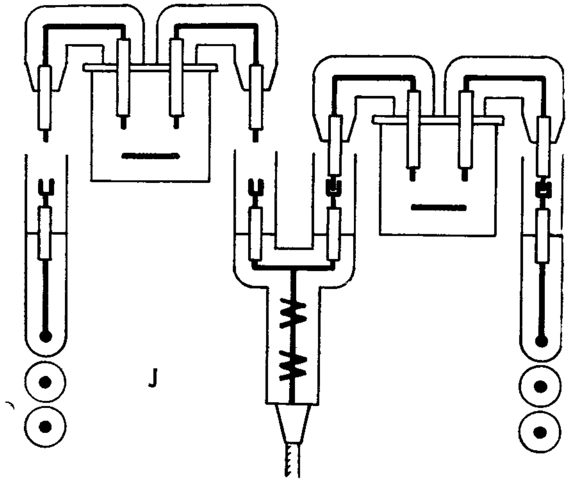


J

Figs. 1E TO 1J.—DIAGRAMMATIC REPRESENTATION OF THE STANDARD METHODS OF ISOLATION AND OF BUSBAR SELECTION WITH METAL-CLAD SWITCHGEAR. (See also Figs. 1A to 1D.)

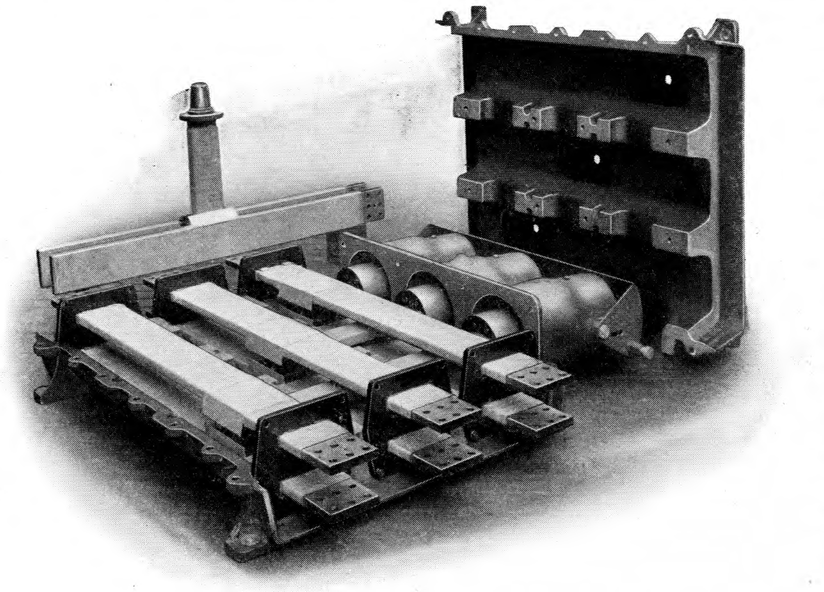


Fig. 2.—4,000-AMP. BUSBAR UNIT, PARTLY ASSEMBLED.
Note bars spaced apart, close to casings, which are recessed. (*Metropolitan-Vickers.*)

For the very high voltages (66 kV. and upwards), ordinary transformer oil is preferred as a dielectric filler, as being at once a better, more reliable insulator, and one which can be tested periodically and easily brought up to strength if need be. Necessary joints in the casings are much harder to make and keep good. Consequently, oil is not used on the smaller, lower-priced equipments.

If it is known that metal-clad apparatus will be subjected to short-time overloads, it is permissible to work at quite high densities, since the mass of surrounding dielectric increases the heat storage capacity of the gear.

Filling the Casings.

Casings which are not likely to be opened again are usually filled with a moderately hard compound, poured while hot. To avoid the formation of voids, the casing and contents should be warmed first, and the compound heated to within close limits of temperature, so that it flows freely, but does not give off gas. For these reasons, factory filling is desirable as far as possible.

Current transformer casings, and the couplings between adjacent units, are often filled with material more of the consistency of vaseline, which is fairly easy to remove, if transformers have to be changed, or switchboards extended. Considerable care is needed in selecting these semi-plastic fillers, as most of them are markedly hygroscopic.

Interlocking Arrangements.

It is a universal characteristic of all metal-clad switchgear, irrespective of maker or type, that the various parts are interlocked so that operations can be performed only in the right order, and to prevent access to live metal in all circumstances.

As a principle, these arrangements should be carried out by mechanical means, the fastenings of which are normally inaccessible. Even in very big equipments, it is usually counted better to employ rather elaborate linkages to interlock moving parts widely separate, instead of using electrical locks, which may be affected by minor insulation failures.

Horizontal Isolation.

Fig. 3 gives a good idea of the arrangement of parts adopted, when isolation of the circuit breaker is effected by drawing it forward along a track carried on the supporting frame. A rack and pinion, or other device giving good mechanical purchase, is used, chiefly to force the

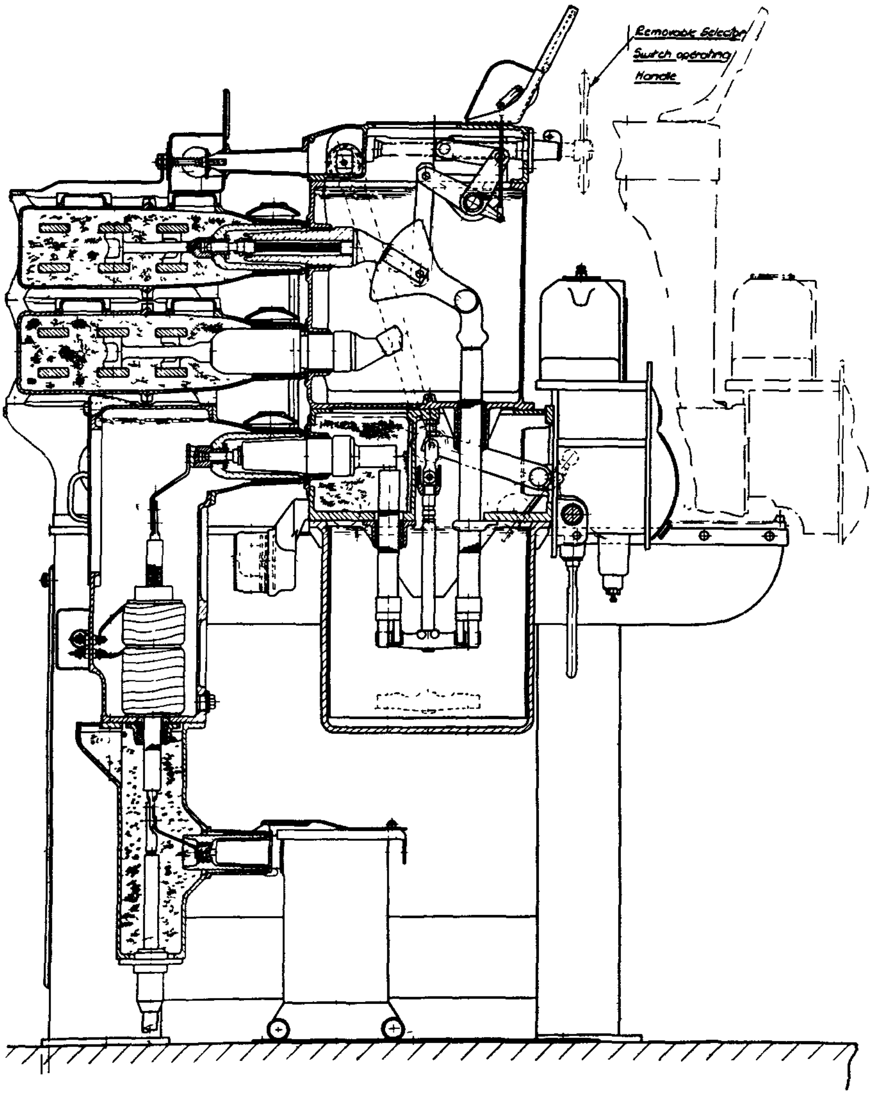


Fig. 3.—CROSS SECTIONAL DRAWING OF HORIZONTALLY ISOLATED METAL-CLAD UNIT, WITH BUSBAR SELECTION, METHOD C, FIG. 1. (*Metropolitan-Vickers.*)

isolator plug contacts into place. Although both parts of these contacts are jig set, it is necessary to provide some freedom of movement in one member, to ensure uniform pressure on contact surfaces.

When the circuit breaker is in the working position, bolts hold it to the side frames, to prevent movement due either to electro-magnetic repulsion when heavy short-circuit currents pass, or to the impact of oil thrown up when the breaker operates on load.

Changing from One Set of Busbars to Another.

In early designs of drawout gear, selection between busbars was effected by racking out the breaker, then shifting the upper plugs from one position to the other, and finally racking back into place

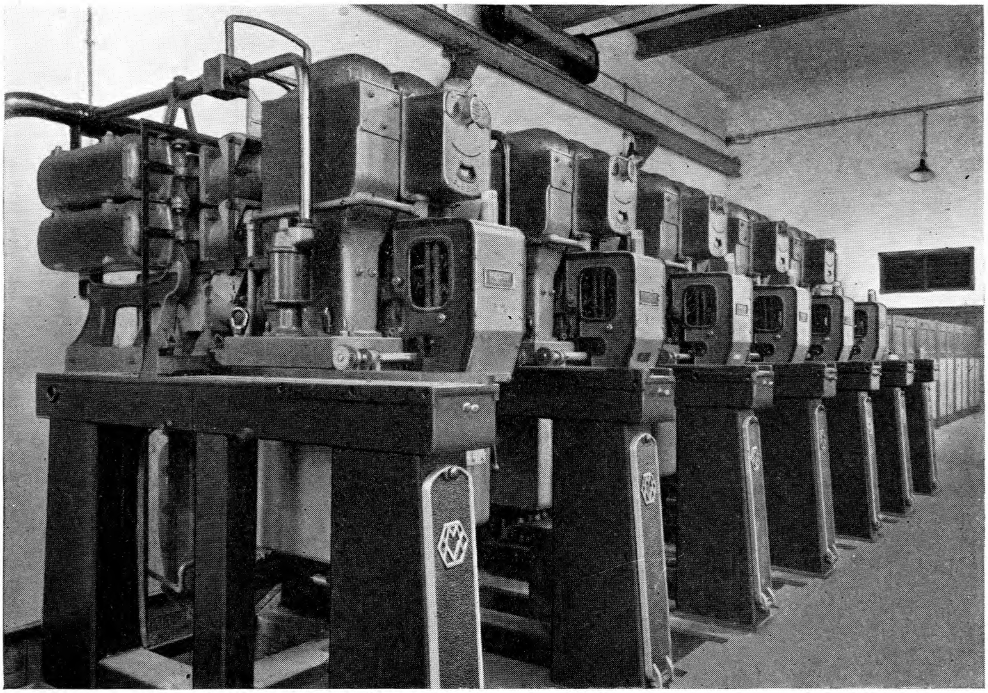


Fig. 4.—6.6 kV. Metal-clad Switchboard, with Breakers 500,000 kVA. Capacity. Stoke-on-Trent generating station. (*Metropolitan-Vickers.*)

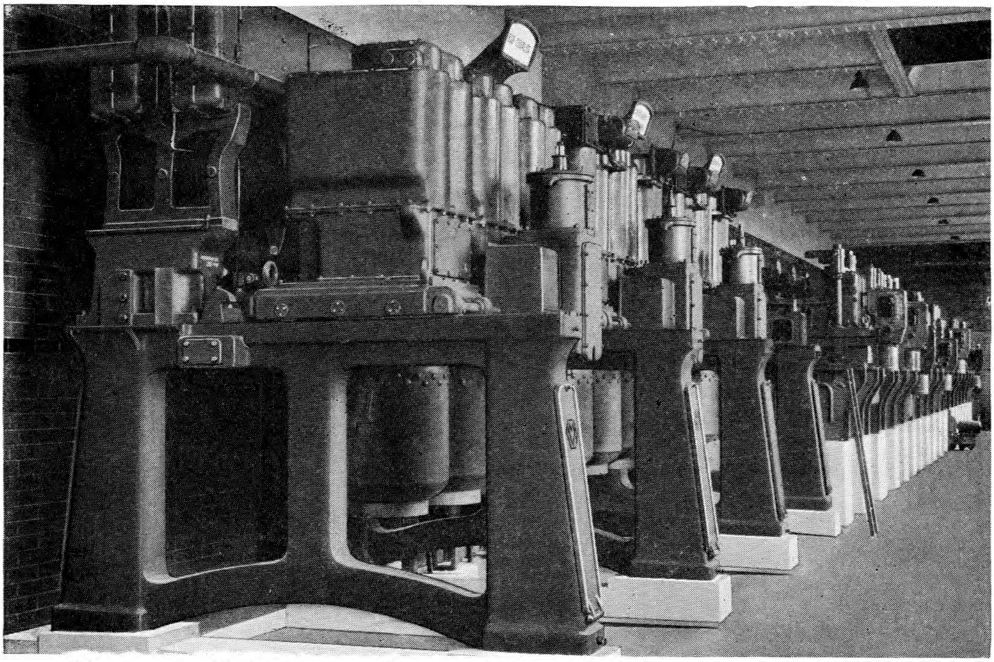


Fig. 5.—33 kV. Metal-clad Switchboard with Breakers for 1,000,000 kVA. Portishead power station. Bristol Corporation. (*Metropolitan-Vickers.*)

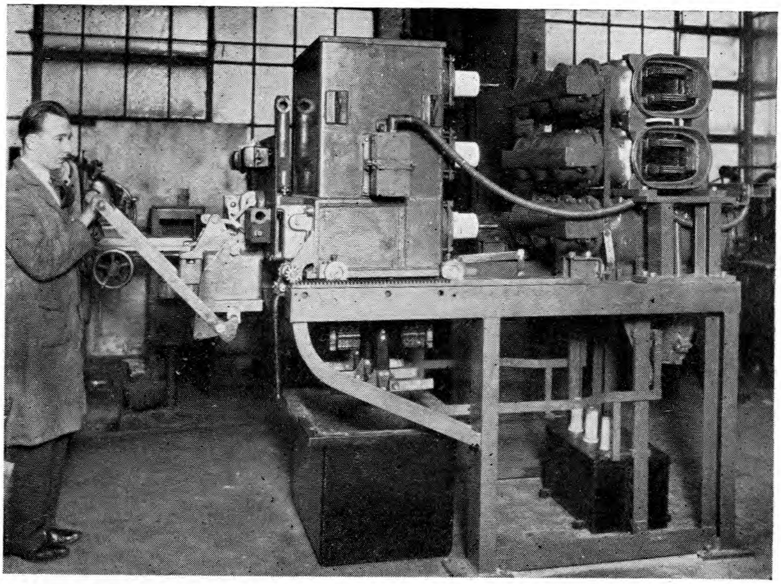


Fig. 6.—11 kV. Metal-clad Unit Showing Potential Transformer Dropped Down, and Flexible Jumper to Permit Breaker Being Operated when in Isolated Position. (*B.T.H. Co.*)

Modern practice demands that the circuit voltage transformer shall be a plugged-in unit, accessible without opening the oil circuit breaker. The method by which this is done will be seen in Fig. 3, where the transformer contacts are carried in the incoming cable box.

VERTICAL ISOLATION.

The horizontal method of isolation generally (see Fig. 1A). This involves complete interruption of the circuit for several minutes. Hence the majority of equipments used to-day incorporate an oil immersed selector switch above the circuit breaker. If there is a busbar coupling switch in the equipment, changeover can be effected without any circuit interruption, using method C, in Fig. 1. If there is no busbar coupler, it is still possible to change from one busbar to the other with an interruption of only several seconds, and without need to shift the circuit breaker itself. In this case, the selector switch blade breaks from one set of busbars, before contacting with the other, as shown in B, Fig. 1.

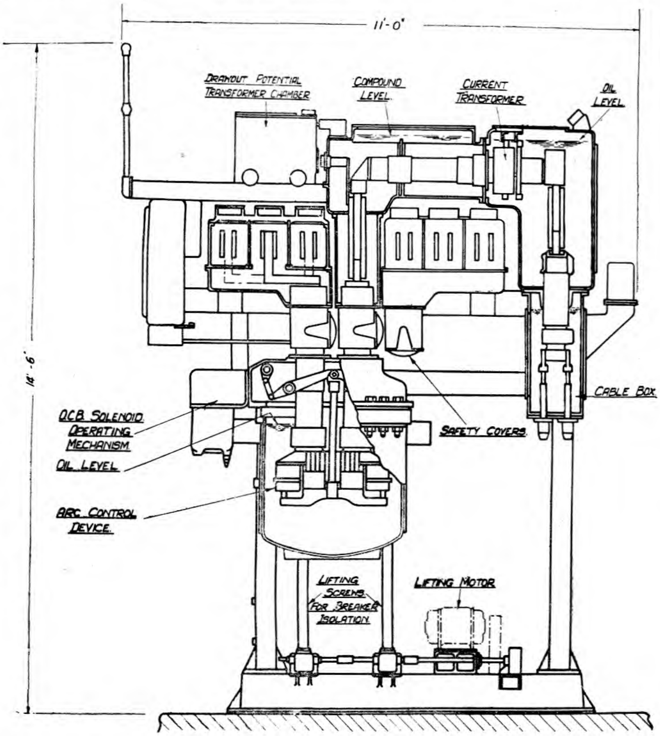


Fig. 7.—Sectional Elevation of Duplicate Busbar, Vertically Isolated Metal-clad Unit. (*Ferguson Pailin, Ltd.*)

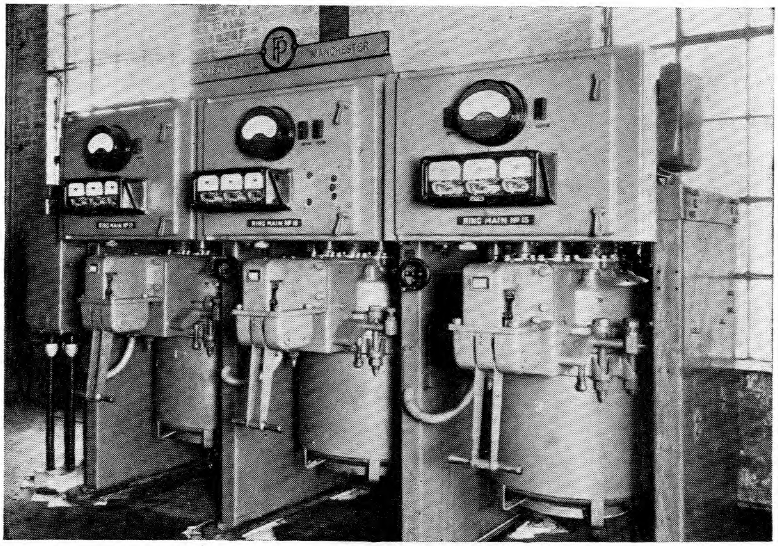


Fig. 8.—3-Panel, Type "V.S.R." Single Busbar, Metal-clad Switchboard for Direct Manual Control. (*Ferguson Pailin, Ltd.*)

results in a structure of minimum height. By arranging the circuit breaker below the busbars, while the structure height is increased, the net floor space occupied is cut down. Not infrequently this advantage proves imaginary rather than real. With most metal-clad designs, space behind the gear is necessary during erection. If the cable dividing box is high up, as it often is in vertically isolated equipments, more space is needed for jointing than when the work can be done on the floor. Usually it is possible to work at the cable joint from front and rear, when the circuit breaker racks out horizontally.

An Important Advantage.

One inconvertible advantage of vertical isolation is that the number of insulating bushings can be a minimum. No matter how carefully designed and made, bushings are always potential sources of weakness. From a manufacturing angle, also, the vertical design is valuable, since the circuit breaker unit may be the same, whether used in a metal-clad structure, or incorporated in a sheet steel or concrete cubicle. A study of Fig. 7, which shows in section a typical vertically isolated unit, and comparison with Fig. 3, will make these points very clear.

The withdrawable voltage transformer is seen at the top of the equipment; a position the inaccessibility of which is only excused by the fact that fuses and oil need little attention. The current transformer chamber also is high up, but is probably more easy to get at than in most horizontal equipments.

The chief difficulty is that both sets of busbars are almost inevitably closed in by other casings, which interfere with heat dissipation. In horizontal designs, the upper casing has one side and the top in direct contact with free air, and is, therefore, used for the main busbar.

Method of Busbar Selection.

The most common method of busbar selection is to open the circuit breaker, lower it, move horizontally, and raise into contact with the second set of busbar spouts. (Method F, in Fig. 1.) This calls for a considerable degree of accuracy in making the horizontal movement, so that the plugging contacts may engage properly. The time of circuit interruption when changing over is markedly longer than with the selector switch on a horizontal equipment.

To avoid the horizontal movement, one maker has adopted the turret-head arrangement shown in Fig. 1D. The bushings one side of the circuit breaker are rotated *en masse* and thus bring the offset plugs opposite one or other set of busbar spout contacts. The circuit breaker has to be opened and dropped down while this operation is performed.

Electric Arc Welding Practice

By "Voltus"

ELECTRIC arc welding has now become firmly established as an essential process in many industries, not only in manufacturing work but also for repairs and reclamation of otherwise scrap items. Typical manufacturing applications include ship construction, structural work and the fabrication of tanks. A recent development in this line is the complete fabrication of motor and generator frames up to the largest sizes in service.

Much reclamation work is carried out in railway and tramway shops in the repair of broken parts and the building up of worn parts. Many large castings are saved in steel works by having blowholes filled in whereas otherwise they would be scrap.

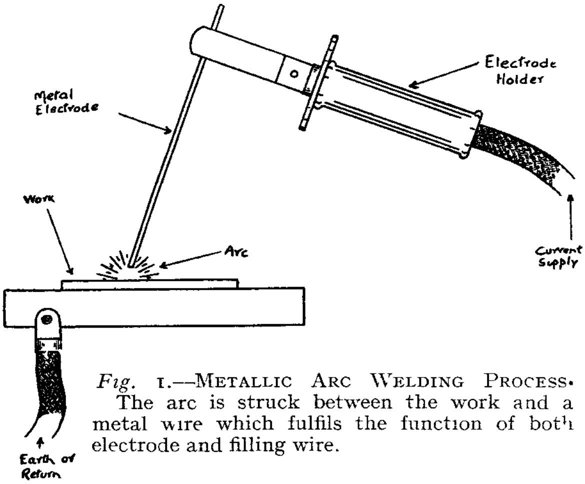


Fig. 1.—Metallic Arc Welding Process. The arc is struck between the work and a metal wire which fulfils the function of both electrode and filling wire.

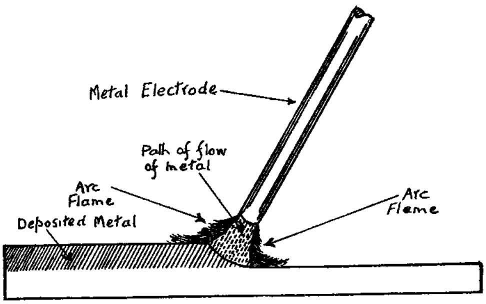


Fig. 2.—The Metallic Arc. The gap between the work and the electrode is bridged by an arc of intense heat. Metal of electrode is molten and flows on to the work. The metallic arc method of welding is used for nearly all work. Another type of electric welding—the carbon arc process—which consists of drawing an arc between a carbon pencil of the work and applying a separate filling rod for depositing the metal, is limited to rough heavy work where speed and economy are of primary importance.

Two Types of Electric Welding—The Carbon Arc.

There are two classes of electric welding in general use, the carbon arc and the metallic arc. The carbon arc process consists of drawing an arc between a carbon pencil and the work, a separate filling rod being used if metal is to be deposited. This process is limited to rough heavy work where speed and economy are of primary importance such as filling blowholes, cutting and the welding of copper.

The Metallic Arc Process.

In the metallic electric process the arc is struck between the work and a metal wire which fulfils the function of both electrode and filling wire. This method is employed for nearly all work and is particularly valuable where welds of great strength are required.

A.C. or D.C.

Arc welding can be carried out with A.C. or D.C. apparatus. The A.C. arc is not as steady as the D.C. but the plant is much cheaper and consists of a step-down transformer, either single or three-phase, working in conjunction with a stabilising reactance for current control.

The D.C. equipment often employs a special generator designed in such a manner

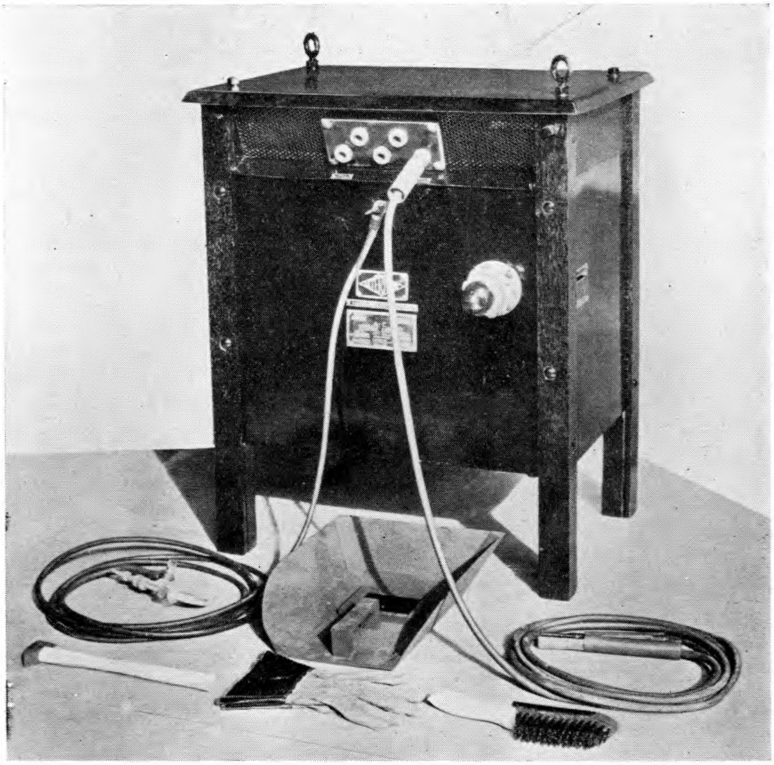


Fig. 3.—A.C. Welding Equipment.
The transformer steps down current from A.C. supply to suitable voltage for welding. Current may be regulated by tapping holes.

that as the current in the arc increases so the voltage falls, excitation for the generator is obtained from a small exciter. The open circuit voltage will vary from 60—90 volts, coarse regulation being obtained by a regulator inserted in the series field, fine adjustment being made in the shunt field. As the welding connections are taken direct without the interposition of resistance the armature must be made strong enough to withstand what is practically a continuous short circuit.

Advantages of Welding in Manufacture.

Fabrication of structures by welding offers a number of real advantages, such as reduction of weight with consequent reduction of freight charges, and reduced cost in machining and saving in patterns which are not required. When welding is put forward as a substitute for castings, certain inherent disadvantages of the latter are removed. For example, frequently the limiting feature in settling thickness of metal at any point is not the strength, but the difficulty of casting thin complicated sections.

Types of Joint Required for Welding.

The preparation of the joint before welding is of the utmost importance if full strength is to be obtained from the weld. The chart given on pp. 530-1 will cover the majority of applications and at the same time will allow the designer to specify exactly the type of joint which is required. Where thick plates are veed sufficient gap must be left to enable penetration to be made right through to the opposite side and to assist this point a thin electrode should be used.

The Current Required.

The current required will vary both on the size of the electrode and its nature. The welder should work to the maker's recommendation and where a very short arc is being maintained work to the higher figure given, but not sufficient to make rod splutter and metal to splash. The actual current will also depend on the thickness of the plate. A thin plate will not require the amount of heat for an efficient weld as would a thick plate and it is for this reason that the maker's tables should be consulted.

AVERAGE CURRENTS FOR MILD STEEL WELDING.

Electrode	4 S.W.G.	Current	150 to 175	amps.
,,	6 ,,	,,	130 ,, 150	,,
,,	8 ,,	,,	100 ,, 130	,,
,,	10 ,,	,,	80 ,, 110	,,
,,	12 ,,	,,	45 ,, 75	,,
,,	14 ,,	,,	25 ,, 45	,,

Welding Data.

The following information is put forward as a guide to the size of electrode and current value which will be required for some classes of work.

Two $\frac{1}{16}$ thick plates butted together as shown under symbol A would require a 14 S.W.G. electrode and a current of 25 to 30 amps. Other thicknesses of plate and the required currents are:

$\frac{15}{64}$ thick, a 14 S.W.G. electrode using 35 to 40 amps.

$\frac{3}{32}$ thick, a 12 S.W.G. electrode using 45 to 50 amps.

$\frac{1}{8}$ thick, a 10 S.W.G. electrode using 60 to 80 amps.

A plate $\frac{1}{8}$ thick is the limit at which plates should be butted together, above that value a gap must be left between the edges as shown in symbol C and heavier currents and electrodes.

$\frac{3}{16}$ thick, a 10 S.W.G. electrode using 80 to 100 amps.

$\frac{1}{4}$ thick, an 8 S.W.G. electrode using 100 to 120 amps.

The above sizes can be welded with a single run of electrode but thicknesses of $\frac{5}{16}$ and above will require two or more runs using different gauges of electrode and consequently varying currents.

Typical values are given in the table on the left.

Plates $\frac{5}{16}$ to $\frac{3}{8}$ thick welded in two runs, the first with No. 10 electrode using 80 to 90 amps. followed by No. 8 electrode using 100 to 130 amps.

Plates $\frac{1}{2}$ thick are welded in three runs firstly with No. 10 and 90 to 100 amps., followed by No. 8 with 110 to 130 amps. and finishing with No. 6 electrode increasing the current to 130 to 145 amps.

Electrodes for Different Metals and Purposes.

A large number of different types of electrode are in use, it now being possible to find a suitable type for whatever work is under consideration, whether it be mild steel plates, heat-resisting steel or depositing a very hard material where wearing qualities are most important.

Protecting the Weld.

The molten metal in the weld will readily absorb oxygen and nitrogen from

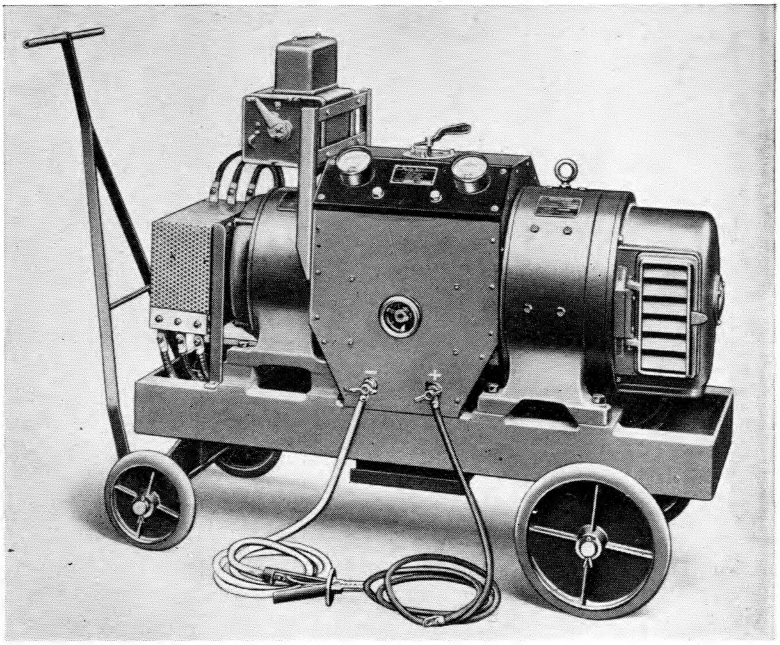
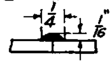


Fig. 4.—D.C. WELDING EQUIPMENT.
Showing a generator driven by electric motor. The generator is of the drooping characteristic type, i.e., as the current in the arc increases so the voltage falls.

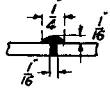
STANDARD JOINTS USED

PLATES 1/8" THICK — SYMBOL

LIGHT WELD — **A**

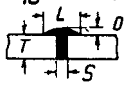


HEAVY WELD. — **B**

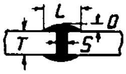


PLATES 3/16", 1/4", 5/16" THICK.

LIGHT WELD — **C**



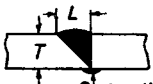
HEAVY WELD. — **D**



Thickness	T	3/16	1/4	5/16"
Length	L	5/16	3/8	1/2"
Depth	D	1/16	1/16	1/16
Space	S	1/8	1/8	3/16

PLATES 3/8", 7/16", 1/2" THICK

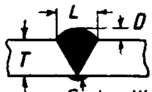
LIGHT WELD. — **E**



Sealing Weld

Thickness	T	3/8	7/16	1/2"
Length	L	3/8	7/16	1/2"

HEAVY WELD. — **F**



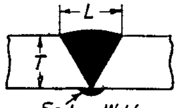
Sealing Weld

Thickness	T	3/8	7/16	1/2"
Length	L	7/16	1/2"	9/16
Depth	D	1/8"	1/8	1/8"

NOTE— T—Thickness in all cases refers to thinner of the 2 plates joined.

PLATES 9/16" & ABOVE. — SYMBOL

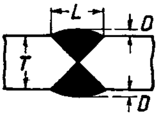
LIGHT WELD — **G**



Sealing Weld.

Thickness	T	9/16"	5/8"	3/4"	7/8"	1·0
Length	L	11/16	3/4"	7/8"	1·0	1 3/16"

HEAVY WELD — **H**

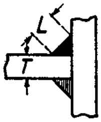


Thickness.	T	9/16"	5/8	3/4"	7/8"	1·0
Length	L	9/16"	5/8"	3/4"	7/8"	1·0
Depth	D	1/16"	1/16"	1/8	1/8"	1/8"

PLATES ALL THICKNESSES 3/16" & ABOVE

LIGHT WELD
Single or Double as specified.
Length L = 1/2 Thickness T.
3/16" Minimum. — **J**

HEAVY WELD One Side
FULL STRENGTH WELD
Two sides as specified. — **K**



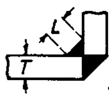
Thickness	T	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	3/4"	7/8"	1·0"
Length	L	1/4"	5/16"	3/8"	7/16"	9/16"	5/8"	11/16"	3/4"	15/16"	1 1/16"	1 3/16"

EQUAL PLATES

ALL THICKNESSES NO MACHINING.

RIGHT ANGLED
LIGHT WELD — **L**

RIGHT ANGLED
FULL STRENGTH WELD — **L.R.**



Length L = Thickness T

This chart gives data on the types of joint required for the majority of welding applications.

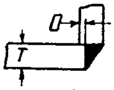
the atmosphere with consequent deterioration of mechanical and other qualities, unless the weld can be protected. The method of protection adopted is usually to coat the wire with a material which in burning will give a slightly neutral or reducing atmosphere. Cellulose materials such as paper, cotton, wood pulp and dextrine are often used in conjunction with some silica slag-forming reagent

IN METALLIC ARC WELDING

EQUAL PLATES — SYMBOL

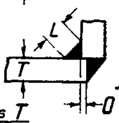
ALL THICKNESSES NO MACHINING

RIGHT ANGLED LIGHT WELD



M

RIGHT ANGLED FULL STRENGTH WELD



MR

Length L = Thickness T

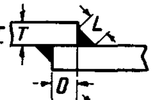
Thickness	T	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	3/4"	7/8"	1·0"
Overlap	O	1/16"	1/8"	1/8"	1/8"	3/16"	3/16"	3/16"	1/4"	1/4"	1/4"	5/16"

ALL PLATE THICKNESSES — SYMBOL

LIGHT WELD

Length L = Thickness T

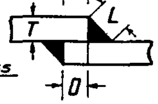
Overlap O not less than T



R

HEAVY WELD

Overlap O = not less than T

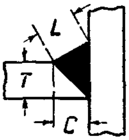


S

Thickness	T	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/15	5/8	3/4	7/8	1·0
Length	L	3/16	1/4	3/8	7/16	9/16	5/3	11/16	13/16	7/8"	1 1/16"	1 1/4	1 7/16

PLATES 3/8" UP TO 5/8" THICK & ABOVE 5/8 WHEN WELD CANNOT BE MADE ON BOTH SIDES

FULL STRENGTH WELD



N

Thickness	T	3/8"	7/16"	1/2"	9/16"	5/8"
Length	L	7/16"	1/2"	9/16"	11/16"	3/4"
Cut.	C	3/8"	7/16"	1/2"	9/16"	5/8"

LIGHT WELD

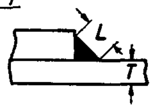
Space Welding where specified.

T

Length L = 1/2 Thickness T

3/16" Minimum.

HEAVY WELD



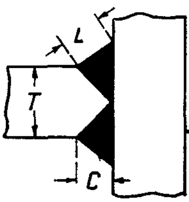
U

Thickness	T	1/8"	3/16"	1/4"	5/15"	3/8"	7/16	1/2"	9/16"	5/8"	3/4"	7/8"	1·0
Length.	L	3/15"	1/4"	3/8"	7/16	9/16	5/8"	11/16"	13/16	7/8"	1 1/16"	1 1/4	1 7/16"

PLATES ABOVE 5/8

This Weld applied only when Weld K cannot be used.

FULL STRENGTH WELD

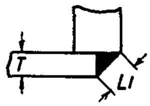


P

Thickness	T	3/4"	7/8"	1·0
Length	L	7/16"	1/2"	9/16"
Cut	C	3/8"	7/16"	1/2"

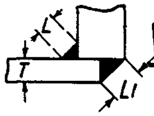
UNEQUAL PLATES NO MACHINING.

RIGHT ANGLED LIGHT WELD



W

RIGHT ANGLED FULL STRENGTH WELD



WR

Length L = T Thinner of Two Plates.

Thickness	T	1/8"	3/16"	1/4	5/16"	3/8"	7/16	1/2	9/16"	5/8"	3/4	7/8"	1·0
Length	LI	3/16"	1/4	3/8"	7/16	9/16	5/8"	11/16"	13/16"	7/8	1 1/16"	1 1/4	1 7/16"

which will allow the weld metal to cool slowly; this latter feature is of especial importance with welds having a high carbon content.

Amongst slag-forming coverings the blue asbestos covering, a sodium, iron, silica asbestos, is one of the most popular, the covering acting both as a shield and acting as a protecting slag.

We are indebted to the Metropolitan-Vickers Electrical Co., Ltd., for the interesting details given in the chart on this and the facing page, and for some of the illustrations which accompany this article.

D.C. EQUIPMENT FOR ELECTRIC SHIP PROPULSION

By E. M. JOHNSON

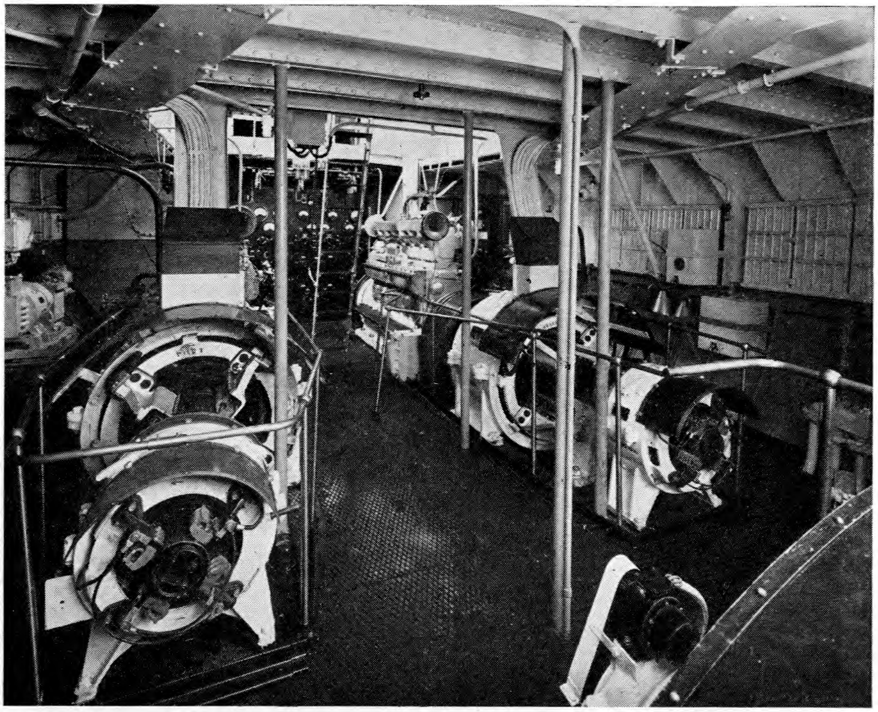


Fig. 1.—AN INTERESTING EXAMPLE OF ELECTRIC SHIP PROPULSION—THE FIRST BRITISH DIESEL-ELECTRIC TUG.

The engine room on the " Acklam Cross," a single-screw vessel, showing the two G.E.C. 200 kW. 900 r.p.m. Diesel-driven D.C. generators, auxiliary generators and control switchboard. Part of the main propulsion motor is seen in the foreground on the right. A tugboat works under conditions which are particularly suitable for Diesel electric propulsion. It must be ready for service at a moment's notice, and be capable of rapid manœuvring and of exerting maximum power over a wide range of speeds, while it should have negligible fuel consumption when standing by. (*The General Electric Co., Ltd.*)

Systems of Connections.

DIRECT CURRENT ship propulsion equipments may be regarded, from the point of view of system of connections, as falling into three main categories, viz. :—

1. Single screw, single generator systems.
2. Twin screw, two generator systems.
3. Single or twin screw systems with more than one generator per screw.

In all cases Ward-Leonard control is used, i.e., constant normal motor excitation with control of speed and direction of propeller rotation by generator field variation. The generators run at constant speed and are always separately excited.

SINGLE SCREW SYSTEMS.

Main Connections for Single Screw, Single Generator Systems.

The single screw, single generator system is the simplest of all and its essential

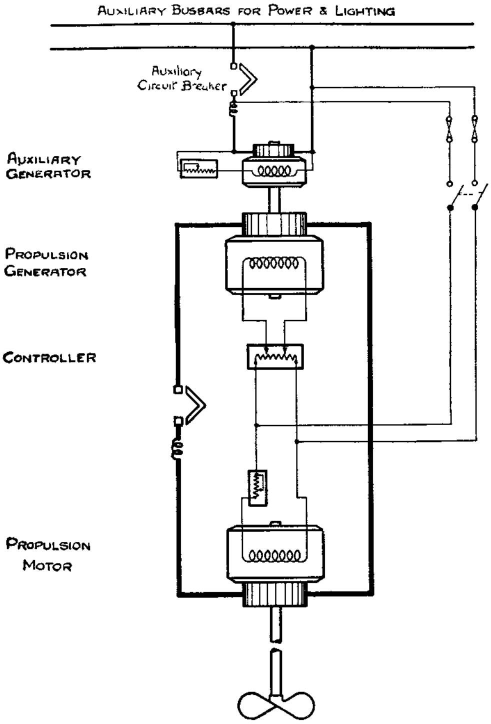


Fig. 2.—DIAGRAM OF CONNECTIONS—SINGLE-SCREW D C. PROPULSION EQUIPMENT.

connections are shown in Fig. 2. Excitation for both propulsion machines is shown supplied as part of the load of an auxiliary generator driven in tandem with the main generator. This arrangement is convenient and economical but not essential. The excitation may be taken from independent auxiliary generators or from independent exciters if this suits the plant in other respects.

Function of the Motor Field Rheostat.

The manœuvring controller consists essentially of a reversing rheostat. The motor field rheostat is provided to allow for variations in propeller characteristic. Suppose, for example, the vessel to be running at a draught below normal. Then when normal propeller revolutions are reached (corresponding to normal voltage on the generator), the power will be less than normal. It is not permissible to obtain the increase in revolutions by increasing the generator voltage, as this would produce excessive iron loss and field heating in the generator. On the other hand, by weakening the motor field, its speed may be increased until full power is reached and then no such effect is produced. Analogously, if the vessel should encounter a head wind, the torque required for a given propeller speed will be increased above normal. This will result in the motor drawing a current also above normal in the same ratio. The motor field may then be strengthened to reduce to normal the main current required for the excess torque in question. (The motor torque being proportional to the product of main current and field strength.) It will be noted that a similar result may be obtained by reducing the generator volts, but with this important difference that, if this course be adopted, then when normal full load current is reached, the voltage will be below normal and the available power consequently also below normal in the same proportion. This constitutes a limitation which is absent when motor field strengthening is employed. It is, therefore, important that the necessary margin for this should be provided in the motor. In a tug, this is particularly so, because a very large increase in torque is required when towing as compared with running light (the usual allowance is about 30 per cent.).

Fault Protection.

Fault protection may take the form of a circuit breaker in the main connection, set to operate at say two and a half times normal full load current. This high setting is permissible because sustained overloads are not to be expected in a ship propulsion system. It gives assurance that the breaker will not trip under the momentary overloads experienced during manœuvring or in a seaway; such peaks may reach 150 to 175 per cent. of normal current.

Avoiding Accidental Opening of Circuit Breaker.

It will be realised that accidental opening of the circuit breaker may constitute a source of danger to the vessel if it should occur during manœuvring. The ordinary catch-released breaker is not ideal for this service because of the liability of the catch to slip under shock or vibration. The Metropolitan-Vickers Electrical Co. employ a special breaker which is held closed by spring pressure and opened by the direct pull of a solenoid energised by the main current. No other action can open the breaker. It is held open, when operated, by a detent.

The Excitation Supply.

In Fig. 2 the excitation supply will be seen to be taken from the machine side of the auxiliary generator circuit breaker. The object of this arrangement also is to safeguard the essential supply to the propulsion machinery. Opening of the auxiliary generator circuit breaker due to a fault on the auxiliary system leaves the excitation supply intact.

Protecting the Excitation System.

Faults in the excitation system itself may be taken care of in two ways. In small plants, where the excitation power is small, the field circuits may have discharge resistances permanently connected in parallel with them. In this case the excitation circuit may be protected by heavy fuses against the consequences of an internal fault. The discharge resistances may take the form of electrolytic valves or rectifiers for the fields which are not reversed, in which case no continuous loss of energy is involved. In larger plants a circuit breaker of the same type as that employed for the main circuit may be used but fitted with a contact for a short rated discharge resistance.

It is usually sufficient to provide earth indicating lamps to give indication of the state of the insulation of the system. Some users prefer to have automatic earth leakage protection.

The system just described will only be used for very small powers. In larger powers, more than one generator and prime mover are the practice. The reason for this lies partly in the superior engine room layout which results from a subdivision of the engine power into two or more units and partly in the greater reliability thereby obtained, and in the economical running at reduced power which the subdivided plant makes possible. The use of a smaller individual engine power is usually accompanied by a higher engine speed. This results in smaller, lighter and cheaper engines and generators.

Main Connections for a Single Screw, Two-generator Equipment.

The diagram of the main connections for a single screw equipment with two generators is given in Fig. 2A. This diagram shows a tandem motor to which reference will be made below. The essential difference in the main circuit connection consists in the introduction of the two main

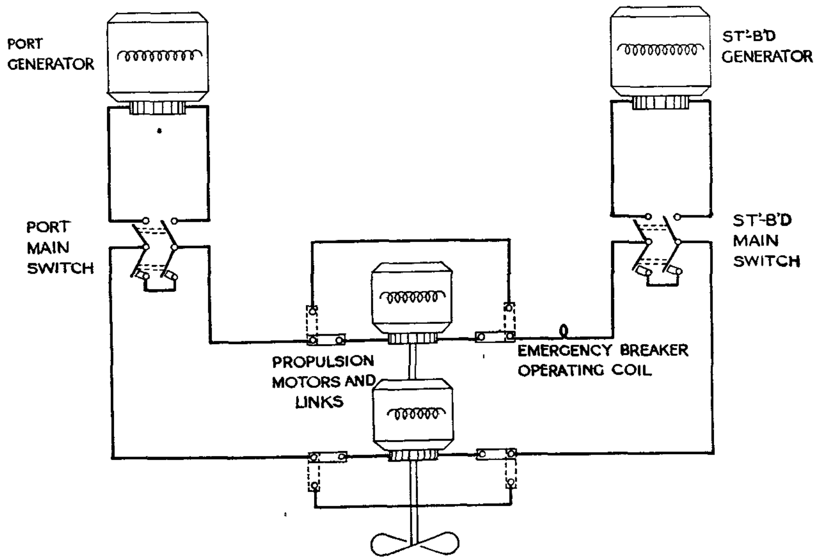


Fig. 2A.—Diagram of Main Connections—Single Screw, Two Generator Propulsion Equipment.

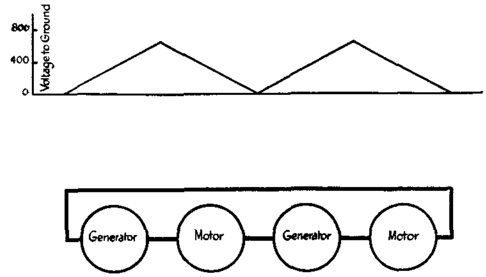


Fig. 3.—Tandem Motor with Interleaved Connection. Diagram of Voltage to Ground.

switches. The function of these switches is to permit either of the two generators to be disconnected. It will be noted that the two generators are in series with one another. When one generator is disconnected it is, therefore, necessary to bridge the gap left in the circuit. This is accomplished by means of a double throw switch as shown in the diagram. An isolating switch is also provided for each generator field circuit.

Withdrawing One Generator from Service.

To permit of the withdrawal from service of any one generator without interruption of supply to the propulsion motor, the main switches are constructed to bridge the generator before breaking circuit. Naturally, before this can be done with safety, the generator voltage must be reduced to zero. The main and field switches of each generator are, therefore, interlocked so that the main switch cannot be moved to the " generator disconnected " position until the corresponding field switch has been opened.

The Excitation System.

In other respects the essentials of the system remain as in Fig. 2. The two generator fields are paralleled on to the manœuvring controller, each through a separate field switch. Each main generator may have an associated auxiliary generator, in which case the main excitation switch would be made double throw and arranged to connect the complete excitation circuit to either one or the other auxiliary generator in a similar manner to that shown for the single auxiliary generator in Fig. 2. Alternatively, the excitation may be divided between the two auxiliary generators by being connected direct to the busbars.

Why Tandem Motor is Used.

The reasons leading to the use of a tandem motor and the effect on the system are as follows :—

The maximum desirable working voltage for one commutator or to ground, except in the largest sizes of machines, is usually considered to be 650. With a single motor, therefore, and two generators, the maximum voltage per generator would be 325 and the maximum system voltage 650. By employing a tandem motor, the system voltage may be raised to 1,300, each generator and each motor having a voltage of 650. Hence the current to be carried by each machine and the switchgear and cables is halved. At the same time the diameter of the motor may be reduced very considerably, which facilitates economical layout in most cases, and the reliability of the vessel is increased because either unit of the tandem motor may be used alone.

The Interleaved System.

The system voltage of 1,300 mentioned

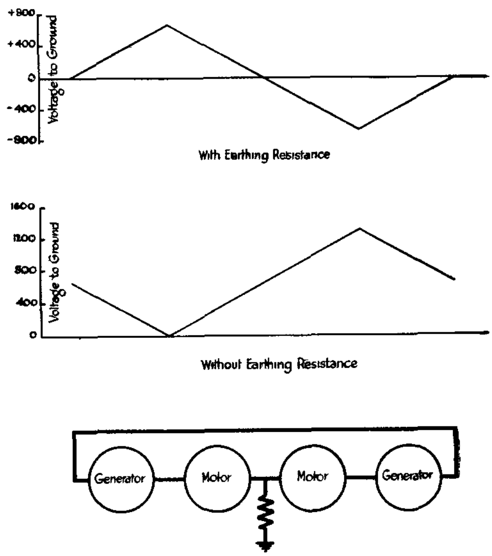


Fig. 4.—Tandem Motor with Plain Series Connection. Diagram of Voltage to Ground.

above does not involve insulating any part of the plant for this pressure. In Fig. 2A the generators and the two motors are "interleaved," i.e., the generators are separated in the circuit by the two motors. Hence the maximum voltage to ground is only 650. This is illustrated in Fig. 3, where an earth is assumed to occur at one of the machine terminals. An earth elsewhere would give a lower voltage to ground.

The "interleaved" system of connections shown in Fig. 2A involves two sets of cables to the tandem motors. In an alternative arrangement illustrated diagrammatically in the lower part of Fig. 4, the two motors are connected together electrically. In this system of connections only one set of motor cables is required, but it is necessary, in order to limit the voltage to ground, to provide an earth connection either between the two motors or between the two generators. The effect of the earth connection is illustrated in the upper part of Fig. 4. Any earth fault which occurs with this arrangement constitutes a short circuit of part of the system and it is necessary, therefore, for the earth connection to include automatic apparatus either to remove the normal earth connection in the event of a fault (in which case a high voltage to ground may result) or to interrupt the excitation supply (which results in cessation of power supply, which may be dangerous). The "interleaved" system does not suffer from these disadvantages and is, therefore, to be preferred. Systems analogous to the foregoing may be arranged with any number of generators. The tandem motor is then particularly helpful in avoiding the use of abnormally low voltages and heavy currents for the relatively smaller generators involved.

Operation of Multiple Generator System.

The possibility, in a multiple generator system, of using less than the total number of generators leads to economical running at speeds below normal and the effect is very soon available as the speed is reduced because of the disproportionately great reduction of power with speed. For example, in a four-generator equipment the following speeds are theoretically obtainable with the different number of generators :—

4 Generators	..	100.0	per cent. speed.
3 ,,	..	90.9	,, ,,
2 ,,	..	79.4	,, ,,
1 ,,	..	63.0	,, ,,

The remaining generators still rotate at full speed and, therefore, are capable of giving their full rated power. With, for example, three generators running there is available three-quarters full power and three-quarters full voltage. Under this condition, the motor would naturally drive the propeller at 75 per cent. speed and the power required would only be 42 per cent. of full power. As already explained, however, the motor speed may be increased by field weakening until the full available power of the generators is absorbed. This, as given in the table above, occurs at 90.9 per cent. speed.

This effect may be produced by a motor field rheostat. If, however, the fourth generator were reintroduced without the motor rheostat being returned to its normal setting the motor would continue to run at a speed higher in the above ratio of 75 to 90.9 per cent. than that corresponding to the generator voltage, i.e., the motor would tend to run at 21 per cent. above normal speed. If this occurred, the power required would represent an overload of 78 per cent., which would cause the engines to slow down to an extent which might endanger the whole auxiliary supply of the vessel if obtained in the usual way from auxiliary generators driven in tandem with the propulsion generators.

It is, therefore, normal practice to weaken the motor field for this purpose by means of blocks of resistance which are inserted in the motor field circuit by auxiliary switches operated from the generator isolators. The motor field is thus automatically weakened and strengthened in accordance with the number of generators. This arrangement does not give exact adjustment, however because it must insert equal blocks of resistance as each generator is disconnected whilst for exact adjustment different amounts should be inserted in the first second and third steps. The agreement is however, fairly close and the discrepancy can be adjusted by a rheostat. Careles

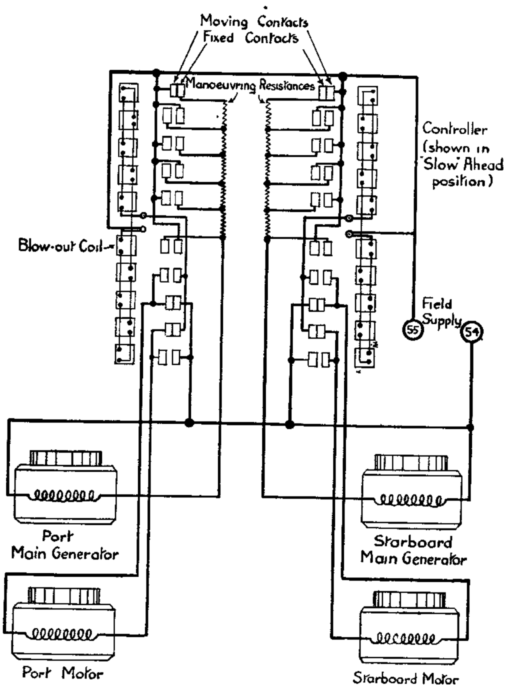


Fig. 5.—Twin-screw D.C. Propulsion Equipment.
Key diagram of interconnections between controller, propulsion motors and generators.

handling can still, however, produce an overload though not of serious amount.

Cutting Out Motor Unit.

It should be noted that one unit of the tandem motor is not cut out except in the case of breakdown. In such a case we have a half power unit running at reduced speed, so that the power available is also reduced and the speed is 70.7 per cent. of full speed. Since the cutting out of one motor unit is an emergency operation, it may be performed with the system dead. Bolted links mounted on the motor are conveniently used for this purpose as indicated for the main circuits in Fig. 2. In some cases, however, isolating and short circuiting switches may be included with the switchgear. This is particularly adapted to the interleaved system as all motor terminal leads are required to be brought up to the switchgear to interleave with the generator connections. The motor isolators may be fitted with auxiliary switches to insert resistance in the generator field circuits and so limit the voltage obtained when one motor is isolated.

TWIN SCREW SYSTEMS.

In general a twin-screw system consists simply of two single-screw systems, and the foregoing principles of single screw systems apply as long as the port and starboard equipments remain electrically independent. Any association between the two, however, introduces a fresh set of conditions.

Supplying Two Motors from One Generator.

In a twin-screw equipment consisting of one motor and one generator set per screw, each set independent of the other, if one of the generator sets should be out of commission, its motor must either be shut down or supplied in parallel with the other motor from the remaining generator. The second plan is clearly the better since it keeps both propellers in commission and avoids running with the helm well over. It is, however, subject to certain limitations. When the two motors are connected to one generator they will, in the

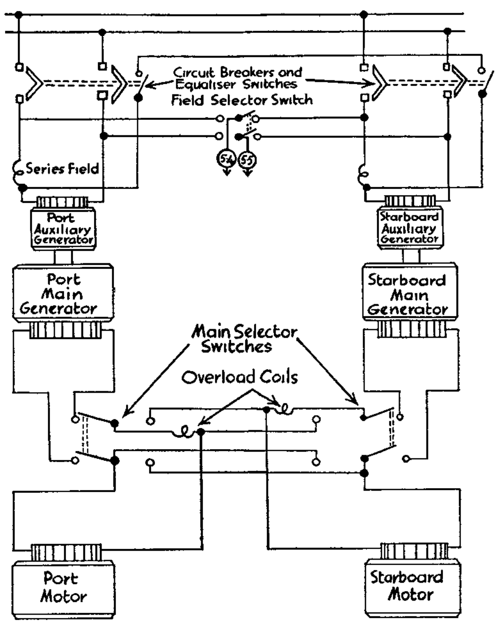


Fig. 6.—Twin-screw D.C. Propulsion Equipment.
Key diagram of connections between propulsion motors, generators and auxiliary gererators.

adaptation of the two single-screw systems described, both run at the same speed and in the same direction. There is not much disadvantage to have the two motors always running at the same speed. It is, however, definitely disadvantageous that they should both rotate in the same direction, since the main manœuvring advantage of the twin-screw vessel is lost. In the system employed by the Metropolitan Vickers Electrical Co. for shallow-draught vessels, this disadvantage is removed by employing motor field reversal for changing the direction of rotation of the motors. Speed variation is still obtained by generator field control as in the single-screw systems. When, therefore, the two motors are connected to the generator, they both rotate at the same speed, but they may be made to rotate in the same or opposite directions as required.

The type of vessel in question employs fairly high speed motors which are, in consequence, relatively small, and their fields build up rapidly. By providing in the controller a small time delay between the application of excitation first to the motors and then to the generators, the motor field is enabled to build up sufficiently to prevent a heavy current overload being imposed on the system as would be the case if voltage were applied to the armature of an under or unexcited motor.

Excitation Precautions.

With this system, a precaution is necessary to prevent voltage being applied to one unexcited motor whilst the other is being used. In the Metropolitan-Vickers system, when the two motors are connected to one generator, the two generator controllers are connected in series and, being coupled to the motor field reversers, are, therefore, made to ensure that the generator excitation circuit is not completed unless both motors are excited. This is shown diagrammatically in Fig. 5, whilst Fig. 6 shows the main connections, including the main selector switches for coupling the motors in parallel. Analogous connections are made for the excitation circuits. Fig. 6 also shows the connections for two auxiliary generators used one at a time, as exciters.

System with Motor and Generators in Series.

In an alternative system proposed for twin-screw vessels, the two motors and generators are connected in one series circuit and motor field control only is provided. In order to prevent current overloads and instability between the two motors—disadvantages from which this system would otherwise suffer—special generators are necessary having constant current characteristics. The system provides the control required since it gives

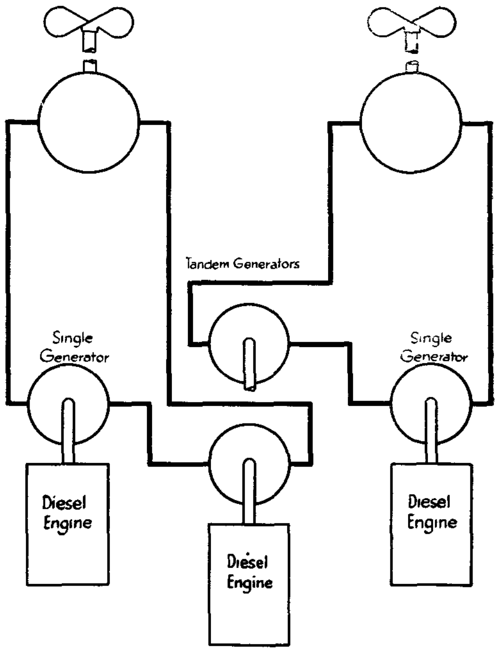


Fig. 7.—TWIN SCREW, THREE-ENGINE D.C. DIESEL ELECTRIC PROPULSION EQUIPMENT. Key diagram of main connections.

independent control of speed and direction of rotation of both motors under all conditions. Either generator, may, of course, be put out of commission without affecting the operation of the equipment. In its simple form, just described, this system would have several operating disadvantages, but various regulating arrangements have been proposed to impart the necessary stability and will, no doubt, be tried out in the near future.

The constant current series arrangement just described may equally well be used whatever the number of generators. This may be an advantage where in a twin-screw vessel it is desired to use an odd number of engines (either as the total number or as one of the conditions of operation).

If, on the other hand, it is preferred to have the two propeller systems normally separate, clearly the number of generators must be a multiple of the number of propellers. The method of dealing with this problem consists in using tandem generators. At least one engine must be fitted with a tandem generator and all the engines may be. The arrangement will be clear from Fig. 7, which illustrates a three engine plant, of which one generating set is a tandem unit. The isolating switches are omitted to simplify the diagram. It will be seen that the output of the centre engine may be equally divided between the two shafts and that independent control of both motors may be obtained on the Ward-Leonard system. It will also be evident from the diagram that this control will be possible with balanced power on the two screws if all engines are running, if the two wing engines only are running, or if the centre engine only is running.

If, however, the isolating switches for the units of the tandem generator are made double throw, and each arranged to connect its generator alternatively to port and starboard propeller systems, then independent control and balanced screw power may be maintained whatever number of engines is in commission.

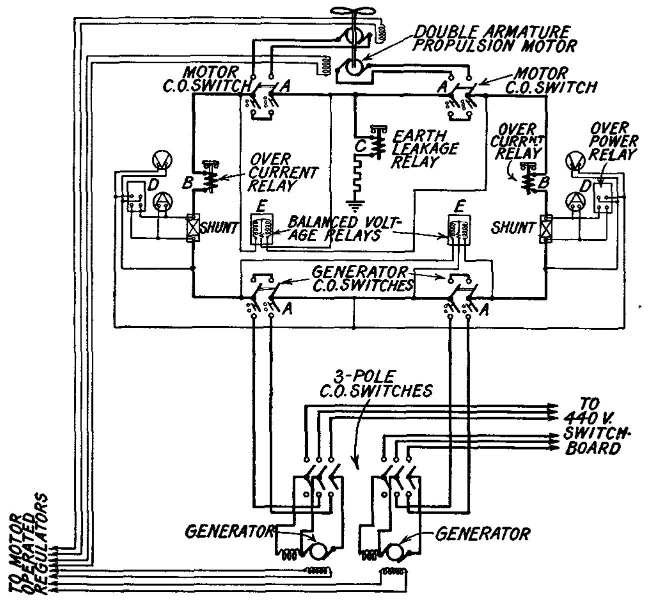


Fig. 8.—Single-screw D.C. Diesel Electric Propulsion Equipment with Auxiliary Supply from Main Generators.

In the Italian Ferry, mentioned above, all three engines are fitted with tandem generators, one unit of each set being connected to the port motor and the other to the starboard motor. This system employs somewhat simpler switchgear than that just described, but the generators are more costly and require more space.

Generators to Supply Auxiliary Load.

A diagram of connections for a case where the propulsion generators are used to supply auxiliary load when the requirements for propulsion power are low, or the vessel is stationary, is given in Fig. 8. This is the diagram of the EMV "Cement Karrier," the main generators of which are used to provide the heavy power required for cargo loading and unloading. The electrical equipment was supplied by the G.E.C. Each generator is provided with an isolating and short circuiting switch in the propulsion circuit, also a double-throw switch to enable either generator to be allocated at will either to propulsion or to auxiliary services. The two switches may be combined into one unit. The generators operate as shunt wound machines on propulsion service and as compound wound machines on auxiliary service. The question of A.C. propulsion equipment and A.C. and D.C. control will be dealt with in a later article.

FUSES FOR HIGH VOLTAGES

By W. A. COATES, M.I.E.E., Fel.A.I.E.E.

ALL designs of fuse are subject to a definite upper limit of normal current, set by the amount of heat which can be dissipated by the fuse casing. Their very function of fusing implies a heating rate higher than that of the conductors they protect. A second limit—to breaking capacity—is set by the mechanical strength of the casing, and the arc quenching medium. Even without these limitations, fuses would be inadmissible as protective devices on important circuits because of the time wasted in replacement after operation.

On high voltages (e.g., transmission systems, 33 kV. and more), the low price as compared with circuit breakers makes the fuse the only commercially feasible protective device for small-power circuits.

Breaking the Arc.

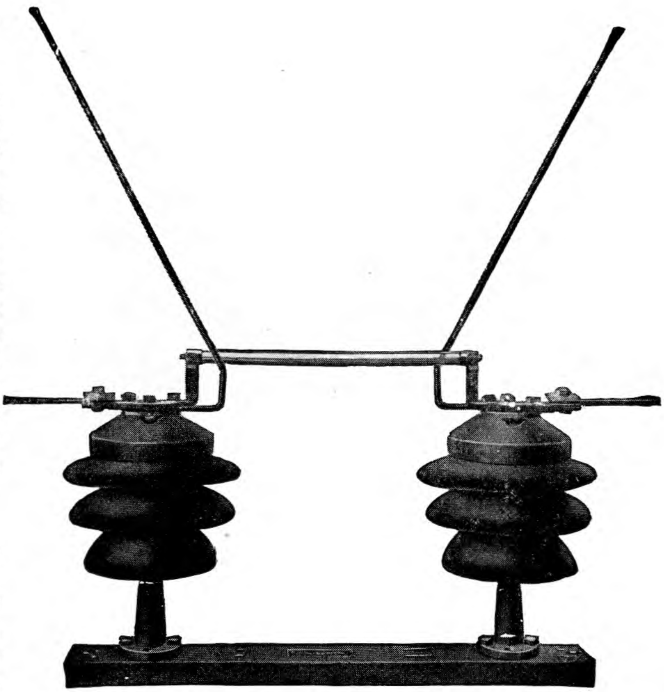
On such service, the lengths of break must be greater in proportion, and it is more than ever necessary to quench the arc in minimum time, to avoid complete destruction. When mechanical means, such as springs, are used to accelerate the action, the fusible element has to give release. For the small normal current ratings which are frequently necessary, the fuse proper is sometimes used to melt or explode a more robust spring detent.

Special Fuses for Voltages Higher than 33 kV.

Up to 33 kV., fuses of the cartridge, expulsion, horn, and porcelain tube types are all quite practicable, and differ only in dimension from those used on lower voltage. Here reference need be made only to the forms which are usable on the highest voltages.

Horn Gap Fuse.

The horn gap, bridged by a fuse wire, either open or enclosed in a fragile weather casing, is the oldest, as well as the cheapest of these (see Fig. 1). As with the horn break-switch, the duration of arcing is quite fortuitous, and with favourable air currents the arc may stretch five or even 10 times the distance, which would be a safe air clearance for the voltage. Hence, although horn fuses can be constructed for any working pressure, their use is strictly limited.



TYPICAL HORN BREAK FUSE FOR 33 KV., WITH FUSE WIRE IN BREAKABLE GLASS TUBE. (Metropolitan-Vickers.)

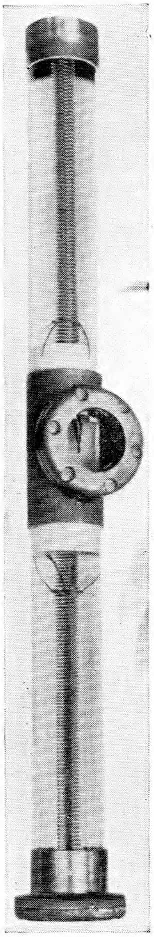


Fig. 2.—FUSE UNIT OF THE LIQUID TYPE FOR 132 kV. (Allen West.)

Liquid Fuse.

Within recent years, the carbon tetra-chloride fuse has been developed up to the highest voltages, and quite recently it has been tested out on the Grid 132 kV. system with considerable success. To get an adequate break in minimum time, and thus avoid so large an arc energy as to shatter the fuse tube, a double-ended arrangement is used, the fusible element coupling two spring-loaded terminals, both of which retract in operation. Even thus, Pyrex glass tubes are needed, and a bursting disc is located over the centre of the breaking distances. Fig. 2 shows such a unit, which is claimed to have broken over 900,000 kVA. 3-phase equivalent on the 132 kV. system at Kirkcaldy.

Explosion Pot Fuse.

Another type employs the principle of the explosion pot. It is, in fact, built largely of oil circuit breaker components, as may be judged from the sectional drawing in Fig. 3. In this case the porcelain tube is partly filled with oil, and the fusible element breaks within a moulded insulation explosion pot. As in a circuit breaker, the products of arcing expel the upper electrode, and assist to obtain a very high breaking speed. This design of fuse also has been proved successful in tests by the Central Electricity Board at Kirkcaldy, similar to those mentioned in the previous paragraph. The design has considerable advantage in keeping to a minimum the floor space occupied.

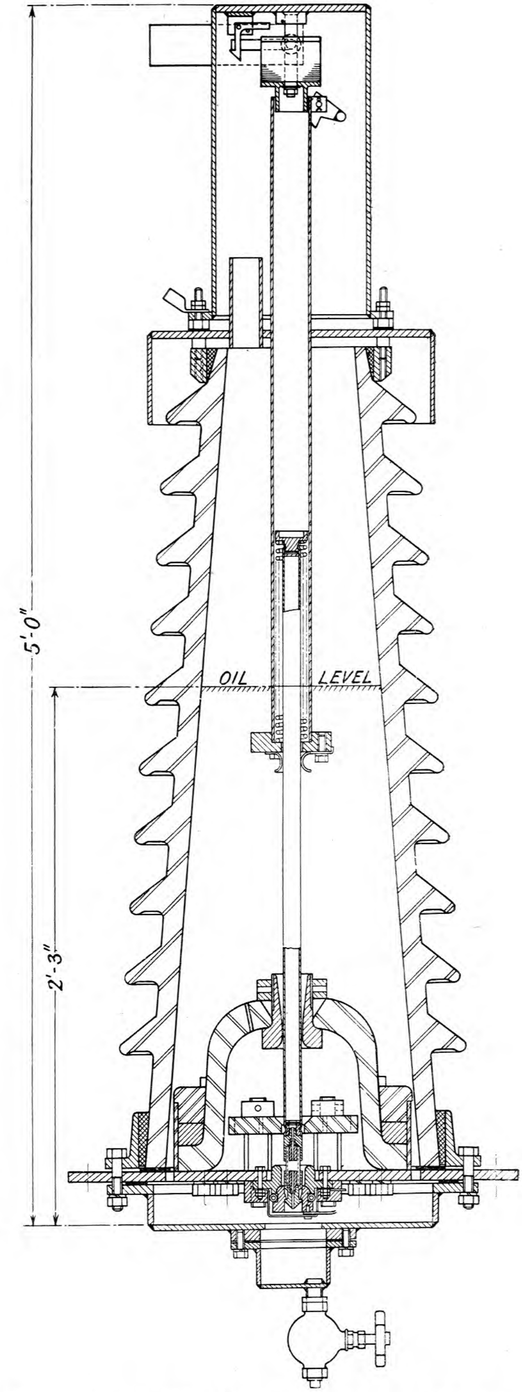


Fig. 3.—EXPLOSION POT TYPE OF 132 kV. FUSE. (B.T.H.)

WINDING SMALL MOTOR ARMATURES

By K. H. Greenly

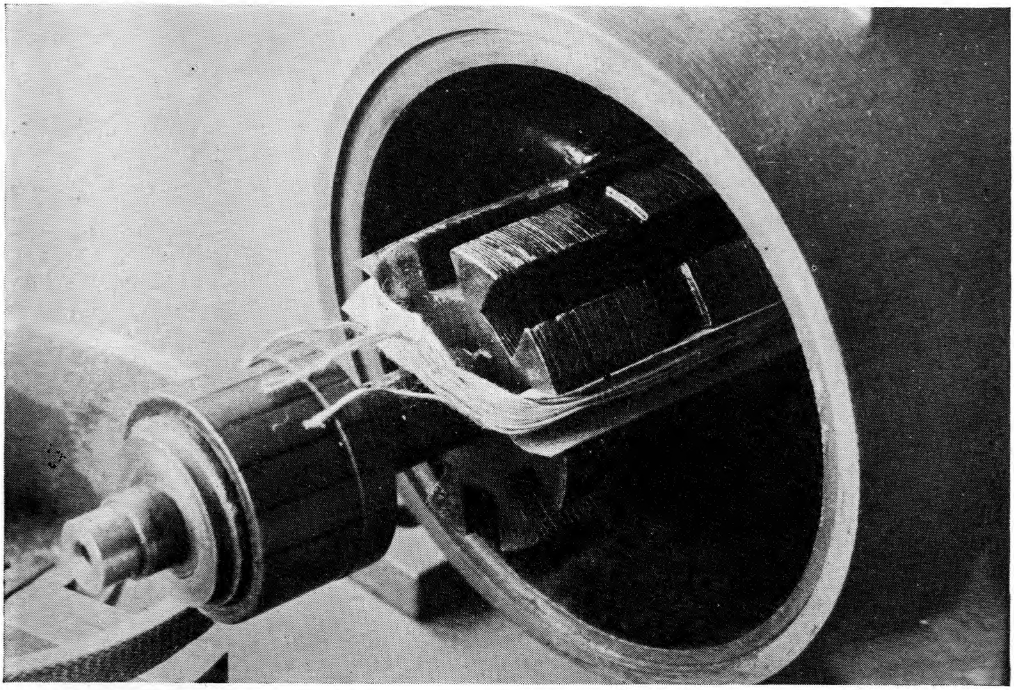


Fig. 1.—A Fractional-horse-power Armature in Course of Winding
It is intended to provide 8 coils (two per slot), each coil having a centre-tapping for lap-connection to a 16-bar commutator.

THE principle underlying all electric prime movers is the interaction of the magnetic field produced by a conductor carrying a current, and an independent field. A set of conditions illustrated in Fig. 2 is not a stable one. The single conductor bearing a current away from the reader will tend to move in an anti-clockwise direction.

The direction of motion of any such combination may be obtained from Fleming's Left-hand Rule (Fig. 2A), it always being assumed that the lines of force *leave* the face of a North Pole and enter a South Pole.

To produce a continuous and even torque, our rudimentary motor must consist of a series of conductors capable of rotating round an axis and presenting their lengths to a fixed field system. Furthermore, the direction of the currents which the conductors bear must always be such as to produce a co-acting torque. This condition is arranged by a commutator, which also forms a feeding point for power.

Rules to be Observed.

Armature winding comprises such an arrangement of conductors and must conform to certain conditions :—

(1) It shall be symmetrical about its axis to produce mechanical balance and an even torque.

(2) It shall be continuous with tappings taken equidistantly round the windings and brought out to a commutator from which current may be fed. The number

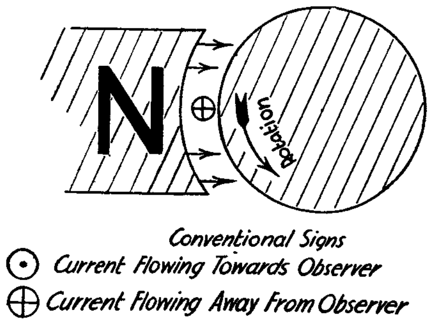


Fig. 2.—Showing the Action of a Conductor in a Fixed Field.

of tappings is arranged with a view to the voltage of the supply and in an A.C. series-wound machine to the frequency.

It is also desirable that iron shall be present in the armature core to reduce the reluctance of the field circuit to magnetisation, thus minimising the current wasted in energising the field. It is not essential that the core should be polar. Indeed, polar types have now died out except the Siemens "H" armature which is used for special purposes, such as magnetos for ignition and bell-ringing.

The Ring Armature.

One of the earliest forms of non-polar types was the ring armature, now obsolete (Fig. 3).

The winding is wound on an iron ring built up of stampings, and consists of a continuous and re-entrant coil of wire with tappings, surrounding the ring. In view of the distortion of the field by the presence of the ring-shaped iron core, it is clear that the only conductors which are active in producing a torque are those on its outer surface. The turns on the inside are inactive and merely preserve the electrical continuity. Though simple, this form of winding is inefficient and wasteful of copper, but is useful from the theoretical standpoint for analysing more complicated windings.

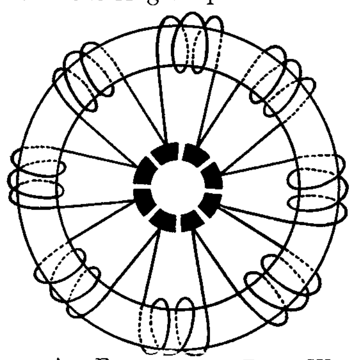


Fig. 3.—An Elementary Ring Winding.

The Modern Slotted Drum Armature.

The slotted drum is now almost universal practice in armature core design. Fig. 4 shows two types of lamination in general use. The windings, instead of surrounding the drum, consist of conductors spanning a certain number of slots with connecting loops at either end. With the exception of these "end turns" the whole of the wire lies in the best relationship to the field flux and, therefore, assists in producing the torque. A drum winding only differs from a ring winding in the disposition of the coils in relation to the iron core. The turns are still continuous and re-entrant.

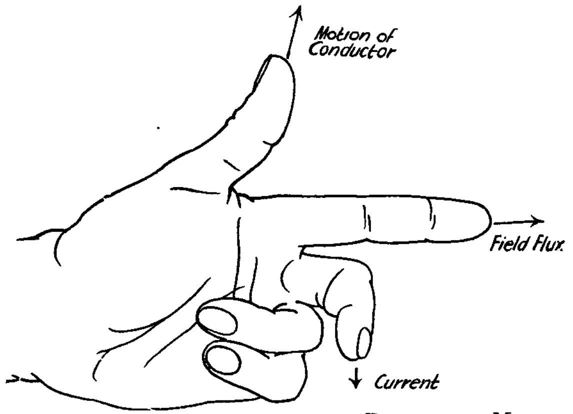


Fig. 2A.—Fleming's Left-hand Rule for Motors.

Relation of Winding Pitch to Pole Pitch.

In order that the two sides of a loop comprising one coil through which current circulates shall be under the influence of the correct field poles, the winding pitch must bear a definite relationship to the spacing of the poles. From Fleming's rule it is clear that the arrangement shown in Fig. 5 is workable with a 2-pole field. The current circulating in the coil, shown by the arrow, produces a left-hand torque under a North Pole, and a left-hand torque under a South Pole. The nett torque is, therefore, the sum of the individual torques. Now consider the same armature in a 4-pole field (Fig. 6). The individual torques will be in opposite directions and will neutralise one another.

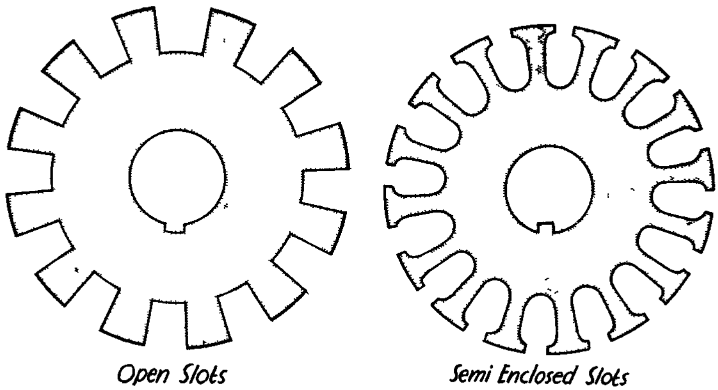


Fig. 4.—Two Common Types of Armature Stampings.

A first requirement of a drum winding, then, is that the winding pitch shall be as nearly as possible equal to the "pole pitch"—the pole pitch being the number of armature slots "N" divided by the number of poles "P."

Lap and Wave Windings.

All modern armature windings are what are called lap or wave windings or modifications of these (Fig. 7). The two types differ in the arrangement of the conductors at the commutator end. In the figure it is assumed for clarity that each slot contains only one conductor. This construction is used in large machines. In small machines it is more usual for a bundle of several conductors to be housed in each slot, as explained later.

In the lap winding each element comprising a coil is pitched alternately forwards and backwards, the progressive pitch y being the difference of the forward pitch y_f, and the backward pitch y_b. Each element gains y slots round the armature, until in the complete winding all slots are occupied.

In the wave or series winding the progressive pitch is the sum of the partial pitches y_f and y_b. The winding elements circulate very rapidly round the armature, but, as before, each slot houses the same number of conductors.

Simple Lap Winding.

The method of arriving at the various pitches is best shown by an example. Let us take the case of a two-pole machine with a 12-slot armature and assume for

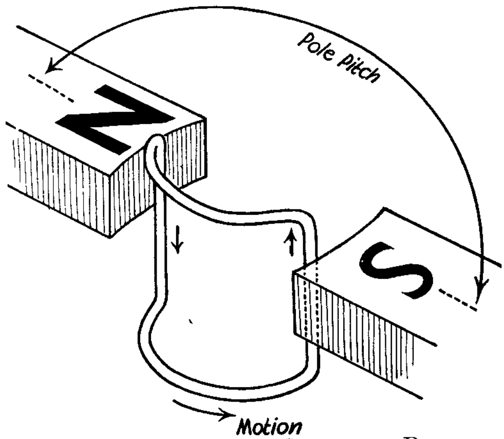


Fig. 5.—The Action of a Correctly Pitched Winding Loop in a Stationary Field.
The direction of the current is indicated by the vertical arrows.

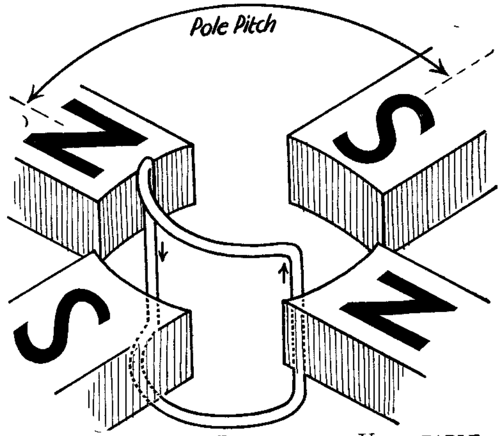


Fig. 6.—The Same Loop in an Unsuitable Field.
The winding pitch must obviously match the pole pitch.

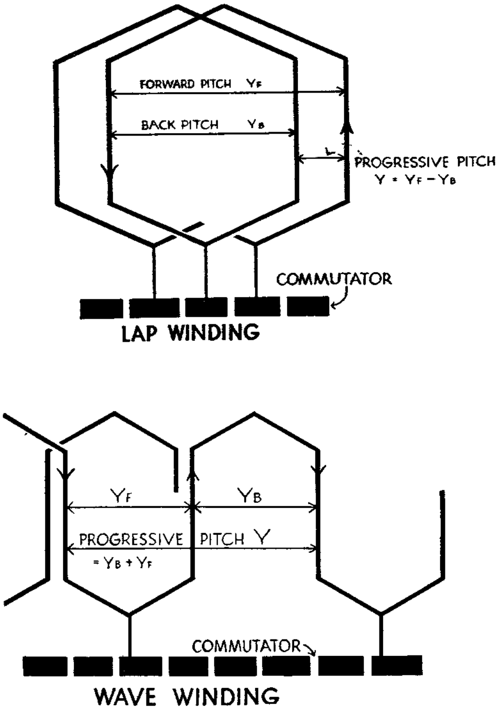


Fig. 7.—Lap and Wave Winding.
It is here assumed that each slot houses one conductor.

simplicity, that there is to be one conductor per slot.

The pole pitch in this case is $\frac{12}{2} = 6$, hence we must choose values y_f and y_b, which close to this figure. Furthermore, with one conductor per slot they must be odd numbers with a difference of 2, otherwise it will be found that when a portion of the winding has been laid we shall return to a slot which is already occupied. Suitable values are $y_f = 7$, $y_b = 5$.

A lap winding with these values drawn as a developed diagram is shown in Fig. 8. At the ends, where the diagram becomes discontinuous the corresponding leads are numbered. Connections to the commutator bars are made at each coil, hence, the number of bars must be one-half the number of armature slots.

Simple Wave Winding.

In a wave winding the conductors are pitched constantly forward, at partial pitches roughly equal to the pole pitch. Thus, when a number of conductors equal to the number of poles has been laid on, the winding will have passed right round the armature. Since we need only *one* conductor per slot it must be prevented from returning exactly to the starting point; it must return to a point two slots ahead or behind the starting point. In other words :—

$$y \times p = N \pm 2, \text{ or } \quad y = \frac{N \pm 2}{p}$$

where p = number of *pairs* of poles. Also $y = y_f + y_b$ = progressive pitch.

Let us take the case of a 22-slot armature in a four-pole field. The pole pitch is $\frac{22}{4} = 5\frac{1}{2}$.

Since $p = 2$

$$y = \frac{22 \pm 2}{2} = 12 \text{ or } 10.$$

We must choose values of y_f and y_b to total either 10 or 12 and they must both be odd numbers. Furthermore, they must each be nearly as possible equal to the pole pitch $5\frac{1}{2}$.

Of the values possible, $y_f = y_b = 5$ are the most suitable, and a winding with these values is shown in a developed form in Fig. 9.

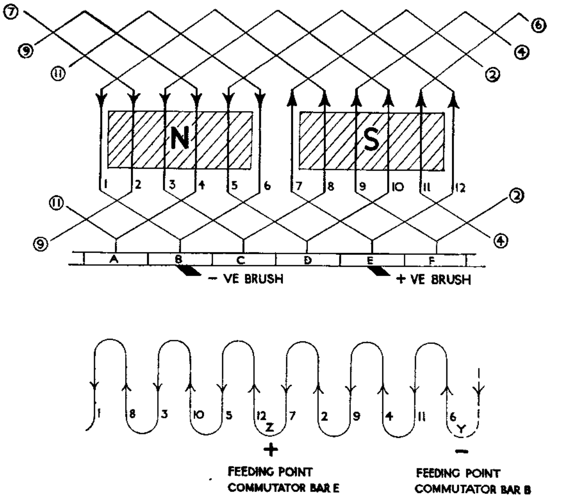


Fig. 8.—A Two-pole Lap Winding in a Developed Form.

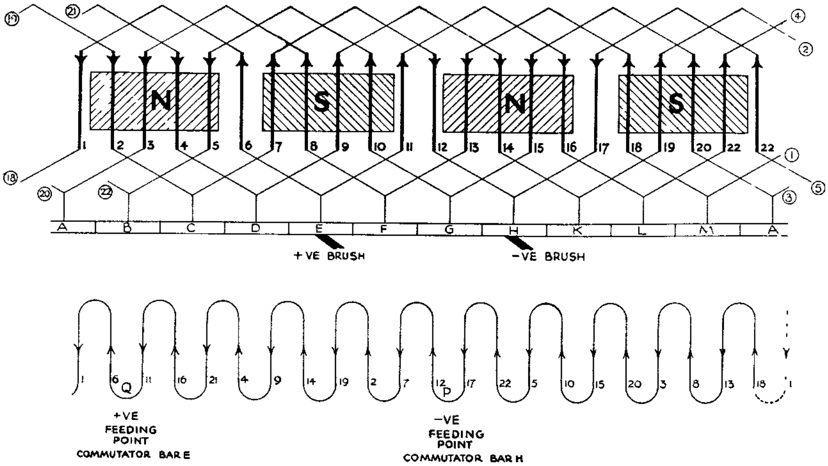


Fig. 9.—A DEVELOPMENT OF A 4-POLE WAVE WINDING.

Equivalent Ring Winding.

In the diagrams, Figs. 8 and 9, one position of the pole faces in relation to the armature has been shown stippled. It is clear that for a co-acting torque to be obtained the conductors under a North Pole must carry opposite currents from those under a South Pole. This, of course, is an instantaneous condition. The arrows indicate these currents.

If now the conductors which are connected together are sorted out and drawn adjacent to one another below the main diagrams we obtain a continuous zig-zag, which represents the equivalent of a ring winding, with the difference that all conductors are on the surface of the armature.

We must now put in the direction of the currents obtained from the arrows already in the upper parts of the diagram.

We see that in the case of both the lap wave connections the windings divide themselves into definite electrical circuits the number of these being dependent on the type of winding and the number of poles.

In Fig. 8 there are clearly two meeting points of current, Y and Z in the lower part of the diagram, corresponding to the conductors 12 — 7 and 6 — 1 respectively.

These must be feeding points, i.e., the position of the brushes. Current from a positive brush at Z will divide itself between the two paths available, one to the right and one to the left, circulate through the armature and rejoin at Y. The armature, therefore, has two parallel paths and in this case two brushes will be required. The points Y and Z correspond to commutator segments B and F respectively opposite the centres of the pole faces. It is immaterial what position the poles are assumed in relation to the winding. If the currents in the conductors are traced out in the same way, it will always be found that brushes must be placed opposite the pole centres.

The Short-circuited Coils.

Imagine the winding moved one slot distance to the right. Each of the brushes will now be spanning two adjacent commutator bars and consequently short circuiting the coil connected between them. Though at first sight it may appear incorrect, we see that the conductors concerned are in the gaps between the poles and are, therefore, producing little or no back E.M.F. This is obviously the best position for commutation. In practice, of course, it is necessary to retard motor brushes slightly (against the direction of rotation) to compensate for the distortion of the field by armature reaction.

Referring to Fig. 9 of a wave-winding with four poles, the winding may be

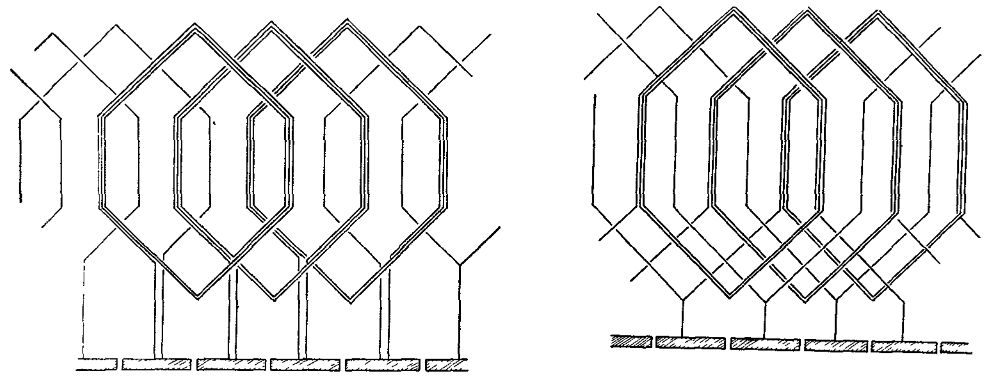


Fig. 10.—Multi-turn Coils Arranged for (*a*) Lap Connection ; (*b*) Wave Connection. The placing of the coils in the slots is identical in both cases. The difference lies in the connections to the commutator, which forms a convenient place for the inter connection of the free ends of the coils. The coils would, of course, be former-wound.

analysed in the same way. The equivalent ring-winding is drawn in below the main diagram, and from the direction of the arrows it is seen that there are two meeting points at P and Q corresponding to armature conductors 6 — 11, and 12 — 17 respectively. These must be feeding points and the brush positions are, therefore, at commutator segments E and H.

Number of Parallel Paths.

It is important to note that the number of parallel paths through a lap-wound armature bears a definite relationship to the number of poles. In Fig. 8, we found by analysis two such paths. Had we taken a 4-pole armature, four parallel paths with four current meeting points would have been found and, therefore, four brushes (two positive and two negative) would have been required.

The general rule is that the number of paths in a lap-winding is equal to the number of poles.

In a wave-winding, however, it is found that there are *always* two paths with any number of poles. Only two brushes are required and though on a large machine it is usual to employ more than two, their effect is merely to short circuit a coil between the poles, and the number of circuits remains two.

Multi-turn Windings.

In small machines, A.C. and D.C., the number of armature conductors may amount to some hundreds.

It is obviously impossible to employ a separate slot for each and the winding is invariably composed of a series of coils containing many turns insulated from one another as in Fig. 10. A shows lap connections and B wave. Comparing the two it is seen that the arrangement of the coils in the slots is identical and it is only in the connections to the commutator that the windings differ.

The coils are invariably wound on a former and then placed in position on the armature core. The commutator is a convenient place for interconnecting the free ends of the coils and each segment receives two coil ends. The winding thus becomes electrically continuous with equidistant tappings to the commutator. In Fig. 3 the ring winding has been connected in the same way.

The number of slots and the partial pitch must be chosen with the previous considerations in view. A number of slots suitable for lap winding will not necessarily do for a wave-winding.

A.C. and Universal Motors.

Though in principle armature windings for D.C. and A.C. commutator motors are the same, there are in the latter some special considerations to be met. We have seen how during rotation of the armature, the coils are short circuited in

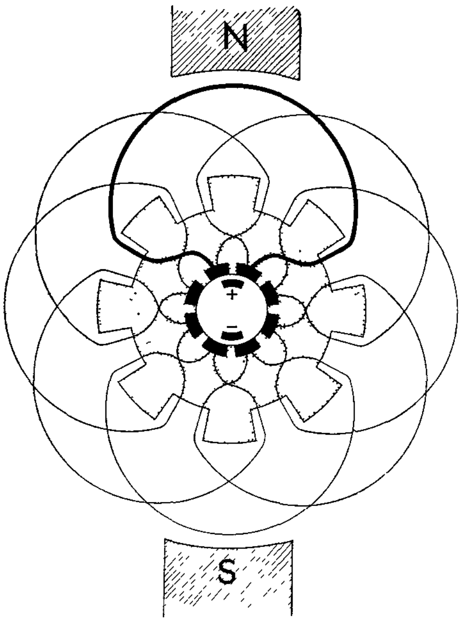


Fig. 11.—An 8-slot Arrangement with Two Coils Per Slot.

One coil has been thickened to show more clearly the commutator connections; the brush positions are also shown.

turn under the brushes, and how this happens when they are cutting the least number of lines of force. In an A.C. motor of this type, there is, besides the dynamically induced E.M.F. due to the rotation of the armature, a statically induced E.M.F. due to transformer action between the armature coils and the field coils, which may give rise to excessive sparking at the brushes. To mitigate this trouble the number of turns suffering short circuit by the brushes must be reduced to a minimum. In other words, the number of separate coils and the number of commutator bars must be made as high as possible. To avoid using a larger number of armature slots—small slots are more troublesome to wind and further there is a loss of space due to " slot insulation," it is common to accommodate more than one bundle of conductors in each slot.

Typical Arrangement of Coils.

Fig. 11 is the end view of a typical arrangement of coils in an 8-slot core with a two-pole field. Fractional h.p. machines are commonly 2-pole, and here there is nothing to choose between lap and wave-winding as regards the number of armature conductors in series active in developing a back E.M.F. The number of parallel paths through the armature is two in both cases. With lap connection, the forward pitch is commonly one less than the pole pitch (three in this case) with a progressive pitch of one. This will produce two coils per slot, and there will be as many commutator bars as armature slots. The illustration also shows the connections to the commutator and the position of the brushes relative to a two-pole field.

An arrangement of coils as seen from the end in a 16-slot drum with two coils per slot is illustrated in Fig. 12. Where there is an odd number of slots, a similar procedure would be followed, the coil pitch being in this case the nearest whole number below the pole pitch, e.g., 8 in a 17-slot drum, with a progressive pitch to the commutator of one.

It is sometimes desirable to use a commutator with more segments than armature coils. In such cases, equidistant tappings may be brought from the coils for connection to adjacent commutator bars. Such coils would be former wound and appear diagrammatically in Fig. 13. This is an

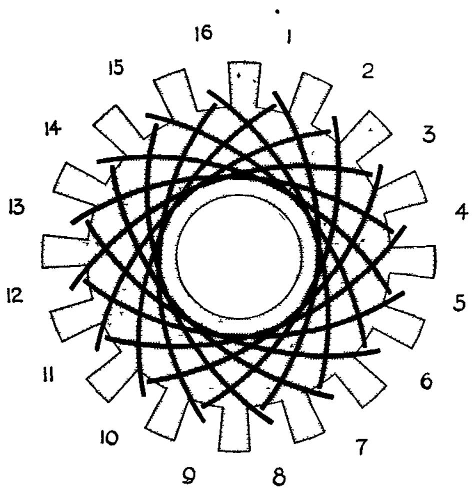


Fig. 12.—A 2-Pole Armature with 16 Slots.
The coils are arranged two per slot and span six clear slots.

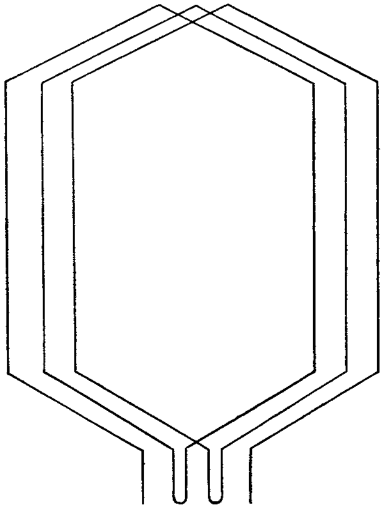


Fig 13 —A " Treble " Coil.

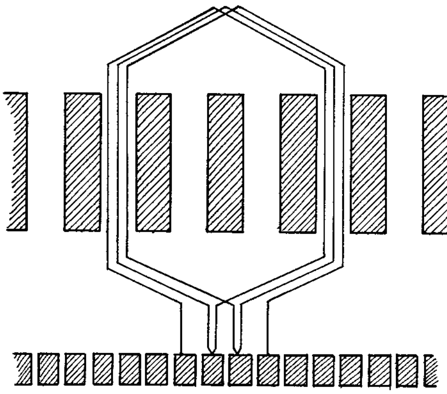


Fig. 14.—A " Treble " Coil, Showing Connections to Commutator.

example of a " treble " coil with two tappings and two free ends. The commutator connections are made as shown in the development (Fig. 14). Three bars per coil would obviously be required.

A photograph of an 8-slot armature for a 2-pole field connected to a 16-bar commutator is reproduced in Fig. 11.

Here only one coil has been laid on and this has a single tapping brought out intermediately between the free ends.

NINTH CONFERENCE OF THE ELECTRICAL CONTRACTORS' ASSOCIATION HELD AT BUXTON

(By Our Special Correspondent)

SIR William Ray, M.P., the recently appointed Executive Chairman of the Electrical Development Association, led off with an Address which, to say the least of it, was provocative in its suggestion that the day of the independent contractor was over, and that the supply undertakings would be taking wiring business more and more into their own hands. The subsequent discussions showed that the contractors held a very different point of view. Mr. H. M. Drake, of the firm of Drake & Gorham, Ltd., scored one decidedly good point in his complaint that the supply undertakings in competing with contractors in wiring work tried to pick and choose. Mr. Drake suggested that they should either be prepared to compete on the difficult jobs as well as the easy jobs, or else leave the whole business of wiring alone.

QUESTIONS AND ANSWERS BY PRACTICAL MEN

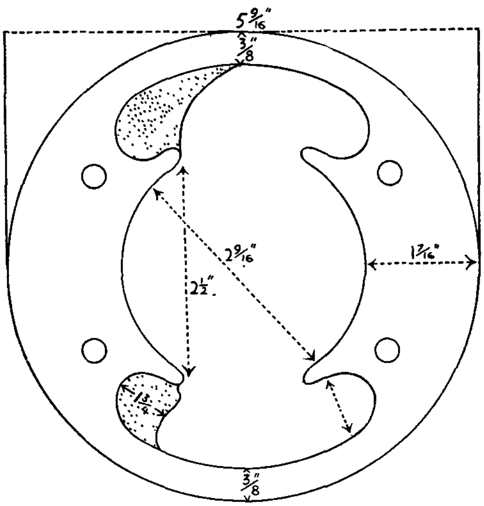
Readers are invited to send problems of practical interest. Letters should be addressed to " The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2. Envelopes to be marked " Problem " in the top left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTH'S NEW QUESTIONS

Rewinding for $\frac{1}{8}$-h.p. Motor.

I send enclosed particulars of the field and armature of a $\frac{1}{8}$-h.p. motor. Armature: Diam. of core, $2\frac{1}{2}$ ins.; length of core, $1\frac{3}{4}$ in.; diam. of slots, $\frac{3}{8}$ in.; No. of slots $\frac{3}{8}$ in. diam., 12; No. of comm. bars, 24. I desire rewinding for 200 v. D.C. at 1,000 r.p.m. (approx.) Could you please oblige with winding data?

R. WIBBERLEY (Radford).



FIELD DETAILS OF MR. WIBBERLEY'S $\frac{1}{8}$ H.P. MOTOR.

The Trumpy Voltage Regulator.

Could any of your readers supply me with technical details of an automatic regulating switch for voltage regulation on a central battery of " Tudor " manufacture? There are 112 cells on the battery, 21 of which are regulating cells.

The regulator is known by the name of " Trumpy Automatic Regulating Switch," and apparently was manufactured by a firm of the name of Messrs. Richm, Frey and Co., Hagen, 2.W.

I would be very grateful for any help that you can give me to obtain particulars, and if possible a circuit diagram of this particular system of voltage regulation.

J. R. L. WILLIAMS (Tongwynlais).

Machines for Manufacturing Heating Elements.

I am anxious to obtain some information regarding the manufacture of electric-iron and other flat heating elements, and I should be very grateful if you could supply me with names of manufacturers of machines suitable for this purpose.

B. C. CHASE (Liverpool).

REPLIES TO PREVIOUS QUESTIONS

Generator Calculations.

Can you please give me a formula to calculate :—

The rate of change of current in amperes per sec. in a 6 kW. 200 volt 4-pole generator, running at 694 r.p.m. The number of commutator segments is 160 and the brush just covers 2 segments and 1 mica.

Could you recommend me a book of formulæ dealing with electric generators and motors, etc.

THOMAS MARKS (Cornwall).

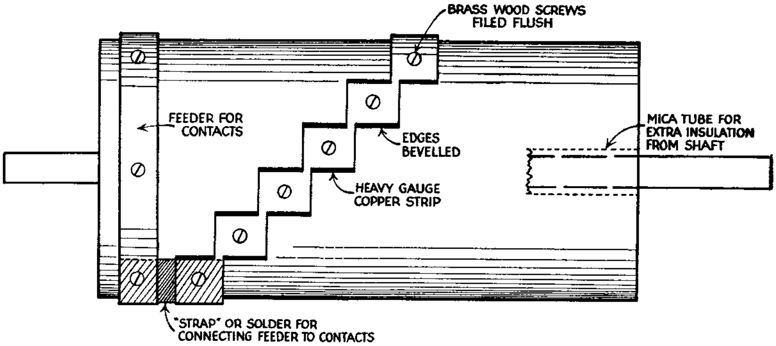


Fig. 1.—DRUM FOR FLASHER.

The rate of change of current in the armature coils of the generator due to commutation will depend on whether the machine is wave or lap-wound (i.e., the number of parallel paths through the armature and upon the number of brushes).

Since one brush covers two segments, the time taken by the brush to short circuit one coil equals approximately $\frac{2}{160}$ or $\frac{1}{80}$ of a revolution. This is assuming that the short circuit takes place while two segments and two micas move under the brush. Since the commutator makes 694 r.p.m., the time of short circuit equals

$\frac{1}{80} \times \frac{1}{694}$ min. or $\frac{60}{80 \times 694}$ seconds.

$$\text{The current per coil} = \frac{\text{Load current}}{\text{Paths through armature.}}$$

(Considering wave winding with two paths)

$$\text{Current per coil} = \frac{6{,}000}{200 \times 2} = 15.$$

This current is reversed (30 amps. change) in $\frac{60}{80 \times 694}$ secs.

$$\text{Now rate of change} = \frac{\text{Change of current}}{\text{Time of change}}$$

$$= \frac{30}{\frac{60}{80 \times 694}}$$

$$= \frac{30 \times 80 \times 694}{60} = 27{,}760 \text{ amps. per sec.}$$

for one brush.

For lap-winding, the number of paths through the armature equals the number of poles, in this case four, so the current change per second equals half that of wave-winding, i.e., 13,880 amps. per sec.

The above can be written as the formula given below.

Rate of change of current in amps. per sec. for one brush equals :—

$$\left(\frac{\text{K.W. output} \times 2}{\text{Voltage} \times \text{No. of paths}}\right) \div \left(\frac{\text{Fraction of comm. under brush}}{\text{r.p.m.}} \times 60\right)$$

A very good book is "Junior Technical Electricity," by R. Hutchinson, University Tutorial Press, at 4s. 6d.

C. W. S. (Chingford).

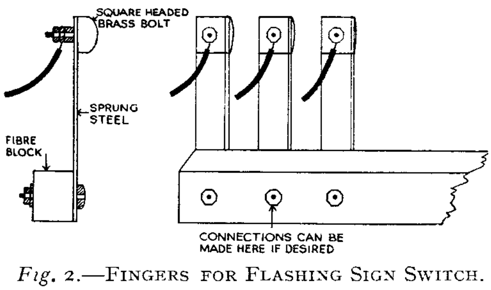


Fig. 2.—FINGERS FOR FLASHING SIGN SWITCH.

Flashing Electric Sign Switch.

I want to fix a crawling type of flasher round a streamer board. Can you tell me how to construct a drum and contact fingers suitable for four to six circuits totalling 60 to 120 lamps ?

WILLIAM MARTIN (Notts).

The drum for the flasher can be a piece of hard wood with a steel shaft in the centre, or a piece of fibre tube mounted on end plates (see Fig. 1). The contacts can be secured by countersunk wood-screws, or setscrews if the tube is used. These screws should be of brass and filed flush with the contact strip. A diameter of four inches will provide for a circuit of 20 lamps, while the length for this number will be 20 times the width of the fingers, plus clearance, and allowance for the live feeder ring and finger.

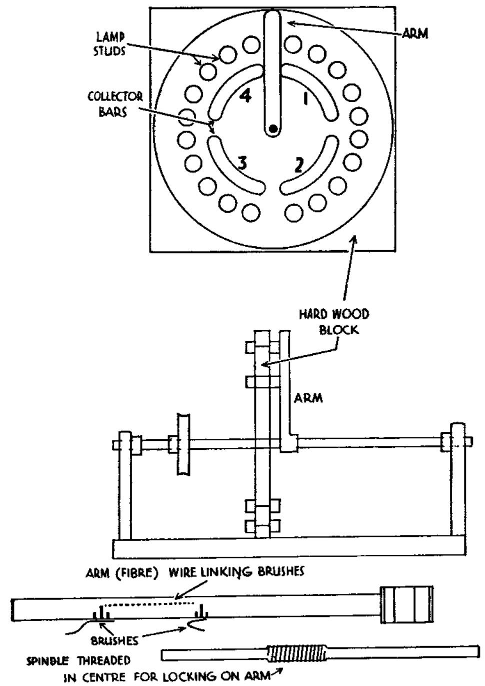


Fig. 3.—ANOTHER SUGGESTION FOR FLASHING SIGN SWITCH.

The fingers can be made of spring steel, $\frac{3}{4}$ in. × $\frac{1}{64}$ in., with contacts made of square-headed brass bolts, the heads being rounded off on two edges (see Fig. 2).

The leads to the lamps can be connected direct to these bolts, or to the bolts holding the spring steel to the fibre block. The spring steel is similar to that used for gramophone springs.

H. EASTHOPE.

Another Suggestion for Flashing Electric Sign Switch.

Divide the number of lamps into equal parts, 4 if possible, to keep down the number of collector bars. Procure a piece of hard wood (oak or teak), or better still, a slate panel, with a breadth sufficiently wide enough to accommodate a circle of studs equal to the number of lamps. Add one collector bar to each quarter of the circle (the bar can be made of brass or copper) about an inch and a half nearer the centr of the circle (Fig. 3).

For the arm obtain a piece of harc fibre ; the length will, of course, be a littl over half the diameter of the circle, anc just wide enough to pass over the stud without dropping between them.

Brushes can be made of phospho bronze (springy), about 21 gauge, anc screwed to the underside of the arm. Th two brushes can be linked together by suitable gauge wire let in on the side o the arm. The centre of the spindle shoul have a larger diameter than the two end and should be threaded ; the arm shoul be locked on by two nuts, one each side.

Means of mounting the spindle an method of driving can be left to the builde to suit himself.

Speed of crawl will depend on the spee of the driving apparatus.

An isolating switch (double pole) shoul be inserted in the incoming mains to th fuse board.

E. G. BELSTEN.

A Question re Neon Advertising Signs.

I have often seen in shop windows a neo tube of circular shape in which the luminou discharge appears to revolve in wave-for manner. Whilst being acquainted with th fundamental facts of neon tube lighting, s far I have been unable to account for th real or apparent motion. I should l greatly obliged if you can answer th problem.

J. CLANCHY (Southampton).

These tubes are commonly calle "wriggle" tubes.

Instead of being filled with a pure ga they contain a small proportion of anoth gas which has a higher electrical resistanc

The discharge takes place through t pure gas only, avoiding the other as mu as possible. In doing so, it meets a certa amount of opposition, and so takes on t wriggling motion.

W. CHAPPLE (Cork).

END OF VOL. II.

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Index to Contributors.

	PAGE
A. G. AREND ..	396
H. J. BALDWIN	170, 216
COLIN N. BENNETT	268
N. H. BENTLEY, Grad.I.E.E.	441
V. V. BRITTAIN, B.Sc. (Eng.), A.M.I.E.E., A.M.I.Mech.E.	15, 57, 88, 275, 314, 491
H. E. J. BUTLER	359, 361, 479, 439
E. CHISHOLM	389
B. G. CHURCHER, M.I.E.E.	502
W. A. COATES, M.I.E.E., Fel.A.I.E.E.	483, 520, 540
W. R. COX, B.E., A.M.I.E.E.	498, 431
S. S. DANKS	143
C. C. DOWNIE	302, 494
K. H. GREENLY, B.Sc. (Eng.)	21, 542
C. HARGREAVES	362, 398
F. H. HAYWOOD	489
H. E. HUTTER, A.Am.I.E.E.	177, 300, 506
O. HOWARTH, M.I.E.E., M.Am.I.E.E.	195
E. M. JOHNSON	532
H. W. JOHNSON	152, 306, 449
A. W. JUDGE	410
E. T. NORRIS, M.I.E.E., Fel.A.I.E.E.	421
P. W. PANTRY	428
R. H. RAWLL, A.M.I.E., A.M.I.Mech.E.	343
ROBERT RAWLINSON, A.M.I.E.E.	467
S. W. RICHARDS, M.I.M.E.	107
H. W. RICHARDSON, B.Sc.,M.I.E.E.	172, 498, 431
J. ROWCROFT	453
D. WINTON THORPE, A.M.I.E.E.	115, 159, 168, 242, 289, 383, 515
FRANCIS G. TYACK, Grad.I.E.E.	199
PROFESSOR MILES WALKER, M.I.E.E., F.R.S.	97, 329
W. T. WARDALE, A.M.I.E.E.	228
C. W. WATSON, A.M.I.R.E.	81, 131, 180, 208
J. H. A. WHITEHOUSE	375
R. HARCOURT WOODALL, A.M.I.E.E.	40, 223

INDEX TO VOL. II

A.C. TESTS, instrument, switchboard for making, 74
Accumulator stands, 451
Accumulators—
aircraft, 227
celluloid, frothing of, 94
connecting, 452
L.T., charging circuit for, 352
"Acklam Cross," electric propulsion on, 167, 532
Aerial, using electric mains as, 250
Aircraft—
electrical apparatus for, 223
engines, electric starting of, 226
generators, 223
"homing" wireless beacon, 375
navigation lamps, 225
Alternator design, utilisation of space in, 329
Alternator, petrol engine driven, 37
Amalgam solder, useful cold, 215
Ammeter, inserting in 3-phase motor circuit without stopping motor, 321
Ammeters, connecting, on A.C., 276
Amplifier, sound projection, 271
Amplifiers, neutralised, 220
Amplifying equipment, sound, installation of, 61
Anaesthetic, electricity as an, 208
Anestygun, 211
Arc lamps, regulations for, 116
Arc welding, electric, practice, 527
Arcing horns and rings, 484
Armature—
drying out, 457
faults, 403
ring, 543
slotted drum, 543
testing, 248, 453
withdrawing, 260, 453
Armatures—
D.C., testing, 362
Armatures.—*Contd.*
earthed and short circuited, 156
motor, small, winding, 542
Autoflex traffic control system, 199
Automobile, constant voltage control regulator, 168
Auto-transformer—
faults, 215
starter, connections, 104
starting, 314
Auto-valve lightning arrester, 488
BAIRD television system, 49
Battery charger—
electrolytic, 232, 326
3-amp., for A.C., 439
Batteries, dry, wax for, 194
Bayonet cap adaptors, loose, 458
Bell, single stroke, 414
Booster voltage control, 59
Bridge for measuring inductances, 33
British Industries Fair, 236, 328
Brushes—
care of, 405
sparking at, 155
B.T.H. progress, 235
Buchholz protective device, 424
Buttonhole microphone, 150
CABLE—
calculator, rapid, 279
erection, 321
Manufacturers' Assoc., registered classification, 159
measuring, 321
racking, 321
Cables—
choice of, for wiring, 163
classification of, 159
C.M A. (Regd), 160
lead-covered, 166
motor, size of, 263
"Nonazo," 160
rubber-covered, 166
taped and braided, 166
tough rubber-sheathed, 166
used in wiring, 159
"Vicma," 160
"Vinazo," 160
Cables.—*Contd.*
V.I R , grades of, 160
Calibration of instruments, 459
Calomic resistance alloy, 427
Carbon arc, 527
Cathode, heat shielded, 5
Cathode Ray—
television system, 52
tube, 52, 335
Ceiling, finding the centre, 413
Charger, trickle, for model railway, 186
Charging circuit for L.T. accumulators, 352
Choke coil lightning arresters, 486
Circuit breaker—
contacts, maintenance of, 284
high speed, 172
Circuit—
breakers, inspection of, 284
finder, improvised, 249
Circuits, testing electrical, 242
Class B valve uses of, 157
Clutches, electro-magnetic, 506
C.M.A. (Regd.) cables, 160
Commutator—
faults, 156, 404
testing, 454
Condenser—
effect of connecting, in A C. circuit, 443
rating, determination of, 444
Condensers,—
static, connections of, 445
static, construction of, 445
Conductors to motor, size of, 103
Conduit—
continuity of, testing, 384
fixing on outside walls, 366
running and fixing, 309
runs in reinforced concrete, 429
screwing, cutting and bending, 308
threading wiring in, 294, 310
tools for installing, 289
Contactors, care of, 408
Contactor—
control, equipments, A.C., care of, 407
springs, weak, 408

Continuity—
of conduit testing, 384
of metal sheathing, testing, 124
Contractors' Association, ninth conference, 549
Control—
gear for power purposes, 88
remote, of substations, 431
Cooker—
circuit, 20
control, 20
pilot lamp problem, 510
Cooke's cutters, 294
Cooking appliances, control of regulations for, 119
Copper bullion, refinery, construction of, 494
Cosmic rays, 198
Country house generating plant, installing, 449
Croydon, "Homing" beacon, 375
Crystal oscillators, 220
Current—
consumption of domestic appliances (Table), 241
limiting resistance, 324

DETECTOR circuits, using Westector in, 125
Distribution boards—
house, 17
inspecting, 490
marking, 478
Distribution—
gear for power purposes, 88
high voltage, metal-clad switchgear for, 520
low-tension, voltage regulation in, 59
power, scheme for factory, 88
system—
cost of, 196
house, planning, 15
Domestic appliances—
current consumption of (Table), 241
testing, 247
Door opener—
automatic, 419
garage, electrically operated, 511
Double diode-triode valve, uses of, 158
Drives—
aligning, 473
belt, 471
chain, 472
direct coupled, 473
gear, 473
rope, 472
Dynamo—
design, utilisation of space in, 97
fields, protection for, 361
plant, installing, 450
water turbo, 398
Dynamo.—*Contd.*
50-volt, reconnecting, 464
EARTHING—
clips, 68
leads, 67
metal-sheathed wiring, 155
motor frame, 477
regulations, 67
single phase transformer, 418
terminals, 68
Ebonite panels, filling holes in, 249
Electric eye television system, 55
Electricity supply, costs of, 195
Electro-deposition of nickel and chromium, 512
Electrolethaler humane killer, 210
Electrolytic—
battery charger, 232, 326
lightning arresters, 487
Electro-magnetic—
clutches, 506
vibrating screens for A.C. supply, 264
Electro-magnets, safety device for, 361
Eton College floodlighting, 44
Evershed & Vignoles, visit to works, 406
Explosion pot fuse, 541

FACTORY—
lighting with gas discharge lamps, 465
power distribution scheme, 88
Fescol process, 512
Fibre rod, hard, turning, 194
Field coils, winding, 457
Field magnet windings, earthed, 156
Fittings—
construction of, 69
portable, regulations for, 71
Flashing sign switch, 170, 551
Flashing sign switch, electro-magnetic, 216
Flexible cord, maximum carrying weight of, 70
Floodlight—
enamelling outside of, 138
landing, aircraft, 226
Floodlighting—
applications of, 187
Eton College, 44
Frequency—
booster, 352
changers, 351
changing over, 343
doublers, 220
standardisation of, 343
Furnace—
electric, small construction of, 396
electric, small operating, 398
Fuseboard, 518
Fuse hint, 249
Fused plugs, 20
Fuses—
behaviour of, 366
faults in, 153
for high voltages, 540
for motor capacity of, 103
for protecting small A.C. motors, 414
radio relay line, 184
vaseline for, 250

GARAGE door opener, electrically operated, 511
Gas discharge lamp—
Mazda Mercra, 3
Sodium vapour, 5
Gas discharge lamps, industrial lighting with, 465
G.E.C. progress, 236
Generating plant, country house, installing, 449
Generating set, private, 233
Generation, electricity, costs, 195
Generator—
air driven, 223
calculations, 550
Greyhound racing tracks, legal points on, 371

HAIRDRESSING establishment, luminous signalling for, 365
Hartley oscillator, 219
Heating—
appliances—
control of, regulations for, 119
installation of in laundries, 428
buildings, by heat wiring system, 466
circuits, house, 18
element, Torribar, 38
elements, rewinding, 489
Heaters, immersion, installation of, 389
Horn gap fuse, 540
Horn lightning arresters, 486
Hospital signalling systems, 111
Hotel switchboard, Neophone, 143
Hot-point Torribar immersion heater, 389
House—
distribution system, planning, 15
wiring, 366
wiring extensions, 306
Humane killing with electricity 208

ICONOSCOPE television system, 55
Igranic buttonhole microphone, 150
Illumination—
measuring, 6

Illumination—*Contd.*
- meter, Weston, 6
- minimum, 10

Immersion heaters, installation of, 389
Incubators, and brooders, electric plant for, 93
Inductances, measuring, bridge for, 33
Induction regulator—
- operation, 499
- use of, 59

Installation, additions to, regulations for making, 124
- designing, 515

Installations, testing, regulations for, 121
Instrument switchboard for making A.C. tests, 74
Instruments, calibration of, 459
Insulation resistance—
- measuring, of installation, 122
- wiring measuring, 383

Insulation, wiring, testing, 383
Insulators, breakdown of, 483
Iwel humane killer, 211

JUNCTION box, wiring, 319

KANGO electric hammer, 293
Kaplan turbine, 138

LAMP—
- gas discharge, Mazda Mercra, 3
- light spray, 52
- Mazda Mercra, 3
- prices, 48
- scophony, 52
- traffic, control, 204

Lampholder adaptors, regulations for, 72
Lamps—
- aircraft navigation, 225
- coiled-coil filament, 465
- measuring illumination of, 8
- Osira, 465
- pneumatic electric, 40
- regulations for, 115
- sodium vapour, 5

Lap winding, 455
Laundries, installation of heating appliances in, 428
Lifting magnets, 177, 279
Light spray lamp, 52
Lighting—
- circuits, house, 17
- dog track, 136
- for fiery mines, 40
- house, miniature circuit breaker for, 139
- industrial, with gas discharge lamps, 465
- installations, faults in, 152
- plant, 50-volt, 369
- pneumatic electric, 40
- wiring for, 306

Lightning arresters—
- arcing horns and rings, 484
- auto-valve, 488
- choke coils, 486
- electrolytic, 487
- horn, 486
- oxide film, 487
- thyrite, 487

Lightning—
- character of, 483
- protection for transmission lines, 483

Liquid fuse, 541
Liquid rotor startor, 318
Live wire, finding, on D.C. circuit, 139
Local supply Authority, powers of, 368
Luminous signalling—
- for hairdressers, 365
- systems, 107
- systems, supply for, 113

MAGNETIC—
- apparatus, controlling, 300
- clutches, 506
- materials, testing, 502
- pulleys, controllers for, 300
- separation, 129
- separators, controllers for, 300

Magnets, lifting, 177, 279
Master oscillator system, 220
Mazda Mercra lamp, 3
Mazda thyratron valve, 14
Megger circuit testing ohmmeter, 242
Mercury arc rectifiers—
- automatic operation of, 498
- glass bulb, starting and paralleling of, 498
- protective devices for, 500
- steel tank, starting and paralleling of, 500

Mercury—
- cup switches, 250
- vapour lamp, 3

Metadyne, 278
Metallic arc, 527
Meter—
- illumination, Weston, 6
- rent, legal aspect, 511

Metering, two-part tariff prepayment, 411
Meters, connecting, on A.C., 276
Microphone, buttonhole, 150
Micro telephone, 147
Midworth distant repeater control, 432
Mines, fiery, lighting for, 40
Model railway, trickle charger for, 139, 186
Modulation systems, 221
Motor—
- A.C., converting for D.C., 415

Motor—*Contd*
- armatures, small, winding, 542
- D.C., making connections to, 334
- drawing pulley off shaft, 258
- drives, 471
- drives, aligning, 473
- for petrol electric vehicle, 418
- foundation, strengthening, 257
- frame, earthing, 477
- induction, three phase, fault conditions in, 323
- induction, $\frac{1}{8}$ h.p. squirrel cage, making a, 21
- pulley, lining up, 259
- small lap wound, rewinding, 453
- small, windings for, 186
- wiring up, 321
- $\frac{1}{20}$ h.p., winding for, 359
- $\frac{1}{4}$ h.p., converting to A.C. working, 370
- $\frac{1}{3}$ h.p. single phase induction, windings for, 415
- 220-volt D.C., rewinding, 322

Motors—
- A.C., mechanical faults, 215
- control of, regulations for, 117
- D.C., installing, 251
- D.C., operation of, 252
- distribution and control gear, 88
- drying out, 469
- fixing to wall, 258
- induction—
  - faults in running of, 213
  - installing, 102, 467
  - location of, 102
  - measuring slip of, 458
  - operation of, 103
  - reversing rotation of, 478
  - starting, 104
  - starting troubles, 212
  - starting up, 477
  - testing, 468
  - three phase, direction of rotation of, 228
  - three phase, startors for, 314, 417
- moving to running position, 256
- position of regulations for, 117
- preventing vibration of, 257
- reversing direction of rotation, 399
- single phase, current taken by, 400
- slip ring, starting, 316
- squirrel cage, starting, 314
- starting up, 264
- suspending from ceiling, 258
- synchronous, armature troubles, 215
- synchronous—
  - field troubles of, 214
  - starting faults, 214

Motors—*Contd.*
unloading from lorry, 254
wiring to, 262
wiring up, 476
Mumetal high permeability alloy, 388
Mysore, hydro-electric development, 149

NEON
lamp safety device for electro-magnets, 361
sign installations, 296
tube timer circuits, 200
"Neon Tube Practice" (review), 128
Neophone—
hotel switchboard, 143
instruments, 147
Nickel plate adhesion, 249
Noise in electrical machinery, methods of detecting, 353
"Nonazo" cables, 160

OFFICE signalling, systems, 107
Oil—
conservators, 422
filters, 425
maintenance, transformer, 424
seals, 422
sludge in, 423
Oscillators—
crystal, 220
Hartley, 219
master, 220
push pull, 219
Osira lamps, 465
Oxide film lightning arresters, 487

PATRASSES, fixing, 310
Pendants, flexible, faulty, 154
Pentagrid valve, uses of, 158
Pentode H.F. valve, uses of, 158
Petrol electric vehicle, motor for, 418
Phases of A.C., how to tell, 371
Photo-electric cell—
door opening equipment, 419
photronic, 265
Photronic cell, 265
Plugging wall, 413
Plugs and sockets, regulations, for, 73
Plugs, fused, 20
Pneumatic electric lighting, 40
Porous pots, renovating, 366
Power—
circuits, house, 18
factor, average, method of obtaining, 505
factor, improvement—
of 441
economic limit of, 445
saving effected by, 448
schemes, 446

Power.—*Contd.*
factors, a question about, 280
installations, faults in, 155
plugs, wiring for, 311
purposes, distribution and control gear for, 88
supply, costs of, 197
Private generating—
plant, installing, 449
set, 233
Projector lamp transformer, 1,000-watt, 342
Propulsion, ship—
electric, 167
equipments, D.C. 532
Protection of mercury arc rectifiers, 500
Pump, electrified, 106
Push lamp signalling system, 108
Push-pull oscillators, 219

QUIESCENT push-pull systems, uses of, 157

RADIATOR bars, rewinding, 489
Radiators, installing, 413
Radio—
"Homing" beacon for aircraft, 375
receiver servicing with Weston analyser, 189
receivers, testing, 247
relay line fuses, 184
relay lines—
erecting, 131
fault location on, 180
relay—
station, design and operation of, 81
through electric mains, 466
short wave, transmission and reception, 219
metal, 410
Range transmitter receiver, 325
Rectifiers, mercury arc—
automatic operation of, 498
glass bulb, starting and paralleling of, 498
steel tank, starting and paralleling of, 500
Refrigeration at Singapore, 171
Refrigerator power point, 19
Regulations—
earthing, 67
for—
control of heating and cooking appliances, 119
control of motors, 117
fitting of domestic appliances, 69
lamps, 115
making additions to installations, 124
position of motors, 117
testing complete installations, 121

Relay—
notching—
construction of, 409
operation of, 409
reverse current, construction and action of, 45
Relays—
current limit, 409
notching, care of, 410
Remote control of substations, 431
Resistance, current limiting, 324
Reverse current—
meaning of, 45
current relay, construction and action of, 45
Rhometal, 405
Roofs, wiring in, 153
Rotary converters, care of, 401
Rotor—
checking for balance, 28
startor, faceplate, 317

SAFEWAY adaptor, 295
Scophony—
lamp, 52
television system, 52
Scott system of transformer connections, 492
Screened-grid valve, adding to 2-valve set, 326
Scruit connectors, 319
Shade ring tool, 295
Sherwen screen, 264
Ship propulsion—
electric, 167
equipments, D.C., 532
Ship supply, A.C. or D.C., 234
Short wave transmission and reception, 219
Short waves for television, 56
Sign switch—
flashing, 170
flashing electro-magnetic, 216
Signalling—
luminous, for hairdressers, 365
systems—
hospital, 111
luminous, 107
luminous, supply for, 113
office, 107
push lamp, 108
Silver refinery, construction of, 302
Single—
diode tetrode valve, uses of, 158
phase from three-phase supply, obtaining, 491
Six-foot rule, the 71
Slide rails, arrangement of, 414
Sodium vapour lamp, 5
Solder, amalgam, useful cold, 215
Soldering nickel parts, 194

Sound—
amplying equipment, installation of, 61
projector—
installation and adjustment of small, 268
systems, 270
Sparking at motor brushes, 155
Splitter, use of, 17
Star-delta starting, 314
Starter, motor, faults, 156
Startor—
rotor, faceplate, 317
rotor, liquid, 318
for three-thase induction motors, 314, 417
Starting—
auto-transformer, 314
star delta, 314
Stator, winding, 29
Switch—
lampholders, regulations for, 72
for small currents, 300
sign, flashing, 170
Switchboard—
fixing, 451
Neophone hotel, 143
Switchboxes for aircraft, 226
Switches—
main, 17
mercury cup, 250
Switchgear—
ironclad, earthing, 155
metal-clad—
operation and maintenance of, 283
high voltage distribution, 520
S.V.D., 169
Substations, remote control of, 431
Super-heterodyne short wave receiver, 222
Super-regenerative short wave receiver circuit, 222
Synchronising. turbo-alternators, 12

TALKING film projector, installation and adjustment, 268
Tap wrenches, 290
Tariffs for electrical energy, 195
Telephone —
circuits, testing resistance of, 248
line, equipment for, 510
micro, 147
receiver, semi-inset, 148
switchboard, hotel Neophone, 143
system, automatic, intercommunication, 298
systems, central battery, 143
transmitter, immersed electrode, 147
Telephony, side tone in, eliminating, 148
Television—
progress of, 49
short waves for, 56
systems—
Baird, 49
cathode ray, 52
disc, 49
electric eye, 55
Iconoscope, 55
mirror drum, 51
Scophony, 52
velocity modulation cathode ray, 281, 335
Televisor, bush radio, 49
Testing completed wiring installation, 383
Thermostat, immersion heater, 391
Thyrite lightning arresters, 487
Thyratron valve, 14
Tools—
electrically driven, trouble with, 370
for electrical installation work, 289
Torribar heating element, 38
Traffic control system, autoflex, 199
Transformer—
cooling, alarms on apparatus, 423
cores, material for, 410
earthing single phase, 418
factory, B.T.H., 230
insulation, drying out, 425
oil maintenance, 424
protective devices, 424
safe load indicators, 422
secondary voltage, calculating, 46.
tappings, changing, 58
winding temperature indicator, 422
400-watt projector lamp, 479
1,000-watt step down, 342
Transformers—
instrument, connecting, on A.C., 276
lightning protection of, 485
mains, noisy, curing, 229
power—
installation of, 427
maintenance of, 421
operation of, 427
Transmission—
cost of, 196
high-voltage, voltage regulation in, 57
lines, lightning protection for, 483
medium voltage, voltage regulation in, 59
Trickle charger for model railway, 139, 186
Tube—
bending, 291
erecting, 293
inserting wire in, 294
Tube.—*Contd.*
removing burrs from inside, 291
vices, 290
Tubing—
steel, tools for cutting, 289
threading, 290
Tuning coils for new wave lengths, 324
Turbo-alternator, air, 41
Turbo-alternators, synchronising, 12

VALVE—
class B, uses of, 157
double diode triode, 114
double diode triode, uses of, 158
H.F. pentode, uses of, 158
pentagrid, uses of, 158
single diode tetrode, use of, 158
systems, quiescent push-pull, uses of, 157
testing with Weston analyser, 189
Thyratron, 14
variable-mu, uses of, 157
Valves—
short wave, transmitting, 221
universal, 412
Variable-mu valve, uses of, 157
" Vicma " cables, 160
" Vinazo " cables, 160
Voltage—
control regulator, constant voltage system, 168
regulation in high-voltage transmission, 58
regulation in low-tension distribution, 59
regulation in medium voltage transmission, 59
variation in supply, limits of, 57
Voltmeters, connecting, on A.C., 276
Vulcanised india rubber cables, grades of, 159

WASHING machines, selling points for, 420
Water, hot tank, lagging, 395
Wax for dry batteries, 194
Welding—
electric arc, practice, 527
using motor generating set for, 279
Westector, 125
Weston radio set analyser, 189
Wimbledon supply undertakings experiment, 237, 281, 288, 327
Winding—
field coils, 457
lap, 455
small motor armatures, 543
stator, 29

Windings—
- field magnet, earthed, 156
- for small motor, 186
- for a $\frac{1}{20}$ h.p. motor, 359
- lap, 544
- motor, removing, 454
- wave, 545

Wire stripper, 289
Wires, easy identification of, 413
Wiring—
- awkward fitting, 414
- cables used in, 159
- distribution—
  - house planning, 15
  - planning the, 515

Wiring.—*Contd.*
- "earthed," on lighting and power circuits, 154
- for lighting, 306
- for power plugs, 311
- house, 366
- house, extensions, 306
- immersion heater installation, 395
- in roofs, 153
- installation—
  - designing a, 515
  - calculating load on, 517
  - testing, 248
  - testing completed, 383
- joining, 319

Wiring.—Installation.—*Contd.*
- junction box, 319
- metal sheathed, earthing of, 155
- points—
  - layout of, 100
  - making schedule of, 516
- threading into conduit, 294, 310
- to motors and switchgear, 262
- tools for, 289
- up domestic appliances, 250
- up motor, 321

Wylex junction box, wiring, 319