THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

VOL. 31 JULY, 1938 PART 2

CONTENTS

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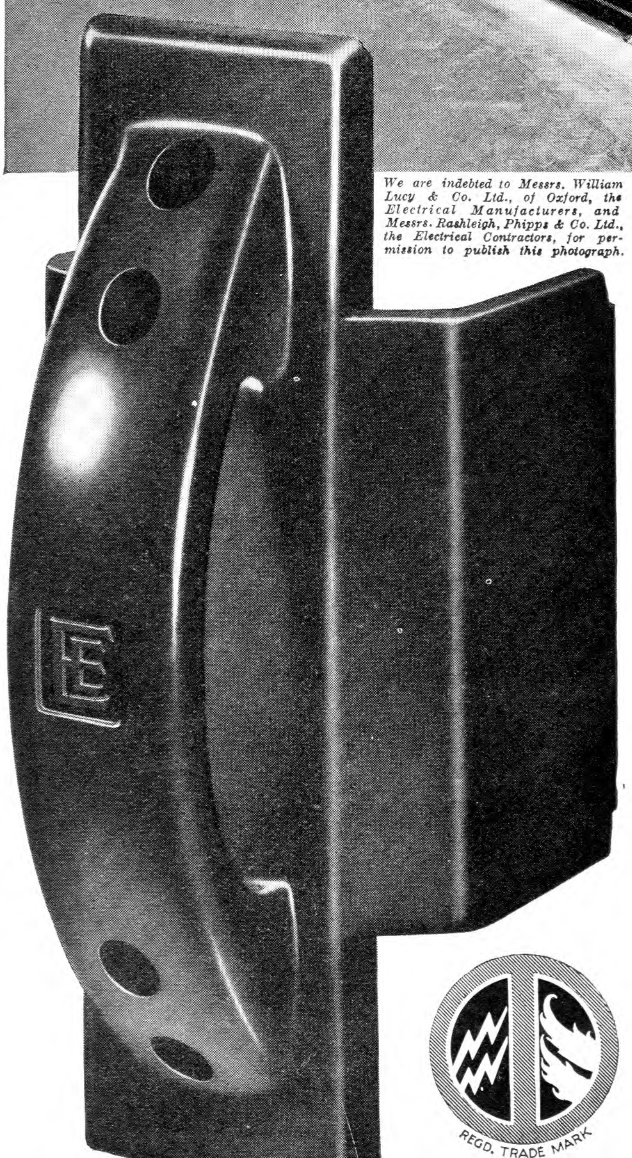
THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

IN THE SWITCHROOM OF A MODERN NEWSPAPER OFFICE . . . .

We are indebted to Messrs. William Lucy & Co. Ltd., of Oxford, the Electrical Manufacturers, and Messrs. Rashleigh, Phipps & Co. Ltd., the Electrical Contractors, for permission to publish this photograph.



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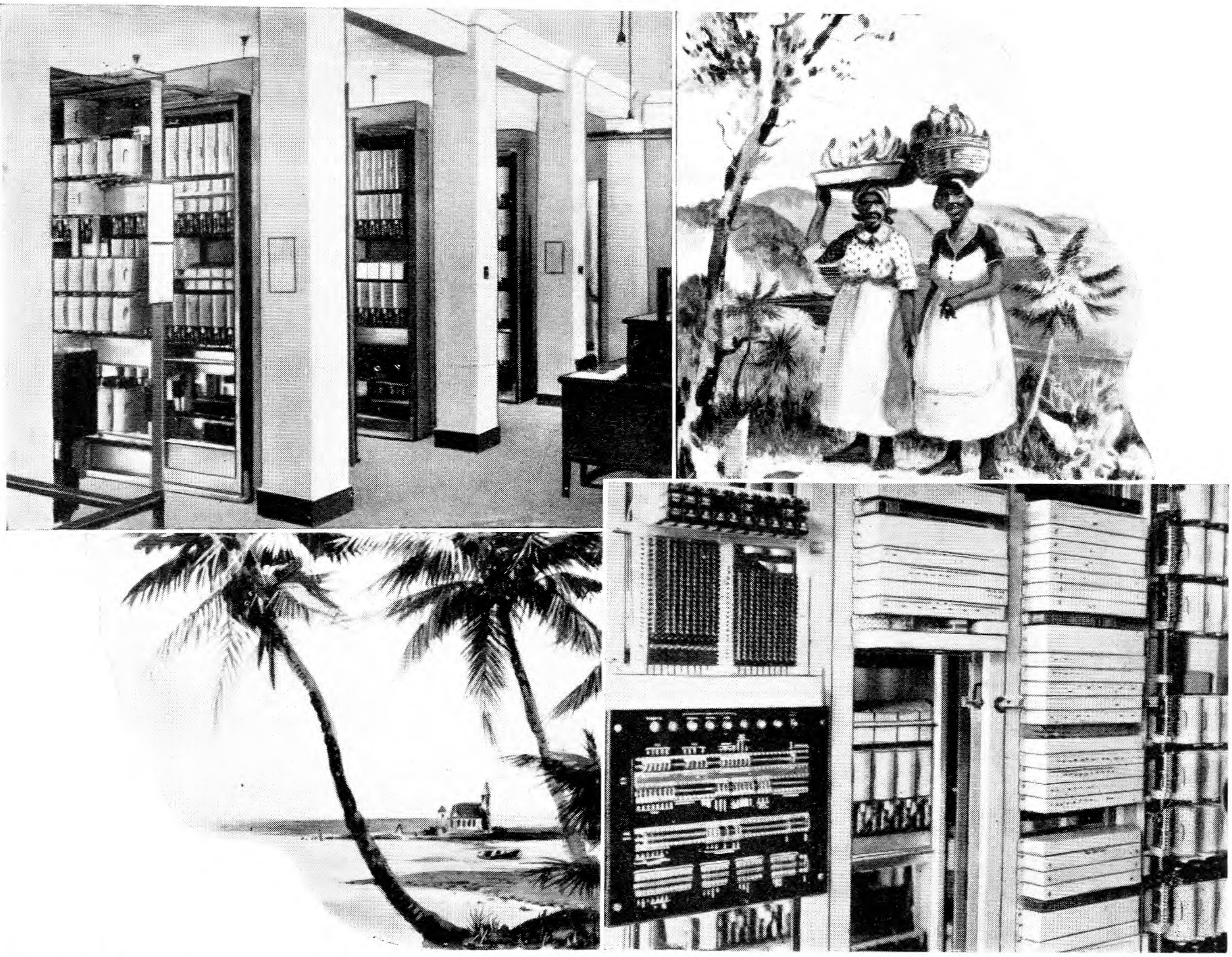

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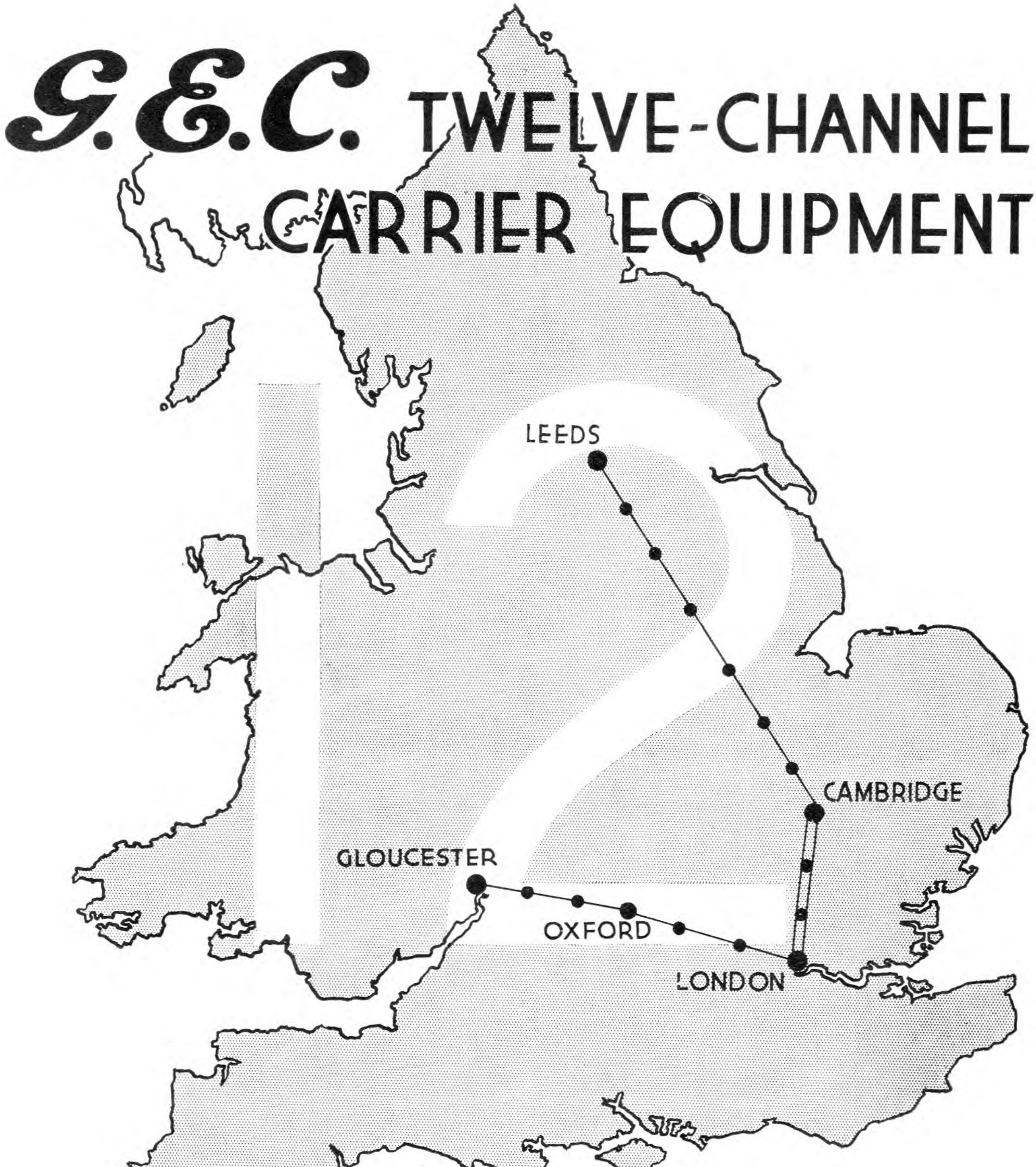

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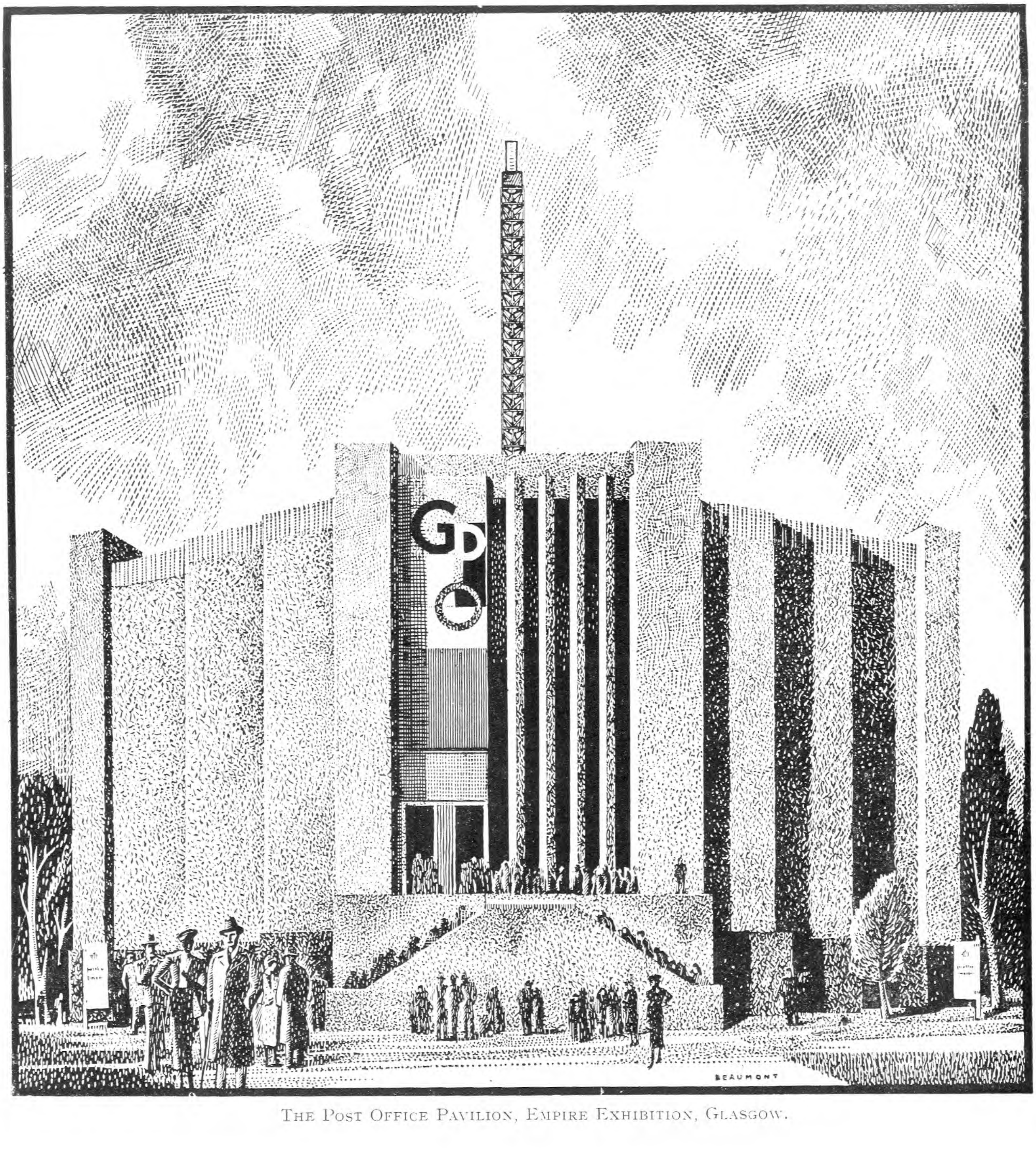


THE POST OFFICE PAVILION, EMPIRE EXHIBITION, GLASGOW.

THE POST OFFICE
ELECTRICAL ENGINEERS' JOURNAL

Vol. XXXI July, 1938 Part 2

Post Office Pavilion at The Empire Exhibition, Bellahouston Park

A. G. FREESTONE, A.M.I.E.E.,
and A. H. ENDECOTT

The authors describe the engineering features of the Post Office Pavilion at the Empire Exhibition in Scotland. One of the outstanding successes is the use of ultra violet rays and fluorescent paint for various displays and effects.

Introduction.

THE publicity activities of the Post Office since 1932 have undoubtedly been progressive and watched with interest by the advertising world. The Public Relations Department of the Post Office has been responsible for this upward trend in advertising Post Office services, not only by press advertisement and film, but by staging interesting exhibitions in very many towns in the United Kingdom. It is a statement of fact that millions of the public have visited these exhibitions and have generally been surprised not only by the novelty of the exhibits, but what is more important, by the number of services at their command not previously known to them. In all these publicity efforts, the Post Office Engineering Department has played its part, and the Publicity Section of the Engineer-in-Chief's Office has co-operated with the Public Relations Department throughout the years.

When conversations on the Empire Exhibition were started, it was realised that something unusually novel must be employed in the Post Office Pavilion if the Post Office was to maintain its high standard in advertising. It will be appreciated that, although the Post Office employs a large and varied assortment of apparatus in its daily work, there is a limit to the number of exhibits that can interest the public, and also a limit to the methods employed in exhibiting this same apparatus from time to time. This problem of new technique is no stranger to the Engineer-in-Chief's Publicity Section, but the Post Office Pavilion in Bellahouston Park, Glasgow, had to be different from anything attempted before.

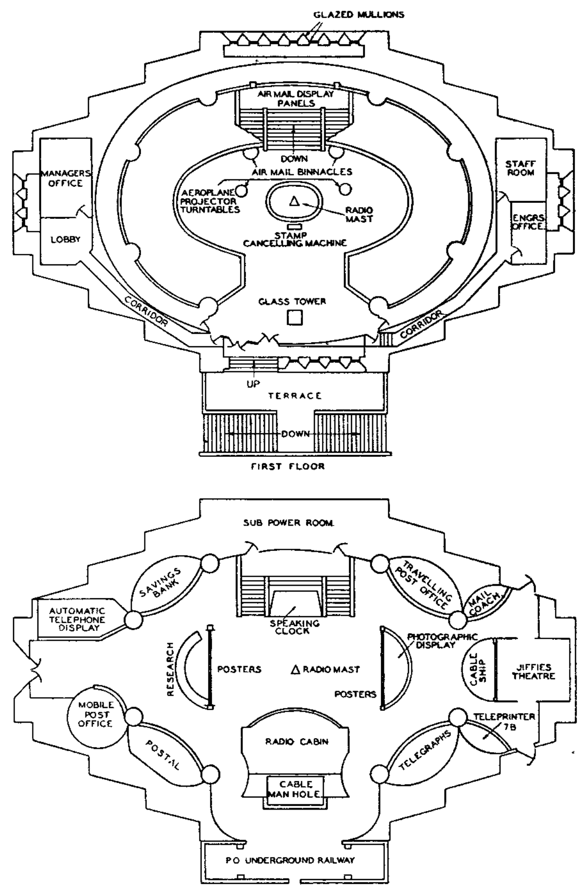


FIG. 1 —PLAN OF THE PAVILION.

The Pavilion.

The Pavilion is oval in shape and has two floors (Fig. 1). The ground floor covers the whole area whereas the first floor is a central platform supported on stanchions from the ground floor. There is a space of 10 feet between the platform and the gallery which surrounds the pavilion. This gallery is used for concealing certain lighting effects, distribution boards, etc., and is not available to the public. The platform has one or two exhibits on it, but it is mainly used to view special effects described later, and secondly to provide the public with a viewing point of the activities of the ground floor prior to their descent. The main entrance is via a flight of steps and terrace, thence through the large glazed doors to the platform mentioned above. There are eight pillars round the gallery running from ground floor to ceiling, and each is illuminated by a thin strip of light on its face. The difficulty presented by these pillars to the special effects about to be described will be obvious to the reader later.

Air Mail Exhibit.

At various exhibitions during the last two years, the Empire air routes have been demonstrated by means of press-buttons housed in chromium-plated binnacles and associated with glazed indicators similar to large thermometers, so that, for instance, when a button labelled Adelaide was pressed, two columns of light, one red and one blue, would commence rising and would ultimately show the saving of time in days between normal and Air Mail postings. The background for these indicators has recently been improved by the addition of moving clouds, and a photograph of a seaplane mounted in the clouds. As the Public Relations Department wished to add to this usually attractive Air Mail display, it was decided to provide, in addition, an illuminated silhouette of a seaplane travelling right round the walls of the pavilion over cut-out maps representing various parts of the British Empire. (*See* Fig. **2**.)

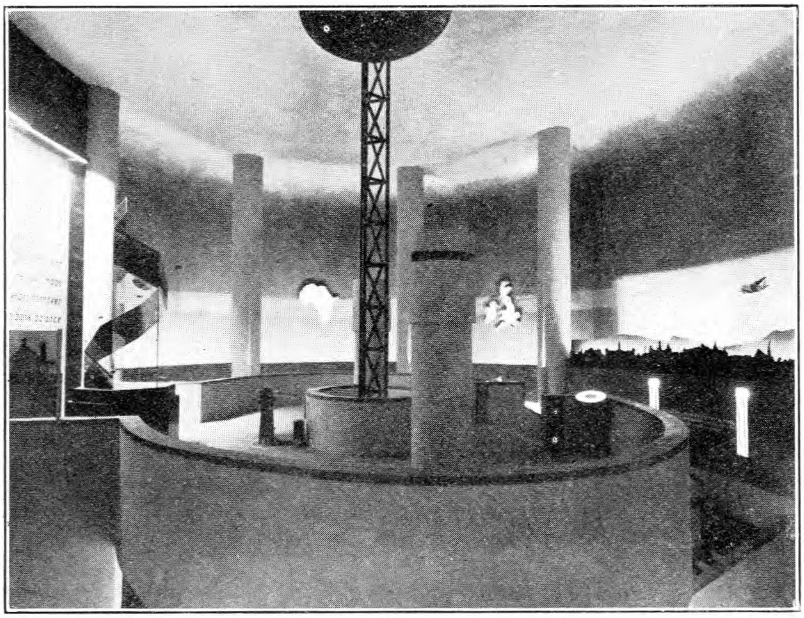


Fig. **2**.—General View of First Floor.

For previous exhibitions projectors and moving cloud effects had been obtained from the Strand Electric & Engineering Company, a firm that specialises in theatrical effects, and conversations were started with this firm's engineers and experiments commenced. It is due to the co-operation of this company with the Engineer-in-Chief's Publicity Section that the results have proved so satisfactory.

It was obvious from the start that the simplest method to provide this seaplane was to project from a rotating lantern in a central point of the hall. This, however, was not so easy as it at first seemed. There is a wireless mast in the centre of the pavilion which runs from the ground floor right through the ceiling out into the open, and it was not desirable to encumber this mast with apparatus. This rendered it impossible to place the projector in the centre of the pavilion, and if it were displaced to one side or the other, at one part of its travel it would be obstructed by this mast. It was, therefore, decided to use two projectors, one for each end of the hall, these projectors being synchronised in a manner described later, so that when one projector had traversed its side of the room, the projection was changed over instantaneously to the other projector which carried on and gave the impression of one continuous travel of the seaplane.

The next point encountered was the need to project the light on the walls only, and give the impression of the seaplane passing behind the eight pillars previously mentioned. In addition, the whole projecting apparatus had to be concealed inside dummy columns 3 ft. in diameter, one of which is seen in the foreground of Fig. **2**.

The Introduction of Ultra-Violet Ray Projection.

Using ordinary visible light projection the problems presented several difficulties. Owing to the relation of the diameter of the projection gate to the travel of the projector, to provide masks which would cut off the beam while each column was being traversed, was not a feasible proposition. A mask to do this would have had to be constructed in three tiers brought in at appropriate times of the travel. The same section of mask could not be used over and over again, as, due to the oval shape of the building, the angular spacing between columns is not always the same.

There was another objection to using ordinary white light projection, in that the ray from the dummy columns in which the projectors were concealed would be visible, and would indicate to the public how the job was done and thereby detract considerably from the attractiveness of the display. In any case, whatever form of projection was used, the main hall lights would have to be dimmed, both to enable the public to concentrate on the display and furthermore to render the seaplane projection sufficiently intense.

Taking every consideration into account, it was decided to experiment with projection by ultra-violet rays, commonly known as blacklight. Ultra-violet rays, or at least that region of the spectrum just beyond the visible section, are invisible to the human eye unless projected on to certain chemicals which are then excited and give off visible light, this property being known as fluorescence. The source of ultra-violet light now generally used is a 125 watt mercury discharge lamp of the well-known type fitted with a bulb of special glass which filters off all the visible radiation and allows only the ultra-violet wavelengths to pass.

The chemical used in conjunction with these lamps can be arranged to fluoresce in various colours. Furthermore, certain chemicals which are invisible under white light, can be used. Thus it is possible to have a piece of white paper, which under white light appears as a plain white sheet; but under ultra-violet light can present a blue cross on a black ground.

The application of this blacklight to the particular requirement under discussion is obvious. If the projectors could project a seaplane of ultra-violet light no ray would be visible, and furthermore, no seaplane would be visible except where the wall was treated with special chemical paints, so that by treating the wall between the columns and also painting the maps with fluorescent paint, invisible blue and invisible red respectively, and not treating the columns, the seaplane would be able to travel around the room without any apparent source of projection, and furthermore would vanish behind the columns in the desired manner. This type of projection has, as far as is known, never been carried out before anywhere in the world.

Experiments were continued in the Strand Electric & Engineering Company's private theatre with such pleasing results that it was decided to carry the scheme out to maturity. Not only on account of the seaplane projection but on other counts mentioned below, the Post Office Pavilion represents a most daring experiment.

To add to the effectiveness of the display, the whole of the ceiling of the pavilion was treated with invisible blue ultra-violet paint, and around the gallery eighteen projectors were provided, fitted with photographic glass discs, so that the ceiling could be covered with the images of clouds. The majority of these glass discs are driven by small silent electric motors at a speed of one revolution in five minutes, giving the illusion of clouds travelling right across the hall. To treat the ceiling with the fluorescent paint was rather a problem, as the chemical itself, at the present stage of development, is made up in a solution which is highly inflammable. To spray a large area such as this ceiling, which is 3,500 square feet, would have been a risky business, so specially treated paper was used which could be pasted up by an ordinary paper hanger.

Associated with this display is an automatic dimmer and timing device, which ensures that once every ten minutes the pavilion is darkened and the display is put into operation, the display itself lasting just over a minute.

Apparatus.

Seaplane Effects.—The projectors for the seaplane effects necessitated a considerable amount of experimental work. As previously mentioned, the projection of fixed designs or patterns such as a seaplane or clouds, had never been carried out before, and therefore there was no experience to go on in this matter. The throws also were rather long, being in the neighbourhood of 30 ft. The seaplane lanterns have a lens system designed to collect the maximum solid angle of light from the ultra-violet (black) lamp. In designing an optical system for use with a black lamp it is not possible to use reflectors behind the lamp, as by the time the ultra-violet light travels out through the lamp bulb, hits the reflector, returns through the black bulb, making three traversals of the glass in all, the resulting light is not worth anything at all. Therefore, in the projectors for the Post Office pavilion, optical systems were designed which collected the maximum solid angle of light in front of the lamp and not subject to obstruction by it. Immediately in front of the black lamp a $4\frac{1}{2}$-in. diameter meniscus lens is placed, and three further lenses are used to collect the maximum amount of light possible.

One interesting fact arises out of the seaplane projectors in that, owing to the restriction of having to work inside a three-feet diameter column, the necessary focal length to focus the requisite size seaplane, together with the maximum gate aperture to pass as much light as possible, could not be done in one straight line. Therefore, after the light passes through the seaplane slide (in this case a metal cut slide), it is reflected by a mirror backwards, and then again reflected by a mirror forward and finally focused. This arrangement cuts down the length of the lantern by a considerable amount. All the lenses of the reflecting mirrors were carefully designed to obstruct the ultra-violet light as little as possible. As is well known, ultra-violet rays are appreciably lessened by passing them through glass, and that is why, as the lenses are essential in projection, it was so necessary to use an optical system of the maximum efficiency from the light-collection point of view to counteract the wastage due to transmission through the lenses.

These two seaplane projectors are mounted on rotating turntables fitted with the necessary tilting arrangements to enable them to be set accurately on the fluorescent track. The front of the lantern is fitted with a magnetically operated blackout shutter which is brought into action automatically during the period when the seaplane display is not in action. It is not possible with these mercury discharge lamps to switch them on and black them out when required, as they take an appreciable time, two to three minutes, to obtain the maximum luminosity. It was undesirable to show the seaplane before the display, but it was equally undesirable for the seaplane to obtain maximum luminosity after the display was over. The turntable mechanism (Fig. 3) incorporates a synchronous motor drive and slip rings to feed the

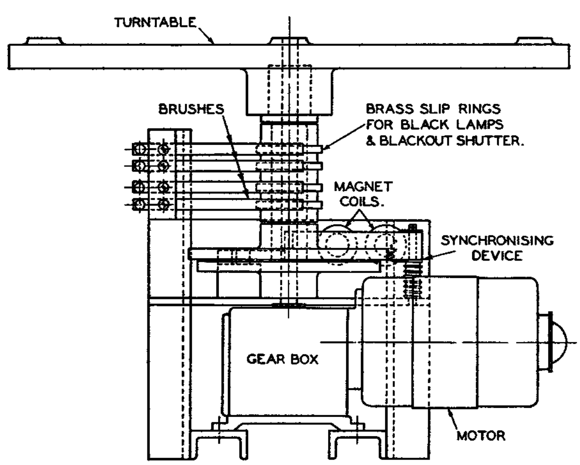


FIG. 3.—TURNTABLE MECHANISM.

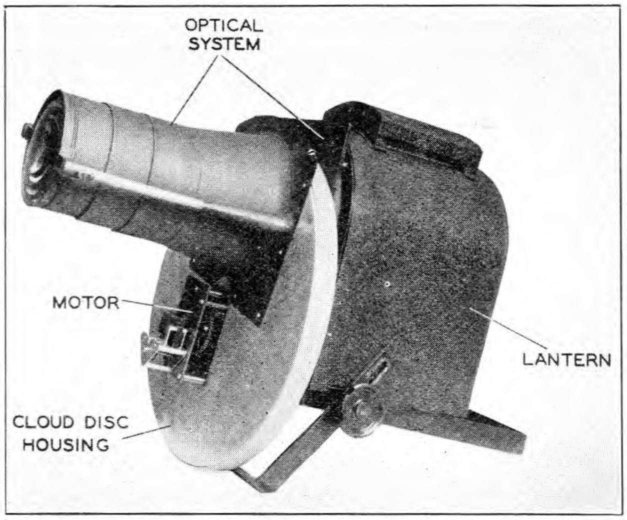


FIG. 4.—CLOUD EFFECTS PROJECTOR.

black lamp and magnetic blackout shutter. Incorporated in the base of this turntable is a synchronising device. It is obviously essential if the seaplane is to travel round the room as one seaplane that the two projectors shall be accurately synchronised. No difficulty would be experienced, of course, once the machines were running, as two synchronous A.C. motors were used, but trouble would be experienced in the start in that one motor might attain its full speed slightly before the other. To get over this a slipping clutch is provided in the base of the turntable and, once the motors are started and after they have attained their final running speed, a magnetic catch is released and the two seaplanes start off from exactly the same position.

Cloud Effects.—The cloud effect utilised a completely different optical system from the seaplane projectors, as the beam angle required was considerably larger. Again, the maximum amount of light had to be collected from the front of the lamp, and to achieve this the Stelmar pattern reflector unit was used. This reflector unit, which is made up in metal chromium plate, collects an extremely large solid angle of light. After the light has been collected by the Stelmar unit it is passed through a section of the cloud slides, 8 in. in diameter, and is then re-focused by a single plano-convex lens at the end of a telescopic front on to the ceiling. A certain amount of striation is obtained using this method, but for cloud projection this is not noticeable. The cloud effect discs are driven by an extremely small motor which can be seen in Fig. 4, and although twelve discs are in operation no motor hum can be detected.

Dimming Device.—The dimmer bank (Fig. 5) is of the metallic type and arrangements are made to dim the total load in the hall upstairs and also in the hall downstairs. For the downstairs load, an adjustable limit is provided so that the lighting is dimmed to a pre-determined position and not extinguished completely.

Also associated with the dimmers are contactors to bring in the amplifier and noise effect for aero-engine noises and to switch on the cloud effects three minutes before the cycle is due to begin, to be sure that they shall have obtained their full luminosity.

An interesting feature of the dimmer is that a constant motor drive is provided in one direction. This drive rotates a control drum which carries out the necessary dimming and brings in the various circuits as required. Also driven from this motor are two constantly revolving shafts to which the dimmers are connected by magnetic clutches. One shaft revolves at such a speed as to move the dimmer to the down position in 15 seconds. The other shaft revolves at such a speed as to move the dimmers to

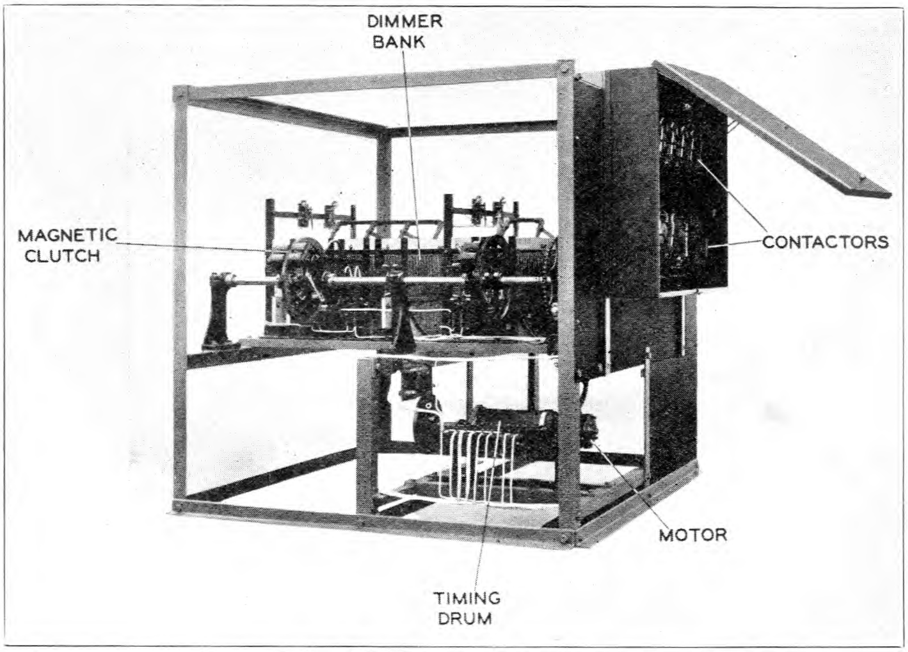


FIG. 5.—DIMMING EQUIPMENT.

the up position in 5 seconds. The appropriate magnetic clutches are energised from the control drum and dimming up or down at the various speeds required is entirely independent of the motor speed.

The motor drives the whole device through a slipping clutch with a magnetic catch similar to those fitted on the seaplane projectors. This catch is, of course, to ensure not only that the seaplanes are both pointing in the same direction, but that they start with exactly the same relationship to the cycle each time. For instance, when the lights in the hall are dimmed the seaplane has to appear in the centre of the Air Mail display and disappear in the same position. As mentioned previously, this Air Mail display consists of press buttons contained in chromium-plated binnacles situated on the platform and associated with light indicators fixed on the wall. Above these indicators is a cut-out diorama of well-known Glasgow buildings with a mountain background (Fig. **2**), and immediately above this is a space for displaying moving clouds, using white light and mirrors. In the centre of the display is a painting of a mail-carrying seaplane. These effects are seen during the light period in the pavilion. This light period lasts for ten minutes and the dark period for approximately one minute.

A delay action relay is provided so that when the start button is pressed all three motors—the dimmer motor and the two seaplane projection motors—are rotating, and after six seconds the magnetic catches are cut out. Shutting-down contacts are provided in conjunction with the catches on the seaplanes and dimmer, so that when the stop button is depressed the seaplanes will continue to rotate until their catches fall in, whereupon their motors are shut down. The dimmer will also continue to rotate until it reaches an appropriate part of the cycle for its catch to fall in, whereupon the dimmer motor is shut down.

The start and stop buttons are situated in the Charge Engineer's Office so that in an emergency during the darkened period of the pavilion all lights can be switched on.

General Lighting.

It has been the aim to refrain from disclosing the source of lighting the pavilion as "naked" lights often distract the visitors' attention. In the gallery blue and white bulbs are hidden and arranged to deflect the light on to the blue-coloured walls. The bulbs are, of course, dimmed during the dark period. The remainder of the general lighting downstairs is mainly effected by thin spotlights focused on the apparatus or batten lights of the theatrical type hidden behind the stand facias or wooden pelmets.

The total lighting load is of the order of 63 kW and eight miles of wire have been employed to provide the lighting and power circuits. The main power and battery room is housed in a building remote from the pavilion and previously used as a golf house prior to Bellahouston Park being selected as the site for the Exhibition. Underground steel conduits were run between this building and the pavilion. There is also a sub-power chamber between the inner and outer walls of the pavilion. The system is 3-phase at 250 volts, and much thought and attention has had to be given to maintain balance of the phases. To provide for any alterations of the scheme during installation spare circuits were run on a draught-board system and have proved of value.

Exhibits.

Of the exhibits shown in the Post Office pavilion only those of particular interest to engineers are mentioned briefly.

The Automatic Telephone Demonstration (Fig. **6**).—Departure from the usual automatic demonstration

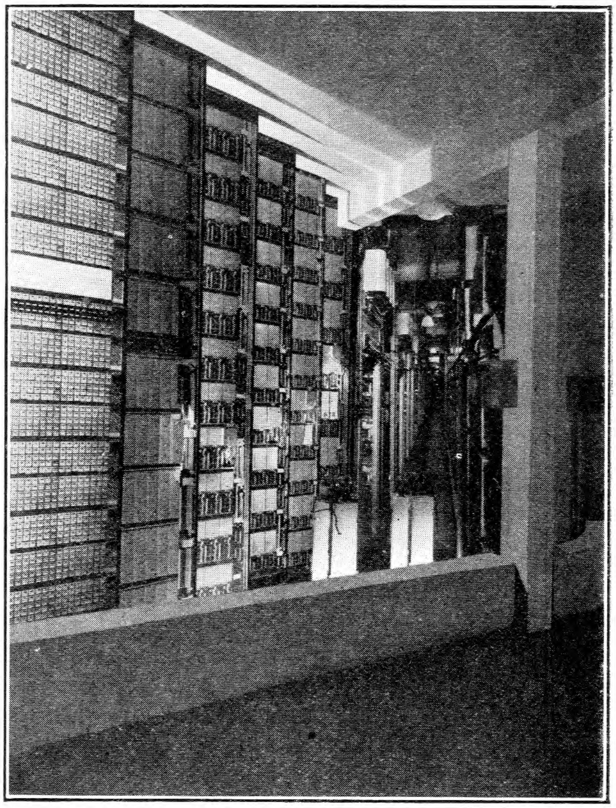


FIG. **6**.—AUTOMATIC TELEPHONE DEMONSTRATION.

set was considered essential and arrangements were made with the G.P.O. Film Unit to photograph switch racks in a modern 2,000 type exchange. These photographs have been enlarged and fixed to wooden panels 12 feet in height. One photographic switch has been cut out of each of the panels and a "live" switch substituted in such a way that the working switches and the photographs line up. The switches are spot lit and the public can dial a 4-digit number and see the call metered. The addition of a perspective photograph at the end of the staggered panels lends depth to the model exchange.

The Research Exhibit.—The Research Station has produced very interesting items, including a slow motion teleprinter. It is possible to see the cams and type head slowly operating when a letter key on the keyboard is depressed. The code set up is shown on an illuminated panel.

Stereoscope and microscope invite the public to look into the question of lead sheath corrosion and metal deterioration. By pressing keys one can hear

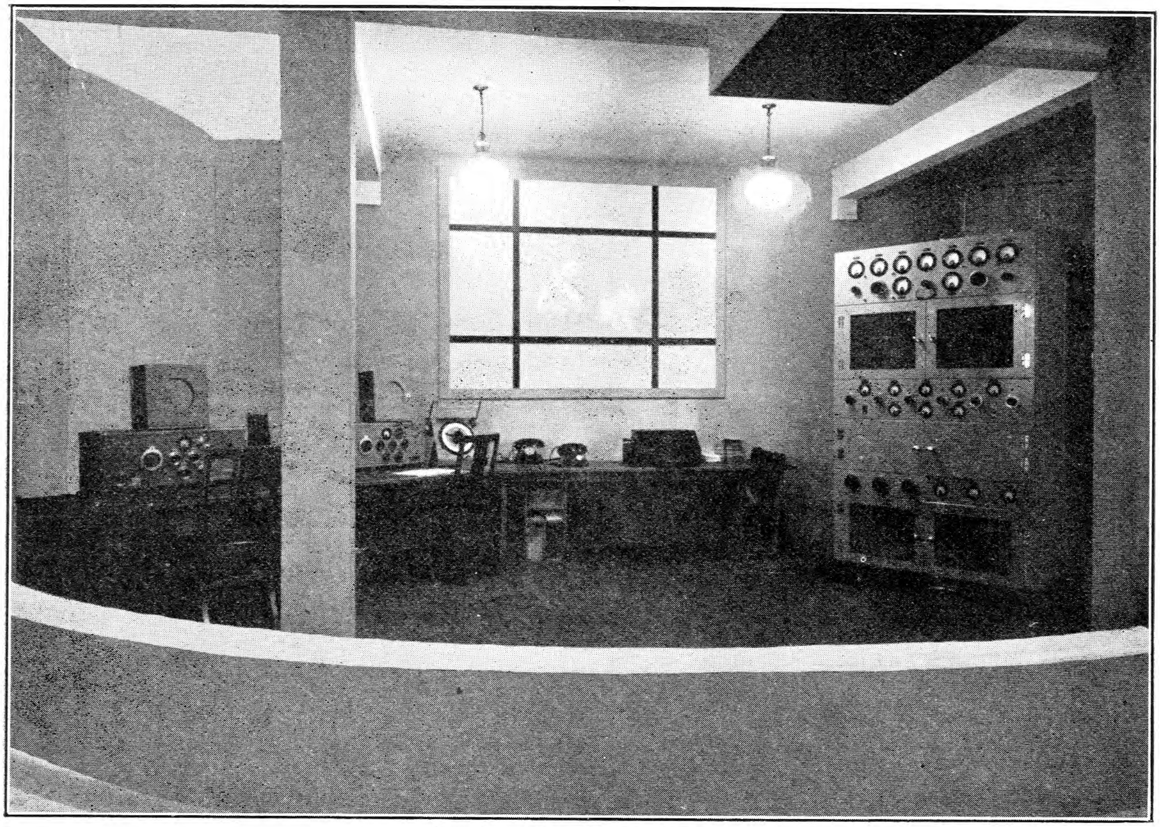


Fig. 7.—The Radio Cabin.

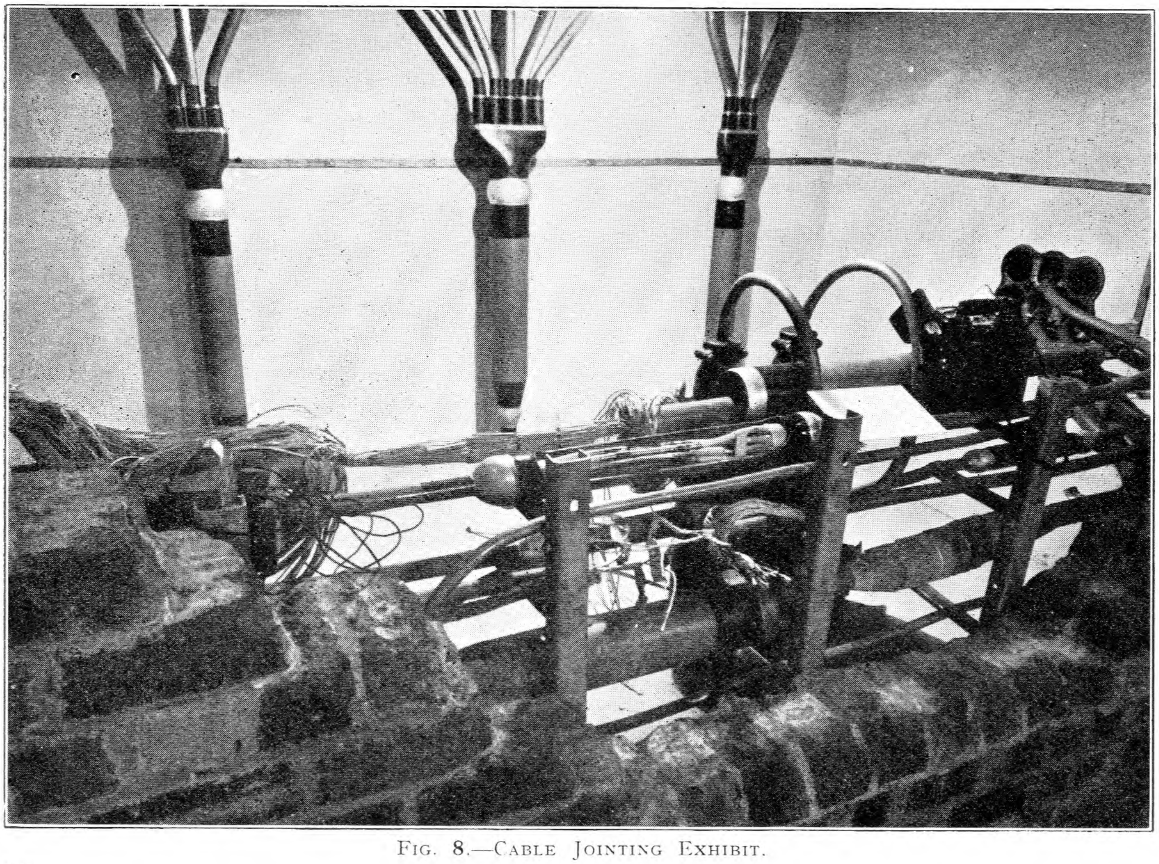


Fig. 8.—Cable Jointing Exhibit.

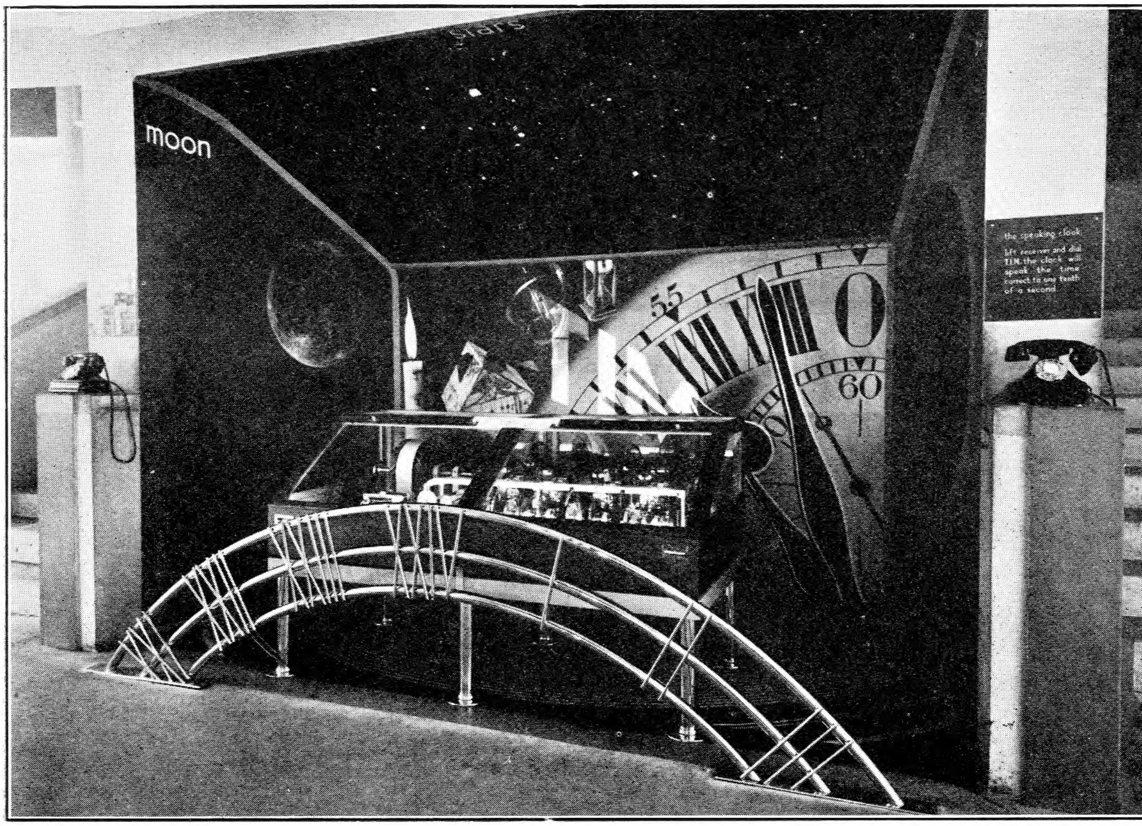


FIG. 9.—THE SPEAKING CLOCK.

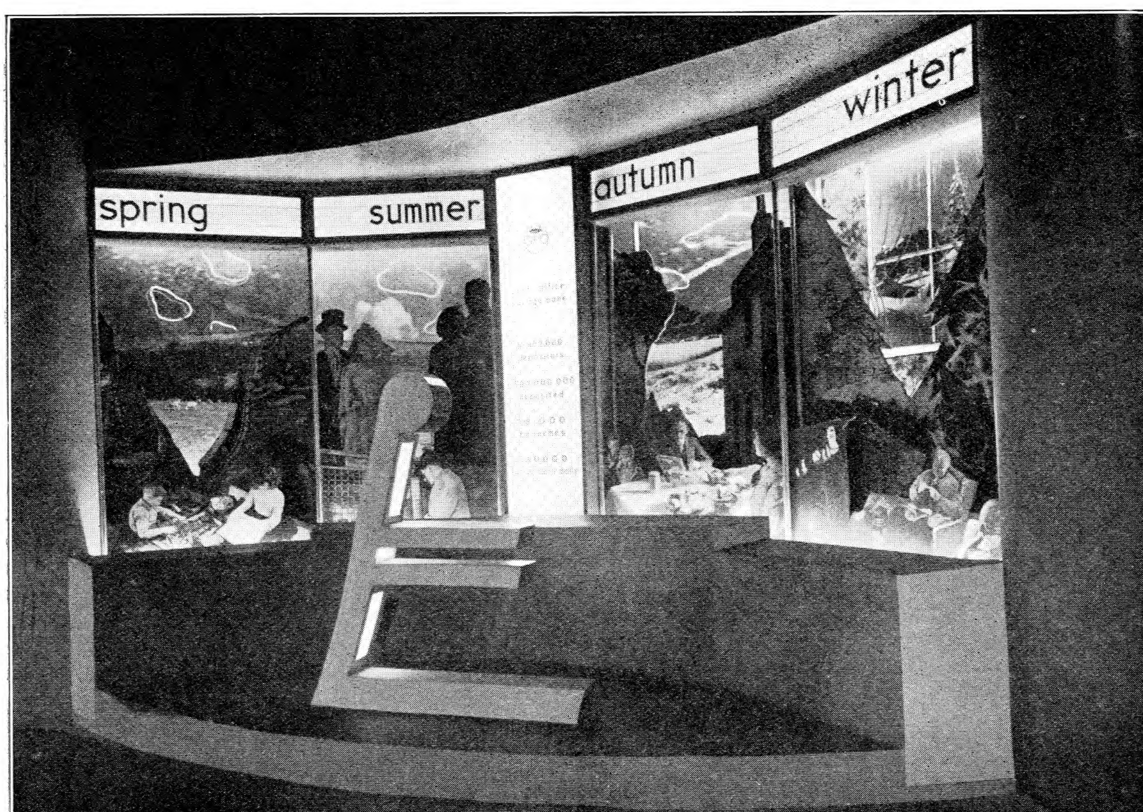


FIG. 10.—SAVINGS BANK EXHIBIT.

normal speech inverted and again restored to normal, and, of course, the cathode-ray tube is there complete with telephone and filters to permit music or speech to be seen and heard and various bands of frequencies eliminated.

The Radio Cabin (Fig. **7**).—The Radio Branch has produced a fine working exhibit of a coast station transmitter and receiver. This model station is in communication with a model ship's wireless cabin situated in the United Kingdom pavilion, and it is hoped to use telephony to a trawler at sea from time to time via the Seaforth station. To assist the demonstrator in putting over his story a film from a small hidden projector can be switched on by pressing a button.

The radio mast which projects for 30 feet above the pavilion is surmounted by a neon beacon which continuously flashes out " G.P.O." in morse code.

Cable Jointing Exhibit (Fig. **8**).—Many model cable manholes have been produced in Post Office exhibitions, but this one is a tribute to the Scottish Region jointing staff. Coaxial and television cables and joints are on view.

The Post Office Railway.—A complete train of two motors and one car has been transported from the Post Office London underground system to the Post Office pavilion and, together with the manhole mentioned above, provides a complete underground exhibit. This is made most realistic by the lighting method employed.

The Speaking Clock.—The Speaking Clock mechanism never fails to attract an audience, and at Glasgow the attractiveness of the exhibit was enhanced still further by the novel setting shown in Fig. **9**. A photo montage background depicting " timetellers " through the ages, with the letters TIM in illuminated silhouette, immediately calls attention to the exhibit. The apparatus is situated in an alcove, the ceiling and sides of which have been used to show enlarged photographs of the sun, moon and stars, and the front of the mechanism is protected by an unusual guard rail.

Other Exhibits.—The Savings Bank can be proud of its artistic exhibit (Fig. **10**), designed by the P.O. Film Unit. The four seasons are shown, together with appropriate events illustrating reasons why money should be saved. The whole of the scenic work is set in three planes with shadowless lighting between two of them, the glass facia and column being illuminated by recessed tube lights. Among other exhibits are a model Mobile Post Office shown in a charming scene of an agricultural show, a Travelling Post Office depicted by means of a model train situated on a viaduct, treating symbolically the climb over Beattock, and a Telegraph Office composed of photo montage and working teleprinters (Fig. **11**).

FIG. **11**.—TELEGRAPH EXHIBIT.

Perhaps the most novel, or to be more correct, the most humorous exhibit, is " Jiffie's Theatre," staged by the G.P.O. Film Unit. In this small theatre an audience of perhaps twenty people can watch a revolving stage, each revolution of which shows in humorous fashion scenes where Jiffie, a messenger boy in kilts, brings a Greetings Telegram to an appropriate function such as a wedding or a birth, etc. The scenes are accompanied by music from a barrel organ. The revolving stage, complete with a synchronised dropping curtain per scene, is the work of the Research Station and, stripped of its humorous settings, would in itself prove a proud exhibit of engineering craftsmanship.

Conclusion.

The pavilion itself was designed by Mr. G. O. Pratt, F.I.A.A., M.Inst.R.A., of the Department of Overseas Trade, Exhibition Section. Its external colouring of red artistically blended with gold, its front façades and the electric blue background of gold mullioned windows 30 feet in height, floodlit at night, combine to make the Post Office pavilion a principal object of interest ; so much so that 30,000 people entered its portals on the first Saturday after His Majesty the King had opened the Exhibition on Tuesday, May 3rd.

In conclusion, the combined craftsmanship of the artist, the model-maker, and the engineer, has produced a display worthy of the Post Office.

The Introduction of Ultra-Short Wave Radio Links into The Telephone Network

A. H. MUMFORD, B.Sc. (Eng.), A.M.I.E.E. and D. A. THORN, B.Sc. (Eng.), A.M.I.E.E.

The authors discuss the suitability and scope of application of ultra-short wave radio links as part of the telephone network. The equipment which has been developed for this purpose is described and a brief summary is given of circuits already in operation. A reference is made to the trend of future development.

Introduction.

THE use of ultra-short wave radio links as an integral part of, or in association with, the normal telephone network is of comparatively recent origin, the first circuit of this type to be employed on commercial traffic, at least in Great Britain, having been brought into service in 1932. As is to be expected of so new an adjunct to the telecommunication art, considerable advances in the technique have been made during the last few years and, although finality has by no means been attained, the equipment designs are now such as to permit the extensive application of ultra-short wave radio links to provide telephone facilities to places which for economic or other reasons could not otherwise be served.

Definition, Advantages and Scope of Application of Ultra-Short Waves.

Ultra-short waves are usually considered to comprise that band of the frequency spectrum lying between 300 and 30 megacycles per second, corresponding to wavelengths of from 1 to 10 metres. Within this band it has been found that propagation conditions are particularly suitable for the provision of stable short-distance radio links. Provided that the transmitting and receiving aerials are within optical sight of one another fading is apparently non-existent. Weather conditions do not appreciably affect the actual propagation and only severe local thunderstorms produce any noticeable atmospheric interference. The ignition systems of motor vehicles, if unscreened, may give rise to interference unless care is taken to place the receiving aerial at least 400–500 yards from such traffic. With coastal sites similar consideration must be given to the possible proximity of motor boats. Interference from aeroplane ignition systems, however, is not usually severe, as adequate screening will have been provided to enable the aircraft radio equipment, which is carried in the majority of aeroplanes, to be operated satisfactorily.

Objects such as trees and buildings in the propagation path have little effect, but may under certain conditions give rise to interference patterns. In this connection it has been observed that aeroplanes having metal struts, bracing wires, etc., the dimensions of which approximate to half a wavelength, cause a flutter in the resultant rec ived field when the normal ground wave is weak and the aeroplane is situated in a strong field. Under such conditions the re-radiated field from the aeroplane structures may be comparable in strength with that of the normal ground wave. The flutter is, of course, dependent on the speed and direction of flying of the aeroplane.

It has been found that under suitable conditions communication may be established on ultra-short waves over distances considerably greater than the optical limit. Such propagation is considered to be due to diffraction and refraction round the earth's surface, and not to reflection and refraction in the ionised layers of the upper atmosphere, as with short and medium wavelengths. The line of demarcation is not sharply defined but it is generally considered that wavelengths below 8 metres are not reflected back to the earth by the upper atmosphere except under freak conditions. Over these non-optical paths considerable fading is experienced, manifested as a short-period decrease in the received field on the one hand and a long-period variation in the value of the mean field on the other. These long-period changes appear to be partly seasonal, with a tendency for the field strength to be lower in winter than in summer, and there is also evidence of a possible cyclic period spreading over some years.

It is evident from the foregoing brief discussion of propagation conditions on ultra-short waves that, from this aspect at least, such wavelengths might well be used for the provision of short-distance radio-telephone links having a stable overall transmission equivalent, particularly over optical paths. There are, however, still further advantages from the equipment point of view in that the transmitters and receivers may be relatively simple in construction and easy to handle. The use of a high radio carrier frequency also facilitates the use of wide-band transmission for multi-channel working and efficient aerial systems having a high gain and good directional characteristics may be constructed simply and in a relatively small physical space.

The economic advantages of ultra-short waves, compared with the submarine cable alternative, are considerable, particularly on capital costs. Maintenance charges over a period of years may not show a great saving, but the facility with which faults may be cleared, especially in inclement weather, is considered to afford an appreciable service advantage.

Method of Application to the Telephone Network.

When an ultra-short wave radio link is introduced as part of a normal trunk circuit it is usual to arrange for the latter to be 4-wire between the trunk terminals, and the radio link functions virtually as a four-wire repeater as shown in Fig. 1. With such arrangements no stabilising devices, other than those normally inserted on a long-distance trunk circuit, are required in order to maintain an overall transmission equivalent as low as 3 db. The normal 500/20 trunk ringing is used and no technical difficulties are to be anticipated in the use of the latest systems of V.F. signalling provided that due consideration is given to the level of the signals which are to be handled by the radio equipment.

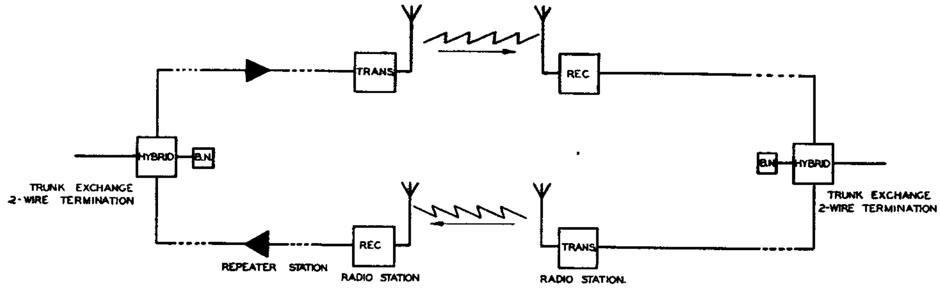


FIG. 1.—U.S.W. LINK AS PART OF TRUNK CIRCUIT.

Where telephone circuits between small islands and the mainland are required for the transmission of telegrams, radio-phonogram circuits may be used, and simplified equipment operating as either transmitter or receiver provides the requisite simplex circuit. Provision may be made for automatic calling as will be explained later.

The requirements to be met by a radio link forming part of a 4-wire trunk circuit may be summarised as follows :—

(*a*) The signal-to-noise ratio should not be worse than that afforded by the associated lines ; a figure of 55 db. for a subscriber talking at reference volume may be taken as the minimum for a good circuit.

(*b*) The overall stability should be such that the gain of the radio link does not change by an amount sufficient to cause " singing " on the overall circuit. Actually a stability of $\pm$ 1 db. may be obtained without the need for frequent adjustment of the equipment.

(*c*) The radio link should be capable of handling the standard 500/20 trunk ringing. This requirement may be met provided that due regard is given to the ratio of the ringing and peak speech levels at the transmitter input.

(*d*) In order to reduce the cost of maintenance and in view of the inaccessibility of the outlying stations, maintenance visits must be required only at infrequent intervals.

Aerial Systems and Characteristics.

Array type antennæ of the Koomans or pine tree type are usually employed for ultra-short wave links. From the radio propagation aspect there is little to choose between horizontal and vertical polarisation, but from the point of view of possible interference from cars, etc., the former is to be preferred and is, therefore, generally used. Arrays consisting of up to 24 half-wave elements, including reflectors, may be erected on light pole structures, but with stouter masts, arrays of up to 128 elements have been used at a wavelength of 5 metres. Fig. 2 shows a typical 32-element array of this type. In this array 16 half-wave elements are connected to the transmission lines, the remaining 16 forming a reflector curtain which is suspended a quarter of a wavelength behind the main or radiator curtain. A considerable advantage can be realised by reducing the wavelength to 2 metres when arrays of up to 40 elements may be accommodated on light pole structures. Horizontal diamond and inverted " V " arrays have also been used with successful results. Parallel open wire transmission lines of characteristic impedance $Z_0 = 600$ ohms are used, and quarter wavelength line matching may be employed to match the array to the transmission line impedance if required.

Choice of Wavelengths.

When the question of the immediate application of ultra-short wave radio links was considered in 1931, it was concluded from the experimental data then available that the band 4–6 metres should be used. The lower wavelength limit was determined by the design of the tuned circuits together with the types of valves available, whereas the upper limit was set by the receiver performance, it being established that the design of super-regenerative receiver then employed was not so satisfactory at wavelengths much above 6 metres. For these reasons wavelengths in the band of 4 to 6 metres have been adopted for the majority of the existing links, but subsequent developments are now resulting in an extension of this band, particularly in the lower wavelength direction.

Transmitters.

The early transmitters consisted of anode modulated self-oscillators, an arrangement which, while affording good efficiency and giving reasonable power output, suffered from the deleterious effects of frequency drift and frequency modulation. These effects limited the closeness of the frequency spacing between

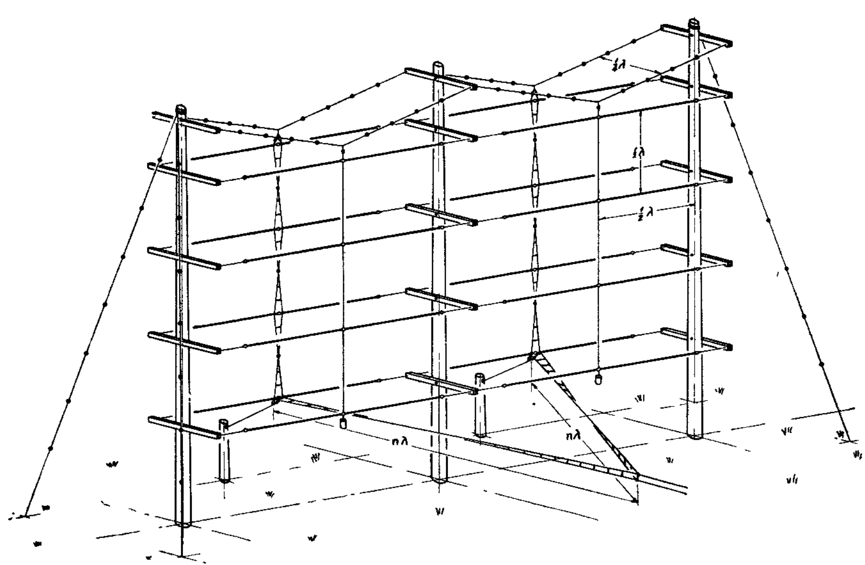


FIG. 2.—TYPICAL 32-ELEMENT ARRAY

the respective radio channels and required a receiver having a uniform response over a wide frequency band to avoid frequent re-tuning, even then giving rise to various degrees of distortion and instability.

The first attempt at frequency stabilisation of the transmitter consisted in using a design of transmitter similar to the self-oscillator type but having coupled to the actual oscillator a tourmaline crystal adjusted to resonate at the required carrier frequency. This arrangement afforded a satisfactory control but set a serious limitation on the carrier power obtainable. Attention was then directed to the use of quartz crystal control, the crystal stage itself generating oscillations at a sub-multiple of the final radio frequency, successive frequency multiplying stages enabling an output at the required carrier frequency to be obtained. Concurrently, the development of the design of high frequency amplifiers together with improvements in valve technique have made it possible to construct transmitters having power outputs of from 1 to 250 watts. Valves are now available which are capable of giving considerably greater output, but for the present requirements there is no advantage to be gained from the use of output powers in excess of 250 watts.

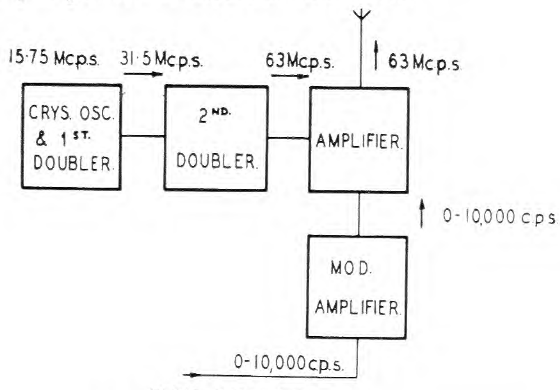


FIG. 3.—BLOCK SCHEMATIC OF 1-WATT TRANSMITTER.

Fig. **3** shows in block schematic form the arrangement of the smallest of the present standard range of transmitters, giving a carrier output power of about 1 watt, and Fig. **4** is a photograph of an actual transmitter of this type. The valves used in the high frequency stages are of the low frequency pentode type, rated at an anode dissipation of 12 watts. The final amplifier valve is modulated on its suppressor grid, requiring only a very small power output from the speech amplifier or modulator stage for full modulation. With the single stage speech amplifier employed, an input level from line of —14 db. relative to 1 milliwatt on steady tone is sufficient to give full modulation.

Higher power transmitters are built up from the basic 1 watt transmitter by adding successive amplifying stages. In these transmitters it is usual, with the exception of a standard 10 watt transmitter, to modulate on the anodes of the last in the chain of radio frequency amplifiers. In the 10 watt transmitter only one amplifying stage follows the 1 watt equipment and it is practicable to amplify the modulated output from the basic unit.

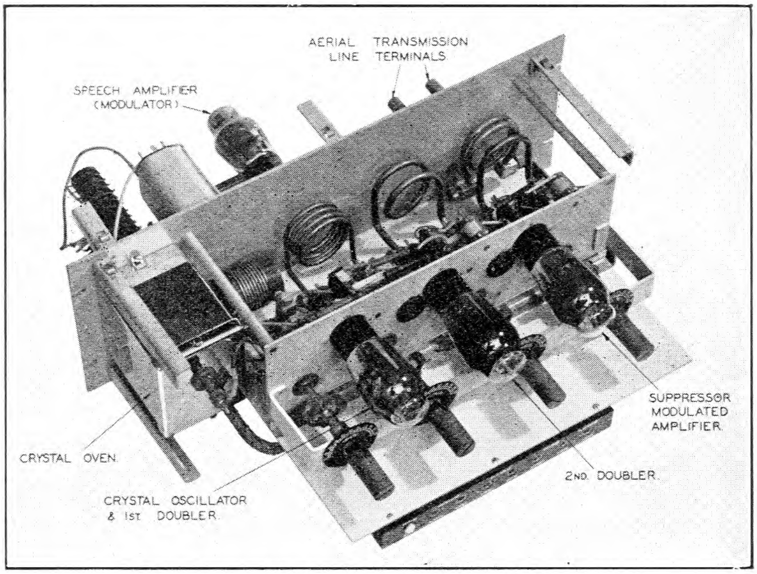


FIG. 4.—1-WATT PENTODE TYPE TRANSMITTER.

Receivers.

Super-regenerative receivers were used on the early circuits, quench frequencies of 15 to 60 kc.p.s. being employed. Such receivers, having a poor selectivity characteristic, were particularly suitable for use with self-oscillator transmitters, and the inherent automatic gain control characteristic maintained reasonable stability. The presence of frequency modulation on the transmitter tended, however, to nullify these advantages.

With the advent of the crystal controlled transmitter, attention was directed towards the design of a super-heterodyne type of receiver having a crystal-controlled beating oscillator. Such a receiver (Fig. **5**) was developed and is now standardised for general use on ultra-short wave circuits. Good selectivity can be obtained, and a signal-to-noise ratio some 16 db. better than that realised with the super-regenerative receiver has been achieved.

The arrangement of the standard ultra-short wave super-heterodyne receiver is shown in block schematic form in Fig. **6**. It will be seen that the beating oscillator is crystal controlled, the crystal together with that used in the associated transmitter being provided as a matched pair. The crystal control ensures stability of tune over long periods without any attention. The intermediate frequency amplifier stages are provided with automatic gain control which minimises the change in low frequency output level of the receiver, consequent upon variations in the received field, in the ratio of about 40 to 1. The standard type of receiver has an intermediate frequency bandwith of 36 kc.p.s., 6 db. down from the response at mid-band frequency, which together

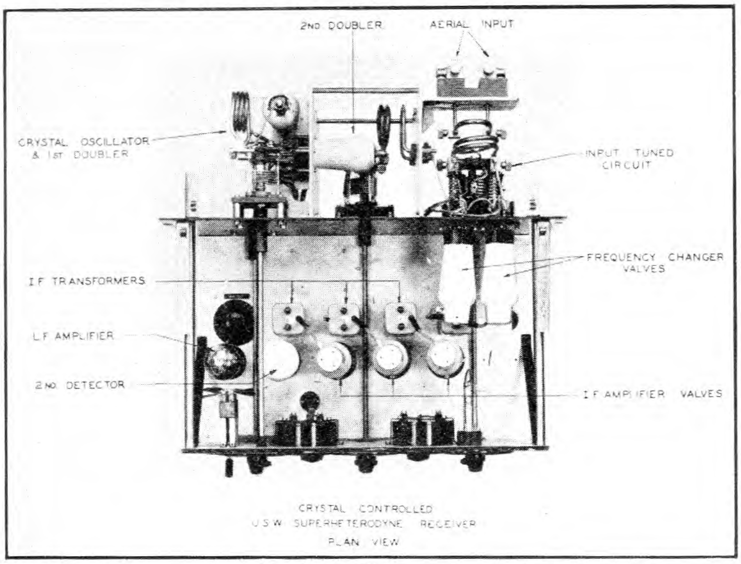


FIG. 5.—PLAN VIEW OF RECEIVER.

with equalisation in the second detector stage gives a low frequency characteristic which is sensibly flat from 100 to 10,000 c.p.s. Simple modifications to the intermediate and low frequency amplifiers enable the receiver to be used with carrier systems requiring a greater bandwith. The power unit associated with the receiver incorporates voltage stabilisation of the valve heater and anode voltage supplies in order to ensure the maximum degree of stability with variations in the mains supply voltage.

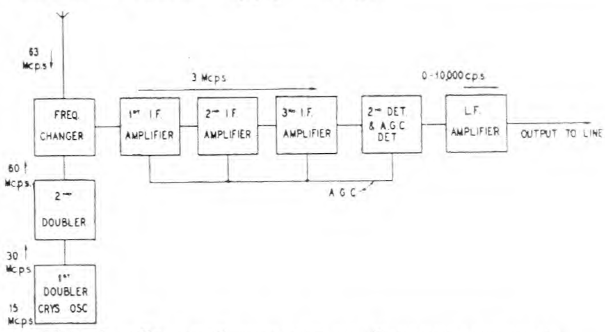


FIG. 6.—BLOCK SCHEMATIC OF SUPERHETERODYNE RECEIVER.

Multi-Channel and Carrier Working.

Where traffic conditions are such as to warrant the provision of more than one speech circuit on any given radio link the problem may, in general, be approached in one of two ways. In the first, additional radio channels may be provided, each of which will give one speech channel ; alternatively some form of carrier working may be adopted on one or more radio channels. The former has the advantage of simplicity, but results in the occupation of a comparatively large frequency band, while the site space required for the aerial systems increases in almost direct proportion to the number of circuits. The use of carrier working has the advantage of requiring a relatively small frequency band and the radio equipment and aerial systems required are reduced to a minimum. A further advantage is that such a system possesses inherent privacy without the use of any additional equipment. The disadvantages are that the failure of one radio link may render a comparatively large number of speech circuits inoperative, and, for the longer distance links, the power output of the transmitter required to give the requisite signal-to-noise ratio may become uneconomic or impracticable at the present stage of the technique. Under such conditions the number of carrier circuits which could be provided on each radio link would have to be curtailed. The present tendency is to use some form of carrier working exclusively.

The frequency spectrum of the two-channel carrier system which is in use on the Guernsey (Channel Islands) service, and will be used where not more than two circuits will be required, is shown in Fig. **7.** In this system one audio channel is inverted to provide privacy and occupies the frequency band up to 3,200 c.p.s., while the second audio channel is translated to the frequency band, 6,400 to 9,600 c.p.s.

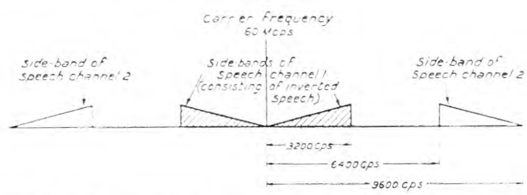


FIG. 7.—FREQUENCY SPECTRUM OF 2-CIRCUIT SYSTEM.

Fig. **8** illustrates the frequency spectrum used in the 9-circuit ultra-short wave carrier system which has been developed by the Standard Telephone & Cable Co., Ltd., and described in a recent issue of this JOURNAL.[1] It will be seen that in this system each sub-carrier, together with both of the associated side bands, is transmitted over the radio link.

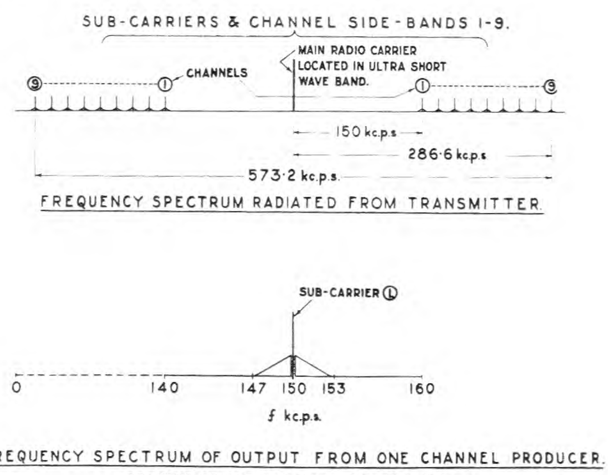


FIG. 8.—FREQUENCY SPECTRUM OF 9-CIRCUIT SYSTEM.

[1] *P.O.E.E.J.*, Vol. 31, p. 33.

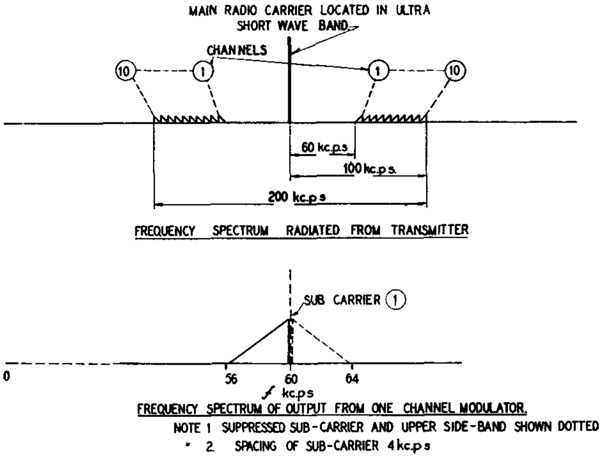


FIG 9 —FREQUENCY SPECTRUM OF A 10-CIRCUIT SYSTEM.

It is evident that in any carrier system the most efficient and economical arrangement is that which requires the transmission over the radio link of the minimum frequency band and side band power per channel for a given signal-to-noise ratio. Fig. **9** shows the frequency spectrum of a 10-circuit carrier system in which the bandwidth has been very considerably reduced by utilising a group of channels from a single side band suppressed carrier system to modulate the final radio carrier, the group being first suitably translated in the frequency spectrum to minimise the effect of the intermodulation products produced in this final modulation process. So far as is known this system has not yet been applied commercially owing to the difficulty of reducing to a sufficient degree the unwanted intermodulation products. Even on this system a still further reduction, 5 to 1, could be effected by the adoption of single side band suppressed carrier working over the radio link. No attempt has yet been made to apply this system to the ultra-short wave band as the technical problems involved are considerable and the need for the consequent reduction in bandwidth and transmitter power is not at present sufficiently acute to warrant the development of the necessary technique.

Privacy[2].

The problem of affording adequate privacy on radio-telephone links is one on which much time and money has been spent. On the trans-oceanic services devices known as scramblers, inverters and wobblers have been used, but the high cost of the standard schemes prohibited their direct application to ultra-short wave links and a simplified form of inverter was developed. Considering a speech frequency band of 0-3,200 c.p.s., and inversion about a frequency of 1,600 c.p.s., a speech frequency component of, say, 300 c.p.s. appears in the transmitter output as a modulation frequency of 2,900 c.p.s., the requisite re-invertion being carried out at the distant receiving station.

With the introduction of carrier working a certain measure of inherent privacy is afforded and the necessity for the addition of inverters or similar equipment is to a great extent eliminated. Where, however, it is essential that the maximum possible degree of privacy should be provided, or for use with a number of single-channel links not incorporating individual privacy equipment, a device known as the Channel Switching Privacy System may be used. This system (Fig. **10**) can be applied only to radio links where more than one speech circuit exists, since the basic principle consists in transmitting each speech channel over various radio channels in turn. Speech on pair 1 passes over radio channel (*a*), and that on pair 2 over radio channel (*b*) in the first condition. In the second condition the radio channels are changed over so that speech from pair 1 now passes over radio channel (*b*) and that from pair 2 over radio channel (*a*). If this change from condition 1 to 2 and back to 1 again is made fairly rapidly, say once every two seconds, it is evident that anyone listening on

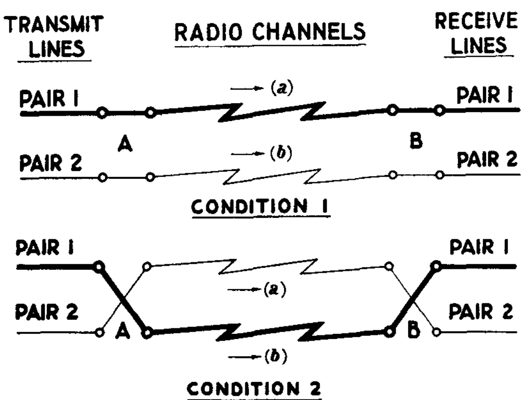


FIG. 10.—CHANNEL SWITCHING PRIVACY SYSTEM

radio channel (*a*) or (*b*) would hear scraps of the two conversations so broken up as to be virtually unintelligible. Where several circuits are available a greater degree of privacy may be afforded, since there are more channels over which the switching may be distributed and the sequence of switching may be more varied. The actual switching at the radio stations is effected by uniselectors, bridging wipers being used so that at each change all the circuits are bunched and shorted momentarily. The lines are connected to the wipers and the respective radio channels are wired to the bank contacts in such a way as to provide the required sequence of switching. Synchronism between the selectors at the two radio stations is afforded by a control tone transmitted over a pilot channel; this tone controls the operation of the drive magnet relays. When the selector drive magnets at the controlling station have been operated (it must be remembered that the wipers do not step until the magnet is de-energised) the control tone passes over the pilot channel, thus operating the selector drive magnets at the distant station. The tone is then passed over the return pilot channel into a timing circuit at the originating end, where, at a predetermined interval after the arrival of the tone, the original source of tone is cut off, thereby removing tone from both pilot channels simultaneously. The removal of the tone simultaneously at all points of the circuit releases all the uniselector drive magnets at

[2] *P.O.E.E.J.*, Vol. 26, p. 224.

precisely the same instant, thus resulting in synchronised switching. This system has been tried out experimentally and is shortly to be put into commercial operation on the North Channel link.

Power Supplies.

With the earlier commercial installations batteries were used to supply the requisite high and low tension power, suitable arrangements being made for charging or floating from the public supply mains.

On the latest equipments A.C. operation has been adopted throughout in order to enable the transmitter and receiver units to be standardised. Where a D.C. supply only is available suitable inverted rotary converters will be employed, and at those stations where there is no public supply, diesel-alternator, or diesel battery-charging sets followed by inverted rotary converters, will be used. The latter arrangement is designed for use where the total load taken by the equipment is below the minimum loading for the smallest size of diesel engine. Where the service requirements are such that uninterrupted communication must be maintained, standby diesel sets are installed which take over the load automatically in the event of a failure of the public supply.

Radio Phonogram Equipment.

The radio phonogram equipment consists essentially of a simple transmitter-receiver, providing telephonic communication in one direction only at any given time, the change-over from transmit to receive being effected by the manual operation of a switch at each terminal. This arrangement necessitates the use of only one aerial or array system at each terminal and considerable power economy is afforded from the fact that the supplies are switched on only during the progress of a call or, as will be explained later, for one minute each hour to prepare the calling circuit. Such equipment is not, of course, suitable for use as a link in a 4-wire circuit but fulfils the requirements of a circuit for the transmission of telegrams between such points as an island and the mainland where, for purely economic reasons, the capital and operating costs of the equipment must be reduced to the minimum.

In Fig. **11** are shown the essential circuit conditions obtaining when (*a*) transmitting, (*b*) receiving, and (*c*) receiving with the calling circuit set up. It will be seen that a push-pull self-oscillator circuit V3 and V4 provides the radio carrier in the transmit condition and acts as the oscillating detector of a super-regenerative receiver in the receive condition.

When transmitting, the speech is amplified by a single stage triode amplifier V1, the output being coupled to a class B push-pull modulator V2 which, in turn, is transformer coupled to the oscillator anode circuit.

In the receive condition, the valve V2 which in the transmit condition was used as a push-pull modulator is used as the quench oscillator, the two triode sections of the valve being connected in parallel. The quench frequency is fixed at 15 kc.p.s.

As the traffic to be handled on a radio-phonogram

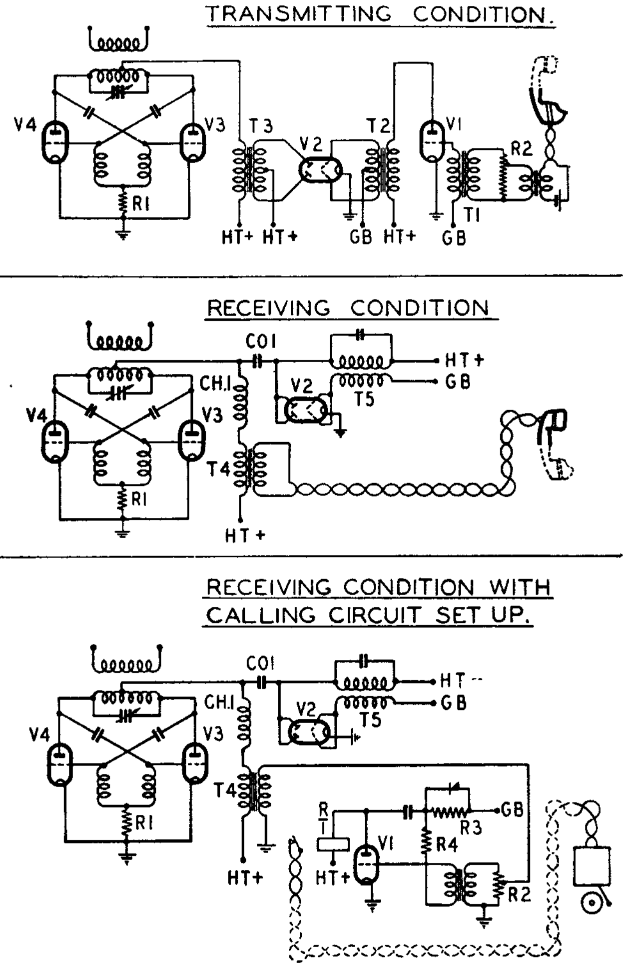


Fig. **11**.—Radio Phonogram Equipment, Circuit Conditions

circuit is very small, and in order to economise in battery power, provision is made for automatic calling in either direction. The method adopted is to arrange for the equipment to be switched on in the receive-calling condition, by means of a time switch, for about one minute every hour. Then, if the distant end wishes to call, the calling set is switched on in the transmitting condition during this time. The result at the called end is that the receiver output noise is reduced by some 40 db. by the incoming carrier, and this change in noise level is utilised to release a calling relay R via a rectified-reaction amplifier stage so energising the calling bell. The valve V1 used for the latter purpose is that which serves as the first speech amplifier when transmitting. In order to provide for calling in each direction the time switches are staggered by half an hour, providing for calling in the one direction at every hour and in the other at half-past every hour. When communication has been established the change-over from transmit to receive is effected by the operation of a small switch fitted on the base of the telephone at each terminal.

Power for operating the equipment is obtained from a 2-volt accumulator for the valve filaments and dry cells for the anode and grid bias supplies.

Two types of radio-phonogram equipment have been developed and are known as local and remote

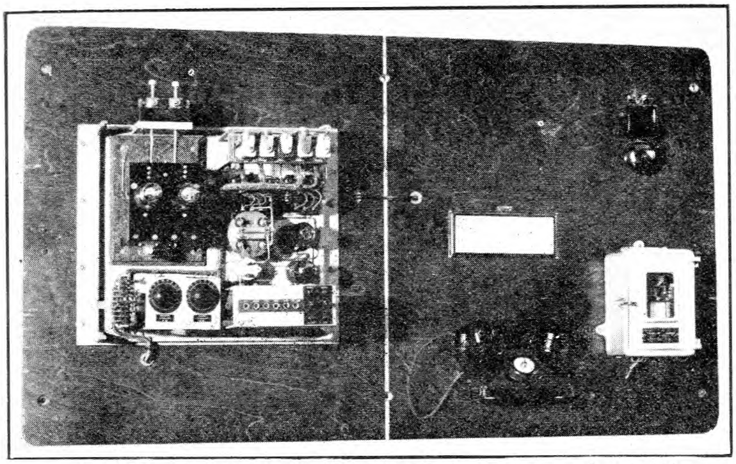


FIG. **12.**—RADIO PHONOGRAM EQUIPMENT (LOCAL CONTROL).

control respectively. The former is intended for use where the telephone and radio equipment can be accommodated in the same building. Sometimes, owing to geographical conditions, the building (usually the local Post Office) where the telephone is required is unsuitable as a radio site. The remote control equipment is then used and, as only a single pair telephone line is required to connect the actual phone point and the radio equipment, the latter may be situated in the most suitable position from the point of view of the radio requirements. Relays are used to effect the various switching operations, the remote control equipment requiring a somewhat more complex circuit arrangement than the local control. Fig. **12** shows a photograph of a local control radio-phonogram set complete with telephone, time switch and bell.

Commercial Installations.

Table I gives a summary of the ultra-short wave radio links which have been installed in the British Isles as part of, or in association with, the normal telephone network, and the map shown in Fig. **13** gives the location of the respective radio stations. A brief description of these links follows :—

Cardiff-Weston.[3]—The first commercial circuit incorporating a radio link was set up on an experimental basis between Cardiff and Weston-super-Mare in October, 1932. This circuit was worked on a wavelength of about 5 metres and used self-oscillator type transmitters and super-regenerative receivers. Considering the experimental nature of the equipment the results obtained were very encouraging, a maximum period of unattended operation of some 1,000 hours, i.e. six weeks' continuous service, being realised. During the two years that it was left in service much useful data was accumulated, forming the basis of later designs.

North Channel—Six-Circuit P.O. Equipment.[4]—Following on the successful operation of the Cardiff-Weston circuit, equipment was designed and constructed to provide six radio circuits. The self-oscillator type of transmitter and super-regenerative receiver in a somewhat improved form were again used. Wavelengths of 4·16, 4·48, 4·80, 5·12, 5·44 and 5·76 metres were used in one direction, and 4·24, 4·56, 4·88, 5·20, 5·52 and 5·84 metres in the other direction. After some months of experimental work between

[3] *P.O.E.E.J.*, Vol. 25, p. 303.
[4] *P.O.E.E.J.*, Vol. 28, p. 121.

TABLE I
SUMMARY OF U.S.W. RADIO LINKS ESTABLISHED IN BRITISH ISLES

Length of Path (Miles)	Link	No. of Radio Circuits	No. of Speech Circuits	Date Opened for Service	Type of Equipment
13 (1)	Hutton-Dinas Powis (Weston-Cardiff) ..	1	1	Oct., 1932	Self Oscillator Transmitters and Super-regenerative receivers.
39	Portpatrick-Ballygomartin .. (North Channel)	6	6	Dec., 1934	Self Oscillator Transmitters and Super-regenerative receivers.
39	Do. do.	1	9	Aug., 1936	S.T. & C., 9-channel equipment.
85 (2)	Guernsey-Chaldon	2	4	May, 1936	Crystal controlled super-heterodyne receivers and high power transmitters.
15	Arran-Ardrossan	5	5	March, 1937	Crystal controlled transmitters and super-regenerative receivers.
30	Lands End-Scilly Isles .. (St. Just-St. Mary's)	2	2	Jan., 1938	Crystal controlled super-heterodyne receivers and 1 watt transmitters.
25	Lerwick-Skerries	1 Phonogram		Nov., 1934	Radio-Phonogram (early model)
18	Sandness-Foula	Do.		April, 1937	Do. (later standard model)
5	Sandness-Papa Stour ..	Do.		Aug., 1937	Do. do.
6	Huna-Stroma	Do.		June, 1937	Do. do.
7	Soay-Elgol	Do.		Dec., 1937	Do. do.

NOTE : (1) This circuit was withdrawn from service in November, 1934, as it had been established for experimental purposes only.
(2) All circuits with the exception of Guernsey–Chaldon have " optical " paths.

FIG. 13.—U.S.W. RADIO LINKS INSTALLED IN THE BRITISH ISLES.

sites on either side of the Bristol Channel the equipment was installed at Portpatrick and Ballygomartin in December, 1934, to provide six additional trunk circuits between Scotland and Northern Ireland. This equipment is still in service and has provided satisfactory service day and night for the past three years.

North Channel—Nine-Circuit S.T. & C. Equipment[1]—Concurrently with the development of ultra-short wave equipment by the Post Office, Messrs Standard Telephones & Cables, Ltd., produced a nine-circuit equipment using one main radio carrier in each direction, nine separate speech circuits being provided by the use of sub-carrier frequencies located between 150 and 300 kc.p.s. Crystal-controlled transmitters and receivers, the latter being of the super-heterodyne type, are used together with arrays of the inverted " V " and horizontal diamond pattern. The equipment was inaugurated officially in August, 1937, to provide a further nine circuits between Scotland and Northern Ireland.

Guernsey-Chaldon.[5]—From 1934 onwards experimental work has been carried out to explore the possibility of the use of ultra-short waves for communication over non-optical paths. The results of tests between Guernsey and the mainland indicated the practicability of working over a distance of some 80 miles on 5 and 8 metres. A commercial circuit was set up between Chaldon, near Weymouth, and Fort George, Guernsey, in July, 1936. Subsequently high power transmitters together with two-channel carrier equipment enabled a total of four circuits to be provided to Guernsey. The two radio circuits, one working on about 5 metres and the other on about 8 metres, each carry one inverted audio and one carrier circuit.

Arran-Ardrossan Circuits.—Towards the end of 1936 equipment was installed at Ardrossan and Brodick (Isle of Arran) to provide five radio circuits initially with an ultimate capacity of seven. This equipment is similar to that used for the North Channel six-circuit installation described earlier, except that tourmaline crystals are used to control the transmitter frequencies. This equipment has been in regular commercial operation since March, 1937, and has given satisfactory results.

St. Just–St. Mary's (Scilly Isles) Circuits.[6]—Equipment was installed at St. Just and St. Mary's towards the latter end of 1937 to provide two radio circuits. The equipment, which was brought into service for commercial operation early in 1918, consists of super-heterodyne receivers and 1 watt pentode transmitters, both crystal controlled. At the outset one audio-frequency telephone circuit is provided on each radio circuit, but it is intended to instal at a later date carrier equipment, similar to that used on the Guernsey–Chaldon circuits, to provide a total of four telephone circuits.

Radio-Phonogram Circuits.

The following radio-phonogram circuits have been installed and are now in operation :—

Lerwick–Skerries, Sandness–Foula, Sandness–Papa Stour, Huna–Stroma, Soay–Elgol.

Proposed Links.

An extensive programme for the provision of additional radio links of the type already described in this article has been prepared and the construction of the stations and equipment is at present in progress. The majority of these new links will serve the various Scottish Islands. For some time past the question of providing an ultra-short wave radio link with France has been under consideration by the French and British Administrations and negotiations are now proceeding to determine a design of equipment which would be mutually agreeable.

Future Developments.

Future developments in the ultra-short wave technique are likely to be concerned on the one hand with the provision of multi-channel carrier circuits enabling the maximum possible number of speech channels to be worked on each radio link, and on the other hand with the extension of the useful frequency spectrum up to 150 megacycles per second (2 metres), and ultimately even higher. The demand for services and frequency allocations in the ultra-short wave band is already heavy, and still further demands are to be anticipated. Thus the stability of tune of the transmitters and receivers is becoming more and more important and it is to be anticipated that in the near future restrictions and tolerances, similar to those applying to the other radio bands, will be imposed.

[5] *P.O.E.E.J.*, Vol. 29, p. 124.

[6] *P.O.E.E.J.*, Vol. 31, pp. 76 and 101.

Telephone Communication for the Scilly Islands

H. BARKER, B.Sc.(Eng.), and
M. R. SHEARING

Introduction.

THE Scillies are a group of small islands lying 25 miles west by south of Land's End. Among a large number of smaller islands there are five inhabited ones—St. Mary's, Tresco, St. Martin's, St. Agnes and Bryher. St. Mary's is the most important, and round it, separated by distances up to three miles, lie the others. The total population is about 2,000 and for these people the main industry is the growing of flowers; but the islands are, of course, popular holiday resorts. There are several coastguard stations dotted about, and the frequent reference to the Scilly Islands in weather reports and forecasts points to their importance as a meteorological station. It is interesting, in addition, to note that the Bishop Light, popularly known because it is the point to which trans-Atlantic liners are timed in their race for the Blue Riband, lies just off St. Mary's.

When on the Islands, and particularly when studying a map, it is amazing to see the extent to which they have at various times been fortified. This is common to many of the small islands on our coasts, but the Scillies seem more than most to be crowded with defences, ranging from ancient earthworks to modern gun emplacements. One other thing will remain for a long time in the minds of several people who have been interested in providing modern communications to the Islands—the sea crossing. Most of the work was done in mid-winter and at least one man after five hours of gale in the little motor ship "Scillonia" wished on reaching St. Mary's that he might never have to leave again. However, for bad sailors in bad weather there is an aeroplane which does the journey in twenty minutes from Land's End Airport.

Until this year the only telecommunication with the mainland has been a simplex sounder circuit working over a single-core submarine cable between St. Mary's and Porthcurno (Fig. **1**). The Porthcurno-Deep Point cable, consisting of a single-core 107 lb. per naut., G.P. insulation 150 lb. per naut., brass tape, 10/2 armouring, was laid in 1886 and had a total length of 27·534 nauts., subsequent repairs and replacements have left two lengths of the original cable, 8·505 nauts. and 0·9 naut, the existing cable having a total length of 28·786 nauts.

At Deep Point the cable runs from the cable hut down a rocky cliff face to the sea, and has been embedded in cement in certain places for protection. Near the mainland the cable crosses several telegraph cables and runs in on a sandy beach to the Cable & Wireless Company's telegraph station.

An investigation was made three years ago to ascertain whether it was possible to obtain a commercial telephone circuit and a composite telegraph circuit over this cable with repeaters at Porthcurno and St. Mary's. One possible source of difficulty was the amount of interference picked up at the Porthcurno end due to the close proximity of the Cable & Wireless Company's cables. One cable, "Fayal 1906" (Azores-Porthcurno) follows a parallel route for some distance and then crosses several times.

Following tests made it was decided that satisfactory telephone and telegraph sub-audio working could be obtained between Hugh Town, Scilly Isles—and Penzance, the equivalent being such that calls from the Islands could be extended to the mainland and international networks. Such a scheme, however, was incapable of expansion, and when it was decided that a telephone service should be given, short-wave radio circuits were chosen.

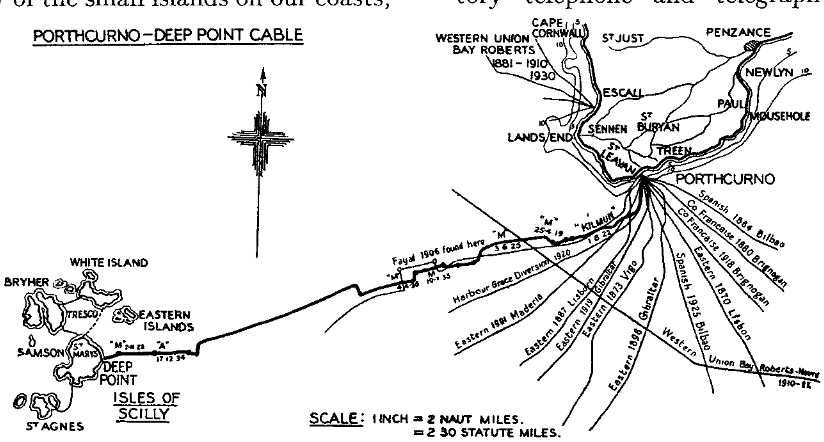


FIG. 1.—SUBMARINE CABLES AROUND PORTHCURNO.

The Radio Equipment.

A new radio station has been built at St. Just, Cornwall, to work to another on St. Mary's. Two circuits have been provided and they are extended to Penzance on land lines. During the day one circuit is in use as a telephone trunk and teleprinters are worked over the other; during the night the telegraph circuit is closed down, both circuits are used as trunks, and any telegraph traffic is handled telephonically. These are the first radio circuits in the country over which teleprinters have been commercially worked and there is an added interest

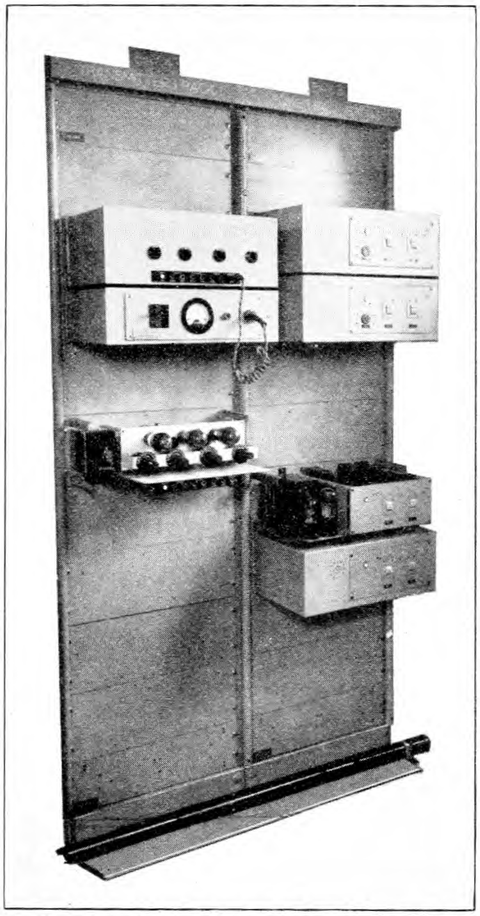


FIG. **2**.—TRANSMITTER AND POWER BAYS.

because they replace one of our last sounder circuits.

The radio terminal at St. Just is 620 feet above sea level and that at St. Mary's, installed in the coast-guard station, is 150 feet above sea level. There is a public power supply at each place and the equipment is entirely mains operated. At the moment two channels are worked in each direction with a separate wavelength for each channel. The transmissions to the Scillies are on wavelengths of 4·77 and 4·97 metres (62·9 and 60·4 Mc.p.s.), and in the reverse direction wavelengths of 4·31 and 4·42 metres (69·6 and 67·9 Mc.p.s.) are used. It may be explained here that the propagation characteristics of wavelengths between about 1 and 10 metres over visual ranges are ideally suited to the requirements of communication links where high stability of the radio circuit is essential. There appears to be no reflection of these waves from the ionosphere : propagation takes place by ground wave only and this is not affected by changes in atmospheric conditions, so that for uniform transmitted power the received field remains sensibly constant at all times. In addition, atmospheric interference on these wavelengths is absent.

Reference has been made in a previous article[1] to the Diplex system of working of radio in which two speech channels are given on one radio circuit. Equipment of this design to provide one additional circuit is on order for the Scillies and will be fitted shortly. This will enable the traffic requirements of two circuits to be met and at the same time allow one of the radio equipments to be retained as a spare.

Each transmitter (Fig. **2**) employs four valves in the following stages :—Crystal oscillator/frequency doubler, second frequency doubler, modulated amplifier and speech amplifier. Frequency control of the transmitter is given by a quartz crystal which is contained in an oven controlled to a temperature of 50° C. The transmitter gives an output power of 1 watt which can be 100 per cent. modulated by a signal level of about −15 db. on one milliwatt applied to the 600 ohm input circuit of the speech amplifier stage. Superheterodyne receivers (Fig. **3**) are used, and these are identical with those provided on the Channel Islands circuits described in the article previously noted. All the equipment has been designed so that the station may be unattended, and for this reason is enclosed in cabinets so as to avoid the necessity of heating the whole building. Tubular heaters are fitted at the bottom of the apparatus racks with thermostatic control to maintain the temperature inside the cabinets at a suitable level.

Koomans type horizontal aerial arrays are used for transmission and reception. Two similar aerials are arranged between three 55-foot poles, the transmitting and receiving pairs at each station being separated by about 50 yards. Each aerial contains 32 half-wave elements arranged in two " curtains "

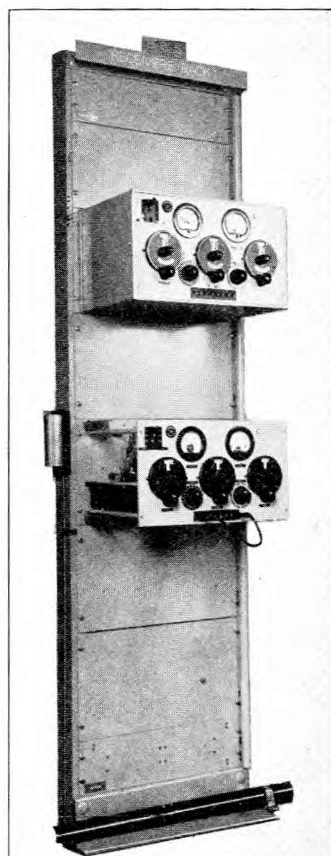


FIG. **3**.—SUPERHETERODYNE RECEIVER.

[1] *P.O.E.E.J.*, Vol. 29, p. 124.

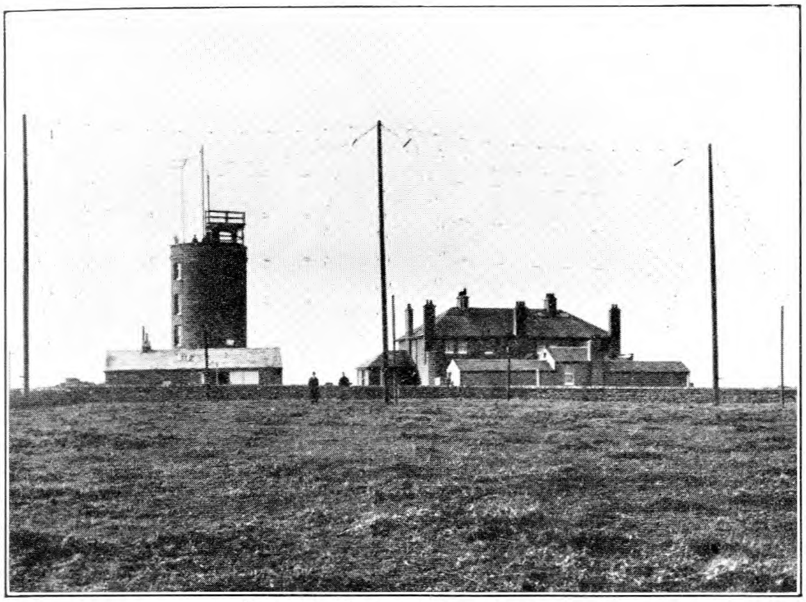


Fig. 4.—Transmitting Arrays.

spaced a quarter of a wavelength apart in the direction of working, the back elements acting as reflectors. Open wire transmission lines connect the aerials to the radio equipment. A photograph of the transmitting aerials at St. Mary's is shown in Fig. **4**. The photograph also shows the coastguard buildings, the Telegraph Tower from which the coastguards have a good view all round the Islands, and also the old twin aerial which was used with a spark transmitter for many years by the coastguards.

The radio circuits are extended on 4-wire lines, mainly overhead, over the 8 miles from St. Just to Penzance ; on St. Mary's they are extended over $1\frac{1}{2}$ miles on 4-wire lines in a cable. At Penzance and St. Mary's exchanges 4-wire terminations and 500/20 ringing equipment have been installed. In the past considerable trouble has been experienced on circuits involving short-wave radio links in obtaining a satisfactory ringing system. It is necessary to limit the level of the 500/20 ringing signal sent out so as not to overload the radio transmitter, and the signal received at the distant end is therefore lower than usual. The ringing receiver must therefore be made sensitive, and in this condition noise picked up on the radio channels is liable to bring into action the relays designed to prevent voice operation of the ringer and so prevent proper working. On the Scillies circuits valve type 4-wire ringing terminations, of an earlier design, have been used with satisfactory results.

Teleprinter Service.

When the circuits are taken over for telegraph use a standard Teleprinter No. 3A is used on a slightly modified table. Signals at a frequency of 1,500 c.p.s. are sent out from a standard V.F. convertor, but the normal 15 milliwatt output from the convertor is reduced to 1 milliwatt so as to avoid overloading the radio transmitters on which the modulation has been adjusted to give the best conditions with speech. No special adjustments of the teleprinters are necessary to work them on the reduced power received. The teleprinters are brought on to the trunks by switching through in the exchange and the voice frequency ringing equipment is therefore left in circuit. This arrangement necessitates careful adjustment of the ringing receivers to prevent their operation from the teleprinter signals, but it has the advantage that it is possible to fit a hand-generator on the telegraph tables so that a calling system is obtained and the teleprinters need not be permanently switched on.

It is interesting to note that on the Penzance–St. Mary's link with a sent power of one milliwatt and an overall circuit equivalent of 3 db., the power which the convertor receives is equal to that received when the sent power is 15 milliwatts and operated on a circuit with an equivalent of 15 db. This is the most satisfactory level at which to operate the convertor from a distortion point of view.

Each of the two teleprinter equipments at St. Mary's can be switched to either of the two Penzance circuits, thereby providing a spare teleprinter with access to both circuits. As part of the telegraph facilities two positions of separate phonagram and telephone telegram equipment have been provided in the Post Office at St. Mary's.

Local Telephone Service.

The local telephone service on the Islands has hitherto been very much restricted. Tresco, St. Martin's, St. Agnes and Bryher are linked up to St. Mary's by single-core cables. Over these cables omnibus circuits have been worked to the Post Offices to deal with telegraph traffic and the coastguards have also had connections to them. A magneto exchange has now been installed on St. Mary's and over 60 lines have already been joined up with applications still being received. A scheme for the other islands is now under consideration. The dream of every development engineer must have been realised by the man who planned the St. Mary's layout, for he was providing a brand new telephone system in virgin country. A 54-pair and 100-pair cable serving 15 distribution poles have been laid down with a junction cable to the radio station. The work was undertaken by gangs specially sent from the mainland and they spent several months on the islands. There is no motor tax in the Scillies and no driving licences are required, but in spite of this there do not seem to be very many vehicles on the road and the lorries taken over by the Superintending Engineer, South-West District, for the use of his gangs, were by far the most up-to-date motor vehicles to be seen.

After some discussion it was decided to call the new exchange " Scillonia," the old name for the Islands, and the service was inaugurated on January 28th, when Major Dorrien Smith spoke from St. Mary's to the P.M.G. at Salisbury.[2] During its first week Scillonia passed 254 calls to the mainland and received 142, and it is interesting to speculate whether any of these calls were made by people who had never used the telephone before.

[2] *P.O.E.E.J.*, Vol. 31, p. 75.

The Application of a Constant Volume Amplifier to a Short Wave Single Sideband Transatlantic Radio Circuit

L. T. ARMAN and
P. R. HUTTON-PENMAN

The volume variations due to fading on this circuit are not fully compensated by normal methods of automatic gain control on the receiver, and the provision of a constant volume amplifier at the output of the receiver to remedy the defect is discussed. Two types of amplifier, one of which was developed for another purpose and was used experimentally, are described.

Introduction.

IT was found that the speech volume received at the Radio Telephony Terminal from U.S.A. over the single sideband short-wave radio circuit which has been recently set up between London and New York is subject to a degree of variation, due to fading, which could not be controlled to a sufficient degree by normal methods of automatic gain control on the receiver. This is largely because the fading is at times of a selective character, as a result of which the energy in portions rather than in the whole of the received audio frequency spectrum may be considerably attenuated. Apart from the question of whether a varying volume is acceptable to the subscriber it is necessary to maintain a constant volume at the output of the receiver in order to ensure correct operation of privacy apparatus and singing suppressors located at later points in the circuit.

At the time when the variations were first noticed a device for automatic control of the outgoing volume to the transmitter was in course of experimental test at the Radio Telephony Terminal, and this was pressed into service as a remedial measure. This device in its entirety is being developed as an automatic technical operator for use at the terminal, and, as such, will be the subject of a later article. The section employed on the single sideband circuit is described in outline in the first part of this article. A considerable improvement was obtained by its use on the circuit, but, in addition to being unnecessarily complicated, the design was not entirely suitable for this particular use. The development of a constant volume amplifier to fulfil requirements was, therefore, put in hand, and this, which is on similar lines to that previously described by Dr. Ryall,[1] is the subject of the second part of this article. It was temporarily inserted in the receiving path before the singing suppressor as shown in Fig. 1, but will ultimately be located at Baldock.

[1] *P.O.E.E.J.*, Vol. 29, p. 6.

General.

From the noise aspect a constant volume amplifier should add nothing to the gain in the circuit in the static or idle condition. Therefore, with a device which works from a maximum to a minimum gain proportionately with increases in speech level, some auxiliary means must be adopted to reduce the gain to zero in the absence of speech. Further, this auxiliary device must be rendered inoperative as early as possible after the arrival of speech; that is, it must have the maximum sensitivity possible, commensurate with the noise levels to be expected at that point in the circuit.

The ideal device would be one which operated about this zero gain point, but unfortunately the method of obtaining such a performance has not so far presented itself, and the nearest approach, obtained by using a device of maximum gain tempered to zero by an auxiliary control, has been adopted. If the noise level exceeds the sensitivity of the auxiliary device then the noise is amplified to a constant level and the amplifier must either be taken out of circuit or the volume ranges catered for must be reduced to allow for a decrease in the sensitivity of the auxiliary device.

Constant Volume Amplifier (Relay and Selector Type) as Used on the "Auto Technical Operator."

To meet the conditions required for its use as part of the Automatic Technical Operator this amplifier is designed to provide a constant output for input variations of 40 db., as well as numerous other facilities not necessary for its temporary use.

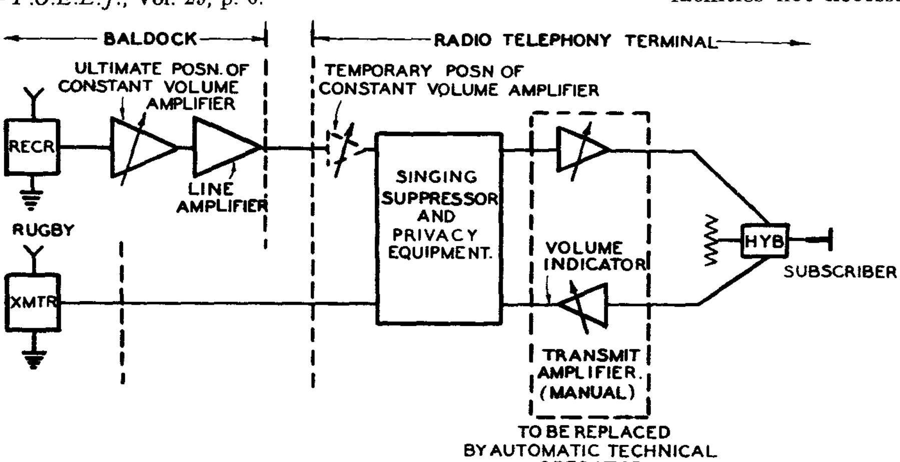


Fig. 1.—Uses of a Constant Volume Amplifier on a Radio Telephone Circuit.

The amplifier proper is split into two parts, 1 and 2 (see Fig. 2), to meet the requirements of constant impedance input and high overall gain. The input potentiometer R1 is so connected to one contact bank of a selector switch as to give the 40 db. range in steps of 2 decibels. In the home position of the switch the whole of the input voltage is applied to amplifier 1. The selectors employed are known as both-way selectors, having each two magnets and being capable of rotation one step at a time in either direction.

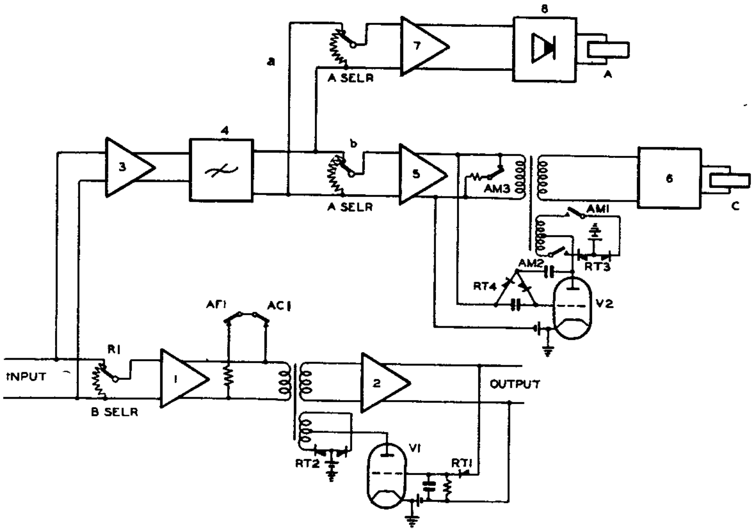


Fig. 2—Relay and Selector Controlled C.V.A.

The control circuit, comprising rectifiers RT1 and RT2 and the valve V1, connected to the output of 2, operates so as to increase the shunt loss in the speech path in a manner proportional to the increase of the input voltage. To do this, the speech is rectified and applied as a positive bias on V1 to increase the D.C. through RT2, and so reduce its impedance as seen from the speech path.

Two other control paths branch from the output of amplifier 3 and filter 4, which are connected to the input of the circuit by the amplifier 7 and amplifier detector 8 using rectified reaction[2], and the amplifier 5 and trigger relay 6[3] with a rectifier impedance control, RT3 and V2.

The auxiliary device controlling the gain in the idle condition consists of the control path (a) operating the master relay A, which in turn operates two relays AC and AF to remove a shunt loss from the speech path via contacts AC1 and AF1. Of these two relays one has a long releasing time and the other a minimum operating time. Speech arriving at the input to the device operates relay A to restore the gain in the speech path to its maximum value as described above, and prepare the operating circuit for the selector magnets. Initially the whole of the control is performed by the circuit RT1, V1 and RT2, and practically no operating time is involved here in covering the whole of the range.

Simultaneously the speech also passes through control circuit (b) and, neglecting RT3 and V2 for the moment, operates relay C which steps the selectors A and B to reduce the gain in the control and speech paths respectively. When the level into the trigger relay 6 has been reduced by the A selector to the point where relay C releases, this same selector reverses one or more steps in accordance with the value of input level to re-energise C. No delay, other than the inherent operating time in the circuit, is placed on the control path (b), so that it operates to reduce its own gain on peaks of speech but does not subsequently increase this gain by more than 2 decibels unless the input voltage fails to reach the previous operating value within a period of the order of 200 milliseconds. This may be more clearly understood by considering an oscillatory current at a frequency of 5 c.p.s. having a certain maximum amplitude applied to the input to the control path (b). This would step the A selector forward to a position depending upon this maximum amplitude so that thereafter the selector would alternate between this setting and one step in the reverse direction.

The B selector controlling the gain in the speech path is controlled by the A selector. It follows A in the forward direction, but reverses only when A fails to reach again its maximum forward setting, as determined by a particular input, within a certain period. It then reverses one step for every 200 milliseconds approximately until it is held again by the A selector.

Once the B selector has been set to a point representing the general input level it is undesirable that the mechanical system should follow minor surges in level which may occur only at infrequent intervals. As stated before, the operation of RT1, V1 and RT2 is practically instantaneous over the whole range and controls the circuit during the operating time of the switches, its subsequent function being to provide a vernier adjustment for increases of about 5 decibels in the input level for which the selectors remain unaffected.

Obviously this would not so function if the A selector were allowed to follow surges. To meet this condition it is arranged that the control circuit RT3, V2 and RT4 acts on the control path (b) so that the input to the trigger relay 6 has a constant value over this particular range. It is ineffective up to this point, controls over the next 5 decibels and then becomes ineffective again. In the idle condition of the circuit, relay AM is not operated ; it is energised by relay A after a certain period in order to give the mechanical system time to adjust itself to the input level and releases with A. The contact AM3 connects a shunt loss to simulate the loss imposed by the rectifiers in the static condition.

On the cessation of speech the selectors are locked at their last setting by means of auxiliary relays for an arbitrary period of 10 seconds. Although this period is effective from the point of view of one side of the conversation only, when using the device as a constant volume amplifier, it is arranged in the complete " Automatic Technical Operator " that speech in the other direction maintains this setting. Thus the device should require but little adjustment for each passage of speech. At the end of use the selectors are restored to their home positions in the normal manner.

The input to the control path (a) is also a function of the A selector. It is arranged, however, that no reduction in input occurs until the switch has moved over the first five steps. It should be remembered that relay A maintains the device in an operative

[2] *P.O.E.E.J.*, Vol. 25, p. 190.
[3] I.P.O.E E., Paper No 136.

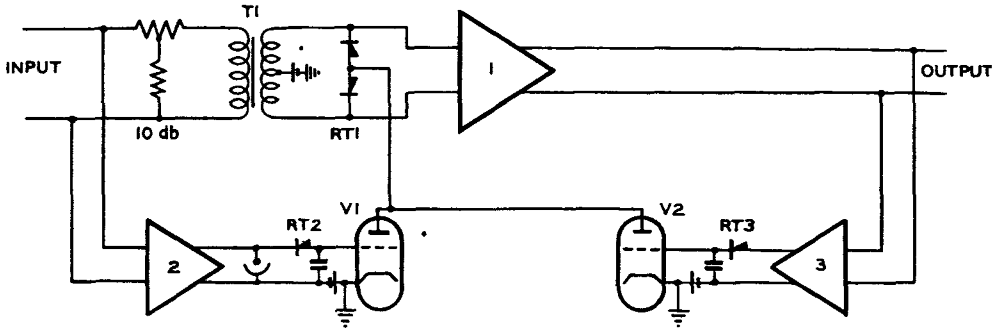


FIG. 3.—VALVE AND RECTIFIER CONTROLLED C.V.A.

condition and the maximum sensitivity is retained on this account for input levels somewhat above the allowed minimum.

The master relays A and C are of a fast operating type, and the auxiliary relays are of the P.O.3,000 type.

The use of a relay of the trigger type to perform the functions of amplifier detector 6 is invaluable for the successful operation of this device. It causes the application of a predetermined voltage to the input to raise the current in relay C from zero to its maximum value, and by its internal circuit arrangement restores it to zero when this input voltage level falls by 2 decibels, with an additional advantage of instantaneous current changes.

It might perhaps be mentioned here that an experimental model of a complete automatic technical operator, including a constant volume amplifier of the above type, has been installed at the Radio Telephony Terminal and has been placed in circuit with promising results. Such factors as radio and line noise, hybrid out-of-balance, and weak talker volumes place limits upon the device, as indeed they do on most of the apparatus in the circuit, and the period of unattended service to be expected has not yet been determined. These matters are still being investigated.

Constant Volume Amplifier—Valve and Rectifier Type.

As stated previously the use of the relay and selector type of amplifier was a temporary experiment, and this has since been replaced by an amplifier of the valve and rectifier type as shown in Fig. 3. A 10 decibel attenuation network and a transformer T1 shunted by the rectifiers RT1 is connected to the input of amplifier 1 in the speech path. The operation of the control circuit including amplifier 3, rectifier RT3 and control valve V2, on the rectifiers RT1 is similar to that described for the relay and selector type of amplifier. The attenuation network reduces the reflected impedance changes due to RT1, and the transformer raises the impedance of the circuit in order to obtain a sufficient range of control with the variation in impedance of the shunt rectifiers.

The maximum overall gain in the speech path is 17 decibels, which is reduced to zero by the requisite current flowing from V1 through RT1 in the idle condition, V2 adding nothing at this stage.

Incoming speech passes through the amplifier 2 and is rectified by RT2 to bias V1 negatively and reduce its anode current to zero, thus restoring the gain in the speech path to 17 decibels. This gain is then controlled by RT3, V2 and RT1 in the normal manner for such arrangement.

The static loss due to V1 is completely removed from the circuit by a change in the input level of 4 decibels, commencing with an input of 29 decibels below 1 milliwatt. Provision is made for a reduction in this sensitivity if desired when a high noise level exists. The neon tube connected across the output limits the input to the rectifier RT2 at the higher levels, resulting in a constant hangover time at this point for levels above a certain value.

An input-output characteristic of the amplifier as a whole is shown in Fig. 4. The controlled range covers inputs of +5 to −15 decibels referred to 1 milliwatt, the output being 1 milliwatt within the accuracy of the device as shown by Fig. 4.

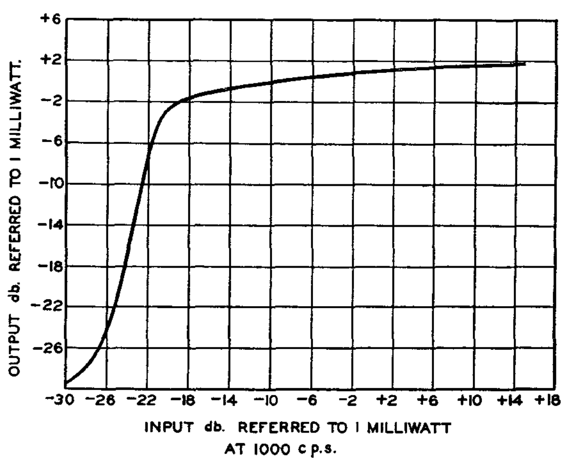


FIG. 4.—VOLUME CONTROL CHARACTERISTIC.

The harmonic content in the experimental model does not exceed 2 per cent. for the maximum input level.

Amplifier 1 is of the two stage feed-back type, being employed for reasons of stability and frequency response correction. The requirements are that the response shall be uniform within the frequency band of 100 to 6,000 c.p.s. to cater for new types of privacy equipment. Towards the upper limit of this band the shunt loss due to the capacitance of the rectifiers RT1 increases, and in order to counteract this degradation the feed-back on the amplifier 1 has been

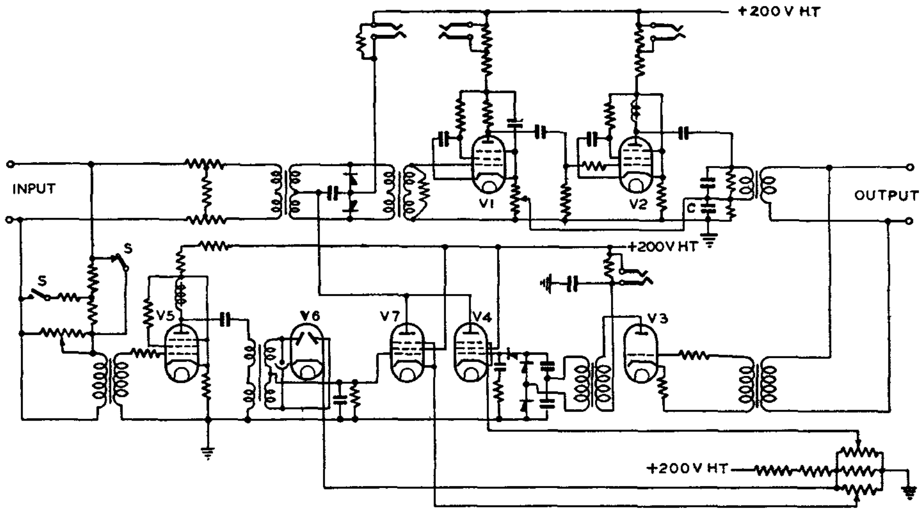


FIG 5.—CIRCUIT OF VALVE AND RECTIFIER CONTROLLED C.V.A.

reduced at these higher frequencies by the addition of a condenser C (see Fig. 5).

The frequency characteristic for the experimental model is uniform over the range 100 to 6,000 c.p.s. within an accuracy of ± 1 decibel relative to the gain obtaining at 1,000 c.p.s.

It is expected that with the use of better transformers in the models now under construction the value of the attenuation network and the gain in amplifier 1 can be slightly rearranged to reduce the A.C. voltage across the rectifiers RT1 and so further improve the harmonic content.

The hangover time is of the order of 3 seconds; that is the gain is restored to its normal value in this period of time following the disconnection of the input.

The complete circuit for use at Baldock, excluding details of the power supply, which will be obtained from the A.C. mains, is shown in Fig. 5. A double-diode valve V6 is used in place of the rectifier RT2 shown in Fig. 3, the anodes being biased negatively to a value of 20 volts in order to obtain the necessary steepness of the characteristic of speech input volts against the rectified volts applied to the grid of the valve V7. The values of the anode currents are derived by measurement of the voltages across resistances placed directly in the anode circuits. The meter has a resistance of 1,000 ohms, 1 volt giving a full scale deflection, and is terminated in a plug and cord for insertion in the various jacks. This method has the advantages that key contacts in the circuit are avoided, measurement when operating in the circuit does not give rise to interference, which otherwise might happen due to imperfect key contacts, and the function of a locking key is obtained without complications, ensuring that no two points in the circuit can be connected together.

The switch contacts S provide for the insertion of 5 decibels of attenuation if desired on high noise levels.

The complete unit is mounted on a $10\frac{1}{2}$-in. panel for single-sided mounting on a standard rack, the power supplies for four units occupying another $15\frac{3}{4}$ in. of rack space.

The presence of the device, as far as commercial quality speech is concerned, is noticeable on the radio circuit only by its effect in eliminating the fluctuations of output volume from the receiver. The existing hangover has so far satisfied all conditions, but it may be desirable, as a result of further lengthy tests, to make some modification in this respect.

No difficulty has arisen during the tests so far carried out from false operation by noise. It would appear that with an increase of the noise level to such a value as to cause false operation, the degree of fading becomes less severe and accordingly it is considered that a reduction in the sensitivity to meet this condition would not have any adverse effects.

This particular device is now in use on the circuit and has resulted in a great improvement, volumes varying over a range as much at times as 15 to 20 decibels being limited to variations within ± 2 decibels of the volume required.

A Differentiated Impulse System of Dialling Over Long Junctions

W. H. B. COOPER

The author describes a method which is being developed to permit D.C. dialling over long junctions. The system, which is based on telegraph practice, is designed to fill the gap between the circuits over which D.C. dialling by existing methods is possible and those on which the alternative 2 V.F. equipment can be economically employed.

Introduction.

THE fundamental principles of a system for establishing tandem connections automatically using a subscriber's or operator's dial are very similar to those of a system for the transmission of any other form of information. With an ordinary audio-frequency telephone circuit, the amount of information which it is required to transmit in a given time, for directing the connections automatically, is small compared with that which the circuit can carry ; and so it would seem that the problem is simply one of making the " message fit the line," i.e. choosing the right part of the available frequency scale at which to transmit the dialling signals. The larger the frequency band width which is available for dialling purposes, the better. The theoretical ideal is a complete dialling system using voice frequencies and, as such is out of the question except for long and expensive circuits, simpler and cheaper methods must be used where possible. Apart, then, from the system about to be described, the B.P.O. has two standard methods of transmitting dialling signals; by direct current for subscribers' lines and shorter junctions, and by voice-frequency currents for long-distance lines. The development of the latter system, which will be put into operation between zone centres early in 1939, has necessitated the solution of many other problems in spite of the available band width. An attempt to cater for the entire dialling requirements of the B.P.O. by these two systems would set an uneconomical lower limit to the length of line over which the 2 V.F. system would have to be used. It is for this reason that the method described in this article of dialling over lines with direct current was developed. In more concrete terms this system is suitable for operating over lines varying from the shortest to those equivalent to a hundred miles of 20 lb. star quad phantom circuit, a direct current loop path being essential. Neglecting inductance this represents a maximum value of CRl^2 approximately equal to 0·075 where C and R are loop mile constants. This is probably the most useful method of comparing lines for such a system.

Factors Contributing to and Methods of Eliminating Signal Distortion.

Factors contributing to signal distortion can be divided roughly into three classes :

(1) The presence of reactive or energy-storing elements either distributed or lumped in the transmitting medium.

(2) The electrical and mechanical properties of the transmitting and receiving apparatus.

(3) (*a*) Interference with the signals in the transmitting medium, i.e. from other circuits in the same cable.

(*b*) Interference with signals from other apparatus incidentally linked up with either or both transmitting and receiving circuits, i.e. surges from relay operation in other parts of the connection which are passed via the speech transmission bridges into both ends of the circuit in question.

The existing direct current dialling systems suffer from all of these apart from 3 (*a*), and particularly from 3 (*b*).

To overcome these limitations necessarily means more elaborate apparatus, and by dissociating all incidental equipment from the line during the dialling period, troubles due to 2 and 3 (*b*) can be very considerably reduced. This may be effected by a complete re-design of the circuits involved and by arranging to store the impulses from the subscriber's or operator's dial in train order so that some form of "pre-dialling signal" may be obtained. This signal would be utilised to dissociate the line from all incidental terminal apparatus, and to connect an impulse-generating circuit at one end and suitable receiving apparatus at the other during the dialling period. On the completion of dialling the circuit would revert to normal speaking conditions.

A very suitable form of mechanical impulse regenerator which is available for the above purpose has been fully described elsewhere.[1] The only special feature of immediate interest is that its transmitting mechanism resembles that of an ordinary automatic dial, so that impulsing is accomplished with just one pair of springs.

The major portion of the problem now lies in correcting for the reactive nature of the line ; a matter which, commencing as early as 1855 with Lord Kelvin, has engaged the attention of many mathematicians and engineers. A variety of direct current telegraph methods have resulted from these researches and, for the present purpose, it is necessary merely to select the most suitable, bearing in mind that the requirements are briefly as follows :

(*a*) Signal distortion over the link from the regenerator transmitting contacts to the contacts which impulse the selector " A " relay to be kept as low as possible, an alteration of signal length of ± 8 milliseconds being about the maximum tolerable.

The limit of distortion is actually imposed when a signal of 11 impulses per second, 28 per cent. make period, from the transmitting contacts is shortened due to distortion by 8 milliseconds.

(*b*) Apparatus to work satisfactorily with the very minimum of individual adjustments for line length and different types of lines.

(*c*) Receiving relay to be inexpensive and simple to adjust with no special adjusting equipment

[1]*P.O.E.E.J.*, Vol. 30, p. 261.

other than that used for ordinary telephone relay maintenance.
(*d*) Utilisation of existing exchange power plant.
(*e*) System to be as completely balanced to earth as possible.

Methods of Transmitting Direct Current Signals.

Fig. **1** shows three methods of single-current working where the line is represented by a simple "T" network.

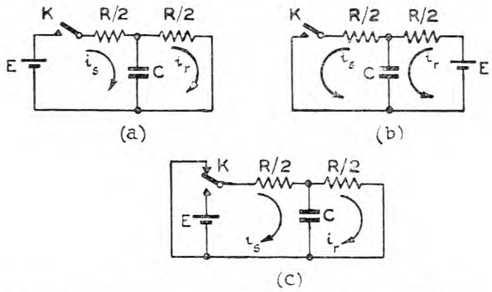
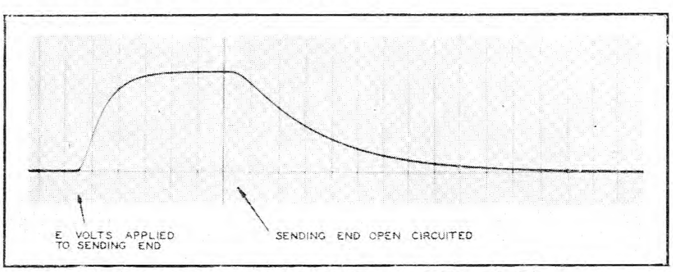


FIG. 1.—THREE METHODS OF SINGLE CURRENT WORKING.

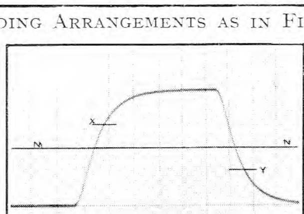
Fig. **1** (a) and **1** (b) will be recognised as battery and loop dialling arrangements respectively; both yield very similar received current-time curves.

Fig. **1** (c) is quite different from **1** (a) and **1** (b), and has undoubtedly been avoided hitherto for dialling purposes because its application introduces circuit difficulties. In the first two figures signals are generated by changing the circuit connections whereas in Fig. **1** (c) signals are really generated by changing the sending battery from 0 volts to E volts. Oscillograms forming Figs. **2** (a) and **2** (b) which were taken at the end of 100 miles of artificial cable of $CRl^2 = 0{\cdot}075$ show clearly the difference between arrangements 1 (a) and 1 (c). The calculated arrival curves for the two conditions are in close agreement with the oscillograms.

Consideration of Fig. **2** (b) shows that, if the key is again depressed, say 40 milliseconds after it was last released, the arrival curve will be almost identical with that resulting from the first depression of the key. If now the same operation is carried out on the circuit of Fig. **1** (a) (oscillogram **2** (a)), the arrival curve on the second depression of the key will be unlike that of the first because a current is still flowing due to the release of the key; the actual current will be the algebraic sum of the two considered separately. Consequently the arrangement of Fig. **1** (c) permits of a higher speed of signalling than that of Figs. **1** (a) or **1** (b), for to receive a series of signals which are faithful reproductions of those transmitted one essential condition is that the received current must sensibly reach its steady state value during each interval. Assuming that the circuit of Fig. **1** (c) is used and a suitable relay placed at the receiving end, it is clear that the relay will produce distortionless signals only if it is adjusted so that its operate and release currents fall equally about the midway line MN in oscillogram **2** (b), e.g. operate at X milliamps and release at Y milliamps. The above reasoning neglects differences between the mechanical operate and release times of the relay. This necessitates a separate relay adjustment for each line length, and hence is an undesirable arrangement. Fig. **3** shows calculated arrival curves for three different line lengths, and demonstrates clearly the reasons for separate relay adjustments. The inductance of the receiving relay will, in general, still further increase the build-up line of the arrival curve.



(a) SENDING ARRANGEMENTS AS IN FIG. **1** (a).



(b) SENDING ARRANGEMENTS AS IN FIG. **1** (c).

FIG. **2**.—CURRENT ARRIVAL CURVES AT END OF 100 MILES OF ARTIFICIAL CABLE.

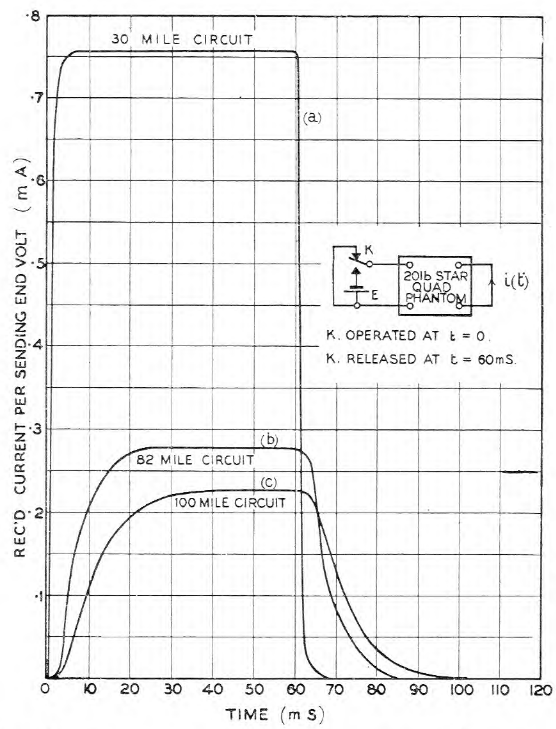


FIG. **3**.—CALCULATED ARRIVAL CURVES FOR DIFFERENT LINE LENGTHS.

Means of Overcoming Signal Distortion due to Reactive Elements of the Line.

The relay adjustment problem can to some extent be overcome by virtually shifting the line MN of

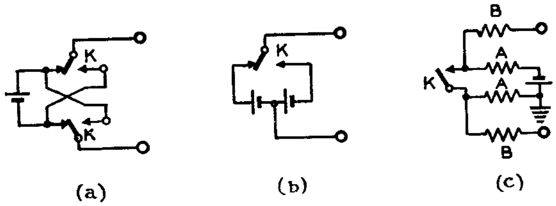


FIG. 4.—OTHER METHODS OF TRANSMITTING D.C. SIGNALS.

Fig. 2 (b) down to the zero current axis, either by using one battery and reversing it at each operation of the key as in Fig. 4 (a) or by using two batteries as in Fig. 4 (b). These methods are known as "Double Commutation" and "Double Current" respectively. The former method requires a set of well-synchronised transmitting contacts whereas, for the "Double Current" method, a well-balanced double battery supply is required. Both systems necessitate the use of a repetition stage following the simple break contacts of the mechanical impulse regenerator. If single current methods can be used, then, by a suitable choice of resistances A and B the circuit of Fig. 4 (c) will generate signals very similar to those of Fig. 1 (c), thus avoiding the additional repetition. Furthermore, such an arrangement provides a generator which is well balanced to earth. Accordingly, consideration was given to methods of improving the slope of the arrival curve, since even single current signals if corrected to approximate a square-topped formation would enable the relay to operate with negligible distortion over a comparatively wide range of adjustment.

Improvement of Signal Shape.

When one is concerned about a change in signal length of the order of one millisecond, a build up time of 25 milliseconds is poor, and steps were taken to improve this.

If the transmitted voltage signal is represented by a Fourier Series of sufficiently low fundamental frequency the arrival current curve may be obtained by a summation of the steady state received currents.

The reason for the long build up time is to be found in the reactive properties of the line causing a rapid increase in attenuation with frequency, so that the amplitudes of the higher order harmonics are considerably reduced compared with the fundamental.

Line equalisation over the essential frequency range was obtained on a voltage basis by terminating the line in a suitable transformer so that more or less complete differentiation of the arrival current wave was performed. The time constant of the primary winding is also of considerable importance[2].

As a result the received voltage wave consists of steep-fronted "Double Voltage" signals as in Fig. 5—excellent qualities but possessing one inherent drawback; due to the phase shift

[2] Dr. W. H. Malcomb. "The Theory of the Submarine Telegraph and Telephone Cable."

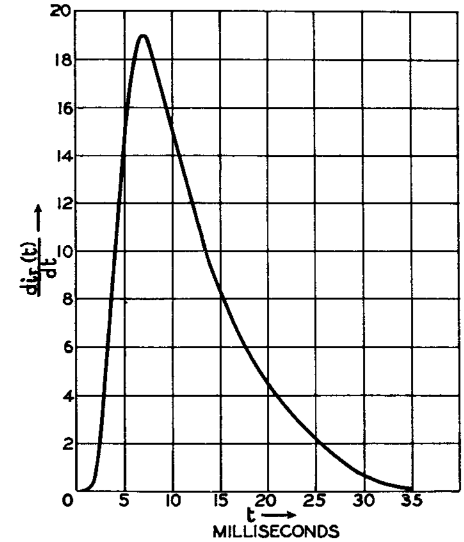


FIG 5.—RECEIVED VOLTAGE CURVE (100 MILE CIRCUIT).

introduced by the receiving inductance there is little body in the signal. The steep wave fronts, however, accurately mark the beginnings and ends of the signals.

The method by which such impulses are utilised for operating the receiving relay is shown in Fig. 6. The relay P/1 is a robust type of polarised relay with windings arranged to deflect its armature in the directions shown. The steady state flux due to coil A is balanced out by that of coil B. Coils C and D hold P1 on to the "make" and "break" contacts respectively with a force of about 18 grams measured at the contacts. On the depression of K the resulting negative grid voltage reduces the ampere-turns in the A winding so that the B coil takes control and drives P1 to the left when H operates (in 2 milliseconds), changing over the holding circuit from coil C to coil D so that P1 remains on the left contact. When K is released the positive grid voltage causes the A coil to take control and drive P1 back to the right-hand contact where it is held by coil C. The resistance R serves to adjust the ampere turns in the A coil to balance out those of coil B and, furthermore, renders

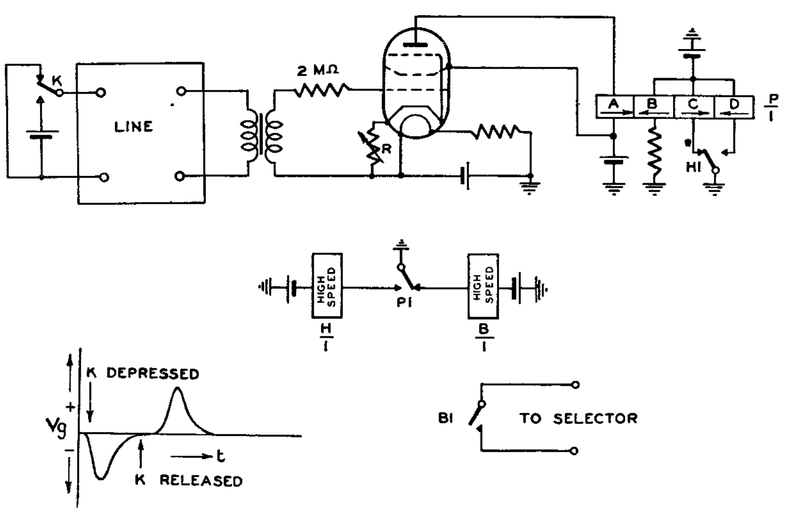


FIG. 6.—METHOD OF UTILISING DOUBLE VOLTAGE SIGNALS.

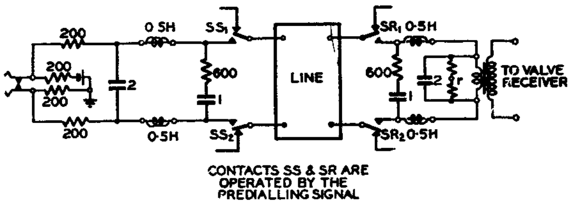


FIG. 7.—COMPLETE TRANSMISSION CIRCUIT.

the value of the plate current relatively immune from battery voltage variations. In addition R reduces the mutual conductance of the valve circuit to about 20 per cent. of its normal value so that the arrangement will be less subject to changes resulting from variations in valve characteristics. The complete transmission circuit includes other refinements as follows (See Fig. 7) :

(*a*) Sending end filter to suppress unwanted frequencies from the square-topped generated wave, since on amplified circuits such frequencies would pass through the speech termination and probably interfere with the amplifying equipment.

(*b*) Receiving end filter to attenuate frequencies above about 100 cycles per second so that the receiver may be as immune as possible from extraneous line noise.

(*c*) The filter inductances enable both the transmitting and receiving circuits to present approximately 600 ohms to the transmission line at speech frequencies.

(*d*) The resistance r has two settings and serves to adjust the time constant of the receiving inductance.

With this arrangement working over 100-mile phantom circuit of 20-lb. star quad cable, the build-up time of the voltage wave impressed upon the grid of the valve is not greater than 10 milliseconds, so that the maximum signal distortion resulting from mechanical and electrical bias of the relay will be ± 10mS. It is not anticipated that this figure will be approached in practice.

Typical Test Results.

Signal distortion was measured when sending at a speed of 11 i.p.s., 28 per cent. make period, from the regenerator transmitting contacts to the B1 contact of Fig. 6. The usual exchange battery voltage variations, relay design and adjustment tolerances were taken into account, two typical results being as follows :

Line	Alteration in signal length (make period)
73 miles, 20-lb. star quad 4 w. cct. signalling over phantom ..	± 4 milliseconds
100 miles 20-lb. star quad 4 w. cct. artificial, with 2 terminal amplifiers, signalling over phantom	± 5 milliseconds

Application to P.O. Requirements.

The possible applications of this system of impulsing are being closely studied and circuits embodying the principle are being rapidly developed by the Post Office for use between auto-manual boards and automatic switching plant, and between automatic exchanges. Details of these developments will form the subject of an article in this JOURNAL in the near future.

The Study of Small Mechanical Movements with The Duddell Oscillograph

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(Ericsson Telephones, Ltd.)

An oscillographic method of recording mechanical motion simultaneously with associated electrical phenomena is described. Some details concerning the practical design of the apparatus are given, together with examples of the application to automatic switching problems.

Introduction.

THERE is little doubt that the Duddell Oscillograph is one of the most important items of testing equipment used in a development laboratory for the study of problems in automatic switching. It is, in fact, indispensable for any serious work. The observation of complex functions in signalling and switching circuits, the timing of relay and switch operations, and the study of impulsing problems are but everyday applications. In addition the oscillograph has been adapted to record magnetic flux[1] and also mechanical movements[2].

This article describes an improved method of recording mechanical movements of comparatively small amplitude, a method which should be readily adaptable to most Duddell oscillograph equipments.

A system has been developed by H. N. Wager and H. E. Hill, of the American Bell Telephone Laboratories[3] and applied to an oscillograph using string galvanometers. The arrangement described below is based on the same principles, but some improvements have been effected. Further, the requirements of the Duddell oscillograph are somewhat different, and this instrument offers marked advantages, as compared with the aforementioned type, for this class of work. The projection apparatus does not impose any restrictions on the use of the oscillograph loops for the simultaneous recording of current changes in associated circuits.

Although certain cases may arise which do not admit of solution, the method here described can be applied to most problems involving the study of the motion characteristics of automatic switching apparatus.

The cost of the equipment is comparatively small, and is fully justified by the increased facilities available.

Description of the System.

It should be stated at the outset that this description applies to equipment which has been built up in the laboratory and model shop of the Ericsson factory at Beeston, Nottingham, and that it is designed to work with an existing oscillograph without substantial modifications. It will be appreciated that many variations of the arrangement could be effected and that refinements could be added which would bring the apparatus into the category of precision scientific instruments. For most purposes, however, such elaboration is not necessary and the equipment described has been limited to a minimum.

The apparatus employed is similar to that used for the contour projection of screw threads, small piece parts, etc., and the principle of the application is that an image of a small section of the moving part is projected on to the face of the oscillograph cylindrical lens. The image appears as a patch of shade on an illuminated ground, and the movement of the part is caused to modulate the band of light falling on the cylindrical lens.

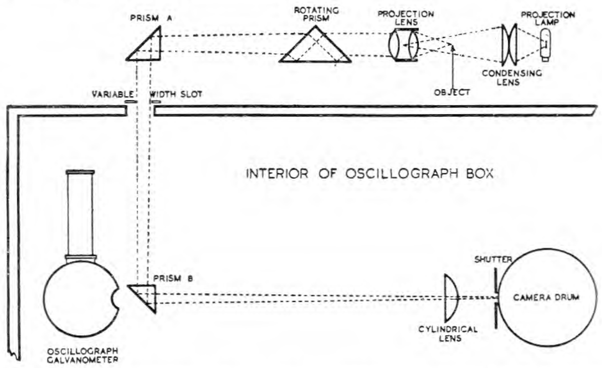

FIG. 1.—DIAGRAMMATIC ARRANGEMENT OF THE PROJECTION APPARATUS.

Fig. **1** shows a diagrammatic representation of the projection apparatus, which differs but little, optically, from the arrangement of the projection lantern as used in lecture theatres. The right-angle prisms A and B are used merely to turn the beam through 90°. Ordinary glass mirrors are not suitable for this purpose owing to the production of multiple images. The function of the rotating prism is described later.

The apparatus is illustrated in Fig. **2**. It will be observed that the components are arranged on a

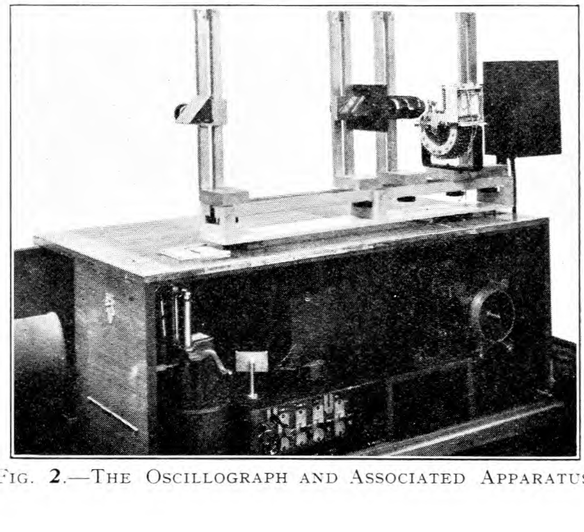

FIG. 2.—THE OSCILLOGRAPH AND ASSOCIATED APPARATUS.

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[1] *P.O.E.E.J.*, Vol. 24, p. 206.

[2] Engineering Supplement, *Siemens Magazine*, August, 1931, "Recent Relay Progress," E. A. Bryan; and "Experimental Investigation of Vibrations in Turbine Wheels and Blades," Pochobradsky, Jolley and Thompson, *Engineering*, Vol. CXXXII, No. 3,433, 1931.

[3] "Vibration Studies with the Rapid Oscillograph," H. E. Hill. *Bell Laboratories Record*, Vol. XVI, No. 1, September, 1937.

simple form of optical bench. For the purpose of accommodating objects which differ widely as regards shape and size, the mountings have been designed to allow all the components to be moved vertically in guides, and, with the exception of the lamp and condensing lens, to be adjusted horizontally along the axis of the system. The light source is normally derived from a 200 watt projection lamp, and the position of this, with respect to the condensing lens, is capable of limited adjustment in order to cater for different lamps and for the purpose of modifying the character of the light beam if necessary.

Three sizes of projection lens are used, viz. $f=\frac{1}{2}$ in., 1 in. and 2 in. These are interchangeable, and give a range of magnification from 20 to 120, approximately. The aperture of the lens is controlled in the usual manner by an iris diaphragm, and a focusing adjustment is also provided on the lens mounting.

The original oscillograph time base, a 50 c.p.s. tuning fork shutter, has been preserved, but this has been re-arranged somewhat in order to accommodate the additional equipment.

The appearance of a screen placed over the shutter aperture, with the cylindrical lens removed, is shown in Fig. **3**. The brightly illuminated strips A and B

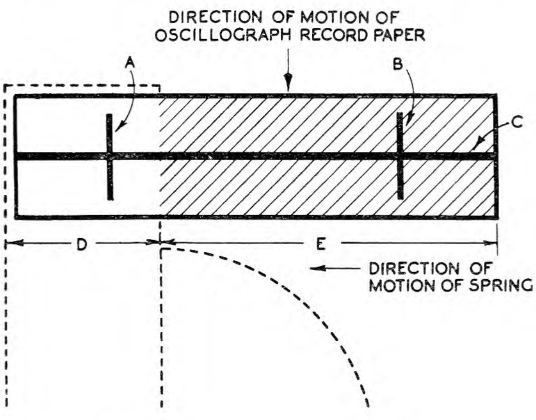


FIG. **3**.—APPEARANCE OF SCREEN.

are from the beams of the oscillograph galvanometers, and the strip C from the tuning fork shutter. The areas of light and shade, D and E, are produced by the projection apparatus, D being the shadow of a section of a relay spring, the outline of which is shown dotted for explanatory purposes. It is essential that the image should be in sharp focus on this screen if good definition is to be obtained. It is also necessary to ensure that the edge of the image is straight, vertical, and that it moves in a direction at right-angles to the direction of motion of the recording paper. A further requirement is that the image should extend completely across the aperture of the cylindrical lens in a vertical direction. A typical record is shown in Fig. **4**, which illustrates the motion of the lever spring on a Strowger relay when operated at 20 i.p.s.

It is, of course, not always possible to mount the object in such a manner that the motion of the part under consideration is horizontal, and in the correct sense. This difficulty is overcome by the use of the

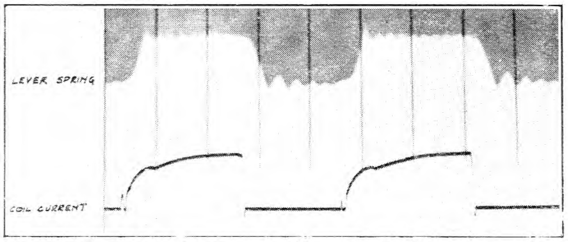


FIG. **4**.—STROWGER RELAY AT 20 I.P.S.

rotating prism previously mentioned. This prism is capable of rotating in a plane at right angles to the optical axis. When mounted with the hypothenuse face horizontal, either in the upper or lower positions, this prism will simply invert the beam. Rotation of the prism through 180° will, however, turn the image through 360°. It is thus possible to obtain the correct direction for the movement of the image, irrespective of the direction of the original motion, provided that this is in a plane at right-angles to the optical axis.

A difficulty may arise where the motion of the part under observation is along an arc of a circle, if the object moves through an appreciable angle, as the edge of the image may be vertical in one position, but at the extremity of the movement will be inclined at an angle. This will, of course, result in the definition on the record becoming progressively worse as the image moves away from the vertical position. The effect is illustrated in Fig. **5**, which also shows how the definition may be improved by reducing the vertical length of the image. This is accomplished by means of a slot of variable width, placed, for convenience, just below prism A.

Details of Design.

The design of the optical system is mainly influenced by the following factors:

(*a*) the range of magnification required;
(*b*) the overall length available for the optical system;
(*c*) the class of apparatus to be studied; and
(*d*) the type of light source to be used.

If "u" is the distance of the object from the projection lens, and "v" the distance from the lens to the image (i.e. the oscillograph shutter), then the magnification is given by v/u. The maximum value of "v" is obviously limited by the length of the

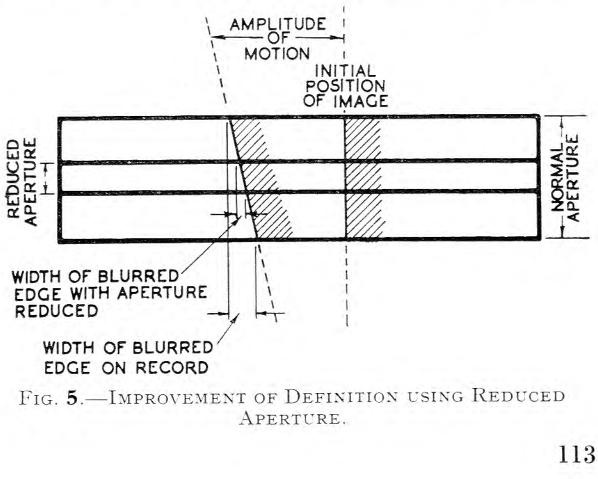


FIG. **5**.—IMPROVEMENT OF DEFINITION USING REDUCED APERTURE.

optical system, and the magnification can be increased beyond a certain point only by a reduction in the value of "u," i.e. by reducing the focal length of the projection lens in accordance with the fundamental relationship,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

where f is the focal length of the projection lens. In this connection it should be remembered that "v" has a negative sign for this particular arrangement. The fraction of the total length of the optical system available for the distance (v + u) is governed by the maximum distance which must be allowed between the condensing and projection lenses. This is, of course, determined by the size of the object. Having assigned a minimum value for (v + u) it is then a simple matter to calculate the focal lengths required for the projection lenses necessary to cover the given range of magnification.

The ideal light source, from the point of view of efficiency, is the arc lamp, on account of the great brilliance and the concentrated form of the arc. Good results can be obtained, however, with a gasfilled projection lamp, provided that the type of lamp is chosen with due regard to the size of the projection lens aperture. Theoretically, the maximum illumination is obtained with the image of the lamp filament produced in the projection lens, as this means that all the light passed by the condensing lens is used for illuminating the background of the image. The focal length of the condensing lens is therefore governed by the necessity for ensuring that the image of the lamp filament in the projection lens is not larger than the aperture. Consideration will show that an increase in the wattage of the projection lamp will not necessarily increase the illumination, if this change involves using a lamp with a larger filament. The improvement can be effected only by using a lamp having a filament of higher intrinsic brilliance.

The results obtained in practice have shown that the definition of the image is poor when the light beam is arranged as described above, and that it is necessary to close the projection lens aperture considerably in order to obtain sharp focus. This is believed to be due to the fact that the lenses in use are not achromatic combinations. The best results have been obtained with the lamp filament placed at the focal distance from the condensing lens. This procedure results in some loss of light, but, on the other hand, it permits the use of a much larger projection lens aperture, and this compensates to some extent for the former disadvantage.

With an oscillograph using string galvanometers, where the record is normally dark with a white trace, it is necessary to shield a section of the record paper from the oscillograph light source in order to render the projection record distinguishable. With the Duddell oscillograph, however, the intensity of the illumination may be controlled so that it is possible to follow the trace of the oscillograph loops and time base over the dark area on the record. The whole width of the paper is therefore available for the projection record, with the normal oscillogram

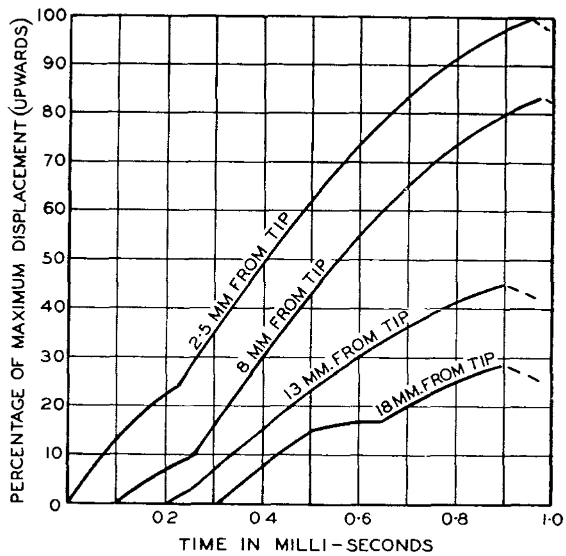


FIG. 6.—DISPLACEMENT OF SPRING AS A FUNCTION OF TIME.

superimposed upon this without risk of confusion. This allows the use of large amplitudes for both oscillogram and projection record, if required.

Examples of the Application of the Method.

Uniselectors. In the course of some investigations into the characteristics of an experimental uniselector, records were taken in order to determine the behaviour of the interrupter spring. By cementing a small "marker" made of duralumin foil on to the edge of the spring the motion of that particular point was recorded. This procedure is justified where the mass of the marker is negligible in comparison with that of the spring and if the construction of the marker is such that it will follow the motion of the spring faithfully. By taking several records with the marker placed at known intervals along the length of the spring, it was possible to plot the displacements of the various points as a function of time (Fig. **6**).

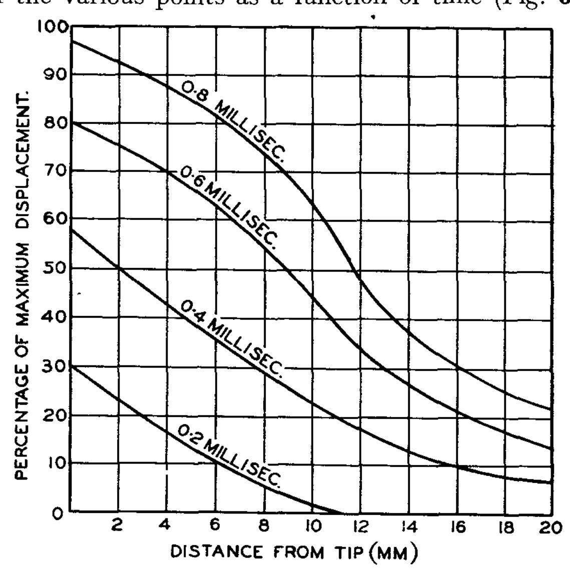


FIG. 7.—DISPLACEMENT OF SPRING AS A FUNCTION OF DISTANCE.

The reference point was taken as the opening of the interrupter contact, an oscillograph loop being included in the magnet circuit for this purpose. The first set of curves, shown in Fig. **6**, were then translated into the form illustrated in Fig. **7**, from which the shape of the spring could be drawn, to an enlarged scale, at any particular instant in its operation. On records previously taken it was noted that the armature struck the core face at the instant that the interrupter contact opened, although the latter was gauged to break with the armature 9 mils. from the core face. The records of the spring motion explained this, showing that the time taken for the disturbance to travel down the spring to the contact was comparable with that taken by the armature to complete the last 9 mils. of the stroke.

The positions in the stroke at which the interrupter contact opens and closes are, to a marked extent, responsible for the speed and running characteristics of the switch. It is clear from the foregoing that the gauging of the interrupter contact under static conditions is not the only factor to be considered. The mass, stiffness, and nominal pressure of the moving spring all have an important bearing. For example, a heavy spring with only a small nominal pressure will fly off the operating buffer when the armature rebounds from the core face. The reclosing of the magnet circuit thus occurs late in the return stroke and causes slow running.

Fig. **8** illustrates the movement of the armature, pawl and detent of a uniselector. It should be explained that for the pawl and detent the motion registered is the component along a projected radius of the ratchet wheel. Considering the armature motion, it will be noticed that the return stroke is arrested twice. The first check is caused by the pawl striking the ratchet tooth and taking the load of the wiper system, whereas the second is due to the loss of the restoring force provided by the interrupter spring. A further point of interest is that the restarting of the magnet current has little effect on the velocity of the return stroke. The armature rebounds from the back stop and remains practically stationary for a short period until the operating torque has increased sufficiently to produce a forward acceleration.

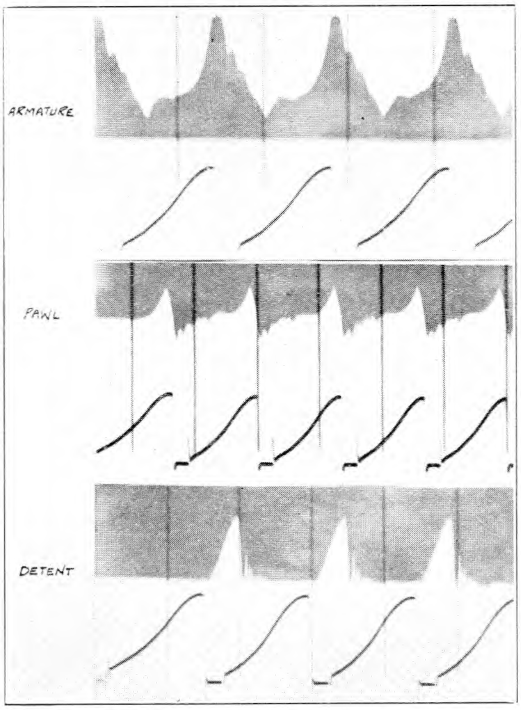


Fig. **8**.—Uniselector Characteristics.

The irregularities in the movement of the pawl, after dropping over the tip of the tooth, are caused by the changing of the point of contact between pawl and ratchet tooth. This is due to an incorrect pawl striking angle, which, as a result of the rubbing action produced, tends to increase wear on the ratchet teeth.

2,000 *Type Selector*.—Difficulties have been experienced on the 2,000 type selector owing to the presence of wiper vibration at the end of the vertical action. It has been found that there is a risk of wipers fouling the bank, on cutting in, unless a suitable pause is arranged after the vertical action, in order to allow time for the wiper vibration to die away appreciably. Fig. **9** shows a record of the vibration at the wiper tip on a 2,000 type line finder. The maximum amplitude of the oscillation is approximately 60 mils., this being determined from a knowledge of the magnification used in taking the record.

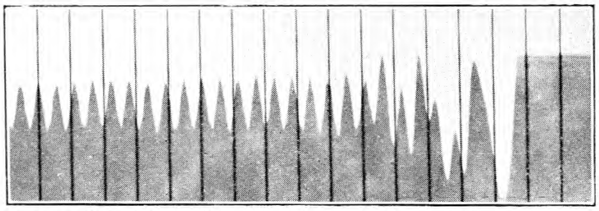


Fig. **9**.—Wiper Vibration on 2,000 type Selector.

Contact Bounce, etc.—A particular case, where contact bounce produced a complete breakdown of the connection, occurred on early final selector circuits using a 50 + 50 ohm D relay with ballast resistor. The make-before-break contact in the private circuit was subject to severe bounce on the operation of the relay. It was thus possible to release the group selector switching relays when the called party flashed.

The rapid armature movement resulting from heavy energisation was sufficient to cause the make spring to fly off the lever spring when the armature struck the core face. This, and the ensuing oscillations of the springs, which had different mechanical characteristics, produced a series of breaks in the electrical circuit.

A record of the case in question is shown in Fig. **10**.

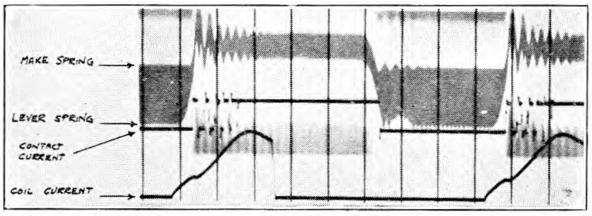


Fig. **10**.—Contact Bounce on Ballast D Relay.

It is interesting to note that the first few cycles of the spring oscillations reveal a marked dissimilarity as between the make and lever springs, but that the two vibrations eventually fall into phase.

Tone Generating Relays and Ringing Vibrators.—It is perhaps not entirely untrue to say that, although the original design of a tone relay or ringing vibrator may be based on sound theory, its final form is usually evolved as a result of many trials and many errors. This type of apparatus, in particular, appears to behave in a somewhat irrational manner at times, and this may be attributed to the complex mechanical vibrations which occur. In this connection, therefore, a simple method of recording the various movements is particularly valuable.

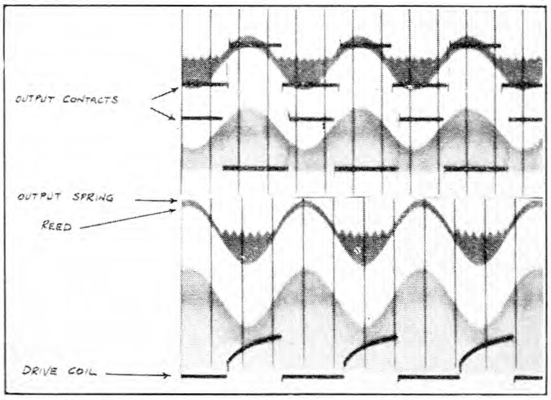


FIG. **11**.—25 C.P.S. RINGING VIBRATORS.

Fig. **11** illustrates the movement of the reed and one output contact of a 25 c.p.s. ringing vibrator. The oscillograph loop records show the current in the drive coil and the characteristics of the output contacts when connected in a non-inductive circuit.

Conclusion.

It is appreciated that the description and details given in the foregoing are by no means exhaustive. They should, however, serve as an introduction to what is a most useful addition to oscillograph equipment. Although requiring a somewhat modified technique, the operation of the projection apparatus is nevertheless simple, and the method is, in the author's opinion, superior to other known systems for this class of work.

In conclusion, it is desired to express thanks to Messrs. Ericsson Telephones for the facilities afforded, and for permission to publish details of work carried out in the Circuit Laboratory at Beeston. The author also wishes to acknowledge the helpful co-operation of his colleagues in that department.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM

TELEPHONES AND WIRE MILEAGES. THE PROPERTY OF, AND MAINTAINED BY, THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31st MARCH, 1938.

Number of Telephones	OVERHEAD WIRE MILEAGES					Engineering District	UNDERGROUND WIRE MILEAGES					
	Telegraph	Trunk	Junction	Exchange*	Spare		Telegraph	Trunk	Junction‡	Exchange†	Telephone Spares	
											Junction‡	Trunk
1,125,396	324	1,096	2,002	55,436	5,448	London	32,718	297,484	915,980	3,070,006	364,292	79,300
137,975	1,677	1,494	11,172	53,919	12,896	S. Eastern	6,037	125,918	21,580	389,149	23,804	67,418
163,079	2,020	10,920	25,745	103,628	10,854	S. Western	19,531	135,934	12,586	331,797	15,757	66,844
116,254	2,995	11,838	25,421	86,338	16,212	Eastern	7,472	143,190	16,598	231,502	16,280	75,314
134,645	3,383	12,096	17,870	68,311	26,058	N. Midland	9,218	207,232	18,146	272,784	15,972	100,206
151,098	1,852	6,875	20,200	77,025	18,073	S. Midland	10,335	183,550	29,816	386,822	30,788	65,546
79,351	1,139	6,246	16,698	56,064	12,148	S. Wales	5,813	77,882	15,298	152,162	9,820	43,890
198,818	1,548	9,561	23,030	85,888	20,899	N. Wales	12,137	199,250	98,147	424,838	41,456	124,044
238,059	971	1,581	3,615	35,758	8,777	S. Lancs.	9,853	118,594	105,289	667,193	58,148	58,316
99,146	739	2,170	5,088	36,111	16,649	N. Western	5,996	114,904	19,878	268,042	15,384	77,378
39,199	2,870	7,868	6,273	16,830	1,092	N. Ireland	1,386	11,626	7,703	86,949	3,419	25,046
282,807	4,718	15,397	22,998	93,259	29,397	N.E. Region	16,921	237,842	67,453	706,481	38,210	131,174
260,252	6,336	24,839	31,534	97,107	25,026	Scot. Region	9,317	213,690	26,620	507,435	24,191	119,606
3,026,079	30,572	111,981	211,646	865,674	203,529	Totals	146,734	2,067,096	1,355,094	7,495,160	657,521	1,034,082
2,983,093	30,819	119,150	1,066,789		204,337	Totals as at 31 Dec., 1937	145,076	1,990,970		9,356,421		983,976

* Includes low gauge spare wires, i.e. 40 lb. ‡ Wholly Junction Cables. † Includes all spare wires in local underground cables.

Bristol Station Sorting Office Conveyors

J. G. BEASTALL, B.Sc. (Eng.)

A description is given of the conveyors installed in the Bristol Station Sorting Office and between the Sorting Office and Temple Meads G.W. Railway Station.

Introduction.

THE system of conveyors that has been installed in the newly-erected Bristol station sorting office to carry the mail between the railway platforms of the Great Western Railway Temple Meads station and the sorting office and to expedite the handling and sorting of mail within the office, is the largest system of mechanisation put into a provincial office. It reduces not only the handling of mail at all stages from the time it is received by van or train, but the arrangement ensures that mail is sorted and despatched with the minimum loss of time, making earlier train connections and earlier deliveries possible.

The new station sorting office is erected on a site adjoining Temple Meads station. Various methods of transporting the mail between the trains and the sorting positions in the office were examined. Originally, the possibility of having a bridge over the railway station extending to the sorting office and carrying a system of selective distributing conveyors was considered, but this was abandoned as it would have interfered with the sighting of the railway company's signals and occupied too much railway platform space. The use of electric trucks and lifts was considered, but after discussion with the Great Western Railway Co. it was decided to install conveyors in a subway which would be constructed underneath the railway station. The subway was constructed to the Department's requirements by the Great Western Railway Co., from whom it is leased by the Post Office, and the conveyor installation described in this article was accordingly designed by the Post Office Engineering Department. The subway conveyors are constructed so that by pressing buttons in a control cabin situated on the sorting office loading platform, bags of mail can be delivered on to any selected railway platform. The return conveyors have been so arranged that mail can be dropped down chutes from any railway platform and be immediately carried to the sorting office.

The ground floor of the sorting office has been constructed as a garage, the first floor forming the sorting office, the floors above being used for office accommodation. A loading platform forms an essential part of the scheme and the sorting office conveyors have been so designed that the mail can be delivered either to a position from which it can be despatched by the subway conveyors to the railway station or by van from the loading platform. These positions are referred to subsequently as the " rail " and " road " positions of the loading platform. All mail arriving at this point by road or subway conveyors is carried by conveyors and risers and delivered to the appropriate section on the first floor for dealing with that particular class of mail. The sorted mail is despatched to the loading platform either to the " road " or " rail " position, the selection being made by switches within the sorting office.

The operation of the conveyors is so interlocked that operation of the control pushes and switches is rendered foolproof, and an automatic system of signalling in the sorting office, on the railway platforms and in the control cabin on the loading platform

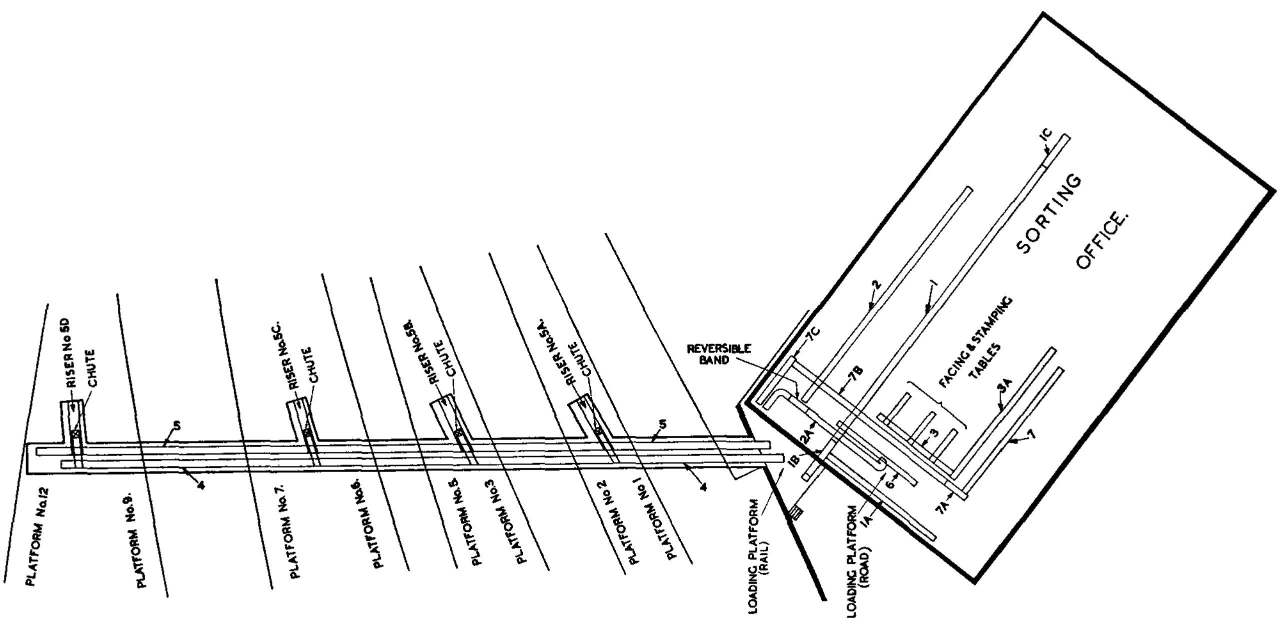


FIG. 1.—LAYOUT OF SORTING OFFICE AND RAILWAY STATION CONVEYORS.

has been designed to provide other safeguards and to assist the staff in handling the mail.

Each group of conveyors has been specially designed to deal with the particular class of mail which it is called on to handle. This may be either loose letters, bundles of letters, packets, loose parcels, letter bags or parcel bags.

In the event of a breakdown of the conveyors, lifts serving the sorting office can be used, and emergency chutes from the sorting office to the loading platform have been provided for use in the event of a failure of the power supply.

The installation was completed early in 1938 and was formally opened in the presence of a large assembly by the Postmaster-General on May 10th.

The layout of the sorting office, railway station, subway and conveyors is illustrated in Fig. **1**.

Constructional Details.

As many constructional features are common to all the conveyors, these are now described before each conveyor is described individually.

The conveyors consist of artificially stretched solid woven cotton belts running in sheet-steel troughs which are braced and supported by angle iron. The upper edges of the troughs are stiffened either by flanging the plate or by riveting angle iron to it throughout the length of the conveyor. The underside of each conveyor is fitted with a dust trap into which the dust is brushed from the band by a brush fixed inside the container.

Both the carrying and return belts are normally supported on rollers, but those of the conveyors which run through the garage underneath the floor of the sorting office are supported on steel plates to reduce the depth of the conveyor. This was necessary to give sufficient overhead clearance in the garage. When the bands are supported on rollers, those supporting the top part of the bands are spaced not more than 3 ft. apart, and those supporting the lower part of the bands are spaced not more than 9 ft. apart. Wherever mail is loaded on to the band, or where mail is discharged from one chute or conveyor to another conveyor, a pad of sorbo-rubber about 1 in. thick is fitted underneath the band to prevent the mail being damaged.

Fig. **2** shows a variation of the normal roller construction as used on the loading platform conveyor No. 1A. The top belt is not supported on rollers or steel plate in the normal way as loose parcels are loaded on to this conveyor throughout its length, and damage to parcels is prevented by adopting the construction shown. Care has been taken in the design and construction of the conveyors to ensure that mail is carried without damage and that it does not get jammed between the guides and the band. Butt joints have been made in the troughing wherever possible and the troughs have been constructed so that there are no projections and crevices inside them.

The rollers are constructed of steel cylinders, turned on the outside, and are designed so that the bearings can be greased while the conveyors are running. The main driving drums, countershafts and gear spindles run on roller bearings, the idlers

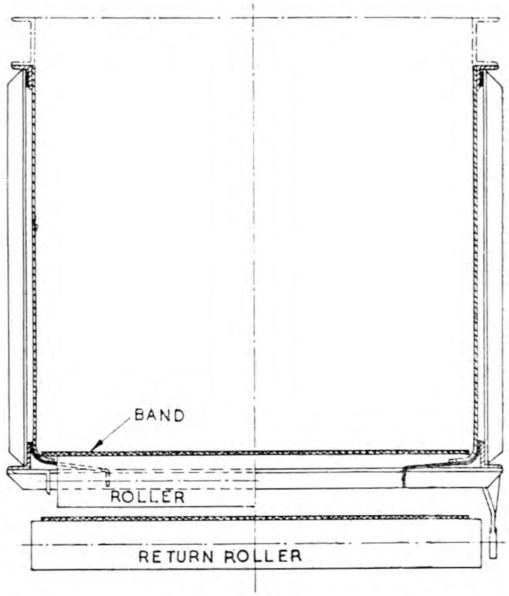


Fig. **2**.—Section of Loading Platform Conveyor Belt.

and others being fitted with ball bearings. Adjustable rollers are fitted at the ends of the bands to permit adjustment to the alignment of the bands. The width and speeds of the belts, depth of the troughs, and other relative information is given in Table I.

Each conveyor, except those with short bands, is fitted with a weighted tension gear (Fig. **3**) which maintains an even and adequate tension on the band and automatically takes up any stretch. Conveyors with short bands are fitted with screw tension gear so that the tension in the band can be adjusted by

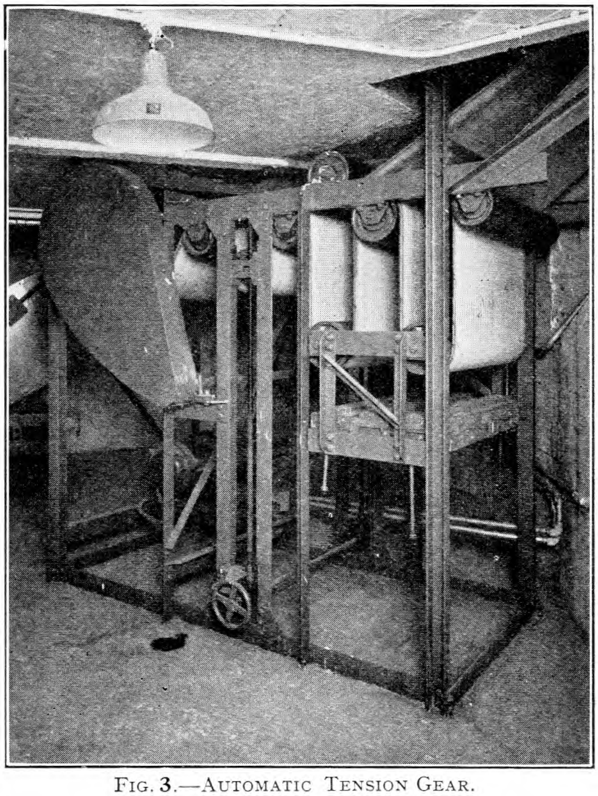


Fig. **3**.—Automatic Tension Gear.

Table I

Conveyor Number		Length between End Rollers	Width of Belt	Speed in Ft./Min.	Depth of Trough	Total Length of Belt (approx.)	Motor H.P.	Reduction Gear Details
		ft.	in.		in.	ft.		
1, 1B & 1C	Inward parcel or	300	42	180	36	700	$7\frac{1}{2}$/5	Flat Belt and Chain
1A	parcel bag	52	36	180	36	110	2	Do.
2	Outward parcel or	135	42	180	36	290	5	Do.
2A	parcel bag	52	42	200	36	110	2	Do.
3	Packets . .	120	24	180	18	275	5	Vee Rope and Chain
4	Inward subway	380	42	180	24	825	$7\frac{1}{2}$	Do.
5	Outward subway	380	42	180	24	825	$7\frac{1}{2}$	Do.
5A, B, C, D	Outward subway	72	48	180	24	156	6	Do.
6	Inward letter	105	36	180	24	220	$7\frac{1}{2}$	Do.
7	Outward letter to	60	36	180	36	150	3	Do.
7A	"road"	14	36	180	24	35	3	Do.
7B	Outward letter to	100	36	200	24	225	$7\frac{1}{2}$	Do.
7C	"rail"	34	42	200	36	80	—	Do.
Bag Opening Table		27	12	30	—	65	$\frac{1}{2}$	Do.
Stamping Table		8	18	180	—	20	—	Do.
Facing Table		28	10	30	—	75	$\frac{1}{2}$	Do.

the operation of a hand-wheel which operates through bevel gears and moves each end of the roller through an equal distance, so that alignment of the band is not effected by adjustment of the tension. The conveyors and twin band risers are driven by slip-ring or squirrel-cage induction motors of the enclosed ventilated type, those over $\frac{1}{2}$ h.p. being connected to a three-phase 365 volt supply. Smaller motors are connected to a single-phase 210 volt supply. The motor speeds do not exceed 1,000 r.p.m. so that no undue noise is produced. The drive is transmitted either by vee ropes if the centres are close or by flat

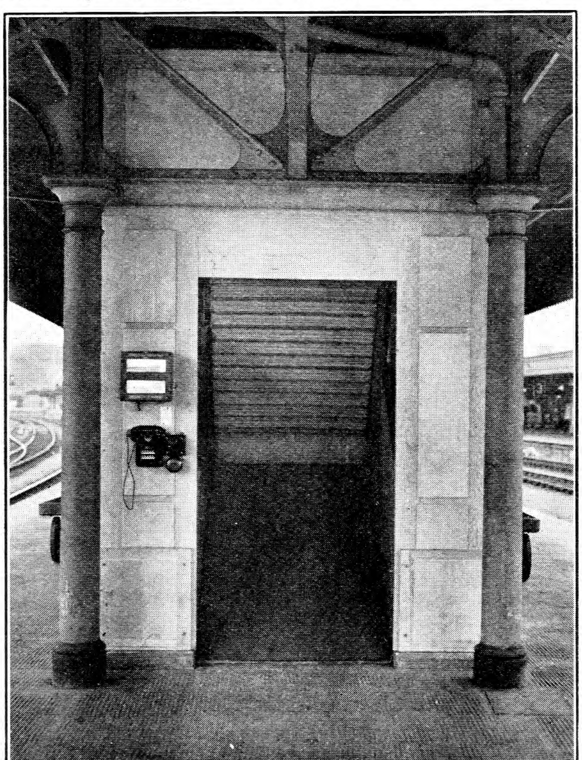


Fig. 4.—Discharge on Railway Platform from Twin-Band Riser.

belts if the centres are more than about 6 ft. apart. Where second speed reductions are required these are obtained through countershafts and silent chain drives. The motors and driving gears of the conveyors and twin-band risers are enclosed in wire mesh enclosures up to a height of 7 ft., and each driving belt or chain within the enclosure is separately guarded. On the railway platforms, loading platform and in the sorting office the twin-band risers are covered by wooden enclosures (Fig. 4), the sides and tops of which can be removed to give access to the conveyors. To facilitate the examination and maintenance of the conveyors in the garage, inspection platforms, which can be reached by trap doors from the sorting office, have been suspended alongside each of these conveyors. The conveyors and driving gear of the conveyors in the garage are totally enclosed so that fumes from the garage cannot reach the sorting office.

Mail is loaded on to the conveyors through loading cabinets, one face of which is hinged along its top edge and is free to swing inwards to permit a bag to be inserted. This arrangement has the advantage that it prevents staff falling into the opening and also prevents draughts from entering the sorting office. The loading platform conveyor runs beneath a row of balanced trap doors through which the parcels are emptied from bags on to the conveyor. These balanced doors have the advantage that they do not take up space on the loading platform when they are not being used. There are four letter and parcel bag twin-band risers, Nos. 5A, 5B, 5C, 5D, two letter bag twin-band risers, Nos. 6A, 7C, two parcel bag twin-band risers, Nos. 1B, 1C, and one packet twin-band riser, No. 3A, associated with the conveyors. The maximum angle at which twin-band risers will lift mail is 60° to the horizontal, but where space permitted the angle has been reduced to avoid any possibility of mail being damaged. The patent rights of these risers are held by Messrs. Sovex, Ltd., who installed the plant described in this article.

The construction of a twin-band riser is shown in Fig. 5. It consists essentially of a steel trough shaped

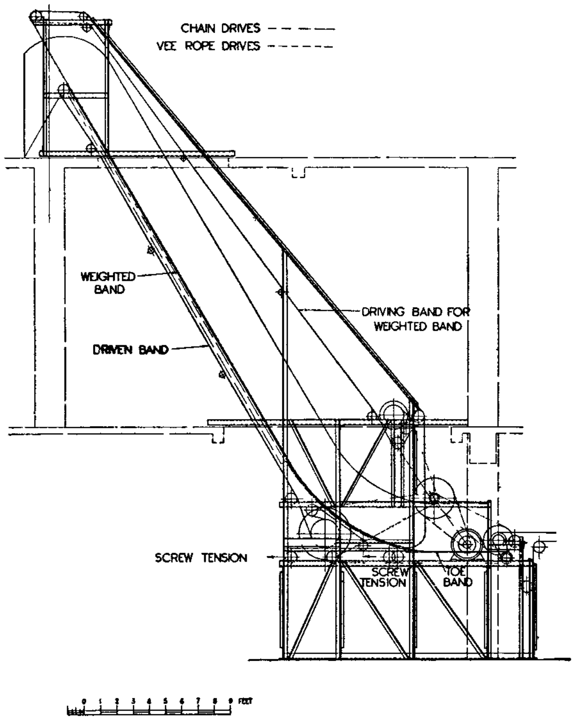


FIG. 5.—CONSTRUCTION OF TWIN-BAND RISER.

as shown in the diagram. Along the bottom of the trough runs a band which is lightly tensioned with a screw tension so that it can follow the shape of the trough. This band is driven from a drum and also by the short toe band. The toe band is tensioned by a screw tension device and driven at a speed slightly higher than that of the belt it drives, which is thus induced to follow the shape of the trough. On the top of this band and moving at the same speed is a band weighted at intervals throughout its length with steel rods fastened to the outside of the belt in pockets made of belting stitched to the band. This belt is driven by frictional contact with another belt automatically tensioned and driven. The mail is delivered on to the bottom band and carried up the trough between that and the weighted band. To ensure that the mail is not damaged by being caught between the bands and the sides of the trough, the twin-band risers are made wider than the conveyors or chutes delivering on to them so that mail is carried in the centre of the trough.

Description of the Conveyors

Subway Conveyors.

Steel chutes have been fixed down which mail can be discharged from the railway platform on to the inward railway conveyor No. 4 as shown in Fig. **1**. If the insides of the chutes are maintained bright and smooth the bags fall gently on to the conveyor. The far side of the conveyor has been extended upwards opposite the mouth of each chute to prevent any bags moving down at abnormally high speeds being thrown over the conveyor.

The outward railway bag conveyor is arranged so that mail can be automatically transferred on to any of the selected twin-band risers Nos. 5A, 5B, 5C or 5D, delivering on to the railway platforms. This is achieved by the arrangement of hinged flaps and scoops illustrated in Fig. **6**. Each section of conveyor rises to a height of about 5 ft. 3 in. at each transfer point and starts again at a height of about 1 ft. 3 in. A steel flap chute having an inside width at the top of 1¾ in. more than the conveyor band is hinged about its lower end and normally rests in the position shown in Fig. **6**, so that bags are transferred down the chute on to the next section of the conveyor. When the bags are to be transferred to a twin-band riser the flap chute is lifted by a crank operated by a ½ h.p. geared motor, into a vertical position, and a scoop hinged about its lower end is lowered by a similar arrangement into the position shown in Fig. **6**. An A.C. brake is connected across one of the phases of each operating motor which holds the flap or scoop in the raised or lowered position. Spring buffers are provided to assist in registering the flaps and scoops and to take the shock as they are finally moved into position

Inward Parcel and Bag Conveyor.

A conveyor (No. A1) runs underneath the "road" loading platform as illustrated in Figs. **7** and **8**. Bags of parcels are emptied on to this conveyor through the balanced trap doors, the positions of which are shown on the key plan (Fig. **7**). This conveyor delivers parcels on to the foot of the inward parcel twin-band riser No. 1B, which feeds the parcels on to the inward parcel conveyor running underneath the floor of the sorting office through which they are finally raised by twin-band riser No. 1C. These conveyors and twin-band risers are also used for

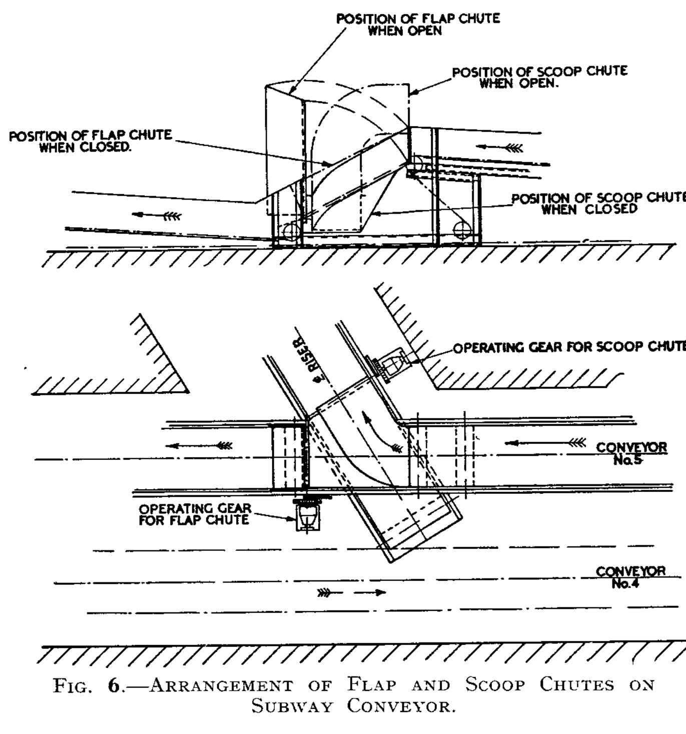


FIG. 6.—ARRANGEMENT OF FLAP AND SCOOP CHUTES ON SUBWAY CONVEYOR.

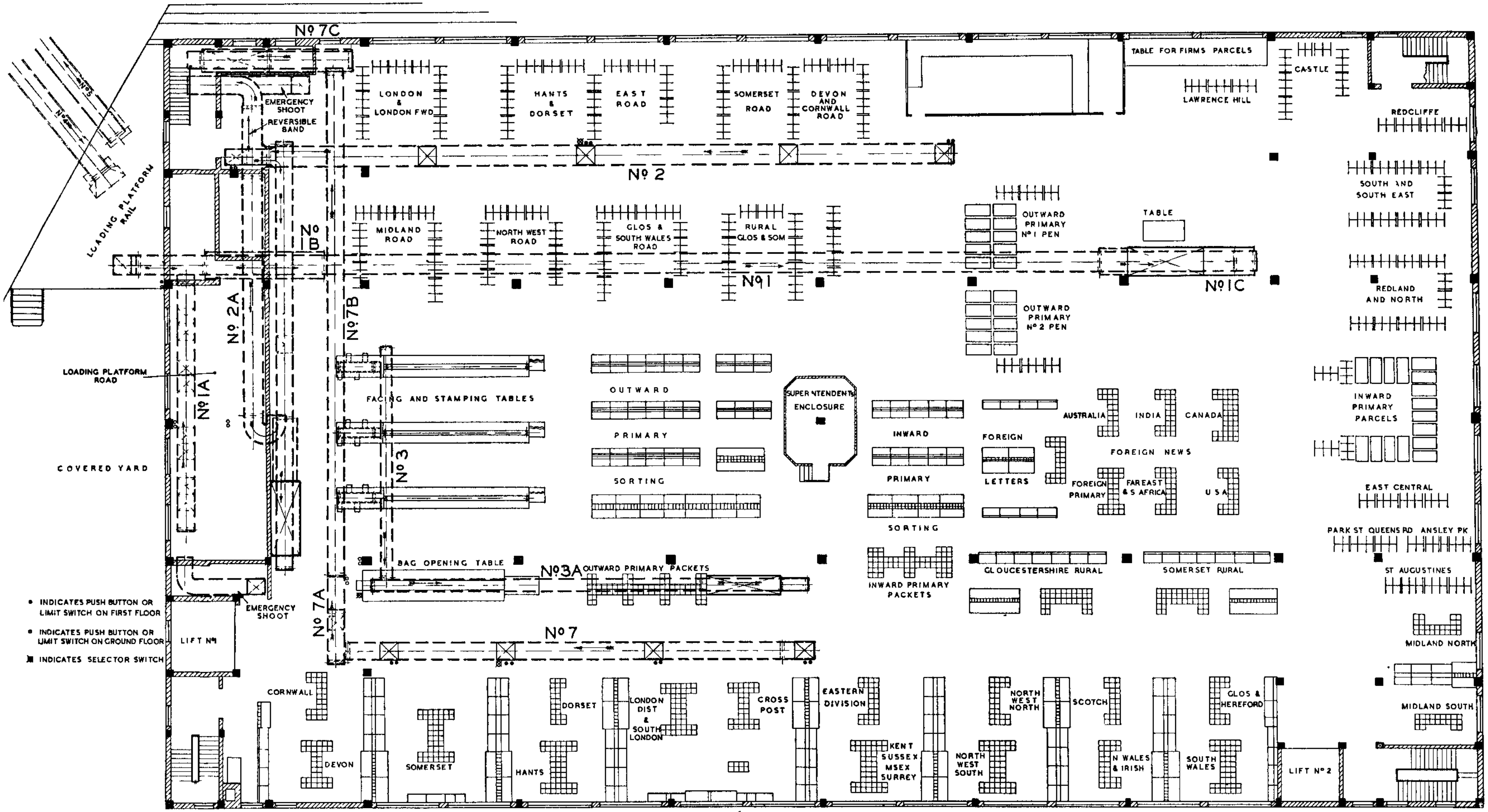


Fig. 7.—Layout of Sorting Office.

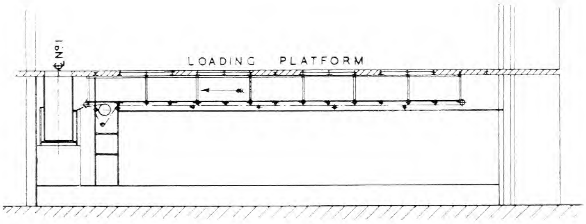


FIG. 8.—INWARD PARCEL AND BAG CONVEYOR.

carrying bags of mail, which are loaded on to them through an opening near the mouth of the subway down a short steel chute. Twin-band riser No. 1C terminates with a short horizontal band from which parcels may be ploughed into baskets on either side by hand-operated deflector plates (Fig. **9**). When the conveyor is being used for bags, the hinged deflector plates are swung back to either side and the bags are discharged off the end of the band down a short steel chute on to the sorting office floor.

Inward Letter Bag Conveyor and Twin-Band Riser.

Letter bags may be loaded on to the inward letter bag conveyor No 6 which runs underneath the " road " loading platform either down a short chute at the " rail " position or directly on to the band at the " road " position (see Fig. **7**). The bags are lifted by a twin-band riser and discharged on to the floor of the sorting office. The discharge roller is 4 ft. 6 in. above floor level to avoid congestion at the discharge head of the twin-band riser.

Outward Parcel and Bag Conveyor.

The outward parcel and bag conveyor No. 2 runs underneath the floor of the sorting office (Fig. **7**) and is equipped with four loading cabinets and chutes for loading the bags on to the conveyors. This conveyor discharges on to a short reversible conveyor running at right angles to the line of conveyor No. 2 as shown in Fig. **10**, so that by running this band in one direction bags can be delivered down a chute on to the loading platform at the "rail" position, or by

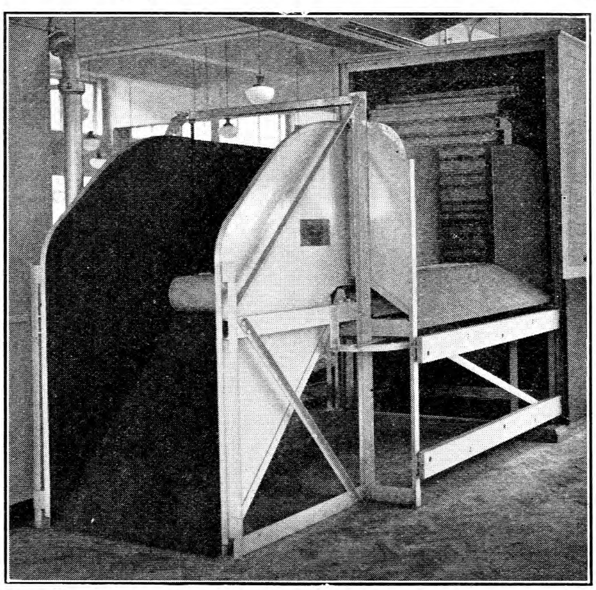


FIG. **9**.—DISCHARGE HEAD OF INWARD PARCEL AND BAG CONVEYOR.

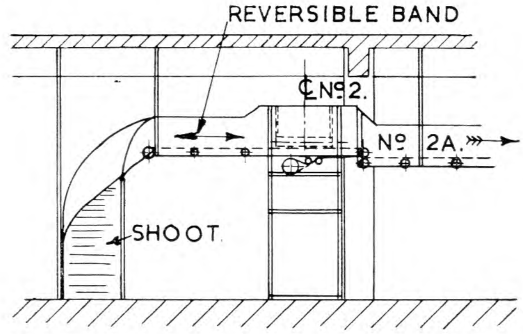


FIG. **10**.—ELEVATION AT JUNCTION OF CONVEYORS NOS. 2 AND 2A.

running it in the opposite direction on to conveyor No. 2A. Conveyor No. 2A runs at a clear height of nearly seven feet above the loading platform and delivers the bags down a spiral chute on to the loading platform at the " road " position.

Outward Letter Bag Conveyor.

The outward letter bag conveyor No. 7 also runs underneath the floor of the sorting office (Fig. **7**) and has four loading cabinets and chutes down which bags may be loaded on to the conveyor. Conveyor No. 7 discharges the bags on to a short conveyor No. 7A which runs above the loading platform. Conveyor No. 7A can deliver the bags either down a straight steel chute on to conveyor No. 7B or on to the loading platform at the " road " position. This is achieved by the arrangement shown in Fig. **11**. When it is desired to deliver the bags on to the loading platform at the " road " position, the hinged chute is lowered until it rests on the bottom chute (Fig. **12**). The moveable chute is balanced by means of weights as illustrated, and is raised by the operation of a geared motor and crank. It is raised when the bags are to be delivered on to conveyor No. 7B which runs underneath the loading platform and discharges the bags on to twin-band riser No. 7C, delivering the bags to the " rail " position. Conveyor No. 7B is fitted with a loading cabinet at the " road " position so that bags can be dropped on to it for transference to the " rail " position.

Packet Conveyor.

The packet conveyor, the function of which is to

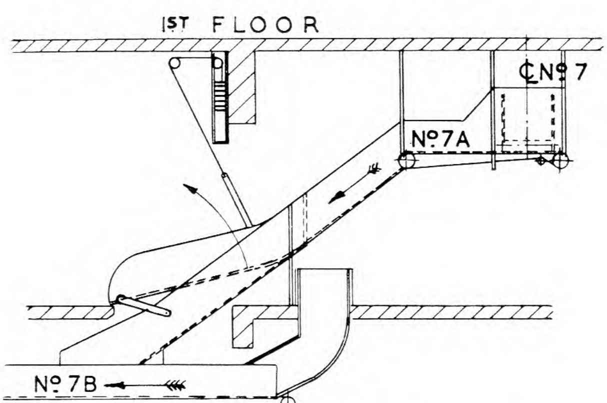


FIG. **11**.—CHUTE AT JUNCTION OF CONVEYORS NOS. 7, 7A AND 7B.

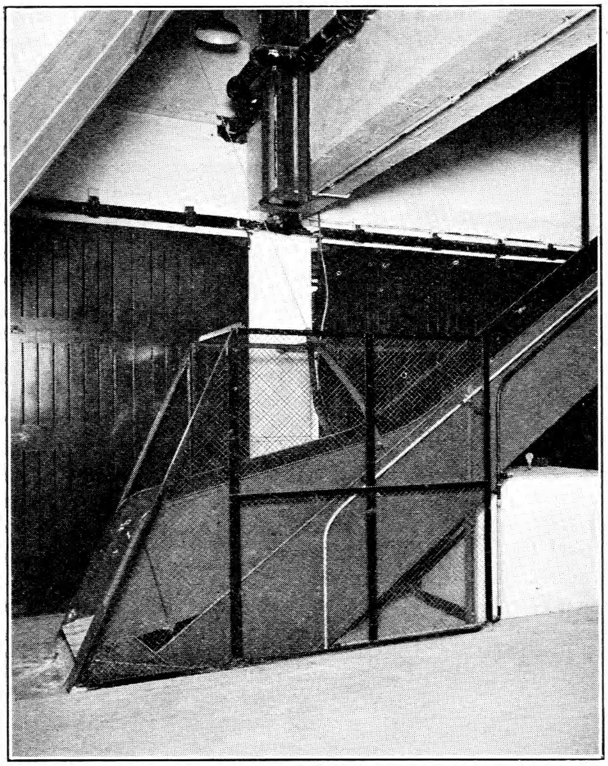


Fig. 12.—Hinged Chute for Outward Letter Bag Conveyor.

assist in the segregation of packets and letters, is suspended underneath the floor of the sorting office, and consists of two sections, 3 and 3A, as illustrated on the plan (Fig. 7). Packets from the three stamping tables and from the bag opening table are delivered on to it down steel chutes. The second section runs at right angles to the first and delivers the packets on to a twin-band riser which rises through the floor of the sorting office and finally discharges the packets at a suitable height for delivery into baskets.

Facing and Stamping Table Conveyors.

Three standard facing tables are fixed in the positions illustrated in Fig. **7**. On each table are erected conveyors, each of which consists of an endless band arranged as shown in Fig. **13**. The bottom band carries faced letters towards one end of the table at which a stamp-cancelling machine is situated. The letters are lifted by hand from the bands on to the stamping machines. The top band carries packets towards the other end of the table and delivers them down a chute on to a stamping table. A conveyor runs underneath the stamping table on to which packets may be dropped down steel chutes, two of which are fixed to each side of the stamping tables. The stamping table conveyors deliver the stamped packets on to packet conveyor No. 3 and are driven from the packet conveyor motor through bevel gearing and a shaft running parallel to the first section of the conveyor, the final dive being transmitted by a silent chain. A common drive for these conveyors makes it impossible for packets to be fed on to conveyor No. 3 while it is at rest, and electrical interlocking of the motor starters is not therefore required.

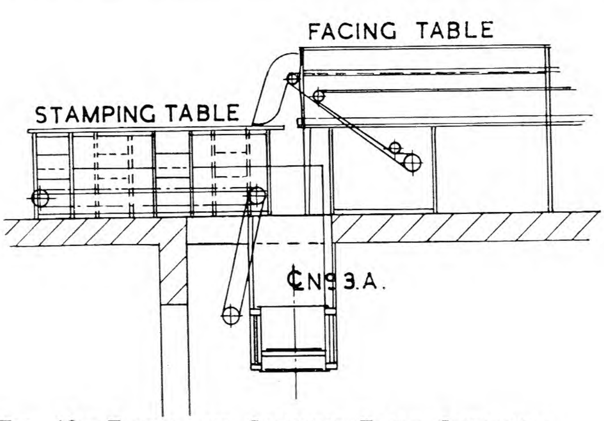


Fig. 13.—Facing and Stamping Table Conveyors.

Bag Opening Table Conveyor.

The bag opening table conveyor is fitted with two conveyor bands separately tensioned and driven. The top band carries bundles of letters to one end and discharges them down a chute on to a table. The bottom band delivers packets either into baskets or down a chute on to the second section of packet conveyor No. 3. This is achieved by a hinged chute arranged as illustrated in Fig. **14**. When the chute is raised the packets may be discharged into baskets, and when it is lowered the packets are deflected by the hinged chute down the straight steel chute on to the packet conveyor No. 3.

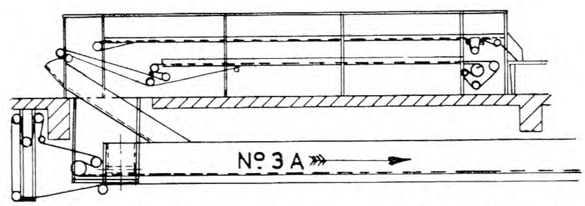


Fig. 14.—Elevation of Bag Opening Table Conveyor.

Method of Control

The control circuits for the motors, flap and chute-operating gears, etc., are operated from a 200 volt D.C. supply obtained from transformers and metal rectifiers connected across the 3-phase A.C. supply. Seven main rectifiers and transformers are used, each of which supplies a controller or group of interconnected controllers.

A typical conveyor motor starter circuit is shown in Fig. **15**. Stop and start buttons are provided in the motor enclosures of all the conveyors and twin-band risers. Two sets of control buttons are used, "remote" and "local." Normally the selector switches SS are in the remote control position, local control being provided only for test and maintenance purposes.

Depression of the start button energises coil a which operates contactor A, causing the conveyor motor to be switched to the mains supply. At A4 and A5 a rectifier is connected across one of the phases, the D.C. output energising the rheostat coil f which cuts out resistance in the rotor circuit.

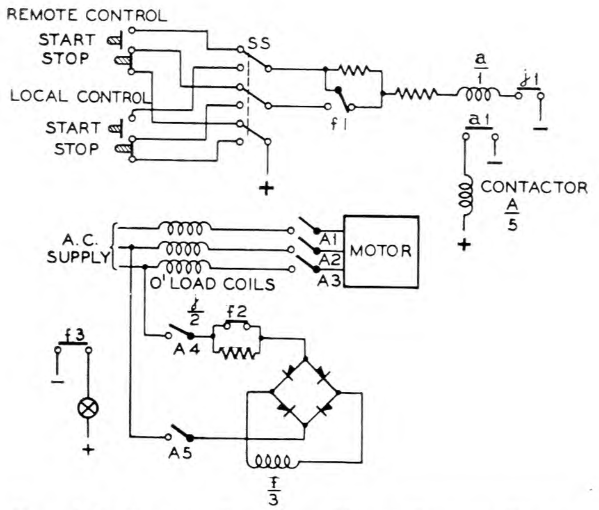


Fig. **15**.—Typical Conveyor Motor Starter Circuit.

Coil f has three contacts which provide a holding circuit for coil a, introduce an economy resistance in the rectifier circuit and light a green indicator lamp at the loading position to signal that bags may be loaded on to the conveyor.

The depression of the stop button releases coil a, thereby causing the release of contactor A and coil f and the conveyor stops.

The above principle is used throughout, though in most instances the control circuit is complicated by the same set of buttons having to control more than one conveyor or twin-band riser. Electrical interlocks are then provided so that all bands are started and stopped simultaneously, or in the correct sequence, so that whatever may be the positions of any of the movable chutes, or in whatever direction the reversible band is running, it is impossible to feed mail on to a stationary conveyor or riser.

The method of operation of the various subway chutes is illustrated in Fig. **16**, which shows the circuit of flap and scoop chutes associated with a twin-band riser. When the riser start button is depressed its associated f coil (see Fig. **15**) is energised and one of its contacts supplies D.C. to operate coil F, which controls the flap chute operating motor. The flap chute is raised and in its final vertical position the

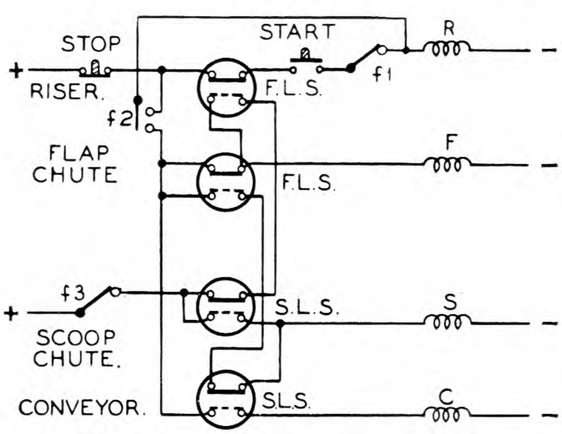


Fig. **16**.—Method of Operating Subway Chutes.

limit switch FLS is operated (as shown dotted). This breaks the supply to F holding the flap chute in the raised position, and energises S which starts the scoop chute operating motor, thus lowering the scoop chute. When the scoop chute is fully lowered the limit switch SLS operates, the circuit to S is broken holding the scoop chute in position, and C is energised which starts the outward conveyor.

Depression of a stop button de-energises C, releases R and therefore f. S is re-energised, returning the scoop chute to its original position, where the scoop limit switch SLS is re-operated and S de-energised. The operation of SLS re-operates F and the flap chute is similarly restored to its normal position.

Signalling.

A system of signalling is installed between the railway platform delivery and dispatch points and the loading platform control panel (Fig. **17**). The circuits for the subway conveyors are illustrated in Fig. **18** and the sequence of operations when bags are being dispatched from the railway platform to the loading platform is described below.

(*a*) The railway platform operator moves the switch to the " bags waiting " position, which illuminates a lamp corresponding to the railway platform on the control panel.

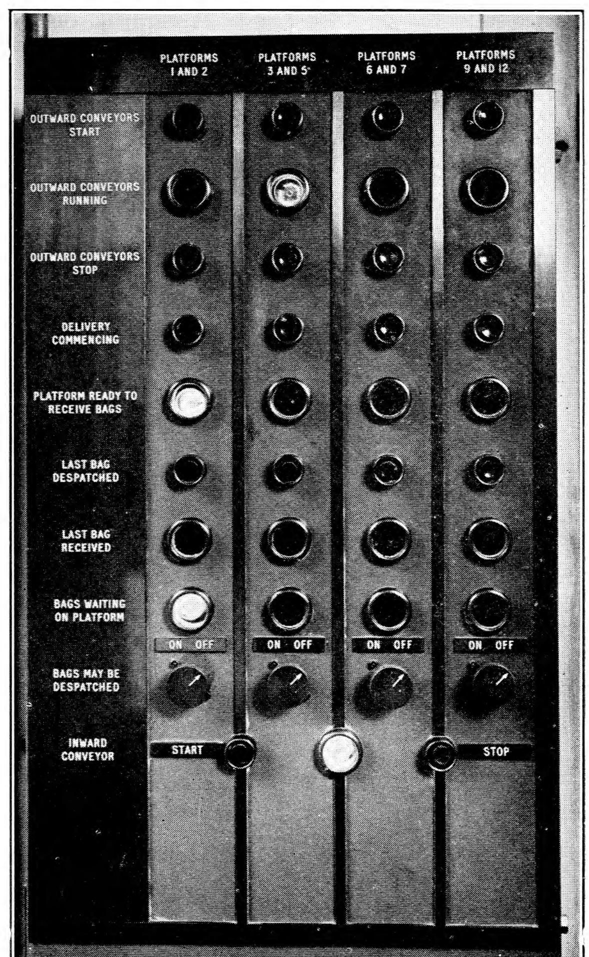
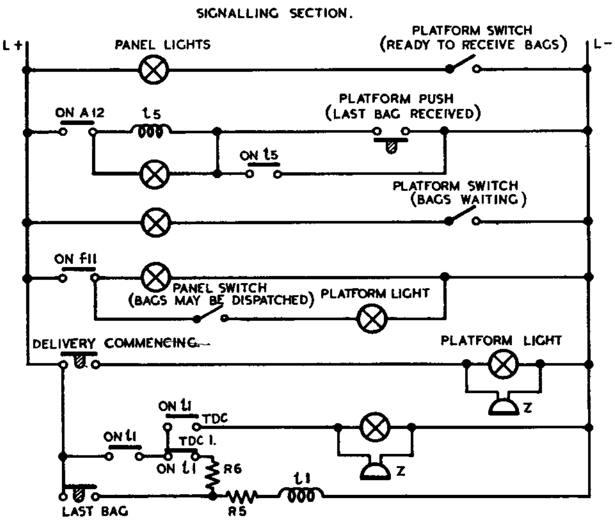


Fig. **17**.—Control Panel for Subway Conveyors.



REF.	DESCRIPTION	REF	DESCRIPTION
A	STATOR CONTACTOR	R6	FINAL RESISTANCE FOR l1
f11	RHEOSTAT COIL	TDC	TIME DELAY CONTACT WHEN MAKING.
l	SIGNAL RELAYS	TDC 1	" " " " BREAKING
R5	INITIAL RESISTANCE FOR l1	Z	BUZZER

FIG. 18.—SIGNALLING CIRCUITS FOR SUBWAY CONVEYORS.

(*b*) The loading platform operator starts up the inward bag conveyor and moves the switch into the " bags may be dispatched " position which illuminates a corresponding signal on the railway platform.

The circuit to these signals is completed through a contact on f so that the signal cannot be given unless conveyor No. 4 is running.

(*c*) The railway platform operator loads the bags down a chute on to conveyor No. 4, and finally restores the " bags waiting " switch.

(*d*) The loading platform operator after a short interval which will ensure that all bags have reached the loading platform stops conveyor No. 4.

When bags are to be dispatched from the loading platform to the railway platform, the following sequence of operations is observed :

(*a*) The loading platform operator presses the " delivery commencing " push which illuminates a corresponding signal and operates a buzzer on the loading platform. At the same time he starts up the necessary twin-band riser and outward bag conveyor as previously described.

(*b*) The railway platform operator acknowledges the signal by closing the switch " ready to receive bags " which illuminates a control panel light.

(*c*) On receipt of this signal the loading platform operator loads bags on to the conveyor.

(*d*) When the last bag has been placed on the conveyor the loading platform operator presses the " last bag " push which makes a circuit to l1, and the time delay contact (T.D.C.) on this relay closes after a period which is set for each contact so that the last bag has time to reach the railway platform before the platform lamp and buzzer is operated.

The platform lamp and buzzer continue to operate until the time delay contact (T.D.C.) opens. The delay is set so that a signal of about five seconds' duration is given in each instance.

(*e*) The railway platform operator acknowledges receipt of the last bag by pressing the platform push labelled " last bag received." This energises l5 and illuminates a lamp on the control panel through the sustaining contact.

(*f*) The loading platform operator stops the outward bag conveyor. A contact on A12 opens and the " last bag received " signal is thereby cancelled.

(*g*) The railway platform operator restores the " ready to receive " bags switch before leaving the railway platform.

Conclusion.

The use of conveyors for collecting mail from the railway platform and of a selective conveyor for distributing the mail from the sorting office to any selected platform, as described in this article, is an innovation in Post Office practice, the usual procedure being to carry the mail by electric trucks.

By adopting the subway conveyor system, which has been described, time is saved in the transference of mail between the sorting office and the railway platforms, the handling of mail on the loading platform is expedited, and the use of electric trucks and drivers is eliminated which may effect a considerable saving where a large amount of mail is being handled. On the other hand, it is necessary to have the point of dispatch and delivery on the railway platform staffed when mail is being delivered to, or dispatched from, any platform.

A Stabilised Repeater and Its Application to Trunk Circuits

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A stabilised repeater with a " break in " facility is described. Examples of its application to trunk circuits are given, with particular reference to 2-wire zero loss circuits.

Introduction.

ZERO loss trunk circuits are a desirable feature of any national or international network because of the simplicity with which such circuits can be put in tandem without increasing the overall loss on the final connection. The alternative to zero loss trunk circuits is either pad switching or cord-repeater switching, both of which, in manual systems at least, are expensive and offer maintenance and operating difficulties of which the zero loss system is free.

In general, 4-wire voice and multi-frequency carrier circuits can be upgraded at small cost and at zero loss have an adequate stability margin. It is not possible to establish stable zero loss 2-wire circuits, on account of the considerable impedance irregularities that may be present. On such circuits, the desired loss can be obtained at small expense by the installation of a stabilised repeater, enabling the circuits to be operated in precisely the same manner as other zero loss trunks. The design of such a repeater and factors affecting the application to the trunk network are discussed in this article.

The Effect of a Stabilised Repeater on Circuit Stability.

The introduction of a voice-operated stabilised repeater into a 2-wire circuit ensures that the two parts of the circuit separated by this repeater become independent circuits in so far as stability is concerned. Thus a zero loss circuit which contains a stabilised repeater having a gain in each direction of 20 db. can be considered to be equivalent, from a stability aspect, to the two separate circuits having a total loss together of 20 db., and each circuit is terminated at one end with the input impedance of the stabilised repeater which is nominally 600 ohms. Hence it becomes a relatively easy problem to convert a 2-wire circuit having six or even seven repeaters to a low loss circuit when a single stabilised repeater is introduced. This repeater is preferably inserted near the centre of the circuit to provide the best operating conditions of the two links. The amplification at the stabilised repeater can be made relatively large so that better stability margins are available at the other repeaters, and for this reason the circuit equalisation is mainly carried out at the stabilised repeater. Thus for cable circuits it should be capable of providing gains up to 30 db. with facilities for providing equalisation of up to 10 decibels. The maximum gain that can be used is generally limited by crosstalk considerations. When applied to aerial 2-wire circuits the equalisation facilities are unnecessary.

The Principle of the Stabilised Repeater.

The circuit can be divided into two parts, first the two-way speech amplifiers or repeaters, each incorporating a voice-operated switch ; and secondly the switching amplifier portion from which are derived

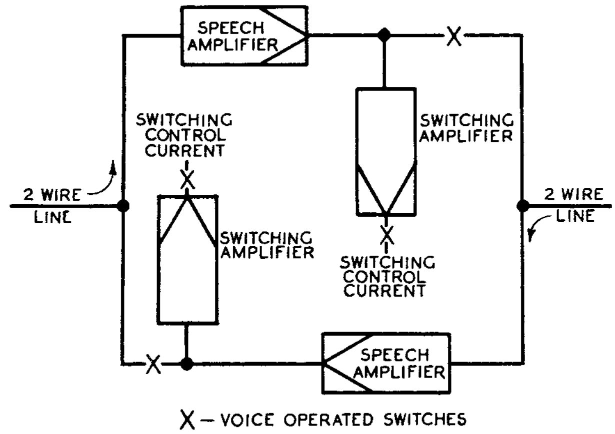


FIG. 1 —SIMPLIFIED BLOCK SCHEMATIC DIAGRAM.

the signals to control the voice-operated switches associated with both the speech amplifiers and the switching amplifiers. The simplified block schematic diagram is shown in Fig. **1**.

The Voice Switching Operation.

The type of voice-operated switching system employed is similar to that which has been described in this Journal for use with a loudspeaking telephone[1] and, in a simplified form, in the P.O. Echo Suppressor No. 5[2]. Four voice-operated switches are provided consisting of rectifier attenuation networks, two being included in the main speech paths and two in the switching signal paths. The attenuations of the networks are varied by a common control current (D.C.) derived from a bridge circuit (Fig. **2**), which includes the anode-cathode impedances of two amplifier valves in the bridge arms.

A rectifier attenuation network is introduced into a signal transmission circuit so that the attenuation of the circuit, due to the introduction of the network,

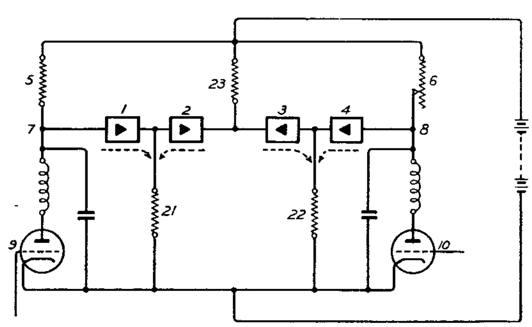


FIG. 2 —DERIVATION OF CONTROL CURRENTS FROM BRIDGE NETWORK.

[1] *P.O.E.E.J.*, Vol. 29, p. 6.
[2] *P.O.E.E.J.*, Vol. 30, p. 186.

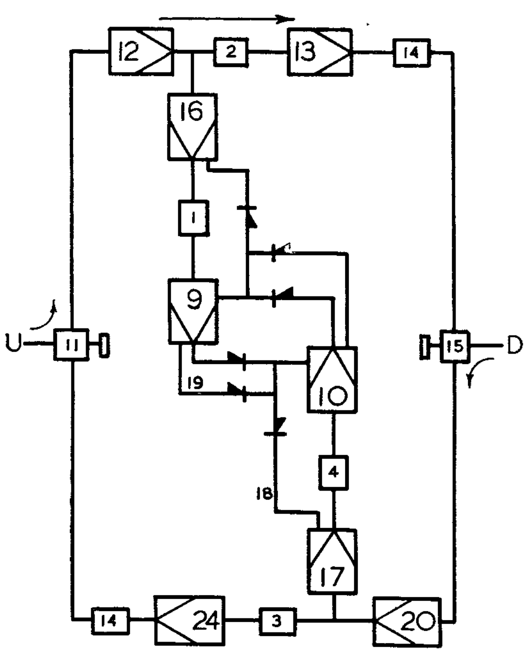
can be changed from less than 1 db. to over 40 and 60 db. when a control current changes by 0.5 and 2.0 mA respectively. Thus when the network has a high attenuation, it effectively interrupts the circuit in the same manner as a switch.

The Derivation of the Direct Control Current.

The control current is derived from a valve bridge circuit, shown in Fig. 2. The four rectifier attenuation networks 1 to 4 have low attenuations to speech signals when their control currents flow in the direction of the enclosed arrowheads, and large attenuations when these currents reverse in direction. The anode impedances of the valves 9, 10 and the resistors 5, 6 form the four arms of a bridge of which the power supply is the anode battery. In the quiescent state the points 7, 8, are given equal potentials by adjusting the value of the resistor 6. The resistors 21, 22, 23 provide steady biasing currents to the attenuation networks in the directions shown by the dotted arrows so that the networks 1 and 4 normally have low attenuations and networks 2 and 3 have high attenuations.

It is seen that a change in control current is obtained when the anode impedance of either of the valves 9, 10 is changed. It will also be observed that if the impedances of both valves alter due to changes in the supply voltages no change in the control current occurs.

The speech signal that is required to control the operation of the attenuation networks or switches is rectified, and this rectified voltage is applied to the grid of the valve 9 or 10 to reduce its normal negative grid bias potential.



Speech Signal Amplifiers	12, 13, 20, 24
Switching Signal Amplifiers	16, 9, 17, 10
Attenuation Networks	1, 2, 3, 4
Break-in Path	18
Anti-echo Break-in Path	19
Low-pass Filters	14

Fig. 3.—Schematic Diagram.

The complete arrangement is shown in the block schematic given in Fig. 3, and is symmetrical for both directions. The speech path in the direction U to D consists of the 4-wire termination 11, an amplifier stage 12 with gain and frequency equalisation adjustment, a variable rectifier attenuation network 2 acting as a switch, a second amplifier stage 13, together with a low-pass filter 14 and a 4-wire termination 15. The switching signal is derived from the output of the amplifier 12, and after additional amplification at 16 passes through a rectifier attenuation network 1 and a final amplifier stage 9. The amplifier valve in this stage, together with the valve in the complementary amplifier 10 form the D.C. valve bridge from which the control current is derived.

In the quiescent state the rectifier network 2 and the complementary network 3 have a large loss, and networks 1 and 4 are of low loss. The U to D signal passes via the amplifiers 12, 16 and 9 to cause a change in the " control " current through the rectifier networks in such a way that networks 1 and 2 become (or remain) of low attenuation so that the signal can pass via the 4-wire termination 15 to the line. At the same time the loss of networks 3 and 4 becomes (or remains) large so that no out-of-balance signal from across the 4-wire termination can cause reverse operation of the system in the D-U direction. The operation in the D-U direction is obtained in a similar manner.

The Hangover or Restoring Time.

Suitable condensers are associated with the rectified grid bias voltage so that the system remains operated during slight pauses between words. The hangover time is approximately 0.5 secs., except when a signal is incoming from the reverse direction, when this time may be reduced as described in the succeeding paragraph.

The Break-in and Anti-echo Break-in Features.

A path is provided so that, when the system is operated in one direction, as described above, speech in the opposite direction can " break in," and cause a reversal of the switches. This is shown in Fig. 3, where speech from the D line, after passing through amplifier 17, is rectified in path 18 and the resultant D.C. is used to discharge the condenser associated with the grid bias circuit of the valve 10. The control current is restored to normal and signals can now pass through rectifier attenuation network 4 to reverse the direction of the switches in the manner described above.

Means must be provided, however, to prevent echo signals from " breaking in " and causing false operation of the system. This is achieved by a signal in path 19, derived from the amplifier 9 which, after rectification, biases the rectifier in path 18 so that it is inoperative for echo signals which occur after an echo time of less than, say, 150 millisecs. The biasing voltage fluctuates with the speech in the U to D direction and so, although the switches remain operated during these fluctuations, speech in the D to U direction can " break in " and obtain control of the switches. This arrangement has been described in detail in a previous article in this Journal.[3]

If satisfactory operation is to be obtained with the wide range of signal intensities that exist in a trunk circuit, saturation of the " break-in " and " anti-echo break-in " signals must not readily occur. Saturation or limiting of the " break-in " signal due to amplifier overloading will reduce the break-in efficiency against a loud signal, whereas saturation of the anti-echo break-in signal may result in echo break-in, causing interrupted transmission, with loud signals. The switching system described enables satisfactory operation to be obtained with the range of signal amplitudes that are experienced.

The Stabilised Repeater Equipment.

The equipment (see Fig. **4**) is mounted on 19-inch single-sided panels as follows :—

(a) A repeater panel $8\frac{3}{4}$ ins. wide,
(b) A switching amplifier panel, $10\frac{1}{2}$ ins. wide,
(c) An anode retard and alarm relay panel, $5\frac{1}{4}$ inches wide of conventional design, per 4 stabilised repeaters.
(d) A filament resistor panel $3\frac{1}{2}$ inches wide per 4 stabilised repeaters.

If the equipment is used in a 2-wire circuit, two combined 4-wire termination and low pass filter panels ($3\frac{1}{2}$ inches wide) are also required.

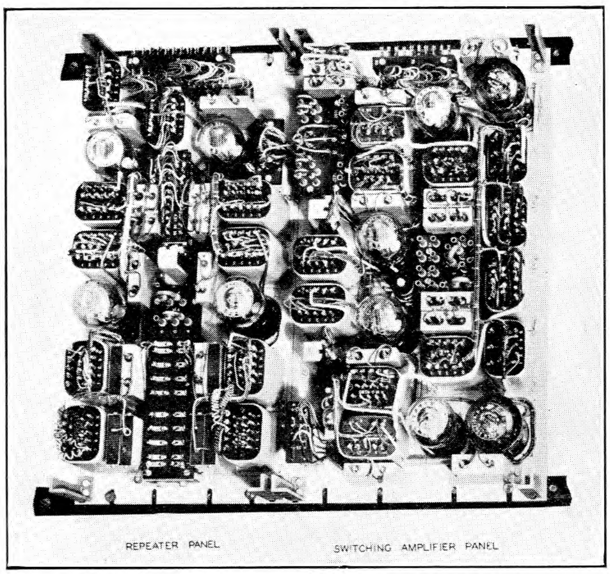


FIG. **4**.—STABILISED REPEATER EQUIPMENT.

Circuit Details.

The circuit diagram of the repeater panel is shown in Fig. **5**. As far as is possible it is similar to the P.O. repeater type 25A both in components and characteristics. It is provided with rectifier attenuation networks between the two amplifying stages.

The input to the switching amplifier is derived from the output of the 1st stage valve, and since the signal level at this point requires to be independent of the repeater gain, the repeater gain control is provided entirely in the repeater input circuit. The switching

[3] *P.O.E.E.J.*, Vol. 29, p. 6.

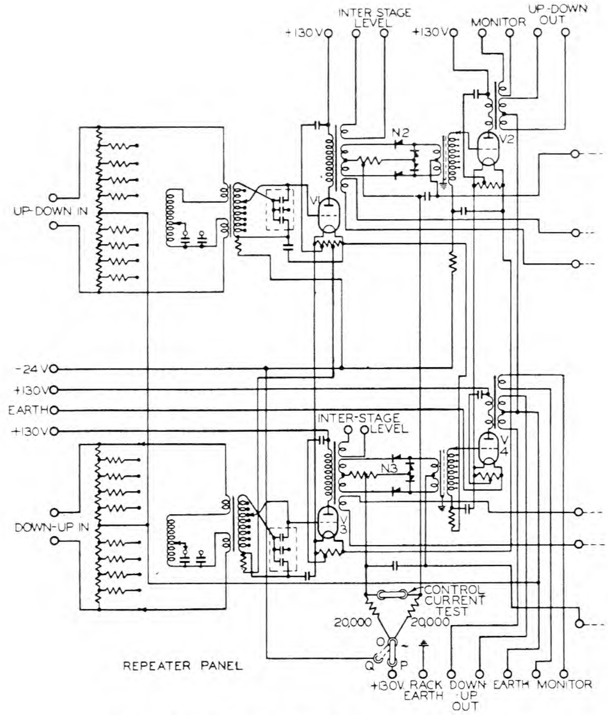


FIG. **5**.—CIRCUIT OF REPEATER PANEL.

amplifier can then be maintained at a -10 db. level, and 1 db. taps on the 2nd stage input enable the output of the repeater to be adjusted and maintained at a $+\ 10$ db. level to $\pm\ 0.5$ db.

The Switching Amplifier.

The circuit diagram is given in Fig. **6**. The input is connected to the repeater panel via U links so that the switching amplifier can be tested independently from the repeater.

After an initial stage of amplification V5 (or V8) part of the signal passes through an attenuation network N1 (or N4) to the control bridge valves V6 (or V9). Pentode valves are used to obtain large control current changes when using only 130 V anode battery. The actual anode voltage of the valve is about 70 V, due to the voltage drop in the anode resistance, with a quiescent current of 10 mA, so that the valve has a long life without its characteristics changing. The output from the valve V6 provides the signal to be rectified to cause a change in the grid voltage of the complementary valve V9. Voltage doubler rectification is used and the time constant of the associated condenser discharge circuit is 500 millisecs. The rectified signal is passed through a resistance-capacitance filter to reduce the amplitude of the A.C. signal that is applied to the grid of the valve. The anti-echo break-in signal is also obtained from the output of the valve V6, but in this instance the time constant of the associated condenser discharge circuit is only 100 millisecs. so that the rectified voltage fluctuates with the speech signals.

A portion of the output of V5 (or V8) also provides the break-in signal, which is amplified by V7 (or V10) to obtain adequate power. The sensitivity of the break-in signal is adjusted by means of taps on the

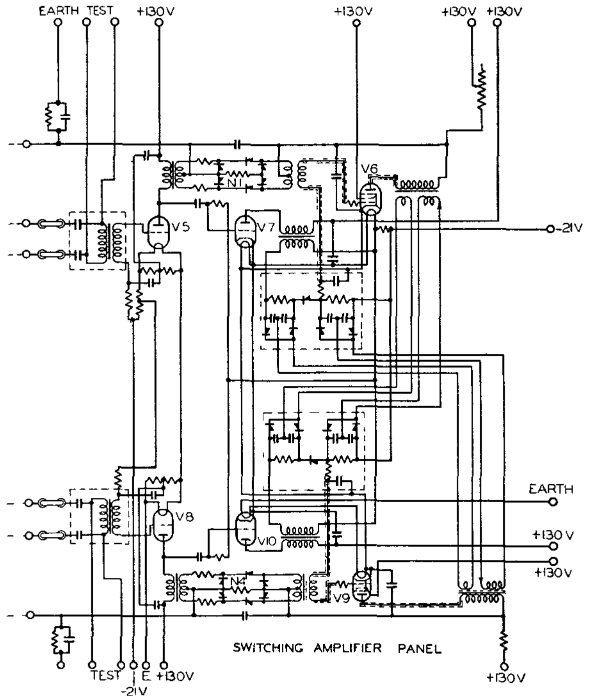


FIG. 6.—CIRCUIT OF SWITCHING AMPLIFIER PANEL.

output transformer, and it is this sensitivity that determines the amount of repeater stabilisation or increased repeater gain over and above that which would normally produce instability if no voice-operated switching system were used. If the maximum break-in sensitivity is used the complementary anti-echo break-in signal fails to prevent echo break-in when the echo signal exceeds the main signal by 15 db., and a reduction of the break-in facility in 3 db. steps enables the repeater stabilisation to be increased correspondingly.

The Control Current Bridge.

A resistor of 2,000 ohms is in series with the anode circuit of valve V9 and the bridge is initially balanced by adjusting the corresponding resistor in series with the anode of V6. The normal anode current is approximately 10 mA, which is increased up to 30 mA when the bridge is unbalanced by a rectified signal applied to the grid of one of the valves.

Conversion of the Repeater to a non-switching form.

This conversion is readily achieved by changing the quiescent control currents through the rectifier networks in the speech paths so that they are of low loss. A resistor is connected between the junction of these networks and earth to provide this current. At the same time the input circuits of the switching amplifiers are disconnected, the changes being made by U links.

Performance Characteristics of the Repeater and Switching Amplifier.

(*a*) *The Repeater Panel:*

With the voice-operated switches in the transmitting condition the repeater has characteristics similar to those of the P.O. repeater 25A. It has a maximum gain of 36 db. with a uniform frequency response from 200 to 3,000 c.p.s. The gain is adjustable in steps of 1 db. and the gain-frequency equalisers are incorporated to compensate for the increased attenuation at the higher audio frequencies of coil-loaded cables.

(*b*) *Switching Amplifier:*

Switching sensitivity. The gain of the 1st stage of the repeater is normally adjusted so that the input level to the switching amplifier is — 10 db. referred to a zero level point. The voice-operated switches in the main signal path are operated with a change of control current of 1.0 mA. The signal input (referred to a zero level point) to produce this current change is shown in Fig. 7. When normal level speech signals

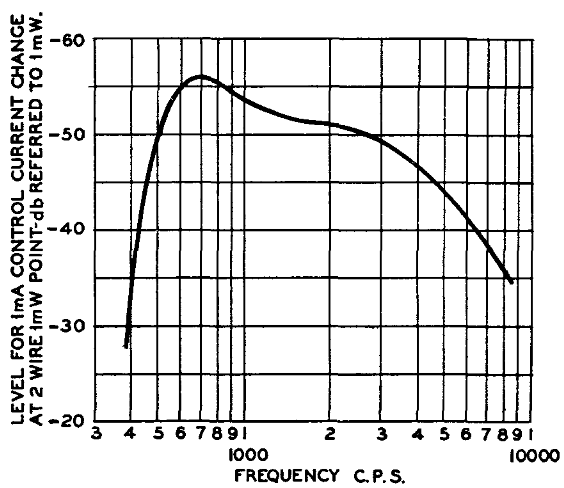


FIG. 7.—SWITCHING SENSITIVITY OF STABILISED REPEATER.

are passing the control current is approximately 6.0 milliamps. Means for reducing the sensitivity are provided, although this sensitivity has proved quite satisfactory in practice. The speed of operation of the switch is approximately 4 millisecs for loud signals, and increases as the signal level decreases. With an input level of — 40 db. referred to 1 mW at a zero level point the operating time is approximately 10 millisecs. Although it is possible to obtain faster operating times by increasing the power of the main operating signal this would necessitate a correspondingly larger power in the break-in and anti-echo break-in signals. This is not desirable as it reduces the effectiveness of the break-in arrangement which is so essential to the successful operation of the repeater in practice.

Break-in Operation. It is difficult to obtain a true measure of the effectiveness of the break-in circuit with a simple quantitative test as the fluctuating nature of the speech influences the break-in efficiency. However, comparative steady tone tests can be made which indicate whether the break-in circuit will operate satisfactorily under working conditions. The amplifier is held operated in one direction with an 800 c.p.s. signal such that the control current change is 3.0 mA and a signal is applied to the complementary amplifier to reverse the operation of the switch. The minimum level of this signal is an indication of the break-in efficiency.

Maintenance Tests.

The normal repeater maintenance is applicable to the equipment, together with a periodic check of the anode currents of the two bridge valves and the control current balance. Although it is considered desirable that the latter test should be carried out monthly, tests over a period of eighteen months on five stabilised repeaters have shown a variation of control current balance of less than 0.2 mA. The balance should be readjusted if the reading is more than ± 0.2 mA.

A three-monthly test of the 800 c.p.s. switching sensitivity should also be made.

Valves and Battery Supplies.

The repeater panel contains the usual valves for P.O. repeater No. 25A, i.e. 2—VT No. 80 and 2—VT No. 78 valves.

Six valves are used in the switching amplifier, i.e. 2—VT No. 78 ($\mu = 7$, $Z = 5{,}500$ ohms), 2—VT 90 (or ML 4) ($\mu = 12$, $Z = 2{,}860$ ohms) and 2 — valves VT 115 (or AC/PEN). These last four valves are indirectly heated.

The total anode current, in the quiescent state is 70 mA (130 V anode supply), and this increases slightly when speech is transmitted. The filament or heater supply is 1.3 amps (21 volt supply).

Application of Stabilised Repeaters to Trunk Circuits.

Stabilised repeaters can be applied to trunk circuits, both 2-wire and 4-wire, aerial line and underground cable, where adequate margin of stability is either not attainable or not maintainable under normal circumstances. Examples of the application to underground cable circuits and to overhead lines are given later.

There are a number of considerations to be borne in mind regarding the application of stabilised repeaters to trunk lines. These are set out as follows :—

(1) In trunk line networks where large groups cannot be justified, the use of stabilised 2-wire repeaters may prove to be the most economical method of providing zero loss circuits. The cost (initial and annual) of the stabilised repeater can be estimated by comparison with repeater equipment of like construction. In highly developed trunk networks such as in this country, the use of 4-wire carrier systems is considered to be more desirable.

(2) In special cases, the utilisation of existing plant may prove to be of considerable importance. The London-Guernsey circuit described later is an example of this. The application of the stabilised repeater enables such plant to be utilised when the improved standards of transmission would otherwise have rendered the plant obsolete.

(3) There are arguments against the use of such equipment, the most important of these being that the equipment is voice-operated and therefore subject to false operation under abnormal conditions where commercial speech could still be transmitted. This can occur, for instance, under conditions of high noise level. Hence, although a stabilised circuit may normally have the performance of a 4-wire circuit, it lacks the simplicity of operation and ease of maintenance. It may be stated however, that the only fault to occur on five stabilised repeaters during two years was due to failure of a resistance coil.

(4) It can be stated as a general principle to be followed in circuit design that the number of voice-operated switches should be kept to a minimum and possibly it should be stated that their use should only be adopted on grounds of necessity rather than of economic advantage.

(5) The performance of a stabilised circuit using existing line plant would be inferior to that of a 4-wire circuit of equal length with regard to crosstalk and babble. The actual magnitudes may of course be satisfactory in both circuits. When planning new circuits, to obtain an equal performance, it follows that stabilised circuits would require higher line crosstalk attenuation values.

(6) The action of the stabilised repeater being "positive," that is to say, there is normally a high attenuation in at least one direction of transmission until the switch is operated, such systems as Telex cannot be accommodated since 1 millisecond of distortion causes signal mutilation. Such systems could only be operated by using a "pilot pulse" transmitted before each train of signals to seize the switch and thus eliminate the distortion introduced during the operating period.

Application to Aerial 2-wire Circuits.

Long distance aerial 2-wire repeatered circuits are often used where traffic is small and only one or two circuits are required. Considerable difficulty is encountered in maintaining such circuits of low overall loss owing to the line impedance variations that are encountered due to weather conditions. The stabilised repeater would enable satisfactory circuits to be maintained under these conditions.

Examples of Application to Underground Cable Circuits

1. *Upgrading of 2-wire Circuits.*

In setting up 2-wire circuits, the factor which limits the overall loss to which such circuits can be controlled is, almost always, the margin of stability attainable. In this country, the margin of stability required with the terminals in the open-circuit condition is 2 db., that is to say, that it should be possible to increase the gain of any repeater in the circuit by at least 2 db. in both directions simultaneously and not reach instability or "howling." On certain 2-wire circuits between London and Leeds, the loading of which was 177/107 mH at 1.136 mile spacing on 40 lb. conductors, the best overall loss determined by the above stability requirement was 5.5 db. The

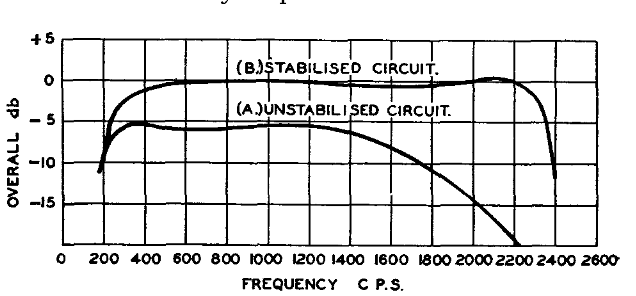


FIG. 8.—OVERALL LOSS-FREQUENCY CHARACTERISTICS OF LEEDS-LONDON 2-WIRE CIRCUIT.

overall-loss/frequency characteristic of such a circuit is shown in Fig. **8**, Curve A. In order to upgrade a circuit of this type to an overall loss of 0 db. (to enable it to conform to the zero loss switching requirements between Zone Centres) it was decided to accomplish this by the installation of stabilised repeaters at Derby. Not only was it possible to attain the required overall loss of 0 db. with adequate margin of stability at the normal 2-wire repeaters but, whereas before stability requirements prevented any appreciable correction of frequency distortion, this was made possible with the installation of the stabilised repeaters. This, for ease of comparison, is shown in Fig. **8**, Curve B. Since the greater part of the frequency correction is done at the stabilised repeater and hence to a certain degree in advance of the actual frequency distortion, abnormally high output levels occur at the stabilised repeater. This is not effective in causing any overloading since the energy in speech of such frequencies is correspondingly small. It is necessary to test, however, at a level of — 10 db. instead of the normal testing level of 1 mW. The margins of stability at the normal 2-wire repeaters on the old and final set-up are given in the following table :—

	Original Circuit	*Final Circuit*
Fenny Stratford	2.0 db.	4.5 db.
Leeds	2.0 db.	4.5 db.

Four stabilised 2-wire circuits of this type have been established between London and Leeds. They have been in operation since July, 1934, and compare favourably as regards faults with 4-wire circuits in the same group.

Tests have also been carried out with these circuits arranged in tandem, up to the maximum available of four. The switching was found to be satisfactory and in fact, apart from considerations of lock-out (which is a possible cause of failure due to there being four voice-operated switches in tandem) actual switching is not different from that for one switch. The impairment due to loss of signal during the switching operation (" initial clipping ") is not noticeable. The final circuit so obtained was not a satisfactory connection, the type of loading employed being unsuitable for circuits of 800 miles. From considerations of stability and voice switching, however, four circuits of this type might, under suitable conditions, be operated in tandem. The danger of lock-out referred to above is not real and causes negligible repetitions until the time separation between the two most distant voice switches exceeds 200-250 milliseconds. In the example quoted the maximum time separation was 50 milliseconds.

2. *London-Guernsey No.* 1 *Circuit.*

This example of the use of a stabilised repeater is interesting, since without it, it would not be possible to obtain a commercial circuit at all from the cable plant available. An earlier article in this Journal[4] has described the circuit between London and Guernsey as originally established with an early type of stabilised repeater. It is sufficient to recall here that the circuit is of 4-wire underground cable construction between London and Dartmouth, at which point a single-core submarine cable connection is obtained to Guernsey worked single wire to earth. The attenuation of the submarine cable is 32 db. at 800 c.p.s. rising to as much as 57 db. at 2,000 c.p.s. The submarine cable having been constructed and maintained as a telegraph cable with regard to im-impedance irregularities, the balances obtainable at the ends of the submarine cable are considerably less than the attenuation. In order to obtain a reasonable overall loss, it is consequently necessary to operate the 4-wire circuit between London and Dartmouth at a gain which would normally render the circuit unstable. To counteract this, a stabilised repeater is employed at Taunton, an intermediate point in the 4-wire portion of the circuit. The amount of equalisation of the overall loss characteristic that can be obtained is, of course, dependent on the stabilisation obtained from the stabilised repeater. As much correction of frequency distortion, therefore, has been obtained as possible while still maintaining proper switching of the stabiliser. The amount of stabilisation finally effected (as measured by the excess of reflected over forward operating levels at the stabilised repeater) rises to as much as 15 db. at frequencies between 1500 and 2,000 c.p.s.

The overall loss-frequency characteristic of the circuit as finally established is shown in Fig. **9**.

The main respects in which the present circuit is improved on the original are (a) in the provision of the break-in facility referred to in this article, (b) the use of a more sensitive voice-switch since break-in enables the switch to be seized against noise operation, and (c) in the overall loss-frequency characteristic finally obtained.

In order to enable V.F. telegraph operation to be carried out between London and Guernsey during emergency telegraph conditions, a switch has been provided on the stabilised repeater which renders the switching amplifiers inoperative and holds the attenuation networks of zero loss in both directions of transmission. The 4-wire termination being removed at London, the stabilisation requirements no longer exist.

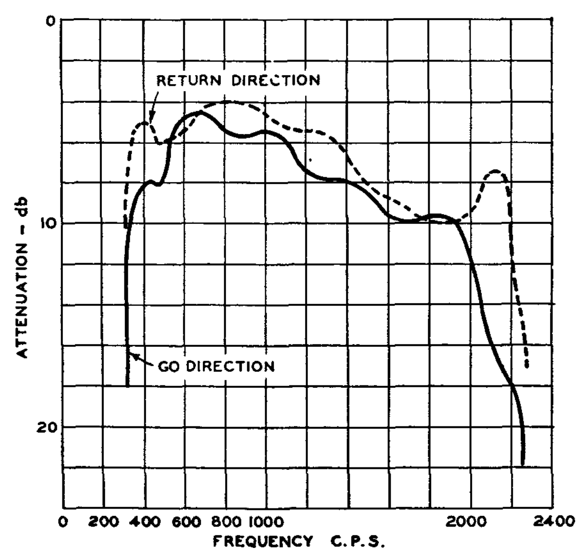


FIG. 9.—OVERALL ATTENUATION-FREQUENCY CHARACTERISTIC OF STABILISED LONDON-GUERNSEY CIRCUIT.

[4] *P.O.E.E.J.*, Vol. 25, p. 276.

The London—Birmingham Coaxial Cable System

A. H. MUMFORD, B.Sc. (Eng.), A.M.I.E.E.

Part IV.—Test Results and Commercial Operation

The author completes this series of articles with particulars of the test results achieved. Although the installation of supervisory and repeater stand by equipment is not yet completed, the first forty circuits are already in commercial operation.

Introduction.

HAVING completed the installation of the apparatus panels that were essential for the transmission of a complete super-group, it was decided to make an immediate test of the simultaneous operation of 40 circuits. Thus the gains of the various modulators and amplifiers were adjusted approximately to their correct values and no attempt was made to equalise the characteristics of individual circuits, the overall loss of each circuit being left at about 3 db. This article describes this first test of a complete super-group and the work that was carried out before staging a demonstration some weeks later when the initial troubles, which are inevitable in a new system, had been remedied and the individual circuits equalised.

The First Test of a Super-Group.

This test was held on March 11th and was arranged in the following manner. Thirty-five of the circuits were connected at each end to telephones adjacent to the terminal equipment, the five remaining circuits being connected to telephones located in situations relatively free from room noise. Separate tests showed that for the normal talker the telephones delivered on the average an output of approximately 8 db. below R.T.P. Since the telephones were connected directly to the 2-wire sides of the hybrid transformers terminating the coaxial circuits, it is to be expected that the power delivered by these telephones during the test was approximately 6 db. above the average value that would be encountered under traffic conditions. The thirty-five circuits first mentioned were loaded by conversations between female switchboard operators and the remaining five were reserved for the use of persons especially concerned with the test.

Briefly, the results of the test were as follows:

(*a*) The articulation on the circuits was considered to be good and there was a complete absence of echo as such; it is certain that an appreciable echo must have been present, but owing to the high velocity circuits employed it appeared merely as side tone and could not be detected.

(*b*) A slight amount of crosstalk was observed which, it was suspected, would have been intelligible if its level had been higher. There was, however, no trace of babble when the operators were conversing normally or when all the operators at one end were talking very loudly.

(*c*) A certain amount of noise was present having the characteristics of A.C. power interference and D.C. generator noise combined.

(*d*) The operators, except one at London and another at Birmingham, expressed the opinion that the circuits were better than the trunk circuits on which they were normally employed.

Modifications Made as a Result of this Test.

Subsequent to the preliminary test the work of preparing the coaxial equipment for traffic was resumed. At the same time an investigation into the sources of noise and crosstalk observed during the demonstration was made with the following results.

The crosstalk was found to be occurring in the audio-frequency bay wiring and was overcome by earthing one side of each of the pairs concerned.

Further, it was found that the noise was introduced into the system at the two terminal stations. Part of the noise was due to direct magnetic induction into the channel receive amplifiers from the power equipment on the carrier supply and repeater bays, and this was overcome by substituting sheet-metal covers for the expanded metal guards protecting the power transformers and chokes mounted on these bays.

The remainder of the noise observed during the test was due to the fact that at London, and to a minor extent at Birmingham, there is a considerable ripple voltage between the "rack" and "silent" earths, affecting both the modulating and carrier-generating equipment. The trouble was overcome by using appropriate earths at various key points in the equipment. Thus it was necessary to insulate the cases of transformers from the panel in certain parts of the equipment; it was subsequently discovered that this practice is normally followed at Faraday Building, London, but not at Telephone House, Birmingham, presumably due to the ripple voltages prevalent at Faraday Building being greater.

The coaxial channels were then equalised with the result that the overall transmission lay, with a few exceptions, between the limits of $\pm$ 1 db. of the value at 1,500 c.p.s., for frequencies ranging from 250 to 3,100 c.p.s.; the characteristics of the channels which came outside these limits will be improved at a later date.

Interference.

A day or two previous to the main demonstration it was found that a 1,000 c.p.s. tone of comparatively low level, more than 50 db. below reference level, was present on one of the circuits during the transmissions of the London National broadcasting station, working frequency 1,149 kc.p.s. A preliminary investigation indicates that the high frequency carrier wave of this station is probably being picked up at one or more of the intermediate repeater stations and demodulated at the terminal stations along with the wanted signals. While the point is being thoroughly investigated, narrow band elimination filters will be used to remove the unwanted signal from this particular circuit.

Characteristics of the Equipment and System.

Channel Filters.—The channel filters incorporated in the terminal equipment include quartz crystal resonators in addition to inductors and capacitors. The characteristics of the network are such that it is necessary to manufacture the individual elements to relatively close limits, and the adjustment of a complete filter is a process calling for considerable precision although it has not been found difficult to train junior staff to carry out the adjustment. As variations in temperature must alter the values of the filter elements to some extent it was considered possible that the performance of the filters in service might prove to be affected materially by changes in ambient temperature. In an investigation of the point, the insertion loss characteristic of certain channel filters was measured, while the temperature of the filter was varied over a range of 18° C., an adequate time interval being allowed during the test to allow the complete filter to attain the extreme limits of temperature. The results showed that, at least over the range of temperature over which measurements were made, temperature had little effect on the performance of these filters. There was no appreciable change in the frequencies at which peak attenuation occurs, but in the pass band there was a slight increase in the average attenuation with increase of temperature and a tendency for small irregularities of attenuation to increase. The increase in attenuation is probably due to a small rise in the power factor of the inductors and the increase in magnitude of the small irregularities is no doubt due to very small changes in the effective reactance of the elements comprising the filter. It was satisfactory to observe that the behaviour of the filters was substantially cyclic. A temperature range of 18° C. is considerably in excess of that likely to be encountered in practice and it is confidently anticipated that the variations of temperature occurring under working conditions will have a negligible effect on the performance of the channel filters.

In view of the fact that the crystal plates are supported in their holders solely by two pairs of contacts pressing on opposite sides along the nodal plane of the plate, it was thought possible that the performance of the filters might be adversely affected by vibration. The effect of vibration was checked to some extent by transporting a number of filters, fairly carefully packed in strong wooden cases, over a distance of 230 miles in a commercial 2-ton van, the characteristics of the filters being measured before and after the journey. The modifications which occurred in the characteristics were so small as to be of negligible importance; they were in fact of the same order of magnitude as the variations in performance among a number of filters of the same type immediately after they have been adjusted; thus vibration should have a negligible effect if the filters are handled with reasonable care.

It is preferable to give the limits, within which lie the characteristics of all the units comprised in a certain part of any system, rather than the characteristics of a few selected isolated samples, the latter method merely showing the degree of perfection attained in any particular characteristic without giving any indication as to how closely the remainder of the units approach this sample. The former method has been adopted here and the limits presented in the form of an envelope, within which the actual characteristic of any particular unit is contained, the reference point being clearly specified. For instance, Fig. **46** shows the envelope of the frequency/loss characteristics of two sets of 22 channel filters, 20 working and two spare in each set, used in connection with the 60-65 and 95-100 kc.p.s. channels in either the first modulation or the final demodulation process; the losses being measured with respect to the loss at the frequency 1,000 c.p.s. below the carrier frequency.

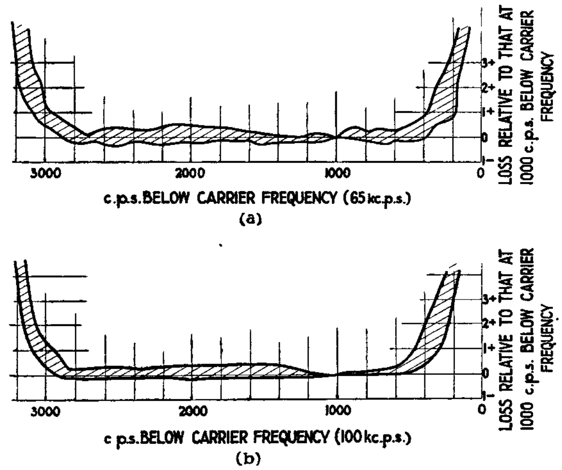


FIG. **46**.—ENVELOPE OF FREQUENCY/LOSS CHARACTERISTICS OF TWO SETS OF CHANNEL FILTERS.

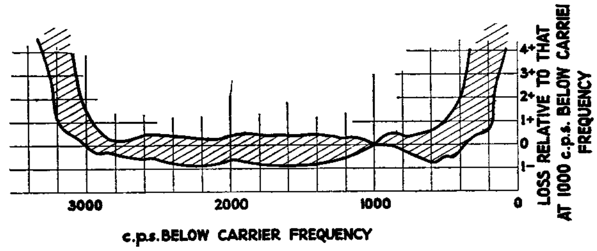


FIG. **47**.—ENVELOPE OF FREQUENCY/LOSS CHARACTERISTICS OF CHANNEL FILTERS IN FIRST SUPER-GROUP.

Fig. **47** is the envelope of the frequency/loss characteristics of all the channel filters made for this first super-group, irrespective of the carrier frequency, the frequency/loss curves of each individual filter being made to coincide at a point 1,000 c.p.s. below the actual carrier frequency of that particular channel. It demonstrates the closeness to which the various sets of channel filters, used in the group combination, have been designed, as well as the constancy of reproduction of characteristics during manufacture and adjustment. It will also be seen that the spread of the envelope does not exceed 2·2 db. at any frequency between 400 and 3,000 c.p.s. below the actual carrier frequencies.

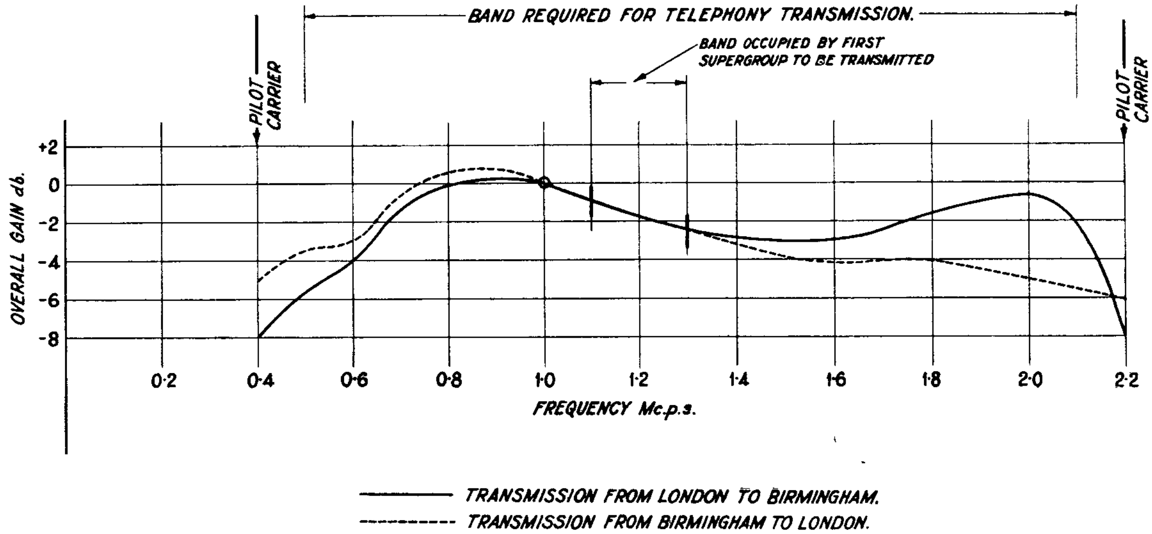


FIG. 48.—OVERALL GAIN/FREQUENCY CHARACTERISTIC OF THE COAXIAL LINE AND REPEATERS (APRIL 23rd, 1938).

The Equalised Line.—The overall characteristics of the coaxial lines, repeaters and associated equalisers between London and Birmingham are shown in Fig. **48**, although it must not be inferred that this represents the ultimate characteristic since, as explained earlier, the experimental work is still continuing. It will be seen that the overall characteristic over the frequency band 0·5 to 2·1 Mc.p.s. lies within ± 3 db. of the value at the midband frequency; the variation over the band occupied by the first super-group imposed on the system being 1·5 db. Some variation of the characteristic must be expected due to the effect of temperature changes and a possible lack of perfect compensation by the temperature compensation equalisers; the present data is far too meagre to discuss the point further.

Overall Gain/Frequency Characteristics of the Audio Channels.—Envelopes of the transmission characteristics, 2-wire—2-wire, of the London to Birmingham channels separated into the five groups forming the super-group are shown in Fig. **49**; the envelopes of the return channels are very similar to those illustrated. It will be seen that a high degree of uniformity in design and adjustment of the various parts of the systems has already been achieved, and yet an improvement, both in the degree of uniformity and width of frequency response for a reduced channel separation, is already envisaged.

Fig. **50** shows the characteristic of the complete super-group of London–Birmingham channels, 2-wire—2-wire, previously considered in Fig. **49** on a group basis, measured with respect to (*a*) 800, (*b*) 1,000, (*c*) 1,500 c.p.s. The specified limits were expressed relative to the gain at 800 c.p.s. and an inspection of Fig. **50** (*a*) will show that the channels comply with the specification. As a matter of some interest, the anticipated transmission characteristic, first disclosed over a year ago, has been superimposed on the envelope. For the 800 c.p.s. reference point, the anticipated curve has proved to be the mean of the envelope.

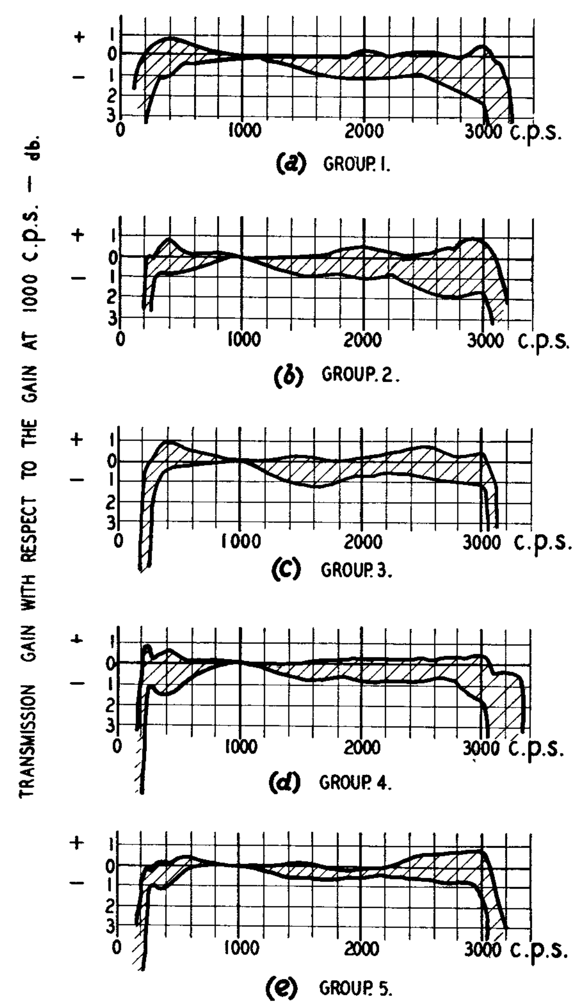


FIG. 49.—ENVELOPE OF THE TRANSMISSION CHARACTERISTICS (2-WIRE—2-WIRE) OF THE CHANNELS COMPRISED IN THE VARIOUS GROUPS.

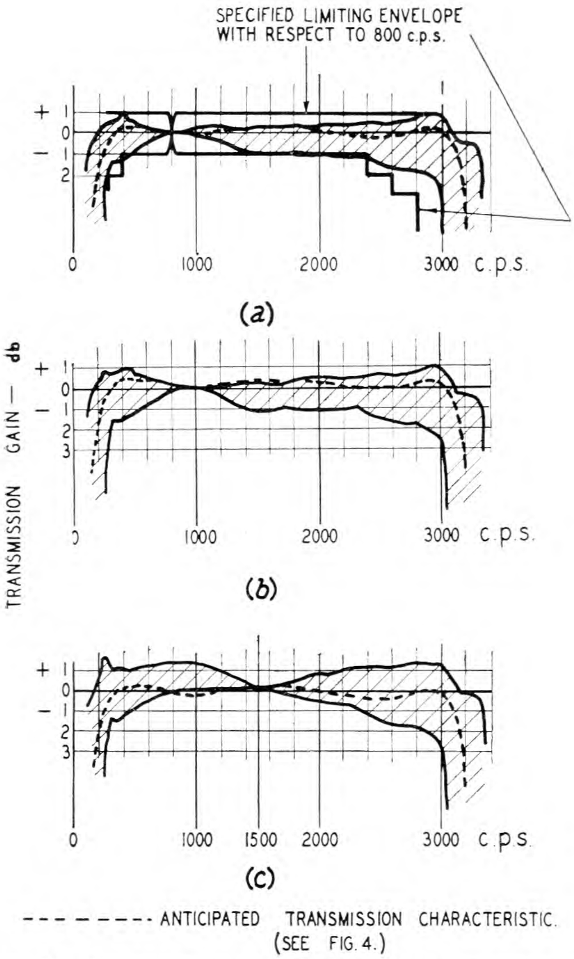


FIG. 50.—ENVELOPE OF TRANSMISSION CHARACTERISTICS OF THE 40 LONDON-BIRMINGHAM CHANNELS (2-WIRE—2-WIRE) WITH RESPECT TO (*a*) 800 C.P.S., (*b*) 1,000 C.P.S., (*c*) 1,800 C.P.S.

The Main Demonstration.

The main demonstration was given on April 11th, 1938, and was carried out on the same general lines as those of the previous test; the circuits being adjusted to have a transmission loss of approximately 1 db. The circuits were quiet, the articulation good, crosstalk and babble completely absent. Certain observers stated they experienced a feeling of confidence in the stability of the circuits in speaking over them which they felt was lacking when using the normal low loss trunk circuits. This is no doubt due to a subconscious reaction against the changing conditions of a normal circuit brought about by the operation of the echo suppressors. As has already been pointed out for a coaxial circuit the echo merges completely with the side tone and echo suppressors are not used.

Towards the end of the demonstration seven circuits were connected in series to form a single circuit some 800 miles long; thus the speech in each channel went through 42 modulation processes and in effect some 133 high frequency repeaters, using 532 valves. The performance of this circuit was good although slightly inferior to that of the single-length London–Birmingham circuit. There was still no noticeable echo, the transmission time between the two ends of the complete circuit still being less than 5 milliseconds. The degradation on performance was obviously due to the six intervening points at which

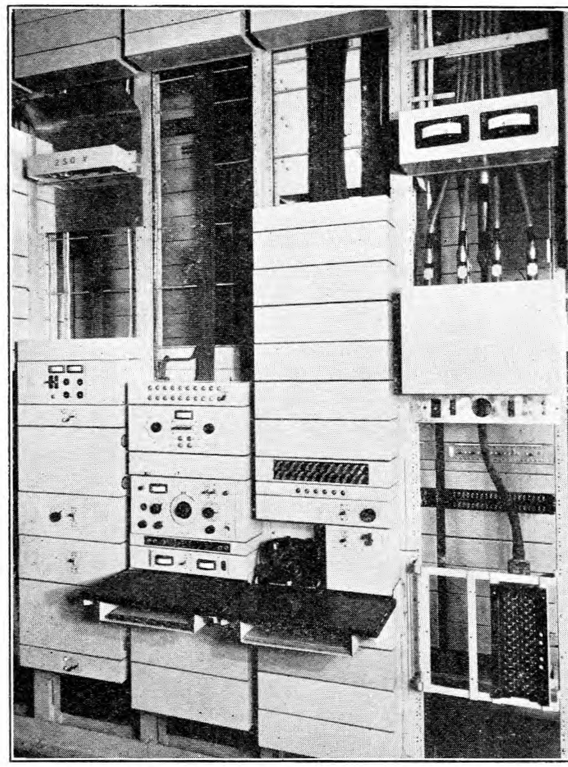


FIG. 51.—TERMINAL REPEATER STATION, LONDON.

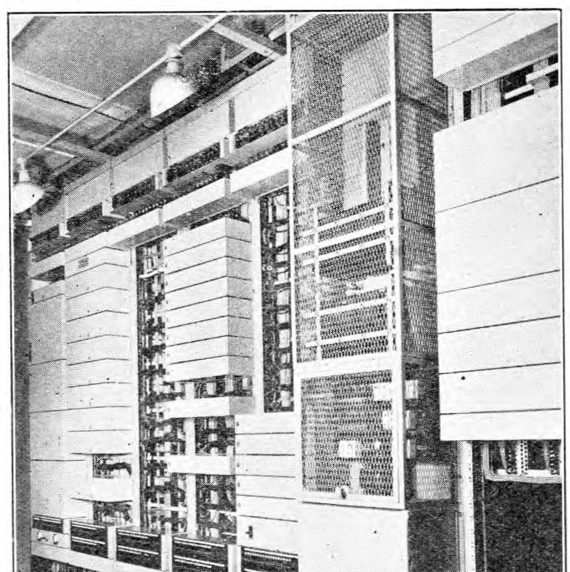


FIG. 52.—CARRIER GENERATING EQUIPMENT, LONDON.

limiting, modulation and demodulation occurred, the majority of which would not normally be present in a commercial circuit of that length.

Commercial Operation.

In accordance with a previous agreement the circuits were handed over for part-time traffic (week-days, 9.30 a.m.–4.30 p.m.) on the day following the main demonstration, i.e. April 12th, 1938. The circuits are at present working traffic very successfully on this basis without the supervisory and repeater standby equipment which is now being installed and adjusted; thus an appreciable risk of breakdown must be faced by the Traffic Group utilising the circuits. The commercial operation is, however, most valuable, since it enables data to be accumulated under the actual conditions of operation at an early stage of the installation, forming an indispensable check upon the previous calculations. It is anticipated that the adjustment of the outstanding equipment will be completed within the next few months.

Figs. **51** and **52** show portions of the completed equipment installed in the London Terminal Repeater Station.

Acknowledgments.

In conclusion, it is desired to thank Messrs. Standard Telephones & Cables, Ltd., the contractors responsible for manufacturing most of the equipment, for their ready assistance in many matters, and also the author's colleagues who have assisted not only in the preparation of this series of articles but also in the development, design and adjustment of the equipment. Obviously, there are many who have contributed materially to the development described but who cannot be mentioned individually. The author would, however, like to mention and thank individually the nucleus, Messrs. R. F. J. Jarvis, C. F. Booth, H. Stanesby and R. A. Brockbank, around whom the team responsible for this work has been built. The remainder of the team know and can rest assured that their efforts are valued and appreciated and will perhaps accept this public expression of thanks as an acknowledgment of their efforts.

Finally, the team desire to record their appreciation of the encouragement and advice received from the Engineer-in-Chief, Sir George Lee, his deputy, Col. Angwin, and Mr. A. J. Gill, under whose immediate direction this work has been carried out.

Mobile Post Office No. 2

As an appreciable number of the demands during 1937 for the first Mobile Post Office[1] could not be met owing to prior bookings, it was decided to build a second vehicle and this was completed in April last. It was formally inaugurated by the Lord Mayor of Leeds, at Leeds, on 13th of that month.

This vehicle is similar to the first but the undermentioned improvements, which suggested themselves after experience in service of the first, were incorporated :—

(*a*) An aperture above the pigeon hole in each service window, to facilitate conversations between public and counter staff.

(*b*) A notice plate above the posting box on the offside, to indicate to the public " Office hours " and " times of collections."

(*c*) A folding step under the door leading to the office compartment.

(*d*) More accommodation for counter clerks by reducing width of each counter by 3 ins.

(*e*) Counter tops of matt finish bakelite. (It was found that the highly polished surface of the counters in the first vehicle soon became disfigured by scratches). Fronts of drawers also faced with this material.

(*f*) Hinged flap in rear nearside office window through which telegrams are handed from counter staff to messengers.

(*g*) Drawer for filing telegrams.

(*h*) To provide for telegraphic traffic beyond the capacity of one teleprinter an auxiliary unit for a second teleprinter was installed. This necessitated the supply of batteries of 50 Ah capacity instead of 30 Ah. (Only one teleprinter, however, is carried on the vehicle; the second, when required, is supplied locally).

(i) Extractor fan in battery compartment and another in office compartment.

In addition, the items mentioned below, which were added to Mobile Post Office No. 1 subsequently, were incorporated in the second vehicle :—

(*a*) Metal rectifier for the charging of batteries when mains current is available. This addition was made to save wear and tear of the engine and the special dynamo on the tractor, which formally were the only means of charging the batteries.

(*b*) Second clock.

(*c*) Two auto-feed boxes for telegraph forms with fittings for attaching to brackets over public counter.

(*d*) The original call office circuits in the first vehicle worked on a post-payment basis in all areas. This system had certain disadvantages and the circuits were altered to provide for prepayment as well as post-payment working.

The trailer and tractor bodies of the second vehicle were built by Messrs. T. Harrington, Ltd., Old Shoreham Road, Hove, Brighton.—W. G. D. & C. F. M.

[1] *P.O.E.E.J.*, Vol. 29, p. 208.

Somerset House P.A.B.X.

R. C. HAWARD

A description of a new Private Automatic Branch Exchange installed at the Headquarters of the Board of Inland Revenue, Somerset House, London.

Introduction.

THE increase in taxation during recent years has resulted in a constant expansion of the staff of the Inland Revenue Department, and for some time past the accommodation at Somerset House has been exhausted and a large number of the staff has had to be housed in offices in the surrounding neighbourhood (at York House, Victory House, Princes House and Red Lion House in Red Lion Street).

The telephone needs of this scattered staff were previously met by three private manual branch exchanges. The main one at Somerset House consisted of five No. 9 positions accommodating 34 exchange lines, 17 tie lines and 534 extensions; 70 of the extensions were in parallel. A three-position No. 9 board to which were connected 17 exchange lines, 7 tie lines and 270 extensions served York House, Victory House and Princes House. The requirements of Lion House were met by a $\frac{10+50}{60}$ board with three exchange lines, one tie line and 33 extensions.

Records showed that the traffic on the Somerset House board greatly exceeded the maximum load for five positions, and as it was not possible to extend this board on account of the limit of accommodation having been reached, the question of adequate and better service became acute.

From the foregoing it will be realised that the telephone service of the different offices was both inadequate and uneconomical, and when the opportunity came to centralise the staffs of three of these offices in a block of Bush House the problem of intercommunication demanded careful attention.

The advantages and disadvantages of manual and automatic working were discussed and it was decided that an automatic system with direct dialling to the public exchange would meet the requirements, and three schemes were prepared for consideration; the one described below was finally approved as being the most economical and likely to render the most efficient service. Briefly the scheme was to have one main installation at Somerset House with one common numbering scheme for all the establishments.

An order was accordingly placed with Messrs. Standard Telephones & Cables, Ltd. The specification called for British Post Office standard racks and apparatus. Certain new circuits were developed by the contractor, in conjunction with the Post Office Engineering Department, to meet the particular requirements of the installation, and these circuits give facilities in accordance with recognised principles of Post Office practice.

The new P.A.B.X., which is comparable with a non-director exchange, was opened for service on April 2nd, and has equipment for 1,100 extension lines initially and 1,500 ultimately.

Street Cabling.

Owing to the congestion in the street cables in the locality the external engineers had some difficulty in routing the large number of external extensions to Bush House, and to add to their troubles the Inland Revenue Department found it necessary to vacate York House and move the staff to Turnstile House. This necessitated drawing in 1,130 yards of 300 pair $6\frac{1}{2}$-lb. cable between Turnstile House and a point outside Somerset House.

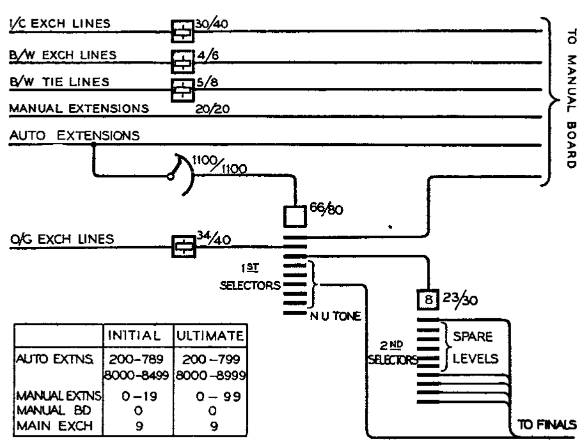
Accommodation.

The accommodation for the exchange offered by the Inland Revenue Department was satisfactory from the point of view of space, but on examination the floor was found to be too weak to carry the dead weight which would be placed upon it, especially as owing to the nature of the ceiling and its height from the floor the cable runways could not be supported from the ceiling. The Office of Works therefore undertook to strengthen the floor and at the same time to erect partitions to divide the manual room from the apparatus room and the entrance. This proved to be rather a long job as steel girders had to be built over the old arches and vaults below the room and the intervening space filled in with concrete. A new floor of $2\frac{1}{2}$-inch maple boards was then laid on the concrete.

The depth below the floor level and the top of the arches being less than one foot in places, a cable trench was not possible, and the external cables had to be tail-ended in the low vaults under the apparatus room which are also used as storing places for records by the Inland Revenue Department. For the same reason the main distribution frame had also to be dealt with in a special way, being stood on the concrete and the footings filled in in a manner similar to that usually employed for intermediate distribution frames.

Numbering Scheme.

The numbering scheme is a mixed 3- and 4-digit one, the range being 200-799 and 8,000-8,499 initially and 200-799 and 8,000-8,999 ultimately. Fig. **1** shows the trunking. Direct access to the Temple Bar public exchange for local calls is obtained from level 9,



	INITIAL	ULTIMATE
AUTO EXTNS.	200–789 8000–8499	200–799 8000–8999
MANUAL EXTNS	0–19	0–99
MANUAL BD	0	0
MAIN EXCH	9	9

FIG. 1.—TRUNKING DIAGRAM.

but trunk and toll calls are obtained via the P.A.B.X. manual board, for which 0 is dialled.

Blocks of numbers have been assigned to the three establishments, each block covering the initial requirements with a margin of spares sufficient for the five-year period. These blocks are :— Somerset House, 200-799 ; Bush House, 8,000-8,249 ; Turnstile House, 8,250-8,499.

Layout.

Fig. 2 shows the layout of the exchange, and although every advantage has been taken of the

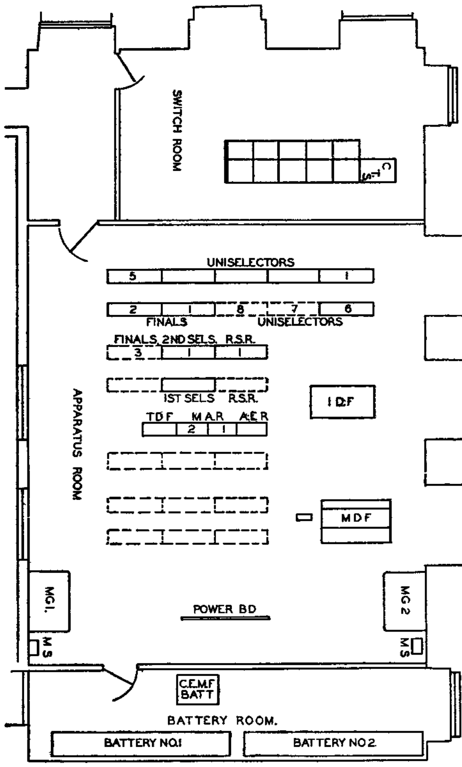


Fig. 2.—Exchange Layout.

ample floor space provided there is plenty of room for growth beyond the estimated ultimate of 1,500 extensions if the necessity should arise.

Frames and Racks.

The main distribution frame has 10 verticals with capacity for 200 circuits per vertical, and two 1,000 pair cables are terminated on the line side. One of the cables serves the various buildings within the precincts of Somerset House, which are all block-wired. The other cable connects with the street cable system in Wellington Street and collects the exchange lines, tie lines and external extensions from Bush House and Turnstile House.

The racks are all 10 ft. 6 in. high of the Post Office standard type[1], and rack lighting and ladders[2] are provided at the usual rate of provision.

Testing Arrangements.

To facilitate the work of the maintenance staff a test rack similar to that provided for exchanges up to 900 lines has been installed, and all line and instrument tests, including dial speed tests, can be made without the assistance of the main exchange. Fault and routine tests of the selectors are carried out with a manual tester (Tester No. 64, Diagram AT 1885).

Alarm Arrangements.

A normal non-director exchange alarm system, providing the usual failure alarms is installed and the alarm, tone and graduated howler equipments are fitted on a standard alarm equipment rack. The time pulses for operating the alarms are provided by a regulation master clock, Clock No. 36.

Manual Board.

The manual board consisting of five positions of the auto-manual type[3], has four positions each equipped with 15 cord circuits and one trunk-offering cord, which are described later. Four positions are sufficient to meet the traffic needs for some time, but as the estimated twenty-year requirements are only five positions, and in view of a possible sudden increase in the incoming traffic, it was considered advisable to install five positions at the outset.

The circuits accommodated in the face panel are the incoming and bothway exchange lines, "0" level circuits, manual extensions and the extension multiple. The provision of the automatic extension multiple facilitates the rapid connection of incoming calls from the public exchange, these calls being the bulk of the traffic handled by the operators. As a further aid to rapid connection of incoming traffic and also to permit of team working, the incoming and bothway exchange lines, tie lines and "0" level circuits have two appearances.

The manual extensions are provided for use as emergency circuits and for extensions where dialling facilities for main exchange calls are not to be given ; only 20 of this class of circuit have been fitted.

Circuit Description.

In the necessarily brief circuit descriptions given below only the more special features are brought out as being of interest to the general reader.

For the automatic extension a standard uniselector circuit without metering is used, but it is slightly modified to provide for access from the manual board. The method of engaging the line on incoming and outgoing calls is illustrated in Fig. 3. It will be

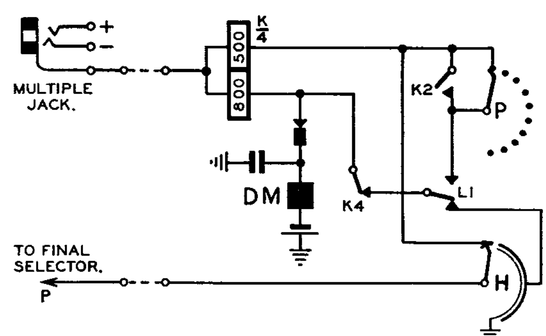


Fig. 3.—Engaged Test on Subscriber's Line Circuit.

[1] *P.O.E.E.J.*, Vol. 23, p. 9.

[2] *P.O.E.E.J.*, Vol. 25, p. 23.

[3] *P.O.E.E.J.*, Vol. 26, p. 255.

seen that relay K has two windings which are joined in series to give the standard 1,300 ohm resistance in series with DM for switching on auto calls. The common point of the two windings is connected to the bush of the multiple jack, the 800 ohm winding only being then in series with DM. When the plug is inserted into the jack, relay K operates from earth, relay D or E (Fig. **6**) (Y contact previously operated), relay K, DM to battery. The free condition of the line, battery potential on the bush of the jack, is replaced by earth potential, and when an operator testing for engaged applies the tip of the calling plug (Fig. **6**) to the bush, a circuit is established via X4, coil of relay B, E3, KS5, to charge the condenser via one winding of retard CT (Fig. **7**). CT acts as an induction coil and a surge of current is induced in the other winding which is across the receiver and the usual click is heard by the operator.

Should the extension be engaged on an extension call earth from the final selector via the private wiper is holding relay K (Fig. **3**) operated and the bush of the jack has earth potential via the 500 ohm winding of K.

In the event of an incoming call when the line is engaged via the manual board, the common point of the two coils of relay K being at approximately earth potential, the final selector testing on the P wire will encounter a 570 ohm earth.

The three exchange line circuits, i.e. I/C, O/G and B/W, are generally similar in design. The circuit of the B/W exchange line (Fig. **4**) is given as being

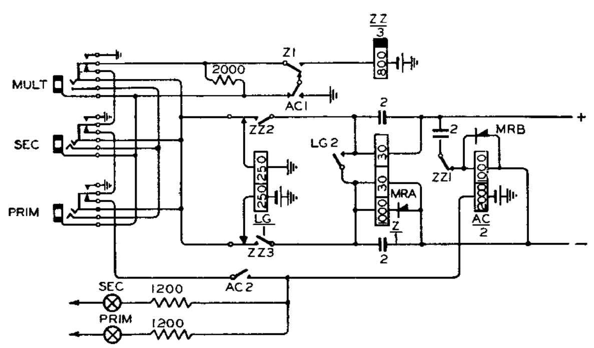


FIG. **4**.—B/W EXCHANGE LINE CIRCUIT.

representative of the three, the chief difference between the I/C and B/W circuit being the outgoing multiple appearance of the latter. The circuit provides for ancillary working with lamp signalling, operator recall, follow-on call trap (which prevents a call, that arrives before the operator has cleared down, ringing the extension still left connected), through-dialling and engaged test. It will be seen that the circuit is quite a simple one, but it is thought that an explanation of the " follow-on call trap " feature may be of interest. On the termination of a call, relay Z releases and at Z1 releases relay ZZ, which disconnects the extension from the exchange at ZZ2 and ZZ3. The relay set is now free to accept another call, although the plug is still in the answering jack, and should one arrive, relay AC will be operated during the ringing period and at AC1 disconnect the full earth lighting the supervisory lamps in the cord circuit (Fig. **6**). Flashing on the supervisory lamps is thus substituted for the normal calling signal, and the ringing is prevented from calling the extension.

The O/G exchange line circuit has no connection to the manual board but is connected to level 9 of the 1st selectors and provides for dialling direct from the extension instrument to the main exchange. As incoming calls are not received on this circuit, relay AC and its circuit shown in Fig. **4** is not included, but an additional guard relay, ZZR, is provided to ensure that the chain of switches in the main exchange system is cleared down before the circuit is freed for a subsequent call. Fig. **5** shows the holding and guarding circuit.

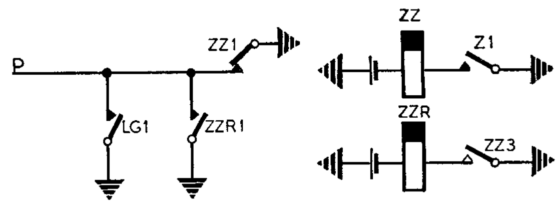


FIG. **5**.—HOLDING AND GUARDING CIRCUIT.

The " 0 " level circuit provides for loop calling, ringing tone feed-back, lamp signalling and selector hold, and calls for no special mention. The same remark can also be applied to the manual extension and tie-line circuits which are similar except that the latter circuit is arranged for generator calling.

The facilities provided by the cord circuit are divided feed on extension to extension calls, through clearing, individual lamp supervision on extension to extension calls, and on extension to exchange calls supervision from the switch-hook only, both supervisory lamps lighting on the termination of the call.

Through conditions exist until the speaking key is thrown and also on exchange to extension calls. Fig. **6**

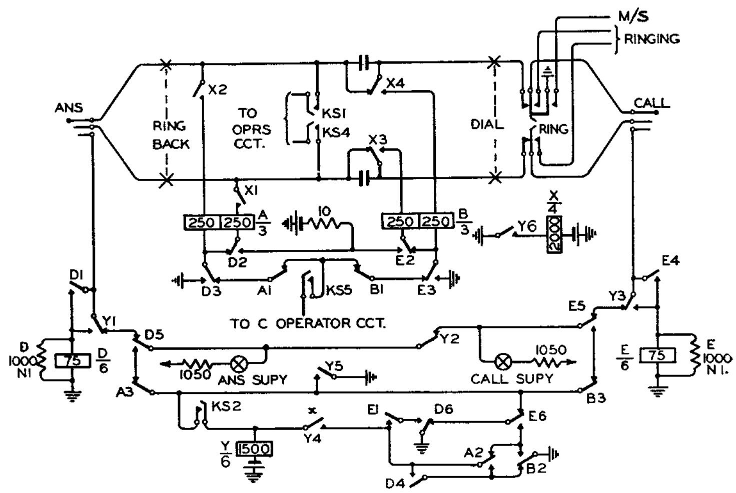


FIG. **6**.—CORD CIRCUIT.

shows the more important features of the cord circuit which will be briefly described in common with a call I/C from the main exchange to an extension.

The operator inserts the answering plug in the jack of the calling line and throws the speaking key KS(5). Relay Y operates from earth at D6 and in turn operates relay X at Y6 and provides a holding loop via the windings of relay A. Referring to Fig. **4** it will be seen that battery will not be returned from the bush of the jack to operate relay D. Relay Y is now held by earth at B2. On ascertaining the caller's demand the operator inserts the calling plug into the jack of the required extension and restores key KS. Relay E operates in series with the 800 ohm winding of relay K (Fig. **3**), and E5 closes and completes a path for the calling supervisory lamp to light from earth at Y5. The operation of the ring key applies ringing, and on being restored feeding battery and earth are applied via the windings of relay B from E2 and E3. Relay B operates when the extension answers and disconnects the supervisory lamp at B3 and also the holding circuit of relay Y at B2.

On the termination of a call, relay Z (Fig. **4**) releases, and at Z1 short-circuits the 2,000 ohm resistance and full earth is fed via the sleeve to operate both supervisory lamps.

The operator's circuit shown in Fig. **7** follows the latest practice for the prevention of acoustic shocks by the addition of two metal rectifiers bridged across the receivers and provides a balanced engaged test.

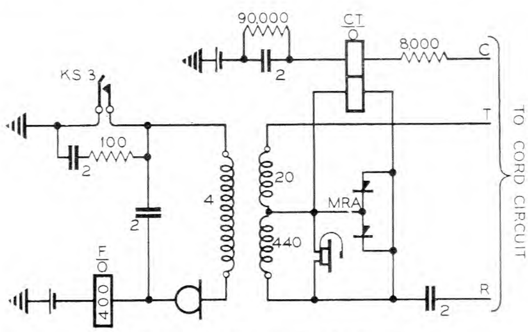


Fig. 7.—Operator's Circuit.

Trunk offering is arranged by the provision of a separate trunk offering cord, with sleeve supervision, on each position.

Power Plant.

A 600 ampere hour, 50 volt, parallel battery float power plant is installed, and follows the general principles described in a paper read before the Institution of Post Office Electrical Engineers on October 9th, 1934.[4]

Two 25-cell, 300 ampere-hour capacity batteries are joined in parallel and are arranged in two rows of two tiers with their positive and negative terminals at the common centre where they are teed together and the main conductors taken away to the distribution points. Four two-cell counter E.M.F. batteries of the nickel-iron type, joined in series with a tap off the negative of each pair are connected to contactors by which they can be inserted into circuit as required for voltage regulation.

Fig. **8** is a view of the battery room and the arrangement of the cells and spacious layout can be clearly seen. An interesting feature of the battery room is its unusual loftiness, being uniform with the remainder of the exchange 16 feet high. The floor is laid with large red tiles, the intersections being filled in with bituminous compound. This treatment prevents percolation of the acid to the structure of the building and gives a very pleasing appearance to the room.

Fig. 8.—Battery Room.

Fig. **9** shows the generator, control and ringer panels, and the principal items of equipment are indicated. The three mercury contact relay switches and the contactors are enclosed with glass-fronted covers and are thus protected against dust and interference.

Two D.C. motor generator sets supply the current for floating the main battery. The input of the motors is 200 V, 14·35 amps., and the output of the generators is 59/67 V, 40/30 amps., and the rated speed is 1,400 r.p.m. Standard ringing current and tones are supplied by two ringing dynamotors fitted with automatic change-over and mounted at the rear of the ringing panel.

This type of power plant has only recently been introduced into Post Office exchanges and this is the first P.A.B.X. at which it is installed.

The Change-Over.

The change-over from the old manual boards to the new system was made during the week-end, this time being the time most suitable as, except for night service lines, service ceases at 1.30 p.m. on Saturday.

Prior to the change-over date all the new lines had been teed to the old ones at a convenient point and tested to the instruments and then wedged out on the main frame.

Immediately work ceased and the old boards were

[4] I.P.O.E.E. Printed Paper, No. 156, p. 15.

officially free, the old exchange lines and extensions on night service were pegged up on the old boards and the wedges removed on the main frame. After they had all been tested O.K. they were plugged up on the new board for night service.

Engineering staffs waiting in the old switchrooms then proceeded to peg up the old boards and remove the fuses. On receiving the all-clear the officers in the apparatus room withdrew the wedges and immediately began testing. By 3 p.m. all lines had been cut over and a condenser test made. Three faults were reported, one of which was found O.K. on re-test.

The external staff next began the task of cutting away the tees while a staff detailed for the purpose checked each instrument and made a call to the test clerk who tested the speed of the dial and ticked off each number as it was tested. The work was carried on over the week-end and by 9 a.m. on Monday morning all lines were reported tested and all tees cut away.

Some idea of the task which the staff had to perform may be gathered when it is remembered that Somerset House itself covers a wide area and the instruments are distributed over this area in hundreds of offices and in offices in six other buildings in the surrounding neighbourhood ; 985 direct extensions with 183 parallel instruments had to be tested.

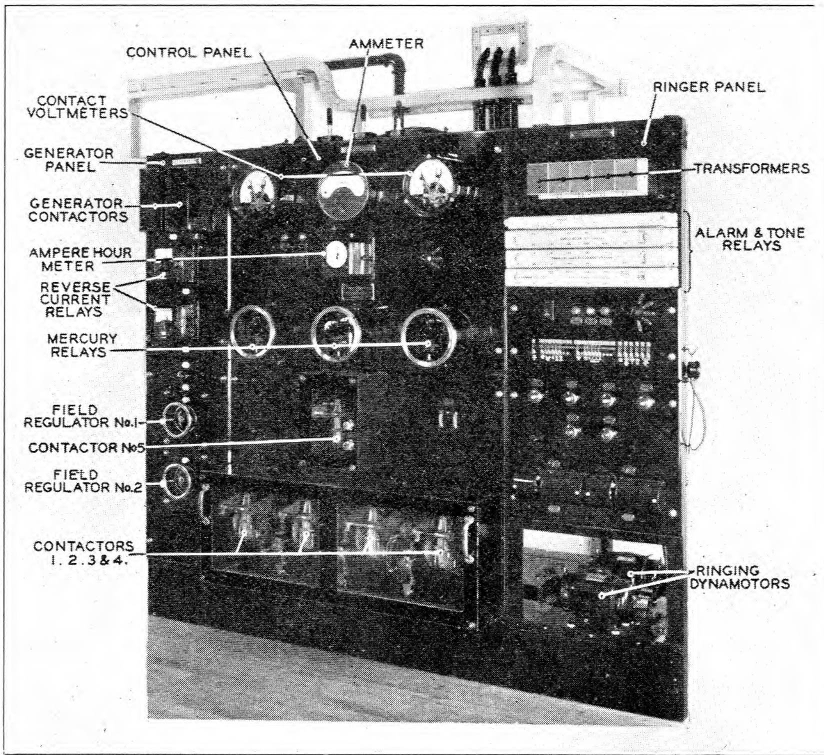


FIG. 9.—GENERATOR, CONTROL AND RINGER PANELS.

No real congestion was reported, and by mid-day the Inland Revenue Department staff appeared to have accustomed itself to the new system.

The manual board is staffed by male operators supplied by the Post Office as was also the practice on the old boards.

A New 54-Way Duct Route in Central London

G. B. W. HARRISON, B.Sc., A.M.I.E.E., and A. MILLER, A.M.I.E.E.

A description is given of the difficulties encountered in providing a new heavy duct route in busy West End thoroughfares, and also of the special measures taken to anticipate and overcome difficulties both above and below ground.

Introduction.

OXFORD Street is the principal direct highway by which one may leave the City of London for the west country and, naturally enough, under its surface are the main trunk cables for that part of England. Along the same route go a much larger number of junction cables serving exchanges in the London network. The original route was laid in this thoroughfare in 1900. Recently the necessity arose for providing further circuits to the west of England, for which the forecast growth is high. Although the use of 12-circuit carrier working for these new circuits reduces the underground duct requirements considerably, there is no longer any room in Oxford Street and a new route had to be projected.

One very natural objection to a new underground route through Oxford Street is the dislocation of traffic along such an important business thoroughfare. Such dislocation would inherently be severe because of the likely depth demanded for the ducts by the presence of existing underground plant. Depth is the result of seeking a straight horizontal route for the track without the expense of moving other undertakers' plant, or of adopting frequent changes of position, for example, from side to side of the road. Unfortunately, depth involves a great quantity of excavated material and a slow rate of progress, both of which are likely causes for public complaint. A partial solution to the problem of littering the road is to make a tunnel for the duct-work with a minimum number of shafts. There is then less soil to excavate and more undisturbed road on which to stack stores, plant and material.

Even with the advantages of tunnelling, the known presence of Post Office and other undertakers' plant precluded any attempt at an Oxford Street route. It was therefore decided to deviate from the direct route to one along Wigmore Street, Seymour Street, Edgware Road and Hyde Park (Fig. 1). The first two of these roads, one the continuation of the other, are some 200 yards north of and parallel to Oxford Street. Along at least half the length of these two thoroughfares it was hoped that tunnelling would not prove necessary.

Choice of Open Trench Work or Tunnel.

There are reasons other than the foregoing that may justify tunnelling when laying plant even at shallow depth. It may not be permissible when crossing a busy thoroughfare to disturb the road surface or other undertakers' plant or cellars may virtually prohibit direct access to the ground. The problem is usually settled by cost. The savings effected by tunnelling include a proportion of the cost of reinstatement, sometimes of the cost of carting away the spoil, if the police cannot permit it to remain on site, and greater independence from interruption of work by adverse weather conditions.

Unfortunately, the debit side of the cost statement is rather prominent. Tunnelling is not a navvy's but a miner's work, and it is, at its best, a slow job because of the cramped conditions for work and handling material. Worst of all, it is obviously difficult to supervise. It is the miner's job to work in these restricted spaces and make the tunnel safe with props and timbering. Collapse of the tunnel or movement of surrounding soil can never be risked because of the danger to life and to buildings in the vicinity. All timbering of the tunnel is a source of extra expense both directly and indirectly. In most instances the timbering must be abandoned *in situ*. For a 6-ft. tunnel at the present time it may be worth 50s. per yard run of tunnel. In addition, the timbering juts out and bays thus formed in the side of the tunnel have to be filled with best quality concrete.[1]

It is also necessary to leave some headroom in the tunnel so that the upper rows of ducts may be laid. This applies particularly in octagonal ductwork.

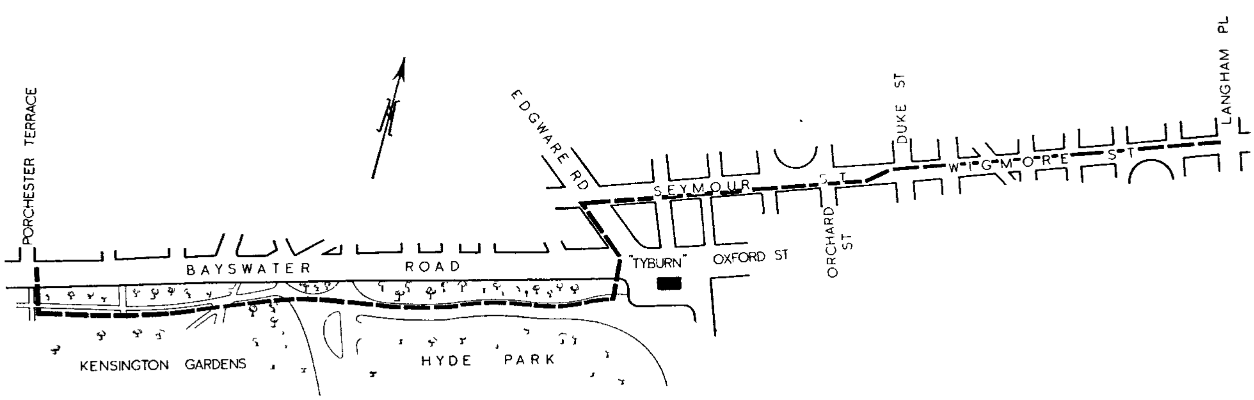


FIG. 1.—MAP SHOWING DUCT ROUTE.

[1] *P.O.E.E.J.*, Vol. 30, p. 94.

After the nest of ducts is completed an empty space on top of them, some 18 in. in height, remains. This also has to be filled in with concrete to avoid subsidence when, in due course, the timber tunnel roof rots. For this purpose the concrete quality need not be the best, and it is possible that in some sandy soils the excavated material might comprise one of the concrete ingredients.

It is hardly necessary to emphasise the disadvantage of deep manholes with which deep duct routes are naturally associated. Pumping water from them is difficult and will demand a special high lift pump if the depth is much in excess of 30 ft. The ventilation of deep manholes is, of course, a serious problem, and to provide for this special ventilating pipes may be led up to small dummy jointing boxes in the footpath. Two pipes are taken from near the floor level of the manhole and a current of air can thus be set up by opening the footway boxes or using a blower if necessary. The additional cost of such ventilating pipes is small if carried out with the main work.

water gave indications of sewage pollution, presumably due to leaks in old brickwork sewers along the course of the stream.

Spare ducts existed at shallow depths from Langham Place to the City and were sufficient for a few years ahead. The new route from Langham Place westwards had to be laid at a depth ranging from 20 to 32 feet measured to the floor of the track. A special manhole was, therefore, necessary at Langham Place to allow for tracks at different levels. This manhole is illustrated in Fig. 2.

The main obstruction to a shallow depth in Wigmore Street was a pedestrian subway crossing the road and joining two business premises. This subway completely blocked the subsoil for a depth of 18 ft., leaving only a space of 4 ft. between its roof and the road level; this space was largely taken up by other plant. Cellars from adjoining premises projected into the street for varying distances; some extended only to the kerb, others projected well into the carriageway. Sewer inlets were generally taken

The Soil encountered in Wigmore and Seymour Streets.

An emphatic objection to ducts at abnormal depths is the likelihood of encountering natural water. This involves working under difficulties, continual pumping, and possibly the extra expense of rapid hardening cement. In addition, the duct route will most probably be waterlogged because, in general, octagonal ductwork does not seem to be watertight. There is also an indirect danger from pumping due to the disturbance of the subsoil in the vicinity and consequent risk of subsidence.

Previous experience is probably the best guide in these matters. Other undertakers, e.g. gas or drainage, may be willing to give helpful information on the matter based on their own experience. In London, there are a number of quite well-known streams that have gradually been built over but are still encountered when excavating.[2] In the area concerned the one likely to be encountered was the Tybourne, which formerly crossed Oxford Street near Bond Street station and at one time caused the engineers building the Central London Railway a considerable amount of trouble. This stream was duly found in Wigmore Street near Marylebone Lane where it passes on its way from Hampstead Heath to the Thames.

Its presence was recognised by a change in the excavated soil from loose loamy sand to shingle and then to wet grey clay. Analysis of samples of this

[2] Information on this subject may be found in an interesting book, " Springs, Streams, and Spas of London," by Foord, published by T. Fisher Unwin.

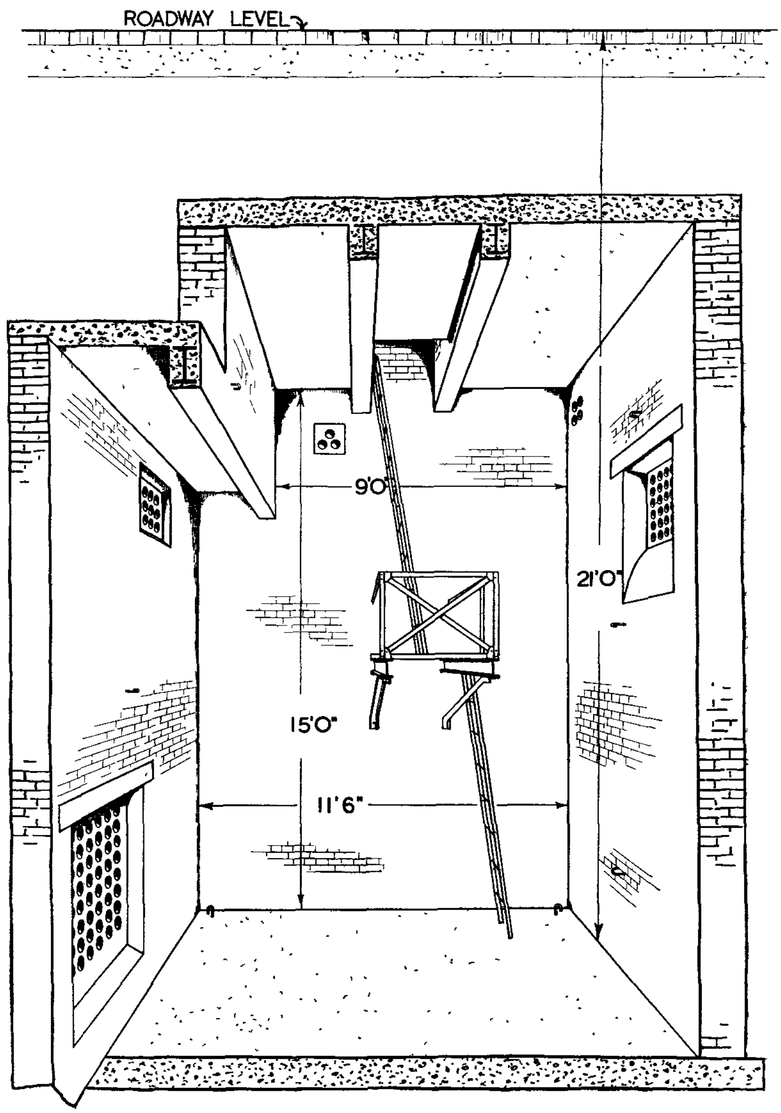


FIG. 2—MANHOLE AT LANGHAM PLACE.

from the floor level of these cellars entering the sewer at a depth of, say, 15 ft. A clear track was therefore impossible at a moderate depth. The average depth of the sewer to the invert was 19 ft., and it was essential to avoid weakening the lateral support to the sewer by excavating at its side. The ultimate course chosen was slightly below sewer level. The line of sewer inlets also prevented a gradual rise from one level to another when conditions were more favourable.

As a consequence of these obstructions, it was necessary to tunnel a length of 750 yards from Langham Place to Duke Street. Working shafts were excavated at intervals of about 30 ft. and headings driven from these shafts. The size of tunnel was 6 ft. 1 in. in height by 3 ft. 10 in. in width, accommodating a block of octagonal ducts 4 ft. 3 in. in height by 2 ft. 11 in. in width, including the concrete surround; 9-in. by 4-in. side and head trees were used, planted on 9-in. by 3-in. floor timbers. The working space to be filled with concrete after the top tier of ducts was laid was thus 1 ft. 10 in., less head trees and poling boards. The tunnel height was slightly increased where longer headings were necessary as when crossing beneath the sewer.

Arrangement of the Work.

Work was commenced from Langham Place early in November last. Two gangs were employed in Wigmore Street separated by a distance of about 500 yards. It was intended at that stage that each would proceed at a rate of about 50 yards per week and complete an appreciable portion in time to avoid serious disturbance to Christmas shopping and trade. However, this was not to be, and it was necessary to close down early in December.

The street was reopened shortly after Christmas and, at the time of going to press, the work is nearly completed, including the sections in Hyde Park and Kensington Gardens. A period of seven months has thus been taken for a total length of two miles. So far as the deep track was concerned the rate of progress was about 20 yards per week for each gang.

Changes of Level.

About halfway along the route from Langham Place to Edgware Road an opportunity arose to decrease the depth of the duct line. This was afforded by a diminution in the obstructions encountered, largely due to the smaller under-road cellars of private houses compared with those of shops. The north side of the road had so far been used for the new track, but it was now obstructed by a block of E.L. cables measuring 6 ft. in width and 11 ft. in depth, which made direct working shafts or manhole shafts impossible. Before the duct route could be allowed to rise it was first necessary to cross the road at a depth of 30 ft. This was sufficiently deep to clear the bottom of the sewer, the safety of which demanded a crossing as near as possible at right angles to its length. Although lessening the chance of disturbing the sewer, the cost of an additional manhole is incurred in a right-angled crossing. As a check that the sewer was not cracked by the work of the Post Office contractor, cement rings were made round its inside by the local authority. Before work was started the sewer was walked through by a Post Office representative to note its general condition and the soundness of the tell-tales.

At the next manhole after the road crossing the change in duct route depth was effected. Here the cables come into the manhole at 29 ft. below the road surface and leave at a depth of 12 ft. 6 in. These depths and others quoted are to the bottom of the excavation. The general requirements for this manhole were :—

(1) Safety for the staff using it.
(2) Convenience for handling cables.
(3) Convenience for jointing cables.
(4) That, if possible, the joints should not be normally submerged if water were present.

Two forms were proposed for the manhole and scale models made of each, with the result that the design shown in Fig. 3 was adopted. The alternative

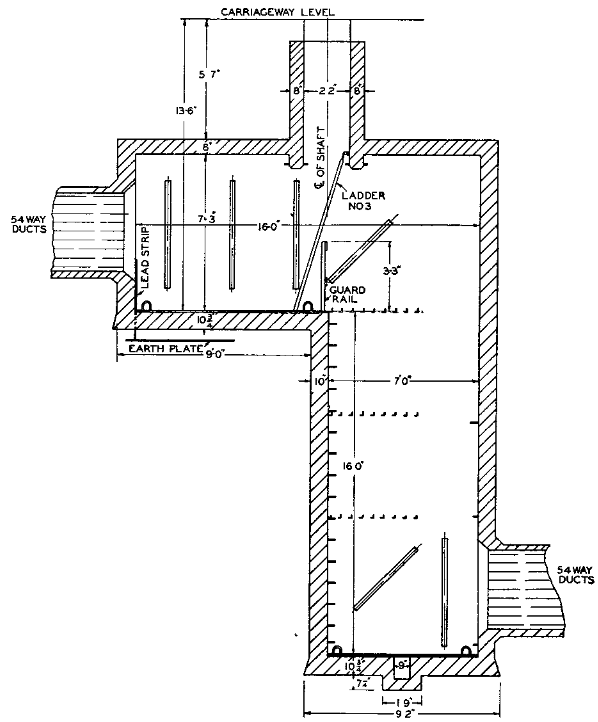


FIG. 3 —MANHOLE IN WELBECK STREET.

considered had a sloped floor comprised of a series of equal steps (18-in. rise and go), the cables rising diagonally across the length of the hole. This idea was rejected principally because of the difficulty of reaching the cables for jointing purposes. The manhole employed is constructed of reinforced concrete throughout with angle irons set in the concrete in the deep " shaft " for cable support. An angle iron is placed on the wall level with the upper floor to form a ledge for a temporary platform. Guard rails have been provided to avoid the risk of accident.

The route continued at a depth of about 10 ft. until near Edgware Road, where it was again necessary to drop to a depth of 20 ft. to cross Edgware Road. As the route will later be continued northwards in Edgware Road the manhole at this point is

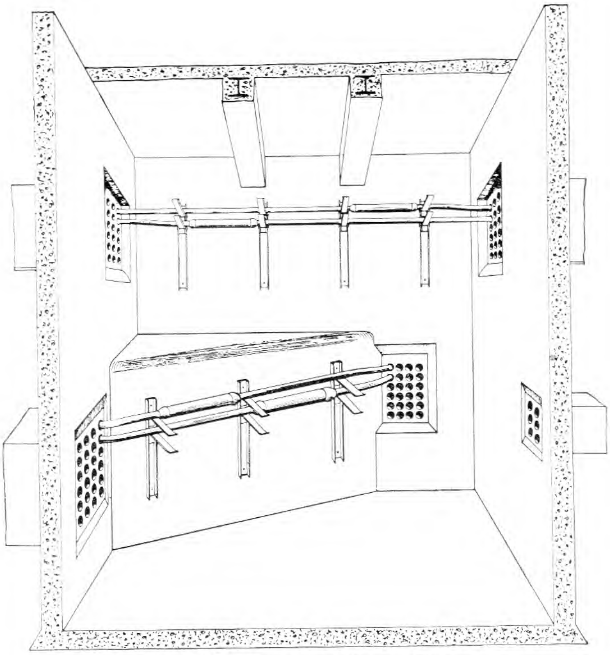


FIG. 4.—MANHOLE AT HYDE PARK.

triangular in shape on the lines of those shown by Mr. Baldwin in an article in this JOURNAL of October, 1932.[3] The route westwards was maintained at 20 ft. as a further deep crossing was involved at Bayswater Road by Tyburn Gate. Entering Hyde Park a further special manhole was necessary as routes were again at two depths. Here a benching was provided for cable bearers at the deep level (Fig. **4**). The route then took a gradual rise and continued through Hyde Park and Kensington Gardens at normal depth.

Co-operation of the Public.

Before opening up roads like Wigmore Street and Seymour Street something more than a wayleave is necessary. Even when every care is taken in heaping the soil and stores, it is, unfortunately, necessary to restrict access to many of the premises on route (see Fig. **5**). The police were largely instrumental in securing the goodwill of the public. After full discussions between the Post Office, the local authorities and the police, an officer visited many of the frontagers to ask their forbearance at the inevitable inconvenience that must arise.

Each time it became necessary to divert traffic or make one-way streets the police authorities were unsparing in their efforts and willingness to meet the requirements of local residents and of the Post Office. There is no doubt that the co-operation of the public contributed largely to the ease and rapidity with which the work was carried through. In return, as already mentioned, the Post Office gave a practical proof of their appreciation by closing down the work in Wigmore Street for a month at Christmas in order that traffic and business should not be dislocated during this important season. The closing down of works of this nature constitutes a problem by itself. There were, for example, manholes in course of construction and 30-ft. tunnelling shafts which were sufficient to block half the road even if work on them was stopped. Excavations that could not be filled in soon enough were decked over after special timbering had been installed to avoid collapse of the excavation wall due, for example, to traffic vibration. The method adopted to provide a safe bridge over a deep excavation can be seen from Fig. **6**. The traffic catered for was typical of inner London main thoroughfare traffic, buses constituting a considerable proportion of the heavy vehicles. Some deflection of the surface

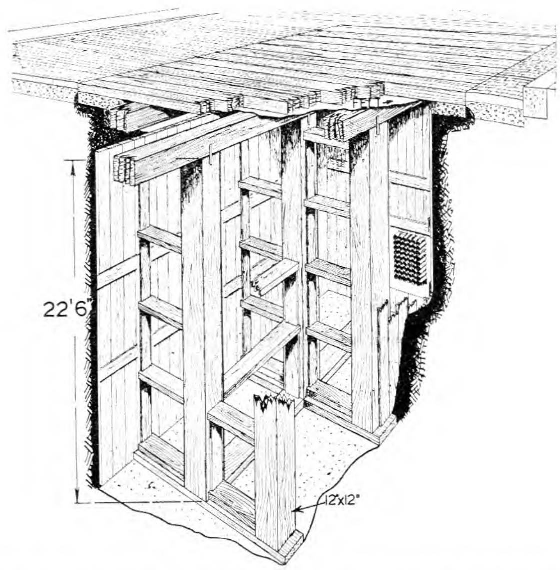


FIG. 6.—METHOD OF TEMPORARILY CLOSING AN EXCAVATION

FIG. 5.—WIGMORE STREET DURING OPERATIONS.

[3] *P.O.E.E.J.*, Vol. 25, p. 225.

The First London-Birmingham Cable

An historical survey is given of the first London-Birmingham cable, which has been in service for 40 years and is the oldest main underground cable in the world.

Introduction.

IT is an interesting coincidence that, while the latest type of telephone cable—the coaxial—is being put into service between London and Birmingham, the oldest main underground cable in the world (London–Birmingham No. 1) has been reconditioned for carrier telephone working.

As the cable was laid in 1898 it was difficult to obtain detailed information, but fortunately Mr. F. Tremain who, with another distinguished pioneer of telephony, the late Mr. A. W. Martin, was concerned with this cable, has filled in some of the gaps in the records and the writer is indebted to him for much of the information in this brief historical note.

Details of the Cable.

An article in " The Electrician " of January 27th, 1899, gives a description of the cable, which was made by the British Insulated Wire Co., of Prescot, Liverpool. According to the article :—"The cable employed at first was a 76-wire cable, the separate wires being laid up in fours, but, after the first 20 or 30 miles had been laid, a 76-wire cable with wires laid up in pairs was employed in preference. The remainder of the cable may, therefore, be described as follows :

"Copper conductors, 97 mils. diameter, weighing 150 lbs. per mile, are used. Each conductor is insulated with a longitudinal wrapping of paper, and laid up in pairs, there being a strip of paper dividing the two wires of each pair. The ' lay ' in twisting the pairs is 12 in. The pairs are arranged in layers of 1, 6, 12 and 19 to make up the complete 38-pair cable, and between each layer and between the last layer and the lead sheathing is a lapping of paper tape. It is a noteworthy feature that no cotton is employed in the cable, in fact, no insulation of any sort except dry paper and air.

" After the cable has been thoroughly dried it is lead-covered, the lead sheathing having a thickness of 160 mils., and the diameter over all is slightly over $2\frac{1}{2}$ in. The whole of the cable is of the British Insulated Wire Co.'s manufacture. Under the specification the capacity must be less than 0·065 microfarads per mile, and the insulation resistance above 10,000 megohms per mile ; but, as a matter of fact, the insulation resistance is greatly in excess of the latter figure, some tests on laid and jointed cable having given 28,000 megohms per mile. Such a high insulation resistance is not by any means exceptional for paper insulated telephone cables, but that it should have been maintained on a length of several miles of cable reflects great credit on the manner the jointing has been carried out.

" Three-inch cast-iron socket pipes carry the cable. These are laid in 9-ft. lengths, and jointed with lead in the usual way. The cable being in 152-yard lengths, of which one yard is left over at each end for jointing and slack, a discontinuity in the pipe 4 ft. 2 in. long is left at the end of each 150-yard section of the route. This is afterwards bridged by a cast-iron sleeve, as will be explained. The pipes are laid at a depth of 2 ft. under the footways and 2 ft. 6 in. under the roadways, with a wire for drawing in the pulling rope. In the event of a breakage in the wire, or a similar mishap, sweeps' rods are used to thread the pipe."

The choice of star quad, which had been patented, together with suitable quadding machinery, by Felten and Guillaume in 1892[1], seems to have been influenced by the example of the guttapercha quad cables formerly used for telegraphs and telephones, and of the twisted square formation then in general use on aerial lines. The star quad proved unsatisfactory, however, in respect of crosstalk (then called overhearing), and was laid only between Cricklewood

[1] Pat. 7029/92.

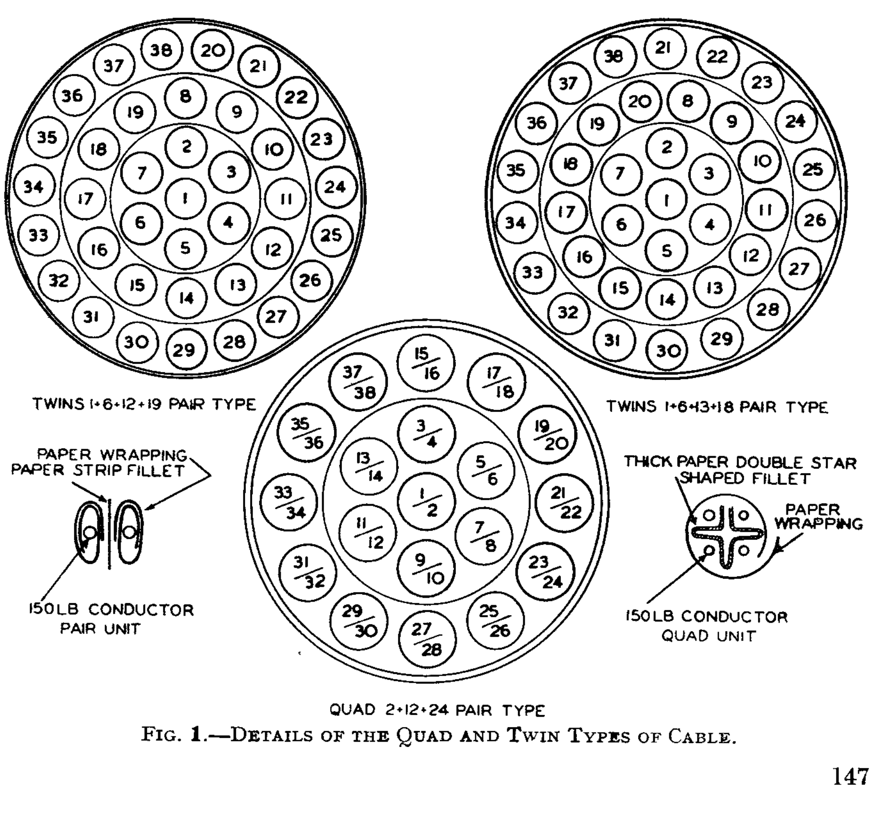


FIG. 1.—DETAILS OF THE QUAD AND TWIN TYPES OF CABLE.

and Eddlesborough, about 28 miles. Thence to Birmingham the cable is made up of twinned pairs, the formation being 1+6+12+19 pairs, except for a short length of 1+6+13+18 near Leighton Buzzard. From London (G.P.O.) to Cricklewood the 1+6+12+19 formation is used. Evidently this section, about 7 miles, was laid after the cabling had passed Leighton Buzzard.

The details of both quad and twin types are shown in Fig. 1.

The same lay of 9 in. was used for each quad and the paper is of the same light brown colour throughout. In the twin section also the paper is of the same colour, and the lay is 12 in. for all pairs.

Early Balancing Experiments.

As soon as the first part of the cable was laid some important experiments, which anticipated modern cable balancing, were begun. It was realised that capacitance unbalances were the cause of the overhearing, which was worst between pairs in the same quad. After numerous capacitance measurements a scheme of cross connection, at the test pillars which were inserted every four miles or so, was worked out. This scheme was practically what is now known as "systematic jointing." The cross-connections were the same at each test pillar and a diagram is given in Fig. 2.

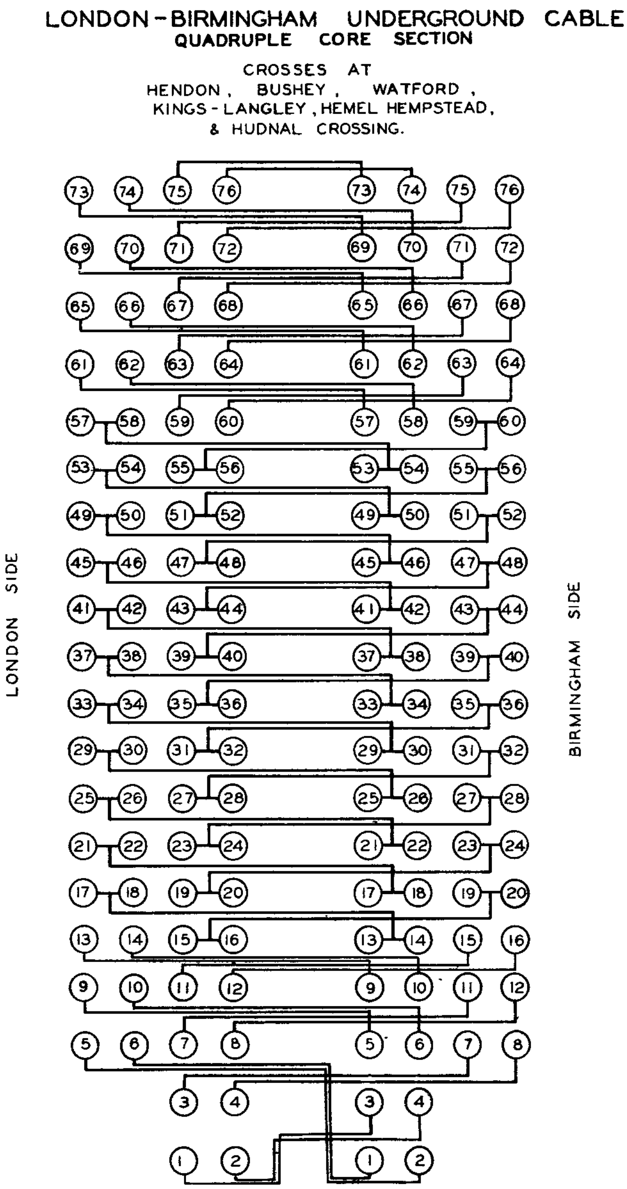


FIG. 2.

Apparently the cross - connection scheme was successful in reducing the crosstalk between pairs in the same quad. The crosstalk between pairs in different quads was satisfactory, and (according to measurements made when the cable was overhauled) about the same as that between adjacent pairs in the twin section. Typical figures are, for a five-mile length, 80 db. between adjacent twin pairs and 65 db. between pairs in the same quad.

In 1901 and 1902 some of the earliest loading experiments were made on this cable between Birmingham and Leamington. Quoting from Mr. Tremain's notes :

" The manufacture and laying of the Birmingham cable provided opportunities for many interesting observations. In the factory I think the most interesting were those which indicated insulation resistance to be a factor in the capacitance of a paper-insulated cable, as it was found necessary to keep the insulation per mile above 5,000 megohms, if the lowest possible capacitance results were to be obtained in a given case.

" Measurements were made on the cable completed between London and Birmingham at the end of 1899 and the beginning of 1900, the entire cable being equipped with telegraphic and telephonic apparatus with a view to ascertaining how far the former interfered with the latter. Mr. Gavey (Engineer-in-Chief) personally observed the results of these experiments at Leamington, and it was realised that the cable, although providing fair telephonic communication for experts between London and Leamington, could not be used for greater lengths than 50 miles for public purposes. In order, however, to render it useful for such circuits, and in consequence of the interference of neighbouring telegraphic circuits with each other, the loop system of telegraph working was devised, and proved effective.

" In the winter of this year (1900-1) I suggested the use of distribution cables in stock at Mt. Pleasant for loading experiments, the coils used in the first instance being ordinary telephone induction coils,[2] and subsequently similar bobbins wound with two pairs of twisted wire so that they could be connected in series or parallel to reduce the resistance and vary the inductance. The coils themselves were also grouped in this way in series and in parallel for the same purpose. The cables were in quarter-mile lengths, and sufficient was available to provide circuits varying in length from 2 to 40 miles. Inductance varying from 10 to 40 millihenrys being thus made available with resistances of $1\frac{1}{2}$ to 24 ohms, according to the disposition and number of the coils used at each point, switches were provided for connecting these

[2] Inductance = about 70 mH.

inductances in and out of the circuit, in which they were placed at $\frac{1}{4}$, $\frac{1}{2}$, 1, $1\frac{1}{2}$ and 2-mile points. The coils were also tried with and without iron, and the conclusion arrived at that iron was to be avoided if possible, the presence of iron increasing the volume at the expense of the articulation.

"The improvement in articulation and volume by the use of inductances was very noticeable, for it was made clear that the treatment would have to be closer than 5-mile points if good results were to be obtained, but that 2-mile points would probably be satisfactory. It was therefore arranged to experiment with the cable itself by erecting additional test pillars near Leamington. By this means access was obtainable to the cable at approximately 2-mile points. Good commercial speech was obtained through 140 miles, with the close spacing, and, with coils at 5-mile points, a marked improvement on the untreated cable. It was therefore decided to fit inductances in a pair of wires in the test pillars between London and Birmingham. The result, however, was rather disappointing, as the telephonic transmission was not so good as had been expected, and it was found on measuring the circuit that this was attributable to the fitting of the coils in iron boxes, which had very greatly increased the self induction of the circuit, and no doubt also introduced losses due to eddy currents.

The cable was at first used for telegraphs and telephones, Wheatstone loop circuits being worked interspersed with telephones. Loading coils were not applied commercially because of the difficulties of obtaining coils suitable for permanent installation. The total attenuation at 800 c.p.s. was about 30 db., and was regarded as too much even in those days; but the cable was used for trunk circuits between London and Fenny Stratford where it was connected to aerial lines. There must have been some invidious comparison, however, with the excellent volume and quality of speech over the heavy aerial trunk lines which then connected London and most of the big towns.

Perhaps this cable was somewhat before its time. If it had been loaded, it might have become the main telephone link between London and Birmingham, but at that time telephony was still regarded as secondary in importance to telegraphy, especially for long distances, and after the loading experiments described above were completed the whole cable was taken into use for telegraphs.

The Reconditioning

In 1920 the test pillars were cut out, only three testing points being left where the cable was led in at Fenny Stratford, Weedon and Leamington. It continued in use as a telegraph cable until 1934, when all long-distance telegraph circuits were converted to voice-frequency working. The whole cable was then handed over to the Research Branch to investigate the possibilities of applying modern technique and making economic use of the cable *in situ*. It was impracticable to pull the cable out and so realise its very considerable scrap value, because in many places the pipes were full of chalk and other sedimentary deposits. After some preliminary crosstalk measurements and the temporary use of a few pairs as 2-wire repeater circuits to meet the sudden demand for trunks when the shilling night rate was introduced, it was decided to straighten out the cable at the old test pillar points, where it had been jointed through without regard to telephone requirements, and to balance in 8-mile sections by means of A and B crosses at the centre points. When this had been done for a few sections it appeared that the crosstalk would be reasonably good and that the cable could be divided into two groups for 4-wire working at audio frequency, with repeaters at London, Fenny Stratford and Birmingham.

The whole cable was reconditioned in this way, and the crosstalk proved to be very satisfactory for audio frequencies. Nineteen 4-wire circuits are now working between London and Birmingham. At carrier frequencies up to 16 kc.p.s. (the range necessary for the 1+4 carrier system) near-end crosstalk was not good enough for 4-wire carrier working on the two groups, even with repeaters at Leamington to divide the long section between Fenny Stratford and Birmingham. Far-end crosstalk, however, could be balanced by means of small condensers at the end of each repeater section.

It would be possible, though hardly economic, to obtain about 70 London–Birmingham circuits by a modification of the 1+4 carrier system, working the voice and the first carrier band in one direction on a pair and the third and fourth carrier bands in the opposite direction on the same pair. This method would, however, involve specially designed filters, and impedance networks.

By dividing the cable into two groups, each pair in the first group carrying the voice channel, first and second carrier channels, and each pair in the second group the voice channel, third and fourth carrier channels, it is possible to obtain 57 circuits on the 38 pairs without special filters, etc.

As regards the constructional features of the cable, the excellent state of preservation in which it was found during the re-conditioning process is a tribute both to the contractors who laid the pipes and the manufacturers of the cable itself. Except where water had penetrated through the joints and deposited chalk, etc., in the pipes, the lead was either clean or covered with a thin layer of iron rust and there was no sign of corrosion. In the section along the Holyhead Road the pipe has become deeply buried in some places owing to road reconstruction, but this is rather an advantage from the maintenance point of view, as it is very unlikely to be damaged.

A. C. T.

Notes and Comments

Board of Editors

Readers will be interested to learn that Mr. P. J. Ridd, after an absence of three years, has returned to the Board of Editors as Chairman, to fill the vacancy arising from the retirement of Mr. Anson. Other newcomers to the Board are Mr. C. W. Brown and Mr. A. H. Mumford, who succeeds Mr. A. J. Gill. The list of members of the Board as now constituted is given on page 166.

Birthday Honours List

We offer our congratulations to all members of the Post Office staff mentioned in the Birthday Honours List. We are pleased to note that the following members of the Engineering Department have been honoured :—Mr. F. G. C. Baldwin, Chief Regional Engineer, North Eastern Region, who becomes an O.B.E., and Mr. C. J. Connelley, Skilled Workman Class I, Northern Ireland, who receives the Medal of the Order.

We also offer our congratulations to Mr. H. P. Brown, upon whom a knighthood has been conferred. Sir Harry, who is the Director-General of the Australian Post Office, used to be a Sectional Engineer in the City and an Assistant Staff Engineer in the Telephone Section of the Engineer-in-Chief's Office.

Mr. Frank Gill, O.B.E., Hon.M.I.E.E.

Mr. F. Gill's many friends will be pleased to learn that the Council of the Institution of Electrical Engineers have elected him an Honorary Member of the Institution. The award is made to " a person who is distinguished by his work in electrical science or engineering," and the present number of Honorary Members is 14. Mr. Gill, who was the last Chief Engineer of the National Telephone Company prior to the " Transfer," is now a Vice-President of the International Standard Electric Corporation, and is associated with other companies in the I.T. and T. system.

Erratum

The McGraw-Hill Publishing Co., Ltd., has drawn attention to an error in the price of one of their books reviewed in the April issue of the Journal. The book is "Measurements in Radio Engineering," by F. E. Terman, and the price should read 24/-.

Retirement of Mr. B. O. Anson, O.B.E., M.I.E.E.

Mr. B. O. Anson, Assistant Engineer-in-Chief, left the Department on the 30th June, 1938, after a total of 42 years' service. His departure leaves a gap in many phases of Post Office life which cannot easily be filled.

He entered the Post Office in 1896 as a Sorting Clerk and Telegraphist, holding this post for seven years. He was then transferred to the Engineering Department and after five years in a clerical capacity he received a technical appointment. After maintenance duties in Leeds and London, he was transferred to the Engineer-in-Chief's Office in 1911. In this position, not only was he responsible for the whole of telephone exchange maintenance, but he also played a large part in the introduction of automatic telephony into this country. Since that time, in spite of growing responsibilities, he has always been closely associated with this phase of our work and has had a continuous and determining influence on its development.

He became an Executive Engineer in 1920 and then rapidly rose to Assistant Staff Engineer (1925), Staff Engineer (1931) and Assistant Engineer-in-Chief (1934).

Apart from his work on automatic telephony in general, Mr. Anson will be especially remembered as chiefly responsible for the establishment of the Training School and the Circuit Laboratory. Not only did he play a leading part in the planning and equipment of these well-known organisations but he was their combined head for a number of years.

Mr. Anson was also very largely responsible for the development of automatic telephony in rural areas, the first milestone of which was the opening of Haynes U.A.X. No. 5 in February, 1929. Though the U.A.X. No. 5 is being superseded by a later type with a wider range of usefulness, there have been over 1,000 brought into service and the equipment has adequately served its purpose of providing a reliable telephone service in many a small and remote district.

In quite another direction Mr. Anson was largely con-concerned with the negotiations with telephone manufacturers of successive agreements for the purchase of exchange equipment.

During his long career Mr. Anson has visited America (1919), Holland (1923), Le Havre (1926), Shanghai (1929), Japan, Hong Kong, Singapore, and India (1929), Paris (1932), Holland and Belgium (1932), and Germany (1932) He has, as will be expected, served on numerous committees covering a wide variety of subjects, including technical, organisation and control, nomenclature, education, Whitley procedure, and promotion.

He was perhaps the chief inspirer of the very successful Telecommunication Conventions held at Swanwick in 1935 and 1937.

Of special interest to the readers of the JOURNAL will be Mr. Anson's work for the Institution of Post Office Electrical Engineers and for the Journal of the Institution. He has had long experience on the Council of the Institution and of many of its Committees, and has been a member of the Board of Editors for 16 years and Chairman of the Board continuously from 1926 to his retirement. At the time he took over the Chairmanship the circulation of the JOURNAL was just over 2,000, and its growth from that time has been continuous until the figure is now over 16,000.

Great as has been the influence of Mr. Anson's activities for the Department and for the Institution he will be long remembered, in addition, for outstanding qualities of personality. The energy and foresight which he displayed to a remarkable degree had in them such a quality of infection that all of those who had the privilege of working for him became imbued with the same spirit in a greater or less degree. An assiduous worker himself he had the knack of inspiring the confidence of his staff so that he was assured, at all times, of their willing and loyal help. He gave every encouragement to the younger members of his staff to use their initiative and to undertake responsibility. In spite of his many occupations he always found time for the social side of the Department and the staff found that many of their activities in sport and in art owed considerably to his interest and encouragement. Many of his colleagues have profited to no small degree by his wide experience of the Department and sound personal judgement which have been freely placed at their disposal.

These notes of his career cannot close without a brief reference to Mrs. Anson who, like himself, is a native of Yorkshire. He will agree that in his career he has always had the great support and encouragement that a happy married life can give. Their many friends in this country and abroad will wish them many years of happy retirement.

G. F. O.

A. J. Gill, B.Sc., M.I.E.E., M.Inst.R.E.

Mr. A. J. Gill, who has just been appointed Assistant Engineer-in-Chief in succession to Mr. B. O. Anson, gained early engineering experience in Yarrow Shipbuilding Yard and at the British Thomson-Houston Works at Rugby. Entering the P.O. Engineering Department as Assistant Engineer by open competitive examination in 1913, Mr. Gill was attached to the Radio Section, in March, 1925 was appointed Executive Engineer in charge of the radio experimental section at Dollis Hill, became Assistant Staff Engineer in December, 1929, and in December, 1932, succeeded Colonel Angwin as Staff Engineer of the Radio Branch. During his term of office in that capacity, Mr. Gill has been responsible for the direction of many new developments which have considerably enhanced the prestige of the Department.

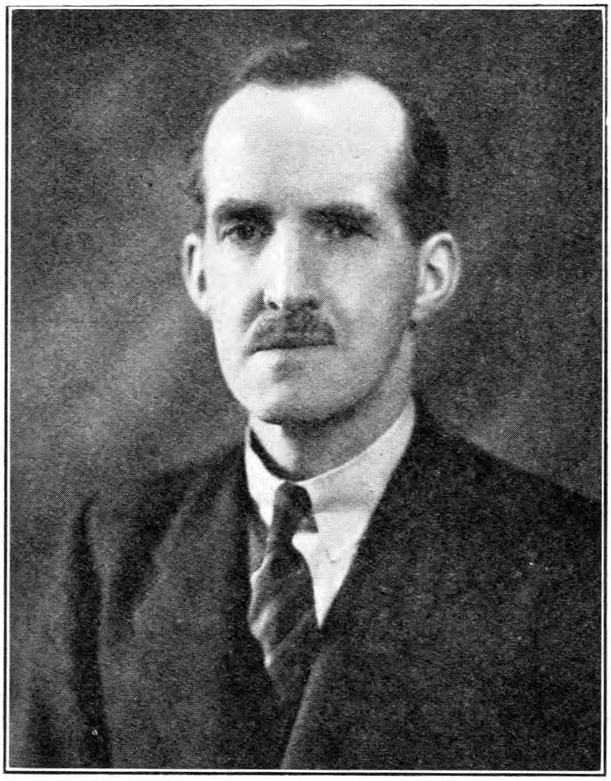
Mr. Gill has made several valuable contributions to scientific journals and has been honoured this year by being elected Chairman of the Wireless Section of the Institution of Electrical Engineers. He has served on many Committees, including the C.C.I.R., C.C.I.F. and that of the Department of Scientific and Industrial Research. He is an ardent motorist, with a penchant for high-power cars, and a keen amateur cinematographer.

Mr. Gill has shown himself to be endowed with the rare qualities of an unusually fertile mind which produces a continuous flow of new ideas, and a fixed belief that difficulties are only made to be surmounted.

His promotion to Assistant Engineer-in-Chief has brought keen satisfaction not only to his Engineering colleagues but also to his many friends in other branches of the Service, who will wish him, with confidence, every success in his new sphere of activities.

J. A. G.

J. Morgan, A.R.C.Sc., A.M.I.E.E.



Mr. J. Morgan, who became Superintending Engineer, South Western District on July 1st, received his technical education at the Imperial College of Science, and the City and Guilds College.

In April, 1913, Mr. Morgan entered the Department's service by open competition as Assistant Engineer and was assigned to the Lines Section. Two years later he was transferred to the South Western District, Exeter Section. He served in France as a Commissioned Officer, R.E. Signals, from 1916, and on demobilisation returned to his old Section and remained there until 1925. In that year the conversion of the exchanges in the Torquay area to automatic working was carried out successfully under his control, the first conversion of its kind in the South-West of England.

On completion of this work he was transferred to the Lines Section at Headquarters, where he was engaged in the design and layout of multi-office areas.

On promotion in December, 1929, he returned to Exeter to take charge of the Section. In May, 1934, he was appointed Assistant Superintending Engineer, Scotland West District, and became Regional Engineer on the formation of the Scottish Region in February, 1936. He returned a little later to the South Western District as Assistant Superintending Engineer.

Mr. Morgan's progress in the Department has been earned as an able, conscientious, yet unobtrusive worker, and his clear thinking and sound judgment will stand him in good stead in his capacity as Superintending Engineer. His impartiality and honest dealing has earned for him the respect and good wishes of the staff in the District with which his long experience has enabled him to become familiar.

W. F. B.

A. H. Mumford, B.Sc.(Eng.), A.M.I.E.E.

Mr. A. H. Mumford, who follows Mr. Gill as Head of the Radio Branch, entered the Post Office service by open competition in 1924 upon completion of his studies at East London College, where he had obtained his B.Sc. in Engineering with first class honours.

Mr. Mumford has spent the whole of his official career in the Radio Branch, where his particular aptitude for experimental work was quickly recognised and led in 1925 to his location at the Radio Laboratories at Dollis Hill. Here his energy and genius have played a major part in all the development work associated with short and ultra-short wave telephony and more recently with the development of the equipment for multiple-circuit working over coaxial cables and with television.

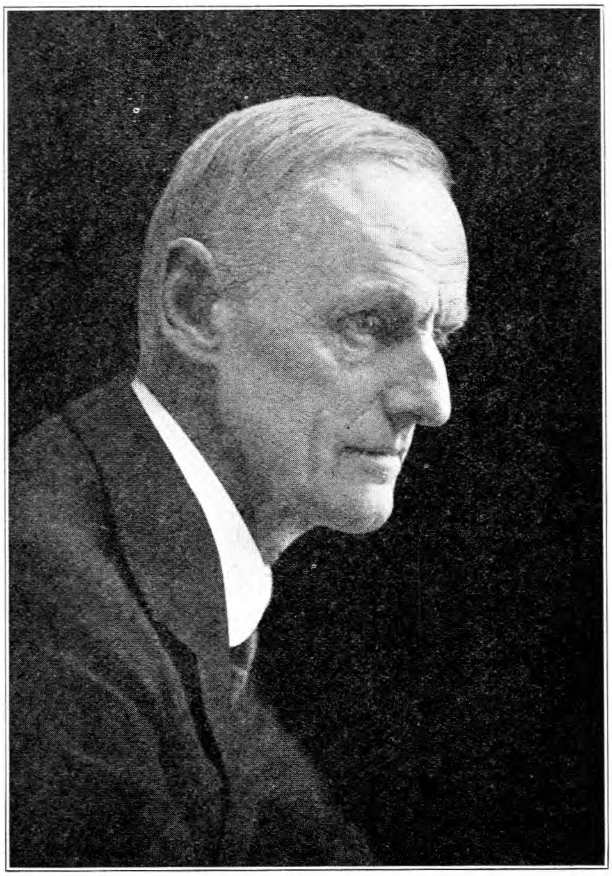
In 1927 Mr. Mumford visited Canada and U.S.A. in connection with the Transatlantic Telephony Service, and in 1934-35 took part in conferences held at Berlin dealing with the question of interference to broadcasting.

Mr. Mumford is a member of various committees of the Electrical Research Association and of the Radio Research Board, and has recently completed a term of office as a member of the Wireless Section Committee of the Institution of Electrical Engineers. He is well known as a contributor to the JOURNAL and was recently awarded the Senior Silver Medal of the I.P.O.E.E.

Mr. Mumford has always taken an active interest in the welfare of his assistants and has done much to establish a healthy team spirit in the large staff under his control. The good wishes of all who have had the pleasure of associating with Mr. Mumford will go with him in his new sphere of responsibility.

F. E. N.

Retirement of Mr. P. T. Wood, M.I.E.E.



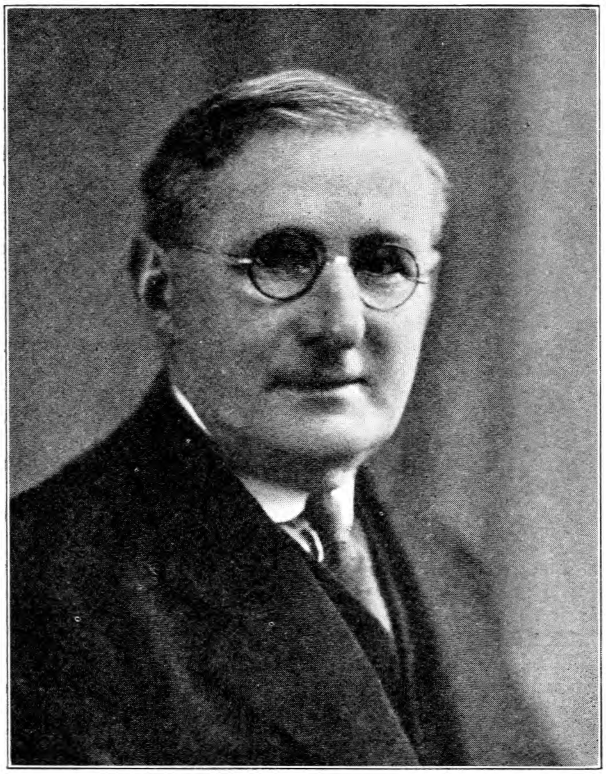
Mr. P. T. Wood, Superintending Engineer of the South Western District, retired from the Service on June 30th. He entered the service of the National Telephone Company in 1894 and became Assistant Electrician of the City District in 1903 after a short period of service with the United River Plate Telephone Company in Buenos Aires. He was promoted to the position of Assistant Metropolitan Electrician in 1907, and at the "Transfer," became Sectional Engineer of the newly formed Centre Internal Section. In 1924 Mr. Wood was transferred to the Equipment Section of the Engineer-in-Chief's Office as Assistant Staff Engineer and effected the initial organisation of the Standards Group responsible for standardisation of exchange circuits and apparatus.

In 1931 Mr. Wood was appointed Superintending Engineer of the South Western District. The ensuing seven years were years of exceptional expansion of plant and of the District staff, and afforded ample scope for engineering control and, particularly, for Mr. Wood's well-known interest in all matters relating to the staff. His courtesy and kindliness of manner made him approachable by all ranks, and these qualities are acknowledged and greatly appreciated throughout the South Western District.

Mr. Wood served as a member of the Committee of the Institution of Electrical Engineers (Western Centre) 1935/38. He is at present Chairman of the Bristol, West District, Boy Scouts Association and a member of the Bristol Choral Society.

In his earlier years Mr. Wood was noted for his long distance walks and, happily, he retains a vigour without which he could not hope to complete the strenuous tasks he has undertaken at the delightful country home to which he will retire. His many friends wish him a most successful issue to his labours as a landscape gardener, and hope that he may share with Mrs. Wood many years of health and happiness. P. J. R.

Retirement of Mr. T. Cornfoot, M.I.E.E.



Mr. Thomas Cornfoot, the Superintending Engineer of the South Midland District, retired on April 30th, 1938. A product of George Heriots School, Edinburgh, he joined the service of the late National Telephone Company as a telephone fitter in 1897. Some years after he was sent to Glasgow to assist on what was known as the "Glasgow re-construction," a work undertaken as a result of public agitation against the telephone service in that city. Returning to Edinburgh in 1903 he was promoted Switchroom Manager. During 1907 he was engaged on the original inventory of Edinburgh which served as a try-out scheme for the general inventory of the country undertaken prior to the transfer to the Post Office of the National Company's plant. In September, 1907, he was appointed Electrician at Edinburgh, and in this capacity afterwards served in Birmingham (1910) and Liverpool (1911). When the transfer took place he was made Executive Engineer at Liverpool. Promoted Assistant Superintending Engineer at Croydon in 1929 and transferred to North Ireland as Acting Superintending Engineer the same year, he returned from Ireland to take charge of the South Midland District in 1932.

Mr. Cornfoot's genial personality has made him many friends both within and without the Post Office. He has always taken a keen and kindly interest in all matters affecting the staff and his cheerful presence will be missed at the numerous staff gatherings which he never failed to support and where his witty after-dinner speeches were greatly appreciated. He enjoys a round of golf and we trust that with the continuance of his present good health he will be able to spend his leisure pleasantly and profitably. F. P.

The Institution of Post Office Electrical Engineers

RECENT ADDITIONS TO THE INSTITUTION LIBRARY

New Books.

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1367 Course of Pure Mathematics.—G. H. Hardy. (1938, Brit.)
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1369 Dare You Speak in Public?—A. Duxbury. (1938, Brit.)
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Vol. I. The Equation, the Formula and the Graph.—H. M. Keal and C. J. Leonard. (1938, Amer.)
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New Editions.

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821 J. and P. Transformer Book: A Practical Technology of the Power Transformer.—S. A. Stigant and H. M. Lacey. (1937, Brit.)
914 Principles of Radio.—K. Henney. (1938, Amer.)
979 Photoelectric Cell Applications: A Practical Book Describing the Uses of Photoelectric Cells in Television, Talking Pictures, Electrical Alarms, Counting Devices, etc.—R. C. Walker and T. M. C. Lance (1938, Brit.)

Local Centre Notes

London Centre

During the 1937-38 session the London Centre held fourteen meetings. They were:

Ordinary Meetings—

1937.

October 5th. — D. W. Glover, M.Sc., A.I.C.—"Chemistry and Communications."

November 9th. — M. G. Holmes, B.Sc.(Eng.), A.M.I.E.E.—"The Work and Functions of the Efficiency Engineer."

December 14th.—W. E. Chinn, A.M.I.E.E., and H. O. Ellis, A.M.I.E.E.—"Impulsing Aspects of Automatisation."

1938.

January 11th.—J. J. Edwards, B.Sc.(Eng.), A.C.G.I., D.I.C., A.M.I.E.E.—"Equipment and Materials for External Works: A Few Recent Developments."

February 8th, 1938.—J. F. Doust and W. J. Sulston, M.Sc., A.Inst.P.—"Properties and Testing of Dielectrics."

March 8th.—C. A. R. Pearce, M.Sc., A.C.G.I., D.I.C.—"Some Recent Developments in Subscribers' Apparatus."

May 10th.—G. J. S. Little, B.Sc., A.M.I.E.E.—"Twelve-Circuit Carrier Systems."

Informal Meetings—

1937.

October 26th.—A. C. Timmis, B.Sc., A.M.I.E.E.—Vice-Chairman's Address—"Research."

November 23rd.—R. W. Palmer, A.M.I.E.E.—"The Selection of Workmen for P.O. Recruitment or Promotion."

1938.

January 25th.—S. Thompson—"Tones: Past, Present and Future."

February 22nd. — R. T. Robinson, A.M.I.E.E., A.M.Inst.T.—"Recent Developments of Engineering Transport and the Trend of Engineering Motor Transport Costs."

March 22nd.—W. T. Wooding—"Maintenance Problems in Auto. Exchanges and their Reactions on the Service."

April 5th.—Arthur Duxbury—"Public Speaking for Engineers."

April 26th.—W. E. H. Kennedy — "Engineering Instructions and Allied Publications."

The Chairman and Vice-Chairman for the session were Mr. R. G. de Wardt, M.I.E.E., and Capt. A. C. Timmis, B.Sc., A.M.I.E.E., and their conduct of the ordinary and informal meetings respectively was much appreciated.

Most of the meetings were well attended, the number present averaging 260 at ordinary meetings and 170 at informal meetings, but the star turns were undoubtedly Mr. Little's lecture on May 10th, which filled the I.E.E. Lecture Theatre (about 400 present) and Mr. Duxbury's lecture on April 5th which produced an attendance nearly as large. Mr. Little very helpfully produced his paper at very short notice when it was found necessary to change the programme. Mr. Duxbury's lecture represented a departure from usual practice and resulted from a suggestion made by Mr. E. S. Byng of Standard Telephones & Cables, Ltd. Several members asked that Mr. Duxbury's lecture should be printed, but that was not possible as a book incorporating much of his material was at the time in course of production. The book has since been published. A copy can be borrowed from the Institution library.

The session's visits were commenced by clearing off outstanding visits to the works of the Gramophone Co. at Hayes. Then followed visits of about 650 members to the headquarters of the L.C.C. Fire Brigade to inspect the fire alarm equipment and see an impressive demonstration of fire fighting. After Christmas followed visits to the battery works of Messrs. Pritchett & Gold and E.P.S. Co., and to the lamp works of the General Electric Co. at Hammersmith. Both visits were made in sections to accommodate all those members who wished to take part. With the membership of the London Centre approaching 1,700 it is rarely possible to find an organisation which can admit at one time all those members who are interested. H. E B.

North Wales Centre

The sixth meeting of the 1937-1938 Session was held at 2.30 p.m. at the usual Shrewsbury rendezvous, Morris's Ballroom, Pride Hill, on Thursday, March 10th, 1938.

The Chairman, Mr. H. Faulkner, presided over a gathering of 132 members and visitors to hear Mr. C. L. Topham, Chief Inspector, Stoke-on-Trent, give a paper entitled "Practical Transmission Measurements." The paper was well illustrated with a large number of slides showing apparatus and circuits, together with typical tests, while the actual apparatus mentioned was on view at the meeting. Of particular interest were the father and mother of the present noise generator which were loaned from the Dollis Hill Research Laboratory. The Chairman, in opening the discussion, said that a very clear and simple paper had been heard and the author was to be congratulated. Faraday once said that nothing was known about anything until it could be measured and the paper had given a simple account of how Telephone Transmission was measured. With the issue of noise generators to maintenance men and the equipment of test desks with the necessary measuring instruments now taking place, it was hoped that the staff would co-operate to bring the District to the forefront with regard to the quality of its transmission. Many members took the opportunity to discuss the paper and the meeting finally terminated at 5.15 p.m. with a hearty vote of thanks to Mr. Topham, seconded in the usual manner by the assembly.

The seventh and final meeting of the session took place at the works of the General Electric Co., Ltd., at Stoke, Coventry, on April 7th, 1938.

Members from all over the North Wales District converged on Birmingham to that familiar landmark, Telephone House, from which, at 1.15 p.m., four streamlined coaches bore 120 members to Coventry.

Arriving at 2.15 p.m. the party was met by the General Manager of the Telephone Works, Mr. H. P. Wells, and other representatives of the Company, and conducted to the magnificent ballroom of the Magnet Club, with its fountains, modern concealed lighting scheme, theatre stage and cinema.

In welcoming the Chairman and members of the North Wales Centre of the I.P.O.E.E., Mr. Wells said that the Company was always glad to see its customers, particularly representatives of its biggest customer, the Post Office Engineering Department. He then introduced Mr. Malcolm, Production Manager of the Company's Telephone Apparatus Works, who gave an interesting talk on "Telephone Apparatus Manufacture."

With the aid of a large plan of the works he illustrated how the various shops and processes were arranged so that the raw material came in at one end and the finished apparatus passed out at the other. The manufacturing stages of various articles of telephone apparatus were easily seen by means of boards bearing samples of the article as it passed each stage of manufacture.

Among the statistics given were those that the condenser shop turns out 2,100,000 condensers per year, and that one of the best girl operatives engaged on multiple-bank wiring of automatic apparatus solders 2,400 tags per hour, an item which an Executive Engineer member of the party later tried to verify in actual practice with his watch. An improvement in the Performance Rating for Terminations is shortly expected in the—Section.

At the conclusion of this excellent talk the main party was split up into small groups of ten to a guide and conducted round the factory to see in practice what had been explained to them.

Two hours later, tired but still interested, the groups rejoined at the Magnet Club to enjoy a delightful tea, after which any questions arising out of what had been seen were answered by Mr. Malcolm.

The Chairman of the North Wales Centre, Mr. H. Faulkner, proposed a hearty vote of thanks to the General Electric Company, Mr. Wells and Mr. Malcolm, for the excellent afternoon that had been spent, a vote that was heartily seconded by all in the approved manner and to which Mr. Malcolm responded on behalf of the Company.

The party finally left the Works at 5.30 p.m. for Birmingham and their homes as far away as Bangor.

As the demand to go to this meeting was larger than usual it was necessary to limit the party to 120, and a second party of 120 visited the Works on April 28th, 1938.

This concluded the activities of the Centre for the session 1937-38, the membership having increased during the year from 255 to 355, or by 40 per cent.

S. T. S.

Scottish Centres

The Scottish I.P.O.E.E. prizes awarded by the Co-ordinating Committee of the Scottish Region for Workmen's Classes in Telephony, Telegraphy and Transmission at Edinburgh, Glasgow and Aberdeen, have been won by the following students:

Edinburgh.	
Telegraphy and Telephony I ..	G. B. Newton
Telephony II	H. Cooper
Glasgow.	
Telephony I	A. McPhail
Telephony II	W. P. Sandeman
Transmission I..	W. P. Sandeman
Aberdeen.	
Telephony I	R. G. Macaulay
Telegraphy I	J. Skene D. S. N. Peters

Congratulations are offered to the successful students and it is hoped their success will encourage further study and act as an incentive to others.

Junior Section Notes

Bradford Centre

Despite the two main obstacles, i.e. late duties and evening classes, which have prevented many members from attending meetings, the Bradford Centre is flourishing, and the keenness of the staff evinced in the activities of the Section during the past session has been very encouraging. The membership now tops the 60 mark, and at least half of this total is usually present at meetings.

On January 27th a Youth-in-Training outlined his impressions and opinions in an unusual type of paper on " My Experiences as a Youth-in-Training." This was followed by a keen discussion on the training afforded to youths in general and the direction in which improvement could be effected. The Department's syllabus for the training of youths was ably explained by a member of the Senior Section who was present.

In view of the conversion of the Bradford C.B. Exchange to automatic working in 1940, it is particularly gratifying to note the evidence of the keen interest displayed by the staff in automatic systems. No less than 35 members attended at the Thornton U.A.X.7 on February 3rd, where demonstrations and practical explanations of the working of such an exchange were afforded by three of our members. Thanks to the efforts of these members, everybody present gained some insight into the intricacies of linefinder working.

Other meetings have included a visit to the Shipley C.B.10 exchange for practical explanations of Straightforward Junction working, and the delivery of papers on such varied subjects as Wayleaves and Coaxial Cables.

The paper on Coaxial Cables delivered by two members of the Senior Section evoked great interest at a well-attended meeting held on February 24th, and the broad principles of carrier working and their applications to a pair of conductors in the form of a central conductor and a coaxial tube were fully appreciated by many of the members for the first time. The most significant points to many of those present were the freedom from interference which was gained by the use of such a pair of conductors, the development of modern amplifiers for handling a very wide frequency range, and the fact that the coaxial cable formed a combination of a telephone cable, a television cable and a power cable. An interesting discussion followed and many queries were raised for the attention of the lecturers.

The forthcoming session will commence with a visit to the B.B.C. North Regional Station at Moorside Edge, on September 24th, and a varied and educative programme, including a lecture on Radio and Television is being arranged.

The officers elected for next winter's activities are Messrs. A. Dobson (Chairman) and A. Annall (Secretary), and members are particularly asked to make every effort to attend the meetings so that their main objects of education of the staff, and development of their ability to discuss technical subjects may be realised to the fullest extent.

Newbury Centre

A meeting of the staff was held in March, when the objects of the Junior Section were explained by our Assistant Engineer, Mr. H. Mortimer, A.M.I.E.E., after which it was unanimously agreed to inaugurate a centre in this area for the session 1938-39. The following officers were elected for the session :—

Chairman : O. Weeks
Secretary : E. F. B. Seaward
Treasurer : W. H. Crosby
Committee : V. H. Wing, C. J. Orchard.

From the following list of papers to be read it will be seen that the Committee have endeavoured to cover a wide range of subjects :—

October.—" Faults and Maintenance Costs." H. Mortimer.
November.—" Primary Vouchers." E. J. S. Roberts.
December.—" Transmission." H. Buy.
January.—" Cable Corrosion." M. W. Neville.
February.—" U. A. X. Construction." S. T. Windsor.
March.—" Wireless Interference." E. Pring.

A very keen interest is being displayed by the staff which indicates the success of the newly formed centre.

Preston Centres

This quarter has seen the closing of an excellent session at each of the Junior Centres in the Preston Section. The old centres in Blackpool and Preston and the newly formed centre at Southport have had average attendances of not less than 20 each, and on a number of occasions the attendances have been as high as 40. One of the members, Mr. J. Singleton, was one of the successful prize winners in the Essay Competition with his paper—" Local Lines—The part played by the Sectional Engineer's Drawing Office in the Organisation of the Engineering Department."

Reading Centre

The programme for the session 1938-39 has been arranged as follows :—

October.—" External Construction." G. W. P. Hills.
November.—" Traffic Branch Organisation." L. G. Hawker.
December.—" Cable Corrosion." M. W. Neville.
January.—" U.A.X. Construction." S. T. Windsor.
February.—" General Survey of Sales Work." L. Hunt.
March.—" Advice Note and MW Control." H. F. Butler.

The syllabus is vastly different from that of the last session and it is interesting to note that representatives of the Traffic and Sales Branches have kindly consented to give us papers on subjects with which we are not very familiar. The two papers should prove of particular interest to the members. It is hoped that with such an excellent syllabus there will be a large increase in the membership.

Southampton Centre

The thanks of the Committee and Officers of the Southampton Centre Junior Section are due to all those members who have maintained their interest and assistance during the past session, also to the following senior officers who have supported the lectures :

Mr. F. W. Friday, A.M.I.E.E. (Sectional Engineer).
Mr. S. Moody, A.M.I.E.E. (Assistant Engineer).
Mr. G. J. Millen, A.M.I.E.E. (Assistant Engineer).
Mr. C. H. Davidson (Chief Inspector).
Mr. C. Steedman (Chief Inspector).
Mr. L. F. House (Chief Inspector).
Mr. C. S. Hale (Inspector).
Mr. W. R. Holt (Inspector).
Mr. E. W. Neall (Inspector).
Mr. J. R. Walters (Inspector).
Mr. A. F. Mockford (Inspector).
Mr. E. A. Plummer (Inspector).
Mr. A. H. Biles (Inspector).
Mr. R. T. Kimber (Inspector).
Mr. W. Harknett (Inspector).

The Salisbury, Winchester and New Forest area colleagues have also been welcomed.

The 1937-38 Session now being ended a brief resumé is given of the work for the year. With a membership of fifty-two and visitors, the following programme has been followed :

October.—" The Relationship of the Drawing Office to the Department." B. F. Wicks.
November.—" U.A.X.s No. 13." S. E. Harvey.
December.—" Unit Construction Costs." V. Smith.
January.—" Repeaters." A. G. Chuter.
February. — " Films of Topical Engineering Interest " projected by Mr. B. F. Wicks with the co-operation of Dr. D. F. Lang.
March.—" Elementary Principles of Wireless Reception and Interference." S. Cox.

Our thanks are due to Mr. C. P. Milton and the Dollis Hill staff for the loan of films and slides, and to Professor Menzies of the Southampton University College for the loan of the projector, which was operated by Mr. R. Savell.

The programme for 1938-39 Session is about to be compiled, and all members of the staff are invited to send in a proposed subject from which a selected number will be chosen. The junior members and the new entrants to the Service are especially asked to join the Junior Section in order to acquire knowledge of the different phases of activity within the Engineering Department.

The retiring officers are :

Mr. C. S. Hale (Chairman).
Mr. E. Andrews (Vice-Chairman).
Mr. N. E. Dodridge (Secretary and Treasurer).
Messrs. F. Baker, R. White, S. E. Harvey, L. T. Jennings and W. Page (Committee).

Finally—

The Service offered by the Library of the Institution includes an extensive selection of volumes on Engineering, Scientific and General Educational themes, all being accessible to members of the Junior Section for the inclusive small fee of membership.

N. E. D.

Windsor Centre

It was decided at an enthusiastic meeting of the staff in the Windsor, Slough and Maidenhead areas held in March, to form a centre for the session 1938-39.

At the meeting the objects of the Junior Section were ably explained by Mr. H. Mortimer, A.M.I.E.E., Assistant Engineer.

The following officers were elected :

Chairman : E. H. Hillard.
Secretary : S. W. Wiltshire.
Treasurer : I. J. Webb.
Committee : H. S. E. Golding, J. Gray, R. Simms.

A very interesting and instructive programme has been arranged and it is hoped that plenty of discussion will ensue, as the subjects cover a wide field of the Department's activities :

October.—" Faults and Maintenance Costs." H. Mortimer.
November.—" Ministry of Labour Training Centre —External Work." G. P. Hills.
December.—" Works Supervision." G. A. Wiltshire.
January.—" Cable Corrosion." M. W. Neville.
February.—" Wireless Interference." E. Pring.
March.—" Surveys." F. J. Fuzzens.

It may interest other Sections to note that the three centres fully cover the whole of the Reading Section. Can you equal it ?

District Notes

London Telecommunications Region

NEW AUTOMATIC EXCHANGES

Six new automatic exchanges, including one U.A.X. No. 7, have been opened in the Region since the beginning of the year. The following details with regard to each of them will no doubt be of interest.

Mountview Automatic Exchange. This exchange which serves the Hornsey area was opened on 24th February at 1.30 p.m. with approximately 6,500 lines and 800 junctions. The exchange, which was installed by the A.T.E. Company, is situated at Crouch End Hill, N.8, in the latest type of building. The manual board is situated at Archway exchange.

Wheathampstead, Hertfordshire. An automatic exchange of U.A.X. No. 7 type was opened on March 18th with approximately 100 subscribers. The parent exchange is St. Albans.

Laburnum Exchange. This exchange which serves the Winchmore Hill district was installed by Siemens Brothers and was opened on March 30th with approximately 2,400 subscribers from the hypothetical Laburnum exchange, and from Enfield and Palmers Green exchanges. The initial capacity is 3,000, ultimate 6,100, and the manual board is situated at Bowes Park exchange.

Riverside Exchange. This exchange was installed by Ericsson's and the transfer of subscribers from the old manual took place on 21st April. The initial capacity is 5,400, ultimate 7,700, and the manual board is situated at Western exchange. Riverside serves an area in the neighbourhood of Hammersmith, and before the opening of neighbouring automatic exchanges it had the distinction of having a special suite of positions to deal with traffic from the various exhibitions held at Olympia.

West Drayton Exchange. This non-director automatic exchange, installed by the General Electric Company, was opened on May 4th with approximately 500 subscribers. The initial capacity is 700, ultimate 2,000, and power is supplied on the parallel battery float system with 300 ampere hour batteries. The manual board is at Uxbridge which is a C.B. exchange.

Finchley Exchange. This exchange installed by Standard Telephones and Cables in a new building adjacent to the old manual was opened on May 19th. Initial capacity is 4,800 lines, ultimate 9,000, and the power is supplied on the divided battery float system with 1,200 ampere hour batteries at present plated to 600 ampere hours. Over 4,000 subscribers were transferred from the old manual exchange which, after certain alterations have been carried out, will be used for postal purposes. The new auto-manual exchange is situated in the new building and the switchroom, which is of very pleasing design, is fitted with the latest type of sound absorbing material.

North Eastern Region

COAXIAL CABLE

The installation of the Leeds-Manchester-Newcastle coaxial cable is proceeding apace in this Region and the contractors have completed cabling operations in the Bradford Area and are engaged on final tests prior to the installation of equipment in the buildings of the U.A.X. type provided at Linthwaite and Huddersfield.

Illuminating evidence as to how tough some forms of rock can prove to be was provided during the duct laying operations near the Linthwaite repeater station, when a stretch of some 200 yards of track occupied the duct contractor's attention for seven weeks, although four compressor drills were almost continuously engaged on this small section of the track.

The rock which was encountered was a form of gannister, used for grindstones, etc., and it is understood that the cost of the petrol consumption alone for the Ingersoll Rand compressors used was in the neighbourhood of £120 for the seven weeks the contractor's staff were engaged on the 200 yards track. Blasting was resorted to, but without much headway being made, the road being fairly narrow and thereby limiting the power of the charges which could be used, for fear of extensive damage to the road surface and adjacent public service mains.

A point of interest regarding the Linthwaite repeater station is that, owing to its isolated position, the cost of a power service was considered to be excessive, and arrangements are being made for the lighting service in the building to be provided from the 350 volt supply fed out over the coaxial cable itself.

Tests on the new type of asbestos cement ducts used for this cable prove that for water tightness they are at least equal in efficiency to the normal earthenware ducts, but although gas tight joints were made, it was not possible to maintain pressure when the trench had been filled in.

North Wales

ENDON EXCHANGE

Automatic working was introduced at Endon in the Stoke-on-Trent Engineering Section at 1.30 p.m. on April 20th, 1938, by opening a new Unit Automatic No. 7 exchange.

The transfer involved 157 subscribers, including 6 coin-box lines and 6 O/G and 7 I/C junctions to the parent auto manual exchange at Stoke. The conversion was effected without any fault.

The automatic equipment at Endon exchange consists of 2 No. 7A units, 1 7B and 1 7D, and the power arrangements consist of two 50 volt, 200 ampere hour batteries charged by a Tungar Rectifier and operated on a charge-discharge basis. Automatic traffic recording is provided.

The air condition of the apparatus room is under the control of a Humidistat and tubular electric heaters are fitted along the bottom of each unit.

The Endon subscribers have direct access via the junctions to the parent exchange to 7,000 subscribers connected to the 7 automatic exchanges in the Stoke multi-exchange area, and also Kidsgrove and Silverdale manual exchanges, which are reached via levels 56 and 58 at Stoke main exchange.

Subscribers in the Stoke M/E area and the two manual exchanges named above have access to Endon subscribers via level 57 at Stoke exchange.

BIRMINGHAM REGIONAL SCHOOL

The photograph of the Overhead Wiring Construction School shows how vacant land can be used to the most advantage. In due course a building for the Regional

Director and Telephone Manager's new office will be erected on this site.

It must not be assumed from the photograph that the Regional School has no students. On the contrary the average number in attendance each week is now about 230-240 with peaks of 253 and 257.

Additional classes are still being formed which will add another 30 or 40 to the weekly total.

MR. R. P. COLLINS

With deep regret we announce the death of one of our former colleagues, Mr. R. P. Collins, who died on May 13th, after an illness of some weeks in Selly Oak Hospital, Birmingham.

He will be well remembered as a keen worker and prominent member of the Society of Post Office Engineering Inspectors, having been President of the Society and a member of the executive council for a number of years prior to his promotion to the Chief Inspector's grade.

In addition to his work for the Society, his Departmental and local activities were almost too numerous to mention, but outstanding was his work on the D.W.C., of which he was Vice-Chairman, the I.P.O.E.E., and his many associations with welfare and sports organisations in the Birmingham Area, many of which he continued after his retirement in February, 1936, until the time of his illness.

The funeral took place at Brandwood End Cemetery on Tuesday, May 17th, and the large attendance, representing all grades of the Service and other organisations with which he was associated, was a remarkable tribute to his popularity.

It is indeed tragic that one so well prepared for a long and happy retirement should so quickly pass away, and we must express our deepest sympathy with Mrs. Collins and family in their particularly sad loss.

North Western

EUXTON ORDNANCE FACTORY

At Euxton, near Chorley, Lancashire, a new factory is in course of construction and work is proceeding at a record speed. The work is under the control of H.M. Office of Works and the main contractor is Sir Lindsay Parkinson & Co., Ltd., of London and Blackpool.

In view of the magnitude and speed of the work rather important telephone facilities have had to be provided by the Department at very short notice. In the office a 10 + 60/180 switchboard is installed with 57 extensions and a 10 + 50/65 switchboard with 26 extensions for the chief contractor. Minor telephone facilities have also been provided for a number of sub-contractors.

On account of the absence of permanent roads on the site and the fact that a 600 line privately-owned automatic exchange will ultimately be installed for use when the factory is in production, all line plant has, of necessity, been placed overhead, and during the various phases of the work it has been necessary to effect plant removals at short notice owing to the rapid erection and removal of premises and also extensive repairs on account of damage caused by building and excavation operations.

During a good part of the work, it was frequently impossible to take a vehicle within half a mile of a route which necessitated adopting special measures such as using a tractor to tow poles on a toboggan over 8 inches or more of mud.

Scottish Region

THE EMPIRE EXHIBITION

The Empire Exhibition was opened on May 3rd, 1938, by Their Majesties The King and Queen and the ceremony was the culmination of months of intensive effort on the part of the exhibition authorities, the contractors and the exhibitors.

It is the policy of the Post Office to provide exhibits at the various exhibitions held throughout the country, even though many of these are of a special and local nature, and no exception in this respect has been made of the Empire Exhibition. In an enterprise of such magnitude and pretention in which so many interests are represented, the Post Office has, as the purveyor of an important public service, played a necessary part. It will be appreciated that in a venture of such an extent, a telephone system is essential not only as a means of communication between the exhibition officials, but also as a necessary adjunct to the whole system of the country.

It was originally intended that the telephone exchange should form part of the Post Office display, but the fact that the buildings for exhibitors would be completed only shortly before the opening date, whereas the building for the exchange was required several months before that date to afford the required time for installing the equipment, necessitated the separation of the exchange from the exhibition. In addition, as the Glasgow auto conversion work is now well in hand and the exhibition exchange had to be C.B. manual on account of the nature of the traffic, there was not much advantage in exhibiting a manual exchange in an area undergoing conversion to automatic working. Various conferences were held with the exhibition authorities and the principal telephone requirements were estimated. A comprehensive underground scheme was prepared for auxiliary M.D.F.'s fitted in all the main buildings to provide flexibility. As the work progressed, the layout of proposed buildings was revised and additional buildings were added, all of which involved changes in the underground scheme as originally proposed.

The engineering work commenced on September 1st, 1937, and was completed in time for the opening of the physical exhibition exchange. As the construction of roads progressed, every opportunity was taken to provide all the ducts for the necessary crossings. In all, some eight miles of underground cables of all sizes were provided.

Meanwhile, the design of the exchange equipment had been put in hand some 12 months before the opening date of the exhibition and data was supplied by the Telephone Manager, Glasgow, on May 12th, 1937. Because of the type of traffic likely to be obtained equipment of the C.B. No. 10 type was decided upon. Normally this type of equipment would be installed by the Telephone Manager's staff but, owing to the very heavy programme of work in the Region, it was felt that the work could not be undertaken without causing serious delay in other directions and a recommendation was made to the Engineer-in-Chief that the work be carried out by contract. This was agreed, and the Automatic Telephone and Electric Co. of Liverpool undertook the work. Advance copies of the complete Specification were supplied to the Contractor on June 23rd, 1937, and the Regional Contract Order was placed on June 30th. The Contractor commenced installation of the equipment on December 21st, 1937, and the exchange was ready for service on March 19th, 1938.

To provide the telephone service required by Building Contractors and the Administration during the erection of the buildings, Exhibition exchange was opened hypothetically on Ibrox exchange on January 6th, 1938.

The physical exhibition exchange was opened on April 25th, 1938, and up to this date the actual telephone requirements had not been clearly defined. During this week, however, the number of exchange lines increased from 100 to approximately 500, all requiring service at once. During the first two weeks the busy hour calling rate was between 3 and 4, which put a great strain both on the operating staff and the equipment.

Some details of the exchange and the communication system are given in the following table.

Exhibition Exchange

Switch Sections, C.B. No. 10	15 A-positions 5 B-positions 1 T & P.U. position
Multiple (Subs.)	960
Multiple (Juncs.)	200
Answering Jacks	960
L. & C. O. Relays	920
Monitors Desk	2 positions
C.T.I. Equipment	62
Subs. Apparatus	15 Switchboards 520 D.E.L's (at May 20th)
Call Offices	69
Junctions	90 Outgoing 114 Incoming 28 Bothway (at May 20th)
Power Plant	2 Batteries 24 V 300 Ah. Worked charge/discharge 1 Motor Generator

Police and Fire Alarm System.

One switchboard PA 150 TD 10 lines with external extensions to police and ambulance. 15 pillars in exhibition grounds for use by public and Police.

Private Exchange.

One 50-line switchboard with lines to each car park for traffic control.

"TIM" service was provided from 7 points in the various pavilions, the telephones being used for this service exclusively.

South Wales

SUBAQUEOUS CABLE AT MILFORD HAVEN

A subaqueous cable, recently laid across the Milford Haven, between Hobbs Point and Neyland, a distance of approximately half a mile, represents a further link in the system of telecommunications for west Wales. The cable forms part of the trunk system connecting Milford and Carmarthen (with spurs to Tenby, Pembroke and Pembroke Dock), and is of the P.C.Q.T. type, 138/20 and 4/40 S/pairs with single armouring and having an approximate overall diameter of 4 in.

The normal means of transport across the Haven is by steam ferry. For the purposes of cabling it was necessary to obtain the services of the s.s. *Eden*, of some 200 tons. Difficulty was at first experienced in manœuvring the crocodile wagon, on which the drum of cable weighing 16 tons had been transported to Pembroke Dock, into a suitable siding from which it could be hoisted into the hold of the *Eden*. The task was, however, eventually accomplished, and early on the morning of February 25th the end of the cable was put ashore and secured at Hobbs Point. The drum, mounted on suitable jacks, was then permitted to revolve slowly as, with a suitable tide flowing, the *Eden* drifted away from the quayside, the rate at which the cable was paid out being controlled by means of an improvised braking gear on the drum. A large pulley slung from a jib overhead supported the cable over the side of the ship (Fig. **1**). A straight course for the landing point at

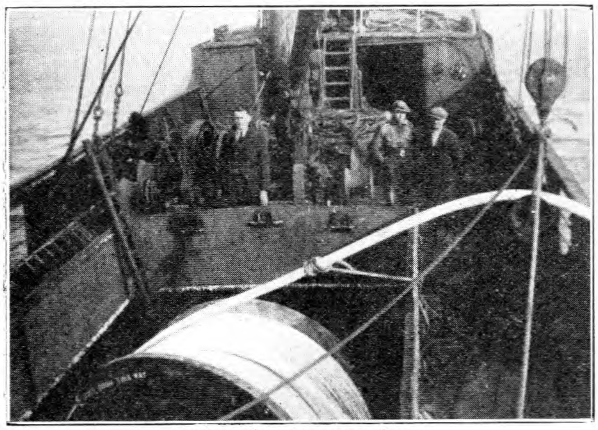

FIG. **1**.—PAYING OUT.

Neyland was followed, the drum being braked continually to avoid laying slack in the cable. As anticipated, the ship grounded in mid-stream and an enforced wait of upwards of an hour resulted, until the rising tide carried her over the mudbank, when cabling operations were resumed. The *Eden* finally grounded some 20 to 30 yards from the shore on the Neyland side and two rowing boats, each manned by four men, were brought into service to handle the " bight " of the cable as it came over the side of the ship (Fig. **2**). A strong

FIG. **2**.—LANDING THE END.

gang of men on shore assisted at this stage of the operations and the end was eventually landed at the Neyland slipway. The whole job occupied eight hours and was accompanied by much shouting and not a little wetting into the bargain. However, all engaged in the task worked with a will and a job which was viewed with some apprehension was completed safely and in good time. Full credit is due to Messrs. The United Telephone Cables, Ltd., who manufactured the cable and carried out the work of laying it.

THE CRANE LORRY

Coming events usually cast their shadows before, but when the crane lorry arrived the question of its possibilities was a matter for conjecture.

In case it comes the way of the reader, the following few notes may be useful :

Experience has shown that as a safety factor it is a valuable asset. When used in connection with the recovery of stout or medium poles, the end of the sling is hooked around the pole, so that it will be slightly butt-heavy when out of the ground. During the jacking-out process the weight is taken and maintained until the butt is just above the ground level. If the position of the sling on the pole has been reasonably judged in the first place, the butt can be drawn back by one man with a short rope or sash line while lowering takes place.

The procedure indicated is applicable to poles up to approximately one ton in weight. The crane takes the weight and when the position is obtained for freedom of movement, the swing of the jib will enable the pole to be moved over the usual obstacles which are encountered, such as E.L. cables, P.O. cables, drains, etc. In the latter case the erection of new poles can often be avoided.

During the partial recovery of a trunk line, some 60 tops had to be cut off, and by extending the jib 10 ft. with a light pole the work was made easy and safe. The pole was lashed to the jib and a snatch block fastened to the end. The rope for lowering was passed through this and secured to the pole top and lorry. This enabled the sawing to be done and the piece of pole to be lowered to the ground.

The question of erecting aerial cable with the help of the crane lorry suggested itself, and a bosun's chair secured to the end of the jib has great possibilities on a fairly straight run, the cable being paid out at the same time from a drum mounted on the lorry.

Sufficient has been said to indicate a few uses of the lorry crane, but it undoubtedly possesses further potentialities.

Owing to the minimum height of 13 ft. to which the jib may be lowered the question of garage accommodation usually presents difficulties, and it is frequently necessary to travel some distance from the work for suitable premises.

The following measurements may be of interest :

Normal working height of jib ..	21 ft. 6 in.
Full height of jib	24 ft. 6 in.
Length of jib	13 ft. 6 in.

South Western

NAPOLEONIC WARS RELIC

On March 22nd, while a gang were excavating a trench in Overgang Road, Brixham, for the purpose of laying a 3-in. S.A.D., the Warsop drill pierced a hole in the road rather too easily.

Further investigation led to the discovery of two chambers under the roadway separated from each other by a substantial stone wall, but with access to one another by a small opening in the wall. From the second chamber a gallery led down to the sea, and at the sea end the opening was partly closed up.

The matter was reported to the District Surveyor, as the Department had agreed the depth, course, etc., of the proposed duct line with him before commencing work.

A brief press report of the result of investigations as to the purpose for which these chambers were used follows:

"NAPOLEONIC WARS RELIC.

Discovery of Old Brixham Powder Magazine.

The room that was discovered at the foot of Overgang Road, Brixham, through workmen excavating the road for laying an underground telephone service during last week, has been traced through the medium of old maps to have been a powder magazine for the escarpment that towered above the entrance to Brixham Harbour during the Napoleonic Wars.

Three similar escarpments remain, one at Fishcombe, another at Round-top, and the third between Berry Head House and the Berry Head Fort, as reminders of the defensive protection of the Brixham side of Torbay. In those days Brixham was a naval watering station for the Channel fleet. It is possible that the room will be walled in to give greater security to the road, which is one of the busiest in the town through being the most accessible from the Quay to the G.W.R. Station."

The question of the responsibility for filling up the cavities arose, and the Surveyor agreed after some discussion that it was the Council's responsibility to fill in and make the road safe.

BRISTOL MAINTENANCE EXPERIMENT

Reference has been made to this experiment in the District Notes in the January, 1936, and January, 1937, issues of the JOURNAL.

At a conference held in Bristol in January, 1938, between Headquarters and District officers, it was agreed that sufficient data had been obtained to enable Headquarters control of the experiment to be relinquished. It was agreed to discontinue the various analyses and special reports to Headquarters and the experiment which commenced in October, 1935, thus lasted for just over two years.

Main Findings of the Experiment.

Internal Plant.—These are the subject of an interesting and comprehensive Engineering Instruction which has been issued recently (E.I. Telephones General A.5901, "Reduction of Faults on Internal Plant, General Notes for Supervising Officers.")

The methods outlined are based mainly on the results of the investigations at Bristol and show the remedial measures taken to deal with various troubles as revealed by the analyses or special investigations.

External Plant.—Information regarding faults on line plant will be contained in E.I. Lines Overhead A.5901.

Special Work undertaken by Experimental Staff.

During 1937 attention was concentrated upon items of plant responsible for high fault incidence, and the following notes show briefly what was done in this direction.

Exchange Plant—Automatic.—Special overhauls of early choice first group selectors, final selectors and discriminating selectors. These were based on the known fault incidence of various contacts and mechanical items as revealed by analysis and scrutiny of fault dockets. Subsequent faults on these switches have been made the subject of special reports to Headquarters. With the exception of functional tests all routines have been suspended on overhauled switches in order to determine periodicities at which future routines should be performed.

Subscribers' Apparatus.—Although faults on P.B.X. switchboard equipment were not covered by the analysis of faults on subscribers' apparatus, investigations revealed that an appreciable percentage of faults occurred on the larger type installations; this applied particularly in industrial areas.

Special overhauls of these installations were made and in some instances the associated extensions were also visited. Special attention was paid to the condition of such items as cords, keys, indicators, relays, etc.

Revisits have been made in a number of cases to determine periodicities for future routine overhauls.

External Plant.—In order to ascertain whether standard methods of construction are satisfactory, a special overhaul of external plant was carried out in Bristol North exchange area. Approximately 300 D.P.'s and associated lines were overhauled. The work consisted mainly in pole strengthening, regulating, renewal of C.D. plugs by block terminals, tidying of D.P.'s, etc. Non-standard methods of construction were altered to conform with standard practice, and vertical to vertical formation was adopted wherever possible.

The overhaul was completed in September, 1937, and the following figures of the fault incidence of external plant in Bristol North exchange area show the improvement affected in faults per telephone per annum:

Sept., 1935	Mar., 1936	Sept., 1936	Mar., 1937	Sept., 1937	Mar., 1938
·31	·31	·35	·23	·15	·08

Exchange Areas under 300 Lines.

The fault incidence of external plant in these areas being usually high, steps were taken to locate those routes having a fault incidence of over 0·75 per telephone per annum. In these cases a scrutiny of fault cards materially assisted in the location of sections of route where external improvement work was most necessary.

General.

Since the conclusion of the experiment in February the special experiment staff has been merged into the normal maintenance staff, arrangements being made to employ the staff as far as possible on the maintenance of plant upon which they have been specially engaged during the experiment.

BRISTOL STATION SORTING OFFICE

The District was honoured by a visit of the Postmaster-General when he opened the New Station Sorting Office at Bristol on May 10th.

The sorting office is situated adjoining Temple Meads railway station, and a system of conveyors has been installed between the railway platforms, the necessary acceptance and delivery points in the Sorting Office and on the loading platform. By this means considerable economies and saving of time in the handling and despatch of mails will be effected. A detailed description of the conveyors is given in a separate article in this issue.

A circuit was installed whereby the Postmaster-General could start up the conveyor system by depressing a button on the platform erected in the main sorting office for the opening ceremony. A public address system was also fitted for the convenience of the speakers, and microphones connected to certain parts of the conveyor installation reproduced the actual noises of starting on the loud-speakers.

The ceremony was attended by a large number of representative people, including the Deputy Lord Mayor, local M.P.'s and members of the Council and Chamber of Commerce.

It is interesting to record that everything worked according to plan and that the 1,000 guests who were served with tea displayed great interest when the building was thrown open to inspection.

The Postmaster-General when inspecting the Office expressed his satisfaction at the engineering services provided.

Staff Changes

Promotions.

Name	District	Date
From A.S.E. to Principal		
Manning, F. E. A.	E.-in-C.O. to Telecoms. Dept.	2.1.38
From A.S.E. to T.M.		
Hay, P. G.	E.-in-C.O. to Norwich	To be fixed later
From A.S.E. to A.S.E. with allowance.		
Edgerton, T. H.	L.T.R.	19.4.38
From Exec. Engr. to Regl. Engr.		
Jones, H. C.	E.-in-C.O. to L.T R.	19.4.38
From Exec. Engr. to A.S.E.		
Moffatt, C. E.	S.M. to S.W.	1.7.38
Gemmell, W. T.	E.-in-C.O.	2.4.38
Stretch, W.	S. Lancs	To be fixed later
From Asst. Engr. to Exec. Engr.		
Kilgour, A.	Scot. Reg.	1.4.38
Akester, A.	E.-in-C.O.	1.4.38
Helman, S. L.	E.-in-C.O.	26.1.38
Pope, G. F.	S.E. to N. Wa.	1.5.38
King, A. G.	S. Wales	1.7.38
Penney, A. E.	L.P. Reg.	8.4.38
Gawthorn, G. J.	L.T. Reg.	19.4.38
Sims, A. E.	E.-in-C.O. to L.T.R.	28.4.38
Scarborough, W. H.	L.T. Reg.	19.4.38
Robinson, O. D.	E. to Sc. R.	1.10.38
Diack, W. H.	N.W. to S.Lcs.	To be fixed later
Millen, G. J.	S. Mid. to L.T.R.	1.7.38
Anderson, E. W.	E.-in-C.O.	1.8.38
Perryman, C. F.	Scot. Reg.	8.4.38
Robinson, A. K.	N.E.R. to L.T.R.	19.4.38
Knapman, D. E.	S. Wales	6.5.38
From Chief Insp. to Asst. Engr.		
Corkett, H.	E.-in-C.O.	28.2.38
Glenn, B.	N. Midland	13.3.38
Burrows, W. N.	N.E. Reg.	To be fixed later
Dennison, R. T. A.	E.-in-C.O. to N.E.R.	do.
McKinnon, N.	Scot. Reg.	do.
Branson, J. W.	Scot. Reg.	do.
England, A. G.	Scot. Reg.	do.
Woodhouse, T.	N.W. to N.E.R.	do.
Standing, F.	T.S. Ldn. to T.S. B'm	1.5.38
Rogers, H.	T.S. B'm to T.S. Ldn.	8.5.38
Reed, T. F.	E.-in-C.O.	1.7.38
Rudeforth, S.	E.-in-C.O.	12.4.38
Joyce, R. M	E.-in-C.O.	12.4.38
Jeynes, E. H.	E.-in-C.O. to L.T R.	19.4.38
Ovenall, E. W.	N. Wa. to L.T.R.	19.4.38
Rance, A. W.	Eastern	12.4.38
Brown, R. C. C.	E.-in-C.O.	12.4.38
Harrold, E. J.	E.-in-C.O. to L.T.R.	19.4.38
Claxton, H. L.	E.-in-C.O.	28.4.38
Palk, E.	E.-in-C.O.	12.4.38
Edwards, W. K.	Scot. Reg.	12.4.38
Smith, E. R.	E.-in-C.O. to L.T.R.	15.4.38
Thomas, G. E. T.	E.-in-C.O. to L.T.R.	19.4.38
Knee, H.	S.W. to S. Wa.	6.5.38
Mathews, W.	N.W. to S.E.	To be fixed later
Curling, T. N.	L.T. Reg.	1.8 38
Rimes, R E.	E.-in-C.O.	1.8.38
Gill, W. E.	N. Mid. to Sc. R.	15.5.38
From Chief Insp. to Chief Insp. with allowance.		
McPhail, W. S. S.	Scot. Reg.	9.3.38
Reid, W. A.	Scot. Reg.	22.3.38
Perkins, B. H.	S. Midland	To be fixed later
Whitehead, W. C.	S.W. to N. Mid.	8.5.38
Spiers, J. C.	N.W. to N.E.R.	8.5.38
From Chief Insp. to Chief Insp. with allowance—(continued).		
Johnson, J.	L.T. Reg.	12.4.38
McLennan, J. A.	L.T. Reg.	19.4.38
Chilvers, W.	L.T. Reg.	12.4.38
Williams, W. A.	L.T. Reg.	12.4.38
Roberts, W. A.	L.T. Reg.	2.5.38
Whenmouth, H.	L.T. Reg.	19.4.38
Rafferty, A.	L.T. Reg.	19.4.38
Lewis, A. F.	L.T. Reg.	19.4.38
Evans, W.	L.T. Reg.	12.4.38
Ellis, F.	L.T. Reg.	19.4.38
Taylor, S. A.	L.T. Reg.	19.4.38
Messenger, C. W.	L.T. Reg.	19.4.38
Scott, W. F.	L.T. Reg.	12.4.38
Morphew, R. O.	L.T. Reg.	19.4.38
Wall, A. A.	L.T. Reg.	12.4.38
Gillman, C. E.	L.T. Reg.	12.4.38
Stow, G.	L.T. Reg.	12.4.38
Budd, W. C.	L.T. Reg.	12.4.38
Boys, E. C.	L.T. Reg.	12.4.38
Mackay, J. W.	N. Western	24.4.38
Williams, C. E.	Eastern	29.3.38
From Insp. to Chief Insp.		
Mallows, E. G.	L.T. Reg.	1.2.38
King, W. D.	E.-in-C.O.	To be fixed later
Denyer, W. C.	E.-in-C.O.	do.
Tilly, C. N.	E.-in-C.O.	do.
Johnson, S. W. J.	E.-in-C.O.	14.3.38
Slater, G. H.	E.-in-C.O.	22.9.37
Smith, R.	S. Midland	12.2.38
Todkill, H.	S. Lancs	28.12.37
Rogers, A. H.	N. Wales	19.12.37
Hicks, C. J.	L.P.R. to N. Ire.	6.12.37
Hobsbaum, J.	E.-in-C.O. to N.E.R.	25.12.37
Johnston, A. N.	Scot. Reg.	19.12.37
Mann, R. G.	E.-in-C.O.	6.12.37
Myers, H. G.	E-in-C.O.	6.12.37
Muir, W. W.	Scot. Reg.	1.3.38
Johnson, L. P.	S.W. to E.-in-C.O.	10.10.37
Moulds, H.	N.E. Reg.	16.1.38
House, L. F.	S. Midland	1.1.38
Buckley, G.	N. Wales	1.2.38
Hardy, J.	N. Wales	1.8.37
Birnie, R. C.	Scot. Reg.	19 9.37
Alston, G. J.	S. Lancs	17.10.37
Hall, G. K.	N.E. Reg.	2.1.38
Wilson, W. A.	S. Wales	To be fixed later
Young, H. T.	L.T. Reg.	12.4.38
Lockie, R. A.	L.T. Reg.	19.4.38
Slocombe, A. E.	L.T. Reg.	12.4.38
Driver, E. G.	L.T. Reg.	12.4.38
Smith, C. A.	L.T. Reg.	2.5.38
James, L. A.	L.T. Reg.	19.4.38
Searle, C. T.	L.T. Reg.	19.4.38
Morgan, L. O.	L.T. Reg.	12.4.38
Powning, S. H.	L.T. Reg.	12.4.38
Davis, A. H.	L.T. Reg	19.4.38
Hutchinson, C. H.	L.T. Reg.	19.4.38
Wootten, L. G.	L.T. Reg.	12.4.38
Blott, F.	L.T. Reg.	19.4.38
Chasmar, W. P.	L.T. Reg.	12.4.38
Cottenden, S. C.	L.T. Reg.	12.4.38
Owen, W. H.	L.T. Reg.	19.4.38
Allison, A. J.	L.T. Reg.	12.4.38
Pocock, D. J.	L.T. Reg.	12.4.38
Bavin, A. E.	L.T. Reg.	23.1.38
Town, A.	L.T. Reg.	13.2.38
Gormley, L. V.	L.T. Reg.	5.4.38
Bradman, A. R.	L.T. Reg.	27.1.38
Duffield, H.	Eastern	27.3.38
Knights, G. A.	Eastern	23.8.37
Such, R. C.	Eastern	25.3.38

From Insp. to Chief Insp. (continued).

Name	District	Date
Pooley, E. H.	Eastern	6.2.38
Barratt, L. W.	E.-in-C.O. to S.W.	3.4.38
Barnes, J. L.	N. Wales	29.11.37
Hartley, C. A.	N. E. Reg.	1.4.38
Robins, R. E.	S. Midland	27.2.38
Devey, G. B.	L.T. Reg.	19.4.38
Beaven, J. H.	L.T. Reg.	19.4.38
Holliday, R. F.	L.T. Reg.	19.4.38
Humphrey, E. E.	E.-in-C.O.	1.7.38
Judson, J. E.	E.-in-C.O.	28.4.38
Hancock, L.	E.-in-C.O.	12.4.38
Pride, C. A.	E.-in-C.O.	1.9.38
Anderson, T. N.	Scot. Reg.	1.4.38
Drysdale, T. W.	Scot. Reg.	19.3.38
McClelland, W. C.	Scot. Reg.	3.4.38
McDougall, R.	Scot. Reg.	1.4.38
Skea, J.	Scot. Reg.	6.6.37
Hopkinson, E.	N.E.R. to E-in-C.O.	10.4.38
Brough, D.	Scot. Reg.	2.1.38
Lockie, J.	Scot. Reg.	1.1.38
Mathewson, J. M.	Scot. Reg.	14.10.37
Biggers, P. S. S.	Scot. Reg.	13.3.38
Quinn, P.	Scot. Reg.	22.12.37
Nicolson, P.	Scot. Reg.	24.4.38
Brown, R.	Scot. Reg.	1.4.38
Arnold, C. W.	E.-in-C.O. to Sc. R.	3.4.38
Hull, J. A.	E.-in-C.O.	1.4.38
Hogg, T. E.	E.-in-C.O.	14.10.37
Shipley, F. H.	E.-in-C.O. to Sc. R.	1.4.38
Arnold, A. F.	E.-in-C.O. to Sc. R.	22.3.38
Russel, J. H.	E.-in-C.O. to Sc. R.	10.4.38
Wilson, F.	E.-in-C.O. to Sc. R.	3.4.38
Sudell, G. R.	E.-in-C.O. to Sc. R.	20.3.38
Henderson, W. G.	N. Ireland	14.3.37
Fearn, J.	N.E. Reg.	To be fixed later
Marsden, B.	N.E. Reg.	do.
Bingham, J.	N.E. Reg.	do.
Martin, B. R.	N.E. Reg.	do.
Lancaster, A. E.	N.E. Reg.	do.
Larner, F. L.	Test Secn. B'm	do.
Blower, G. A.	Test Secn. B'm	do.
Hart, J. A.	L.T.R. to N. Wa.	do.
Barratt, J. W.	L.T.R. to N.E.R.	do.
Trimmer, W. J.	L.T.R. to S.Wa.	15.5.38
Allsup, E. F. W.	E.-in-C.O. to S.Wa.	1.6.38
Roche, J. J.	E.-in-C.O.	15.4.38
Miller, R. W.	E.-in-C.O.	12.4.38
Barton, A. L.	E.-in-C.O.	19.4.38
Judd, F. W.	L.T.R. to S.W.	13.5.38
Whittington, F.	N. Midland	15.5.38
Prichard, F. E.	E.-in-C.O.	8.4.38
Webb, A. W.	L.T.R. to Sc. R.	22.5.38
Blewitt, E.	S. Wales	12.1.38
Abel, G. P.	E.-in-C.O.	12.4.38
Mitchell, C. W. A.	E.-in-C.O.	19.4.38
Pitts, H. E.	L.T.R. to E.	29.3.38
Woods, A. E.	L.T.R. to E.-in-C.O.	10.4.38
Queen, J.	E.-in-C.O.	10.4.38
Andrews, W. E. T.	Eastern	19.3.38
Crosby, S. C.	S. Wales	To be fixed later
Berrill, W. G.	Eastern	do.
Stoney, J. J.	S. Wales	22.9.37
Lee, J. A.	L.T. Reg.	1.6.38
Stovold, A. T.	Test Secn. Ldn.	To be fixed later
Plumpton, F. E.	S.Mid. to E.-in-C.O.	1.5.38

From S.W.1 to Insp.

Name	District	Date
Everett, A. A. F.	Test Secn. Ldn	18.6.38
Gallagher, P.	N. Ire. to E.-in-C.O.	25.2.38
Marrow, T. R.	N. Western	31.10.37
Dell, J. H.	E.-in-C.O.	21.12.37
Wase, A. E. N.	E.-in-C.O.	9.1.38
Woods, R. N.	E.-in-C.O.	23.3.38
Wadsworth, J. H.	Rugby R.S.	30.1.38

From S.W.1 to Insp. (continued).

Name	District	Date
Mickley, T.	S. Western	28.11.37
Steed, F. G. P.	S. Western	24.2.38
Duddridge, A. S.	S. Western	26.11.37
Squire, F. A.	S. Western	24.4.38
Waterman, A. J.	S. Western	24.4.38
Chamberlain, R.	N. Midland	8.8.37
Parker, J. W. H.	N. Midland	12.9.37
Frost, F.	N. Midland	18.2.37
Grieve, J. W.	N. Midland	4.11.37
Avery, A.	S. Midland	2.5.37
Ebbage, H. J.	S. Midland	12.2.38
Penfold, F. L.	S. Midland	2.4.38
Jackson, W. C.	S. Midland	2.4.38
Mettem, D. H. W.	S. Midland	5.9.37
Seward, B. A.	N. Wales	To be fixed later
Fawkes, A. T.	S. Lancs	28.12.37
Moore, E.	S. Lancs	17.10.37
Brook, H.	N.E. Reg.	To be fixed later
Smith, S. W.	N.E. Reg.	do.
Corbett, G.	N.E. Reg.	do.
Wormald, A. R.	N.E. Reg.	do.
Mills, G. E.	N.E. Reg.	do.
Read, A. W.	N.E. Reg.	do.
Tether, C.	N.E. Reg.	do.
Siddle, A.	N.E. Reg.	do.
Guppy, H. L.	N.E. Reg.	do.
Smiddy, F. L.	N.E. Reg.	do.
Mawtus, G. T.	N.E Reg.	do.
Smith, J. W.	N.E. Reg.	do.
Orde, J. R.	N.E. Reg.	do.
Stephenson, S.	N.E. Reg.	do.
Smerdon, J. H	L.P. Reg.	15.8.37
Fox, F. R.	L.P. Reg.	20.3.37
Harman, C.	L.P. Reg.	3.1.38
Cresswell, B.	T.S.B'mtoT.S.Ldn.	To be fixed later
Haig, J.	Scot. Reg.	29.11.37
Garrick, J. W.	Scot. Reg.	30.12.37
Fraser, W. C. A.	Scot. Reg.	4.1.38
Patrick, A. C.	Scot. Reg.	24.4.38
Mason, D. W.	Scot. Reg.	12.5.38
Barnet, A. A.	Scot. Reg.	5.12.37
Aitchison, J. K.	Scot. Reg.	11.2.38
Roberts, J. W.	Scot. Reg.	23.12.37
McCorquodale, J.	Scot. Reg.	19.4.38
Gibson, W. D.	Scot. Reg.	4.1.38
Liddell, A.	Scot. Reg.	2.4.38
Maxwell, D. J.	Scot. Reg.	6.2.38
Gibb, W. F.	Scot. Reg.	26.12.37
Wilkie, N. R.	Scot. Reg.	1.4.38
King, A.	Scot. Reg.	24.4.38
Knight, J. S.	Scot. Reg.	14.10.38
Bathie, J.	Scot. Reg.	27.3.38
McDonald, W. C.	Scot. Reg.	1.4.38
Davidson, J. P.	Scot. Reg.	27.3.38
Price, W. T.	Scot. Reg.	4.1.38
Richardson, R. M.	Scot. Reg.	1.5.38
Muir, R.	Scot. Reg.	3.4.38
Witherow, J.	Scot. Reg.	24.4.38
Bell, A. B.	Scot. Reg.	19.3.38
Richmond, A.	Scot. Reg.	4.1.38
Dykes, H. E. C.	Scot. Reg.	4.1.38
Johnstone, A. N.	Scot. Reg.	4.1.38
McFarlane, H. C.	Scot. Reg.	1.3.38
Pirrett, G. T.	Scot. Reg.	28.9.37
Hay, G. A.	Scot. Reg.	1.4.38
Philip, A.	Scot. Reg.	1.4.38
Steel, J. R.	Scot. Reg.	11.1.38
Mason, D. T.	Scot. Reg.	24.10.38
Bennett, D. C.	Scot. Reg.	3.10.37
Allan, J. M.	Scot. Reg.	19.4.38
Henderson, A. J.	N.E. Reg.	10.4.38
Summer, F.	L.T. Reg.	To be fixed later
Stockwell, W. A.	L.T. Reg.	do.
Jones, S. K.	L.T. Reg.	do.
Darby, T. F.	L.T. Reg.	do.

Name	District	Date
From S.W.1 to Insp. (continued).		
Edwards, G. R.	L.T. Reg.	To be fixed later
Pask, W. J.	L.T. Reg.	do.
Gregory, E. G. S.	L.T. Reg.	do.
Geraghty, J. W.	L.T. Reg.	do.
Sanderson, J. C.	L.T. Reg.	do.
Brett, S. A.	L.T. Reg.	do.
Rees, E. J.	L.T. Reg.	do.
Gillard, J. A.	L.T. Reg.	do.
Walker, J.	L.T. Reg.	do.
Traylor, W. L.	L.T. Reg.	do.
Claydon, R. J.	L.T. Reg.	do.
Adair, C. J.	L.T. Reg.	do.
Kempsell, C.	L.T. Reg.	do.
Rowland, V. G.	L.T. Reg.	do.
Wiedhoft, E. A.	L.T. Reg.	do.
Payne, H. J.	L.T. Reg.	do.
Smith, S.	L.T. Reg.	do.
Scott, C. W.	L.T. Reg.	do.
Pye, H. J.	L.T. Reg.	do.
Weekes, H. H.	L.T. Reg.	do.
Stone, J. A.	L.T. Reg.	do.
Ruck, A. A.	L.T. Reg.	do.
Pugh, J. H. A.	L.T. Reg.	do.
Ward, T. J.	L.T. Reg.	do.
Lethbridge, S. W.	L.T. Reg.	do.
Wood, R.	L.T. Reg.	do.
Williamson, A. A.	L.T. Reg.	do.
Kavanagh, T. E. J.	L.T. Reg.	do.
Searle, E. L.	L.T. Reg.	do.
Goldsack, F. J.	L.T. Reg.	do.
Talbot, C. W.	L.T. Reg.	do.
Henley, F.	L.T. Reg.	do.
Trew, H. W.	L.T. Reg.	do.
Downs, A. E.	L.T. Reg.	do.
Cresswell, C. E.	L.T. Reg.	do.
Marsh, L. E. H.	L.T. Reg.	do.
Monk, R. A. T.	L.T. Reg.	do.
Brown, H. W. D.	L.T. Reg.	do.
Day, L. C.	L.T. Reg.	do.
Pullee, G. C.	L.T. Reg.	do.
Edwards, H. L.	L.T. Reg.	do.
Cooper, E. E. T.	L.T. Reg.	do.
Darby, G. F.	L.T. Reg.	do.
Crump, A. G.	L.T. Reg.	do.
Cousens, A. J.	L.T. Reg.	do.
Smith, F. A.	L.T. Reg.	do.
Davis, H. C.	L.T. Reg.	do.
May, F. T.	L.T. Reg.	do.
Hogben, W. A.	L.T. Reg.	do.
Dyer, L. J.	L.T. Reg.	do.
Whitfield, G. T. V.	L.T. Reg.	do.
Hopkins, W. R.	L.T. Reg.	do.
Papps, E. G.	L.T. Reg.	do.
Wilson, A. L.	L.T. Reg.	do.
Sallnow, C. W.	L.T. Reg.	do.
Newton, A. W.	L.T. Reg.	do.
From S.W.1 to Insp. (continued).		
Norman, S. J.	L.T. Reg.	To be fixed later
Orchard, G. A.	L.T. Reg.	do.
Powell, J. E. H.	L.T. Reg.	do.
Cave, A. W.	L.T. Reg.	do.
Chewter, F. G.	L.T. Reg.	do.
Sutton, S. E.	L.T. Reg.	do.
Wilks, G. A.	L.T. Reg.	do.
Griffin, S. J.	L.T. Reg.	do.
Slater, W. H.	L.T. Reg.	do.
Murray, A J.	L.T. Reg.	do.
Murray, R. E. A.	L.T. Reg.	do.
Valentine, H. A. E.	L.T. Reg.	do.
Johnson, T. E.	L.T. Reg.	do.
Heymer, B. J.	L.T. Reg.	do.
Capon, S. J.	L.T. Reg.	do.
Hickey, J. T.	L.T. Reg.	do.
Waight, T. A.	L.T. Reg.	do.
Harvey, C.	L.T Reg.	do.
Helm, J. T.	L.T. Reg.	do.
Furner, H. W.	L.T. Reg.	do.
Parson, E. G. H.	L.T. Reg.	do.
Turner, J. R.	L.T. Reg.	do.
Ellarby, J. H.	L.T. Reg.	do.
Allen, T. F. H.	L.T. Reg.	do.
Regan, F. M. C.	L.T. Reg.	do.
Newman, R. O.	N.E. Reg.	17.4.38
Greenwood, E. A. J.	Eastern	To be fixed later
Williams, N. R.	Eastern	do.
Benson, J.	Eastern	do.
Kesteven, A. S.	Eastern	do.
Palin, F.	Eastern	do.
Wash, G. H.	Eastern	do.
Faulkner, J. G.	Eastern	do.
Andrews, H. A.	Eastern	do.
Davidson, W. H. J.	Eastern	do.
Newman, J. I.	Eastern	do.
From S.W.2 to Insp.		
Paxton, C.	N. Wales	To be fixed later
Bradbury, J. J.	N. Wales	do.
Worley, H. W. R.	S. Eastern	22.3.38
From U.S.W. to Insp.		
Hiron, M. E.	N. Wales	To be fixed later
Knight, N.	N. Wales	do.
Meller, V. C.	N. Wales	do.
Randall, F. L.	E.-in-C.O.	8.4.38
Wylie, T. S.	E.-in-C.O.	11.4.38
Redhouse, A. R.	E.-in-C.O.	11.5.38
Gavi, L. G.	E.-in-C.O.	To be fixed later
From Draughtsman Cl. II to Insp.		
Chappell, S. H. J.	E.-in-C.O.	6.12.37
Thornton, R.	N.E. Reg.	To be fixed later

Transfers.

Name	District	Date
Exec. Engr.		
Bocock, W.	Sc. R. to L.T.R.	1.10.38
Hodge, G. W.	S. Wa. to S. Mid.	Date not yet fixed
Salter, L. F.	S. Wa. to E.-in-C.O.	15.4.38
Asst. Engr.		
Lister, B.	E.-in-C.O. to S.E.	3.4.38
Riley, C.	E.-in-C.O. to E.	8.4.38
Asst. Engr. (continued)		
Knight, N. V.	E.-in-C.O. to L.T.R.	6.5.38
Calveley, C. E.	L.T.R. to E.-in-C.O.	11.5.38
Inspector		
Rackham, W. A.	E.-in-C.O. to S. Mid.	8.5.38

Retirements.

Name	District	Date	Name	District	Date
Suptg. Engr.			*Chief Inspr.*		
Wright, A.	N. Midland	31.3.38	Adair, H. J.	N. Ireland	18.3.38
Cornfoot, T.	S. Midland	30.4.38	Hill, R. J.	E.-in-C.O.	9.5.38
			Inspector		
Asst. Engr.			Pike, S. F.	L.T.Reg.	15.3.38
			Pullan, J. G. W.	Test Secn. London	9.4.38
Loftus, R. W.	L.T.Reg.	4.4.38	Barry, J. A.	L.T.Reg.	30.4.38
Gresswell, F. P.	S. Western	28.2.38	Gadd, J. I.	L.T.Reg.	30.4.38
Evans, E. C.	L.T.Reg,	14.4.38	Wright, H. H.	Eastern	10.6.38
Cheetham, W. B.	Eastern	6.2.38	Pritchard, W.	N.E. Reg.	1.1.38
Cresswell, H. G. B.	E.-in-C.O.	9.3.38	Hollinshead, F. A.	N.E. Reg.	4.5.38

Deaths.

Name	District	Date	Name	District	Date
Asst. Engr.			*Inspector*		
Miller, D. P. M.	E.-in-C.O.	18.2.38	Whyte, W. J.	Scot. Reg.	9.4.38
			Bull, A.	N.E. Reg.	25.1.38
			Wilson, C. W.	N.E. Reg.	13.4.38

Secondments.

Name	District	Date	Name	District	Date
Exec. Engr.			*Inspector*		
Barker, H.	E.-in-C.O. to Air Ministry	20.4.38	Hudson-Davies, J.	E.-in-C.O. to Egypt. St. Rys.	20.5.38

Appointments.

Name	District	Date	Name	District	Date
To Proby Insp. (Open Comp., Sept., 1937).			*To Proby. Insp. (Open Comp., Sept., 1937)—(continued)*		
Abbott, F. W.	E.-in-C.O. (Trg. Sch.)	28.3.38	Gange, H. G.	E.-in-C.O. (Trg. Sch.)	17.3.38
Akester, K. M.	E.-in-C.O. (Trg. Sch.)	1.3.38	Geddes, W. J.	E.-in-C.O. (Trg. Sch.)	21.3.38
Baker, L. J. D.	E.-in-C.O. (Trg. Sch.)	19.4.38	Gee, F. H.	E.-in-C.O. (Trg. Sch.)	17.3.38
Barrett, G. F.	E.-in-C.O. (Trg. Sch.)	5.5.38	Gill, M.	E.-in-C.O. (Trg. Sch.)	11.4.38
Baxter, G. F.	E.-in-C.O. (Trg. Sch.)	4.4.38	Goodger, J. F.	E.-in-C.O. (Trg. Sch.)	16.3.38
Benton, G. C.	E.-in-C.O. (Trg. Sch.)	2.5.38	Gray, H. G.	E.-in-C.O. (Trg. Sch.)	11.4.38
Berresford, B. H	E.-in-C.O. (Trg. Sch.)	1.4.38	Hales, A. C.	E.-in-C.O. (Trg. Sch.)	28.3.38
Best, F. L.	E.-in-C.O. (Trg. Sch.)	21.3.38	Halford, J. M.	E.-in-C.O. (Trg. Sch.)	19.4.38
Brice, P. J.	E.-in-C.O. (Trg. Sch.)	17.3.38	Hayward, G. O.	E.-in-C.O. (Trg. Sch.)	1.3.38
Brown, H.	E.-in-C.O. (Trg. Sch.)	11.3.38	Hetherington, T.	E.-in-C.O. (Trg. Sch.)	22.4.38
Budgen, J. E.	E.-in-C.O. (Trg. Sch.)	7.4.38	House, F. C.	E.-in-C.O. (Trg. Sch.)	1.3.38
Castellano, E. J.	E.-in-C.O. (Trg. Sch.)	25.3.38	Jeffries, G. L.	E.-in-C.O. (Trg. Sch.)	6.4.38
Cawthra, W. A.	E.-in-C.O. (Trg. Sch.)	4.4.38	Jessop, E. C.	E.-in-C.O. (Trg. Sch.)	19.3.38
Chatwin, W.	E.-in-C.O. (Trg. Sch.)	21.3.38	Keeble, W. R.	E.-in-C.O. (Trg. Sch.)	1.3.38
Chismen, S. H.	E.-in-C.O. (Trg. Sch.)	12.3.38	Kennedy, M. M.	E.-in-C.O. (Trg. Sch.)	19.4.38
Childe, P. F.	E.-in-C.O. (Trg. Sch.)	18.3.38	Kilbey, H. M.	E.-in-C.O. (Trg. Sch.)	11.4.38
Coates, P. J.	E.-in-C.O. (Trg. Sch.)	1.3.38	Langmead, F.	E.-in-C.O. (Trg. Sch.)	17.3.38
Corrin, W.	E.-in-C.O. (Trg. Sch.)	20.4.38	Langridge, A. M. J.	E.-in-C.O. (Trg. Sch.)	11.4.38
Cowling, H.	E.-in-C.O. (Trg. Sch.)	16.3.38	Lawmon, R. J.	E.-in-C.O. (Trg. Sch.)	20.4.38
Day, R. C.	E.-in-C.O. (Trg. Sch.)	24.3.38	Lindsell, R. F.	E.-in-C.O. (Trg. Sch.)	5.4.38
Edwards, A. C.	E.-in-C.O. (Trg. Sch.)	2.4.38	Lucas, J.	E.-in-C.O. (Trg. Sch.)	1.3.38
Edwards, H. W. F.	E.-in-C.O. (Trg. Sch.)	1.3.38	Meades, G.	E.-in-C.O. (Trg. Sch.)	11.4.38
Farmer, K. C.	E.-in-C.O. (Trg. Sch.)	11.4.38	Mihell, R. H.	E.-in-C.O. (Trg. Sch.)	11.4.38
Fielding, H.	E.-in-C.O. (Trg. Sch.)	20.4.38	Mitchell, G.	E.-in-C.O. (Trg. Sch.)	19.4.38
Fish, A. J.	E.-in-C.O. (Trg. Sch.)	12.4.38	Mitchell, J. P.	E.-in-C.O. (Trg. Sch.)	1.3.38
Freere, S. E.	E.-in-C.O. (Trg. Sch.)	25.4.38	Naylor, H. C.	E.-in-C.O. (Trg. Sch.)	12.4.38
Froom, R. P.	E.-in-C.O. (Trg. Sch.)	2.3.38	Neal, C. W. B.	E.-in-C.O. (Trg. Sch.)	8.4.38
Frost, A. C.	E.-in-C.O. (Trg. Sch.)	12.3.38	Newbery, J.	E.-in-C.O. (Trg. Sch.)	19.4.38

Name	District	Date
To Proby. Insp. (Open Comp., Sept., 1937)—*(continued)*		
Norton, F. A.	E.-in-C.O. (Trg. Sch.)	14.3.38
Nuttall, G. H.	E.-in-C.O. (Trg. Sch.)	12.5.38
Palmer, R. W. L.	E.-in-C.O. (Trg. Sch.)	12.3.38
Paterson, A. E.	E.-in-C.O. (Trg. Sch.)	21.3.38
Payne, C. A.	E.-in-C.O. (Trg. Sch.)	25.3.38
Pickering, H. J.	E.-in-C.O. (Trg. Sch.)	21.3.38
Pikett, C. C.	E.-in-C.O. (Trg. Sch.)	1.3.38
Pointing, J. F.	E.-in-C.O. (Trg. Sch)	1.3.38
Powell, E.	E.-in-C.O. (Trg. Sch.)	15.3.38
Powell, G.	E.-in-C.O. (Trg. Sch.)	4.4.38
Prout, A. G.	E.-in-C.O. (Trg. Sch.)	21.3.38
Quellin, A. A.	E.-in-C.O. (Trg. Sch.)	1.3.38
Rodwell, A. A. T.	E.-in-C.O. (Trg. Sch.)	11.4.38
Rae, W. I. L.	E.-in-C.O. (Trg. Sch.)	21.3.38
Rata, S.	E.-in-C.O. (Trg. Sch.)	16.3.38
Reed, D.	E.-in-C.O. (Trg. Sch.)	9.4.38
Rees, T. J.	E.-in-C.O. (Trg. Sch.)	19.4.38
Roberts, C. J.	E.-in-C.O. (Trg. Sch.)	14.3.38
Rogers, M. J.	E.-in-C.O. (Trg. Sch.)	17.3.38
Rumbellow, V. G.	E.-in-C.O. (Trg. Sch.)	11.4.38
Sanders, R. V.	E -in-C.O. (Trg. Sch.)	1.3.38
Sharpe, J. H. W.	E.-in-C.O. (Trg. Sch.)	19.4.38
Shearme, J. N.	E.-in-C.O. (Trg. Sch.)	17.3.38
Sheldrake, R. J.	E.-in-C.O. (Trg. Sch.)	28.3.38
Spinks, J.	E.-in-C.O. (Trg. Sch.)	1.3.38
Spratt, C. J.	E.-in-C.O. (Trg. Sch.)	11.4.38
Squires, F W.	E.-in-C.O. (Trg. Sch.)	11.4.38
Stiles, H. A.	E.-in-C.O. (Trg. Sch.)	21.3.38
Tattersall, R. L. O.	E.-in-C.O. (Trg. Sch.)	7.3.38
Taylor, E. R.	E.-in-C.O. (Trg. Sch.)	1.3.38
Thomas, A.	E.-in-C.O. (Trg. Sch.)	28.4.38
Turner, N. J.	E.-in-C.O. (Trg. Sch.)	25.3.38
Urben, T. F. A.	E.-in-C.O. (Trg. Sch.)	14.3.38
Walker, D. C.	E.-in-C.O. (Trg. Sch.)	28.3.38
Watkins, J.	E.-in-C.O. (Trg. Sch.)	18.5.38
Williams, R. G.	E.-in-C.O. (Trg. Sch.)	20.4.38
To Proby. Insp. (Open Comp., Sept., 1937)—*(continued)*		
Willmot, J. W.	E.-in-C.O. (Trg. Sch.)	1.3.38
Winser, H. W.	E.-in-C.O. (Trg. Sch.)	17.3.38
Wright, S. T.	E.-in-C.O. (Trg. Sch.)	17.3.38
Yirrell, E. W. F.	E.-in-C.O. (Trg. Sch.)	19.4.38
Young, J. R.	E.-in-C.O. (Trg. Sch.)	6.4.38
From S.W.1 to Proby. Insp. (Limited Comp., Sept., 1937).		
Rogers, B. H. E.	E.-in-C.O. to Trg. Sch.	1.3.38
Sugars, E. G.	E.-in-C.O. to Trg. Sch.	1.3.38
Swift, G. L.	E.-in-C.O. to Trg. Sch.	1.3.38
From S.W.2 to Proby. Insp. (Limited Comp., Sept., 1937).		
Beaumont, C. L. G.	S.La. to E.-in-C.O.(Trg. Sch.)	1.3.38
Dean, L.	S.La. to E.-in-C.O.(Trg. Sch.)	1.3.38
Farmer, R. M.	S.La. to E.-in-C.O.(Trg. Sch.)	1.3.38
Bedford, A. H.	L.T.R. to E.-in-C.O.(Trg. Sch.)	1.3.38
Cornforth, F.	L.T.R. to E.-in-C.O.(Trg. Sch.)	1.3.38
Irvine, W. T. L.	L.T.R. to E.-in-C.O.(Trg. Sch.)	1.3.38
Meredith, T. E.	T.S.B'm to E.-in-C.O.(Trg.Sch.)	1.3.38
From U.S.W. to Proby. Insp. (Limited Comp., Sept., 1937).		
Cook, E. A.	L.T.R. to E.-in-C.O.(Trg. Sch.)	1.3.38
Dymott, G. W. T.	L.T.R. to E.-in-C.O.(Trg. Sch.)	1.3.38
Goymer, E. G.	L.T.R. to E.-in-C.O.(Trg. Sch.)	1.3.38
Irving, L. J.	L.T.R. to E.-in-C.O.(Trg. Sch.)	1.3.38
Simmonds, J. P.	L.T.R. to E.-in-C.O.(Trg. Sch.)	1.3.38
Trask, G. W. F.	L.T.R. to E.-in-C.O.(Trg. Sch.)	1.3.38
Dearden, T. T.	S.La. to E.-in-C.O.(Trg. Sch.)	1.3.38
Mawdsley, A. T.	S.La. to E.-in-C.O.(Trg. Sch.)	1.3.38
Stevens, A. J.	S.La. to E.-in-C.O.(Trg. Sch.)	1.3.38
Heaton, N.	N.W. to E.-in-C.O. (Trg. Sch.)	1.3.38
Hinks, W. L. W.	E. to E.-in-C.O. (Trg. Sch.)	1.3.38
Purves, R. F.	E.-in-C.O. to E.-in-C.O. (Trg. Sch.)	1.3.38

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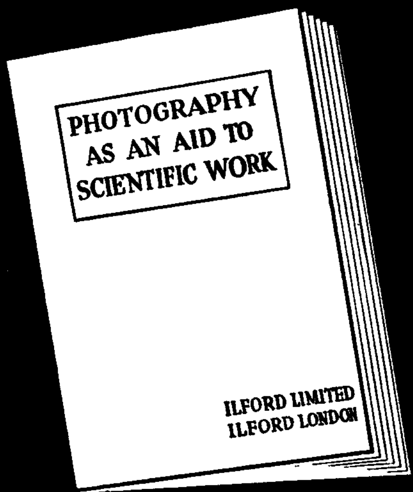

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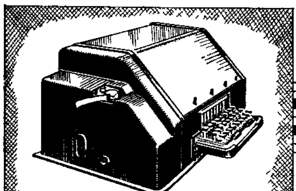
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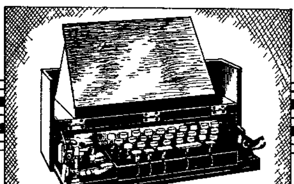
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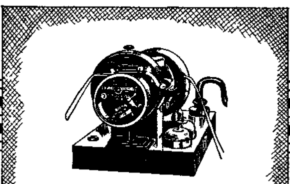
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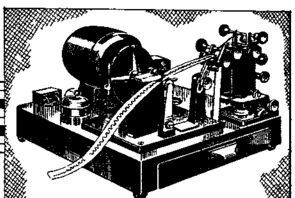
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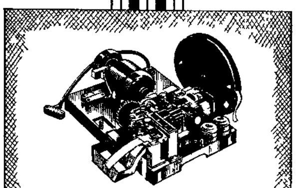
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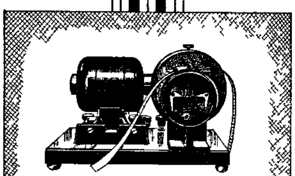
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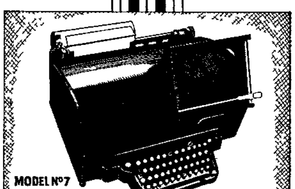
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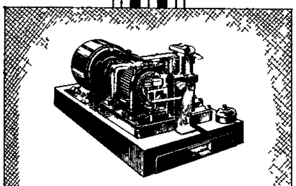
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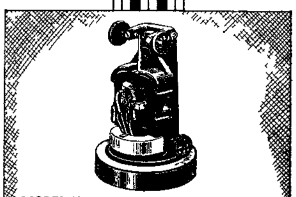
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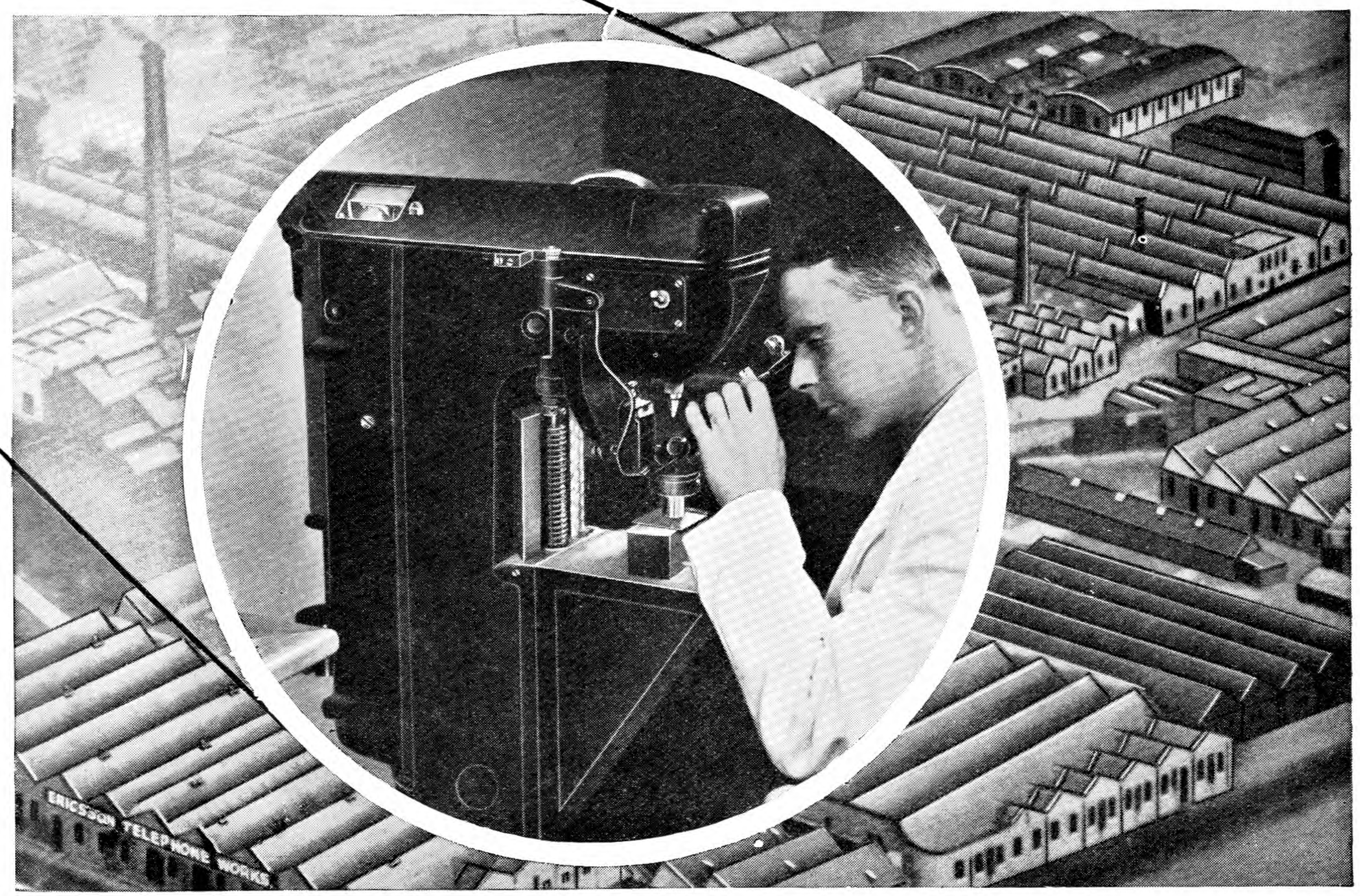

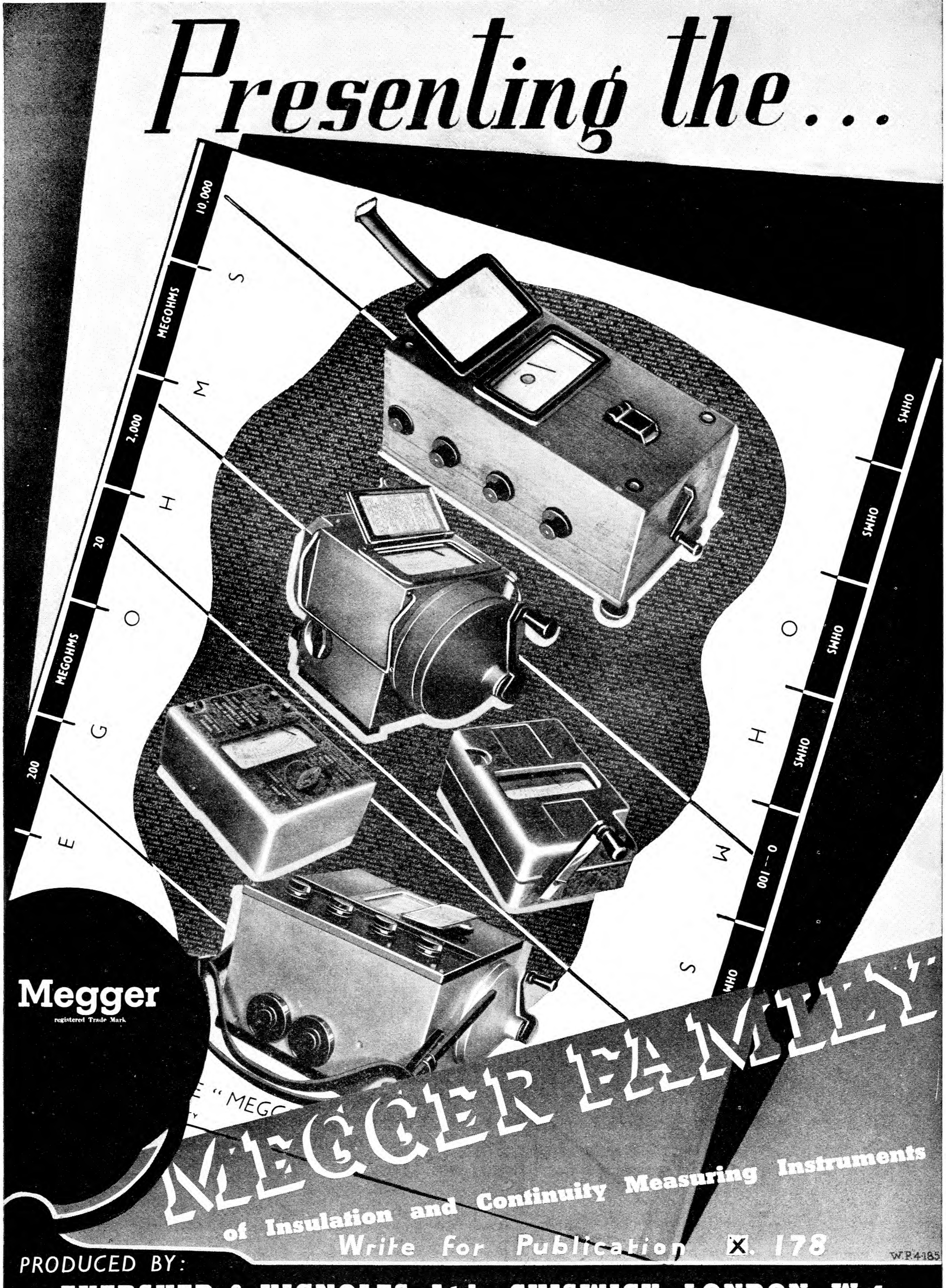

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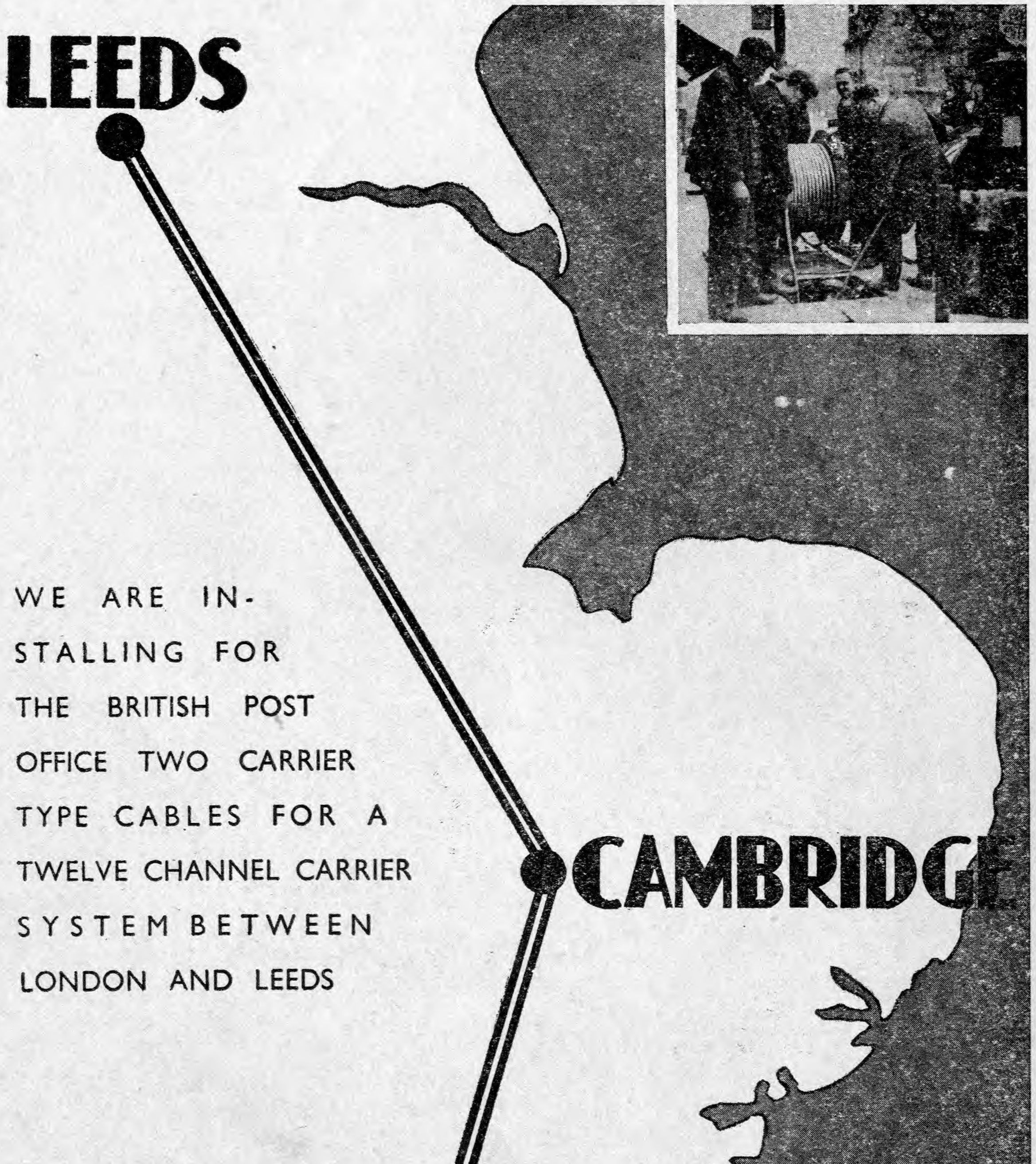

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