THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

NIL SINE LABORE

Vol. 56 Part 1

APRIL 1963

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Price 2s. 6d. (Post Paid 3s. 6d.)

Published in April, July, October and January by *The Post Office Electrical Engineers' Journal*, G.P.O., 2–12 Gresham Street, London, E.C.2.

Annual Subscription (post paid): Home and Overseas, 14s. (Canada and U.S.A., 2 dollars 25 cents).

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

Vol. 56 Part 1 APRIL 1963

The New Post Office Speaking Clocks

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U.D.C. 621.395.91:529.78

After 27 years' service the original British Post Office speaking clocks are being replaced. The new clocks use in-contact recording on magnetically-loaded neoprene and are driven from a crystal-controlled oscillator. The principal advantages of these new clocks, when compared with the original glass-disk machines, are reduced maintenance charges, greater accuracy and improved speech reproduction.

INTRODUCTION

THE speaking-clock service (TIM) was started in London in 1936 with a pair of clocks at Holborn exchange. It was extended to the rest of the country during the following years and a second pair of clocks was installed at Liverpool in 1942 as an additional safeguard against breakdown. Time announcements from these two installations are fed into a double "ring-main" circuit round the country. Under normal conditions one clock at each centre supplies approximately half the country but under fault conditions either installation may take the full load. The London clocks have now been replaced after 27 years' continuous service; the Liverpool clocks will be changed in a month or so.

It seems strange that a speaking clock service should be required at all in an age when mains-driven clocks are in general use, yet calls to the nation-wide TIM service approach 100 million a year. This is probably because mains-operated clocks can be affected by power failures and impulse clocks suffer, as much as anything, from unauthorized correction. Once confidence in a system has been lost it is very difficult to restore it; hence the need for TIM to be absolutely reliable and of unquestionable accuracy. The old clocks have been replaced not because they were failing—the mechanisms were probably good for another quarter century—but because the new clocks are a better economic proposition. The savings in annual charges with the new clocks, which need daily instead of hourly attention, more than justify the cost of replacement. The quality of the speech from the new clocks is also very much higher, the accuracy is greater and the power consumption is considerably lower than that of the old clocks.

BASIC PRINCIPLES

Before describing the new clocks an outline is given of the main features of the machines which they supersede.[1]

†Post Office Research Station.

An announcement is given every 10 seconds in the form: "At the third stroke it will be nine, twenty one, and ten seconds." This is followed by three 100 ms bursts of 1,000 c/s tone at 1-second intervals, known as the "pips." The constituent parts of the announcement are recorded as concentric photographic tracks on four glass disks. One disk carries the initial phrase and the six different seconds announcements, the next disk carries the 12 different hours announcements and the last two disks have the 60 different minutes announcements and the pips recorded on them. The recordings are played by scanning them with six beams of light; the outputs from the associated photo-electric cells are combined in sequence to form the complete announcement. The speed of rotation of the mechanism, and hence its time keeping, is controlled by a pendulum swinging freely in a temperature-controlled cabinet. With hourly corrections from the Royal Observatory this form of control enables an accuracy of ± 0·1 second to be maintained. Because of the optical focusing necessary on the speech tracks the mechanism has to be very well made, and precision engineering of this class is expensive.

The speaking clocks produced for Australia in 1954[2] also use photographic recordings but are controlled by crystal oscillators.

The new clocks for the British Post Office use magnetic recordings. Conventional magnetic tape is unsuitable for this purpose since both the tape and the replay heads would wear out too quickly. Within the last few years, however, a new magnetic recording material has become available that consists of a homogeneous mixture of a synthetic rubber (neoprene) and magnetic iron oxide; this material has already been used for other information-service machines.[3] It has a resilient non-abrasive surface and, so long as a thin film of silicone oil is maintained on it, neither the material nor the read head, which is lightly sprung against the neoprene, suffer any appreciable wear over long periods.

The constituent parts of the speech announcement are recorded as circular tracks on a thick tyre of magnetically-loaded neoprene stretched over a brass cylinder. This drum assembly is driven at constant speed by a motor running in synchronism with a quartz-crystal-controlled oscillator. The assembly of the announcements into the correct sequence is controlled by gears and cam-operated contacts driven from the main drum shaft. The pips are not recorded on the drum but are derived from the oscillator.

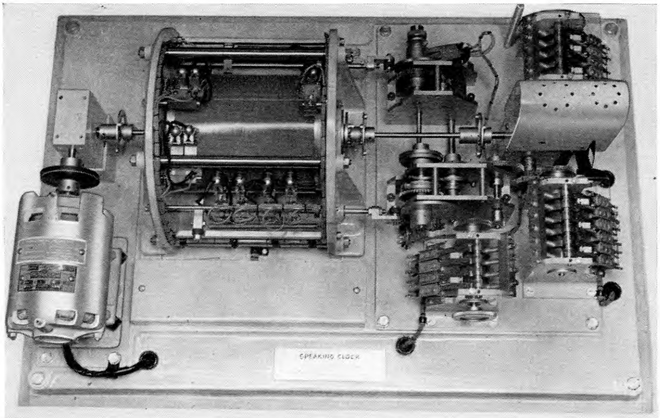


FIG. 1—ANNOUNCING MACHINE

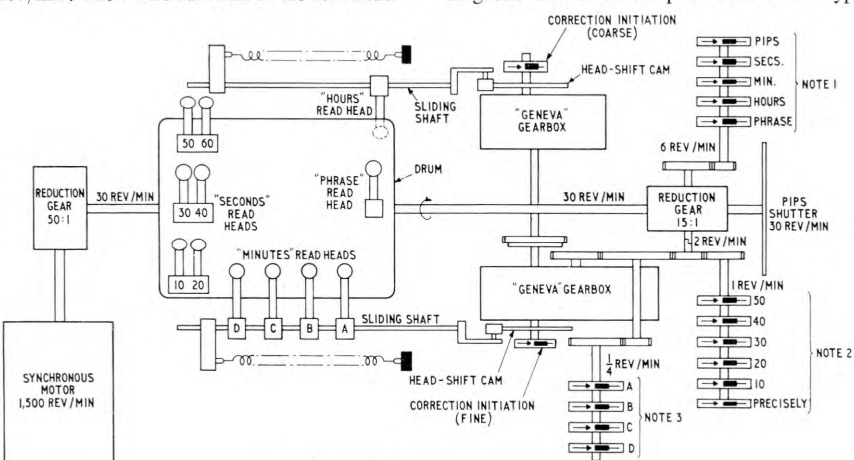
THE ANNOUNCING MACHINE

The announcing machine is shown in Fig. 1 and a schematic diagram of the apparatus is shown in Fig. 2. Only 79 separate phrases are required for a 12-hour clock and these are recorded as circular tracks spaced $\frac{1}{16}$ in. apart along the length of the drum. Reading from right to left: the first track carries the phrase, "At the third stroke"; the next 12 tracks have the hours, "it will be one" to "it will be twelve," recorded on them; then 60 tracks are provided for the phrase "o'clock" and the minutes "one" to "59"; and finally there are six tracks for the seconds announcements, "and ten seconds," to "precisely." Since none of these phrases is longer than 2 seconds the speed of the drum has been made 30 rev/min. The whole function of the remainder of the announcing machine is to build up composite announcements in the correct sequence and at the right time from the phrases on the drum. One possible, but impracticable, method of doing this would be to employ a single replay head and step it backwards and forwards along the drum picking out the phrases as required. Another, equally expensive, solution would be to employ a separate head for each track and assemble the announcements with a set of switches. The most economic solution is a compromise between these two extremes.

The phrase and the six seconds announcements are reproduced by fixed heads. The hours announcements are obtained from a single head which is stepped once per hour along the 12 hour tracks. Four heads are used for the minutes announcements; each covers 15 of the tracks and all four move together every four minutes. Fig. 3 shows the arrangement of the tracks on the drum and indicates the functioning of the cam-operated contacts used for assembling the announcements. This figure also illustrates the way in which large steps in the head movement are avoided by interleaving the announcements.

Head Shift and Announcement Assembly

The heads are moved under the control of "Geneva-type" gear-boxes; as an example consider the hour head. The head must remain on one track for an hour and then move to the next track in the time between the last announcement of one hour and the first announcement of the next, i.e. in less than nine seconds. This type of intermittent motion is easily accomplished by electromagnetic devices of the pawl and ratchet type (e.g. a



Notes: 1. Cam-operated announcement-assembly contacts
2. Cam-operated seconds-selection contacts
3. Cam-operated minutes-selection contacts

FIG. 2—SCHEMATIC DIAGRAM OF AN ANNOUNCING MACHINE

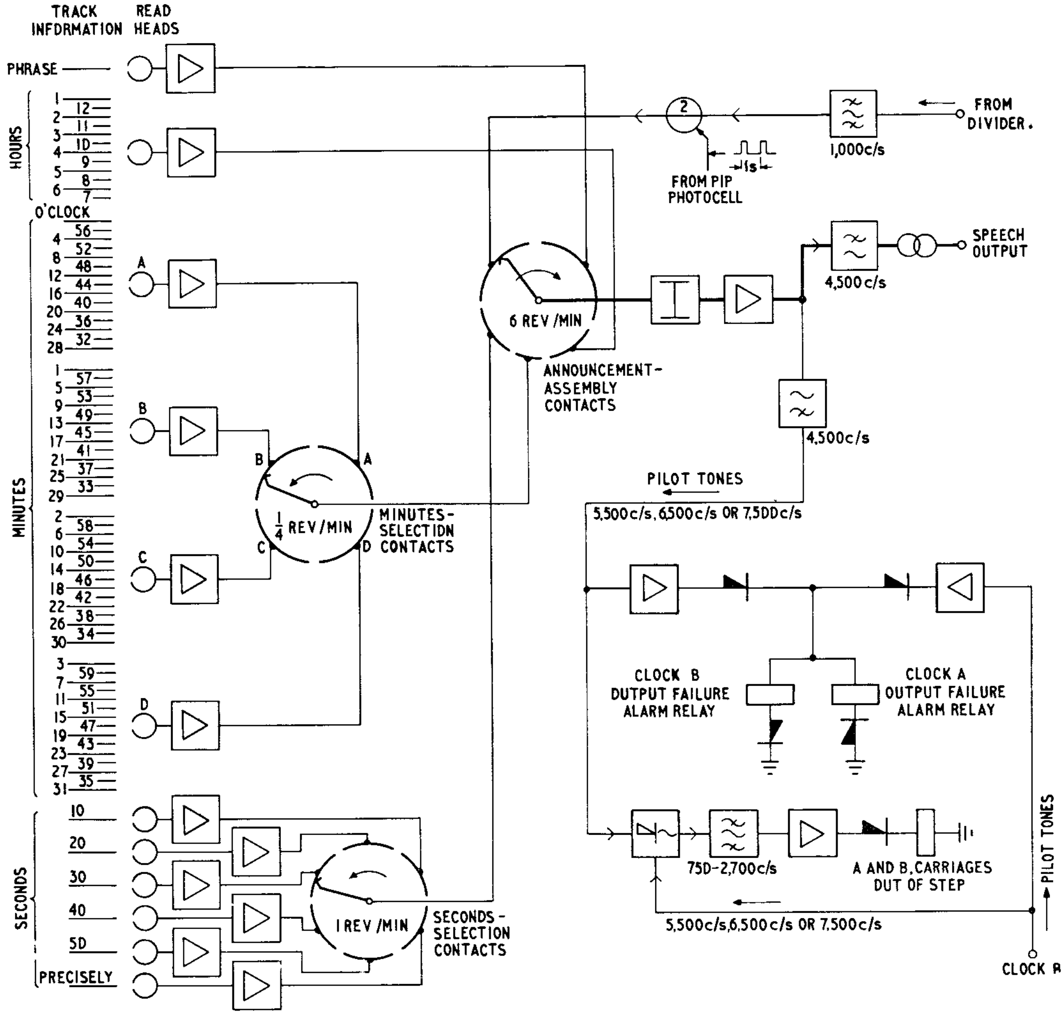


FIG. 3—TRACK ARRANGEMENT AND ANNOUNCEMENT ASSEMBLY

uniselector mechanism). These are not immune from mis-operation when pulse-operated over long periods unless constructed with great precision, and therefore a positively-locked mechanical movement has been adopted. The Geneva-type gear-box which drives the head-shift cams consists of a true Geneva movement and a series of toothed wheels and locking devices such as are commonly used in revolution counters. The hours head is carried on a rod which is free to slide parallel to the length of the drum and one end of this rod is constrained against a heart-shaped cam by a spring. This cam is turned by the gear box in discrete steps of 30° in two seconds once every hour and is so designed that the head is moved along the drum in five steps of $\frac{1}{8}$ in. and a sixth step of $\frac{1}{16}$ in.; the head then returns along the drum in a similar manner. Thus the tracks for the hours one to six are interleaved with the tracks for the hours seven to 12. The arrangement for changing the minutes announcement is similar to that used for the hours except that four minutes heads are used, each movable over 15 tracks, in order to keep the head shift cam down to reasonable proportions.

After amplification, the outputs of the 12 heads are selected and assembled by cam-operated switches. These cams, which are disks of Nylatron (nylon loaded with molybdenum disulphide), are connected to the main drum shaft by a train of gears. The switches are relay-type spring-sets, are fitted with platinum contacts, and are operated by trailing hardened-steel cam-followers.

Pips

The pips are controlled in a slightly different manner from the rest of the announcement. Two different sets of 1-second pulses are required, (*a*) to control the pips themselves, which consist of 100 ms bursts of 1,000 c/s tone and also mark the beginning of the 8th, 9th and 10th seconds in every announcement, and (*b*) to provide a 1-second timing waveform (500 ms on, 500 ms off) for correcting the time of both clocks and detecting when the time of the two clocks of a pair is out of step. Relay-type contacts could have been used for the seconds pulses but, as there are approximately 30 million seconds in a year, the duty is so onerous that the pulses have been produced by using a shutter to interrupt a beam of light falling on a pair of photocells. This shutter can be seen on the end of the main shaft in Fig. 2. The shape of the shutter is shown in Fig. 4. The outputs from the photocells are used to control diode gates.

MOTOR DRIVE AND TIME-CORRECTION CIRCUITS

A functional diagram of the main motor drive and time-correction circuits of the clocks is shown in Fig. 4.

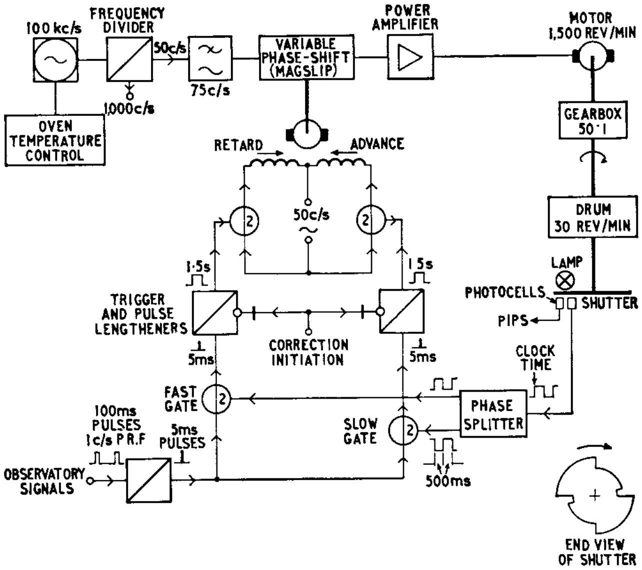


FIG. 4—FUNCTIONAL DIAGRAM OF MOTOR-DRIVE AND TIME-CORRECTION ARRANGEMENTS

Each clock has its own 100 kc/s quartz-crystal oscillator maintained at 50°C in an oven. The output from this is frequency-divided down to 1,000 c/s for the pips and down to 50 c/s for the motor supply.

The phase shifter, a 3-phase Magslip in the motor-drive line, is used for the correction of the clock time. One complete rotation of the Magslip advances (or retards) the phase of the 50 c/s supply by one cycle and thus advances (or retards) the clock by 20 ms. The correction of the clock against a signal from the Royal Observatory is accomplished automatically between 08.56 and 09.00 hours each day in the following manner. The 1-second timing waveform (500 ms on, 500 ms off) is taken to a phase splitter which produces two waveforms 180° out of phase and these control a pair of gates, the fast and slow gates, also 180° out of phase. The correction signal is obtained by land line from the Rugby radio station and is, in fact, the same signal that is used to control the 16 kc/s transmitter (GBR) between 08.55 and 09.00 hours daily.[4] The Rugby signal is essentially a train of pulses at 1-second intervals each 100 ms long. When these 100 ms pulses are received by the clock they are regenerated as 5 ms pulses which are fed to the fast and slow gates in parallel. If the clock is exactly right, half the 5 ms pulse will pass through the fast gate and half through the slow gate. If the clock is more than about 2 ms slow only the slow gate will be open during the 5 ms pulse and the only output will be from this gate. Opposite conditions will obtain if the clock is fast. An output from either the fast or the slow gate is lengthened to 1·5 seconds by the trigger and pulse-lengthener circuits, and this in turn permits a small motor to be driven forwards or backwards for this period. This motor is coupled to the Magslip and thus corrects the time of this clock in the desired direction at a rate of about 2 ms/second.

The whole sequence may be illustrated by considering the clock to be, say, 10 ms slow. At 08.00 hours the coarse-correction initiation contact on the clock closes and at 08.56 hours the fine-correction contact also makes. An earth is extended to the a.m. or p.m. selection circuit (a divide by two relay circuit which, in effect, passes on every alternate signal) and this causes the guards to be removed and correction to proceed. The first pulse from the Observatory, shortened to 5 ms, passes through the slow gate and the Magslip starts to rotate in the advance sense. This rotation would continue until, after about three seconds, pulses pass through both the fast and slow gates and these, acting together, cancel out and rotation ceases. Conditions remain quiescent until 09.00 hours when the correction initiation contacts open and all further correction is barred for 24 hours.

This circuit can only correct to within about 2 ms of true time, an error that is not really significant for most users of the service. Spurious pulses arriving during the correction period can cause false correction for up to a second but this is put right during the remainder of the period.

AUDIO CHAIN

There are two points of interest in the announcement circuits which are illustrated in Fig. 3.

At midband frequencies the outputs from the 12 magnetic heads are of the order of 0·1 mV from an equivalent-generator impedance of 15 ohms. Direct switching of these outputs using balanced transistor switches seemed attractive and this method was tried. However, noise and switching transients proved to be too troublesome and the attempt was abandoned. A single-stage amplifier with an emitter-follower output is used for each head. The 12 emitter-followers feed into a common load via the pre-selecting and combining contacts. The signal level at this point is about 0·2 volt.

Pilot tones of 5,500, 6,500 or 7,500 c/s are also recorded on each of the 79 speech tracks of the drum. These pilot tones are used to detect if the announcements of the two clocks in an installation are out of step or missing; a low-pass filter removes the tones from the audio output.

ALARMS

The country is served by two pairs of clocks at London and Liverpool, respectively, and each installation normally serves half the country. If both outputs from one installation fail the distant centre automatically takes over the entire service. The most likely causes of complete failure of one centre are the loss of the mains supply or of the 50-volt supply to the relays and supervisory equipment. Should either of these events occur an alarm will be given. These alarms have to be manually reset as even a short break in the mains supply would put both clocks out of time.

Three other possible faults will also cause an alarm to be given. Firstly, part of an announcement may be missing from one clock, due perhaps to a faulty head amplifier or announcement assembly contact. To detect this condition the pilot tones from each clock are filtered off from the announcement and are then compared. The presence of a pilot tone from only one clock indicates a fault condition as it is unlikely that both clocks will fail in this way at the same instant.

Secondly, the two clocks in a pair may make the same announcement but their pips may be out of synchronism by more than a prescribed amount, i.e. 50 ms. A continuous check for this condition is made by comparing the 1-second timing waveforms from the two clocks and registering an alarm condition if they are out of synchronism. Thirdly, the clocks may be in synchronism but making different announcements. This condition is only possible if the hours or minutes heads stick and fail to move with their cams or if there is a catastrophic failure of the combining cams. The announcement-out-of-step alarm is controlled by the three pilot tones. These three tones have been recorded on the speech tracks, one per track, in a carefully chosen order which ensures that any natural failure in any part of the announcement assembly mechanism will immediately cause disparate tones to appear at the outputs of the two clocks. The pilot tones from the two clocks in a pair are taken to the two inputs of a double-balanced modulator. Under normal conditions these inputs are of the same frequency, but if a fault occurs a difference frequency of 1,000 or 2,000 c/s is produced which causes the alarm to operate. It is not possible, with three pilot tones only, to make an alarm of this sort completely foolproof but it is proof against all likely failures.

With both the second and the third class of fault it is not possible to detect which clock is in error and both are automatically removed from service to enable their times to be checked.

FIG. 5—CLOCK CONSOLE AND APPARATUS RACKS

MISCELLANEOUS FACILITIES

Although the miscellaneous facilities provided are not strictly necessary to the functioning of the clocks, nevertheless they make maintenance work much easier. Facilities have been provided for the complete output of each clock, and also the separate outputs from the 12 reading heads, to be monitored on a loudspeaker, a cathode-ray oscilloscope or a peak-program meter, and all these items of equipment are built into the clock. Two dial clocks with second hands are provided, driven from the two stable 50 c/s supplies, and a third clock connected to the public mains supply is available nearby. A medium-wave radio receiver is provided as an emergency source of standard time signals should the normal correction signals fail to arrive. One of the clocks can readily be checked against the broadcast "six pips" by displaying the two signals on the dual-channel oscilloscope.

Finally, the Post Office standard 1,000 c/s is multiplied up to 100 kc/s and a beat counter is provided so that the two clock oscillators may be checked against each other and also against the external standard.

GENERAL CONSTRUCTION

The London clocks, assembled in the laboratory prior to installation, are shown in Fig. 5. The console contains the head pre-amplifiers and various testing facilities. The remainder of the equipment, of 51-type construction, is mounted on the three racks, one rack per clock with common testing and supervisory facilities on the centre rack. Apart from the oscilloscope, a commercial item, transistors have been used throughout and this has enabled the total power consumption to be kept down to about 500 watts.

ACCURACY

The inherent accuracy of the clocks is governed by the drift of the oscillators and the closeness of correction. The oscillators are not expected to produce an error in the clocks of more than about 5 ms a day. Because of mechanical and electrical inaccuracies on the motor and gears of the clocks there will always be uncertainty in the time of the clocks and this may amount to $\pm$ 1 ms. To this uncertainty must be added the correction error of up to 4 ms. Thus, just before correction the clocks may be up to 10 ms out and after correction they should be within 5 ms of the Rugby correction pulses as received at the clocks. Any delay on the land line from Rugby to the clocks has been allowed for, as far as possible, in the design of the correction circuits. There will, of course, be further delays on the lines from the clocks to the subscribers which cannot be compensated so easily.

Another major complication involves the question of time scales. For normal civil use the appropriate scale is Universal Time (U.T.). Now the rate of the signals from GBR is maintained by reference to the Atomic Time Scale. Owing to unpredictable variations in the rate of rotation of the Earth (and thus in U.T. with respect to the Atomic Time Scale) the signals from Rugby will differ from U.T. The time difference is allowed to accumulate until a jump-correction of 50 ms is necessary; this is applied at Rugby at 00.00 hours on the first of the month. Thus 9 hours after such a correction the speaking clocks will also be corrected by this amount.

This complication is avoided by claiming that TIM is normally accurate to 1/20th second. The higher inherent accuracy of the clocks should enable them to run for several days without any correction and may, incidentally, be of value to a few specialist users of the service.

CONCLUSION

The new clocks that have been provided for the TIM service are basically very similar to their predecessors. The changes in design are evolutionary rather than radical. Quartz crystals have replaced pendulums, magnetic recording has replaced photographic recording, transistors have replaced valves, and the equipment has become smaller but more complex.

The life of the new clocks will almost certainly be less than that of the earlier glass-disk machines, but the parts that are most likely to wear out, after 10 years perhaps, can all be easily and cheaply replaced. A prototype machine has been giving continuous service to the Research Station P.A.B.X. since January 1960; the only maintenance so far performed has been oiling and cleaning at 6-monthly intervals.

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A Simple Sum-of-Squares Electronic Calculator

L. W. ELLEN, A.M.I.E.E.†

U.D.C. 681.142:519.241.6

A simple electronic calculator is described that facilitates the calculation of the standard deviation of data derived from recording decibelmeter charts.

THE most commonly used statistical measure of the variation from normal of a measured quantity is the standard deviation. This is the root-mean-square value of the deviation from average.

Thus the standard deviation, σ, is equal to

$$\sqrt{\frac{\Sigma(x-\bar{x})^2}{n}},$$

where x = individual value

$\bar{x}$ = mean value, and

n = number of measurements made.

$$\sigma^2 = \frac{\Sigma(x-\bar{x})^2}{n} = \frac{\Sigma x^2}{n} - \frac{2\bar{x}\Sigma x}{n} + \frac{\Sigma(\bar{x})^2}{n}$$

But $\frac{\Sigma x}{n} = \bar{x}$, so that

$$\sigma^2 = \frac{\Sigma x^2}{n} - 2(\bar{x})^2 + (\bar{x})^2$$

$$\therefore \quad \sigma = \sqrt{\frac{\Sigma x^2}{n} - (\bar{x})^2},$$

i.e. the square root of the difference between the mean of the squares and the square of the mean, and this form is often preferable as it permits the calculation of standard deviation without the need to subtract separately the mean from each measurement.

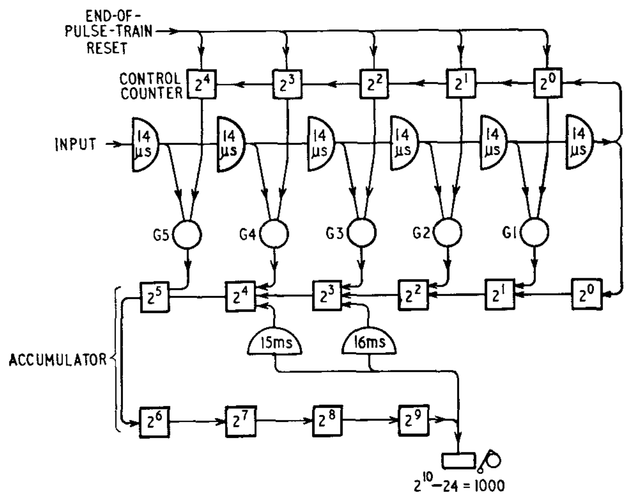
In connexion with the analysis of recording decibelmeter charts it is necessary to calculate the standard deviation of a long series of integers between zero and 31, the integers being available in the form of pulse trains of up to 31 pulses produced by an optical scanner. The pulse rate within the pulse train is about 3 kc/s and the pulse trains follow each other at about 40 ms intervals, i.e. about 25 pulse trains per second. The first stage in the calculation of the standard deviation is to obtain the sum of the squares of the numbers of pulses in each train and a simple sum-of-squares electronic calculator has been developed for this purpose.

It is well known that the square of any integer x is equal to the sum of the first x odd numbers; this follows from the elementary algebraic identity $(x + 1)^2 = x^2 + (2x + 1)$. For example, $4^2 = 1 + 3 + 5 + 7$. If a digital accumulator can be advanced by 1 for each pulse in a pulse train and also advanced by 0, 2, 4, 6, 8, et sqq., by successive pulses, the number added to the accumulator will be the square of the number of pulses in the pulse train.

Two binary counters are therefore provided: one, the control counter, has five stages counting up to $2^5 - 1 = 31$, the maximum train length, and the other, the accumulator, has 10 stages counting up to $2^{10} - 1 =$ 1,023 and registers Σx^2. The incoming pulse train is passed into a simple delay line and each pulse is offered in turn to each of the first six stages of the accumulator. The circuit arrangement is shown in the accompanying figure. Acceptance of the pulse at each stage (except the end one) is dependent upon the state of an electronic gate controlled by the corresponding stage of the control counter. The latter is set to zero before the commencement of each pulse train, and the first pulse finds all the gates shut. This pulse therefore adds only 1 to the accumulator and also advances the control counter by 1, so opening the gate G1 to the second stage of the accumulator. The second pulse therefore registers $2 + 1$ in the accumulator which, with the first pulse, totals $2 + 1 + 1 = 4 = 2^2$. The control counter is again advanced, opening the next gate, G2, and closing the

†Main Lines Development and Maintenance Branch, E.-in-C.'s Office.

first so that the third pulse registers $4 + 1$. The total is then $2^2 + 4 + 1 = 3^2$. The fourth pulse finds two gates,



SCHEMATIC DIAGRAM OF SUM-OF-SQUARES ELECTRONIC CALCULATOR

G1 and G2, open and registers $4 + 2 + 1$, and so on to the end of the train, with a maximum of 31 pulses. Strictly speaking, 32 pulses could be accepted—the thirty-second pulse would find all gates open and would register $32 + 16 + 8 + 4 + 2 + 1 = 63$, increasing the total from 961 ($= 31^2$) to 1,024 ($= 32^2$)—but in practice it is preferred to leave a margin of at least one pulse. The thirty-third pulse would fail.

It is necessary to use a delay line so that the pulses are offered to the accumulator stages successively and not simultaneously, because at each stage a "carry" pulse to the next stage may be generated. This carry pulse must not coincide with a gated pulse because a simple counter cannot accept two simultaneous inputs. The delay line consists of three *LC* sections, of 5 mH and 0·004 μF each, between each gate; the delay time is thus about 14 μs. This is short enough for each pulse to travel past all the gates and for any carry pulses to propagate fully before the next pulse arrives about 300 μs later.

A maximum-length pulse train advances the accumulator by $31^2 = 961$, and this may occur 25 times per second. It is therefore necessary to provide 10 electronic stages in the accumulator, although only six are concerned with the gating arrangements. This gives a capacity of more than 961 and a carry pulse from the final stage cannot occur more than 25 times per second. This is slow enough to drive an orthodox electromagnetic counter. Each time the latter operates, a pulse is fed back to the fourth and fifth stages of the accumulator, adding $8 + 16 = 24$ and reducing the effective count of the accumulator from 2^{10} ($= 1{,}024$) to 1,000. The feedback is delayed so as to occur between pulse trains and thus avoid coincidence with the normal input. The electromagnetic counter therefore counts thousands. The final reading is only needed to the nearest 1,000 and there is no need to provide read-out of the electronic part of the accumulator.

Separate registers record the total number of pulse trains (n) and the total number of pulses in all the pulse trains (Σx). From these and the sum-of-squares (Σx^2) register it requires only a simple and short calculation to determine the mean and standard deviation, especially if the value of n is chosen to be a round number, say 10,000.

A model has been constructed using semiconductor circuits and operates satisfactorily. The speed is low by modern computer standards but no doubt higher speeds could be achieved if necessary, although carry pulse and delay-line difficulties would increase, particularly if the range were extended by adding further control stages and gates.

Book Review

"Programming Systems for Electronic Computers." Prof. D. N. Chorofas. Butterworth & Co. (Publishers), Ltd. xiii+188 pp. 14 ill. 50s.

The stage has now been reached in the development and application of electronic computer systems when their effective use depends at least as much on the effectiveness of the methods used to prepare their programs and schedule their operations as on the engineering performance of their equipment. The terms "software" and "hardware" are increasingly used for these two aspects, and are complementary in that a desired result can be achieved with more programming and less equipment, or vice versa. Professor Chorafas' book is concerned with recent developments in software, and is divided into five parts. Part I, "The Programming Problem," sets the scene. Part II, "Early Programming Media," deals with the use of subroutines, assemblers (i.e. programs for translating other programs from a mnemonic to a machine code) and program testing. One chapter is a rather too detailed account of one of International Business Machines' assemblers, and requires its reader to memorize a number of arbitrary codes to follow the discussion at all closely. The chapter on testing is a useful reminder of the many errors that plague programmers.

Part III, "Procedure-Orientated Languages," discusses methods of programming which aim at letting the average user write more or less in his normal language, namely, algebraic notations for mathematical programs and business English for commercial programs. It uses as examples for detailed discussion I.B.M.'s "Fortran" and "Commercial Translator," and also goes into some introductory detail on two more international procedure-orientated languages "Algol" and "Cobol." Part IV, "Processing Systems," deals with the design of programs for converting procedure-orientated language into machine code. Part V, "Advanced Programming Concepts," outlines a complete programming system in terms of an imaginary example, which includes provision for automatic program testing, hardware stimulation, and for automatic operation of the computer system.

In his preface the author promises that: "In this volume we shall review the evolutionary process of programming in considerable detail." Programming is, inevitably, a subject that deals with minute detail, but in places the principles are obscured by details, and some of the concrete examples are tediously over-lengthy for the light they throw on the underlying concepts. Nevertheless, this is a timely book for, as the author truly writes, "It is not hardware that gets the job done—it is systems conceived in breadth and developed with clear objectives in mind." It follows that this is a book for systems analysts rather than engineers. It would be heavy going for someone having little previous knowledge of computer programming. There are a number of misprints, but none is serious enough to mislead a careful reader. F.J.M.L.

Field Trials of Large Polythene Cables in Subscribers' Local-Line Networks

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U.D.C. 621.395.743:621.315.221.8:678.742.2

Small polythene-sheathed and insulated cables have been in widespread use in subscribers' local-line networks for some years and have been shown to possess a number of advantages over lead-sheathed cables, including being of light weight and clean and easy to handle. A number of larger cables, all with polythene sheaths and some with polythene insulations, have been laid since 1957 as a trial to see whether the advantages experienced with small polythene cables are realized with large cables.

INTRODUCTION

SINCE 1957 a number of large polythene underground cables, all with more than 100 pairs and including some with 2,000 pairs, have been installed for trial purposes in subscribers' local-line networks. Experience with smaller polythene-sheathed and insulated cables has shown that they are of light weight, clean and easy to handle, have good electrical and mechanical properties, and are suited to existing cable manufacturing processes. The object of the trials is to test whether these advantages can be exploited in large cables.

TRIAL CABLES

Two main types of large polythene-sheathed cable are under trial (see Fig. 1), one with paper-insulated conductors and the other with polythene-insulated conductors. In the main, copper conductors of conventional sizes are used, but a few of the cables, referred to later, have aluminium conductors.

(a) (b)

(a) Four-Hundred Pair 4 lb/mile Unit-Twin Cable Having Polythene-Insulated Copper Conductors
(b) Four-Hundred Pair 4 lb/mile Unit-Twin Cable Having Paper-Insulated Copper Conductors

FIG. 1—EXAMPLES OF LARGE POLYTHENE-SHEATHED CABLES

Developments in the cable industry have enabled manufacturers to make cables with polythene sheaths and polythene-insulated copper conductors that have diameters almost the same as those of equivalent lead-covered paper-core cables. The reduction in diameter, compared with earlier polythene-insulated cables, is achieved mainly by the use of thin conductor-insulants and these are used in the large "all-polythene" cables under trial. Wall thicknesses for different gauges of polythene-insulated copper conductors are:

4 lb/mile—6·5 mils.
6½ lb/mile—8 mils.
10 lb/mile—10 mils.
20 lb/mile—12 mils.

The different wall thicknesses enable cables with different conductor gauges to have very similar values of mutual electrostatic capacitance.

Most of the trial cables referred to above are sheathed with polythene of Grade 2 (m.f.i.)* containing an anti-oxidant, butyl rubber and carbon black. This is the usual sheathing material for the Post Office standard all-polythene cables, but some of the large polythene cables under trial are sheathed with polythene of Grade 0·3 (m.f.i.) or a high-density type of polythene. Also, in some cables the carbon black is omitted. The large polythene cables have sheath thicknesses comparable to those of equivalent lead-covered paper-core cables.

The cables containing paper-insulated conductors have their cores laid up in conventional unit fashion, each unit containing the usual 51 or 100 pairs, depending on the size of the cable. The cables with polythene-insulated conductors have cores made up of 25-pair units, each unit being bunched, i.e. the pairs are not in layers. Colour identification of the polythene-insulated conductors makes use of the well-known colour-code: blue, orange, green, brown, slate (or grey). These colours are, in fact, used to indicate the B wires, but the associated A wires are coloured in groups of five wires: white, red, black, yellow and violet. Thus, colour-groups of pairs are formed each containing five pairs, and the groups are designated white, red, etc. Each 25-pair unit therefore comprises five 5-pair colour-groups, and unit identification is achieved by coloured-strand whippings or coloured tapes.

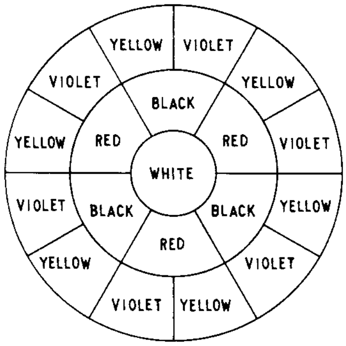
Mirror-Image Core-Formation

A recent development is a core arrangement in which units of polythene-insulated pairs are marked and positioned to give a mirror-image formation. In such a formation, units in certain positions in the core are marked identically, e.g. by similarly-coloured whipping strands or tapes, and a typical example of a mirror-image formation is given in Fig. 2. It will be seen that a cable with a mirror-image core-formation has virtually neither a "clockwise" nor an "anti-clockwise" end, and this, regardless of the direction in which the lengths have been laid, enables joints between lengths of such cable to

†External Plant and Protection Branch, E.-in-C.'s Office.

*m.f.i.—Melt flow index.

be constructed in a straightforward manner with units connected together, colour to colour, without crossing



Each section represents a group (or unit) of polythene-insulated pairs having a binder coloured as shown. The pairs themselves are identified in accordance with the appropriate colour scheme.

FIG. 2—EXAMPLE OF MIRROR-IMAGE UNIT IDENTIFICATION FOR EXPERIMENTAL POLYTHENE CABLE

them. Cables with mirror-image core-formation are already in use in some of the trial schemes.

Aluminium Conductors

A few large polythene cables having aluminium conductors have been produced and are under field trial. One such cable has 400 pairs of paper-insulated aluminium conductors each having a nominal diameter of 0·026 in. and laid up in conventional unit fashion. The resistance of the 0·026 in. diameter aluminium conductor is equivalent to that of a copper conductor having a weight of 6½ lb/mile; a copper conductor of this weight has a normal diameter of 0·020 in. The cables with aluminium conductors are notable for their lightness, a considerable asset for cabling, but they are, however, about 25 per cent larger than equivalent copper-conductor cables and thus occupy more duct-space. The economic and other considerations of the use of aluminium-conductor cable have been dealt with fully in an earlier article* about the Dover–Deal experimental cable, and elaboration is outside the scope of this article. The object of the field-trial of polythene cables having aluminium conductors is largely to follow-up the Dover–Deal cable experiment.

FIELD TRIALS

The scope of the field trials is practically nation-wide, and trials are taking place, or are proposed, in all of the nine telephone Regions and Directorates. In the localities chosen for the trials the amounts of experimental cable vary from isolated lengths in a standard cable network to the many lengths of cable of different sizes and different conductor gauges required for complete local-line development schemes. Opportunities have also been taken to try lengths of experimental cable in unusual circumstances where advantages may be taken of the cable construction, e.g. the use of polythene cable for directly terminated tie-cables in exchange transfer schemes and the use of polythene-sheathed cable on bridges where vibration is such that conventional lead-covered cables traversing these bridges have only a short life.

*Hayes, H. C. S. The Dover–Deal Experimental Cable. *P.O.E.E.J.*, Vol. 48, p.224, Jan. 1956, and Vol. 49, p. 22, Apr. 1956.

Inception of Field Trials

The present program of field trials of polythene cables commenced in 1957, and up to the present about 170 miles of polythene-sheathed paper-core cables, ranging in size from 150 pairs to 2,000 pairs, and about 103 miles of polythene-sheathed and polythene-insulated-conductor cables, ranging in size from 150 pairs to 2,000 pairs, are on trial. The general procedure for the inception of the field trials takes two forms. Each Region and Directorate is either given details of lengths, types and sizes of large polythene cable which is, or will become available, and are invited to accept the experimental cable instead of conventional cable, or, alternatively, each Region and Directorate is invited to submit plans of development schemes with the object of obtaining experimental cable specially for the particular schemes. After suitable schemes have been agreed and it has been decided to proceed with the particular trial, arrangements are made for the manufacture and delivery of the necessary cable. Prior to and during the work of installation, Engineering Department representatives usually visit the localities concerned to discuss the scheme plans and carry out route surveys with local staff, perhaps demonstrate new techniques, and generally serve in an advisory capacity.

Tests and Reports

Shortly before experimental polythene cables are drawn into the ducts, the cables are tested for conductivity and insulation resistance of the cores; these tests are additional to the usual tests that are carried out in the manufacturer's works. After the cables have been drawn into the ducts the tests are repeated in order to ascertain whether or not the cabling operations have caused any faults such as broken conductors. After any necessary jointing of the experimental cables has been completed and before they are brought into service the tests are again repeated. In addition, overall air-pressure tests are carried out. If the experimental cable section exceeds about 440 yards, the electrical tests made are more comprehensive and a testing program similar to that for trunk and junction cables is followed, e.g. capacitance-unbalance and conductor-resistance-unbalance tests are carried out.

After the completion of each experimental cable scheme a report is produced giving details of the scheme, the comments of all involved in the installation work, and electrical test results. Questionnaires are issued to local staff concerned with each scheme, separate questionnaires being given for cabling, jointing and testing work; the information contained in the completed questionnaires is a very useful record and aid in compiling the reports. In order to keep the experimental cables under observation, periodical electrical tests are carried out on test-pairs in the cables, and the results, together with any other relevant information, are embodied in subsequent reports.

LAYING CABLES IN LONG LENGTHS

A policy that is being followed in the installation of the experimental cables is that they are laid in as long lengths as practicable. Apart from other considerations, the use of long lengths of cable without joints enables a better appraisal of the behaviour of the cable itself to be made, the influence of possible weaknesses in the joints on the overall behaviour of the experimental-cable installation being kept to a minimum. Considerable success in laying long lengths of experimental cable has already been achieved, e.g. in the Swansea area approximately 880 yards of 200-pair cable were drawn into a duct, and in the Lowestoft area approximately 600 yards of 500-pair cable were drawn into a duct. Quite clearly, the drawing-in of long lengths of the cable is only possible because the cable is light, easy to handle, very flexible and tough, and possesses a smooth sheath.

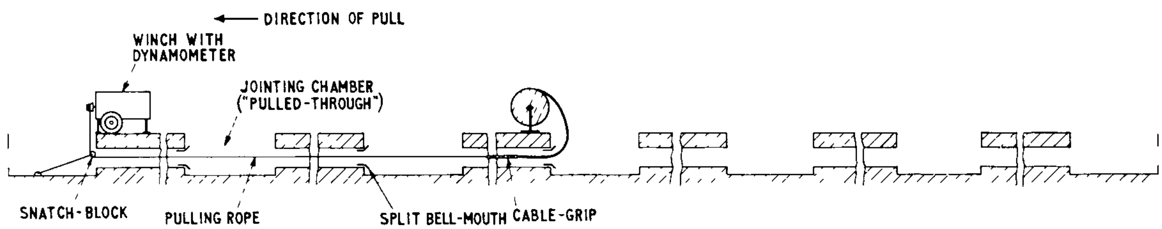
Generally, the procedure when drawing-in lengths of cable commences with drawing a cable-pulling rope into all the duct lengths that will contain the long length of cable. If an attempt is to be made to draw the cable in to the section from end-to-end in one pull it is usually necessary to join lengths of rope together. The cable is connected to the pulling-rope in the conventional manner by means of a cabling-grip and a swivel, though it has been found advisable to consolidate the cable at its pulling-end by driving a steel spike axially into the cable-core. A motor-winch is normally used to pull the cable into the duct, but hand-hauling is sometimes tried, mainly to gain information about its practicability and the manpower required. Drawing the cable into the duct section from end-to-end in one pull is considered first, and is usually attempted unless there are obvious objections, such as arise where the cable-route, considered as a single length, contains one or more sharp angles. When there is a decision against attempting an end-to-end single pull, or if a single pull is attempted but subsequently found to be unsuccessful or very difficult, attempts are made to pull in the length a section at a time using one of the methods illustrated in Fig. 3 and 4.

As in many normal cabling operations, small difficulties arise that are peculiar to a particular operation, and steps to overcome them may sometimes be in the nature of improvisation. Such methods, which provide useful experience, have had to be used on occasions when drawing-in long lengths of experimental cable, e.g. in order to negotiate a right-angled bend whilst the cable was being drawn-in, a 400-pair cable was passed round a large pulley set up in the jointing chamber concerned.

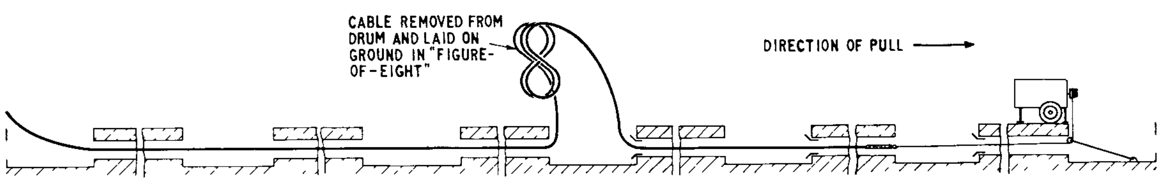
JOINTING

The methods of jointing used so far in the trials of large polythene cables have, generally, conformed to standard Post Office practices. The conductors are twist-jointed, the twists being insulated with paper or polythene sleeves, and the joints are enclosed by lead or polythene sleeves and sealed by means of rubber compression plugs (known as expanding plugs).

Aluminium conductors are twist-jointed and either tip-welded by means of a simple electric arc-welding technique or tip-soldered by using ordinary soldering methods with special aluminium-cored solder. Tip welding is generally used for aluminium–aluminium joints and soldering for aluminium–copper joints; arc-welding is not satisfactory for the bi-metallic joints. Standard Post Office expanding plugs have been used to seal the joints when an appropriate plug has been available. In the main, however, special long plugs have had to be

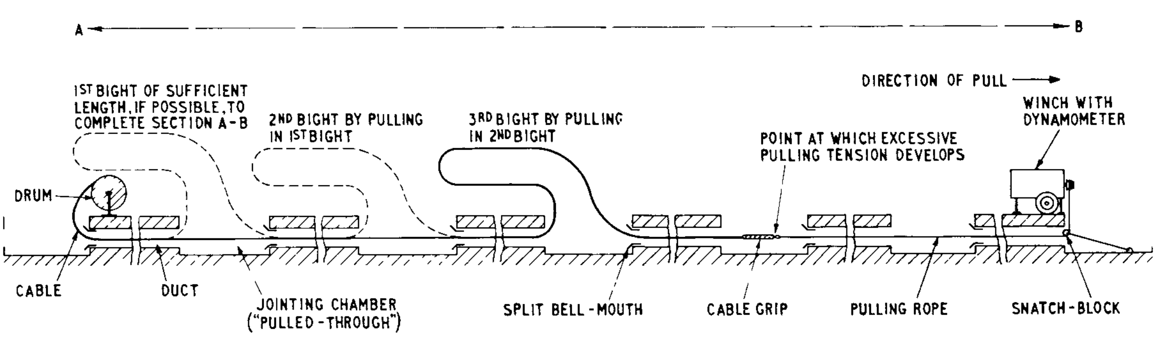


(*a*) Stage 1—Drum Set Up at an Intermediate Point and Cable Drawn-In to One End of Section.



(*b*) Stage 2—Cable Removed from Drum and Drawn-In to Opposite End of Section.

FIG. 3—METHOD OF CABLING LONG LENGTHS WITH THE CABLE FED FROM AN INTERMEDIATE POINT



Note: It is assumed that the duct is satisfactory and that excessive pulling tension is not due to a defective duct or a blockage.

FIG. 4—METHOD OF OVERCOMING EXCESSIVE PULLING TENSION WHEN CABLING LONG LENGTHS

used, and examples of such are illustrated in Fig. 5; only one cable-way is provided in each plug. Multi-hole

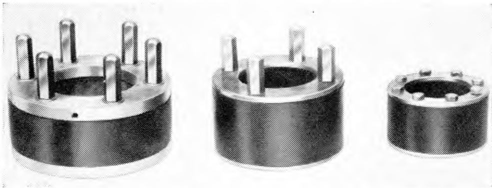


FIG. 5—EXPERIMENTAL EXPANDING PLUGS FOR LARGE POLYTHENE CABLES

plugs to accommodate the large cables have not been made because such plugs would be very large and cumbersome, and they would need to be specially made to cater for the particular number and sizes of cables to be combined and jointed in any given situation. When it has been necessary to construct branch (or spur) joints in the experimental cables and when, in theory, multi-hole plugs would have been required, the procedure has been to construct multi-entry joints, usually out of lead and brass tubes (see Fig. 6), the cables being accommo-

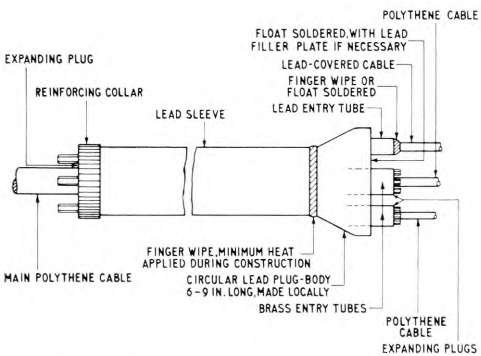


FIG. 6—BRANCH JOINT FOR USE WITH TYPICAL LARGE EXPERIMENTAL POLYTHENE CABLE

dated in individual expanding plugs fitted in the entries.

Other methods of jointing polythene cables are being developed, and the lines of investigation are as follows:

(*a*) Electrical butt-brazing of conductors.

(*b*) Water-proofing wire joints in polythene-insulated conductors by using an electrically-heated tool to weld a polythene sleeve over the wire connexion.

(*c*) Sealing polythene cable joints by an injection-moulding technique.

(*d*) Sealing polythene cable joints by using an electrical heating element interposed between the cable sheath and a polythene sleeve enclosing the joint.

When development of any of the methods under investigation has advanced sufficiently and has been proved reliable, it will probably be adopted for use in future trials of large polythene cables.

Cable Surging

It has been found when drawing large polythene cables into ducts (particularly when the cable length is long) that there is pronounced tendency for the cable to surge if it becomes necessary to apply a heavy tension. It is thought that under conditions of heavy tension the cable stretches and, behaving elastically, contributes to the surging effect. In addition, rope-snatch sometimes develops at the winch-end, which has in some instances been severe enough to break the rope.

Retraction of Cable Sheath

When the end of a polythene cable is cut, the sheathing retracts leaving the core exposed. This effect occurs each time the cable is cut even though a second cut may only be a few inches from the first. With large polythene cables the average amount of sheath retraction is about $\frac{3}{4}$ in., most of the retraction taking place within a few minutes of cutting the cable. The contraction is caused by residual stress in the polythene and it is not certain what period of time must elapse before the limit of contraction is reached at any particular cutting point. With the large polythene cables used for the present trials in local-line networks, heavy pulling-in tensions do not appear to have had a marked effect on sheath contraction, but from observations of trials with large trunk-type polythene-sheathed cables having paper-insulated quads in layer formation the indications are that pulling-in tensions may contribute measurably to sheath retraction. It seems advisable to leave lengths of polythene cable after drawing-in for as long as possible with their sheathing-ends free before jointing operations are commenced.

Cabling Difficulty in Relation to Cable Diameter

Experience indicates that polythene cables up to about $1\frac{1}{4}$ in. diameter can be drawn into the longest sections from end-to-end in one pull without any difficulty providing duct conditions are reasonably good. With cables exceeding $1\frac{1}{4}$ in., however, the difficulties in drawing-in rise sharply with an increase in cable diameter, and the methods shown in Fig. 3 and 4 almost invariably have to be used for very large cables unless the duct-line is straight and clear.

Cable Resilience

When it is necessary to bend a large polythene cable out of its natural line in a jointing chamber, the resilience of the cable is such that usually some means of holding the cable in position are required. So far, improvised methods of fixing the cables have been used, e.g. lashing the cables with wire to convenient brackets. However, special cable-restraining stirrups are being tried. These should be an improvement over lashing and are designed to be simply attached to the normal jointing-chamber bearers. Whilst polythene cables can be bent safely around smaller radii than lead-covered cables, they should not be bent so severely that cracking of the polythene sheathing may result.

Direct Termination of Large All-Polythene Cables

The direct termination of large all-polythene cables on distribution frames obviates the need for special terminating cables, and has obvious merits. All sizes of cables, up to and including 2,000 pairs, have now been directly terminated. The pairs are divided into groups, each group being terminated on a particular vertical bar; forming-out and lacing of the pairs is done very much on conventional lines, although plastic strapping or plastic tubing has been used experimentally in some instances instead of lacing. The soldering of the wire connexions presents no problems, and there is, for example, very little tendency for the polythene insulant to "run" when a hot soldering-iron is applied to the wire connexion. Arranging cable to give a neat lay-out without undue strain at the approach to the distribution frame and, sometimes, in the cable chamber, can be difficult, due mainly to the stiffness and resilience of the cable.

Pushing Cables into Ducts

In short sections of duct up to about 30 yd it has been possible, if the duct is reasonably straight and clear, to push a large polythene cable by hand from end-to-end. This avoids rodding and the drawing-in of rope and has been found particularly useful where a cable section includes a sharp angle at one or both ends, e.g. a right-angled road-crossing. In such circumstances sufficient length of cable is drawn through the duct, or left on the drum, at the point where the duct-line turns through the sharp angle (this will normally be at a jointing-chamber) and is passed, by pushing, into the short section of duct forming the angle.

CONCLUSIONS

None of the large polythene cables has been in use long enough to determine whether paper-insulated or polythene-insulated cables offer more advantage in relation to cost, reliability and effective life. Tests made recently on some of the cables that have been in service for about two years indicate that the insulation resistance is practically the same as it was when the cables were installed.

The potentialities of laying long continuous lengths of large polythene cables (of both types), and the attendant benefits, are very apparent. When attempting to lay long lengths difficulties will occasionally arise, demanding a persistence of endeavour if the desired length is to be laid; e.g. to relieve pulling tension it may be necessary to pull out cable to accumulate slack at a number of jointing chambers in the cabling section concerned. The length of time and effort justifiably spent before abandoning an attempt to lay a desired length of cable will depend on the particular circumstances; in the field trials it was considered worth while continuing an attempt even if the chances of success appeared quite small.

The problems encountered with the jointing of the large polythene cables have not been unduly difficult to overcome, but in some jointing chambers the conditions left much to be desired, mainly because of the small size of the jointing chamber or the congestion caused by other cables. The use of expanding plugs resulted in a number of joints being somewhat cumbersome, but it is hoped that new jointing techniques will be available shortly for use on future schemes in the large polythene cable field-trial program and that improvements will result.

The direct termination of large all-polythene cables can be done satisfactorily and has important benefits; so far, no standard procedure has been evolved and much has been left to the initiative of local staff concerned with the installation. New fuse-mountings for use on distribution frames are now being introduced and trials to determine suitable methods of directly terminating large all-polythene cables on them are now being made. Eventually, no doubt, a standard procedure for the direct termination of large all-polythene cables will be evolved incorporating all the best features from the trial installations.

ACKNOWLEDGEMENTS

Special acknowledgements are due to the many members of Area external staffs concerned with installation work connected with the field trials, for their ready and enthusiastic co-operation.

Book Review

"Microminiaturization." Proceedings of the AGARD Conference at Oslo, July 1961, edited by G. W. A. Dummer, M.B.E., M.I.E.E. Pergamon Press, Ltd. x+355 pp. 264 ill. 105s.

The papers of this symposium were arranged in four groups, viz. Survey Papers, Micromodules, Microcircuits and Solid Circuits.

For the benefit of those who are still catching up with this rapidly-moving subject, the following simple definitions are used in the United Kingdom: Individual component systems—circuits made from components similar to conventional subminiature types but of very small size; Micromodules—stacked individual component systems; Microcircuits—flat or evaporated components as complete circuits; Solid circuits—integrated components (including all forms of molecular electronics).

The underlying theme of the 26 papers was mainly smaller military equipment, but nevertheless many deal with circuits and techniques having a general application. The whole is edited by G. W. A. Dummer who contributed a paper on "A Review of British Work on Microminiaturization Techniques."

Most of the papers contain some novel information for those who so far have not taken much interest in microminiaturization, but the following also contain information which could be applicable to Post Office work:

(*a*) The above-mentioned paper by Dummer which summarizes the considerable amount of work on the subject going on in Britain.

(*b*) "Some Recent Developments in Integrated Electronics and Micro Systems" by Kihn of the Radio Corporation of America which describes details of a selective call system, a microminiature time-division multiplex system, a multivibrator clock and several units for computers.

(*c*) A note by M. Apstein on a pneumatic amplifier which gives gains up to 100.

(*d*) S. C. Dunn gives some ideas for the design of a standard micro element.

(*e*) "A Concept of Microsystems Electronics" by B. G. Bender gives details of Hughes microseal diodes and transistors, and "Swisscheese" circuit boards.

(*f*) "Microminiaturization with Respect to Computers" is dealt with by A. P. Bobenrieth, a Cryotron memory matrix by C. J. Kraus, and "Micrologic Elements" by R. H. Norman and J. R. Nall.

(*g*) "Preliminary Considerations for the Design of a Microminiature Telecommunications Equipment" are given by T. M. Goss (Plessey). A.A.N.

"Better Opportunities in Technical Education"

A. H. WATKINS, C.G.I.A., A.M.Brit.I.R.E.†

U.D.C. 379.3:373.62

New arrangements are described that will affect the technical education of many future engineering recruits to the Post Office.

INTRODUCTION

IN January 1961 a Government White Paper[1] was issued under the title of "Better Opportunities in Technical Education." Two of the many proposals made in that document for the modification of the existing arrangements for technical education will have an appreciable effect on the technical education of Post Office Engineering Department grades. It was proposed that the Ordinary National Certificate courses should be reduced from three to two years and that the standard of entry be raised. It was further recommended that new courses for technicians should be introduced of four and five years' duration.

The Ministry of Education issued in April 1961 a memorandum[2] to local education authorities introducing a new common engineering course leading either into the Ordinary National Certificate (O.N.C.) Course or a new technical course in mechanical engineering, as well as into the existing courses for electrical, telecommunication and aeronautical engineering.

As the new common engineering course leads to either the O.N.C. or the existing City and Guilds of London Institute's Telecommunication Technicians' Course it will inevitably have repercussions on the selection of courses of study to be followed by future engineering recruits to the Post Office, especially Youths-in-Training.

The introduction of these new arrangements will simplify the choice of the type of further education to be embarked upon by the student and should avoid, to a large extent, the possibility of the student selecting a course of study not in accordance with his intellectual capabilities.

GENERAL ENGINEERING COURSE

The General Engineering Course has been designed as either a one-year or two-year course to prepare school leavers, who do not possess the necessary G.C.E. O Level qualifications for direct entry into the O.N.C. Course, for entry to that course or a technicians' course.

The two-year course is intended for those who leave school at the age of 15 years whereas those who leave at 16 years of age should be capable of completing the course in one year.

Each year of the course provides instruction in the following subjects:

(*i*) Engineering Science.
(*ii*) Mathematics.
(*iii*) Workshop Processes and Materials.
(*iv*) Engineering Drawing.
(*v*) English.
(*vi*) General Studies.

Some 240 hours of instruction are required each year on the technical subjects. The minimum time specified for National Certificate Courses in the past has been 180 hours, based upon the student attending college only in the evenings over a period of some 30 weeks each year. The increase to 240 hours per year may necessitate attendance on a part-time day basis, usually one day and one evening each week. Inclusion of the two non-technical subjects requires extension of the course to 330 hours per year as recommended in the Crowther Report.[3]

It is stated in "Better Opportunities in Technical Education" that the Government hope, as a result of a review by the National Advisory Council, that extension of the course to 330 hours will prove acceptable as a firm aim of policy and rapid progress will be made in achieving this object. It follows that an extension to 330 hours will require attendance at college in excess of one whole day and one evening per week. This introduces problems the solution of which will require the co-operation of industry and recruitment of additional teaching staff. Whilst it is the aim to include instruction in English and General Studies in the course, it is not, at this stage, being made obligatory. The Ministry of Education have, however, already published a booklet[4] suggesting material and treatment of General Studies for use when this subject is included in the course.

The course is essentially internal in nature, students being required to complete a technical-college course, including the relevant laboratory and practical work, before examination entry is accepted.

The examinations at the end of the general course are external in nature and held by the following bodies in England and Wales:

(*a*) City and Guilds of London Institute.
(*b*) East Midland Education Union.
(*c*) Northern Counties Technical Examinations Council.
(*d*) Union of Lancashire and Cheshire Institutes.
(*e*) Welsh Joint Education Committee.

Similar arrangements are being made in Scotland and Northern Ireland.

Separate papers, each of 2½ hours' duration, are set on the four technical subjects, with the exception of Engineering Drawing, which is of 3 hours' duration. Successful candidates are awarded either pass or credit certificates.

ORDINARY NATIONAL CERTIFICATE IN ENGINEERING

The new O.N.C. Course, commencing in the 1963–64 academic year, will be of two years' duration and will also be a common engineering course. The Institutions of Civil, Mechanical, Electrical, Production, and Chemical Engineers, the Royal Aeronautical Society, and the Ministry of Education are prepared to approve courses which meet the new requirements for the award of the Ordinary National Certificate in Engineering.

The two years of the course will be known as O.1 and O.2, each year comprising 240 hours of instruction, with a minimum of 60 hours in each of four technical subjects. Again, as in the general course, an additional 90 hours of English and General Studies are considered desirable but at this stage are not being made obligatory.

The subjects of the first year (O.1) will be as follows:

(*i*) Mathematics I.
(*ii*) Mechanical Engineering Science.
(*iii*) Electrical Engineering Science.

†Training Branch, E-in-C.'s Office.

(*iv*) Either Engineering Drawing or Physics I, or both.

In the second year (O.2), of the following 10 subjects Mathematics II will be obligatory, together with any three or more of the remaining subjects:

(*i*) Mathematics II.
(*ii*) Applied Mechanics.
(*iii*) Applied Heat.
(*iv*) Workshop Technology or Instrument Technology.
(*v*) Electrical Engineering A.
(*vi*) Electrical Engineering B.
(*vii*) Physics II.
(*viii*) Mechanics of Fluids or Aerodynamics.
(*ix*) Elementary Surveying.
(*x*) Materials and Structures.

Unlike those for the general course, the examinations will not be of an external character, but will be conducted by the colleges. In the second-year examinations the examiners will work in conjunction with assessors appointed by the Institutions.

PROGRESSION FROM THE GENERAL COURSE TO THE O.N.C. COURSE

One of the objects of the scheme is to prevent the wastage that has occurred in the past due to the failure of many students to complete the course of their choice. This has been particularly noticeable with both the National Certificate and the technicians' courses.

Entry to the first year (O.1) of the O.N.C. Course will require one of the following qualifications:

(*a*) The General Certificate of Education at the Ordinary level in four subjects, including mathematics and one of the following subjects: physics, mechanics, physics with chemistry, engineering science, science (building and engineering).

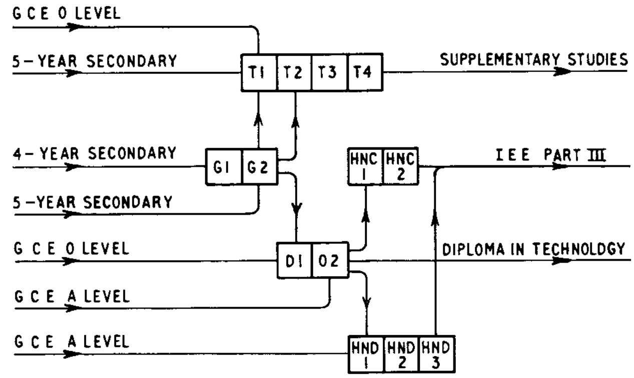
(*b*) Satisfactory completion of the General Engineering Course at a technical college and the certificate awarded by one of the regional examining bodies, or the City and Guilds of London Institute, with credits in Mathematics and Engineering Science and a pass in Engineering Drawing.

(*c*) Any qualification deemed by the committee responsible for the scheme to be equivalent to (*a*) or (*b*).

A student in the General Engineering Course who fails to obtain the necessary credits in Mathematics and Engineering Science will be expected to enter the second year of the appropriate technician course, subject to having passed in three general course subjects at one sitting. Should the student not pass the General Engineering Course he will have to enter the appropriate technician course in the first year or enter an appropriate craft course. Students will not, except in exceptional circumstances, be permitted to repeat the general course.

The diagram shows the possible lines of progression from the various entry points to the more advanced courses.

The course of study undertaken by Post Office minor engineering grades has in the past depended largely on the individual's own assessment of his ultimate academic ceiling and, especially in the case of the younger staff, advice from supervising officers, who have the difficult task of assessing the individual's capabilities. This system has inevitably led to some students taking courses of study leading to qualifications which they were not capable of obtaining and, conversely, other students selecting, or being advised to undertake, courses well below their academic ability. It is difficult to assess which of these two is the more wasteful. In the first instance the student often becomes disheartened, either due to difficulty in absorbing the syllabus material or by failure in the earlier examinations, and abandons his course of study, thus finding himself without qualifications when, had he taken a more suitable course, he would have eventually qualified at a more appropriate level. In the second case the student qualifies with ease and realizes, often too late, that he is capable of higher qualifications, e.g. degree, Dip.Tech., graduateship of a professional institution, or Higher National Certificate. Some 3–6 years may then have elapsed and the student is faced with a completely new start in his studies at an age which in many instances presents a considerable hazard to ultimate success.



T—Technician Course
G—General Engineering Course
O—Ordinary National Certificate or Diploma Course
HNC—Higher National Certificate Course
HND—Higher National Diploma Course

TECHNICIAN AND TECHNOLOGIST COURSES IN ELECTRICAL ENGINEERING

The new scheme will help to ensure that only those with a reasonable expectation of success will commence a course of study leading to a professional qualification, whilst those not so well endowed academically will be enabled to progress to a technical qualification more in keeping with their ability.

Some concern may be felt that Youths-in-Training who take the general course and fail to qualify for the O.1 year of the O.N.C. Course will have lost one or two years' education in telecommunications subjects at a time when this would be most valuable from a vocational point of view. Against this, however, should be placed the advantage of one or two years' grounding in general engineering theory and practice.

CONCLUSION

The introduction of the scheme is an important step in the control of the further education of a large section of school leavers, many of whom have had insufficiently clear guidance in the past. The success of the scheme requires the full co-operation of both industry and technical colleges.

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A Simplified House Exchange System—House Exchange System No. 3

F. L. RANDALL and S. A. L. WARD†

U.D.C. 621.395.26

House exchange systems provide subscribers with a service that is proving increasingly popular, but the two systems at present in use cannot meet modern transmission requirements and are expensive to install. Some of the novel features of a new type of installation that will replace the smaller of the existing systems are described.

INTRODUCTION

A HOUSE exchange system provides intercommunication facilities between a limited number of stations as well as direct exchange-line service at each of these stations, without the assistance of a central switching position. Ideally, a house exchange system combines the facilities provided by a house telephone system or an extension plan with those of a small P.B.X. by enabling users to select for themselves, by a simple operation, the required facility.

The telephone instruments for an installation of the above type must thus contain function-selecting and signalling arrangements that are easy to manipulate but which cannot be misoperated to the detriment of the service at other stations of the system. The mechanical problems created by this requirement were first solved satisfactorily in the house exchange systems introduced by the Post Office in 1935.[1] These two systems, House Exchange Systems (H.E.S.) No. 1 and 2, cater, respectively, for one exchange line and up to six extensions and two exchange lines and up to 11 extensions and have proved increasingly popular with subscribers.

Several disadvantages have, however, become apparent in the techniques used in H.E.S. No. 1 and 2. These disadvantages include the following:

(*a*) The transmission circuit is not adequate for exchange lines having the limits assumed for modern cable-planning schemes.

(*b*) The internal multiple cabling arrangements, relying on a multiplicity of junction boxes, are costly in materials and installation time.

(*c*) Failure of the power supply prevents access to the exchange line except from a non-multiple extension.

(*d*) Considerable desk space is occupied by the telephone instrument and the auxiliary switching units.

These disadvantages have been overcome, existing house exchange system facilities have been retained and additional ones added in a new system, H.E.S. No. 3, catering for one exchange line and five stations. The new system is based on a 700-type[2] intercommunication telephone derived from the Telephone No. 710[3] and coded Telephone, Intercom, No. 3/1, which is available in three colours and in versions suitable for manual or automatic exchange areas. Many of the principles used in the H.E.S. No. 3 are also to be incorporated in a larger system for two exchange lines and 10 stations (H.E.S. No. 4) now under development as a replacement for H.E.S. No. 2.

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FACILITIES

In order to appreciate the facilities offered by the new system it is necessary to distinguish between the various types of station that can be associated with an H.E.S. No. 3 installation.

Multiple Station. A multiple station is one equipped with an intercommunication telephone and linked to other multiple stations by a 21-wire cable.

Main Station. The main station is a multiple station that

(*a*) always receives a ringing signal from incoming exchange calls,

(*b*) assists other stations not directly connected to the multiple to originate local calls, and

(*c*) controls certain additional facilities that are described later.

Non-Multiple Extension. A non-multiple extension is fitted if a station is located beyond the practicable limit of the multiple cabling, e.g. in another building Such a station is equipped with a Telephone No. 710 and is linked to the main installation by a 2-wire line.

As already mentioned, the new system can provide for one exchange line and up to five stations. A non-multiple extension may replace the last multiple station, and private circuits to a P.B.X. or another house exchange system can replace other multiple stations.

The following are the principal facilities afforded by H.E.S. No. 3:

Exchange Service. Exchange calls are secret, and outgoing service is available from any station which is not specifically barred, including the non-multiple extension. Access to the exchange line is obtained by operation of a locking press-button with receiver-rest restoration. Calls, incoming or outgoing, may be held or transferred at any station, including the non-multiple extension. Incoming exchange calls normally ring a standard magneto bell included in the intercommunication telephone at each multiple station, and calls can be answered by any station. The bell at most multiple stations can be silenced by a locking BELL OFF key, but at the main station this key is permanently disconnected from the bell circuit and may be used to control other facilities.

Normal exchange service continues to be available at all stations if the installation power supply fails.

Individual Exchange Lines. A multiple station can be connected to an individual exchange line or P.B.X. extension not available to other stations; these stations can share a common line or extension.

Local Intercommunication Calls. A multiple station can call any other station by means of a non-locking press-button; buzzer signals are given at multiple stations and magneto-bell signal at the non-multiple extension. The non-multiple extension can only call the main station, which assists by signalling the required station. Local calls are not secret.

Conference Calls. All stations can take part in a local conference call; this facility is not available on exchange calls.

Lamp Signals. The exchange-line signalling circuit includes a supervisory lamp, coloured red, which

(*a*) flashes in time with exchange-ringing cadences,

(*b*) glows steadily when the exchange line is answered,

(*c*) flashes approximately twice a second when the exchange line is being held by any station, and

(*d*) glows steadily when a station takes over or is ready to accept a transferred call.

A clear supervisory lamp glows when the local speech circuit has been seized by any station.

Station-Engaged Signal. A multiple station that attempts to call an engaged station operates its own buzzer.

Night Service. The non-multiple extension can be given incoming exchange service by means of switching provided by the main-station instruments. Two-way exchange service continues to be available at all multiple stations.

Extension Bells and Buzzers. Standard magneto extension bells can be fitted at all stations, provided that the total number of bells does not exceed five; one extension bell may also be fitted at the non-multiple extension. An additional buzzer can be connected to each multiple station for local-call signalling.

Association With Other Installations. An H.E.S. No. 3 can be connected to another house exchange system or a P.B.X. either as a subsidiary installation or by a private circuit. In some arrangements, night service can be given over the private circuit.

Operator Recall. When connected as a subsidiary to a P.B.X., operator-recall signals can be given from any multiple station, and the non-multiple extension can recall the H.E.S. No. 3 main station, which can relay the recall signal.

Exchange-Call Barring. As an optional facility, any multiple station can be denied exchange service except at the discretion of the main station. Also, any station can be permanently barred from exchange service.

Exchange-Line Monitoring. One multiple station can, if required, monitor exchange calls from other stations while exchange calls from the monitoring station remain secret.

Subscriber Trunk Dialling Facilities. One subscriber's private meter can be fitted to the installation. Permanent or optional trunk barring can be fitted at any station.

FEATURES OF H.E.S. NO. 3

With the object of achieving economies in equipment and installation costs several departures from techniques used in earlier systems have been introduced into the H.E.S. No. 3.

Series-Multiple Exchange Circuit

To avoid the need for a line-connecting relay in each telephone, without sacrificing the secrecy feature, a series-connected exchange-line multiple has been adopted. With this arrangement the exchange line is normally fed into and out of each station in turn, beginning with station 1; priority of access can, however, be given to any selected station by introducing the exchange line into the multiple at the required point and returning it to the normal sequence by means of spare conductors in the multiple cable.

Single Intercommunication Speech Circuit

Only one speech circuit for local intercommunication is provided in the multiple. Power for the telephone transmitters is fed to this circuit through a double-coil high-impedance relay, the instruments being connected in parallel across the circuit during local conversations. This arrangement also provides a simple conference circuit. The non-multiple extension has its own power feed, but uses the common circuit for local calls. Signalling for local calls is over a multiple conductor exclusive to each station. The use of a common speech circuit working on central-battery principles avoids the need for a power-feeding transmission bridge in each telephone.

Smaller Multiple

The H.E.S. No. 3 requires a minimum multiple of 17 conductors, a reduction compared with the earlier system. As a standard 21-wire cable will normally be used for the multiple, spare conductors will be available for additional facilities, e.g. exchange-line monitoring or for bunching with the power feeds to reduce voltage-drop at stations supplied by long cable runs.

Dual-Purpose Terminal Block

A new type of terminal box (coded Block, Terminal, No. 37A) is used both as a multiple-cable junction box and as a connexion point for a multiple station. The new

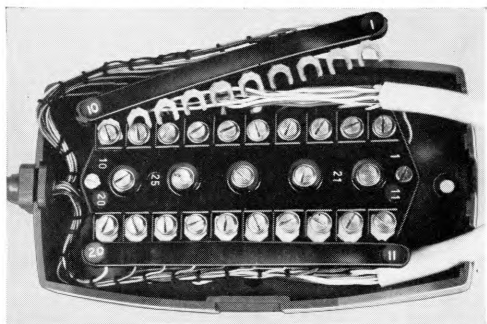


FIG. 1 – TERMINAL BLOCK FOR HOUSE EXCHANGE SYSTEM

terminal block (Fig. 1) contains a double-sided terminal strip with two rows of 10 connexions and five additional terminals between the rows; the terminal strip is housed in a case moulded in toughened polystyrene and having rectangular knock-out sections for cable entries and for securing the standard cord grommet. The case has a snap-on lid.

Multiple cabling is connected to the under-side of the terminal strip; the upper-side accommodates the spade tags of the instrument cord.

Each intercommunication telephone is equipped with a 20-way cord 72 in. long. The spade tags at one end of the cord are moulded into two flexible plastic strips with 10 tags in each; the spacing and numbering of the tags correspond with those on the terminal strip in the block. The instrument is connected to the multiple wiring by loosening the terminal screws to give sufficient clearance for the spade tags to be pushed under the cupped washers on the terminals, the screws then being re-tightened (Fig. 1). The use of an instrument cord with preformed terminations makes for rapid and accurate connexion of a multiple station telephone at low cost. Twenty-five-way cords are also available; these have 20 preformed connexions and five free conductors to cater for additional facilities.

This method of connecting multiple-station telephones avoids the use of separate junction boxes, with their cross-connexions and individual feeder cables to instruments, which were previously connected by plug and socket.

Wall-Mounted Units

The power-feeding relay for the local speech circuit and the signalling and switching relays are housed in units designed for wall mounting, replacing the table-mounted transfer units of earlier systems. Three types of unit are available:

(*i*) for installations with multiple stations only (Relay Unit Q 405),

(*ii*) for installations that include a non-multiple extension (Relay Unit Q 410), and

(*iii*) for an installation connected to another subscriber's installation by a private circuit (Relay Unit Q 415).

A standard installation contains either a Relay Unit Q 405 or a Relay Unit Q 410; Relay Unit Q 415 is added as required.

Fifty-Volt Power Supply

Use of a 50-volt d.c. supply simplifies relay design and allows for extended signalling limits on internal calls. Power unit No. 51A[4] provides the required d.c. from a mains supply; a secondary-cell battery is not required. The maximum current taken is about 750 mA.

A.C. Ringing Supply

A ringing-current input to Relay Unit Q 410 is necessary so that intercommunication calls can be signalled at the non-multiple extension and exchange ringing repeated when the extension is on night service. The Relay Unit Q 415 also requires ringing current when 17 c/s or 25 c/s a.c. signalling is used on a private circuit. These requirements are met by a mains-driven static converter (Converter, Ringing, No. 7) added to the power unit when required. The converter delivers 60 volts r.m.s. at 25 c/s and overcomes the difficulties previously experienced in providing an adequate ringing supply for the bell of the non-multiple extension.

Simplified Installation of Apparatus

Most of the apparatus items forming an H.E.S. No. 3 installation are connected by screw terminals; this also applies to the additional units added as required and to those parts that may have to be replaced during maintenance. Only in the Relay Unit Q 415, which contains a large number of variable connexions, are soldered joints necessary at the time of installation.

DESCRIPTION OF APPARATUS

Intercommunication Telephone

The intercommunication telephone has standard 700-type transmission components and is therefore suitable for use on exchange lines of up to 1,000 ohms loop resistance. Push-button-operated contacts required for function-selection and signalling are contained in a single unit of box construction mounted between the receiver-rest pillars and secured to the chassis of the telephone by four screws. Most of these contacts are permanently wired to an 18-way terminal strip (Strip, Connexion, No. 155 B) also mounted on the receiver-rest pillars immediately behind the regulator and secured by spring-loaded studs; this terminal strip is additional to the usual one on the base of the telephone. Six flexible leads with spade tags connect the remaining push-button contacts to the rest of the telephone circuit, so that the whole assembly comprising switching unit and terminal strip may be readily removed for maintenance; this assembly is shown in Fig 2.

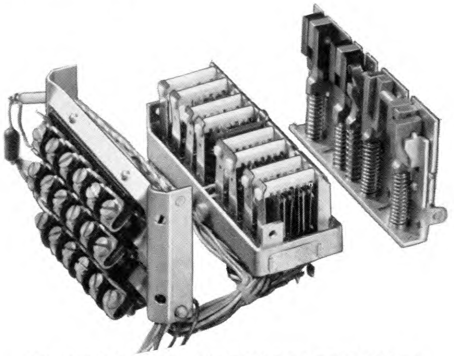


FIG. 2 – PRESS-BUTTON-OPERATED CONTACT ASSEMBLY

The switching unit contains eight sets of comb-operated contacts similar to those used in the 1,000-type key.[5] As in the Telephone No. 710, the appropriate set of contacts is operated by plungers under the control of press-buttons on the top of the telephone case (Fig 3).

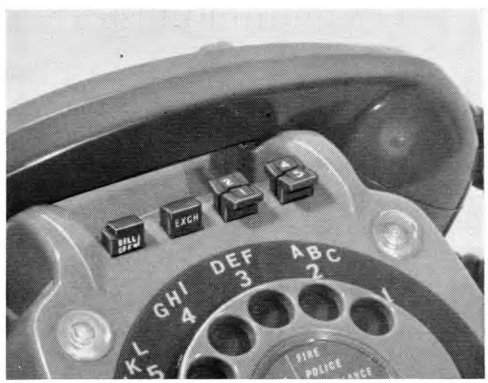


FIG. 3 – PRESS-BUTTONS AND SUPERVISORY LAMPS ON INTERCOMMUNICATION TELEPHONE

Six press-buttons are fitted, four of them being in the two right-hand positions; these are the station-calling buttons that each operate one set of contacts. Each of these buttons is marked with the number of the station that is called when it is pressed. As there can be five stations in the installation and only four calling buttons are available, the numerals are engraved in removable inserts that can, if necessary, be turned over to display the numeral 5.

The exchange-line button, engraved EXCH, operates three sets of contacts, two plungers being mechanically coupled to do this. The exchange button has three positions of rest: (*i*) normal, (*ii*) fully operated, and (*iii*) intermediate. Position (*i*) is taken up when the handset is on its rest, position (*ii*) when the telephone is connected to the exchange line, and position (*iii*) when the exchange line is being held and the telephone connected to the intercommunication circuit; restoration is by operation of the receiver rest. There is also an overpress position that puts a recall condition on the B-wire of the exchange line while maintaining the conditions appropriate to position (*ii*). A rocker-bar underneath the exchange-line plunger prevents operation of the button until the handset is removed. This device prevents interruption of the series-connected exchange-line circuit by accidental operation of the button.

The press-button that cuts off the internal bell occupies the left-hand position; it can be locked in the operated (BELL OFF) condition by depressing the button and then sliding the top part of it to the left. At the main station, the set of contacts that this button controls is disconnected from the bell circuit so that there is always one bell in the installation that will ring on incoming calls. The contacts may be connected to suitable terminals within the telephone and used to control other facilities, e.g. exchange barring or night service to the non-multiple extension. When the press-button in this location is used for other purposes, the BELL OFF button is replaced by another button suitably engraved.

Lampholders of the M.E.S.* type are fitted to, and in front of, the receiver-rest pillars. A lamp with a clear bulb is fitted in the right-hand holder and indicates when the local speech circuit is in use. A red-tinted lamp, indicating when the exchange line is in use, is fitted on the left. A red bulb was chosen, despite a small reduction in light output, in preference to a clear glass bulb with a coloured opal. Two colourless opals in the case present a better appearance, when the lamps are not lit, than one coloured and one colourless; careful contouring and polishing of the inner surfaces of the opals has helped to mask the unlit lamps, which are mounted immediately behind them. The lamps are of a nominal 0·25-watt rating at 6 volts, but have been selected to give a reasonable life, with satisfactory illumination, over the range 5·6–7·2 volts, thus accommodating some variation of the voltage drop in the multiple cabling. The lamps are fed, through a voltage-dropping resistor, from the 50-volt d.c. supply.

The intercommunication telephone includes a 6-volt d.c. buzzer for signalling incoming intercommunication calls. The buzzer is mounted on a synthetic-resin-bonded-paper plate that also carries the voltage-dropping resistor and spark-quench filter, the whole assembly being riveted to an extension of the cord-grommet clip shaped so that the buzzer assembly rests on the telephone case, thus helping in sound distribution.

An exchange-line barring or monitoring facility can be added, when required. Two small relay units, each using a miniature relay, are available to provide these facilities; they are designed to mount on the right-hand bell-gong pillar, above the gong, using the existing fixing screw. Flexible leads with spade tags connect the unit to the main terminal strips at the rear of the telephone.

Relay-Unit Assembly

The larger relay units, which provide signalling and speech current for local calls or connect a private circuit to the system, are all the same width as the power unit, so that a neat vertical assembly of all common apparatus is possible. In the relay units, all components are fitted to a hinged plate that swings away from the wall-mounted plate to give access to relay wiring.

Non-Multiple Extension Telephone

The telephone No. 710 used at the non-multiple extension is fitted with two press-buttons, engraved EXCH and EXTN, respectively, which are associated with mechanically-linked plungers. The EXTN plunger and spring assembly lock, connecting the telephone circuit to the 2-wire line and so to the intercommunication circuit; they are released by operation of the receiver rest. The EXCH button also operates the spring-set associated with the other button, momentarily earthing the loop circuit to send a discriminating signal to the relay unit that switches the 2-wire extension to the exchange line if it is free. If this dual-button arrangement were not used, the main station would be called whenever the handset at the extension was lifted to originate an outgoing exchange call.

CIRCUIT OPERATION

A simplified schematic diagram showing the way in which two multiple stations are interconnected is shown in Fig 4.

Relay Unit Q 405

Relay IL (Fig 4) is the control relay for the local speech circuit and also forms the transmission bridge. The relay operates to a telephone loop and contact IL1 lights the intercommunication-circuit-engaged supervisory lamp in multiple-station instruments.

When the exchange line is being held, earth potential is extended from the holding station to the FL relay via contact FL2. The relay is self-interrupting, the rate of pulsing being controlled by the presence of a 25 μF capacitor to approximately 2–3 pulses/second.

Relay RG is connected in the series magneto-bell circuit and contact RG1 lights the exchange-line supervisory lamp in unison with the periods of ringing. With the RG relay connected in the unit to the B-wire of the exchange line, the ringing circuit is completed by strapping at the far end of the multiple to the A-wire.

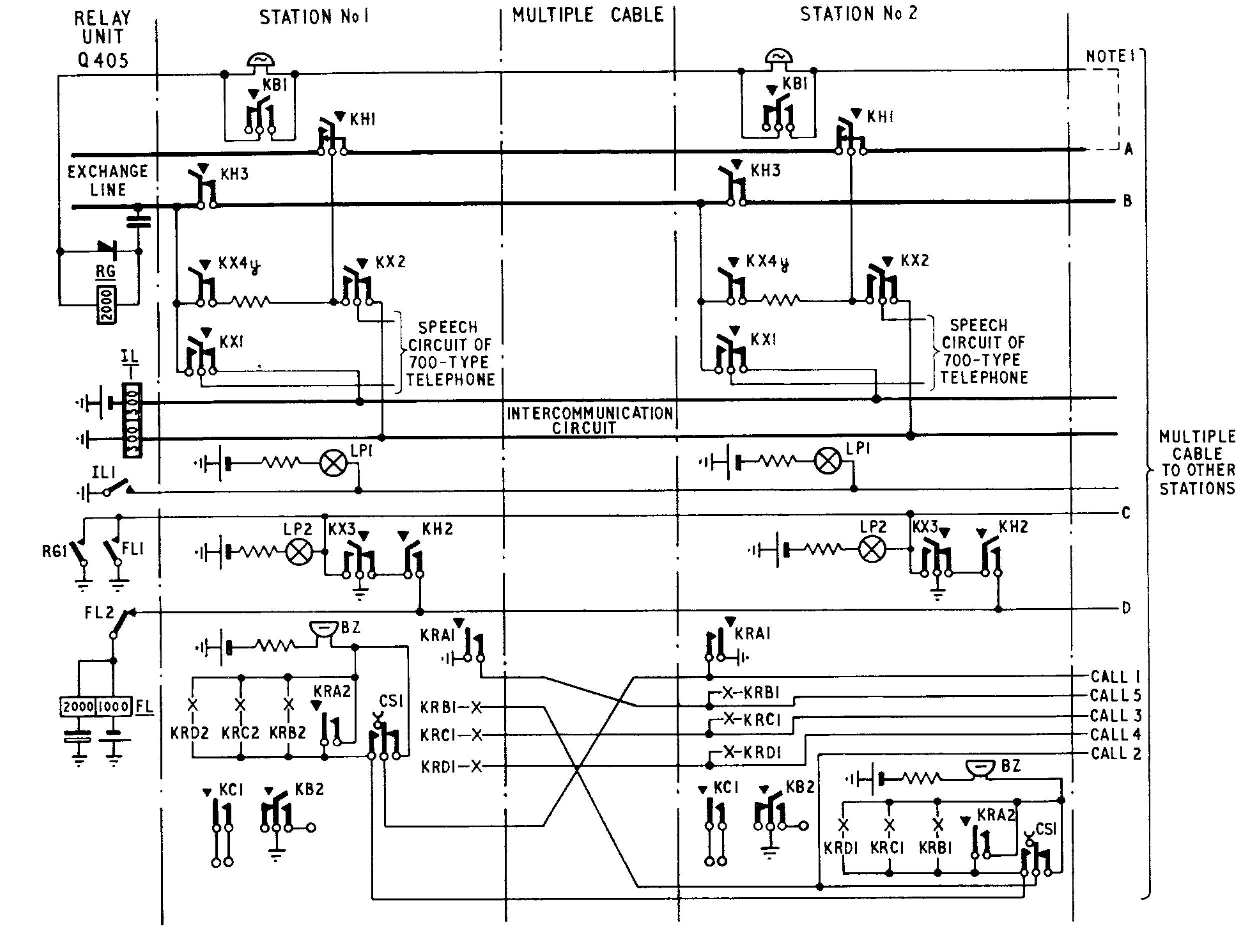
Exchange Calls

Connexion to the exchange is obtained by lifting the handset and pressing the EXCH button, so operating the KX and KH contacts (Fig. 4). The KX contacts switch the telephone to the exchange line and light the exchange-line supervisory lamps (LP2) at each multiple station. The KH contacts disconnect the exchange line from the succeeding stations in the multiple. This breaking of the series connexion ensures that only one station is connected to the exchange-line at any time, and also interrupts the magneto-bell circuit so that it does not shunt the telephone during dialling and speech.

Exchange Call Held

If a station wishes to hold an exchange call and speak to another station, the appropriate calling button (KRA,

*M.E.S.—Miniature Edison Screw.



Contact KC1 is used to provide an operator-recall signal if the house exchange system is connected to a P B X Contact KB2 is used to provide a night-service facility. Lamp LP1 is the intercommunication-circuit supervisory lamp; lamp LP2 is the exchange-line supervisory lamp.

Notes:

1. The connexion shown dotted is provided at the last station in the multiple.
2. For explanatory purposes battery symbols are used in the diagram; the 50-volt supply is in fact derived from a rectifier-type power unit

FIG 4—SIMPLIFIED SCHEMATIC DIAGRAM SHOWING INTERCONNEXION OF TWO STATIONS

KRB, KRC, or KRD) is pressed. The movement of the KR plunger concerned causes a section of the latch plate associated with the telephone switching unit to release the KX contacts while the KR contacts complete the calling circuit. The KX contacts restore the telephone to the intercommunication circuit, switch earth potential from the exchange-line supervisory lamps and apply it, via KH contacts and the D-wire in the multiple to the FL relay, which starts to pulse; the exchange-line supervisory lamps flash in unison. Another KX contact in series with the KH contacts, which are still operated, connects a 200-ohm resistor across the exchange line as a holding loop. When it is desired to resume speaking on the exchange line, the EXCH button is pressed, re-operating the KX contacts. Both KX and KH contacts release when the handset is replaced.

Transfer of Exchange Calls

When it is desired to transfer to another station a call that has been received and held at one of the stations, the EXCH button at the receiving station is pressed, causing the exchange-line supervisory lamps to glow steadily at all stations, the earth connexion from receiving station KX contact being applied to the C-wire.

If the receiving station precedes the transferring station in the multiple it will immediately receive the call, but if it follows the transferring station it must wait for the handset at the transferring station to be replaced and so cause the exchange-line to be extended. The change from flashing to a steady glow from the exchange-line supervisory lamps (due to the operation of the KX contacts) indicates when the receiving station is ready to accept the call.

Station-to-Station Calls

Lifting the handset automatically connects the telephone loop across the local speech circuit, operating relay IL. Contact IL1 lights the intercommunication-circuit supervisory lamps at multiple stations. Pressing the non-locking KR button for the required station connects earth potential via the multiple to the buzzer of the called station. The use of only four press-buttons, as already described, makes it necessary to interchange the buzzer signalling wires at each station. When the called-station handset is lifted, both instruments are in parallel across the intercommunication circuit. The engaged condition is maintained until both stations clear and the IL relay releases.

Should the called station be engaged, the receiver-rest contact (CS1) at that station will connect the engaged signal to operate the buzzer of the calling station via the multiple.

Conference Calls

A conference call is established by pressing the KR buttons of the required stations and, on answering, all instruments are in parallel across the intercommunication circuit, with speech and clearing conditions the same as for a station-to-station call.

Non-Multiple Extension Calls

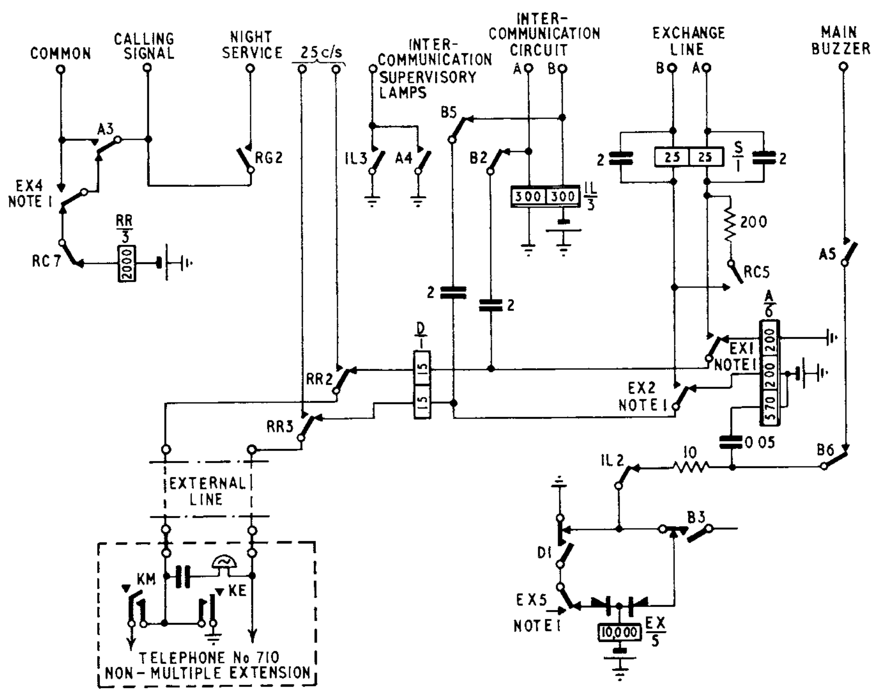
If a non-multiple extension is fitted, Relay Unit Q 410 (Fig. 5) is used to replace Relay Unit Q 405. In addition to incorporating the functions of the latter, Relay Unit Q 410 contains the circuits necessary for the operation of the non-multiple extension.

On local calls the non-multiple extension presents a loop to the line when the handset is lifted and the locking EXTN button, KM, is pressed. This loop operates the A relay through which the extension receives its power feed for speech. Contact A5 extends an earth to the buzzer at the main station, which, on answering, operates the IL relay; contact IL2 disconnects the calling earth.

For incoming intercommunication calls, signals from multiple stations operate the RR relay, which applies 25 c/s ringing current to the non-multiple extension. To call the exchange the non-locking EXCH button, KE, is pressed, also operating the KM contacts. When the EXCH button is released the KE contacts restore, leaving the KM contacts operated. By this arrangement, pressing one button completes the telephone loop via the KM contacts and also applies a discriminating earth potential via the KE contacts. The earth potential operates the differentially-connected D relay in the extension line so preparing the change-over from the local speech circuit to the exchange line. When relay D releases, the EX relay releases and relay S operates to exchange-line current to complete the connexion. When the non-multiple extension handset is restored relay S releases and causes relay EX to re-operate, thus restoring the circuit to normal.

Pressing the EXCH button while the telephone is connected to the exchange line re-operates relay D, and contact D1 operates a recall relay (RC) that places a hold loop across the line. On the release of relay D the non-multiple extension is reconnected to the local speech circuit and the main station is automatically called. The non-multiple extension can be reconnected to the exchange line by re-pressing the EXCH button.

When an exchange call is transferred from the non-multiple extension to a multiple station, the EXCH button is pressed at this station and the exchange line is switched into that instrument and disconnected from the non-multiple extension. This releases the S relay and, when the handset is replaced at the non-multiple extension, the circuit is restored to normal.



Notes:

1. Contacts shown operated.
2. For explanatory purposes battery symbols are used in the diagram; the 50-volt supply is in fact derived from a rectifier-type power unit.
3. Relays B, RC and RG are not shown

FIG 5.—SIMPLIFIED CIRCUIT DIAGRAM OF RELAY UNIT Q 410 USED WITH A NON-MULTIPLE EXTENSION

Night Service

Incoming exchange calls at the non-multiple extension are controlled by the press-button at the main station, the contacts of which extend an earth via contact RG2 to operate the RR relay (Fig. 5).

Power Failure

As will be seen, the multiple stations do not rely on relay switching for exchange service. In the event of a power failure the non-multiple extension is automatically connected to the exchange-line multiple by the release of relay EX (Fig. 5).

CONCLUSION

Where a house exchange system with not more than five stations is required, the H.E.S. No. 3 offers a cheaper, more compact, modern installation with a wider range of facilities than the earlier H.E.S. No. 1.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the co-operation of Ericsson Telephones, Ltd., in the development of the new house exchange system and thank them for permission to use the photograph reproduced in Fig. 2.

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Subscriber Trunk Dialling for U.A.X. Subscribers

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U.D.C. 621.395.374

The use of auxiliary relay-sets and junction hunters will enable facilities for subscriber trunk dialling to be provided at U.A.X.s in the most economical way and with the minimum disturbance of existing equipment. Local-call timing will also be introduced and each U.A.X. will be given direct-junction access to its group switching centre.

INTRODUCTION

IN an earlier article in this Journal[1] dealing with the general plan for subscriber trunk dialling (S.T.D.) it was mentioned that a number of possible methods of providing facilities for S.T.D. at U.A.X.s were being examined. As a result of this examination a scheme using auxiliary relay-sets is being developed for U.A.X.s No. 12, 13 and 14. This scheme can be introduced at existing exchanges with a minimum of cost and disturbance.

Each U.A.X. with S.T.D. will have direct-junction access to its group switching centre (G.S.C.). If the U.A.X. is in a dependent charging group this G.S.C. will be situated in a neighbouring charging group. The G.S.C. will usually be the existing parent exchange for the U.A.X.

TRUNKING

U.A.X.s No. 12 *and* 13

Fig. 1 and 2 show the trunking arrangements for U.A.X.s No. 12 and 13, respectively.

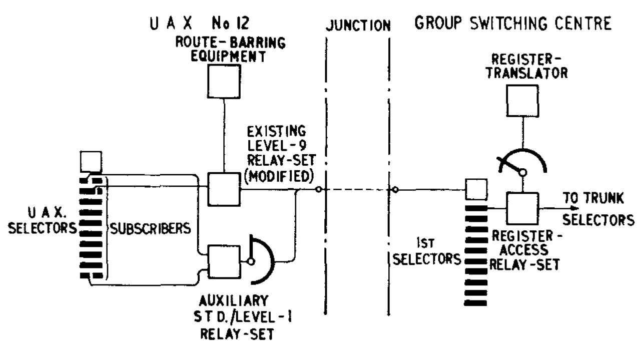
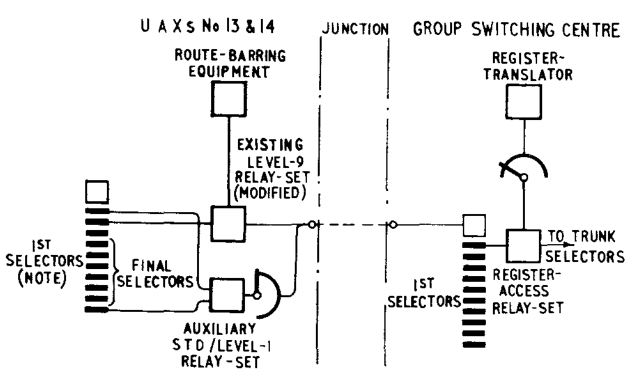


FIG. 1—S T.D TRUNKING ARRANGEMENTS AT U.A X.S No. 12



Note: At U.A.X.s No. 14 1st selectors absorb digit 2 or 3

FIG. 2—S.T.D. TRUNKING ARRANGEMENTS AT U.A.X.S No. 13 AND 14

†Telephone Exchange Systems Developments Branch, E-in-C.'s Office.

Digit 0 is used as the prefix for S.T.D. calls and level 0 is trunked to the auxiliary relay-sets. Access to the auxiliary relay-sets may also be gained from level 1 for the various manual-board services such as assistance operator (code 100), inquiries (code 191) and directory inquiries (code 192). Apart from these level-1 codes, the U.A.X. subscribers continue to use their existing dialling codes, including the code 9 for normal auto–auto access to junctions to the G.S.C. The existing level-9 relay-sets are retained, with minor modifications. Route-barring equipment associated with each level-9 relay-set prevents S.T.D. or level-1 calls being established via level 9.

At U.A.X.s No. 12 it will be necessary to change the numbers of a few subscribers in order to free the necessary outlets on levels 1 and 0.

The new auxiliary relay-sets will be provided only in sufficient quantity to carry the S.T.D. and level-1 traffic. There will probably be from two to four relay-sets in U.A.X.s No. 12 and from three to five relay-sets in the majority of U.A.X.s No. 13. As the S.T.D. program advances and the range of calls that can be dialled by the subscribers is increased, the growth in S.T.D. traffic will be accompanied by a corresponding decrease in code-100 manual-board assistance traffic, and so the number of auxiliary relay-sets required should remain constant, apart from any general change in trunk traffic originating from the U.A.X.

U.A.X.s No. 14

Alternative trunking arrangements will be available for U.A.X.s. No. 14. One arrangement will be that shown in Fig. 2. This scheme suffers from the disadvantage that up to 400 subscribers' numbers might have to be changed in order to free levels 1 and 0 of the 1st selectors.

An alternative is shown in Fig. 3. In this scheme the 1st selectors are modified so that they do not absorb the

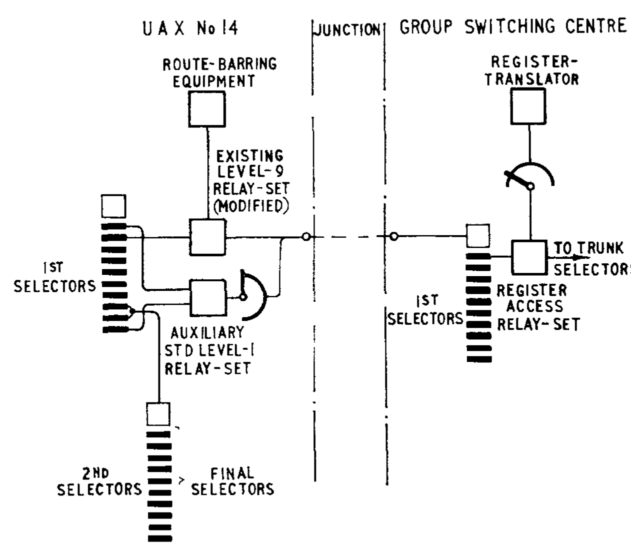


FIG. 3—ALTERNATIVE S.T.D. TRUNKING ARRANGEMENTS AT U A X S No. 14

initial digits 2 and 3. Local 2nd selectors are provided and trunked from levels 2 and 3 jointly, enabling levels 1 and 0 to be freed without number changes. Levels 4–8 are available for non-parent junction routes.

Group Switching Centres

At G.S.C.s all existing U.A.X. incoming terminations will be recovered and the junctions will be terminated directly on 1st selectors; bothway junctions will, however, be taken via a bothway switching relay-set. Manual-board outgoing relay-sets will also be recovered except on circuits requiring joint access for trunk-offering purposes.

S.T.D. register-access relay-sets that provide for metering over junctions[2] will be trunked from level 0. Level 1 will be trunked to 2nd selectors.

AUXILIARY RELAY-SET

On seizure the auxiliary relay-set will accept and store the digits received from the calling subscriber's dial, and an associated junction hunter will search for a free level-9 junction; having seized a free junction the relay-set will generate the digit 1 or 0 according to whether seizure was via level 1 or 0. Digit 1 will be followed by retransmission of the stored digits; digit 0 will be followed by a discrimination digit and then the stored digits. The discrimination digit will indicate

(*a*) the originating charging group, and

(*b*) whether the call is from a coin-box or an ordinary telephone.

Digits 1 and 2, 3 and 4, 5 and 6 will indicate the charging group; digits 1, 3 and 5 will be used to indicate coin-box calls and digits 2, 4 and 6 ordinary calls.

The relay-set will have facilities for manual-hold, repetition of coin-and-fee-checking relay-set control signals and detection of metering-over-junction signals. The relay-set will thus cater for calls to manual-board services as well as for S.T.D. calls.

LOCAL-CALL TIMING

Local-call timing is to be introduced when facilities for S.T.D. are provided at U.A.X.s.

U.A.X.s No. 12 *and* 13

A local-call-timing circuit will precede each selector in a U.A.X. No. 12. In a U.A.X. No. 13 a local-call-timing circuit will be provided on each working outlet of 1st selector levels 2–9. The circuits at both types of U.A.X. will employ a ratchet relay to derive a meter pulse from every 11th local-call-timing supply-pulse. On a call originating from a coin-box line this local-call-timing circuit will be cut off to enable the timing to be controlled independently by the coin and fee checking relay-set. The local-call-timing circuit does not provide forcible release if the called subscriber is held, because circuits to do this are already incorporated in U.A.X.s No. 12 and 13.

U.A.X.s No. 14

A local-call-timing relay-set providing forcible release if the called subscriber is held will precede each 1st selector to which local subscribers have access.

Pulse Supply

It is proposed that groups of U.A.X.s shall be supplied with ordinary and coin-box basic local-call-timing pulses via a carrier system. This will enable the pulse rates to be centrally controlled, thereby avoiding the necessity for special visits to U.A.X.s on occasions when it is required to alter the normal change-over times.

COIN-BOXES

Because of the possibility that the new pay-on-answer coin-boxes[3] may not be installed when facilities for S.T.D. are first provided at a U.A.X., the design of the auxiliary relay-set will enable the present prepayment coin-boxes to be retained temporarily. Alternative strapping in the relay-set will permit the use of either 0 or 100 for the assistance code.

When pay-on-answer coin-boxes are in use the trunking arrangements for coin-box lines will be as shown in Fig. 4. Standard coin and fee checking relay-sets will be

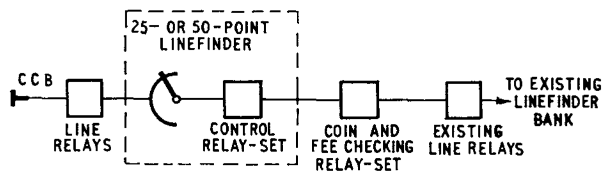


FIG. 4—LINEFINDER ARRANGEMENTS FOR PAY-ON-ANSWER COIN BOXES CONNECTED TO U.A.X.S

provided and coin-box lines will be connected to them by the use of 25-point or 50-point linefinders similar in principle to the 50-point linefinder in use for ordinary subscribers in director and non-director exchanges.[4] The coin and fee checking relay-sets will be directly connected to existing coin-box line circuits.

DATE OF INTRODUCTION

It is expected that the first U.A.X.s will be provided with facilities for S.T.D. during 1965.

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Saving Space in Telephone Exchanges by Using Modern Power Plants

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U.D.C. 621.311.6:621.395.722

The use of large high-efficiency semiconductor-type rectifier power plants in telephone exchanges enables large savings of space to be made compared with the areas that would be occupied by motor-generator power plants of comparable outputs. This is of particular value at exchanges where space for additional equipment could not readily be made available by other means.

THE standard power plant (Power Plant No. 210) for small and medium-size automatic telephone exchanges where the ultimate peak load is less than 800 amp consists of one or two rectifiers, a filter and a power switchboard. This type of power plant can be installed either as a separate group of equipment or in the same suite as racks of exchange equipment, and the space occupied is considerably less than that required for the parallel-battery automatic plants and small motor-generator plants that it superseded.

Until 1960 the standard power plant for larger-size exchanges used motor generators as the d.c. power source. A separate room was usually provided in which the machines were arranged symmetrically, often occupying much greater space than was necessary for adequate maintenance. The introduction of subscriber trunk dialling (S.T.D.) necessitates space for additional equipment racks being made available in existing exchanges, some of which are already congested. At two London exchanges, Mayfair and Whitehall, space was provided by clearing the greater part of each power room. Although concentration of the motor-generator plants to give only the minimum gangway widths would have freed some space, it was found a greater area could be made available by installing rectifiers. In addition to saving space, advantage could be taken of fully-automatic float working which is relatively straightforward to provide if rectifiers are used. This type of working is essential for new plants because of the increased provision of standby generating sets, which permit the use of batteries of smaller capacity.

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The installations at Mayfair and Whitehall exchanges provided a good opportunity to gain experience in the use of the large high-efficiency semiconductor type of rectifier sets then becoming available. The new power plants were installed by the London Telecommunications Region Power Section and became the prototypes of what is now the standard system for telephone exchanges having an ultimate peak load greater than 800 amp. Fig. 1 shows a photograph of the Mayfair exchange plant, which uses three 1,200 amp rectifiers, and Table 1 gives details of the space saved at each exchange.

TABLE 1

Space Made Available by use of Rectifier Power Plant

Exchange	Original Area Occupied by Motor-Generator Plant (ft^2)	Area Now Occupied by Rectifier Plant (ft^2)	Area Freed	
			(ft^2)	Percentage of Original Area
Whitehall	2,030	610	1,420	70
Mayfair	1,930	660	1,270	65

The standard plant, known as Power Plant No. 222, consists of a power switchboard similar to that used with the superseded motor generators, and, ultimately, three

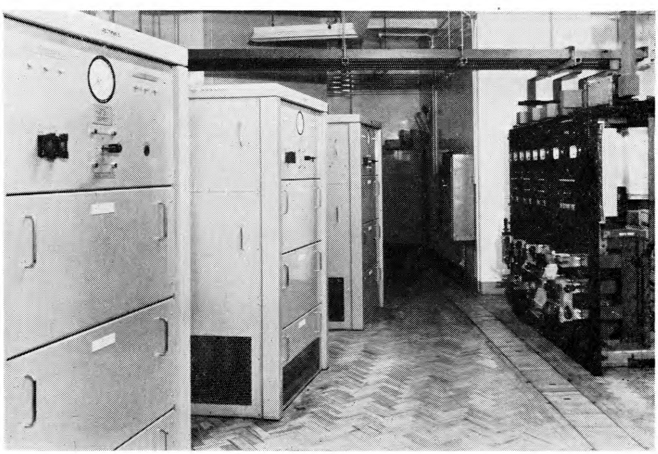

FIG. 1—RECTIFIER POWER PLANT AT MAYFAIR TELEPHONE EXCHANGE

or four rectifiers, of equal output, with individual smoothing filters. Gangways are necessary at the front and rear of the switchboard and at the front and sides of the rectifiers. The filters, which are sited immediately behind their associated rectifiers, require side access. The rectifiers are available in 100 amp steps from 300 amp upwards. The largest plant at present being provided uses four 1,500 amp rectifiers.

TABLE 2

Possible Savings in Floor Area by using Rectifier Power Plants

Load (amp)	Area Required by Motor-Generator Plants (ft²)	Area Required by Rectifier Plants		Area Saved
		Power Plant No. 210 (ft²)	Power Plant No. 222 (ft²)	
800	440	230	—	47%
2,000	790	—	520	34%
4,000	1,145	—	785	31%

Table 2 gives details of the possible reduction in area by the use of Power Plants No. 210 and No. 222 instead of motor-generator plants. In each instance minimum areas are considered, allowance being made for standard-width gangways. The installation of Power Plant No. 210 in a single suite contributes considerably to space saving, and a development of Power Plant No. 222 that will result in a further reduction in space requirements is being achieved by housing each rectifier and filter in a common cubicle and installing the cubicles in a suite together with a control cubicle. The control cubicle accommodates all the equipment previously mounted on the power switchboard, except for the knife switches and current relays associated with each rectifier, which are mounted in the individual rectifier cubicles. Interconnexion is carried out within the cubicles, so that, in addition to saving space, this design offers a uniform and modern appearence without the network of overhead connexions that are necessary if "island" types of layout are used. The first prototype of this arrangement was installed at Waterloo exchange where, as at Mayfair and Whitehall exchanges, it was necessary to make space available for S.T.D. equipment. Initially a standard Power Plant No. 222 was to have been installed, and Table 3 gives details of the space saving that would have been obtained if this had been used, and of the space cleared using the modified arrangement.

TABLE 3

Space Made Available at Waterloo Exchange

Original Area Occupied by Motor-Generator Plant (ft²)	Power Plant No. 222			Modified Power Plant No. 222		
	Area Occupied (ft²)	Area Freed		Area Now Occupied (ft²)	Area Freed	
		(ft²)	Percentage of Original Area		(ft²)	Percentage of Original Area
1,100	470	630	57	260	840	76

Fig. 2 shows a photograph of the power plant at Waterloo exchange. This plant consists of three 500 amp rectifiers and a control cubicle, which is at the end of the suite to simplify connexion to the distribution and to the batteries in the room below.

The type of power plant installed at Waterloo exchange is now being standardized as Power Plant No. 225 and will supersede Power Plant No. 222 in the near future. It is not essential that all the rectifiers of such a plant should have identical outputs; the rectifiers will be available in 100 amp steps from a 300 amp up to a 2,000 amp output, and the largest plant so far being planned will use six 2,000 amp rectifiers. Where the plant cannot be accommodated in one suite it can be split into two or more suites as required.

With the introduction of Power Plant No. 222, d.c. motor generators ceased to be provided for new telephone exchange power plants, and space savings of at least 30 per cent can be expected. This saving will be increased to at least 55 per cent when Power Plant No. 225 becomes standard.

FIG. 2—RECTIFIER POWER PLANT AT WATERLOO TELEPHONE EXCHANGE

Pressurization of Telecommunication Cables

Part 2—The Supply of Dry Compressed Air

J. R. WALTERS, J. F. KEEP and J. F. CRAGGS†

U.D.C. 621.317.333.41:621.315.211.4

The principles of gas pressurization of telecommunication cables were discussed in Part 1 of this article. Part 2 describes how the dry compressed air required for both the constant-pressure and continuous-flow systems considered in Part 1 is provided.

INTRODUCTION

PRESSURIZATION of telecommunication cables involves the supply, in adequate quantities, of dry air at a suitable pressure. The quantity of air required will depend on the number, type, size and length of the cables to be pressurized and also on whether static or continuous flow, or a combination of both systems, is to be adopted. Sufficient dry air must be available initially to charge all the cables to the required pressures, and a large flow of air is also required to maintain a pressure gradient in the cables whilst leaks are being traced and also to make good all losses.

The approximate volume of air required to raise the average pressure inside a cable by any desired amount can be calculated from the equation $Q \simeq \frac{V \times P}{25}$ ft^3 at atmospheric pressure, where V = calculated total volume of the cable in ft^3, and P = required pressure increase in lb/in^2, and assuming an air space inside the cable of nearly 60 per cent of the total volume.

The methods used to obtain dry air for pressurizing the cables depends to some extent on the quantities required and the degree of moisture that can be tolerated in the air supply. From tests made on a number of unpressurized working cables it has been found that the dew point of the air within the cables is of the order of -20°C, and this is taken as the desirable degree of dryness for air used for pressurization.

Dry compressed air can be purchased in cylinders of 110 or 165 ft^3 capacity for use where the expected consumption of compressed air is small. The air pressure in the cylinder is about 2,000 lb/in^2 when full, and a 2-stage regulator is used to reduce the pressure to 9 lb/in^2. For economic reasons the cylinders should require changing as infrequently as possible, and a turnover period of one month is about the minimum that can reasonably be allowed. This limits the flow that may be taken from a 110 ft^3 cylinder to about 0·15 ft^3/hr, and hence continuous-flow pressurization using cylinders is only suitable for very small cable systems.

The humidity of the air supplied increases as the pressure in the cylinder falls, and Fig. 6 shows the variation of dew point with pressure. It will be seen that when a cylinder is discharged to 10 lb/in^2 the dew point is about -20°C.

When large volumes of air are required the foregoing method of supplying dry air is uneconomical, and some form of automatic desiccation must be used. One method of automatic desiccation is to employ a combination of compression and refrigeration, the air being first compressed in a receiver to about 150 lb/in^2 and then cooled to below freezing point. The moisture from the air is collected as frost in the receiver, which is defrosted at regular intervals by means of a built-in electric heater and, during the defrosting period, the air supply is passed to the cables through a vessel containing silica gel.

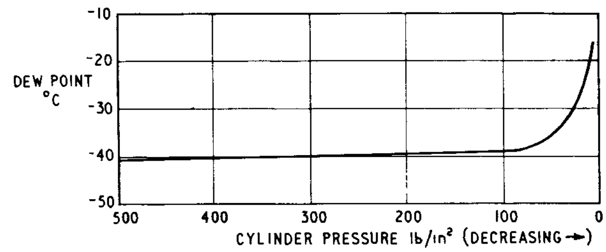

FIG. 6—VARIATION OF DEW POINT WITH PRESSURE

Another method of automatic desiccation is air drying by adsorption. Air is passed over an adsorbent, either silica gel or activated alumina, and the moisture is held in the molecular surface of the adsorber, which has a very much greater surface area than is indicated by its actual volume (it is estimated that the surface area of these materials is of the order of 50,000 ft^2/in^3). The adsorbent material is arranged in two separate beds; whilst one is drying the air supplied to the cables (the desiccating period) the other is being reactivated (reactivating period) and the beds are then changed over automatically. The limitations on the quantity of air supplied in this manner are set by the size of the air compressor and the effective volume of the desiccant.

ADSORPTION-TYPE AUTOMATIC DESICCATION EQUIPMENT

The method of air drying by adsorption is that used by the British Post Office, and two sizes of adsorption-type automatic desiccating equipment have been developed. The smaller equipment is used with up to 18 cables, while the larger equipment can serve a maximum of 60 cables.

The compressors used in conjunction with the desiccators to be described supply oil-free air, to avoid contamination of the adsorber. These compressors are required to run continuously and need careful maintenance. Designs that incorporate air receivers supplied by compressors that operate intermittently as air is required are now being considered.

Compressor-Desiccator for up to 18 Cables

The compressor-desiccator used for up to 18 cables is shown in Fig. 7; it can be mounted on a trolley if required for use as a portable source of dry air. The compressor has two identical diaphragm-pump units mounted on each end of the spindle of a $\frac{1}{8}$ h.p. induction motor, the two pump units being connected in parallel to obtain maximum air flow. The unit will deliver approximately 5 ft^3/hr at 9 lb/in^2.

†External Plant and Protection Branch, E.-in-C.'s Office.

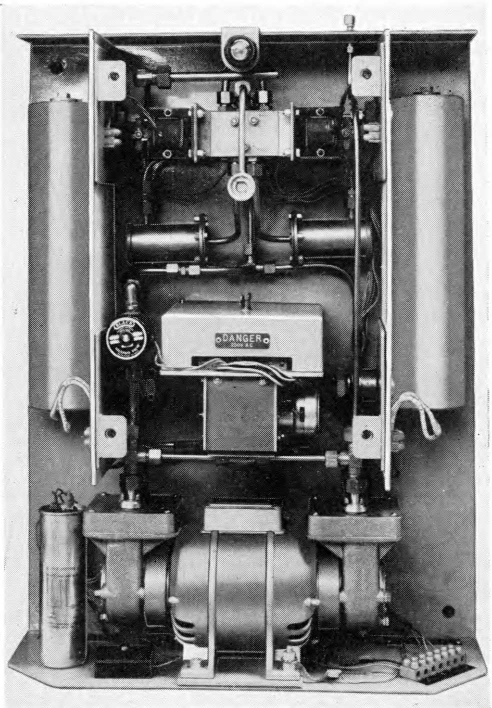

FIG. 7—COMPRESSOR-DESICCATOR FOR UP TO 18 CABLES

Two beds, each containing approximately $1\frac{1}{4}$ lb of silica gel, are used for desiccation, each being used alternately for periods of 8 hours whilst the other is being reactivated. Reactivation is done by heating each bed to about 150°C while air is passed through and out into the atmosphere to remove the moisture collected by the silica gel during the previous desiccating period. After

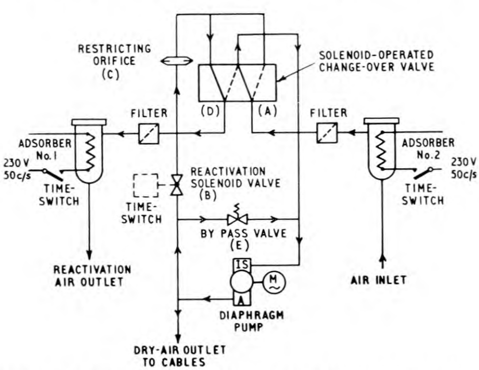

FIG. 8—DIAGRAM OF COMPRESSOR-DESICCATOR FOR UP TO 18 CABLES

4 hours this purging air is shut off, the heating is discontinued and the bed is then allowed to cool for the next 4 hours. Air lines are changed over by means of a solenoid-operated double change-over valve actuated by a mains-driven process-timer. Fig. 8 shows the equipment diagrammatically and indicates the conditions with No. 2 bed in service. It will be seen that the pump draws air through the dry silica-gel bed (No. 2), through a filter and through section A of the solenoid-operated change-over valve; after compression, air is passed to the cables from the output ports of the pump.

A small quantity of air at the output is diverted through the reactivation solenoid valve, B, an orifice, C, to restrict the flow, and section D of the change-over valve to purge moisture from the bed being heated (No. 1). At the end of the period the heater is disconnected and reactivation solenoid valve, B, is closed. A bypass valve, E, between the input and output ports of the compressor, regulates the output pressure to not more than 9 lb/in². The output pressure falls as the rate of flow increases and is about 8 lb/in² at 10 ft³/hr with a dew point not worse than −32°C. The regulation curves of a desiccating unit are shown in Fig. 9. The lower curve shows the regulation with the additional output required for purging during the reactivation period. The upper curve shows the output during the cooling cycle when air for purging is shut off.

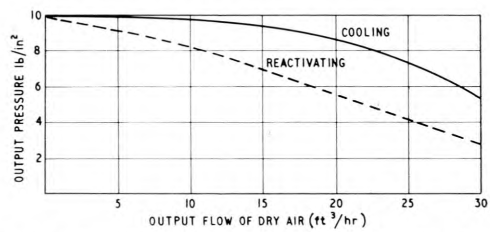

FIG. 9—REGULATION CHARACTERISTICS OF DESICCATING UNIT

Desiccator Unit for up to 60 Cables

The layout of air-compressing and desiccating equipment that has sufficient capacity to serve up to 60 cables is shown in Fig. 10. The desiccator uses silica gel as the drying agent, is fully automatic in operation, and will deliver at least 30 ft³/hr of air dried to a dew-point of −40°C at 9 lb/in².

The method of reactivation differs from that used in the smaller equipment in that electric heaters are not required to dry the silica gel. The action is as follows. Air is supplied to the unit from a compressor at a gauge pressure of about 50 lb/in² and this is routed to the output pressure regulator through one or other of two small adsorber beds of silica gel. The route is determined by a solenoid valve, S, that operates at intervals of 1 minute. The diagram shows the conditions existing when air is passing through bed A to non-return valve V1. On leaving the bed, part of the dry-air stream is diverted through restrictor D and silica gel bed B to the atmosphere via a second path through change-over valve S. The pressure in this bed is very little above atmospheric pressure and is not sufficient to operate valve V2. The stream of air (about

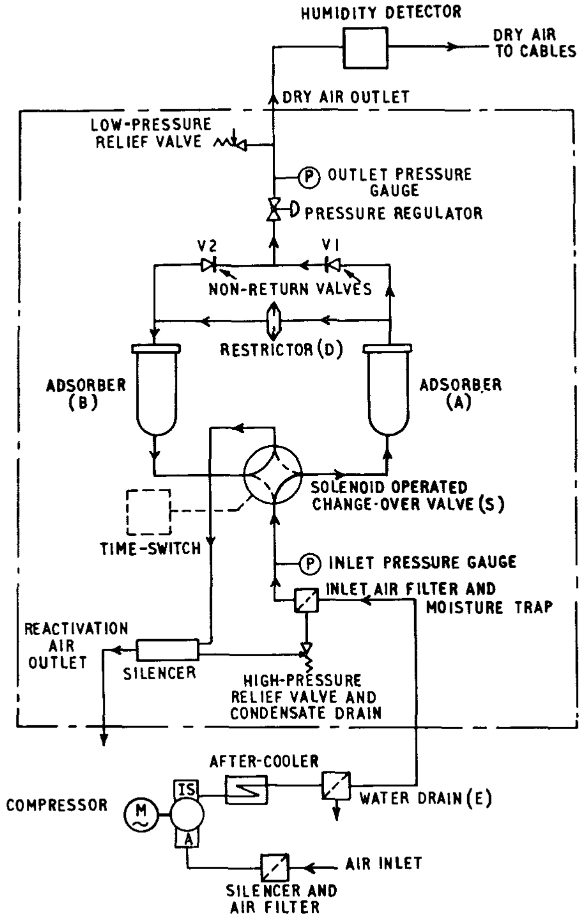

FIG 10—DIAGRAM OF COMPRESSOR AND DESICCATOR FOR UP TO 60 CABLES

8 ft³/hr) flows in the reverse direction during the reactivation period of bed B to the flow during the desiccating period, and this removes the moisture that was adsorbed previously on to the surface of the silica gel.

The drying effect of the air passing over the silica gel during the 1 minute reactivation period would not be sufficient to dry the silica gel in the short period available were it not for two other factors. One is that the comparatively dry reactivation air stream is made about four times drier by expansion, as the indicated pressure falls from 65 lb/in² absolute to atmospheric pressure. The other factor is the slight heating that occurs at the surface of the crystals during the desiccating period. The heat has insufficient time to be dissipated until the next reactivation period, when it tends to vaporize the adsorbed moisture, and at the end of the period the temperature of the crystals returns to normal.

The quantity of moisture dealt with by the desiccator amounts to about 0·0001 lb/min. Because of the rapid reversals of air in the silica gel beds, only the crystals near the inlet connexions are used and only about ½ lb is required in each bed.

Compressor Unit

An oil-free air-cooled compressor is used in conjunction with the self-activating desiccators. The oil-free compressed air is obtained by using a labyrinth piston, which is shown diagrammatically in Fig. 11. In this type of compressor the piston and the cylinder walls are machined to very close tolerances, and the upper piston, which has a large number of small concentric grooves, does not actually touch the cylinder wall. The lower part of the piston acts as a crosshead and is fitted with the usual stepped and oil-scraper rings.

During a compression stroke, part of the air is forced out through the outlet valve and part escapes past the labyrinth grooves in the upper piston into the crank-case via a vent hole about halfway up the cylinder wall. The escaping air carries any surplus oil with it. The effect of the grooves is to reduce the leakage by increasing the drag of the air escaping between the cylinder walls: because of this, oil is never present in the upper cylinder.

The compressor has a measured free-air delivery of 1 ft³/min at an indicated working pressure of 50 lb/in² and is directly coupled to a 0·55 h.p. single-phase electric motor. The crank-case has a large Perspex window through which the crank and oil level is clearly visible for maintenance purposes. The machine runs continuously and an air receiver is not used.

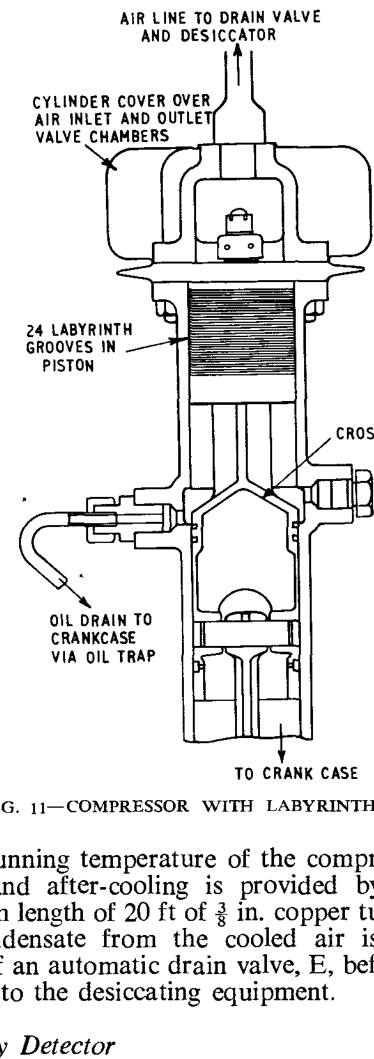

FIG. 11—COMPRESSOR WITH LABYRINTH PISTON

The running temperature of the compressor is about 120°C and after-cooling is provided by means of a minimum length of 20 ft of ⅜ in. copper tubing (Fig. 10). The condensate from the cooled air is removed by means of an automatic drain valve, E, before connexion is made to the desiccating equipment.

Humidity Detector

The small cobalt-chloride indicators inserted in the main airline from all desiccators at present used by the Post Office are not very satisfactory because the required humidity change that occurs before an alteration in the colour of the indicator can be observed is greater than can be tolerated; furthermore, constant inspection is required to detect any colour change. An electrical humidity detector has therefore been introduced that utilizes changes in resistance of a moisture-sensing element. The flat element is rectangular in shape and is made from specially-prepared polystyrene with a carbon conducting track processed into the surface. The resistance of the element falls in a logarithmic manner as the relative humidity rises, and a typical element has a resistance of about 10 megohms at −10°C dew point, 1 megohm at 9°C dew point and 100,000 ohm at 24°C dew point. The element resistance changes due to surface adsorption and it can therefore respond quickly to changes in air humidity.

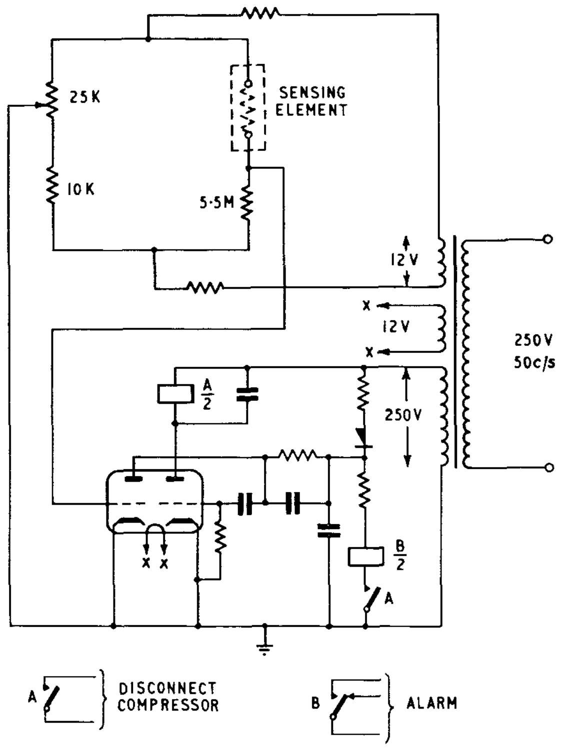

FIG 12—CIRCUIT OF HUMIDITY DETECTOR

The sensing element is connected to a monitoring unit that can be set to disconnect the power supply to the compressor motor and to give an alarm signal when the humidity rises to a preset value of about 10°C dew point. The circuit is shown in Fig. 12.

The indicator utilizes a double-triode valve, one grid of which is connected to the output of an a.c. bridge. The sensing element forms one arm of this bridge, the second half of the valve receives the amplified output from the a.c. bridge and acts as a phase-sensitive detector. As a balance of phase and amplitude is attained by a fall in the resistance of the sensing element, a relay in the anode circuit of the valve releases, providing the required alarm and disconnecting the power supply to the air compressor.

ACKNOWLEDGEMENTS

Acknowledgement is made to Messrs. Reavell and Co., Ltd., for permission to reproduce the information in Fig. 11 and to Messrs. A. M. Lock and Co., Ltd., for permission to reproduce the information given in Fig. 12.

Book Reviews

"Fundamentals of Electrical Measurements." C. T. Baldwin, M.A., M.I.E.E. George G. Harrap & Co., Ltd. 336 pp. 176 ill. 25s.

This book is especially intended for Higher National Certificate and Diploma and is suitable for the use of students up to degree or Dip. Tech. level. The volume covers measuring instruments, meters and the techniques associated with measuring circuits. The main treatment is concerned with power and audio frequencies, but extension of the principles of measurement to higher frequencies and to the field of high-voltage work is included.

The author's declared aim has been to present a concise introduction to the theory and practice of electrical measurement. The book achieves this aim excellently. The style is clear and concise and while the treatment is fundamental, the text is not heavily mathematical, this treatment being wisely limited in its logical development to permit a student to understand the fundamental principles involved without the confusion of excessive mathematical detail.

The rationalized m.k.s. system of units is used throughout and many worked examples are included in the text to illustrate the various mathematical conclusions. Many chapters conclude with a set of exercises, with answers, from degree and I.E.E. examination sources.

This is an excellent book and is thoroughly recommended. It will be of considerable value to students in the electrical-measurement field and the author is to be congratulated on having produced a carefully-prepared work with a student's requirements in mind.

S. W.

"Iterative Arrays of Logical Circuits." F. C. Hennie. John Wiley & Sons, Ltd. x + 242 pp. 112 ill. 40s.

The doctoral thesis of the author at Massachusetts Institute of Technology is published in this book as a Research Monograph. It is essentially a book for the research worker in the areas of information processing, switching theory, and computer design.

Switching circuits composed of logical elements of various kinds and operating in combination or sequentially can be analysed and synthesized by conventional switching theory. The author considers the case of iterative arrays of logical circuits, i.e. identical cells either combinationally or sequentially connected in a regular array, each cell having an input and an output and means of transmitting and receiving discrete signals to and from its nearest neighbours through synchronous intercell delays. The ability to design and manufacture cheaply large networks of this kind would extend the present limited power of solving complex information-processing problems, analogous, for example, to the recognition by the mind of an object regardless of where the image of the object falls on the retina of the eye.

Twenty-five theorems and associated corollaries are deduced to describe some of the properties which networks so formed possess or do not possess. Even so, the work makes only a beginning to the whole subject and it is doubtful whether any practical use can yet be made of the results. The value of the book resides in the techniques and methods used, and the stimulus which it should give to others to continue.

T. H. F.

The Helium System of the Maser Installation at Goonhilly Radio Station

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U.D.C. 621.375.9:621.396.7:621.396.934

The microwave amplification of the signal received at the experimental satellite ground station at Goonhilly Downs is achieved with the aid of a maser. These devices will only operate at very low temperatures, which are obtained at Goonhilly by using the latent heat of vaporization of liquid helium. A description is given of the supply and storage of liquid helium, its evaporation with the aid of a vacuum pump and its collection as a gas and return to the supplier for reliquefaction.

INTRODUCTION

A TRAVELLING-WAVE solid-state maser amplifier is used to provide the first stage of amplification in the receiving system at the experimental satellite ground station at Goonhilly Downs.* While the maser itself was built by an industrial research laboratory, the auxiliary supplies and equipment essential for the operation of this maser were the responsibility of the Post Office Research Station. A major part of this auxiliary equipment consists of apparatus for handling the helium refrigerant.

The use of liquid helium is quite unique in the Post Office, and involves equipment and techniques rarely seen outside the scientific laboratory. The installation was designed and constructed entirely by Post Office staff in a period of only four months. Much of the final installation work took place at night, to avoid interference with the aerial constructional workers during daylight hours.

GENERAL DESCRIPTION

The maser is a type of microwave amplifier in which the amplification takes place in a single crystal of "pink" ruby—crystalline alumina containing a small percentage of chromium. Microwave power, at a frequency of about 30 Gc/s, is injected into the crystal where the energy temporarily disturbs the thermal equilibrium of the outer electrons in the chromium ions in the crystal. Some of the energy stored in this way is available to amplify a low-level signal at a frequency of 4·17 Gc/s. The particular frequencies involved are determined by an applied steady magnetic field. The particular property of the amplifier which makes it so important for use in satellite-communication experiments is its ability to amplify extremely weak radio signals whilst introducing a negligible amount of additional background noise. A disadvantage is that it will only operate at very low temperatures. The present equipment requires a temperature lower than 2°K (i.e. −271°C) and the only possible method of obtaining such a low temperature is to immerse the amplifier in liquid helium. This normally boils at 4·2°K, but the lower temperature required for the maser can be produced by causing the helium to boil at a reduced pressure. A large vacuum pump must therefore be incorporated into the apparatus.

Helium is an expensive substance, and the only available sources are the natural gas wells in the U.S.A. Both for economic reasons, and to conserve the supplies of helium imported from the U.S.A., it is therefore necessary to waste as little as possible. As the liquid helium cooling the maser boils, the vapour must be collected for eventual reliquefaction.

If the maser and all the associated equipment could have been mounted in close proximity, the installation would have been relatively straightforward. However, to make use of the unique low-noise properties of the maser, it was essential that it should be mounted as near as possible to the focus of the 85 ft parabolic reflector, whilst the remainder of the equipment had to be mounted in the rotating cabin or at ground level.

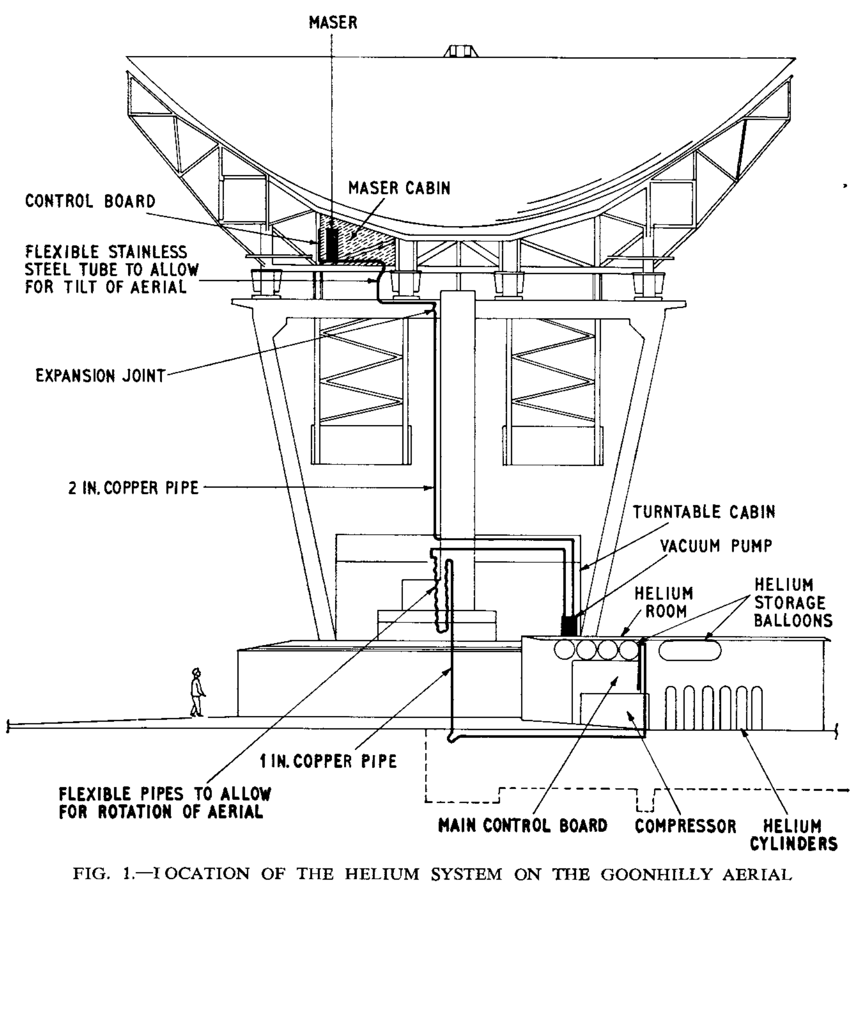


FIG. 1.—LOCATION OF THE HELIUM SYSTEM ON THE GOONHILLY AERIAL

†Post Office Research Station.

*TAYLOR, F. J. D. Equipment and Testing Facilities at the Experimental Satellite Ground Station, Goonhilly Downs, Cornwall. *P.O.E.E.J.*, Vol. 55, p. 105, July, 1962.

It was not practicable to mount the maser actually at the focus because of its weight and because there was already a considerable amount of aerial-feed equipment at the focus. The maser was therefore housed in a cabin constructed on the back of the parabolic reflector, and connected by waveguide to the feed equipment at the focus.

During operation, the axis of the aerial may be tilted between horizontal and 10° beyond vertical, and consequently all the equipment in the maser cabin, including the klystron and magnet power supplies, a small oscilloscope, a nitrogen-cooled reference load and the maser itself, must operate satisfactorily when tilted by 100°. To prevent refrigerant from spilling from the maser as the aerial tilts, it was mounted at an angle of 45° to the axis of the aerial, so that the maser axis is never more than 55° from vertical. However, access to the aerial cabin to fill the maser with refrigerant is only possible when the aerial axis is horizontal, so that the maser must be capable of being tilted in its cradle from the normal operating position through 45° to the vertical position for filling. The helium-gas handling system must also provide for the maser to be tilted inside the cabin, and, when the aerial is in use, for the cabin to tilt with respect to the ground without restricting the flow of helium gas. Sections of corrugated stainless-steel tube are used to provide this flexibility.

Thus, the complete installation consists of the helium control equipment associated with the maser, a vacuum line along and down the aerial structure to the vacuum pump, together with the equipment for controlling the flow of helium gas from the vacuum pump and storing this helium for return to the liquefaction plant. The location of the various items is indicated diagrammatically in Fig. 1.

LIQUID HELIUM AND LIQUID NITROGEN

Liquefied gases are usually contained in metal "dewar" vessels, which are spherical flasks with a double wall. The space between the walls is evacuated to provide thermal insulation. The latent heat of helium is so low that this form of thermal insulation is inadequate. The maser is therefore mounted inside a double vacuum-insulated dewar, with the outer vessel containing liquid nitrogen.

Double dewars must also be used for storing and transporting liquid helium. Storage dewars holding 17 litres of helium and 15 litres of liquid nitrogen are despatched by rail from a liquefaction plant in London to Cornwall two or three times a week.

The temperature of liquid helium is lower than the freezing point of both oxygen and nitrogen, and it is necessary to take precautions to prevent air from freezing inside the neck of the dewar vessels. A non-return valve must therefore be fitted to the dewar, allowing helium gas to boil away from the liquid, but preventing air from entering.

COOLING THE MASER

The maser is mounted in its tipping cradle on one wall of the maser cabin, as shown in Fig. 2. Above it on the wall is a control panel that enables the flow of helium gas to be regulated, and the pressure in the maser to be measured. A flexible stainless-steel tube connects the maser to the control panel. Electrical monitoring equipment is also mounted on this panel, indicating the output of the klystron oscillator and the level of helium in the maser.

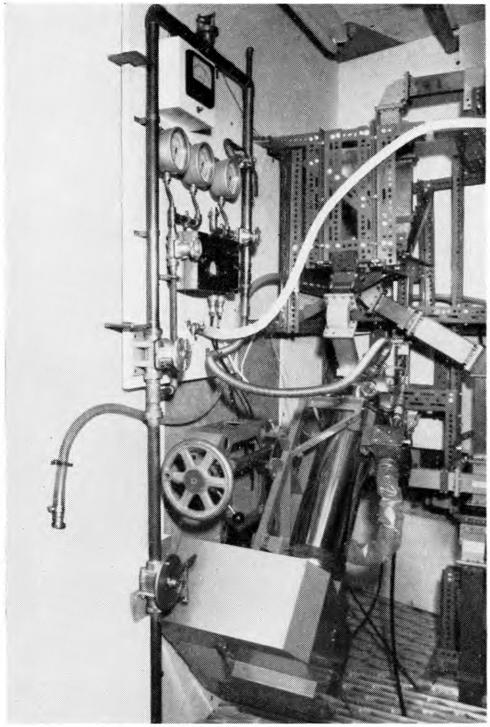


FIG. 2—THE MASER IN ITS OPERATING POSITION

The dewars of liquid helium and liquid nitrogen are lifted to the portal beam of the aerial by a hydraulically-operated platform and carried to the maser cabin. The liquid-nitrogen dewar is connected to a transfer system, that has been permanently installed in the cabin. Compressed nitrogen from a cylinder is used to force the

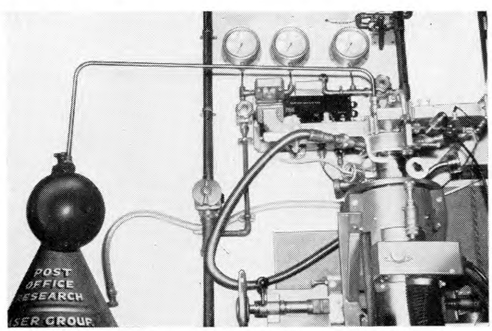


FIG. 3—LIQUID HELIUM BEING TRANSFERRED INTO THE MASER

liquid nitrogen along a thermally-insulated tube into the outer vessel of the dewar containing the maser.

When the outer vessel of the maser dewar is full of nitrogen, the inner vessel is filled with liquid helium. The helium-storage dewar is placed on a hydraulically-operated lift-platform beside the maser dewar, and a transfer tube is inserted into two containers. This transfer tube, which can be seen in Fig. 3, has a vacuum-insulated double wall, to prevent the boiling of helium due to heat entering through the transfer-tube walls. A bladder attached to the helium-storage dewar is used to start the helium transfer. A gentle pumping action agitates the liquid in this dewar, causing increased evaporation. The gas pressure so produced forces the liquid helium through the transfer tube. As the level of the helium rises in the maser container, the storage dewar and transfer tube are raised to keep the outlet of the transfer tube above the liquid surface in the maser container.

Great care must be exercised during the transfer to prevent air or water entering the dewars. When the dewar containing the maser is full, the transfer tube is rapidly removed and the entry port sealed. During the helium transfer, a considerable amount of liquid is evaporated in cooling the structure to 4·2°K. The helium gas so evolved passes along the flexible tube to the control panel, and thence into the helium collection system.

Immediately the maser dewar has been filled and the filling port sealed, the pressure must be reduced to a few torr (mm mercury) in order to lower the helium temperature from 4·2°K to the normal operating temperature, 1·5°K. The rate of change in the pressure must be controlled carefully in order to prevent the risk of damage to the maser.

Some control of the maser gain and bandwidth may be obtained by adjusting the pressure in the dewar, and so changing the temperature of the maser ruby crystal, within the range 1·4 to 2·2°K.

THE MAIN VACUUM LINE

As already mentioned, the nearest position to the maser which could be used for the vacuum pump was in the turntable cabin. The main vacuum line between the maser cabin and the pump therefore had to be about 80 ft in length. Two-inch diameter copper pipe was used, with joints and bends assembled from commercial fittings, silver soldered into position. The pipeline was constructed in sections on the ground and these sections were joined by vacuum flanges sealed with rubber rings and bolted together by stainless-steel bolts.

A great deal of care was taken in assembling the system, to eliminate possible sources of contamination or leakage. Apart from directly reducing the purity of the recovered helium any volatile contamination in the pipeline would increase the background pressure in the system, making subsequent detection of possible leaks much more difficult. The success of the whole installation depends upon the quality of the silver-soldered joints and upon the cleanliness of the system, and elaborate cleaning and leak-testing procedures were devised and followed during the installation.

The 2-in. pipe is supported by a series of brackets fixed to the waveguide ladder which runs alongside the vertical centre member of the concrete aerial structure (Fig. 4). The weight of the pipe is taken on a special flange located near the base of the ladder and a flexible stainless-steel section near the top permits small residual movements.

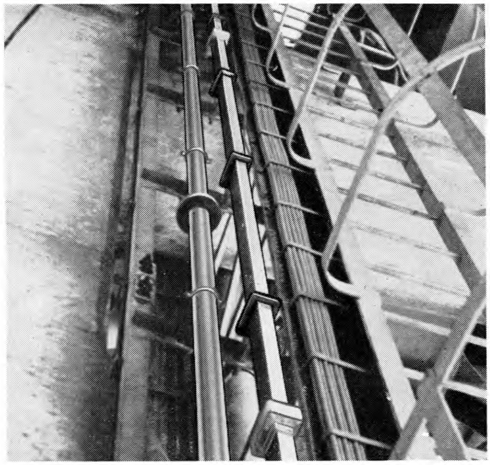


FIG. 4—THE VERTICAL HELIUM PIPE, AND THE WAVEGUIDE CARRYING THE AMPLIFIED SIGNAL FROM THE MASER

THE VACUUM PUMP

In order to handle large quantities of helium, a vacuum pump of large capacity is needed. The rate at which helium gas would be evolved could not be known in advance, as it depends upon the constructional details of the maser structure. A large margin of safety was therefore desirable when specifying the required pump performance. A pump with a capacity of 36 ft^3/min was fitted; this was the largest available air-cooled vacuum pump, air cooling being very desirable to avoid the necessity for an additional water-circulation system on the aerial.

THE HELIUM RECOVERY APPARATUS

The output from the vacuum pump cannot be exhausted to the atmosphere in the usual way, but must be piped away for recovery. Accordingly, a 1 in. diameter copper pipe is connected to the output of the pump to carry the helium over the transmitting equipment to the rotating joint at the centre of the turntable cabin. To carry the helium through this rotating joint, four 17 ft lengths of nylon-reinforced p.v.c. tube are used, hanging as U-loops, connected in parallel. As the aerial rotates, the loops wind round a central pylon, permitting a movement of $\pm 250°$ from the central position. From the bottom of the central pylon the copper pipe goes through underground ducts to the helium room, which is part of the building housing the aerial control gear.

This part of the pipe installation was rendered more difficult to complete than was anticipated, because of the many obstacles that had to be avoided. There were many other services in the underground ducts, and considerably ingenuity was necessary to obtain a safe route for the helium pipe. The total length of the 1 in. pipe is about 120 ft, and the same care over cleanliness was observed in its fabrication as for the 2 in. vacuum section.

The helium room, shown in Fig. 5, contains a large control panel to handle the helium gas which is now at atmospheric pressure. This panel is fitted with over

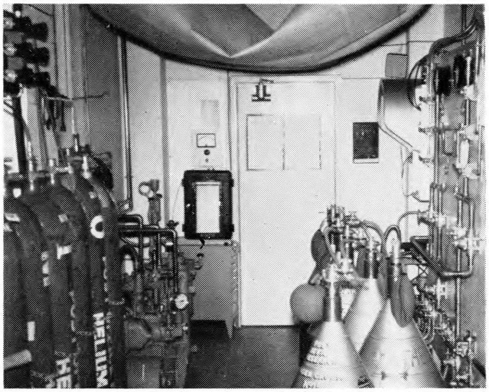


FIG. 5—THE HELIUM ROOM

20 vacuum-type valves to interconnect the pipe which brings the helium gas from the vacuum pump, the temporary gas store, and the compressor.

The helium store consists of 12 rubberized-canvas balloons suspended beneath the ceiling, each balloon holding up to 17 ft^3 of helium.

For return to the liquefaction plant, the contents of the balloons must be compressed into steel cylinders. A modified commercial air compressor is used to compress the helium to 1,000 lb/in^2. Additional facilities are required to collect gas released from the sump and the starting bypass valve, which are normally open to the atmosphere in an ordinary air compressor. Helium, which is a monatomic gas, becomes hotter than diatomic oxygen or nitrogen during compression. To avoid damaging the compressor by over-heating, it must not be used for more than 10–15 minutes at any one time when compressing helium.

The full cylinders are returned by rail to the liquefaction plant in London, for the cycle to begin again. During the first months of operation, a large proportion of the helium supplied as liquid was eventually returned as gas, to the liquefaction plant. The great care taken in construction and operation of the helium system has been justified by the high level of purity attained for the returned gas.

CONCLUSION

The helium system at Goonhilly was commissioned on 25 June 1962, having been completely designed and constructed in four months. The general features of the system have proved satisfactory in operation, requiring little modification to the original conception, although a number of changes have been introduced to simplify the filling of the maser with liquid helium.

ACKNOWLEDGMENTS

The authors wish to thank many members of the staffs of the Royal Radar Establishment, the Mullard Research Laboratories, and the scientific division of the British Oxygen Company for their advice and assistance in the design and commissioning of the helium system.

Polythene-Sheathed Paper-Core Unit Twin Cable

U.D.C. 621.315.221.8:678.742.2:621.395.743

Since the article "Field Trials of Large Polythene Cables in Subscribers' Local-Line Networks"* was written, a decision has been taken to adopt polythene-sheathed paper-core unit twin cable (Cable, P.C.U.T., Polythene Sheathed) as the standard for cables above 100 pairs for British Post Office local-line networks. The cable will have a standard paper-core unit twin core over which is placed a helical lapping of aluminium foil coated on its outer face with a thin film of polythene. The polythene sheath is extruded over the foil, the heat of extrusion melting the polythene film and thus sticking the foil to the inside of the sheath. The aluminium foil forms an additional barrier against the penetration of water vapour through the sheath. All of these cables will have natural polythene sheaths, i.e. without carbon black.

During the financial year 1963–64 it is proposed to purchase 500 sheath-miles of the new cable in order that Telephone Areas may gain experience in its use. The cable will be jointed using expanding-plug joints with either lead or polythene sleeves. Generally, lead sleeves will be used where it is necessary to join existing lead cables to polythene-sheathed cables and at branch joints. Development work continues on jointing techniques, and when a suitable joint to replace the expanding-plug type is available it will be introduced.

Polythene-insulated-and-sheathed cable (Cable, Polythene, Unit Twin) remains experimental for the present, but it will be used for the termination of many of the polythene-sheathed paper-core cables ordered during 1963-64; also, where savings in cost are obvious, it will be used for tie-cables in exchange-transfer schemes.

Long-length cabling techniques, as described in the article referred to above, will be used where possible in order to reduce the number of joints required, and it is expected that considerable savings will be achieved in the overall cost of local-line development schemes. For the present, cable lengths will, in general, be limited to the maximum length that can be wound on an 84-inch drum, because of the difficulties of handling larger drums in Telephone Areas.

N.E.F. and R.H.H.

*HARRIS, R. H., and FLETCHER, N. E. Field Trials of Large Polythene Cables in Subscribers' Local-line Networks. (In this issue of the *P.O.E.E.J.*)

Introduction of International Subscriber Dialling from the London Director Area to Paris

J. V. MILES†

U.D.C. 621.395.374: 621.395.5

Telephone circuits using Signalling System A.C. No. 9 equipment which has been modified to interwork with the French national 1 v.f. signalling system provide subscribers in the London director area with the facility to dial their own calls to automatic-exchange subscribers available from a Paris trunk switching centre. This article describes the method of providing this facility, which has been made as an interim arrangement in advance of the introduction of international subscriber dialling from the United Kingdom to Europe, planned for 1964 using standard international signalling arrangements.

INTRODUCTION

THE basis on which the Signalling System A.C. No. 9[1] (S.S.A.C. No. 9) equipment used in London has been modified to interwork with the French national 1 v.f. equipment was agreed during preliminary discussions with the French Administration early in 1961. By that time, subscriber trunk dialling[2] (S.T.D.) had been provided for central London subscribers and the provision of circuits arranged to carry international subscriber dialled (I.S.D.) traffic[3] could be technically envisaged. While formal negotiations proceeded between the British Post Office and the French Administration the modifications which would be necessary to the S.S.A.C. No. 9 equipment were prepared.

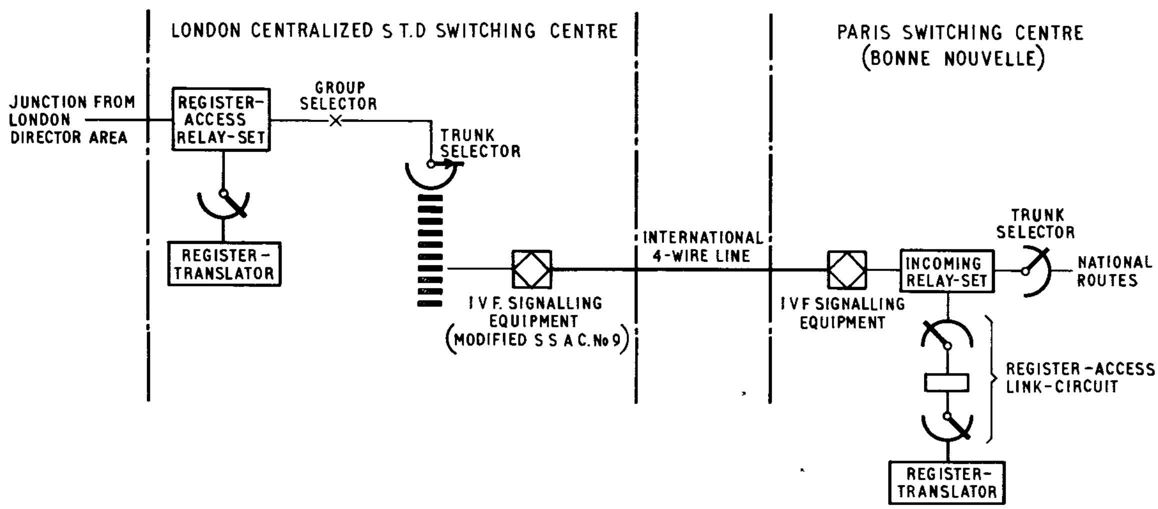
These new 1 v.f. circuits are capable of carrying a major proportion of the London–Paris traffic which, hitherto, has been handled by operators on a manually-controlled basis. Besides giving considerable relief to the Continental Exchange switchboard, it was thought that the provision of the facility whereby London director-area subscribers could dial automatic-exchange subscribers available from a Paris trunk switching centre would prove useful for the assessment of subscribers' reactions to I.S.D. during this interim period.

†Telephone Exchange Systems Development Branch, E.-in-C.'s Office.

THE INTERIM ROUTING ARRANGEMENTS

It was decided that the digital code to be used for gaining access to the 1 v.f. Paris route during the interim period would be 010 331. While the present trunking arrangements, shown in the figure, are entirely different from those to be provided later to meet the standard I.S.D. route-selection requirements, this dialling code for Paris is the same one that will be used with the standard I.S.D. arrangements, thus avoiding a change of code for the Paris route when the standard arrangements are introduced in 1964.

For a full complement of digits to be dialled for a call to Paris the digits 010 331 are followed by the code of the wanted exchange and the subscriber's number, e.g. for the Paris weather service Solférino 9739 the total digits dialled would be 010 331 SOL 9739. Of these digits the initial digit 0 is used in reaching the London



INTERIM TRUNKING ARRANGEMENTS AT THE TERMINAL SWITCHING CENTRES

centralized S.T.D. equipment and each of the remaining digits is received and stored by the S.T.D. equipment.

For metering purposes and route selection the S.T.D. equipment uses an expanded translation of the first four digits it has received, i.e. the digits 1033. Of these, the digits 10 indicate to the register that an international routing is required and the digits 33 are those of the country code for France. Following the metering digit, by which the charge to the caller is determined in the register-access relay-set, the routing digits resulting from the translation select the level from which the 1 v.f. circuits are trunked, and a modified S.S.A.C. No. 9 outgoing relay-set is seized from an outlet of this level. The modified S.S.A.C. No. 9 relay-set then seizes the distant 1 v.f. incoming equipment at the Paris switching centre (Bonne Nouvelle).

The London translator causes the S.T.D. register to omit sending the first five digits it has received and stored. Following the last routing digit, therefore, the register prepares to pulse out SOL 9739. This is the digital information received by the incoming register at the Bonne Nouvelle (Paris) switching centre and will complete the sending sequence. However, before the S.T.D. register pulses out SOL 9739 it provides one normal inter-digital pause of 830 ms followed by three long inter-digitial pauses each of 1,700 ms. Thus, following the two routing digits which the S.T.D. register pulses out to reach the modified 1 v.f. equipment, the S.T.D. register provides an extended pause of a nominal (830 + 3 × 1,700) ms, i.e. 5·93 seconds, before it pulses out the digits SOL 9739. The reason for the inclusion of this 5·93-second pulse in the pulsing-out sequence from the London S.T.D. register is explained below.

SIGNALLING ARRANGEMENTS USED ON THE 1 V.F. CIRCUITS

Interworking Requirements

Signalling System A.C. No. 9, which employs the signal code shown in Table 1, and the 1 v.f. signalling system which the French Administration uses for in-band signalling over its national network are similar in that they both use the single signalling frequency of 2,280 c/s for both line and digital signals. Furthermore, each system has the same signal sending level and complies with the C.C.I.T.T.* specification recommended for 1 v.f. signalling on international circuits.

TABLE 1
Signals Used by S.S.A.C. No. 9 System

Direction of Transmission	Signal	Duration of Signal Transmission (in ms)
Forward	Seizure	50–80
Forward	Pulsing	40–70
Backward	Answer	200–300
Backward	Clear back	200–300
Forward	Forward clear	700 minimum
Backward	Release guard	650 minimum
Backward	Backward busy	Continuous tone

TABLE 2
Signals Used by French 1 V.F. System and Used for Interim I.S.D. System

Direction of Transmission	Signal	Duration of Signal Transmission (in ms)
Forward	Seizure	80–120
Backward	Proceed to send	80–120
Forward	Pulsing	50/50
Backward	Answer	80–120
Backward	Clear back	100/250/100/250 (Note)
Forward	Forward clear	500 minimum
Backward	Backward busy	Continuous tone

Note: The clear-back signal in Table 2 is a continuous signal composed of 100 ms periods of tone alternating with 250 ms periods without tone. The transmission of the signal ceases if the call is re-answered.

For operation on routes switched nationally on a fully-automatic basis, the French system is designed to use a code of signals which provides for the inclusion of end-of-selection signals, that is (*a*) a v.f. signal which has the function of indicating that busy conditions have been encountered, and (b) a v.f. signal that is returned in the backward direction just prior to the connexion of ring tone when the called subscriber's circuit is free. These end-of-selection signals are not compatible with the signal code used by S.S.A.C. No. 9, but the French 1 v.f. system is readily adaptable for use where the receipt of the two line signals is not required. The French equipment with which the modified S.S.A.C. No. 9 equipment has been made to interwork uses the code of signals shown in Table 2.

Seizure Signal

As indicated in the tables, it has been necessary to increase the duration of the seizure signal transmitted by the London equipment. This has been achieved by using the outgoing-pulse corrector to add a controlled output pulse to the seizure signal, and to arrange this required no more than a minor wiring change.

Proceed-to-Send Signal

When the technical possibilities of interworking the two systems were discussed with the French P.T.T., on the basis that the S.S.A.C. No. 9 equipment would be modified to meet the requirements of the signalling code shown in Table 2, a most important consideration arose: the London equipment would receive a proceed-to-send signal, which it would have to avoid recognizing as an answer signal, when register association has taken place at the Paris switching centre. Taking account of the maximum time the French incoming equipment takes to associate with a register, the proceed-to-send signal would be received by the London outgoing equipment within a period normally not exceeding 2 seconds. The London S.T.D. register-translator was capable of being arranged to delay for a period in excess of 2 seconds the pulsing-out of the digits which are repeated over the 1 v.f. circuit. With the extended pause period that the S.T.D. register has been arranged to provide, i.e. 5·93 seconds as mentioned earlier, this problem was resolved by arranging that the modified S.S.A.C. No. 9 outgoing relay-set must receive the proceed-to-send signal before it can identify an answer signal.

Digital Signals

The duration of the pulse element of the digital signals sent by the London equipment is controlled by the outgoing-pulse corrector. The timing limits within the French equipment are such that it will recognize the pulse and gap elements of the digital signals without any change to the output from this pulse corrector, and the modification to S.S.A.C. No. 9 equipment has not, therefore, included any alteration to the pulse corrector.

Forward-Clear Signal

The timing limits imposed by the French equipment for recognition of the forward-clear signal have required no alteration to the controlling circuit for the forward-clear signal in the London equipment. The French 1 v.f. system is not designed for sequenced release guarding on clear down and, in consequence, a release-guard signal is not received from the French equipment. The

*C.C.I.T.T.—International Telegraph and Telephone Consultative Committee.

relays which normally provide the release-guard recognition timing in the standard S.S.A.C. No. 9 equipment have, therefore, been used to provide the release-guarding period required.

Clear-Back Signal

Cessation of the clear-back signal, shown in Table 2, constitutes a re-answer condition, and imitation of the clear-back signal by speech would therefore have to remain operative for the whole of the standard delay of 3–6 minutes which elapses before the forcible release of the forward connexion occurs on S.T.D. routes when the called subscriber is held by the calling subscriber. The protection which the continuous nature of the clear-back signal inherently affords against the effects of speech imitation in these circumstances is thus of an extremely high order. Incidentally, the equivalent forcible-release delay period on the French national network is 10 seconds.

GENERAL MODIFICATIONS TO S.S.A.C. NO. 9 OUTGOING RELAY-SET

With the exception of (*a*) the arrangements necessary to ensure that a proceed-to-send signal must be received before the circuit can identify the answer signal and (*b*) the registration facilities required for international call-accounting purposes, it has been found possible to reconcile the differences between the British and French national signalling systems solely by alterations to the S.S.A.C. No. 9 outgoing relay-set plate wiring and a change to one of the existing relays; it was necessary to change the backward-signal recognition-timing relay to meet the revised recognition-timing limits.

The arrangements for (*a*) above were provided most conveniently at the cost of two additional relays, which were fitted on the relay-set mounting-plate. The arrangements for (*b*) above required the provision of a third additional relay; this relay, which filled the last of the relay spaces on the relay-set mounting-plate, is necessary for the control of the meters which register the information required for call accounting.

All the changes made have been carried out without any modification to the standard S.S.A.C. No. 9 rack wiring and cabling. This was desirable as the equipment will subsequently be required in the standard S.S.A.C. No. 9 form.

RECORDING INFORMATION FOR INTERNATIONAL CALL ACCOUNTING

For the purpose of international call accounting two meters have been provided for each circuit. One of these meters, the effective-calls meter, ECM, is controlled from the modified S.S.A.C. No. 9 outgoing relay-set. On each call this meter operates when the answer signal is received and releases when the caller clears the connexion. The second meter, meter CTM, which is controlled by meter ECM, records the conversation time, or call-duration time, in 6-second units.

When the standard I.S.D. arrangements are introduced in 1964 this information and other traffic records will be obtained using electronic equipment having magnetic-drum stores.

CONCLUSION

I.S.D., in the first instance, must have the aim of relieving the Continental Exchange switchboard of its manually-controlled traffic and the need for such relief becomes more important as the international telephone traffic increases. Initially, 50 1 v.f. circuits in the direction London to Paris have been provided for the interim I.S.D. scheme.

Subscribers' reaction to the provision of a fully-automatic service for their international calls are not readily predictable, however, and this scheme provides an interim period during which it is hoped that useful information will be obtained.

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Book Review

"Fundamental Principles of Transistors," 2nd Edition. J. Evans, B.Sc., Ph.D., A.K.C. Heywood & Co., Ltd. xii+332 pp. 174 ill. 50s.

This is a painstaking revision of the 1st edition published in 1957. Constants in equations and tables relating to properties of semiconductors have, where necessary, been brought up to date, a number of graphs redrawn, and references have been revised and extended. Two new methods (photoconductive decay and surface photovoltage) of measuring the lifetime of minority charge carriers have been added, but it is unfortunate that the Valdes light-slit method had to be omitted. The discussions on Zener and avalanche breakdown of p–n junctions, and of the current gain and cut-off frequency of transistors, have been re-written with some useful clarification. A new section on the charge-control approach to the analysis of transistor-switching transients has been added, and the discussion of small-signal parameters now plunges straight into the h-parameters, with new inter-relationships given between these, the equivalent circuit parameters and the physical structure of the device.

A new chapter has been added on the diffused-base types of transistor and fabrication techniques have been revised. Unfortunately, although oxide masking is described for controlling the areas into which desired impurities are diffused into silicon, the planar structure, using the oxide to protect the sensitive edges of the p–n junctions in the final device, was announced just too late to be explicitly discussed in the book. For a similar reason only shadow masking is mentioned in connexion with the evaporation of electrode areas on to the emitter and base regions of diffused transistors.

New sections have been added covering other semiconductor materials than germanium and silicon, and other semiconductor devices than transistors. Nearly half of the original chapter on the point-contact transistor is still included as Appendix I, while Appendix II, containing makers' data on 10 commercial transistor types, has become a reminder of the rapid changes in fortune of some of their makers.

F.F.R.

An Improved Congestion Announcer

J. H. GEE†

U.D.C. 621.395.66:621.395.625.3

For subscriber trunk dialling short recorded announcements are used to inform callers if all circuits are engaged on the required route from a group switching centre. Equipment that has been developed for this purpose, using magnetic recording, is described.

INTRODUCTION

IN setting up calls on the mechanized trunk system, controlling operators were informed of congestion or the extent of delay at a switching point by an announcement connected automatically should all trunks on the appropriate forward route be engaged. The congestion and delay announcing equipment provided for this purpose was based on the use of glass-disk recordings scanned by photo-electric cells.[1]

For subscriber trunk dialling a simple congestion announcement of the form "Lines from (place name) are engaged, please try later" is required to be connected automatically at a group switching centre when congestion occurs there. While the glass-disk technique[2] could have been used in this application, magnetic recording has the advantages of superior reproduction quality and lower overall cost, and has therefore been adopted for a new congestion announcer known as Equipment, Announcer, No. 8A (Fig. 1).

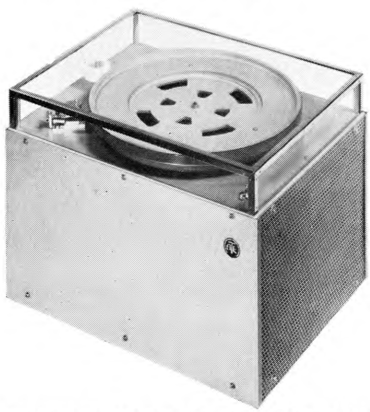

FIG. 1—CONGESTION ANNOUNCER (EQUIPMENT, ANNOUNCER, NO. 8A)

Although only two types of announcement are required at present, namely the congestion announcement for subscribers and an announcement for operators answering test calls set up by routiners on trunk circuits outgoing from selector levels to manual boards, the new equipment has capacity for four announcements to cater for possible future requirements.

The recording medium used (in the form of a band, as seen in Fig. 1) is neoprene impregnated with a magnetic oxide, this material having proved very satisfactory in an earlier experimental announcing machine designed at the Post Office Research Station.[3] The announcements are, in practice, first recorded on tape and then transferred to the neoprene band, using a unit specially developed for the purpose; reproduction is by means of conventional playback heads.

Each announcement is fed to the exchange equipment via a transistor-type pre-amplifier and a main distribution amplifier of the type used for speaking clock and information services,[4] the final output being at low impedance to ensure sensibly constant voltage under varying load and to prevent crosstalk between circuits simultaneously connected to an announcement.

ANNOUNCEMENTS

The announcement cycle produced by the machine is of 10 seconds duration, comprising a 5-second period, during which the announcement is made, followed by a 5-second period for tones that may be recorded later to meet international subscriber dialling requirements.

The period covering the congestion announcement is made up of 0·25 second silence, 3·5 seconds speech, 0·25 second silence and 1 second earth pulse, this pattern being similar to that provided by the glass-disk machine, to meet the conditions imposed by trunk circuits with voice-frequency signalling system S.S.A.C.1.[1] To prevent signal imitation, frequencies in the range 500–800 c/s must be attenuated by some 15 db when an announcement is connected to an S.S.A.C.1 circuit; a conventional filter network is included, as necessary, between the pre-amplifier and distribution amplifier to meet this requirement.

DESCRIPTION OF ANNOUNCING EQUIPMENT

Announcing Machine

The announcing machine shown in Fig. 1 is a playback unit only. It consists of a turntable that rotates at a speed of 6 revolutions/minute and is driven via a simple mechanical reduction unit from a mains-driven, single-phase, constant-speed motor, having a nominal speed of 1,500 revolutions/minute. The speed-reduction unit consists of a small-diameter sleeve, fitted to the motor shaft, that drives a large-diameter flywheel by its rim via an idler wheel fitted with a rubber tire.

The flywheel is balanced and rotates in a sleeve bearing; the lower end of the flywheel spindle rotates on a ball bearing to ensure freedom of rotation. The upper end of the spindle is extended through the top plate of the machine and a drive capstan made from synthetic-resin-bonded linen is fitted. This is held in contact with the inside rim of the turntable and so completes the drive. Tension is applied to both the idler wheel and the drive capstan by means of helical springs and, to prevent flats from forming on the rubber tire of the idler wheel when the machine is not in use, the mounting of the idler wheel is designed so that the wheel can be positioned out of contact.

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Fitted to the lower end of the turntable spindle is a cam which, by means of a spring-set, provides the nominal 1-second earth pulse once every 5 seconds.

The turntable carries a disk located by three studs placed so that a fixed reference point is maintained relative to the turntable. Around the periphery of the disk is the band of neoprene impregnated with magnetic oxide upon which announcements are recorded. To maintain the neoprene in a satisfactory condition and to reduce wear on the playback heads, the surface of the neoprene is lubricated using a felt pad moistened with a silicone fluid supplied from a reservoir.

The playback heads have a nominal impedance of 100 ohms at 1 kc/s and are provided in pairs mounted so that the heads for tracks 1 and 3 are together and tracks 2 and 4 are together. Separation of the heads in this way reduces crosstalk between them. A 3-point adjustment is provided for aligning the heads with the individual tracks.

The head mounts are designed so that uniform contact pressure is maintained between the playback heads and the neoprene during operation, but the heads can be placed out of contact when the machine is not in use.

Pre-amplifier

The four-stage transistor pre-amplifier (Fig. 2) is

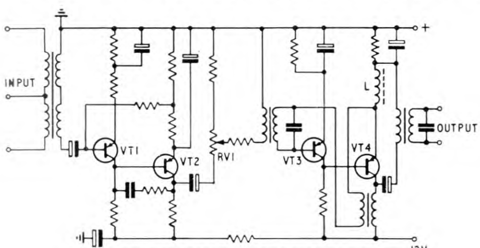


FIG. 2—CIRCUIT OF PRE-AMPLIFIER

designed to have a power gain of 75 db and a nominal output of 0·5 mW into 600 ohms.

The output from the playback head is connected to the amplifier via a 5:1 ratio transformer to match the head impedance to the first stage, which is operated with a low collector current and has an input impedance of approximately 3,000 ohms.

Collector–base feedback is provided in the second stage, by means of a capacitor and resistor in series, to equalize both the recording and the playback frequency responses at the lower frequencies. Treble boost is also necessary, but as its inclusion in the pre-amplifier circuit degrades the signal-to-noise ratio, the recording amplifier is designed to correct for the falling response at the higher frequencies.

The last two stages of the pre-amplifier form a 36 db fixed-gain amplifier having an input impedance of 6,800 ohms for all settings of potentiometer RV1; this potentiometer is included to provide 10 db of adjustment to the overall gain. Both voltage and current negative feedback is provided in the final stages. Fig. 3 shows a typical pre-amplifier output-level/frequency characteristic, assuming a constant input level.

The components are assembled on a printed-wiring board, and the unit is constructed to slide into a mounting on the rack and make connexion via a plug at the front of the unit and a socket on the rack. With the board in position the individual plug-and-socket contact points are bolted together. This special connecting

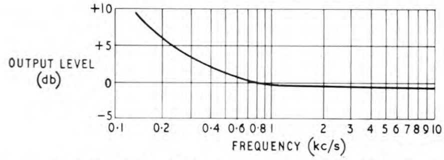


FIG. 3—OUTPUT-LEVEL/FREQUENCY CHARACTERISTIC OF PRE-AMPLIFIER

device was developed to ensure very low contact resistance in the connexions carrying the small alternating currents from the playback heads; at the same time the bolts secure the printed-wiring board to its mounting. A view of the pre-amplifier (Amplifier No. 147A) is shown in Fig. 4.

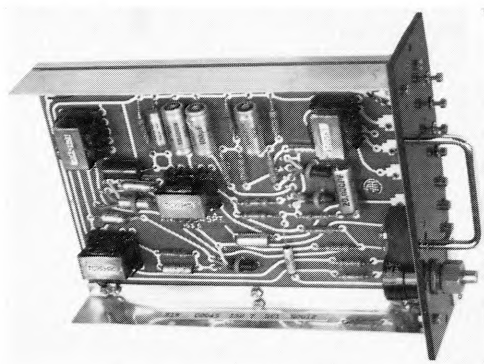
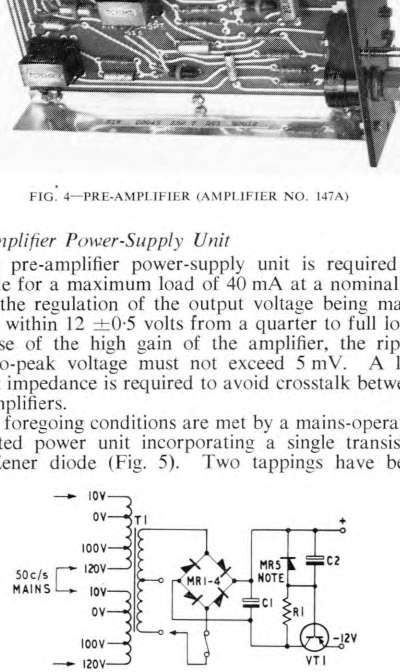


FIG. 4—PRE-AMPLIFIER (AMPLIFIER NO. 147A)

Pre-amplifier Power-Supply Unit

The pre-amplifier power-supply unit is required to provide for a maximum load of 40 mA at a nominal 12 volts, the regulation of the output voltage being maintained within 12 ±0·5 volts from a quarter to full load. Because of the high gain of the amplifier, the ripple peak-to-peak voltage must not exceed 5 mV. A low output impedance is required to avoid crosstalk between pre-amplifiers.

The foregoing conditions are met by a mains-operated regulated power unit incorporating a single transistor and Zener diode (Fig. 5). Two tappings have been



Note: Zener diode.
FIG. 5—CIRCUIT OF PRE-AMPLIFIER POWER-SUPPLY UNIT

provided on the secondary winding of transformer T1 so that the alternating voltage can be adjusted according to the measured turnover voltage of the Zener diode MR5. The germanium-diode bridge rectifiers MR1–MR4 have a low forward resistance and improve the regulation of the output to the stabilizer circuit.

Series regulation is provided by transistor VT1, bias being provided by resistor R1, which also limits the current through Zener diode MR5. Capacitor C2 lowers the ripple voltage across Zener diode MR5 and thus reduces still further the output ripple. The output impedance is also reduced by this capacitor.

Any tendency for the output voltage to vary, due either to an alteration of load or to a variation of mains voltage, is met by a change of voltage across the collector–emitter junction of the transistor of such a sense as to oppose this tendency.

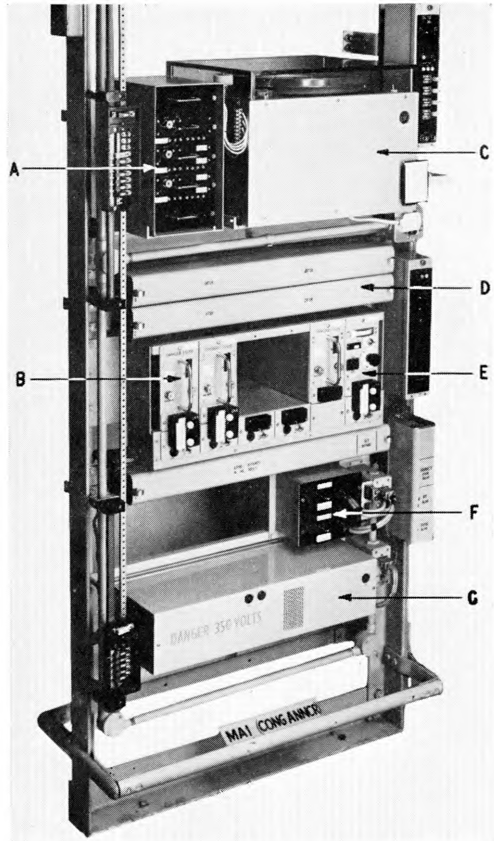
The power unit is constructed on a similar chassis to that of the pre-amplifier, the components being mounted on a printed-wiring board. To comply with safety regulations governing apparatus having voltages in excess of 150 volts r.m.s., the mains supply is taken via a shielded plug and flexible cable to the mains-switch unit.

For the mains transformer, advantage has been taken of the modern range of C-core types available to produce small cheap units of the required electrical specification.

Distribution Amplifier and Alarm Circuit

An outline of the distribution amplifier (Amplifier No. 116A) used with the congestion announcer has been given in a recent article,[4] but the following additional details of the alarm circuit may be of interest. Fig. 6 shows the circuit of the 2-stage amplifier with a double-triode valve, V3, arranged in the form of a trigger circuit to control the current through alarm relay A. The potential applied to grid 1 of this valve is the difference between that obtained from the integrating circuit, consisting of rectifiers MR1, MR2 and the associated resistors and capacitors, and from the potential-dividing network containing potentiometer RV2.

The alarm circuit is calibrated by connecting a reference signal to the input of the amplifier and adjusting its gain by means of RV1 so that the potential measured at point X is a known value. Potentiometer RV2 can then be adjusted so that the alarm relay will release for a fall in signal level greater than 10 db; the adjustment of potentiometer RV2 is sufficient to give a range of 15–40 seconds delay before the alarm relay will release. When the signal is reapplied at a level of −6 db, the reoperate time of the alarm relay is 4–10 seconds.



A—Pre-amplifiers.
B—Distribution amplifiers.
C—Announcing machine.
D—Filters.
E—Test panel.
F—Pre-amplifier power unit.
G—Distribution-amplifier power unit.

FIG. 7—CONGESTION-ANNOUNCER RACK

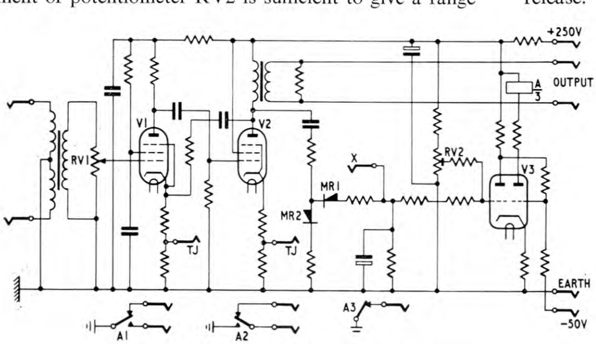


FIG. 6—CIRCUIT OF DISTRIBUTION AMPLIFIER

Congestion-Announcer Rack

The equipment is designed for mounting on a 2,000-type telephone exchange apparatus rack 2 ft 9 in. wide and 8 ft 6 in. or 10 ft 6 in. high, the items on a typical rack being as indicated in Fig. 7.

The test panel provides for measuring the mean level of the announcement, checking the cathode current of valves V1 and V2 (Fig. 6) of the distribution amplifiers, connecting power supplies and a test tone to a spare distribution amplifier for testing and setting up the alarm circuit, and checking the h.t. supply from the power units.

Alarm relays, supervisory lamps, keys and test points to monitor the announcement using a receiver are provided on the right-hand vertical.

DISTRIBUTION OF ANNOUNCEMENTS TO EXCHANGE EQUIPMENT

The congestion announcement is distributed to the exchange equipment either by access relay-sets connected to the overflow outlets of motor-uniselector group selectors or, if 2-motion selectors are used for trunk switching, via the tertiary winding of the A relay in place of busy tone. Under announcement-failure conditions the distribution circuit is arranged to transmit busy tone.

CONCLUSION

A prototype announcing machine has been on field trial since May 1961. It has been examined at regular intervals, and the only maintenance required has been the recharging of the lubricator with silicone fluid at 6-monthly intervals. No deterioration in the volume or quality of the announcement was observed and no visible evidence of wear on the surface of the neoprene or playback head could be seen. The drive was found to be in excellent condition.

ACKNOWLEDGEMENT

The announcing machine, pre-amplifier and power unit were developed in co-operation with the Automatic Telephone and Electric Co., Ltd., with whose permission the photographs of these equipments are reproduced.

References

[1]MANNING, D. J., and MITCHELL, F. J. H. The Congestion and Delay Announcer. *P.O.E.E.J.*, Vol. 47, p. 127, Oct. 1954.

[2]FORTY, A. J. A Photographic Technique of Sound Recording on Glass Discs. *P.O.E.E.J.*, Vol. 47, p. 19, Apr. 1954.

[3]FORTY, A. J., and JURY, R. J. An Experimental Announcing Machine for Information Services. *P.O.E.E.J.*, Vol. 50, p. 231, Jan. 1958.

[4]SMITH, G. L., and HUGGINS, G. Recording and Control of Information Services. *P.O.E.E.J.*, Vol. 55, p. 158, Oct. 1962.

Book Reviews

"A History of Electrical Engineering." P. Dunsheath, C.B.E., M.A., D.Sc., M.I.E.E. Faber and Faber. 368 pp. 119 ill. 50s.

The most noticeable thing about this book is its readability. This is no "whodunnit," and it would not be true to say that one simply cannot put it down without finishing it at one session—rather, one needs to take a moderate amount at a time, so densely packed is the information; but the author has so craftily composed his story that this is very far from being a tedious list of dates. Whereas, in some fields of technology, it may be roughly true to say that science came first, and engineering came later to put to practical use the discoveries of science, in the electrical world it is more nearly true that for the last 150 years the two have progressed together. This in itself helps to make a more interesting story, but the author goes further and shows also something of the personalities involved. Natural phenomena are objective but our knowledge of them is conditioned by our own minds which in turn are to some extent affected by the contemporary social climate. Thus, there have been famous disputes between great men which now appear almost to be absurd—a salutary reminder that some questions which today give rise to forcefully expressed disagreements may before long be regarded as having obvious solutions.

The book is well illustrated with 48 plates and 71 line drawings. The latter are simple, and therefore clear, and convey the essential information without unnecessary fuss. In a book of some 360 pages it is obviously impossible to treat all aspects in detail and the emphasis is, quite properly, on the earlier stages of development.

Unfortunately the parts of the book dealing with more recent developments show signs of hurried preparation for the press, though not all of the errors can be attributed to the printers. For example, it is said that squirrel-cage motors are widely used in vacuum cleaners but every owner of a television receiver will know that commutator motors are used. A diagram purporting to show biassing of the grid of a triode for bottom-bend detection shows no d.c. path to the grid. The diagram is correctly copied from Armstrong's paper of 1915 in the *Proceedings of the Institution of Radio Engineers* but it is not explained that Armstrong used a soft valve, or used a leaky capacitor with a hard valve. The Moullin valve-voltmeter is dated 1943 but it was in fact described in the *Journal of the Institution of Electrical Engineers* in 1930. There are also mistakes in spelling of names of inventors; it is to be hoped that these things will be corrected for a second edition.

At the end of the book there is a chapter on the social and historical background. This chapter has 13 pages only and it is a pity that it is not at least twice as long for it is equally as interesting as the other parts of the book dealing with purely technical developments. H.D.B.

"British Technology Index"—A Current Subject-Guide to Articles in British Technical Journals. Vol. 1, No. 1, January 1962, 70 pp. Published monthly by the Library Association. Annual subscription for 11 monthly issues and bound annual volume (in cumulative form) £15 15s. 0d.

On 15 February 1962 the first issue appeared of the British Technology Index, a useful subject-guide to articles appearing in some 400 British technical journals. The Index covers all branches of engineering and chemical technology, metallurgy, metal and wood manufacture, textiles, clothing, papermaking, packaging, works management, and also industrial economics of particular industries, industrial health and safety, and technical education. Entries are arranged in alphabetical subject order, with a liberal use of cross-references and related subject headings, and each title listed is followed by complete bibliographical details. The publishers regret that this first issue, which comprises approximately 62 pages of references to articles published during January 1962, contains appreciably less material than had been anticipated due to the fact that the receipt of 120 journals had been delayed by the postal dispute. One might expect each future issue to contain about 90 pages of references.

One of the most valuable features of the Index is that it will list articles within a month or so of original publication. The monthly issues, and especially the bound annual cumulation, should prove extremely useful in all libraries and information centres which handle engineering and technical enquiries, and should be particularly useful to small firms unable to afford a full-scale library service. It is hoped that the Index does not suffer the same fate as one or two other previous publications of a similar type.

D.C.G.

Transistor-Type 4-Wire Audio Equipment

L. J. BOLTON, B.Sc., A.M.I.E.E., and G. H. BENNETT†

U.D.C. 621.375.4 + 621.372.5:621.395.514

The advent of transistors, ferrite cores and modern light-weight forms of mechanical construction has made it possible to design a form of 4-wire audio equipment that is compact and versatile. Panels need not be supplied until required for traffic, thus reducing idle-plant costs and making for economical operation. Out-of-service time is reduced since it is possible to substitute spare panels whilst faulty ones are being repaired. For equivalent facilities the power consumption is less than 20 per cent of that for valve-operated equipment and only one power supply is required instead of two.

INTRODUCTION

BEFORE the employment of high-frequency systems became commonplace, trunk circuits were usually provided on a 4-wire basis, using loaded cable and audio-frequency amplifiers. Equipment required at a repeater station for the amplification of any circuit was brought into use as necessary by making the requisite connexions on the repeater-distribution frame (R.D.F.), the terminals of most items of equipment installed in the repeater station being cabled to terminals on this distribution frame.

Such an arrangement was attractive when the number of amplified circuits was small and amplifying equipment was expensive. Maximum flexibility of use was maintained and the cost of the internal cabling and of the terminals on the R.D.F. formed a relatively small part of the total cost of the amplifying equipment. However, the rapid growth of high-frequency systems has reduced the number of long audio circuits, and nowadays 4-wire audio-frequency amplified circuits are usually provided for short distances, e.g. up to 50 miles, on low-density traffic routes. In order that the cost per mile of such audio circuits should not be disproportionate to that of high-frequency routes, an inexpensive method of providing audio-frequency amplifying equipment has become necessary. The power economy resulting from the use of transistors and the flexibility provided by 51-type construction[1] have enabled this to be done.

DESIGN FEATURES

In order to achieve as much economy as possible, the following features were regarded as desirable.

(*a*) 51-type panels, which are capable of being inserted or withdrawn easily from their rack-side, would be employed. Each rack-side would be installed initially with its full complement of rack-side connexion strips, to which a certain amount of wiring, e.g. power-supply wiring, would be provided. Panels and rack-side-to-panel connectors would not be provided initially but stocks would be held centrally and items would be fitted as and when necessary for circuit provision.

(*b*) All the transmission wiring necessary for a fully-equipped rack-side would be provided at the time of installation of the rack-side. This cabling would terminate directly on to the rack-side connexion strips: connexion strips at the top of the rack-side would not be used.

(*c*) Two-unit panels (i.e. $3\frac{1}{2}$ in. deep), would be used and all apparatus needed for the amplification, and, if necessary, equalization, of one 4-wire circuit, whether through or terminal, would be accommodated on one panel. The number of wires per 4-wire circuit connected to the R.D.F. would, therefore, be fewer than for most previous types of equipment.

(*d*) It would be possible to accommodate a large number of different circuit arrangements. Commonly used assemblies, e.g. those necessary for amplification, equalization, impedance-matching to 20/88/1·136 cable*, and for using d.c. signalling over the phantom, would be stocked as completely-equipped 51-type panels. For other circuit arrangements required infrequently, uneconomic storing would be avoided by stocking 51-type 2-unit panels to which a certain amount of basic wiring had been added. Component items, e.g. amplifiers, equalizers, attenuators, etc., would also be stocked. Any required circuit arrangement could then be built up locally as required.

(*e*) The equipment would normally be battery operated. Space would, however, be left at the foot of the rack to accommodate a power-supply filter. For those rare occasions when mains operation was required, this space could be used to accommodate a mains unit.

DESCRIPTION OF RACK-SIDE

The rack-side, on which up to 24 audio transmission panels may be fitted, is 9 ft high and of 51-type construction. The rack-side (Equipment, Miscellaneous, No. 2B) includes the following items:

(*a*) Power-distribution area.

(*b*) Suitable rack-side connexion strips and power-distribution wiring to each current-consuming panel-position from the position occupied by the power-supply filter.

(*c*) A monitoring panel (Panel, Monitoring, No. 15B) incorporating a meter and switches that enable a monitoring potential developed by any amplifier to be measured, the necessary inter-panel wiring being provided as part of the equipment. The panel also includes alarm relays that extend a loop to operate the station alarm in the event of failure of the power supply to the rack-side.

(*d*) A 1-unit panel on which four test-circuits may be terminated.

The appearance of an Equipment, Miscellaneous, No. 2B equipped with 24 audio panels for through working is shown in Fig. 1(*a*). The rack-side wiring and mechanical construction can be seen in Fig. 1(*b*). It will be realized that any 2-unit type panel may be accommodated in place of any of the panels shown; it is only necessary to ensure uniformity of power-wiring connexions and to fix suitably engraved rack-side labels in place of those already fitted. This flexibility is a particularly valuable feature in small repeater stations, since it enables various types of panel to be fitted on one rack-side instead of the several separate racks that would have been necessary using earlier designs of equipment.

†Main Lines Development and Maintenance Branch, E.-in-C.'s Office.

*20 88 1·136 cable—cable having 20 lb/mile conductors loaded with 88 mH at intervals of 1·136 miles.

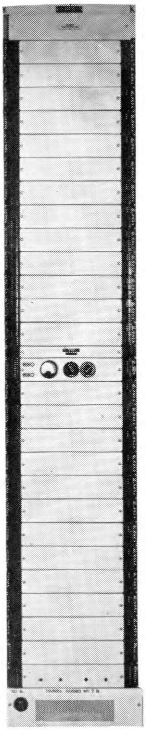


Fig. 1(*a*)

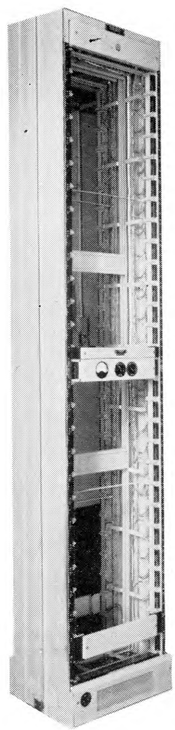


Fig. 1(*b*)

(*a*) Rack-side Equipped with 24 Audio Panels
(*b*) Rack-side without Panels, showing Wiring and Mechanical Construction

FIG. 1—EQUIPMENT, MISCELLANEOUS, NO. 2B

Where the initial requirement is for less than a fully-equipped rack-side it is now the practice to provide only those panels necessary and to fit additional panels as and when required. A worthwhile reduction of idle plant can be achieved in this way.

COMPONENT ITEMS

A complete range of the more common items of audio equipment have been developed specifically for fitting to 51-type panels, and these are described briefly in the following paragraphs.

Amplifier No. 121A

The Amplifier No. 121A is an audio-frequency amplifier having a gain of 30 db and input and output impedances of 600 ohms. It has been described in detail elsewhere.[2, 3] The amplifier employs two transistors in a "single-ended" circuit, direct coupling between transistors being employed. It meets in full the specification requirements of the Amplifier No. 32,[4] for many years the Post Office standard audio-frequency amplifier. Particularly noteworthy is the absence of electrolytic capacitors. Storage difficulties often associated with equipment containing such capacitors do not therefore arise. The amplifier is contained in a 51-type can 2 in. wide; the general construction can be seen in Fig. 2.

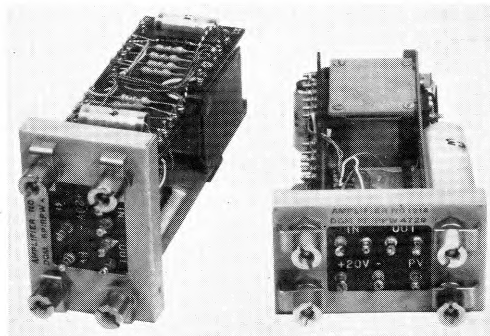


FIG. 2—AMPLIFIER NO. 121A

It has been found that Amplifiers No. 121A perform satisfactorily with power-supply voltages within the range 18–24 volts. As the supply varies, the gain and overload-level change as shown in Fig. 3 and 4. It will be seen that satisfactory results are obtainable with voltages higher than 24 volts. However, it is widely held that the lives of transistors are lengthened by keeping the temperature of the collector–base junction as low as

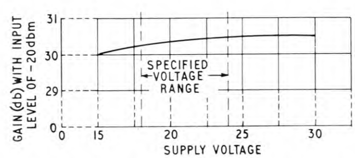


FIG. 3—GAIN/SUPPLY-VOLTAGE CHARACTERISTIC OF AMPLIFIER NO. 121A

possible. For this reason it is proposed that in normal circumstances these amplifiers should work with supply voltages between 18 and 24 volts but that no special measures should be taken to exclude the application of slightly higher (or lower) voltages that might arise, for relatively short periods of time, under exceptional conditions.

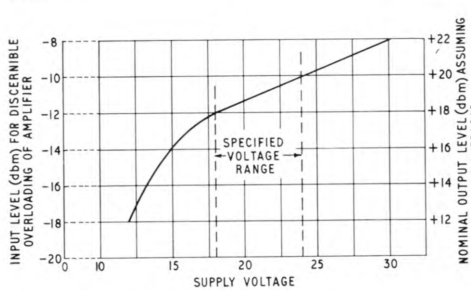


FIG. 4—OVERLOAD/SUPPLY-VOLTAGE CHARACTERISTIC OF AMPLIFIER NO. 121A

Equalizer No. 33A

The Equalizer No. 33A (Fig. 5) is of the shunt type and is electrically equivalent to Equalizer No. 9A, the

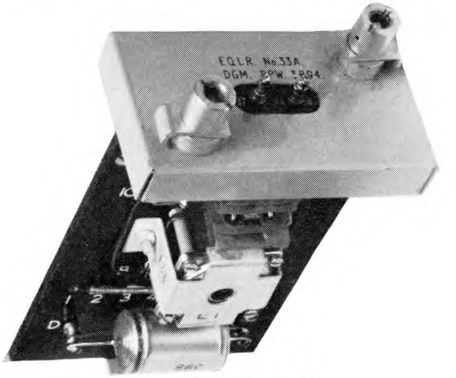


FIG. 5—EQUALIZER NO. 33A

pre-51-type Post Office standard. The new equalizer uses a ferrite-cored inductor, high-stability cracked-carbon resistors and a plastic-foil capacitor. The equalizer occupies a 2-unit can $1\frac{13}{16}$ in. wide. The limited area of the can lid would have made it difficult to adjust the equalizer if all the necessary tags had been fitted on the lid. It was therefore decided to fit only two terminals on the can lid and to carry out adjustment by appropriate strapping within the can. Since the panel has to be withdrawn from the rack-side in order to carry out the adjustment, it is desirable that a process of successive approximations be avoided in obtaining the desired characteristic. The tolerances on each component of the new equalizer have therefore been made closer than on the Equalizer No. 9A, so that a more uniform performance between production items is obtained. The required settings are determined by using a variable equalizer, i.e. one in which the connexions are made by operation of switches. Once the settings have been determined, similar connexions are made on the equalizer mounted on the panel and the required equalization characteristic obtained.

Equalizer No. 56A

More recently, as a result of the availability of still smaller components, it has become possible to design an equalizer on a mounting board 2·3 in. × 2·5 in. capable of fitting in the upper position on a 51-type panel. This has the additional advantage of having all adjustment tags easily accessible without removing the panel from the rack-side. This equalizer (Equalizer No. 56A) will be the future Post Office standard.

Transformer Unit No. 4 . . .

For nearly all applications in audio circuits an even number of transformers is required. In order to use the available space as efficiently as possible it has been found convenient to house two transformers of like ratio inside a 2-unit 51-type can $1\frac{13}{16}$ in. wide, connexions to the transformers being made via terminals mounted on the can lid. The voltage ratio of the two transformers forming such a unit (Transformer Unit No. 4 . . .) is indicated by a suffix letter. For convenience it has been arranged that the suffix letter has the same significance as when applied to the older-type Transformers No. 48 . . .

Transformer Units No. 4 . . . are often employed in circuits similar to that shown in Fig. 6. This makes it

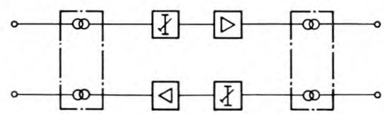


FIG. 6—ARRANGEMENT OF 4-WIRE THROUGH REPEATER

necessary to specify a high value of crosstalk attenuation between the component transformers. In one version this is achieved by the use of astatic windings. It is, however, possible to avoid this complexity by mounting the two components with their axes mutually at right angles.

The specification for each transformer in a Transformer Unit No. 4 . . . resembles that for a Transformer No. 48 . . . , but is more stringent in regard to amplitude frequency distortion and change of insertion loss with change of signal level. The superior performance is obtained by using nickel-iron instead of silicon-iron laminations.

Terminating Set No. 4A

The Terminating Set No. 4A comprises two audio-frequency transformers of 2:1 impedance ratio, two 1 μF paper tubular capacitors and one 600-ohm resistor. So far as is possible, a construction similar to that of Transformer Unit No. 4 . . . is adopted. Similar types of transformers are employed in both items. The mechanical differences are limited to the provision of the capacitors and resistor, fixing points for them, and a differently-designated tag panel on the can lid. The 600-ohm resistor contained within the can normally serves as a balance, but may be disconnected if it is required to substitute an external balance.

The performance of Terminating Set No. 4A is at least equal in all respects to the pre-51-type Post Office standard Unit, Terminating, No. 6B.

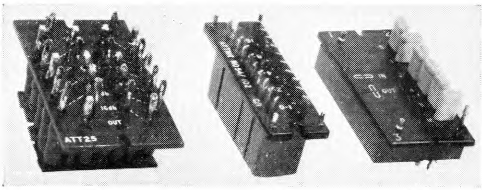
Attenuators

Attenuators No. 25. The Attenuator No. 25 is an assembly of 600-ohm balanced-pads of value 1, 2, 4, 8 and 16 db. Any or all of the pads may be brought into circuit by making the appropriate soldered connexions. The pads are constructed from high-stability cracked-carbon resistors, the employment of which has made it possible to mount the whole attenuator on a flat mounting plate $1\frac{1}{2}$ in. × $2\frac{17}{32}$ in. It is mounted in the upper position of a 2-unit 51-type panel. The performance is at least equal in all respects to that of the pre-51-type Post Office standard, Attenuator No. 4A.

Attenuator No. 54/102. Recently, a range of 600-ohm balanced pads contained within an encapsulation of resin has become available. This has enabled the same facilities as Attenuators No. 25 to be provided in less space and at the same time the attenuator is less susceptible to mechanical damage.

Attenuator No. 62/1A. Attenuator No. 54/102 and Attenuator No. 25 are adequate for many purposes, but for some applications it is necessary to be able to change the attenuation setting rapidly and in small increments. The problem is eased by adopting unbalanced structures and by using U-links to adjust the attenuation. Such an attenuator, adjustable from 0 to 31½ db in ½ db steps, has been coded Attenuator No. 62/1A. It is designed to be fitted in the same space as an Attenuator No. 25.

The three types of attenuator described are shown in Fig. 7.



(a) (b) (c)

(a) Attenuator No. 25 (b) Attenuator No. 54/102
(c) Attenuator No. 62/1A

FIG. 7—ATTENUATORS FOR USE ON 51-TYPE PANELS

POWER-SUPPLY ARRANGEMENTS

The low power consumption of transistor-type equipment has provided opportunity to increase the reliability of the network. It is now economically practicable to employ secondary-cell installations and so avoid the high cost and relatively poor reliability of no-break a.c. supplies.

For new repeater stations in which transistor-type audio equipment is to be installed a 12-cell battery will be provided. The voltage from this (measured at the input terminals of the transistor equipment) may have any value between 28·15 and 21·8 volts, depending on the state of charge and the length of feeder cabling etc., between the battery and the audio-equipment rack-side. Transistor-type audio equipment is designed to operate over the range 18–24 volts, but a low source impedance is necessary if coupling between units is to be avoided. One 2-unit panel (Panel, Filter, Suppression, No. 3B) is provided at the foot of each rack-side; into this space up to four filters to provide voltage adjustment and decoupling may be fitted as required. The circuit of such a filter (Filter, Suppression, No. 46B) is shown in Fig. 8.

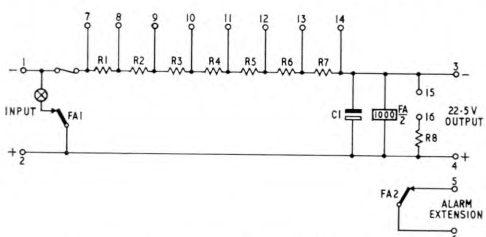


FIG. 8—CIRCUIT OF FILTER, SUPPRESSION, NO. 46B

The series resistors enable the voltage at the output to be pre-set as closely as possible to 22·5 volts, and the decoupling capacitance (1,000 μF) provides a low output impedance at all audio frequencies.

If the current drawn from the output of the Filter, Suppression, No. 46B is suddenly reduced, e.g. by some panels being removed from the rack-side, the voltage at the output will rise. With the input voltage at its maximum of 28·15 volts it is possible to remove at least 8 panels from the rack-side before the voltage applied to the remaining panels reaches 24 volts. If all the panels except one are removed from the rack-side the voltage applied to the remaining panel could approach 28 volts. From experience to date it appears that no damage will be done to the transistors. Since removal of a large number of panels from a rack-side is extremely unlikely to occur in practice, the arrangement is considered acceptable, especially since any other arrangement would involve heavy expenditure for voltage regulators on every current-consuming rack-side.

For a fully-equipped rack-side of 4-wire repeaters the total current consumption is about 0·8 amp and for this application only one Filter, Suppression, No. 46B is necessary. In general these filters are provided on the basis of one per 1 amp output current. Although it is thought that the majority of installations of transistor-type audio equipments will be of sufficient size to justify, economically, the provision of a separate power supply, it has been found desirable, in some circumstances, to work from other power supplies, e.g. the 24-volt supply in some existing repeater stations or a 50-volt telephone exchange battery. The former presents no problem, but when using a 50-volt supply care has to be taken to ensure that a voltage rise of such magnitude as to damage transistors does not occur if the rack-side current is suddenly decreased. It is possible that a transistor d.c.–d.c. converter to give 22·5 volts output from a 50-volt input may be suitable for use in such installations. Pending development of such an item, it is proposed to use a series dropping resistor and shunt decoupling capacitor. A relay winding in series with an avalanche diode is connected across the load terminals. Normally the diode will be non-conducting, but if the voltage rises sufficiently it will conduct and the relay will operate. Contacts of this relay connect a dummy load and thus protect the transistors. The unit, has been coded Panel, Filter, Suppression, No. 4A.

POSSIBLE FUTURE DEVELOPMENTS

The audio equipment so far described has been developed using 51-type equipment on the basis of providing all the apparatus necessary for amplifying and equalizing one 4-wire circuit on one 2-unit 51-type panel. The cost of a 51-type panel and the proportionate rack-side are such as to form an appreciable fraction of the total price of an audio panel. There is more to be saved by reducing this "metalwork" cost than appears possible by economies in the circuit design of the items of transmission equipment. The possibility of fitting all apparatus necessary for amplifying and equalizing two 4-wire circuits on to the 2-unit 51-type panel has been investigated and proved possible, but the final design has not yet been completed.

CONCLUSION

The 4-wire transistor-type audio equipment described embodies a larger number of new features than usually accompanies a redesign. This was necessary if full advantage was to be taken of the possibilities afforded by transistors, ferrite-cored inductors and 51-type practice. In addition to being smaller and less power-consuming, and possessing the convenience of only one low-voltage power supply instead of the two required for valves, it is hoped that the equipment will prove to be cheaper to manufacture and install, more easily maintained and have a lower fault liability than any earlier type.

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Preservation of Cable Drums

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U.D.C. 674.04:621.315.292

The effects of decay on timber are described, and from the results of an investigation of samples of timber from damaged cable drums it is concluded that a more thorough preservative treatment is economically justified.

INTRODUCTION

THE life of a cable drum is, to a large extent, dependent on the mechanical strength of the timber used in its construction. The mechanical properties of timber are impaired by decay, and, until the work described in this article was completed, it was not known how large a proportion of cable-drum timber that had failed in service was infected with decay. In general it had been assumed that, as a result of the rough handling of cable drums, the chief cause of failures was the mechanical damage of sound timber. It had accordingly been thought that the cost of a thorough treatment against decay, which would involve impregnation under pressure with a suitable preservative, was not economically justified. Cable drums were therefore treated against decay by the cheaper but only partially effective method of dipping the timber in creosote.

DECAY OF TIMBER

Decay of timber is caused by certain fungi that are capable of breaking down the complex constituents of wood into more simple substances. The most familiar types of decay in wood are due to fungi that cause brown and white rots. Brown-rot fungi attack the cellulose in wood, leaving a brown residue consisting mainly of lignin; white-rot fungi attack both cellulose and lignin leaving a white residue. Another common type of decay, known as soft rot, is caused by microfungi that decompose the highly-lignified cell walls of wood.

Other fungi that are not able to decompose the main constituents of wood but use simpler carbohydrates for their nutrition also grow in wood. They often cause staining in sapwood, such as the blue stain of coniferous timbers. If present in excess, sapstain fungi cause some reduction in the strength of timber, especially in its resistance to shock.

Fungal attack will only proceed in wood that is permanently or intermittently damp, and is most likely to occur in timber when out of doors, especially if it is embedded in, or in contact with, the ground. As decay proceeds, the weight and mechanical strength of the affected wood decrease and, when it reaches an advanced stage, the change in appearance and the weakening of the wood are obvious from a superficial examination. In the early stages of decay, however, there may be little or no outward signs of deterioration although the strength of the wood may have been seriously impaired. For example, the impact strength of timber may in fact be reduced by 50 per cent when the loss in weight of the wood is as small as 5 per cent, although at this stage the degradation is not obvious to the naked eye and the outward appearance of the wood remains normal.

The significance of these facts in cable-drum performance is obvious, and an investigation was therefore carried out to determine the proportion of failed cable-drum timber that was infected with decay either in the visible or in the incipient stage.

Detection of Incipient Decay

The early stages of decay can only be detected by the microscopic examination of very thin sections of wood. The photographs show photomicrographs of such sections illustrating the appearance of wood infected with various types of fungi. The type of mycelium of fungi producing brown and white rots is illustrated in (*a*), and a typical sapstain fungus is shown in (*b*). The result of attack by a soft-rot fungus is shown in (*c*); the fungus itself is not visible, but the numerous bore-holes in the cell walls completely alter the microscopic appearance of the wood. A section through sound wood is illustrated in (*d*) for comparison with (*c*).

EXAMINATION OF CABLE-DRUM TIMBER

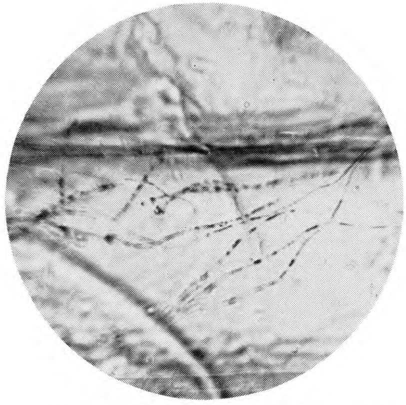
A sample of damaged timber from each cable drum repaired at the Kidbrooke and Birmingham depots during a period of one month was used for the investigation. Initially the samples were examined for the presence of visible decay. A proportion of the remaining samples was then examined microscopically for incipient decay and excessive sapstain.

Of the samples, 25 per cent were found to be visibly decayed, and the microscopic examination revealed some degree of decay or excessive sapstain in a further 30 per cent, giving a total of 55 per cent of infected samples. The figure quoted for incipient decay may be regarded as a minimum, as this defect is difficult to detect.

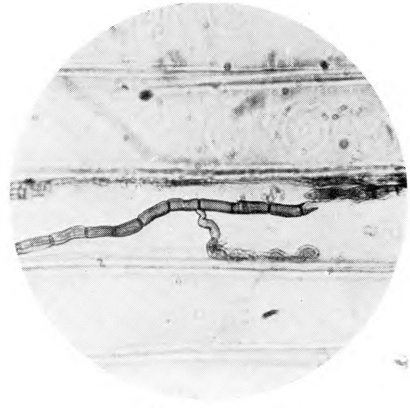
CONCLUSION

It was apparent from the investigation that decay in cable-drum timber is more widespread than is generally realized, and although decay may not always be

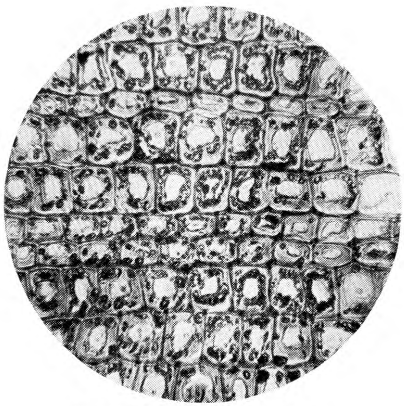
†Test and Inspection Branch, E.-in-C.'s Office.



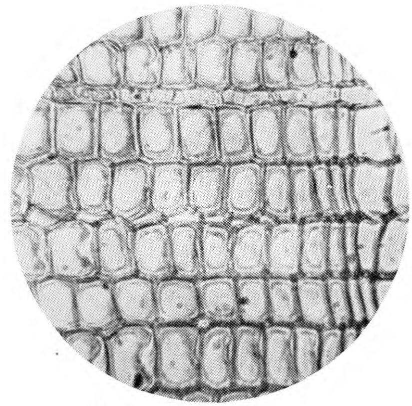
(*a*) Mycelium of Fungi producing Brown and White Rot.



(*b*) Typical Sapstain Fungus.



(*c*) Result of Attack by Soft-Rot Fungus.



(*d*) Section of Sound Wood.

PHOTOMICROGRAPHS OF THIN SECTIONS OF WOOD

directly responsible for cable-drum failures it will always be a contributing factor. The cost of treating cable drums with wood preservative by a pressure impregnating process is approximately 6 per cent of the cost of the cable drum. This slight increase in cost seemed well justified in view of the amount of decay detected. As a result an amended specification has been issued which calls for all cable drums to be pressure-treated with either creosote or certain water-borne preservatives.

Book Received

"Solution of Problems in Telecommunications and Electronics." Second Edition. C. S. Henson, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E. Sir Isaac Pitman & Sons, Ltd. xi + 330 pp. 167 ill. 27s. 6d.

The problems collected in this book have been taken from examination papers of the University of London and The Institution of Electrical Engineers, with some original problems added. Each chapter contains three sections: some theoretical work, a number of fully-worked-out examples of typical problems, and problems together with numerical answers for the student to solve. The theoretical work consists of brief notes covering one or two aspects of the chapter subject-matter only, but references are made to text-books which will assist the student.

In this new edition many additional problems from recent examinations have been included; there are now more than 250 problems for which answers are provided and over 50 fully-worked-out examples. The scope of the book has also been widened by the addition of new material covering the motion of electrons, rectifiers, operational amplifiers and waveform generators, servomechanisms, and transistors.

The Use of Magnetic Cores in Logical and Memory Circuits

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U.D.C. 621.3.042.1:621.395.659 + 621.374.5

Some of the techniques of magnetic-core switching, which are being introduced into telephone exchanges, are described together with an introduction to the design of circuit-elements and the practical application of different types and sizes of cores.

INTRODUCTION

TELEPHONE exchanges have a basic need for large-scale storage and switching processes. Until recently these were performed by electromechanical means but various electronic methods have now been proposed instead. One of these methods uses rectangular (or nearly rectangular) hysteresis-loop magnetic cores[1] in conjunction with transistors, and for this method the following advantages are claimed:

(*a*) Core logic can be achieved with very low power consumption.

(*b*) The magnetic core (including the ferrite type) is proving to be a very reliable component with long-life expectancy.

(*c*) Rectangular-loop cores have a definite operating threshold and can operate with low-impedance circuits, so that they are relatively immune from interference surges and are suitable for installation alongside electromechanical equipment.

(*d*) The speed of operation of cores is fairly fast with switching times of a few microseconds so that time sharing of logic and switching circuits is possible.

RECTANGULAR-LOOP MAGNETIC CORES

Symbols

H = Magnetizing force, in ampere-turns per metre
H_m = Magnetizing force required to produce magnetic saturation
H_s = Magnetizing force used in practice to switch a core, chosen so that $H_s/2$ does not switch a core
H_c = Coercive force
B = Flux density, in webers per square metre
B_m = Maximum flux density
B_r = Remanent flux density
Φ = Flux, in webers
I = Current in amperes
I_m = Current, through a particular coil, required to produce H_m
I_s = Current, through a particular coil, required to produce H_s
N = Number of turns on a particular coil
A = Cross-sectional area of a core, in square metres
L = Mean length of magnetic path, in metres

Shape of Hysteresis Loop

The behaviour of a magnetic material under the influence of a varying magnetizing force is often deduced from the corresponding hysteresis loop. Fig. 1 shows the shape of such a loop for materials which might be used for transformer cores where a smooth response is desired and saturation is avoided, e.g. soft iron and some ferrites. For application in logic-circuit elements of the type under consideration here, it is necessary for the

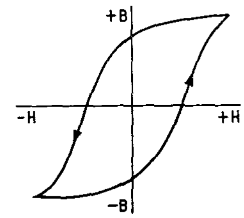


FIG. 1—TYPICAL HYSTERESIS LOOP FOR TRANSFORMER CORE MATERIALS

hysteresis loop to have discontinuities (known as knees) in both directions of magnetization, as indicated ideally in Fig. 2. Characteristics approximating to this ideal can be obtained in several ways, two examples of which are as follows.

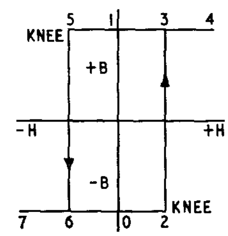
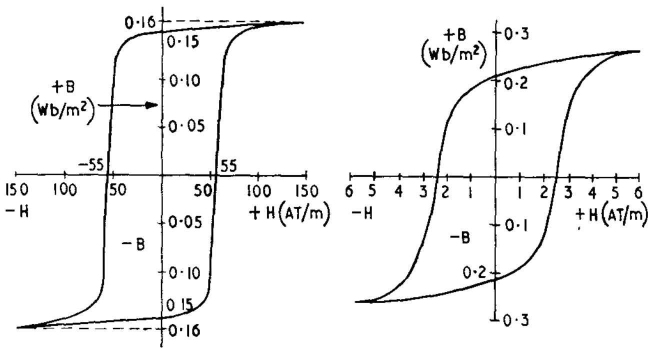


FIG. 2—HYSTERESIS LOOP FOR IDEAL RECTANGULAR-LOOP MATERIAL

(*a*) A ferrite powder is prepared from an accurately proportioned compound of manganese, magnesium and iron oxides and, after suitable heat treatment in a mould, the core so formed has a hysteresis loop shaped as shown in Fig. 3(*a*).



(*a*) (*b*)

FIG. 3—HYSTERESIS LOOPS FOR FERRITE AND METAL-TAPE CORES

(*b*) A molybdenum-permalloy billet, produced by a powder-metallurgy process, is rolled along its length until it attains a thickness of about 0·001 in. This causes the grains of the metal to become long and thin so that the tape is easier to magnetize along the direction of rolling than across the tape; the process is known as grain orientation and the effect as magnetic anisotropy. The tape is wound spirally on a ceramic former and, after

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heat treatment in a magnetic field, the core so formed has a hysteresis loop as shown in Fig. 3(*b*).

Both methods of construction are used to produce cores in their more usual form of a ring on which toroidal coils can be wound. This shape is particularly able to maintain a magnetic field circumferentially since magnetization takes place most readily along the greatest dimension of any hole in the material. Any tendency of the core to demagnetize is resisted by the formation of what are known as "free poles," i.e. opposite poles produced on the surfaces when the magnetic field becomes no longer circumferential.

A core may be operated so that the magnetic flux is always changed from saturation in one direction to saturation in the other, but it is often necessary to use values of magnetizing force H other than those which cause maximum flux density. For example, it may be required to choose a value of magnetizing force, H_s, that definitely switches the core, but is of such a magnitude that half this value, $H_s/2$, does not switch the core. The choice depends on the tolerances permissible to both H_s and $H_s/2$, to the slope of the hysteresis curve near the knee, and to the switching time desired. Consider a core with a hysteresis loop, shown partly in Fig 4, where the core

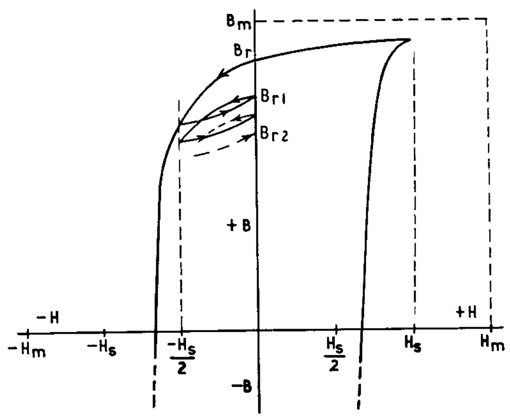


FIG. 4—MINOR HYSTERESIS LOOPS

magnetization is changed from $+H_s$ to $-H_s/2$ and then alternates between $-H_s/2$ and 0. The path of operation does not traverse the main hysteresis loop but forms a series of minor loops, as shown in Fig. 4. With the ideal characteristic of Fig. 2 this would make no difference, but in the practical case a gradually decreasing value of remanent flux density, B_r, results. Fortunately, each successive reduction of B_r is only half the preceding reduction, so that the total reduction for many cycles does not exceed twice the reduction due to the first cycle. If the value of B_r at the first reduction is B_{r1} and the lowest value is B_{r2}, then $B_{r2} = B_r - 2(B_r - B_{r1}) = 2B_{r1} - B_r$. A measure of this value, and hence of the usefulness of a core, is obtained from the squareness ratio, R_s, which is defined as,

$$R_s = \frac{\text{Value of } B \text{ at } - H_m/2}{\text{Value of } B \text{ at } H_m}.$$

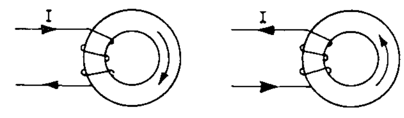
The hysteresis loop of cores, especially of ferrite types, is affected by temperature. Generally speaking, a higher temperature causes a decrease in the coercive force and reduces the squareness ratio, thus making the core more susceptible to changes in $H_m/2$. Methods of combating this effect are outlined in a later paragraph.

CORES IN LOGICAL-CIRCUIT ELEMENTS

Memory Function

The ideal characteristic of Fig. 2 indicates that a core has two stable states, given by points 0 and 1, in which there is a large remanent magnetic field in one direction or the other. These two stable states can be used in the following manner to provide a memory of the last stimulation applied to the core.

Current is passed through a winding on the core in a particular direction, producing a magnetizing force H which causes a flux to pass through the core as shown in Fig. 5(*a*). If H is made sufficiently large, saturation will occur and the point 4 of Fig. 2 is reached. On removal



(*a*) (*b*)
FIG. 5—MAGNETIZATION OF A CORE

of the current, H is reduced to zero but the flux density remains constant, at the value indicated at point 1. Thus, although the stimulus has ceased, the core remembers indefinitely that one has occurred and the direction of the field indicates the sense of the original input. Subsequently, another pulse of current can be applied, either through the same winding or through another winding on the same core. This second pulse must be either in the same or in the opposite sense to the first pulse, the effect being completely different in the two instances:

(*a*) *Current Pulse in the Same Sense.* The operating point moves from point 1 towards point 4 and back. In the ideal case there is no change in flux density but, in practice, the flux density increases slightly during the pulse and then decreases slightly after the pulse.

(*b*) *Current Pulse in the Opposite Sense.* Assuming that the pulse is sufficiently large, the operating point moves from point 1, through points 5 and 6 to point 7 during the current pulse, then back via point 6 to point 0. The direction of magnetization has reversed, as shown in Fig. 5(*b*), so that a large change in the flux has occurred. The core now remembers the sense of the last input; it no longer indicates the sense of any pulses before that, i.e. all previous information has been destroyed.

If another winding is wound on the core it can be used to detect when a change of flux takes place, since any flux change will produce an e.m.f., e, such that

$$e = \frac{N\,d\Phi}{dt},$$

where N is the number of turns of the winding, and Φ webers is the instantaneous flux. It should be noted that a proportionate e.m.f. is also induced in all other windings on the core. For (*a*) above the small change in flux produces only a small e.m.f., but for (*b*) the large and rapid change of flux can generate e.m.f.s of the order of ½ volt per turn. The polarity of the e.m.f. depends upon the direction of switching and the convention chosen, e.g. a positive e.m.f. for a transition from point 0 to point 4, and a negative e.m.f. for a transition from point 1 to 7. In order to identify the two states of the core it is usual to designate one of them as the "switched," "set," or "1" state, and the other as the "normal," "reset," or "0" state. The particular convention for any system has always to be defined since the operation of the cores is quite symmetrical.

One way of using the memory property of the core is to have two series of pulses, A and B: the A pulses contain the information to be stored and so can occur in various patterns, while the B pulses are used for interrogating the cores and usually occur at regular intervals. An A pulse sets the core and is always followed by a B pulse in the opposite direction, which resets it causing a large e.m.f. output. Should the core be in the reset state when a B pulse arrives, the field is changed very little so that a small e.m.f. results. When a B pulse is followed by an A pulse, a large e.m.f. is again induced but with the opposite polarity, permitting ready distinction. Fig. 6 illustrates

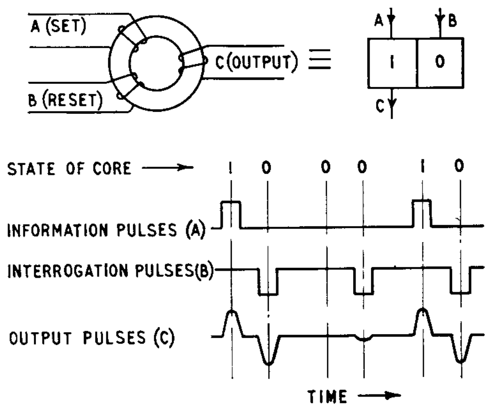


FIG. 6—CORE USED AS MEMORY DEVICE

the various conditions possible, and also shows the symbol which is used as a form of shorthand in logic diagrams so that the core and its circuit need not be drawn in full.

To summarize, a toroidal core with one or more windings can be used as a memory of one of two possible states. In order to discover which state is stored, it is usual to apply a resetting signal and so destroy the information—a process known as destructive readout. Non-destructive readout techniques,[2] whereby the state of the core remains virtually unaltered after interrogation, are possible but are not in general use since multi-aperture devices are preferable for such applications.[3]

AND *Function*

Very often it is required to perform an operation as a result of the coincidence of two or more signals—such action is known as an "AND function." This function can be performed readily with the aid of a rectangular-loop magnetic core. Fig. 7 shows such an arrangement, where two signals, one in winding X and the other in winding Y, are required to coincide before an output pulse, C, can be given. The output pulse may be obtained immediately on receipt of the simultaneous pulses or it may be delayed by using the memory function just described and interrogating with a resetting pulse later: the former method is outlined here for simplicity. Also shown in Fig. 7 is the symbol used for a circuit performing an AND function; the circle represents a "gate" which can regulate the passage of signals, and the number inside the gate indicates the number of inputs that must be present before an output is permitted.

Considering a core with ideal characteristics and assuming the core is in its reset state (point 0), then with the application of a magnetizing force, e.g. by a current in winding X, not quite sufficient to take the core to

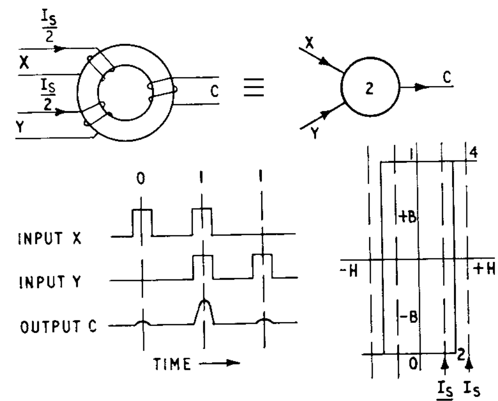


FIG. 7—CORE USED AS *AND* GATE

point 2, there will be no major flux change. If now the magnetizing force is increased by a contribution from a current on another winding in the core, e.g. winding Y, then the core state will change towards point 4, giving a large flux change which can be detected by the resultant e.m.f. in output winding C. Only on coincidence of the two magnetizing forces will this e.m.f. be detected; hence the arrangement provides an AND function. In practice, if a current I_s is just sufficient to switch the core, then the AND function can be provided by limiting the current in each of two similar control windings to $I_s/2$, so that coincidence of the two currents will cause the core to experience the effect of $I_s/2 + I_s/2 = I_s$, and the core will switch.

This method of operation is quite satisfactory if close control is kept of all the circuit parameters, i.e. of the rectangular-loop material, the number of turns, and the current amplitudes, but precautions are necessary if large variations of temperature are expected. With the reduction in size of the hysteresis loop as the temperature rises, a higher temperature might allow a current of $I_s/2$ to switch the core. Two of the methods which can be used to overcome this difficulty are:

(*a*) The automatic reduction of the value of $I_s/2$ as the temperature increases, which can be done quite readily by the insertion of a temperature-sensitive device, such as a thermistor, in the core driving circuit.

(*b*) The addition of a third winding carrying a steady bias current of $-I_s/3$ and the increase of the two control currents to $2I_s/3$ each, where I_s is the current value required to set the core at the lowest temperature with adverse tolerances. As shown in Fig. 8, switching is

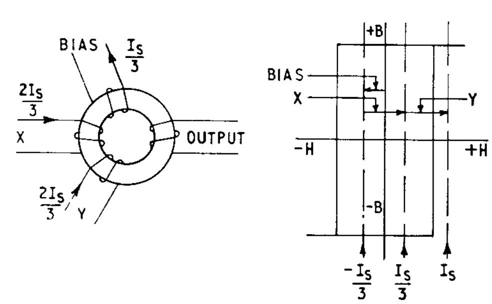


FIG. 8—*AND* GATE WITH TEMPERATURE COMPENSATION

obtained with a total current of $2I_s/3 + 2I_s/3 - I_s/3 = I_s$. With only one input, the total current $= 2I_s/3 - I_s/3 = I_s/3$, which is less than $I_s/2$. The margin has therefore been improved from 2 : 1 to 3 : 1 for both a temperature change and other variable factors.

Extension of the method to give an AND gate suitable for more than two inputs is possible but the tolerances become much more stringent, and it is usually preferred to perform the function by a series of 2-input AND gates or with the aid of multi-aperture devices.

It should be noted that all core gates give an automatic memory, so that once they have been set a resetting pulse has to be applied before the logical function can be used again.

OR *Function*

Complementary to the AND-function gate is one with an "OR function," i.e. a gate which gives an output when any one (or more) of the inputs is applied (see Fig. 9).

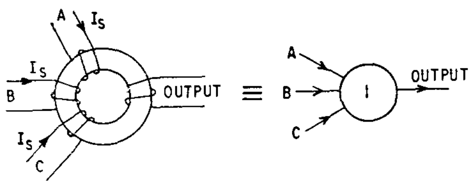


FIG. 9—CORE USED AS *OR* GATE

No bias winding is necessary and each input must be sufficient by itself to switch the core. Since every winding on the core has an e.m.f. generated in it when the core switches, diodes are sometimes inserted in the input leads to prevent information being passed backwards to preceding circuits and to avoid damping the switching of the core.

Negatory Input

Normally, the input circuit to a gate is arranged so that the presence of a signal on the input is one of the requirements for an output signal to be produced. Sometimes, however, it is more convenient for the absence of an input signal to be the controlling factor. Fig. 10 shows

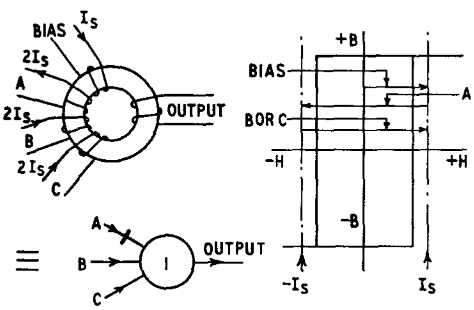


FIG. 10—*OR* GATE WITH NEGATORY INPUT

an OR gate requiring an input which can be either the presence of a signal on one of two leads or the absence of a signal on the third lead (in the symbol the third lead is indicated as the input with the short crossing line). This can be effected by having a bias winding giving NI_s ampere-turns, the negatory input winding normally giving $-2NI_s$ ampere-turns, and either of the other two windings giving $2NI_s$ ampere-turns when energized. Thus, a change in any one of the input-winding signals gives an output signal.

Inhibit Input

It is sometimes required that one input shall have overriding control of a gate, so that when that input is present no output is possible. Such an input has an inhibiting function, and the input concerned is denoted by a small circle on the input lead of the gate symbol, as shown in Fig. 11. The function can be performed by

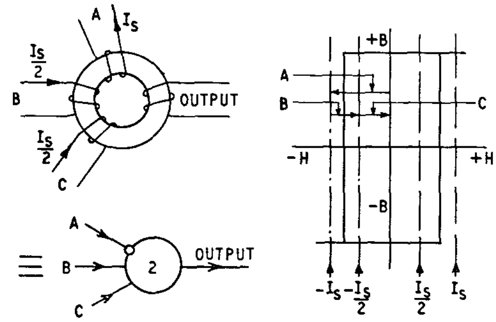


FIG. 11—*AND* GATE WITH INHIBIT INPUT

passing through the particular winding a bias current sufficiently large to prevent switching by any or all of the other windings, e.g. if there are two normal inputs which each give $NI_s/2$ ampere-turns, then an inhibit bias of $-NI_s$ ampere-turns is effective.

Negatory Inhibit Input

The inhibit function may be combined with the negatory to give the negatory inhibit input. The gate is then completely inoperative until that particular input is present. Again, an appropriate bias value would be used.

READING-OUT INFORMATION STORED IN A CORE

As already explained, an output indicating the previous state of the core can always be obtained by applying a pulse of appropriate polarity to one of the input windings. The relationship between the output signal, the core-switching process and the input pulse will now be considered, and the very important and related factor of switching time will also be discussed.

Use is made of the terms "reversible" and "irreversible" flux changes. The former term refers to those changes which exist only while the magnetizing force is present and correspond with those found in a simple transformer. The irreversible flux changes are those which remain after the force causing them has been removed, so that they can be nullified only by the further application of energy, e.g. magnetic or heat energy. The two effects can occur simultaneously or may be sequential, with an overlap in time, as described below.

Consider when a pulse from a constant-voltage source, i.e. one with low impedance, is applied to one winding of a core, as in Fig. 12(*a*). The inductive reactance of the coil delays the rise and fall of the corresponding current pulse. A magnetic field is induced in the core in various stages and the rate of change of this field determines the e.m.f. generated in the second coil (see Fig. 12(*b*)). During the first stage, from A to B, mainly reversible flux changes occur[4] and a pulse of e.m.f. is induced, its amplitude being governed by the rise time of the current. However, the duration of this pulse is short and there is only a small area under the e.m.f. curve between A and B, indicating that little change of magnetization is involved. An irreversible magnetization change now takes place

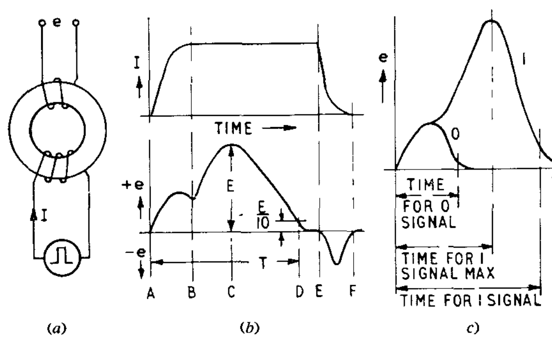


FIG. 12—PULSE OPERATION OF CORE

(the core switches), resulting in an induced e.m.f. that forms the main portion of the e.m.f. curve, with a peak value E at point C. The total area under the e.m.f. curve is governed by the energy available, which in turn is dependent upon the magnitude of the current pulse (up to core saturation point). Since the maximum e.m.f. generated varies with the speed at which the field is established, the duration and shape of the e.m.f. pulse also depend upon the amplitude of the current pulse. The time between the application of the input and the reduction of e to 10 per cent of its maximum value E is known as the switching time T of the core for the particular circumstances under consideration, and is given by the time between points A and D in the diagram. The final pulse, from E to F, is due to the restoration of the small reversible flux changes to their previous state on disconnexion of the driving pulse.

Provided that the core is saturated for each operation, it can be shown that the switching time is inversely proportional to the applied magnetizing force, a typical graph being given in Fig. 13. The graph can be extended theoretically (but not practically) to cut the H-axis at some value of H known as H_0. It is found that H_0 is

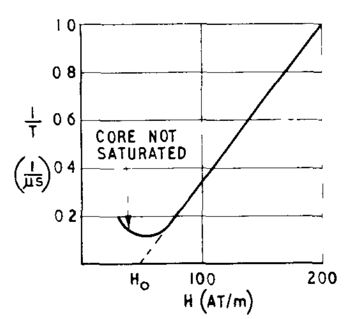


FIG. 13—RELATIONSHIP OF SWITCHING TIME TO MAGNETIZING FORCE

approximately equal to H_c, the coercive force, and so represents the minimum force needed to switch the core. The equation of the curve is of the form $1/T = H/S - H_0/S$, or $T(H - H_0) = S$, where S is a constant known as the switching coefficient. For minimum switching power it is obviously desirable to use minimum H, i.e. H_0, but for maximum speed H should be as large as possible. In practice, where half-current operation is not required, a compromise value of $H = 2H_0$ is often chosen as the working value.

Only in the ideal case are the current and voltage waveforms as shown in Fig. 12(*b*). They are both considerably modified by back e.m.f.s, reflected loads from other windings, and non-linearities from the associated circuits, until the actual voltage outputs from the core appear as in Fig. 12(*c*). These pulses are short and of rather indeterminate waveform, and so are not ideally suitable for directly switching other cores, although this is possible within certain limitations. Also, if it is required to provide a bias for a succeeding core stage, e.g. to perform an inhibit function, the indeterminate output pulse from a strobed core is not suitable, a pulse of much longer duration, say, 10μs instead of the original 2μs, being required. A suitable basic circuit[5] which may be used to regenerate the core output pulse with defined amplitude and time duration is shown in Fig. 14. It consists of a transistor amplifying stage (VT1), an emitter-follower stage (VT2), a strobing gate (D2, D3, R5 and R6), an emitter-follower trigger stage (VT3) and a blocking oscillator[6] (VT4).

CORE MATERIAL AND SIZE

The choice of the correct material for the cores is an important design consideration at the beginning of a development. Some desirable factors, which must be balanced against one another, are:

(*a*) Fast switching time, to facilitate time sharing and to give a large output e.m.f.

(*b*) High saturation flux density, to reduce core size or to give a greater output for the same size.

(*c*) High squareness ratio, to permit greater tolerance in the driving conditions.

(*d*) High coercive force, to reduce susceptibility to interference.

(*e*) Low coercive force, to reduce driving power.

(*f*) Low hysteresis and eddy-current losses.

(*g*) Small change of parameters with temperature variations.

(*h*) Ease of production.

(*i*) Uniformity of final product.

(*j*) Cheapness.

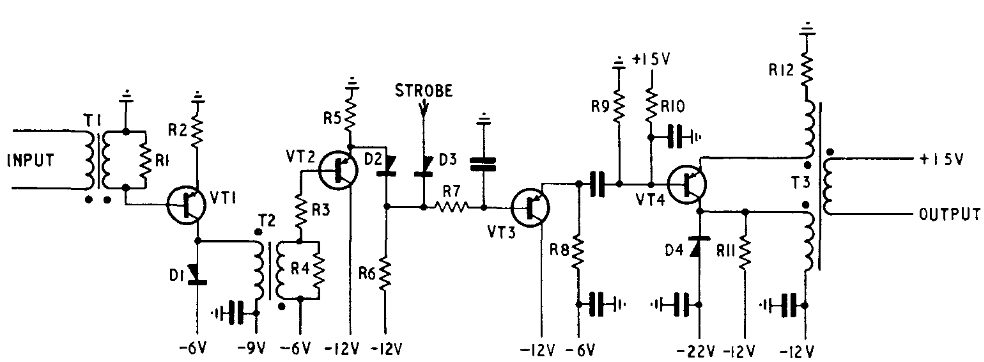


FIG. 14—CORE-OUTPUT PULSE SHAPER

Needless to say, no one material or core size gives all the above advantages simultaneously and, furthermore, core size is also a function of several other considerations as follows:

(*a*) Of two cores of different size, the core with a larger cross-sectional area will store more energy, so that it can give either a larger power output than the smaller core for the same time or the same power for a longer time. This is equivalent to a source of lower impedance, and use is made of this fact where pulses have to be fed into low-impedance transistor circuits, sometimes over long leads. It must be remembered, however, that a larger core needs a larger power input.

(*b*) The inductance of the windings varies with the volume of the core in such a manner that minimum inductance can be obtained for a particular core size. Since it is desirable to keep the inductance, and hence the back e.m.f., as low as possible, the standard size of core immediately above this optimum value is chosen wherever possible.

(*c*) The number of wires passing through the core determines its minimum internal diameter, and hence its external dimensions for a particular volume of material. Where it is required to obtain the maximum e.m.f. output it is desirable to use as many turns as possible, consistent with physical size and impedance-transfer requirements. Individual cores may be designed on this basis and so are usually of the larger diameter type. For matrices, however, the cost of winding more than one turn per core is very much greater than that of passing a single wire through all cores, and so the latter method is generally adopted.

(*d*) Where a multiplicity of cores is provided, e.g. in a matrix of 40,000 cores, the physical size of each core must be reduced to the absolute minimum.

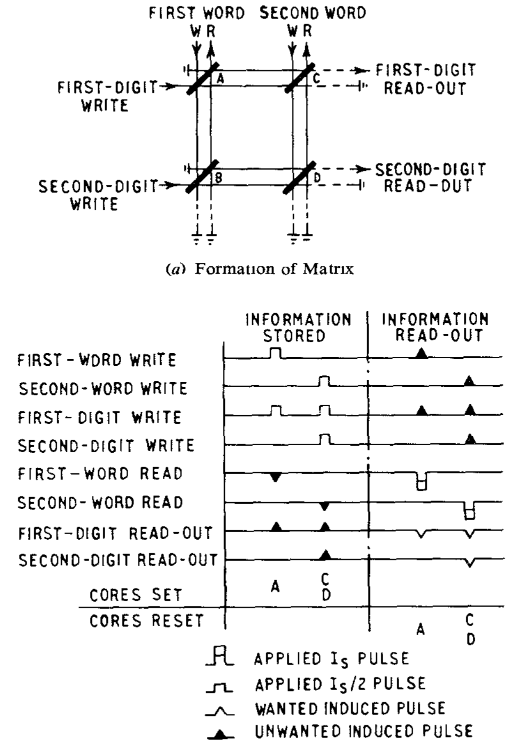
(*e*) As the mean length of the magnetic path increases, the magnetizing force for a given value of ampere-turns decreases.

In practice it is usually necessary to adopt a range of components each being suitable for a particular application, and in Appendix 1 details are given of the properties of three different cores together with an indication of their uses in a specific equipment design. In Appendix 2 typical calculations are given for the input signal required to switch one of the cores detailed in Appendix 1 and for the output signals obtained when the information in the core is read out.

MAGNETIC-CORE MATRICES

Construction and Operation

Whilst it would be possible to use individual cores for all logical and memory purposes, very large economies can be achieved by combining batches of cores with similar functions into matrices, whereby common write and read circuits and common computing logic can serve many cores. A simple 2 × 2 matrix is shown in Fig. 15(*a*). The vertical and horizontal thin lines represent the wires threading the cores, while the thick short diagonal lines represent a side view of the cores themselves, one core being at each crossing point of the horizontal and vertical wires. It is possible to write information into any core by passing a current corresponding to half the switching magnetizing force through each of any two wires threading it. These currents are usually known as half-write currents, or $I_s/2$. In this and subsequent diagrams, the return path is shown as being via earth—in practice, the actual return path is designed to suit the particular circuit.



(*a*) Formation of Matrix

(*b*) Pulses on Matrix Leads

FIG. 15—2 × 2 CORE MATRIX

Consider the storage of two words, each consisting of two binary digits, e.g. the first word 10 and the second word 11. The writing-in sequence is as follows, assuming that all cores are initially in the reset condition.

First word. A positive $I_s/2$ pulse is applied to the first-word write-wire (W) at the same time as a positive $I_s/2$ pulse is applied to the first-digit write-wire, but no signal is connected to the second-digit write-wire. Core A will be set and core B will remain reset.

Second word. A positive $I_s/2$ pulse is applied to the second-word write-wire (W) at the same time as positive $I_s/2$ pulses are applied to the first-digit and second-digit write-wires. Cores C and D will both be set.

The information can be read out, one word at a time, at any subsequent moment by the application of a full negative I_s pulse to the appropriate word read-wire, e.g. for the first word a negative I_s pulse is applied to the first-word read-wire (R) and this resets core A but hardly affects core B, causing a large output to appear on the first-digit read-out wire and a very small output on the second-digit read-out wire. These pulses are of insufficient magnitude to affect cores C and D so the information in the second word is undisturbed and can be read out later by application of a negative I_s pulse to the second-word read-wire.

It can be seen from Fig. 15(*b*) that quite a number of unwanted pulses exist besides those actually required for reading out the stored information. Discrimination between the wanted and unwanted pulses can be achieved by means of rectifiers (for polarity discrimination), limiters (for amplitude discrimination) and strobes (for time discrimination).

Possible economies in the matrix can be obtained by combining the functions of the read and write wires, so that each core is threaded by only two wires. However, this means that the input and output pulses have to be switched by external circuits and the cost of this must be taken into consideration.

Theoretically, cores can be built up into a matrix of any size, but a practical limit is usually set by considerations such as core series inductance, leakage capacitance, overall size, difficulty of accommodating and terminating the large number of wires, and the cost of replacement should an individual core fail. Accordingly, the cores are usually assembled on "planes" of, say, 32×32 or 50×50 and the planes themselves are built up into a complete matrix. A 10×12 matrix is illustrated in Fig. 16, where the three planes have been drawn flat instead of on top of one another, as they are physically mounted; the store caters for 10 words each of 12 digits. Fig. 17 shows the construction and relative size of a single-plane 10×10 matrix using 2 mm cores.

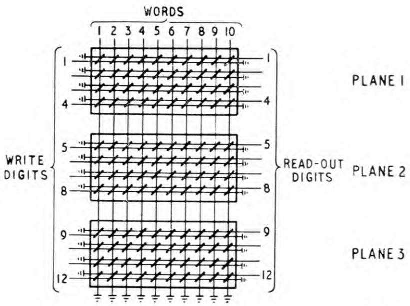


FIG. 16—INTERCONNEXIONS OF 10×12 THREE-PLANE MATRIX

The matrix configuration just described is known as the Cambridge "direct selection" or "word organized" store,[7] since each word is dealt with separately and has a

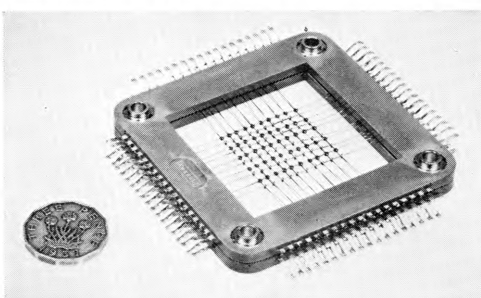


FIG. 17—SINGLE-PLANE 10×10 MATRIX USING 2 mm CORES

single wire to itself. This gives a simple matrix but means that rather complex external circuits may be required to obtain the necessary word selection. Other matrices have been designed which are more complex in themselves, but which tend to simplify the writing and reading devices. Two examples of these are as follows:

(*a*) *A Two-Core per Bit Matrix.* In this matrix each digit has two cores, only one of which is affected by each operation. After a read pulse, cores A and C are reset and cores B and D are set. The digit input consists of a positive half-write pulse for 1 or a negative half-write pulse for 0. Assume that the word 10 is to be stored. Considering the first digit, with the matrix connected as shown in Fig. 18, the first-digit write-pulse and the first-word write-pulse add in core A but cancel out in

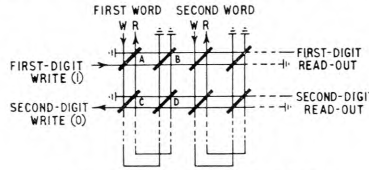


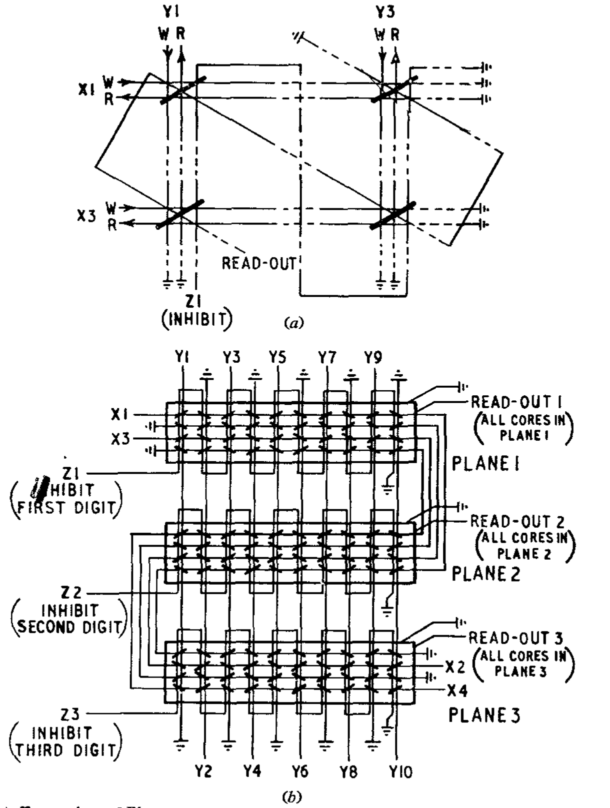
FIG. 18—TWO-CORE PER BIT MATRIX

core B. Core A is set and core B remains set. For the second digit, however, the digit write-pulse is of opposite polarity, so core D resets and core C remains reset. Subsequent application of a word-read full pulse resets core A, giving a positive output on the first-digit read-out wire, and sets core D, giving a negative output on the second-digit read-out wire. The output signals are thus distinguished by their polarity only, and not by magnitude, allowing very wide current and temperature margins. Very fast operation can also be obtained by the use of pulses of large amplitude and short duration that only partially switch the cores, but nevertheless produce a recognizable output signal.

(*b*) *M.I.T. Coincident-Current or Bit-Organized Store.* With the M.I.T.* coincident-current or bit-organized store[8] reading-out as well as writing-in is performed by the simultaneous application of $I_s/2$ pulses on two co-ordinate wires, so that each core, or bit, is picked out individually. All the cores appertaining to a particular digit have a common wire threaded through them (see Fig. 19(*a*)) and they usually form one plane of a matrix. This read-out wire is so connected that the small disturbing pulses from non-switched cores tend to cancel each other, although this does mean that genuine output pulses may be of either polarity, depending upon their origin, so that the reading amplifier must not have polarity discrimination. Sufficient planes to form the complete store are provided and have their corresponding X and Y coordinates connected in series (Fig. 19(*b*)). An inhibit wire (Z wire) is passed through all the cores on each plane and taken to the digit-selection circuit. When it is desired to write-in to a particular plane or planes a half-write pulse is applied to the Z wires of all the other planes not required in such a direction that the switching of their cores is inhibited. The inhibit function is not used when reading out, since it is usually desirable to read all digits in a word at once by the simultaneous application of X and Y read pulses to all planes. The store illustrated in Fig. 19(*b*) caters for $4(X) \times 10(Y) = 40$ words each containing 3 digits, i.e. 1 digit per plane. It will be seen that adjacent rows and columns are arranged in opposite directions. This is to simplify the wiring by allowing the inhibit wire to run in a zigzag fashion instead of requiring external straps between columns and to give an even distribution of external connexions round the matrix.

When several cores are connected in series, special consideration must be given to the method of feeding the

* M.I.T.—Massachusetts Institute of Technology.

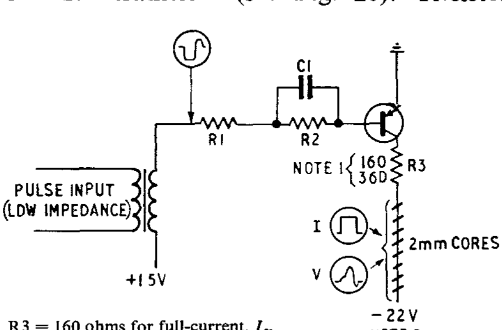


(*a*) Formation of Plane
(*b*) Interconnexion of Planes to Form a Store with Read and Write Leads Combined
FIG. 19—M.I.T. COINCIDENT-CURRENT OR BIT-ORGANIZED STORE

drive pulses. This is not only because the driving power necessary increases with the number of cores in series but also because the back e.m.f. encountered depends upon the number of cores to be switched. Thus, if 10 cores are driven from one pulse source, the available e.m.f. must be sufficient to overcome the back e.m.f. due to the 10 cores and still switch them reliably, but must not be so great that the current exceeds the safe $I_s/2$ value when no cores are to be switched. The conditions are made even more difficult by variations in loading on the cores.

Wherever possible, it is usual to arrange that each driving circuit switches a fixed number of cores. The following types of driving circuit are used:

(*a*) Constant-current drive is applied where coincident-current working necessitates control of the current magnitudes. This implies a high-impedance source, as provided by a resistor in series with the collector circuit of a bottomed transistor (see Fig. 20). Resistor R3



Notes 1. R3 = 160 ohms for full-current, I_s.
R3 = 360 ohms for half-current, $I_s/2$.
2 —22-volt supply is thermally controlled for half-current operation.
FIG. 20—CONSTANT-CURRENT DRIVING CIRCUIT

determines the steady current passing through the matrix, while capacitor C1 acts as a "speed-up" capacitor to provide the initial base charge necessary for a fast current rise in the collector circuit. Since $H = NI/l$, constant current implies a fixed value of H also.

(*b*) Constant-voltage drive is applied where it is generally necessary to maintain accurate timing of the core switching.

As already indicated $\int e.dt = NA \int dB$ so that, for a particular change in B, et must have a given value. If now, e is maintained constant, then the time t is also fixed despite temperature and other variations. A suitable circuit is given in Fig. 21, where it can be seen that when a negative input pulse is applied, say $-$ 7·5 volts, the

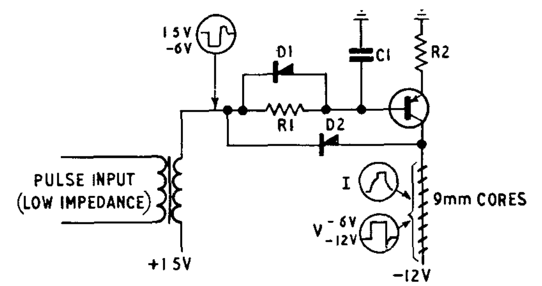


FIG. 21—CONSTANT-VOLTAGE DRIVING CIRCUIT

transistor tends to saturate but diode D2 prevents the collector potential from exceeding $-$ 6 volts. Thus, the potential difference across the cores rises rapidly to 6 volts and remains constant during switching.

The use of a word-organized storage matrix means that it is necessary to select, perhaps in random order, any word reading-wire or writing-wire and drive it with a pulse appropriate to the number of digit cores. As a simple example, it is assumed that nine words can be stored in a matrix and it is desired to select one out of nine wires at any particular moment. Economy can be obtained as shown in Fig. 22 by fitting a 3×3 matrix of switching cores (or other gating devices) so that only

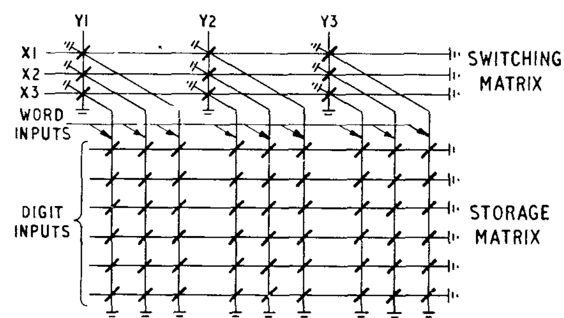


FIG. 22—USE OF SWITCHING MATRIX TO CONTROL STORAGE MATRIX

six (or $2\sqrt{n}$, where n is the number of words) inputs are finally needed. Of course, a much bigger reduction than this would be needed in practice to justify the extra circuits, but such is generally the case.

ACKNOWLEDGMENTS

The authors are indebted to Ericsson Telephones, Ltd., for assistance in compiling the article, to The Plessey Co., Ltd., Ilford, for information concerning the ferrite cores, and to Geo. L. Scott & Co., Ltd., Ellesmere Port, for data on the metal-tape cores.

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APPENDIX 1

Properties of Three Typical Magnetic Cores

In a register-translator, designed by Ericsson Telephones, Ltd., it has been found possible to perform any matrix function by a choice from the following three cores:

(*a*) A core of 2·03 mm outside diameter and ferrite material.

Characteristics of Three Specific Magnetic Cores
(Typical values at 25°C are shown)

Property	2 mm Ferrite Core	9 mm Ferrite Core	0·001 in Metal-Tape Core
Outside diameter (metres)	$2{\cdot}03 \times 10^{-3}$	$9{\cdot}5 \times 10^{-3}$	$7{\cdot}9 \times 10^{-3}$
Inside diameter (metres)	$1{\cdot}27 \times 10^{-3}$	$6{\cdot}75 \times 10^{-3}$	$6{\cdot}34 \times 10^{-3}$
Thickness (metres)	$0{\cdot}635 \times 10^{-3}$	$3{\cdot}17 \times 10^{-3}$	$6{\cdot}34 \times 10^{-3}$
Volume (cubic metres)	$1{\cdot}26 \times 10^{-9}$	111×10^{-9}	316×10^{-9}
Coercive force, H_c (ampere-turns/metre)	55	55	2·5
Switching coefficient, S (Note 1) (ampere-turns-second/metre)	150×10^{-6}	150×10^{-6}	32×10^{-6}
Maximum flux density, B_m (webers/square metre)	0·16	0·16	0·26
Remanent flux density, B_r (webers/square metre)	0·15	0·15	0·21
Squareness ratio, R_s	0·85	0·85	0·75
Maximum temperature, Curie point (°C)	300	300	95
Hysteresis loss (Note 2) (joules/cubic metre-cycle)	32	32	2·1
Typical maximum switching time, T (seconds)	3×10^{-6}	6×10^{-6}	3×10^{-6}
Maximum frequency (Note 3) (cycles/second)	Under 50 kc/s	Under 50 kc/s	Over 50 kc/s
Nominal drive (ampere-turns)	0·4	1·6	0·3
Typical 1-output e.m.f (volts/turn)	0·04	1	0·5
Time to 1-output peak e.m.f. (seconds)	$1{\cdot}55 \times 10^{-6}$	$1{\cdot}55 \times 10^{-6}$	2×10^{-6}
Cost	Cheap	Cheap	More expensive
Uniformity	Good	Good	More difficult to produce
Use	Register memory	Counters, shift registers	Translator decoder

(*b*) A core of 9·50 mm outside diameter and the same ferrite material as for (*a*).

(*c*) A core of 7·90 mm outside diameter and metal tape.

The relative properties of these cores are given in the table.

Notes:

1. The figures apparently indicate that minimum switching time (S/H_c) is less for a core of ferrite (3 μs) than for one of metal tape (13 μs) but this does not take account of the permissible conditions. In fact, it is true when each material is operated at H = twice its own H_c, but if both are operated at the same H, the metal tape is much faster.

2. The hysteresis loss per unit volume is less for metal tape than for ferrite and this advantage is multiplied since the former's higher remanence allows the core to be smaller for the same energy storage. Alternatively, for the same volume, metal tape will require a much smaller drive than ferrite and will deliver a larger power, a fact which is taken advantage of in the register-translator for the translator-decoder matrix.

3. Both materials will switch at speeds in excess of 50 kc/s but the repetition frequency for ferrite is limited by its greater temperature rise, due to its greater loss per core (note 2) and its lower thermal conductivity.

APPENDIX 2

Calculations for the Input and Output Signals for a 2 mm Core

The following calculations are for the input signal required to switch a 2 mm core of the type detailed in the table of Appendix 1 and for the output signals obtained when information in the core is read out.

Assume that a nominal input pulse of 0·4 amp is passed through the single turn of the input winding.

$$\text{Magnetomotive force} = 0{\cdot}4 \text{ ampere-turns.}$$

$$\text{Mean length of magnetic path} = \frac{2{\cdot}03 + 1{\cdot}27}{2}\pi \times 10^{-3} \text{ metres,}$$

$$= 5{\cdot}2 \times 10^{-3} \text{ metres.}$$

$$\text{Magnetizing force, } H = \frac{0{\cdot}4}{5{\cdot}2 \times 10^{-3}}$$

$$= 77 \text{ ampere-turns/metre.}$$

The coercive force, as given in the table in Appendix 1, is 55 ampere-turns/metre so that the core will switch.

The flux density changes from $-B_r$ to B_m, i.e. from $-0{\cdot}15$ to $0{\cdot}16 = 0{\cdot}31$ webers/square metre.

$$\text{Cross-sectional area} = \frac{2{\cdot}03 - 1{\cdot}27}{2} \times 0{\cdot}635 \times 10^{-6}$$

$$= 0{\cdot}242 \times 10^{-6} \text{ square metres.}$$

$$\text{Corresponding change of flux} = 0{\cdot}31 \times 0{\cdot}242 \times 10^{-6} \text{ webers,}$$

$$= 7{\cdot}5 \times 10^{-8} \text{ webers,}$$

$$= 7{\cdot}5 \times 10^{-8} \text{ volt-seconds.}$$

The core will switch in about $2{\cdot}8 \times 10^{-6}$ second (from the table in Appendix 1). Assuming the output e.m.f. waveform to be triangular, the area under the curve represents the integrated output $= (E_1/2) \times 2{\cdot}8 \times 10^{-6}$ volt-seconds, where E_1 volts is the maximum e.m.f.

$$\text{But the output e.m.f., } e = N\frac{d\Phi}{dt},$$

$$\text{or } \int e\,.dt = \int N d\Phi$$

$$\therefore (E_1/2) \times 2{\cdot}8 \times 10^{-6} = N \times 7{\cdot}5 \times 10^{-8}$$

$$E_1/N = 0{\cdot}054 \text{ volts/turn.}$$

If the input had been in the same direction as the pulse already stored, the flux density would have changed from 0·15 to 0·16 = 0·01 webers/square metre.

$$\therefore \text{Change of flux} = 0{\cdot}242 \times 10^{-8} \text{ weber}$$

The core will take about $1{\cdot}3 \times 10^{-6}$ seconds for this change, whence, if E_0 is the maximum output e.m.f., $E_0/N = 0{\cdot}004$ volts/turn.

The ratio of wanted to unwanted signal is therefore over 13 : 1 so that discrimination is quite straightforward.

Notes and Comments

New Year Honours

The Board of Editors offers congratulations to the following engineers honoured by Her Majesty the Queen in the New Year Honours List:

Chester Telephone Area	A. H. Willitt	Assistant Engineer	Member of the Most Excellent Order of the British Empire
Engineering Department	Capt. J. P. Ruddock	Commander, H.M.T.S. *Alert*	Officer of the Most Excellent Order of the British Empire
Engineering Department	P. N. Parker	Senior Executive Engineer	Member of the Most Excellent Order of the British Empire
Lincoln Telephone Area	J. P. Loftus	Technical Officer	British Empire Medal
Sheffield Telephone Area	F. W. Pedler	Assistant Engineer	Member of the Most Excellent Order of the British Empire
South West Area, London Telecommunications Region	C. W. Brown	Technician I	British Empire Medal

Retirement of Capt. C. F. Booth, C.B.E., M.I.E.E.

Capt. C. F. Booth retired on 31 March, 1963, after some 40 years service in the Post Office. His was a most distinguished career, during which he achieved a well deserved reputation, both nationally and internationally, as one of the world's leading authorities on radio matters. It was therefore singularly appropriate,

and no doubt a matter of personal gratification to him, that his outstanding work during the last few years of his service, in the field of communication via satellites, culminated in the highly successful operation of the satellite ground station at Goonhilly Downs, Cornwall, which has brought so much prestige both to the Post Office and to United Kingdom industry.

Capt. Booth joined the Radio Branch Laboratories at the Post Office Research Station, Dollis Hill, in 1923, and worked there for some 25 years, becoming an expert in quartz-crystal techniques and primary frequency standards, and achieving the distinction of becoming the first Staff Engineer in charge of the Laboratories when in 1949 they became a separate Branch.

In 1951 he left Dollis Hill to take charge of the Radio Planning Branch, and was later appointed Deputy Director of the External Telecommunication Executive when it was set up in 1952. He was promoted to Assistant Engineer-in-Chief in January, 1954, and to Deputy Engineer-in-Chief in February, 1960. He was awarded the O.B.E. in 1947, and the C.B.E. in 1956.

His wide experience and acknowledged competence led to his selection for international conference work. He led the U.K. delegation at the Plenary Meetings of the C.C.I.R. at Stockholm in 1948, Geneva in 1951, Warsaw in 1956, Los Angeles in 1959, and Geneva in 1963. The Los Angeles meeting was followed almost immediately by a meeting in Tokyo of the Plan Committee, C.C.I.T.T. and E.C.A.F.E., at which he also led the U.K. delegation. He was the senior U.K. technical delegate at the Extraordinary Administrative Radio Conference in 1951, and at the Ordinary Administrative Conference in Geneva in 1959. In 1961 he led the U.K. delegation to the V.H.F./U.H.F. Broadcasting Conference at Stockholm, when agreement was reached on frequency-assignment plans for television developments (Bands IV and V). In addition, he has served as Chairman of C.C.I.R. Study Group IX.

There can be no doubt that his contributions in the international field have been quite exceptional, and have done much to maintain the position and prestige of both the Post Office and the United Kingdom. He is a powerful debater, and has shown a resilience and tact which have enabled him to conclude successfully many complex and difficult negotiations.

In spite of these many preoccupations, he found time to play an important part in the work of The Institution of Electrical Engineers, and was for many years a member of the Radio Section Committee and its Chairman in 1950–51. He has written many technical papers for The Institution, for a number of which he has received prizes and premiums, including the Page Thesis Prize in 1932, the Duddell Premium in 1935, and The Institution Premium in 1941. He also delivered the 1948 Institution Christmas Lecture, and his appetite for work was such that he even managed, in collaboration with Mr. P. Vigoureux, to write an excellent textbook entitled "Quartz Vibrators and their Applications", which was published in 1950.

Capt. Booth served for many years in the Territorial Army, and saw service during the early part of the last war in the Royal Corps of Signals.

It is not surprising that, with such a background, he was able so successfully to lead the Post Office technical effort in the field of satellite communication, with which work he was intimately concerned during the last three years of his service. His unique radio knowledge and international experience served him well during this period, during which he made a number of visits to the U.S.A., Australia, Canada, France and Germany, and collaborated with the National Aeronautics and Space Administration (N.A.S.A.) of the U.S.A., and with other countries in planning tests of the experimental communication satellites to be launched by N.A.S.A. All this involved, incidentally, upwards of 70,000 miles of international travel!

The first phase of this work resulted in the design and provision of the Post Office ground station at Goonhilly Downs, a station of all-British design, which was completed within one year of obtaining access to the site. The spectacular results achieved at Goonhilly, using the Telstar satellite, are too well known to need detailed repetition, but it is important to remember that they included the first colour-television transmission from Europe to the U.S.A., and that the first multi-channel transatlantic telephone transmissions using a satellite were made between the Goonhilly station and Andover, Maine, in the U.S.A.

This personal association with such a vital and successful step forward in communications history constituted a fitting climax to the career of a man who has devoted so much of his life to the advancement of radio communications. His many friends at home and abroad will wish him and his wife health and happiness in the future, and will long remember and appreciate his outstanding services to the art and science of telecommunications.

D.A.B.

J. H. H. Merriman, O.B.E., M.Sc., A.Inst.P., M.I.E.E.

The appointment of Jim Merriman as Assistant Engineer-in-Chief in charge of radio and allied matters has given widespread pleasure to his many friends throughout the Post Office and other Government Departments, and in the telecommunications and computer industries. It is indeed gratifying to see so able a man

attain this rank at the comparatively youthful age of 48 years and at a time when so many new developments are taking place in the field of radio engineering. Mr. Merriman is eminently suitable by nature, training and experience for the onerous duties which confront him and these will give plenty of scope for his analytical and imaginative mind and his abounding energy.

His career has been an interesting and distinguished one, as may be judged from the following brief review. He graduated at Kings College, London, and did post-graduate work on non-linear oscillations under Appleton to gain his M.Sc. He also worked on cosmic-ray counting under Blackett.

His Post Office career started on 1 July 1936 when he entered as an Assistant Engineer (old style) and was engaged at the Research Station, Dollis Hill, in the measurement of the arrival angles of short-wave pulses from the U.S.A. This work provided essential data for the subsequent development of the steerable-aerial system M.U.S.A.

At the outbreak of war in 1939 he was moved to South Wales to set up and run radio laboratories at Castleton, near Cardiff. His work there included a study of frequency modulation and the (then) very high radio frequencies as a means of relaying multi-channel telephony and television. In 1949 he was promoted to Executive Engineer (old style) and returned to London two years later to join the activities of Radio Branch in the planning and provision of radio links. Included in this work was a study of the design and use of error-correcting radio-telegraph systems, and this laid the foundations on which much development has since taken place in the utilization of these systems in the Post Office Cable and Wireless services.

In 1951 Mr. Merriman was promoted to Assistant Staff Engineer and his continuing work on planning and provision of radio links brought him into close touch with the International Radio Consultative Committee (C.C.I.R.) and also with the (then) C.C.I.F. and other international bodies.

In 1954 he was selected for a year of training at the Imperial Defence College. On his return to the Post Office Engineering Department in 1955 he took charge of the Organization and Methods Section of the Engineering Organization and Efficiency Branch and was concerned with studies of the Post Office Cable and Wireless services following nationalization. He also saw the start of studies relating to the use of electronic digital computers in the Post Office and he was characteristically quick in grasping the essentials of this new subject and to foresee its far-ranging importance for the future. It was no surprise, therefore, when he was selected by H.M. Treasury in 1956 to assist them in the formulation of policies and programs for the utilization of computers in Government Departments. During his secondment for nearly four years he was Assistant Secretary in charge of the Office Machines Branches and in 1957 he produced a basic report entitled "A Preliminary Appraisal of the Place of Automatic Data Processing in Government Service." Many of its recommendations have since guided the planning and exploitation of computers in Civil Service Departments and the value of his contribution was recognized and honoured by the award of the O.B.E. in 1960.

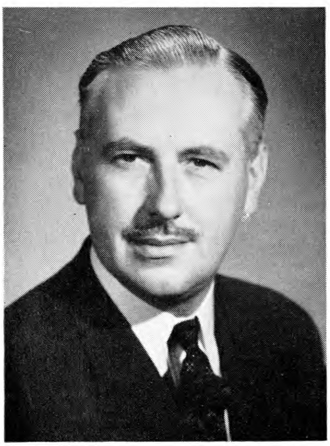
In August 1960 Mr. Merriman returned to the Post Office as a Staff Engineer and took charge of the Overseas Radio Planning and Provision Branch from which he subsequently moved to the Inland Radio Planning and Provision Branch. His return to Post Office work in these two Branches was a natural and pleasing step for him and was warmly welcomed by his colleagues. One important area of his activities has been concerned with the engineering implications of the Pilkington Report and the substantial expansion of inland radio systems that this involves. In addition, he has undertaken important duties as International Vice-Chairman of C.C.I.R. Study Group IX which embraces "Broadband Micro-Wave Radio Relay Systems". His overseas experience was further extended in June 1961 when he attended the annual meeting in Moscow of the A.S.POPOV Association of the U.S.S.R. as an Institution of Electrical Engineers' representative.

Mr. Merriman has always been an active contributor to the work of the Institution of Post Office Electrical Engineers and the Institution of Electrical Engineers as well as to Post Office staff associations. We offer him our cordial congratulations and wish him success in the wider field of activities which lies before him.

J.W.F.

T. Kilvington, B.Sc. (Eng.), M.I.E.E., F.T.S.

Mr. T. Kilvington has been appointed Staff Engineer of the Inland Radio Planning and Provision Branch with effect from 1 April 1963. A native of Bournemouth, he received his early education at Bournemouth



School whence he proceeded to University College, London, to take an honours degree in engineering. He entered the Post Office as a Probationary Assistant Engineer (old style) in 1936 and after the usual few months of preliminary training was appointed to the Radio Branch at Dollis Hill in January 1937. Here he was soon engrossed in the new and exciting field of television, the initial growth of which was all too soon curtailed by the war. During the war period Mr. Kilvington was mainly concerned with various aspects of radio aids to navigation and for nearly a year was seconded to the Admiralty for special work in this sphere. In December 1946 he was promoted to Executive Engineer (old style), and with the re-opening of the public television broadcasting service was responsible for the development and application of new techniques for the transmission of television signals over cable and radio circuits. On the broadcasting side he took part in several projects aimed at assessing the essential requirements of telecommunication links used for outside broadcasts and for the interconnexion of studios and transmitters.

With the world-wide expansion of television Mr. Kilvington's extensive and specialized knowledge of the subject proved of great value at international conferences and he soon established himself as a most useful member of various C.C.I.R. committees and kindred bodies. Here he has gained a well-deserved reputation for his tact and imperturbability in negotiations. With his promotion to Assistant Staff Engineer in January 1955 this work was carried on with increasing emphasis and, since his transfer to the Inland Radio Planning and Provision Branch in August 1961, has continued unabated.

On his promotion to Staff Engineer of the Inland Radio Planning and Provision Branch Mr. Kilvington carries with him the very best wishes of his many friends in the Post Office and elsewhere for a happy and successful career in what is not so much a new field but rather a logical development of that which he has already achieved.

D.A.T.

H. B. Law, B.Sc.(Tech), A.M.I.E.E.

Mr. H. B. Law, recently appointed Staff Engineer in charge of RWS Division of Research Branch, was born in Lancashire and received his professional education in Manchester. He joined the Department as Assistant Engineer (old style) by open competition in 1937, and was posted to the old Radio Branch at Dollis Hill. Here he worked on quartz-crystal oscillators for time

standards and the generation of stable frequencies for control of radio transmitters and multi-channel carrier telephone systems. The period of most rapid development in this art coincided with the war, and application to navigational aids such as Gee and Oboe was a natural outcome. Later Mr. Law represented this country at C.C.I.R. meetings on frequency standards and was concerned with the development of the MSF standard-frequency service from Rugby radio station.

Radio telegraphy was the next main subject to engage his attention. A fundamental study of the effects of fading and noise on transmission led to the demonstration that dramatic reductions in the rate of errors on poor circuits, and consequent economic advantages, could be achieved by comparatively simple changes in the techniques used for reception and decoding. This work was the subject of a number of papers before the Institution of Electrical Engineers, which led to the award of the Kelvin Premium to the author.

On promotion to Assistant Staff Engineer in 1955, Mr. Law moved to RC Division of Research Branch to work on carrier telephone systems. One result was a bandwidth-economizing system with close channel spacings to provide additional traffic capacity on the heavily-loaded transatlantic telephone cable. The use of compandors to combat circuit noise and crosstalk, and investigation of pulse code modulation were other fields to engage his interest. The latest move returns him to the radio fold, now "integrated" as a Division of Research Branch. He brings with him an energetic nature and a keen technical mind, with a built-in tendancy to doubt whether the established way of doing things is necessarily the best.

Despite his long residence in the South, it was to Scotland that Mr. Law turned for a wife, and at holiday times he is as likely as not to head North again with car, family and tent in search of hills and scenery in keeping with the rugged tastes of a mountaineer. His many other interests have nowadays to compete for his limited leisure with the Watford Grammar School for Boys Parents' Association, of which he is the secretary.

E.W.A.

Reprint of Articles from the Special S.T.D. Issue of the Journal (Vol. 51, Part 4, Jan. 1959)

A further reprint of selected articles from the special subscriber trunk dialling issue of the Journal (Vol. 51, Part 4, Jan. 1959) has been produced. This 32-page reprint, price 2s. 6d. (3s. post paid) per copy, contains some notes drawing attention to developments that have taken place since the original publication of the selected articles and which affect the information contained in these articles. The articles in the reprint are as follows:

The General Plan for Subscriber Trunk Dialling.
Controlling Register-Translators, Part 1—General Principles and Facilities.
Local Register for Director Exchanges.
Periodic Metering.
Local-Call Timers.
Metering over Junctions.
Subscribers' Private Meter Equipment.

Orders and remittances, which should be made payable to *The P.O.E.E. Journal* and crossed "& Co," should be sent to *The Post Office Electrical Engineers' Journal*, G.P.O., 2–12 Gresham Street, London, E.C.2.

Circulation of The Post Office Electrical Engineers' Journal

The Board of Editors is pleased to note the continuing increase in the circulation of the Journal, as shown by the following statistics.

Journal Issue	Number of Copies Printed
Vol. 55, Part 1, Apr. 1962	24,400
Vol. 55, Part 2, July 1962	24,800
Vol. 55, Part 3, Oct. 1962	25,300
Vol. 55, Part 4, Jan. 1963	25,800

Approximately 10 per cent of the Journals are sold to overseas readers in more than 50 countries.

Correction

It is regretted that an error occurred in the acknowledgement at the end of the article by Mr. K. W. Hix entitled "Telephone Equipment Connexions" (Vol. 55, p. 66, Oct. 1962). The acknowledgement referring to Fig. 2 should have referred to Fig. 3, and an additional acknowledgement to The General Electrical Co., Ltd., and International Computers & Tabulators, Ltd., should have been included for Fig. 2.

Book Review

"A Survey of Switching Circuit Theory." E. J. McCluskey and T. C. Bartee. McGraw-Hill Publishing Co., Ltd. ix + 205 pp. 58 ill. 60s.

This book is based on a series of 11 papers presented to the American Institute of Electrical Engineers in 1960, and is intended to give an introduction to switching-circuit theory and circuit-logic design.

The six papers in Part I include an introduction to switching algebra with the Boolean concepts presented in a way which is easy to understand, and without unnecessary complication. Other chapters are concerned with binary numbers and codes, the formation of switching problems and the techniques for their solution. Chapter 6, describing the use of digital computers for analysis and synthesis of switching networks, is of special interest although the potential of computers for switching-circuit design has not yet been realized significantly. The authors point out that digital computer solutions have been restricted by the lack of sufficiently powerful machines and the programming effort involved. Trends towards microminiaturization and reliability-engineering, using designed redundancy, will make digital-computer solutions increasingly important. The last five chapters, which form Part II, are concerned with the application of switching theory to sequential circuits of the type common in the design of computers and similar circuitry. The meaning and value of state tables and diagrams are well defined, and the methods of circuit synthesis from state tables are introduced. It is as well that the reader is warned against excessive optimism in the use of the design techniques, allowing for the influence of rapidly changing circuit and component technology on the conception of what results in an optimum design.

Although the 11 chapters were written by nine different authors, the editors have succeeded in presenting a logical work, with little overlap, that is easy to read and reflects the authors' experience in the art. The book can be recommended to engineers concerned with switching-circuit problems.

R.O.B.

Institution of Post Office Electrical Engineers

Retired Members

The following members, who retired during 1962, have retained their membership of the Institution under Rule 11 (*a*):

T. E. Taylor, 48 Fairfield Drive, West Monkseaton, Northumberland.
W. E. Hudson, O.B.E., 83 Parkside Way, North Harrow, Middlesex.
P. C. Rowell, 67 Woodbridge Hill, Guildford, Surrey.
E. J. C. O'Brien, Woodlands, The Glade, Fetcham, Leatherhead, Surrey.
F. V. Partridge, 218 Salmon Street, Kingsbury, London, N.W.9.
F. W. Allan, 23 Gunnergate Lane, Marton in Cleveland, Middlesbrough, Yorkshire.
D. W. Glover, Walton Lea, Levens Way, Silverdale, Carnforth, Lancashire.
J. T. Haines, 34 Anson Road, Tufnell Park, London, N.7.
G. C. Bunn, 11 Hulse Road, Salisbury, Wiltshire.
J. McOwen, C.B.E., 20 Roundwood Park, Harpenden, Hertfordshire.
J. Hay, 47 Keswick Gardens, Ilford, Essex.
F. I. Ray, 19 Shepherds Road, Watford, Hertfordshire.
T. P. Pitloh, M.B.E., 147 Runnymede Road, Ponteland, Northumberland.
W. T. Gemmell, C.B.E., 35A Augustus Road, Birmingham, 15.
Brig. F. Jones, C.B.E., 12 Selwyn Road, Edgbaston, Birmingham, 16.
R. C. Smith, 43 Reedley Road, Bristol, 9.
A. Edwards, 147 Valley Road, Kenley, Surrey.
R. T. A. Dennison, 48 St. Georges Road, Petts Wood, Orpington, Kent.

S. WELCH,
General Secretary.

Additions to the Library

Library requisition forms are available from Honorary Local Secretaries, from Associate Section Centre Secretaries and representatives, and from the Librarian, I.P.O.E.E., G.P.O., 2–12 Gresham Street, London, E.C.2.

2677 *Mathematical Methods for Science Students.* G. Stephenson (Brit. 1961).
Assumes a good knowledge of mathematics up to A level G.C.E.

2678 *Physics for Electrical Engineers.* W. P. Jolly (Brit. 1961).
Assumes A level G.C.E. in mathematics. The author has tried to provide a coherent account of the nature of matter and energy.

2679 *Thinking Machines.* I. Adler (Brit. 1961).
A layman's introduction to logic, Boolean algebra, and computers.

2680 *Miniature & Microminiature Electronics.* G. W. A. Dummer and J. W. Granville (Brit. 1961).
Covers the three main systems of microminiaturization: micromodules, microcircuits, and solid circuits. Mathematics are largely eschewed.

2681 *Magnetism.* D. S. Parasnis (Brit. 1961).
An essentially non-mathematical treatment.

2682 *Introduction to Microwave Practice.* P. F. Mariner (Brit. 1961).
A simple approach to all the problems using argumentive rather than mathematical deduction.

2683 *Design Manual for Transistor Circuits.* J. M. Carroll (Editor) (Amer. 1961).
A complete manual for the designer of transistor circuits.

2684 *Semiconductor Devices & Applications.* R. A. Greiner (Amer. 1961).
A textbook providing the background necessary so that new devices may be understood and used to good advantage.

2685 *Physics for Engineers & Scientists.* R. G. Fowler and D. I. Meyer (Amer. 1961).
An introductory course; assumes the mathematical preparation that a student has normally acquired after one year of college mathematics.

2686 *Playing with Infinity.* R. Peter (Brit. 1961).
Written for intellectually-minded people who are not mathematicians.

2687 *The Insulation Handbook.* G. Shepherd (Editor) (Brit. 1962).
Brings together as many facts and figures as possible to help those using or specifying thermal, acoustic and vibration insulation.

2688 *Mathematical Models.* H. M. Cundy and A. P. Rollett (Brit. 1961).
Gives detailed instructions for making a wide variety of models illustrating mathematics.

2689 *Automatic Data Processing.* D.S.I.R. (Brit. 1961).
A review of the development of automatic data processing systems and of the achievements of those who have contributed to that development.

2690 *Intelligent Machines.* D. A. Bell (Brit. 1962).
An introduction to cybernetics.

2691 *Edison.* M. Josephson (Brit. 1961).
A biography which paints the background of the society in which he lived.

2692 *Automobile Brakes & Brake Testing.* M. Platt (Brit. 1961).
Deals with braking principles and the construction, maintenance and testing of braking systems.

2693 *A History of Electrical Engineering.* P. Dunsheath (Brit. 1962).
This history includes reference to the social context of the discoveries and to the lives and characters of the men who made them.

2694 *Engines.* D. H. Mater (Brit. 1962).
Designed to appeal to a wide range of people interested in this subject.

2695 *How Photography Works.* H. J. Walls (Brit. 1959).
Assumes no scientific knowledge from the reader, only a keen interest and healthy curiosity.

2696 *The Atom, Friend or Foe?* C. N. Martin (Brit. 1962).
A comprehensive discussion on all aspects of nuclear energy.

2697 *Physics for the Inquiring Mind.* E. M. Rogers (Amer. 1960).
Treats a series of topics intensively; topics chosen to form a co-ordinated structure of knowledge. The book demands that much of the thinking be done by the reader.

2698 *Adventures in Algebra.* N. A. Crowder and G. C. Martin (Brit. 1962).
An introduction that includes just enough technique to enable the important ideas of mathematics to be explained.

2699 *The Trachtenberg Speed System of Basic Mathematics.* A. Cutler and R. McShane (Brit. 1960).
A revolutionary new system of high-speed calculations.

2700 *The Arithmetic of Computers.* N. A. Crowder and G. C. Martin (Brit. 1962).
An introduction to binary and octal mathematics.

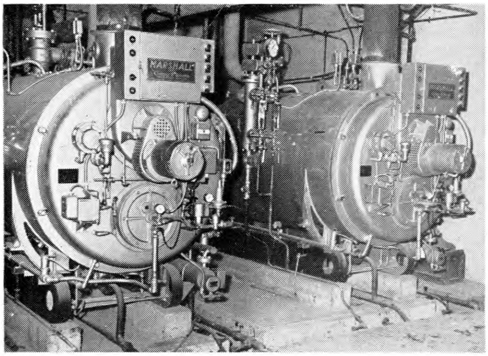
W. D. FLORENCE,
Librarian.

Regional Notes

Wales and Border Counties

NEW BOILER PLANT AT THE FACTORIES DEPARTMENT'S CWMCARN FACTORY

This factory, employing about 500 people mainly on telephone repairs, had a battery of four large hand-fired cast-iron sectional boilers for space heating and gas-fired boilers for raising steam used in factory processes. These boilers have now been replaced by three Marshall Cleaver Brooks packaged steam boilers which burn heavy oil and are completely automatic. Two of the boilers are shown in the photograph.



NEW BOILER PLANT AT CWMCARN FACTORY

Process steam is fed direct from the boilers. Calorifiers are installed to supply the hot-water space-heating installation, the steam supply then being varied automatically according to the outside temperature. Special equipment has been installed adjacent to the calorifiers to use the heat from flash steam generated when the condensate from the calorifiers passes through the steam traps; this facility gives a theoretical saving of nearly 9 per cent of the total heat.

The oil-burner control equipment is arranged to start up and shut off the burners in a controlled sequence and to regulate the supply of oil in accordance with the steam pressure. Conventional high-pressure, flame-failure, high-water level and double low-water level protection circuits are installed.

The boilers, of two sizes to cater economically for summer and winter loads, are four-pass, dry-back, fire-tube types with hinged front and rear doors for easy maintenance. They have integral fans and associated motors mounted on the front doors; swivel joints allow these doors to be opened without disconnecting any pipes or wiring. The fuel oil is preheated by steam or electricity and passes to the burners from the tanks in the adjacent fuel bunkers. A check on combustion conditions is obtained from flue thermometers, and carbon-dioxide and smoke-density indicators.

Besides providing copious supplies of process steam cheaply, the installation is giving a much better space-heating service than was obtained from the hand-fired plant.

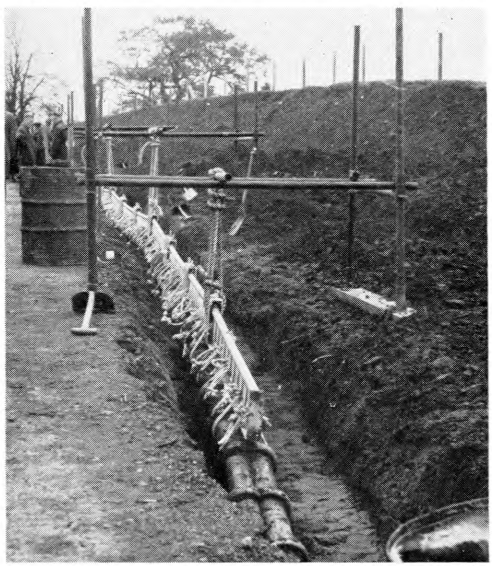
The savings shown by the use of this modern centralized plant compared with the cost of operating the old plant will pay for it in a few years.

C.T.L.

SLEWING AND LOWERING OF DUCT TRACK AT BRECON

Road-widening operations often necessitate the re-positioning of underground-duct tracks, and consideration is given first to the slewing and lowering of the track to its new position, rather than to the usually more expensive alternative of changing over to a newly-laid section. The increase in the number of road works over recent years has, of course, increased the number of occasions when slewing and lowering has had to be considered, and has justified the general distribution of detailed engineering information on approved standard techniques by the External Plant and Protection Branch of the Engineering Department. The recent Brecon–Hay road works affected approximately 120 yd of 2-way earthenware duct containing two 96 pr. 20 lb/mile M.U. cables and one 75 pr. 10 lb/mile local cable, and the occasion was used to try out the new specifications.

The progress of the road works had left the duct on a bank which was 2 ft 6 in. above the new carriageway at its highest point, and the slewing and lowering operation required a maximum lateral movement of approximately 4 ft with a maximum vertical lowering of 4 ft 6 in. Towers, 6 ft high, made of steel scaffold tubing were first erected over the track at 25 ft intervals and the duct line was securely lashed (two ties per duct) to Kwikform lattice-steel reinforcing beams which had been supplied by Brecon County Council to serve as "strongbacks." The strong-backs were attached at the towers to steel-scaffold sling poles using 3 in. ropes with four turns around the sling poles to provide adequate frictional control, and made off with half hitches prior to the lowering operations. The supporting arrangements are illustrated in the photograph.



SLEWING DUCT TRACK AT BRECON

The trench to accommodate the track was then dug, the bottom being filled with a 4 in. layer of stone-free material.

Before any shifting work was attempted the M.U. cables were gas pressurized over the loading section concerned and all joints were freed in the joint boxes adjacent to the length to be slewed. By applying a chain puller at each tower in turn the track was lifted an inch or so to allow it to be slewed out just clear of the bank. It was then lowered on the chain puller to transfer the load to the ropes, so taking up their initial stretch. At this stage the track was fully supported throughout its length on the towers and minor adjustments were made to take out irregularities in the line. The main slewing and lowering operation was next carried out. With two men at each of five towers the track was eased out to the required new position. This move was carried out over 50 ft sections at a time, with minor movements at the towers beyond to avoid sharp bends being involved. This was repeated with the same precautions until the whole track was in position to be lowered. With the same labour force the centre portion of the track was lowered at five towers, concurrently, to the limit of permissible deviation. Moving each side of centre alternately the operation was continued until the track was approximately 15 in. above its final position at the centre. At this point it was judged that the maximum increase in length of track had been reached and all joints were then caulked with a fresh mixture comprising 1 part of cement to 4 parts of compound by volume. This mixture formed a stiff mastic which could be applied as a putty. The lowering operation was then continued until the track rested on the 4 in. soft bed previously referred to. Sound bedding was ensured by excavating at the collar positions with a hand trowel. The final lowering caused the track to shorten, forcing the spigots tightly into the sockets and only two joints were discovered where the mastic was not firmly bonding the ducts. These were recaulked. No collars were broken during the operation and the track as relaid was considered to be in a very good condition.

The whole shifting operation was carried out by Brecon Borough Council labour under supervision of the local Area staff and substantial savings were achieved.

W.H.D.

North-Eastern Region

INAUGURAL CALL VIA TELSTAR

On Thursday, 23 August 1962, telecommunication history was made in the North East Region when, at 8.10 p.m., the Lord Mayor of Bradford, Alderman H. K. Watson, J.P., received a telephone call, via Telstar, from Mayor Jack Still of Bradford, McKean County, Pennsylvania, U.S.A.

The call had been arranged by the telephone authorities in Bradford, U.S.A., to commemorate the conversion of their telephone system from manual to automatic working, and was routed over the normal trunk network of both countries and the international switchboards in New York and London. The Lord Mayor's telephone in Bradford, Yorkshire, was connected to public address equipment in the Lord Mayor's Parlour enabling the guests, including Mr. B. R. Bailey, the recently retired Telephone Manager of Bradford Telephone Area, to listen to the conversation.

The two civic heads spoke for approximately 12 minutes, and in comparing their two communities it was disclosed, among other things, that Bradford, U.S.A., had a population of 17,000 and was in the centre of a prosperous oil field. Towards the end of the conversation the operator warned the speakers that time was running out but they carried on until the conversation faded away as Telstar, on its 406th orbit, passed below the horizons of Andover, Maine, and Goonhilly Down. The inaugural call was recorded and the tape was presented to Alderman Watson as a memento of the occasion.

A rather striking feature of the call was that an invention of over 50 years' standing was being introduced to the telephone subscribers in Bradford, U.S.A., and publicized by means of one of the most advanced telecommunications techniques.

C.T.

Home Counties Region

EXPLOSION AT TAKELY U.A.X.13

At 7.30 a.m. on Wednesday, 14 November 1962, the 300-line U.A.X. 13 at Takeley, Essex, was destroyed by a gas explosion. The timber building disintegrated, the apparatus racks were laid flat and every cell of the battery was smashed, as shown in the photograph. This event marked the beginning of a period of intense activity which ended 76½ hours later, at noon on Saturday, when full service had been restored with a mobile exchange.

The first report of the incident was received at 8.20 a.m. Staff were sent to the site to investigate and a request for a mobile exchange was made.

The immediate need was for a skeleton service and this was provided at 11.45 a.m. from four kiosks, which were set up and directly connected to Bishops Stortford

EXPLOSION AT TAKELY U.A.X.

exchange. The public took these into immediate and continuous use.

The presence of gas and three further underground explosions, one of them in the exchange manhole, prevented any complete inspection of the damage being made until mid-day.

In the village schoolroom two members of the development group, equipped with a complete set of external-plant records, prepared diversion schedules. A third, using a camera which produces a print at the time the picture is taken, took a record of the damage to Post Office plant and the surrounding private property.

The most suitable site for the mobile exchange, which consisted of two vehicles each 21 ft 6 in. × 7 ft 6 in. × 12 ft 6 in. high, was in the school playground. Here there was space to manoeuvre and to park on hard standing. In addition, use of this site made it possible to intercept all the cables with a minimum of external work. The Education Authorities, while being ready to provide parking for the night, were understandably reluctant to accommodate the exchange for a longer period. However, they agreed to do so on the understanding that permanent restoration would be carried out at all possible speed.

When the mobile exchange arrived at 7.15 p.m. the ends of the underground cable were already on site for jointing to the cable tails within the exchange. Although a tractor was available to draw the vehicles into the floodlit site it was found to be necessary to manhandle them into their allotted positions. This was done in pouring rain. The opinion was expressed that much time could have been saved had the vehicles been steerable at both ends.

The task of cabling together the two separate sets of equipment each contained in its own vehicle proved to be much greater than had been expected. This was a disappointment since it delayed the final restoration of service. However, much progress was made during the night. In the mobile exchange it was necessary for jointers and fitters to work crouched on the floor while other fitters worked above them supported on planks and packing cases.

By noon on Thursday, service had been restored to the 15 emergency subscribers and seven junctions to Bishops Stortford were working. By noon on Friday, these figures had been increased to 245 subscribers and 16 junctions. At noon on Saturday restoration of service was completed.

The Lord Lieutenant of Essex and the Chairman of the local council expressed their great satisfaction at the speed of restoration.

By Sunday, the roof was on the new B1 building but the lining did not arrive until 21 November and then panel heaters were installed to dry out the building. Installation of a new exchange with a 400-line multiple started on 28 November and the new exchange was working by 21 January 1963.

R.C.L.

Associate Section Notes

Edinburgh Centre

The first half of the 1962–63 session has been marked by the efforts of the committee to obtain improved attendances at meetings, and the results to date have been reasonably good.

In addition to two visits, there have been three meetings this session. In November, Mr. H. M. Allan of the Edinburgh group switching centre presented a paper on "Electronics" which was well supported and appreciated. December brought Messrs. G. C. Costa and W. F. Irvine from Post Office Regional Headquarters, Scotland, with a paper entitled "Exchange Long-Term Planning," a subject new to most of our members and of considerable interest. Mr. D. M. Plenderleith's program of films has become almost a tradition in this Centre and even the worst of January weather did not deter his audience on this occasion.

With two excellent papers to follow in the comfort of a centrally-located hotel and a system of notifying members of individual meetings, hopes are high for an upsurge of interest in the activities of the Centre.

D.S.H.

Cornwall Centre

Mr. C. A. May of the Telephone Electronic Exchange Systems Development Branch, Engineering Department, gave us a paper on "An Introduction to the Electronic Telephone Exchange" for our November meeting. This was a most interesting paper covering the elementary aspects of the electronic telephone exchange. The annual dinner-dance was held at Newquay in December. A very successful evening was enjoyed by all. Major C. P. Ingram, Area Engineer, proposed the toast to the Cornwall Centre. For our January meeting we had Mr. Lawson of the experimental satellite ground station at Goonhilly Downs giving us a talk on "Microwaves for the Layman."

The membership has now reached the 200 mark.

A.R.B.

Bletchley Centre

Winter commenced with a vengeance and chose to mark the occasion on the day of our visit to London Airport by presenting a very cold and frosty morning.

Members were guests of the British Overseas Airways Corporation and they enjoyed a very interesting tour of the establishment. The tour commenced with an inspection of the new P.A.B.X. No. 4. Next the party viewed the flight-operations control room and were able to observe B.O.A.C. aircraft movement all over the world being plotted in one large spacious room. An inspection of the telegraph communications room was then made and an appreciation of the necessity for immediate communication with other overseas offices was realized.

Before lunch the party was able to inspect a Boeing 707 aircraft in the repair bays and try out the luxurious first-class seating.

A visit followed after lunch to the aircraft-approach control room in the airport centre area and we had a roof-top view of the new buildings, and the opportunity of watching aircraft landing, taxiing to the unloading bays and discharging passengers; this sequence of operations was much admired. Here we had to say farewell to our guide, Mr. Robinson, to whom we are greatly indebted for making the tour most interesting. We continued to Skyport telephone exchange, where the staff entertained us to afternoon tea before we visited the repeater station and telephone exchange. We very much admired the view of the airfield from the balcony of the canteen and everyone felt envious of those who enjoy such a daily view.

In December a talk was given by Mr. H. B. Hadden of the B.B.C. central program-operations department. The committee had feared that the meeting would have had to be cancelled due to the fog. The meeting was open to the students of the school and it commenced with Mr. Hadden describing simple studio programs and discussing the problems of sound reproduction to the listener. The world of drama was then entered and Mr. Hadden gave a realistic demonstration by producing a battlefield-in-sound of artillery fire supported with machine gun and rifle (with or without ricochet effect), all emitting from two small electronic devices. Demonstrations of creaking doors, garden gates and telephone kiosks were performed. The meeting finished with demonstrations of stereophonic sound.

We are indeed very sorry that fog prevented members from Leighton Buzzard and Bedford from coming to the meeting.

By the time this report is printed we shall have lost at least eight of our members by promotion to Assistant Engineer or Inspector. The committee would like to wish them every success in their new posts and indeed feel very proud of them.

We would like also to take the opportunity of advertising to members of other centres that should they ever be at the training school they are cordially invited to our meetings.

Our present membership is 99.

A.J.H.

Stoke-on-Trent Centre

At the annual general meeting of the Stoke-on-Trent Centre, held 10 April 1962, the following officers were elected for the 1962–63 session: *President:* Mr. H. Todkill (Telephone Manager); *Chairman:* Mr. A. E. Paterson; *Vice Chairman:* Mr. A. E. Fisher; *Secretary:* Mr. A. E. Foden; *Assistant Secretary:* Mr. C. Bennion; *Treasurer:* Mr. C. Bell; *Librarian:* Mr. E. J. Foden; *Committee Members:* Messrs. Wilson, Roberts and Walker; *Auditors:* Messrs. Colclough and Yates.

The meeting was the final event in a highly-successful season during which membership increased and many well-attended lectures and excursions were held.

The following lectures were held during the season.

25 October 1961: "Radio Investigation." An excellent lecture by one of our members, Mr. K. Guy. His dry sense of humour and his interesting material made the night.

22 November 1961: "Telephone Equipment Connexions," by Mr. K. W. Hix. We were all convinced that only solderless connexions would be used in the near future.

13 December 1961: "An Illustrated Talk on a Tour Round the World" by Mr. A. R. Powell. Mr. Powell is a member of the Senior Section of the I.P.O.E.E. who, in six weeks, travelled round the world taking some excellent colour photographs. This was an open social evening.

24 January 1962: "Computers." A lecture by Mr. J. Boothroyd held at the English Electric Works, Kidsgrove. Mr. Boothroyd's excellent material and fascinating subject stimulated much discussion among a large audience. After the lecture he demonstrated one of the English Electric computers.

21 February 1962: "Weather Forecasting," by Mr. J. E. B. Raybould. This lecture immediately followed the gales at Sheffield and the Centre was able to hear a first hand account of the damage from the lecturer.

21 March 1962: "Colour Television," by Mr. H. V. Sims of the B.B.C. Training Department. This was the most popular lecture of the season and was attended by 110 members. Our high expectations of an enthralling evening were realized.

Visits have also been made to the following firms: Bass, Ratcliffe and Gretton, Burton on Trent; Ericsson's Telephone Works, Beeston; English Electric, Kidsgrove; Hem Heath Colliery; Quickfit and Quartz; Fodens, Sandbach; B.I.C.C., Prescot; and Austin Motor Works.

The following lectures were held in 1962–63:

10 October 1962: We had an excellent lecture from Mr. J. K. S. Jowett on "Satellite Communication Systems." As this was a topic of great interest due to the recent broadcasts by means of the Telstar satellite a large enthusiastic audience was present. Mr. Jowett's equipment included a model of the aerial at Goonhilly Downs and a half-size model of Telstar which greatly helped in understanding the subject. Discussion time emphasized the fact that an evening devoted to the maser would be very profitable and interesting.

21 November: "Atomic Radiation and its Genetic Effect," by Professor Alan Gemmell of Keele University and B.B.C. Gardeners' Question Time.

6 December: "An Introduction to Sailing," by Mr. G. Mainwaring.

23 January: "Railway Electrification," by Mr. H. Walker.

27 February: "Special Ceramics," by Mr. Popper of the British Ceramic Research Association.

A.E.F.

Belfast Centre

Over the past two years the Belfast Centre has been in a dormant state due to such things as an extensive S.T.D. program and technical studies. However, at a special meeting held on Monday 10 November, with unanimous decision of the 43 members present, it was agreed to reform the Belfast Centre.

Mr. J. Knox, E.R.D., Chairman of the Northern Ireland I.P.O.E.E. Centre, gave a short address on "The Engineer Today" in which he emphasized that with the expansion of knowledge in the electronic and electrical engineering spheres, the engineer had to rely on printed papers and addresses by people who had an intimate knowledge of the new developments. These papers were normally read at meetings of learned societies where engineers could meet to increase their knowledge. One of these societies was the Institution of Post Office Electrical Engineers which Post Office engineers had formed to increase and develop knowledge in the telephonic and telegraphic fields. In order that the junior members of the Post Office could also enjoy these benefits the Associate Sections had been formed.

The following office bearers were elected for the remainder of the 1962–63 session: *Chairman:* Mr. T. T. Dearden; *Treasurer:* Mr. C. C. Smyth; *Secretary:* Mr. F. H. Elliott; *Committee:* Messrs. S. Montgomery, R. W. Davidson, W. A. Kane, J. J. McAnee, D. A. C. Smyth, H. Gabby and E. P. Bennett.

The Chairman and members of the Senior Section who were present conveyed their sincere good wishes to the Associate Section in Belfast for a long and successful life.

At a committee meeting on 20 December, the following program was arranged:

10 January: A lecture and film show on "Cine-Photography," by Mr. S. J. Lemon, a member of the Senior Section.

14 February: A lecture (with working models) on "Motor-Car Maintenance," by Mr. P. Thompson, of the Belfast Education Authority.

14 March: "S.T.D." This was a lecture on S.T.D. and questions were answered by a panel of members directly concerned with Belfast exchange.

A visit has been arranged for April to the new Standard Telephones and Cables, Ltd., factory at Monkstown, near Belfast.

F.H.E.

Exeter Centre

With this newly-formed Centre now firmly consolidated, a series of evening visits were organized to the local I.T.A. transmitter station at Stockland Hill, and to the associated Post Office radio-link stations at Halwell and Whitestone.

In addition a coach party made the long journey to visit the experimental satellite ground station at Goonhilly Downs and were very fortunate in being present whilst information was being received from Andover, Maine (U.S.A.). The committee would like to express their appreciation to the engineer-in-charge and his staff for the excellent manner in which the tour was conducted.

During this winter session, a varied set of papers were read, including the following:

(*i*) "Telecommunications in the Netherlands," by Mr. Wilson, Dundee, and Mr. Leckenby, York.

(*ii*) "Introduction to Electronic Exchanges," by Mr. C. A. May, Telephone Electronic Exchange Systems Development Branch, Engineering Department.

(*iii*) Capt. C. F. Booth's paper "Space Communication" read by Mr. C. F. Davidson, Research Branch, Engineering Department.

(*iv*) "Transistors and Their Application to P.O. Equipment," by Mr. J. A. T. French, Research Branch, Engineering Department.

(*v*) "Gas Pressurization and Its Use for Fault Location," by Mr. J. Fielding, Regional Headquarters, Bristol.

(*vi*) "P.B.X.s: A Current Review of Development," by Mr. A. J. Forty, Subscriber's Apparatus and Miscellaneous Services Branch, Engineering Department.

(*vii*) "Subscriber Trunk Dialling," by Mr. R. J. Pyne, Exeter Area.

The attendances at meetings have been very good, especially in view of the difficult weather conditions that we have experienced and the distances that many of our members have to travel.

This Associate Centre was re-formed in June 1962 with 127 members and the committee had set themselves a target of 200 members before the end of the year, but unfortunately the target was missed, the total being three short. However, this was a very encouraging effort and we sincerely hope that the members have found the papers interesting and enlightening.

F.R.S.

Plymouth Centre

In October at a meeting of 60 members it was decided to restart the Plymouth Centre.

The following officers were appointed: *Chairman:* Major C. P. Ingram, E.R.D.; *Secretary:* Mr. S. W. Pateman; *Assistant Secretary:* Mr. D. H. Scoble; *Treasurer:* Mr. D. Grant.

In November a visit to the Westward Television Studios was such a popular attraction that two visits were necessary to cater for the 80 members wishing to attend.

We were fortunate in having Mr. C. F. Davidson, for our December meeting. Mr. Davidson gave Capt. C. F. Booth's paper on "Space Communication," which was illustrated with slides and film. A lively discussion followed.

We are happy to report that our membership now stands at 116.

S.W.P.

Barnstaple Centre

The Barnstaple Centre has been reformed this session, after a lapse of some years, with a present membership of 50.

The following officers were elected: *Chairman*: Mr. R. H. Palmer; *Secretary*: Mr. H. J. Hutchings; *Treasurer*: Mr. F. D. Colwill; *Committee*: Messrs. D. H. J. Bawden, J. N. Gould, W. W. Holbourn, C. H. Howard and A. G. Somerville.

Our 1962–63 program was as follows:

11 October: Inaugural meeting. "The T.M.s Area" by Mr. W. F. Hickox, E.R.D. Film Show.

8 November: "The C.I.D. and Police Organization," by Detective Sergeant Fear, Devon Constabulary.

13 December: Film Show.

10 January: "Automatic Alternative Routing—Traffic and Economic Aspects" by Mr. A. T. Harmston, Telephone Exchange Systems Development Branch, Engineering Department.

17 January: "Satellite Communications" by Mr. D. Wray.

14 February: "S.T.D. and the Non-Director Exchange" by Mr. B. G. Woods, Telephone Exchange Maintenance and Standards Branch, Engineering Department.

14 March: "Subscribers' Installations, Past, Present and Future," by Mr. Downes, Guildford Telephone Area.

11 April: "Overhead Line Practice. Are Our Methods Obsolete?" by Mr. A. F. Turner, London Telecommunications Region.

I would like to record our thanks to all Senior Section members at London, at Regional and at Area Headquarters, and at Barnstaple who have assisted us to re-start the Barnstaple Associate Section.

H.J.H.

Bournemouth Centre

This has been a successful session—visits being made to:

(*i*) Hall and Woodhouse brewery.

(*ii*) Bournemouth Daily Echo printing works.

(*iii*) A lecture on "Telstar," by Mr. D. Wray, at the invitation of the Salisbury Centre.

(*iv*) Mullard's transistor plant at Southampton.

The popularity of our activities is shown by an increase in membership from 54 to 72 during this session.

A.E.A.B.

Swindon Centre

The inaugural meeting of the Swindon centre was held in November when the following officers were elected. *Chairman*: Mr. R. Woodford; *Vice-Chairman*: Mr. D. H. Stephenson; *Treasurer*: Mr. W. J. Waldron; *Secretary*: Mr. A. J. Bevan; *Committee*: Messrs. R. Glastonbury, P. King, G. Emery and A. Furze.

A program of events for 1963 is being prepared.

A.J.B.

Bath Centre

The Television Centre, London, was visited by a party of 10 in May. The lucky 10 were selected from over 30 applicants, by a draw from the hat. The party was led by Mr. J. Moxham and in the evening they attended a recording session of the then new programme "Steptoe and Son."

In June the Centre visited the Port of Bristol and Avonmouth Docks. Dockland in full swing was quite impressive, as were some of the trading statistics—over £4 million worth of tea was stored in a single warehouse; tobacco imports are the highest for any British port; at peak periods a dozen tankers each discharged at the rate of 1,000 tons per hour. The variety of products seen being unloaded was extensive, and ships from all corners of the world were in berth. The wartime pipe-line P.L.U.T.O. terminated at Avonmouth, and the guide gave an excellent historical account of its development and significant contribution to the Allied European victory.

Another "Powell-Parffitt" treasure hunt was held in August, though it was regrettably dogged by stormy weather. The final station was again sited at Peasdown, where all entrants assembled with or without their assorted and improbable collection of "treasures."

A return quiz with the local supervising officers was "fought out" in September. The Assistant Engineers recorded their second successive victory, under the captaincy of Mr. G. E. Smith.

Tribute is due to Mr. R. Darke for his organization of the successful transistor course held in October and November. This was an innovation for the centre and was well supported. Six weekly lectures were given by staff from Bristol University, on the theory and application of transistors. The support for this new venture suggests an extension of such courses in future.

The long-awaited visit to Rootes Group, at Coventry, materialized in November, when 30 members saw the complete assembly of both cars and engines. A stop in the city enabled members to view the new Civic Centre and the renowned Coventry Cathedral.

Even longer awaited was the trip to Esso, Fawley. A week before Christmas the Fawley refinery and the Montague Motor Museum at Beaulieu were visited. At the refinery, an excellent introductory lecture on oil processing proved to be most helpful in interpreting the jungle of pipes and towers. The Esso representative, Mr. Scott, was the ideal Public Relations Officer; it was thanks to his fluent and detailed explanation of the operations involved that the visit was unanimously enjoyed.

D.G.R.

Norwich Centre

At an inaugural meeting on 29 October the Norwich Centre was revived after being dormant since 1952, and the membership quickly rose to 100 before the first meeting, which was a visit to the Miller Organ Company in Norwich, a leading firm in the development of electronic organs. The 28 members present were told of the development of the company and the instruments they make, and of their distribution throughout the world.

After the talks and demonstrations, the meeting broke up into informal groups questioning the company's representatives, Mr. Pitcher and Mr. Lockwood, who revealed their musical talents on the demonstration instruments.

T.H.C.

London Centre

The October talk was given by Mr. W. Lampitt of the Ministry of Works and Public Buildings. Called "The Story of the Museum Telephone Exchange Radio Tower," the talk was illustrated with slides and dealt mainly with the constructional aspect, and described the progress made to that date.

"Communication in the A.A." was the title of the

November talk, given by Mr. D. J. A. Stevenson, Communications Manager of the Automobile Association. Mr. Stevenson covered the activities of the Association from its earliest days, when a few cycling "Scouts" formed the nucleus of the Patrol Service, to the present day, when radio patrols operate in most of the more thickly-populated parts of Britain and in Ireland. He described the complex communications network now in use, and operated a portable transmitter-receiver so that members present could hear "Fanum One," the London transmitter, sending radio patrols to the assistance of stranded motorists in the area.

In December, Mr. J. R. Abrahams of Enfield Technical College, talked about "D.D.D. in the Bell Telephone System." This is the American subscriber trunk dialling system, and Mr. Abrahams gave a general survey of its use in North America, discussed the system generally, and made comparisons with the British S.T.D. arrangements. Illustrated lecture notes were distributed.

The final of the 1961–62 inter-Area technical quiz took place at Fleet Building on 14 November, resulting in a win for the City Area against South-West Area. Traditionally, the winners, supported by the losing finalists, take part in the inter-centre quiz with Brighton; this session the match took place in the Royal Pavilion at Brighton on 11 December. The question master was Mr. A. J. Leckenby, President of the Associate Section and Deputy C.R.E., Home Counties Region. The contest was won by the Brighton team.

The Christmas Dance took place on 14 December, in the Assembly Hall, Fleet Building, to the music of the Leon Sextet. The dance was well supported, and a great success.

The January talk was given by Mr. H. T. A. Sharpe, Area Engineer, City Area. He spoke on "The Progress of Telex," from its earliest days to the present time when it is possible to send a written message round the world. To add emphasis to his words he demonstrated this on teleprinters which had been specially provided by his staff. A short message was sent from a teleprinter on one side of the hall, round the world via landlines, transatlantic cable, radio links, etc., to another teleprinter on the other side of the hall. At the conclusion of his talk interested members of the audience were taken on a conducted tour of the Telex automatic exchange and test room.

"Tape Recording and Some of its Faults" was discussed by Mr. H. J. Houlgate (B.B.C. Engineering Designs Department) in the February talk. He explained the process of magnetic recording in non-mathematical terms, and indicated the contributions to the overall characteristic made by the heads and tape. The talk was illustrated by numerous slides. He emphasized the need for precise adjustment of heads and mechanical perfection of the tape transport, for best results, and ended his talk with a series of recordings illustrating in an exaggerated form many of the most common faults.

E.S.G.

Book Reviews

"Electronic Fundamentals and Applications." J. D. Ryder. Sir Isaac Pitman & Sons, Ltd. xii + 721 pp. 488 ill. 60s.

This is the second edition of Professor Ryder's text book on electronics and brings the first edition up to date with a considerable amount of material on transistors. The book originates from the U.S.A. and is included in the well-known Prentice-Hall Electrical-Engineering Series. The standard is that required for students reading for university degree.

As is to be expected from the title, the book sets out to cover a very wide field, with chapters on electron ballistics, cathode-ray tube, emission, semiconductor and vacuum diodes, power supplies and filters, four-terminal networks, vacuum-tube and transistor control devices, small-signal amplifiers, feedback, audio frequency amplifiers, radio-frequency amplifiers, oscillators, modulation, demodulation, wave shaping, gaseous conduction, power rectification, gaseous control tubes and circuits, and photoelectric devices.

In the text dealing with applications common to both valves and transistors, the author adopts a joint treatment since both have common ground concerned with the study of conduction and charge movement in solids, gases or vacuums.

The treatment of thermionics, valve circuits and valve applications is excellent and extremely comprehensive. The treatment of transistors, while mostly adequate, is not so comprehensive in some cases. Transistor analysis is introduced by a treatment on the properties of four-terminal networks and transistor applications are then included in the subsequent chapters. It is a matter of regret that the various transistor characteristics are presented in non-conventional form to British readers and that the important properties of transistors in regard to switching and pulse applications receive very little treatment.

The chapters on emission, vacuum-tube control devices, amplifiers, modulation, demodulation and wave shaping are excellent and comprehensive, but that on power supplies could well be expanded with advantage to include stabilization.

Each chapter concludes with a set of problems and a list of references, the latter, understandably perhaps, all being from U.S.A. sources.

This is a very useful book for student purposes. It is comprehensive ,and, in the main, the various analytical treatments are very thorough, student requirements clearly being kept in mind. In view of the scope of the book and the high standard of production of the text and diagrams, the price is by no means excessive.

S.W.

"Halbleiterbauelemente—I." Walter Guggenbühl, Dr.Sc. Tech., Max. J. O. Strutt, Dr.Tech., Dr.-Ing. e.h., and Willy Wunderlin, Diph.E.L.-Ing.ETH. Birkhäuser Verlag. 255 pp. 136 ill. 38.50 D.M.

As the authors explain in their foreword, this book is intended to meet the needs of the German reader, in particular for the reader with an engineering background, for a text on the physics, technology and circuit properties of semiconductor devices. About a third of this first volume deals with the physics and preparation of semiconductor materials, and the remaining two thirds mostly with p–n junction diodes, their fabrication and properties. Brief sections on point-contact, selenium and copper-oxide diodes are included, and tunnel diodes are given 15 pages. The treatment of the physical theory and of the related circuit properties is thorough but not long winded, and is well-illustrated by clear diagrams and curves. The sections on technology are brief and largely qualitative.

A second volume is to be devoted to transistors and will include a section on noise in semiconductor devices.

F.R.R.

Staff Changes

Promotions

Name	Region, etc.	Date
Staff Engineer to Assistant Engineer-in-Chief		
Merriman, J. H. H.	E.-in-C.O.	1.4.63
Assistant Staff Engineer to Staff Engineer		
Law, H. B.	E.-in-C.O.	11.2.63
Kilvington, T.	E.-in-C.O.	1.4.63
Senior Executive Engineer to Assistant Staff Engineer		
Rymer, N. B.	E.-in-C.O.	22.10.62
Area Engineer to Regional Engineer		
Jackson, G.	Mid. Reg. to W.B.C.	22.10.62
Area Engineer to Deputy Telephone Manager		
Jalland, K. F.	Scot.	1.10.62
Executive Engineer to Area Engineer		
Young, G.	Mid. Reg. to S.W. Reg.	22.10.62
Smith, J. R. G.	L.T. Reg.	5.11.62
Rolls, A.	S.W. Reg. to Scot.	14.11.62
Burley, N.	N.E. Reg.	21.11.62
Executive Engineer to Power Engineer		
Tarbet, A. G.	Scot.	4.12.62
Executive Engineer to Senior Executive Engineer		
Bellew, T. K. (*In absentia*)	Nigeria	19.10.62
Dowden, B. F.	E.-in-C.O.	5.11.62
Hutter, J.	E.-in-C.O.	12.11.62
Baker, D.	L.T. Reg. to E.-in-C.O.	8.11.62
Roberts, H. E.	E.-in-C.O.	8.11.62
Hatfield, W. D.	E.-in-C.O.	12.11.62
Gambier, D. M.	E.-in-C.O.	21.12.62
Gaut, R. G. (*In absentia*)	War Office	19.10.62
Goodison, H.	E.-in-C.O.	31.12.62
Executive Engineer (Open Competition)		
Jefferis, A. K.	E.-in-C.O.	26.10.62
Skellern, T. R.	E.-in-C.O.	31.10.62
Johnston, C.	E.-in-C.O.	9.11.62
Redington, B. H.	E.-in-C.O.	7.11.62
Uphill, A. J.	E.-in-C.O.	19.11.62
Shurrock, C. R. J.	E.-in-C.O.	26.11.62
Powell, H. J.	E.-in-C.O.	16.11.62
Whitecross, G. L.	E.-in-C.O.	30.11.62
Miller, R. W.	E.-in-C.O.	4.12.62
Assistant Engineer to Executive Engineer		
Jennings, L. T.	S.W. Reg.	22.10.62
Jones, H. L.	H.C. Reg.	1.10.62
Procter, R.	N.E. Reg.	22.10.62
Long, M. C.	S.W. Reg.	15.10.62
Axford, C. J.	H.C. Reg.	1.10.62
Somerville, J. L.	Scot.	19.11.62
Forster, E. L.	N.E. Reg. to E.-in-C.O.	12.11.62
Brown, S. F.	H.C. Reg.	29.10.62
Bayley, M. W.	S.W. Reg. to W.B.C.	5.11.62
Baugh, T. H.	E.-in-C.O.	2.11.62
Cheyney, C. E.	E.-in-C.O.	9.11.62
Howells, A. W.	E.-in-C.O.	19.11.62
Tipple, R.	E.-in-C.O.	29.11.62
Parks, F.	E.-in-C.O.	29.11.62
Cottam, G.	E.-in-C.O.	29.11.62
Gerry, W. E.	L.T. Reg. to E.-in-C.O.	29.11.62
Hilton, C. G.	E.-in-C.O.	29.11.62
O'Dell, S. H. G.	E.-in-C.O.	29.11.62
Tomlin, V.	E.-in-C.O.	29.11.62
Weller, W. F. E.	E.-in-C.O.	29.11.62
Gee, J. H.	E.-in-C.O.	29.11.62

Name	Region, etc.	Date
Assistant Engineer to Executive Engineer—continued		
Meadows, A.	E.-in-C.O.	29.11.62
Mills, C. S.	E.-in-C.O.	29.11.62
Bell, N.	E.-in-C.O.	29.11.62
Gardiner, R.	E.-in-C.O.	29.11.62
Ford, A. E.	E.-in-C.O.	29.11.62
Lees, G. N.	L.T. Reg. to E.-in-C.O.	29.11.62
Bennett, G. H.	E.-in-C.O.	29.11.62
Luff, E. E.	L.T. Reg.	23.11.62
Robinson, T. O.	H.C. Reg. to L.T. Reg.	17.12.62
Sutcliffe, N.	N.W. Reg.	23.11.62
Youens, R. T.	L.T. Reg.	23.11.62
Wheldon, E. V.	Mid. Reg.	26.11.62
Kynaston, W. I.	S.W. Reg.	10.12.62
Salter, F. C.	Mid. Reg.	26.11.62
Rycroft, J.	N.E. Reg.	3.12.62
Marshall, L. C.	L.T. Reg.	23.11.62
Inspector to Assistant Engineer		
Stratford, S.	L.P. Reg.	2.8.61
Otway, J.	W.B.C.	1.10.62
Marsh, E. C. N.	H.C. Reg.	10.10.62
Dewar, C. G.	W.B.C.	22.10.62
Cutts, W. J.	L.T. Reg.	16.10.62
Firth, J. M.	L.T. Reg.	16.10.62
Miles, G. F.	Mid. Reg.	26.11.62
Vicary, W. T.	S.W. Reg.	7.11.62
Hodgkins, C. T.	S.W. Reg.	31.10.62
Penn, L. C.	S.W. Reg.	7.11.62
Nicholson, G.	N.E. Reg.	12.11.62
Whittaker, A.	N.W. Reg.	28.12.62
Technical Officer to Assistant Engineer		
Brown, E. E.	L.P. Reg.	10.1.61
Riches, L. D.	L.P. Reg.	6.2.61
Lock, B. D.	L.P. Reg.	6.2.61
Stevens, B. J.	L.P. Reg.	26.4.61
Plant, F. C.	L.P. Reg.	28.7.61
Ravenscroft, V. C.	L.P. Reg.	29.12.61
Latham, H. S.	L.P. Reg.	29.12.61
Cook, J. A.	L.P. Reg.	25.1.62
Berg, I. W. S.	L.P. Reg.	5.4.62
Carrington, R. M.	L.P. Reg.	5.4.62
Littlewood, N. D.	Mid. Reg.	22.10.62
Garner, D. A.	W.B.C.	1.10.62
McEwan, D.	Scot.	1.10.62
Goodwin, P. W.	L.T. Reg.	1.10.62
Ralph, G. D.	L.T. Reg.	5.10.62
Bishop, P. H. N.	L.T. Reg.	16.10.62
Collins, R. A.	L.T. Reg.	29.10.62
Maddams, J. H.	H.C. Reg.	22.10.62
Leach, P. R.	H.C. Reg.	22.10.62
Tuppen, W. F.	H.C. Reg.	22.10.62
Ridgway, E. H.	N.E. Reg.	1.10.62
Fernell, R. P.	N.W. Reg.	2.10.62
Harper, J. A.	E.-in-C.O.	30.10.62
Jones, R. J.	W.B.C.	8.10.62
Baldwin, K. E. R.	L.T. Reg.	16.10.62
O'Hara, P. R.	L.T. Reg.	16.10.62
Butcher, K. A.	L.T. Reg.	16.10.62
Quinn, K. F.	L.T. Reg.	16.10.62
Burden, S. A.	L.T. Reg.	16.10.62
Heath, P. T.	L.T. Reg.	29.10.62
Johnson, H. G.	N.E. Reg.	23.10.62
Earle, D. G.	N.E. Reg.	23.10.62
Rodger, A. C.	N.E. Reg.	23.10.62
Rogers, A. H.	S.W. Reg.	12.10.62
Taylor, F. W.	E.T.E.	17.10.62
Sneddon, T.	N.W. Reg.	23.10.62
Atkins, N. D.	N.W. Reg.	23.10.62
Hall, W.	N.W. Reg.	29.10.62
Leonard, J. B.	Scot.	22.11.62
Newman, P. E.	L.T. Reg.	16.11.62

Name	Region, etc.	Date
Technical Officer to Assistant Engineer—continued		
Mitchell, R.	H.C. Reg.	5.11.62
Hicks, R. A.	H.C. Reg.	5.11.62
Juffs, R. D.	H.C. Reg.	5.11.62
Larke, J. W.	H.C. Reg.	8.11.62
Walters, L. J. S.	H.C. Reg.	5.11.62
Hawkins, J. W.	H.C. Reg.	8.11.62
Harlow, W. E.	H.C. Reg.	5.11.62
White, J. F. T.	H.C. Reg.	8.11.62
Parker, L. J.	H.C. Reg.	5.11.62
Howard, J.	H.C. Reg.	8.11.62
Currell, B. H. G.	H.C. Reg.	5.11.62
Bandy, B. R. W.	H.C. Reg.	5.11.62
Lambert, F. L.	H.C. Reg.	8.11.62
Calfe, D. J.	H.C. Reg.	8.11.62
Roberts, C. F.	H.C. Reg.	5.11.62
Sharp, J. A.	H.C. Reg.	5.11.62
Wells, P. J.	H.C. Reg.	5.11.62
Pope, M.	H.C. Reg.	5.11.62
Harrison, A. J.	H.C. Reg.	5.11.62
Black, C. I.	H.C. Reg.	8.11.62
Baxter, W. T.	H.C. Reg.	5.11.62
Clarke, E. A.	E.-in-C.O.	28.11.62
Hill, A. J. W.	H.C. Reg.	19.11.62
Smith, J. M. T.	H.C. Reg.	19.11.62
Asplin, I. C.	H.C. Reg.	19.11.62
Brown, J.	H.C. Reg.	19.11.62
Cooper, P. L.	H.C. Reg.	19.11.62
Ovenden, E. J.	H.C. Reg.	19.11.62
MacIntosh, G. H.	H.C. Reg.	19.11.62
Whitmore, T. W.	H.C. Reg.	19.11.62
Garfath, B.	H.C. Reg.	26.11.62
Mercer, R. J.	H.C. Reg.	26.11.62
Graham, G. A.	H.C. Reg.	19.11.62
Collins, C. H.	H.C. Reg.	28.11.62
Honeysett, B. H.	H.C. Reg.	19.11.62
Collier, D.	H.C. Reg.	19.11.62
Wash, J. B.	H.C. Reg.	19.11.62
Hubbard, W. H.	H.C. Reg.	19.11.62
Fenn, M. W.	H.C. Reg.	26.11.62
Smith, T. W. A.	S.W. Reg.	7.11.62
Llewellyn, R. A.	H.C. Reg.	28.11.62
Parsell, D. F.	H.C. Reg.	28.11.62
Sainty, J.	H.C. Reg.	28.11.62
Casey, H. H.	H.C. Reg.	29.11.62
Stainer, R. P. W.	H.C. Reg.	29.11.62
Willbery, J. K.	H.C. Reg.	29.11.62
Bristow, E. W.	H.C. Reg.	29.11.62
Cullon, D. T. F.	H.C. Reg.	29.11.62
Shelton, R. J.	H.C. Reg.	29.11.62
Weait, M. G.	H.C. Reg.	29.11.62
Raffe, P. E. L.	H.C. Reg.	29.11.62
Whittle, O. F.	H.C. Reg.	29.11.62
Hayter, W. J. L.	H.C. Reg.	29.11.62
Tait, P. G.	H.C. Reg.	29.11.62
Rayner, J.	N.E. Reg.	22.11.62
Rennolds, D. M.	S.W. Reg.	31.10.62
Pride, A. F.	S.W. Reg.	1.10.62
Grabham, F. W.	S.W. Reg.	15.10.62
Daw, C. J.	S.W. Reg.	8.10.62
Cattell, T.	E.-in-C.O.	3.12.62
Rolph, J. W.	E.-in-C.O.	3.12.62
Dorey, D. A. S.	H.C. Reg. to E.-in-C.O.	3.12.62
Baker, C.	E.-in-C.O.	3.12.62
Rothery, R. G.	Mid. Reg. to E.-in-C.O.	3.12.62
White, A. J. R.	L.T. Reg. to E.-in-C.O.	3.12.62
Wakeham, B.	W.B.C. to E.-in-C.O.	3.12.62
Lord, R. H.	L.T. Reg. to E.-in-C.O.	31.12.62
McKeown, N. J.	E.-in-C.O.	3.12.62
Crane, J. A.	E.T.E. to E.-in-C.O.	3.12.62
Holloway, H. R.	L.T. Reg. to E.-in-C.O.	31.12.62
Domville, R.	N.W. Reg. to E.-in-C.O.	3.12.62
Songi, J. F.	L.T. Reg. to E.-in-C.O.	31.12.62
Ramsey, D. C.	L.T. Reg. to E.-in-C.O.	3.12.62
Windsor, G. B.	Mid. Reg. to E.-in-C.O.	3.12.62
Tyrell, W.	L.T. Reg. to E.-in-C.O.	3.12.62
Bibbings, P. E.	L.T. Reg. to E.-in-C.O.	3.12.62
Perkins, P. M.	E.-in-C.O.	3.12.62
Andrews, D. A. E.	L.T. Reg. to E.-in-C.O.	3.12.62
Amos, K.	L.T. Reg. to E.-in-C.O.	3.12.62
Chatfield, J. A.	Mid. Reg. to E.-in-C.O.	3.12.62
Whitehall, D. J.	L.T. Reg. to E.-in-C.O.	3.12.62
Barber, W. A. F.	L.T. Reg. to E.-in-C.O.	3.12.62
Kelley, F. E.	L.T. Reg. to E.-in-C.O.	3.12.62
Kelham, R. E.	L.T. Reg. to E.-in-C.O.	3.12.62
Morgan, R. J.	E.-in-C.O.	3.12.62
Cottenham, W. J.	E.-in-C.O.	3.12.62
Pratt, A. D.	E.-in-C.O.	3.12.62
Huck, J. E. J.	L.T. Reg. to E.-in-C.O.	3.12.62
Vickery, A.	E.T.E. to E.-in-C.O.	3.12.62
Dorward, W. G.	E.-in-C.O.	3.12.62
Vincent, D. E.	E.-in-C.O.	3.12.62
Barnes, B. C.	E.-in-C.O.	3.12.62
Risbridger, J. N.	E.-in-C.O.	3.12.62
Worger, S.	E.-in-C.O.	3.12.62
Povall, K. J.	E.-in-C.O.	3.12.62
Simmonds, R. A.	L.T. Reg. to E.-in-C.O.	31.12.62
Owen, G. G.	E.-in-C.O.	3.12.62
Pearce, A. E.	E.-in-C.O.	3.12.62
Wells, A. J.	E.-in-C.O.	3.12.62
Cook, D. G.	L.P. Reg.	11.12.62
Baker, F. J.	H.C. Reg.	19.12.62
Hall, E. R.	E.T.E.	27.11.62
Sadler, M. J.	H.C. Reg.	31.12.62
Hill, R. W. S.	L.T. Reg.	5.12.62
Millard, E. P. J.	H.C. Reg.	31.12.62
Lane, W. A.	L.T. Reg.	5.12.62
Lloyd, S. D.	L.T. Reg.	5.12.62
Hiscox, J. B.	H.C. Reg.	31.12.62
Atkinson, W. H. T.	L.T. Reg.	5.12.62
Carr, C. F.	N.E. Reg.	17.12.62
Palmer, L. A.	H.C. Reg.	31.12.62
Wildman, A. H.	H.C. Reg.	31.12.62
Parker, G. F.	N.W. Reg.	28.12.62
Swinton, J. J.	N.W. Reg.	28.12.62
Johnson, S. R.	N.W. Reg.	28.12.62
Battersby, J.	N.W. Reg.	28.12.62
Elgey, P. G.	N.W. Reg.	28.12.62
Jones, J.	N.W. Reg.	28.12.62
Myers, J.	N.W. Reg.	28.12.62
Legg, K. J.	N.W. Reg.	28.12.62
Draughtsman to Assistant Engineer		
Mason, K.	N.W. Reg.	5.11.62
Barnes, D. W.	E.-in-C.O.	3.12.62
Wilson, A. R.	E.-in-C.O.	3.12.62
Technical Officer to Inspector		
Dyer, J. W.	H.C. Reg.	10.10.62
Wooltorton, J. L.	H.C. Reg.	10.10.62
Plumridge, A. E.	H.C. Reg.	10.10.62
Restorick, S. I.	H.C. Reg.	10.10.62
Pike, J.	H.C. Reg.	10.10.62
Foot, C. J.	H.C. Reg.	10.10.62
Russell, D. J. M.	H.C. Reg.	10.10.62
Keable, J. S.	L.T. Reg.	1.10.62
Whall, E. E.	H.C. Reg.	29.11.62
Ely, E. C.	L P. Reg.	9.10.61
Chatten, G. W.	L.P. Reg.	19.9.62
Packer, N. H.	W.B.C.	30.11.62
Smith, H. M.	W.B.C.	19.12.62
Jones, I. E.	W.B.C.	19.12.62
Stone, E. J. O.	H.C. Reg.	31.12.62
Technician I to Inspector		
Wilson, J.	N.W. Reg.	22.10.62
Cubbon, V. A.	N.W. Reg.	2.10.62
Gedge, T. W. J.	H.C. Reg.	10.10.62
Arnold, A. R.	S.W. Reg.	8.10.62
Orr, J.	Scot.	8.11.62
McCalmont, C. H. H.	N.I.	3.10.62
Hamer, G. H.	H.C. Reg.	29.11.62
Ladd, D.	S.W. Reg.	5.11.62

Promotions—*continued*

Name	Region, etc.	Date
Technician I to Inspector—continued		
Templeton, H. H.	Scot.	3.12.62
Redpath, P.	Scot.	3.12.62
Downing, R. P.	E.-in-C.O.	3.12.62
Leech, R.	N.W. Reg.	30.12.62
Jennings, R. H.	W.B.C.	24.12.62
Keough, L. W.	L.T. Reg.	5.12.62
Ginmon, G. W.	L.T. Reg.	5.12.62
Bailey, L. C.	L.T. Reg.	5.12.62
Phillips, K. G.	L.T. Reg.	5.12.62
Whichelow, G. H.	L.T. Reg.	5.12.62
Blackburn, J. S.	L.T. Reg.	5.12.62
Welham, G. R.	L.T. Reg.	5.12.62
Farrington, S. E.	L.T. Reg.	5.12.62
Goad, T. L.	L.T. Reg.	5.12.62
Fletcher, F. J.	L.T. Reg.	5.12.62
Marsh, D. G.	L.T. Reg.	10.12.62
Pickess, W. J.	L.T. Reg.	5.12.62
Purdy, H. P. L.	L.T. Reg.	10.12.62
Short, H. W.	L.T. Reg.	5.12.62
Price, P. J.	L.T. Reg.	5.12.62
Experimental Officer to Senior Experimental Officer		
Henderson, J. C.	E.-in-C.O.	8.10.62

Name	Region, etc.	Date
Senior Scientific Officer (Open Competition)		
Hill, A. W.	E.-in-C.O.	4.12.62
Experimental Officer (Open Competition)		
Surtees, B. E.	E.-in-C.O.	10.12.62
Assistant (Scientific) (Open Competition)		
Stace, W. E.	E.-in-C.O.	5.12.62
Workshop Supervisor II to Technical Assistant II		
Campion, J. H.	E.-in-C.O.	31.10.62
Leading Draughtsman to Senior Draughtsman		
Hayes, G. A.	E.-in-C.O.	29.10.62
Draughtsman to Leading Draughtsman		
Hodkinson, W. H.	N.W. Reg.	17.9.62
Wright, R. F.	H.C. Reg. to L.T. Reg.	22.10.62
Dicks, A. O.	Mid. Reg.	5.11.62
Marsden, L.	N.W. Reg. to Mid. Reg.	12.11.62
Executive Officer to Higher Executive Officer		
Bugg, G. L.	E.-in-C.O.	15.10.62

Retirements and Resignations

Name	Region, etc.	Date
Deputy Engineer-in-Chief		
Booth, C. F.	E.-in-C.O.	31.3.63
Area Engineer		
Twycross, A. E.	N.E. Reg.	20.11.62
Senior Executive Engineer		
Drew, L. C.	H.C. Reg.	31.12.62
Executive Engineer		
Kidd, C.	E.T.E.	13.10.62
Rolin, F. W.	L.T. Reg.	31.10.62
Hakecost, W. L.	E.T.E.	31.12.62
Bennett, L. A. M. (*Resigned*)	E.-in-C.O.	7.12.62
Assistant Engineer		
Redford, C. J.	L.P. Reg.	26.5.61
Palmer, R. J.	L.P. Reg.	23.7.62
Durban, F. G.	S.W. Reg.	30.9.62
Dalton, C.	N.W. Reg.	1.10.62
Allen, S. H.	H.C. Reg.	2.10.62
Thomas, W. C.	N.W. Reg.	10.10.62
Martin, J. E.	L.T. Reg.	13.10.62
Murphy, M. J.	N.E. Reg.	14.10.62
Bennett, C. T. W.	L.T. Reg.	15.10.62
Ellerbeck, A. J.	W.B.C.	18.10.62
Davis, G.	L.T. Reg.	28.10.62
Horton, A. E. E.	L.T. Reg.	29.10.62
Hunt, A. (*Resigned*)	Mid. Reg.	7.10.62
Davies, R. G.	E.-in-C.O.	31.10.62
Lauwers, A.	L.T. Reg.	15.11.62
Black, A. R. (*Resigned*)	N.W. Reg.	17.11.62

Name	Region, etc.	Date
Assistant Engineer—continued		
Notley, C.	L.P. Reg.	13.10.62
Rogers, B. E.	E.T.E.	6.12.62
Owen, G. I.	Mid. Reg.	10.12.62
Miller, N. W.	N.W. Reg.	18.12.62
Gibson, J.	Scot.	25.12.62
Bailey G. R. (*Resigned*)	E.-in-C.O.	7.12.62
Allcock, P. R. (*Resigned*)	E.-in-C.O.	31.12.62
Inspector		
Allison, J. A.	N.W. Reg.	22.10.62
Knight, J.	H.C. Reg.	24.10.62
Todd, C. G.	L.T. Reg.	31.10.62
Langley, J. M.	N.E. Reg.	31.10.62
King, J. D.	Scot.	3.11.62
Kirkham, C. E.	Mid. Reg.	3.11.62
Read, T.	W.B.C.	11.11.62
Hallsworth, A. C.	L.T. Reg.	17.11.62
Wright, J. W.	E.-in-C.O.	17.11.62
Brown, D. (*Resigned*)	S.W. Reg.	13.10.62
Harding, C. W.	L.P. Reg.	31.1.62
Poulter, R. U.	L.P. Reg.	16.7.62
Prichard, W. H.	W.B.C.	2.12.62
Kingston, F.	N.E. Reg.	16.12.62
McKinnell, T.	N.W. Reg.	30.12.62
Senior Assistant (Scientific)		
Holland, L. (Miss)	E.-in-C.O.	31.12.62
Assistant (Scientific)		
Cowdry, R. W. (*Resigned*)	E.-in-C.O.	30.11.62

Transfers

Name	Region, etc.	Date
Regional Engineer		
Dixon, J.	W.B.C. to N.E. Reg.	1.10.62
Senior Executive Engineer		
Morgan, T. J.	E.-in-C.O. to L.T. Reg.	1.10.62

Name	Region, etc.	Date
Senior Executive Engineer—continued		
Marks, D. J.	E.-in-C.O. to L.T. Reg.	29.10.62
Baker, H.	E.-in-C.O. to Nairobi	26.11.62
Hix, K. W.	Nigeria to H.C. Reg.	17.12.62

Transfers—*continued*

Name	Region, etc.	Date
Assistant Engineer		
Scott, R. J.	L.P. Reg. to H.M. Prison Commission	1.6.61
Berrington, S.	W.B.C. to Nigeria	9.9.62
Stephens, C. T.	Malaya to E.-in-C.O.	1.10.62
Bright, R. D.	E.-in-C.O. to A & PRD	1.10.62
Stock, E.	E.-in-C.O. to Ministry of Aviation	2.10.62
Perry, W. M.	E.-in-C.O. to D.S.I.R.	15.10.62
Nicholls, D. G.	Mid. Reg. to Ministry of Aviation	29.10.62
Lock, D. C. A.	E.-in-C.O. to L.P. Reg.	5.11.62
Carpenter, J.	L.T. Reg. to L.P. Reg.	3.12.62
Peggs, B. D.	E.-in-C.O. to Ministry of Aviation	3.12.62

Name	Region, etc.	Date
Assistant Engineer—continued		
Bates, E. J.	E.-in-C.O. to Mauritius	28.12.62
Tribe, D.	L.T. Reg. to H.C. Reg.	31.12.62
Principal Scientific Officer		
Bickley, H. D.	E.-in-C.O. to Radio Services Department	22.10.62
Motor Transport Officer II		
White, G.	E.-in-C.O. to Approved Employment	12.12.62
Technical Assistant		
Harris, R. T.	E.-in-C.O. to H.C. Reg.	1.11.62
Leading Draughtsman		
Lewis, G. W. F.	L.T. Reg. to H.C. Reg.	8.10.62

Deaths

Name	Region, etc.	Date
Executive Engineer		
Prior, H.	E.-in-C.O.	10.7.62
Worthington, A. G.	E.-in-C.O.	5.9.62
Donaldson, A. L.	N.E. Reg.	22.9.62
Assistant Engineer		
Gurton, K. C. S.	E.-in-C.O.	21.7.62
Carter, A. A.	L.T. Reg.	11.8.62
Sanders, J. P. C.	Mid. Reg.	23.8.62
Henderson, R.	Scot.	20.7.62
MacIntyre, J. M.	Scot.	21.7.62
Gregory, C.	L.T. Reg.	21.9.62
King, G. O.	L.P. Reg.	7.5.61
Moriarty, J. E.	L.P. Reg.	20.5.61
Bond, B. L.	L.T. Reg.	1.10.62
Pickworth, G. L.	E.-in-C.O.	12.10.62

Name	Region, etc.	Date
Assistant Engineer—continued		
Marsh, G. W. C.	L.T. Reg.	28.10.62
Waddon, E. J.	E.-in-C.O.	3.11.62
Hinchley, R. B.	N.W. Reg.	21.12.62
Inspector		
Wade, C. W.	H.C. Reg.	31.5.62
Rabbitts, A. D.	L.T. Reg.	6.10.62
Hall, E. J. B.	N.W. Reg.	25.11.62
Regional Motor Transport Officer		
Dring, G. S.	Mid. Reg.	13.12.62
Leading Draughtsman		
Brandon, T. L.	Mid. Reg.	17.7.62

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* Mr. Gunning is with the Central Electricity Generating Board, and Mr. Schiller was formerly with the Electricity Council.
† Messrs. Brown, Kell, and Thomas are with The General Electric Co., Ltd.

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This volume of the series is entitled 'Variable Resistors and Potentiometers.' The purpose of the series is to enable users to choose the best component for their particular requirements and to understand its fundamental characteristics. This new second edition of volume two provides more data on commercial types of variable resistor and many new types have been added. A new method of summarizing the choice of variable resistors available is given and there is a new expanded bibliography. 45s. net

ELECTRICITY AND MAGNETISM FOR ELECTRICAL ENGINEERS

A. T. Craven

The subject matter of this book constitutes an entirely new approach to the teaching of elementary electricity and magnetism because it attempts to give the student from the very beginning of his studies, a basic understanding of field concepts and fundamental physical concepts, subjects with which the student is usually faced at a later stage and which are the true fundamentals 55s. net

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'This book contains the most complete and detailed description of nomograms and their construction that we have seen and should be read by all those who may be interested in either the practical application or the purely mathematical side of the subject.'—ENGINEERING

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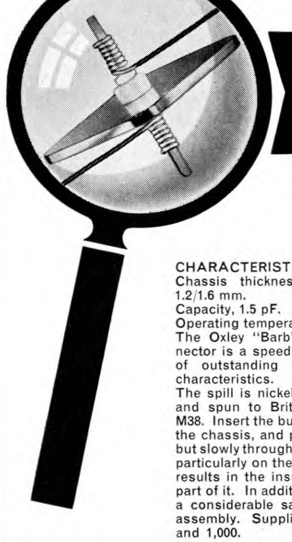

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CHARACTERISTICS

Chassis thickness, 16-18 SWG—048/064"—1.2/1.6 mm.

Capacity, 1.5 pF.

Operating temperature, 55°C—+200°C.

The Oxley "Barb" solderless wrapped connector is a speedily assembled lead through, of outstanding electrical and mechanical characteristics.

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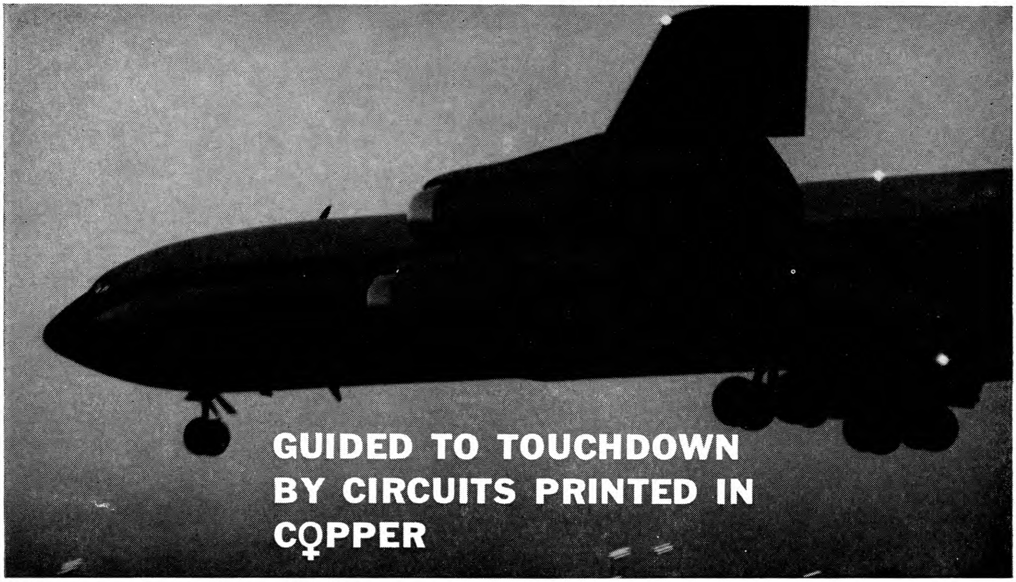


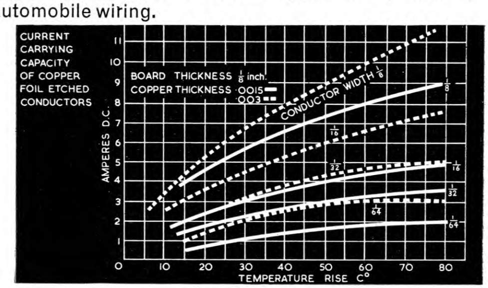
Today's aircraft landing aids—and the radar systems which are their eyes—have their nerve systems printed in copper. Indeed throughout the whole field of electronics today printed circuits are providing, in a planar form, the wiring and the chassis, neatly, compactly and economically. Printed circuits demonstrate the outstanding electrical conductivity of copper in the way connecting ribbons of minute physical dimension can be used to carry considerable currents without heat problems.

The electrolytically deposited copper foil is bonded to the chosen laminate and is usually of one of the following sizes:

Wt. per sq. ft.	Thickness (approx)
1 oz	.0015 in
2 oz	.003 in
3 oz	.0045 in

As the accompanying graph shows the connecting line need be only of the order of $\frac{1}{16}''$ to $\frac{1}{8}''$ wide. For instance, conductors of $\frac{1}{8}''$ width in a one-ounce copper-clad laminate will carry up to 7 amperes with only a few degrees rise in temperature.

It is typical of copper that it should be so closely associated with this up-to-the-minute technique, as it is with so many new developments. These will certainly open wider fields for printed circuits, both in producing complete electronic units in micro-modular form, and in heavier current applications, such as automobile wiring.



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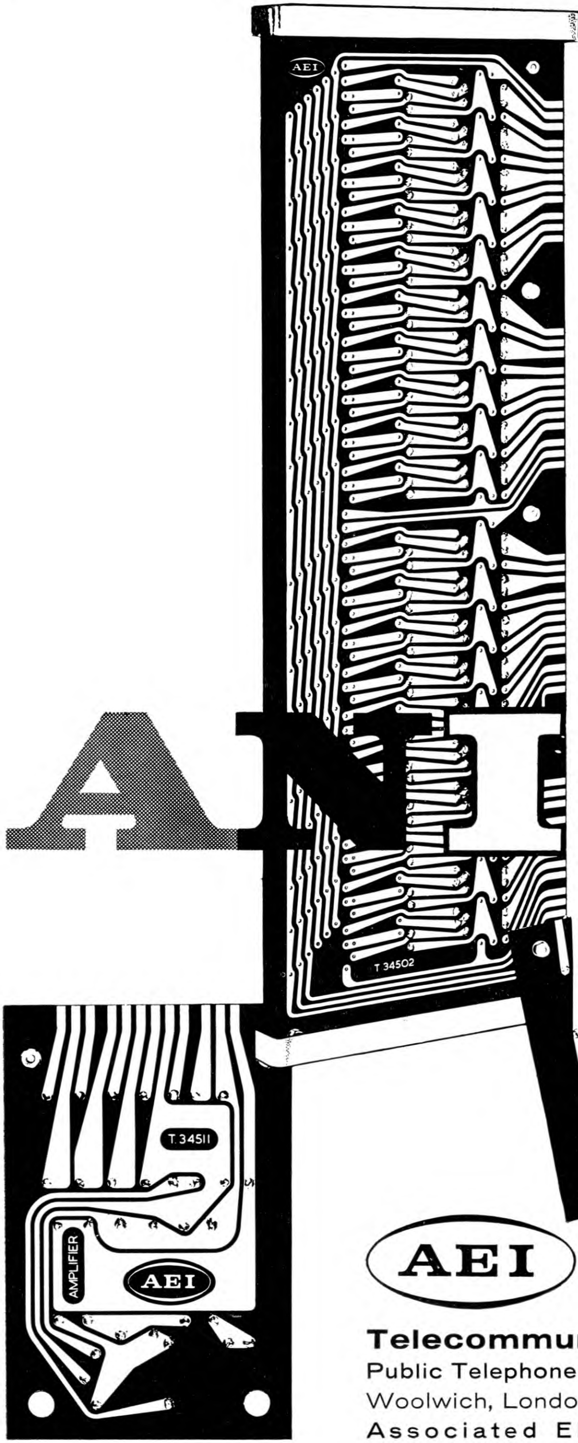
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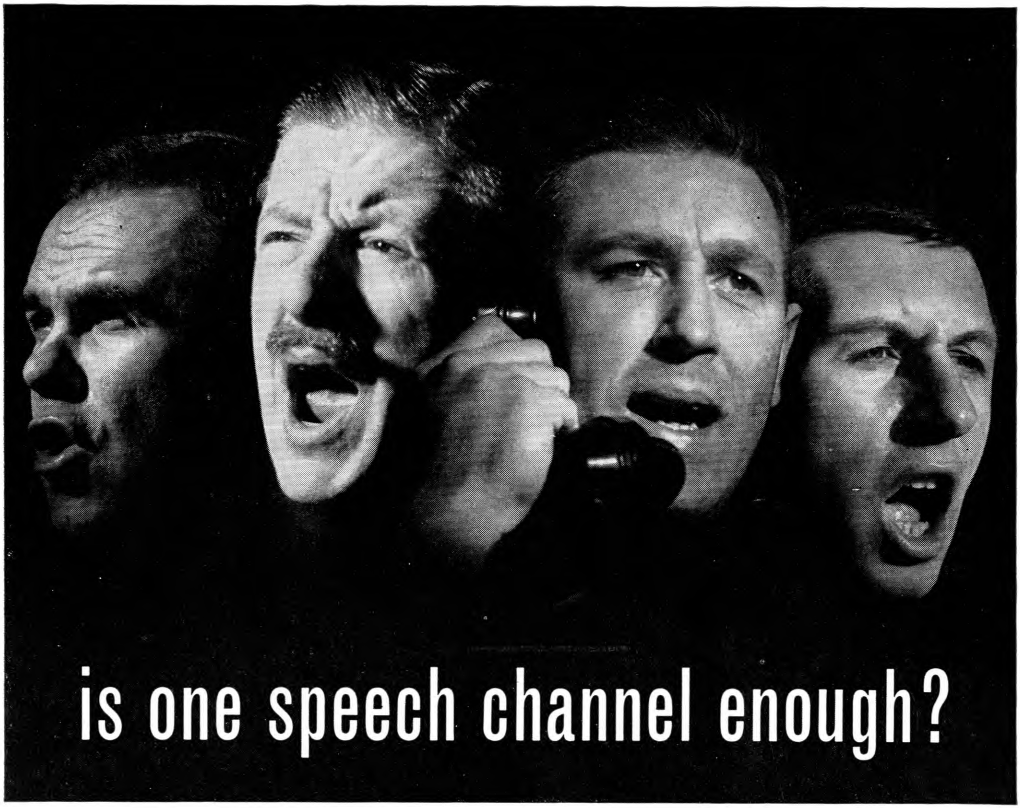

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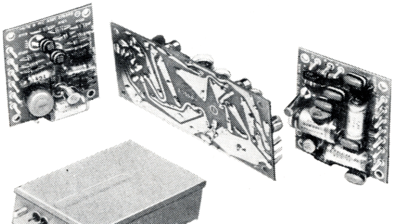

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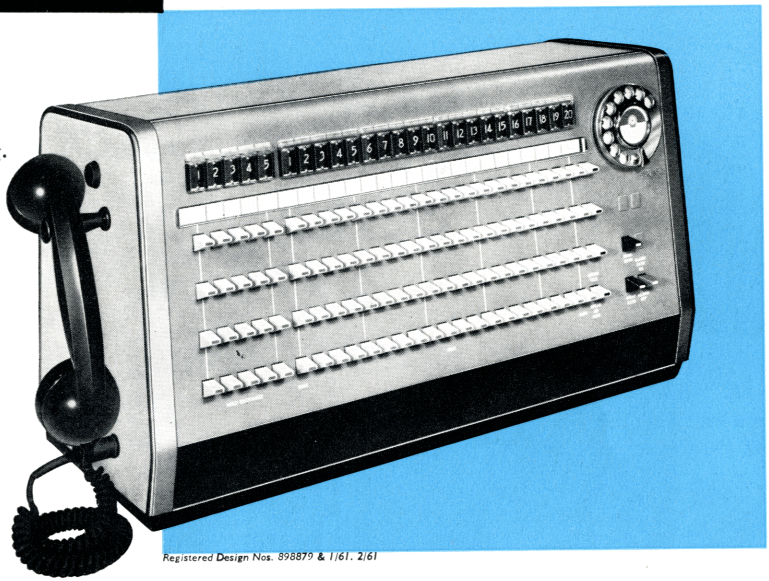

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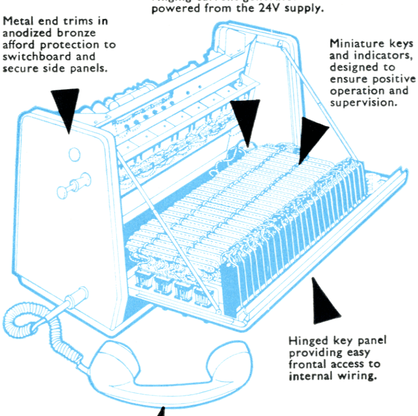

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Can be supplied equipped,
5 exchange lines, 20 extensions, 7 conn. circuits.
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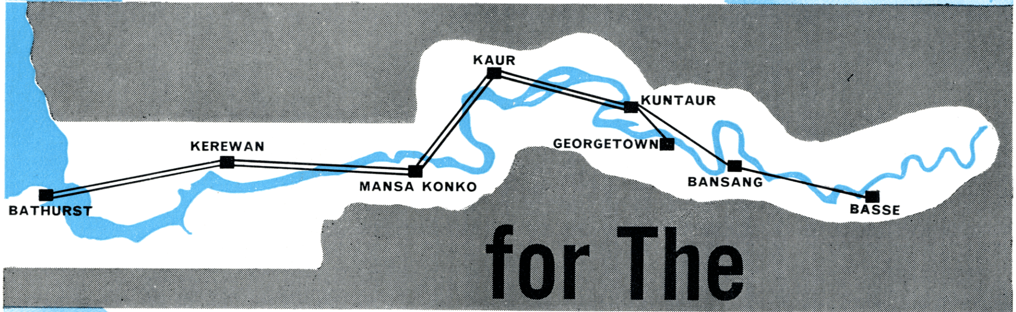

The G.E.C. has supplied a complete radio system for the Department of Posts and Telegraphs of The Gambia to provide speech and telegraph communications between Bathurst and Basse with six intermediate stations each having full communication with the system. The equipment used is G.E.C.'s well-proven 5-circuit junction radio equipment, and the contract was awarded to G.E.C. by the Crown Agents for Oversea Governments and Administrations on behalf of the Gambian Administration. The consultants for the project were Messrs. Preece, Cardew and Rider.

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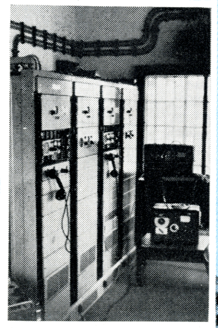

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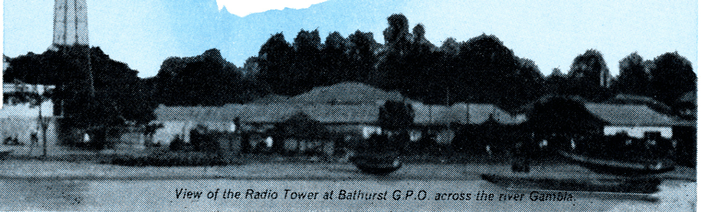

View of the Radio Tower at Bathurst G.P.O. across the river Gambia.

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The Mullard Equipment Limited T.O.R. is a completely new, *fully transistorised* system for the detection and correction of errors due to propagation problems or other interference in Telegraph signals passed over radio circuits. The first transistorised equipment of this type to be in full-scale production in this country, the SL65 offers low power consumption and also a considerable saving in space and maintenance costs.

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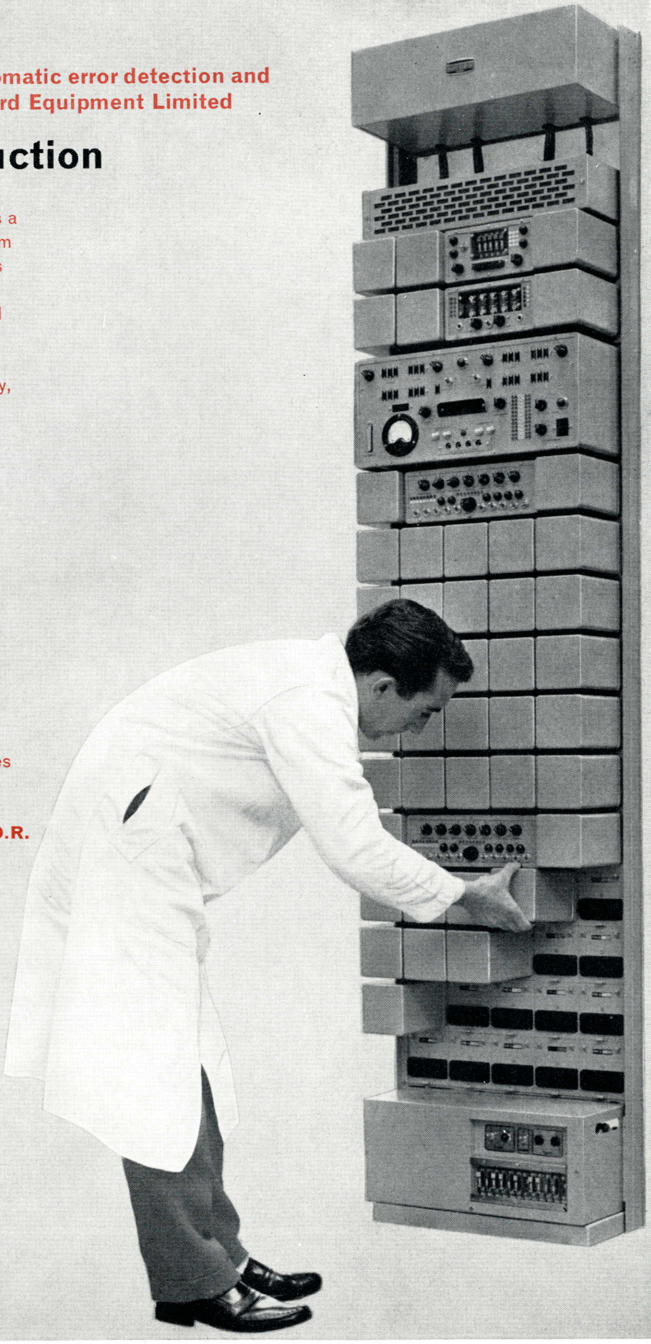
For full operational details on the T.O.R. write for publication No. 9876 quoting reference A6964



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Type 56 transistored channel equipment at Faraday Building.

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G.E.C. transistored channel equipment in Type 56 construction is available in two forms, one for use with separate signalling equipment and the other with built-in out-of-band signalling. The G.P.O. alone has ordered **26,700** channel ends for use with separate in-band signalling equipment, and of this quantity more than **11,800** channel ends are already installed. A nine foot high rackside accommodates 72 channel ends without signalling or 60 channel ends with signalling. *For further information please write for leaflet, SPO. 3006.*

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for frequencies

UP TO 200 Mc/s

Specially selected high-stability resistors make these attenuators extremely accurate precision instruments

74600 type attenuators – up to 100 Mc/s

Models available covering insertion loss ranges:
0 to 0·9 db in 0·1 db steps
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0 to 90 db in 10 db steps
with a characteristic impedance of 50 or 75 ohms

74633 type attenuators – up to 200 Mc/s

Models available covering insertion loss ranges:
0 to 9 db in 1 db steps
0 to 90 db in 10 db steps
with a characteristic impedance of 75 ohms

also available **74615** and **74616** attenuators
operated by rotary switches and having an insertion loss range: 0 to 100 db in 0·1 db steps
74615 has a characteristic impedance of 75 ohms and is for use at frequencies up to 5 Mc/s
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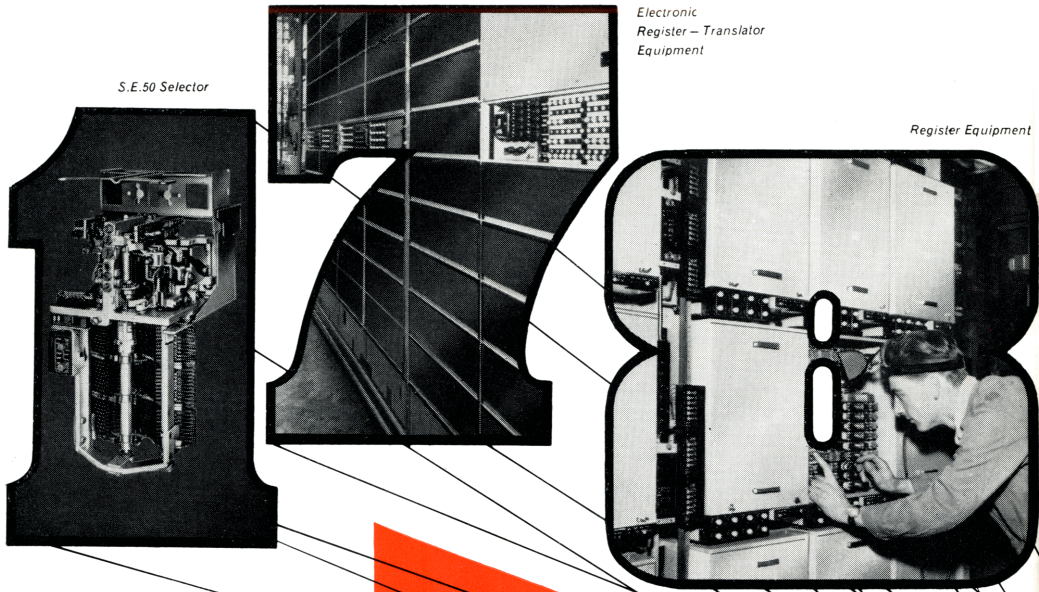

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Since supplying equipment for the first subscriber trunk dialling exchange in the United Kingdom at Bristol, G.E.C. has received orders for STD equipment for 178 exchanges—another example of the vital role played by G.E.C. telephone exchange equipment in the essential field of telecommunications. In addition, countries as far from the United Kingdom as Malaya and Nigeria have opened STD services using G.E.C. equipment. G.E.C. Telephone Exchange Systems are complete, compatible, comprehensive, fully flexible, reliable and simple to service . . . 'as modern as tomorrow', thanks to constant research and development.

The majority of the world's telephone exchanges use step-by-step systems.

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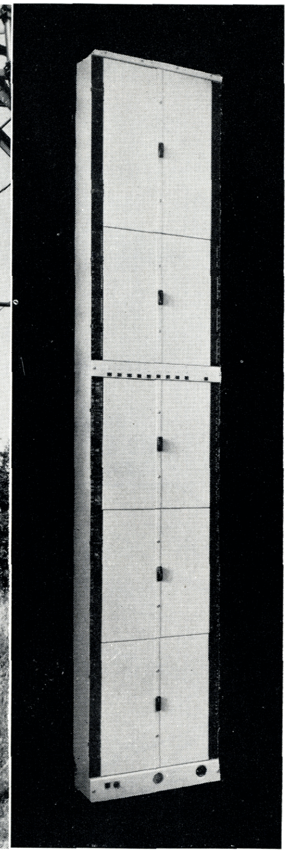
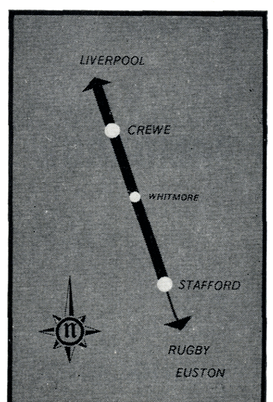


By courtesy of London Midland Region

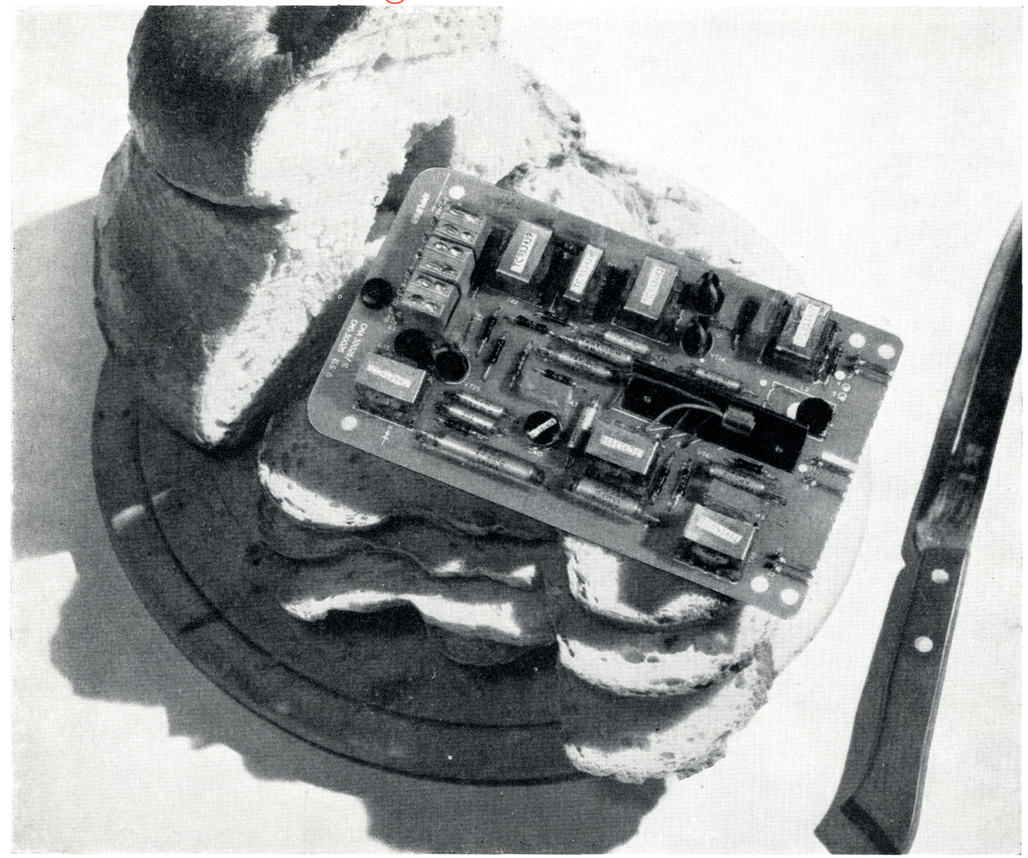
A T & E Type CM carrier equipment has again been chosen by London Midland Region for their general electrification programme — Crewe/Stafford section.

The equipment, which will provide all the necessary channel modulating, frequency generating and out-band signalling, is designed for operation over a composite cable. Three groups of twelve channels, terminated at Crewe, operate over separate carrier pairs via repeaters at Whitmore. Two groups terminate at Stafford, whilst the third passes on via repeater at Stafford.

AUTOMATIC TELEPHONE & ELECTRIC COMPANY LIMITED



it's the filling that matters...



TYPE CM CARRIER

A T & E Type CM Carrier Equipment offers substantial saving in prime and operating costs whilst taking full advantage of the small size and proven reliability of modern components. Thus conventional methods have been discarded in favour of an advanced card mounting printed circuit technique. The result is a compact, reliable system with up to 90% power saving over equivalent valve equipment. A T & E Type CM Carrier Equipment has been chosen by British and overseas railways, and by other organisations, for microwave, open-wire and cable carrier communications.

*Fully transistorized *Plug-in printed circuit cards *Mains or battery operation *Optional in-built out-band 3825c/s low or high level signalling for ring down or dialling *Suitable for extension to existing valve equipment *Up to 96 channels per rackside *Easy accessibility *A third of the size of an equivalent valve equipment.

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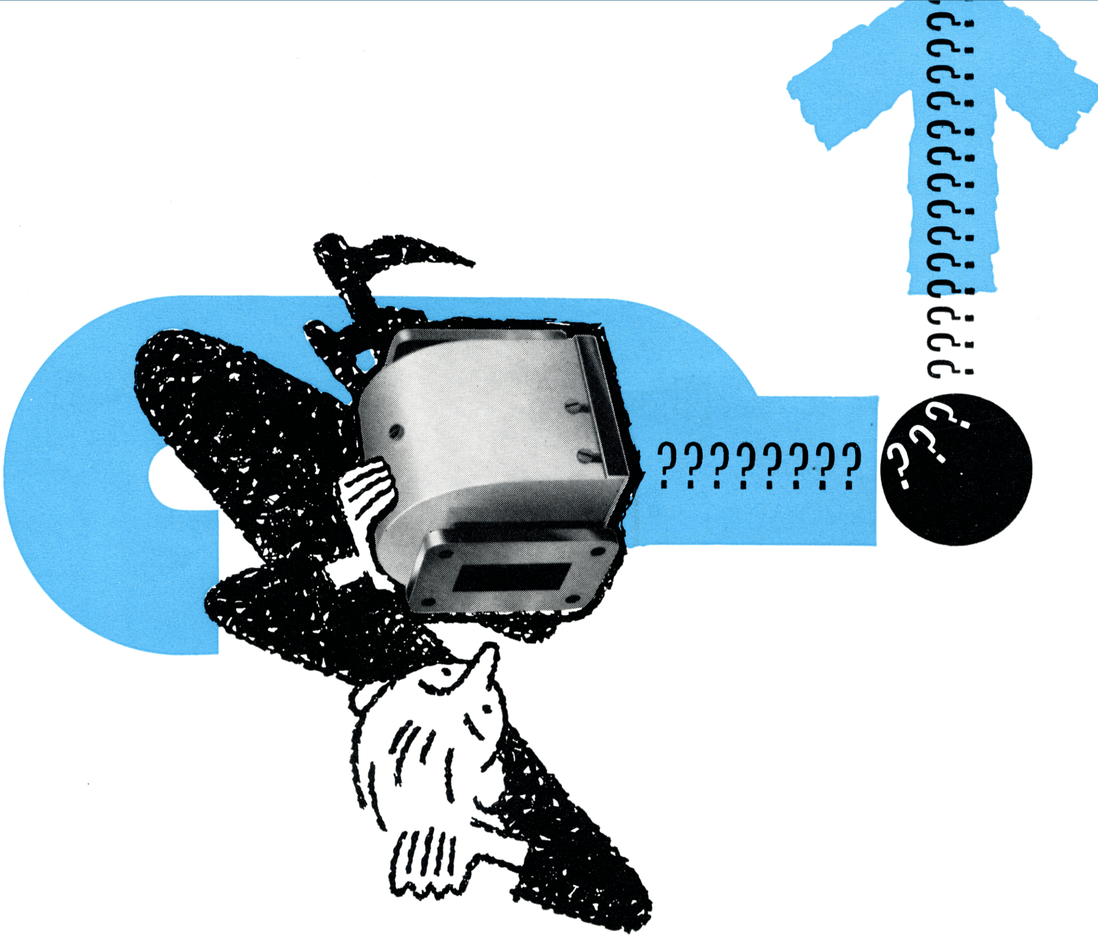

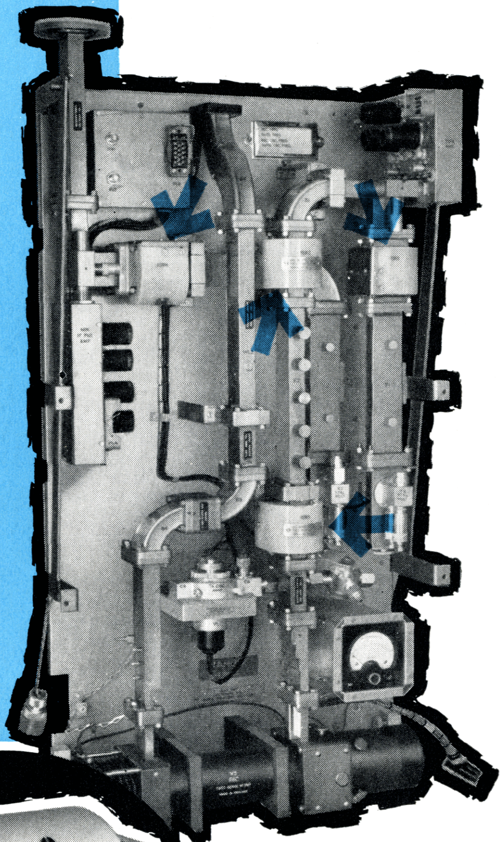

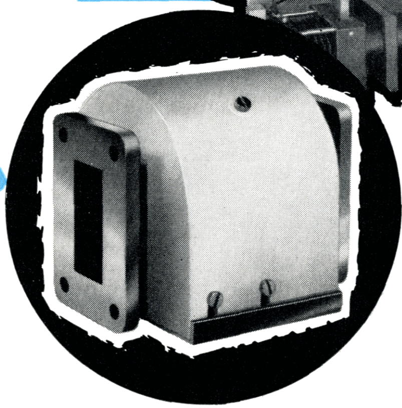

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is a RESONANCE ISOLATOR used in the G.E.C. S.H.F Transmitter/Receiver

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The isolator is a wideband non-reciprocal device giving low attenuation in one direction and high attenuation in the other. It consists of a short length of waveguide with a number of ferrite rods placed in a static magnetic field provided by a permanent magnet. These devices are employed as interstage isolators in the SHF circuitry where good impedance match is essential for optimum performance. The use of these isolators eliminates the need for any adjustment of the SHF circuits during maintenance even when replacing the travelling wave tube.

Transmission Division

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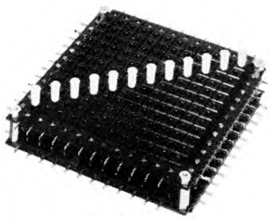

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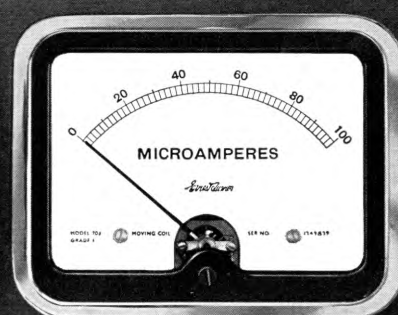

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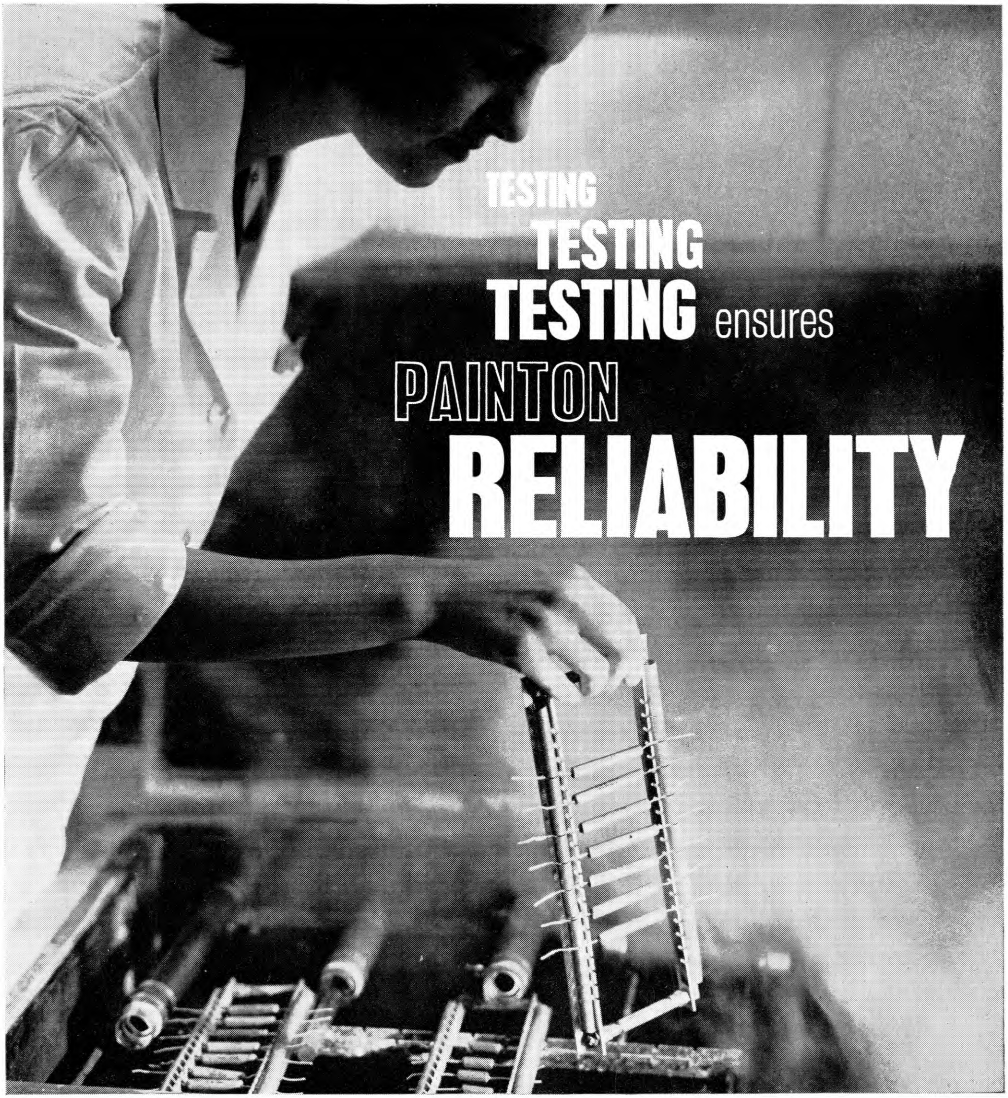
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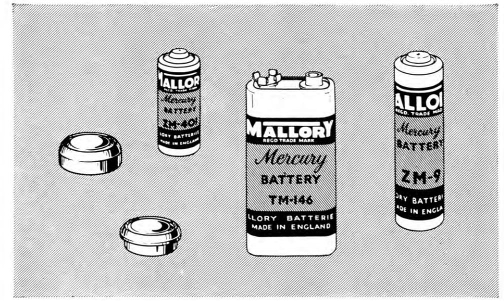
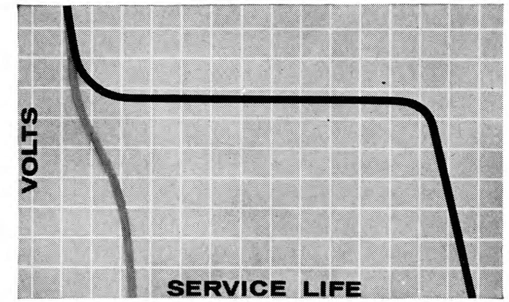
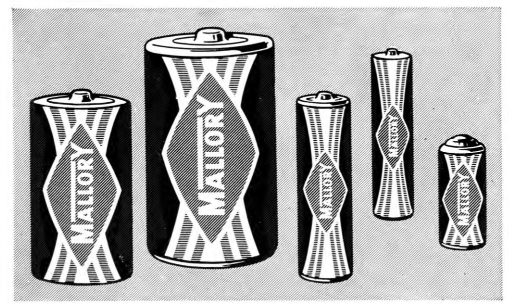
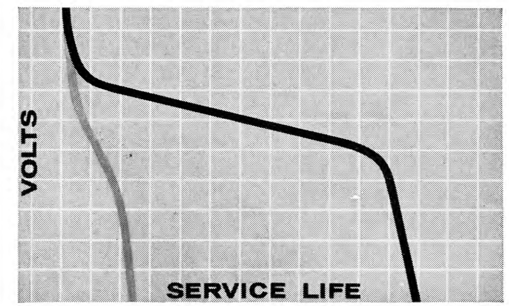




MALLORY MERCURY BATTERIES have the capacity to put lasting power into small spaces, the ability to deliver it without rest at a *constant* voltage level, the strength to withstand extremes of temperature, pressure, mechanical shock. They make even sub-miniaturisation possible with transistorised equipment.





NEW MANGANESE ALKALINE standard size batteries with *at least 3 times more life* for low, moderate and high drain applications. They're fade-free, leak-proof, need no rest even at elevated temperatures. Manganese Alkaline batteries add powerful customer appeal wherever they are fitted—in cameras, 'cordless' shavers, radios, tape recorders, in flashlights, toys and games.

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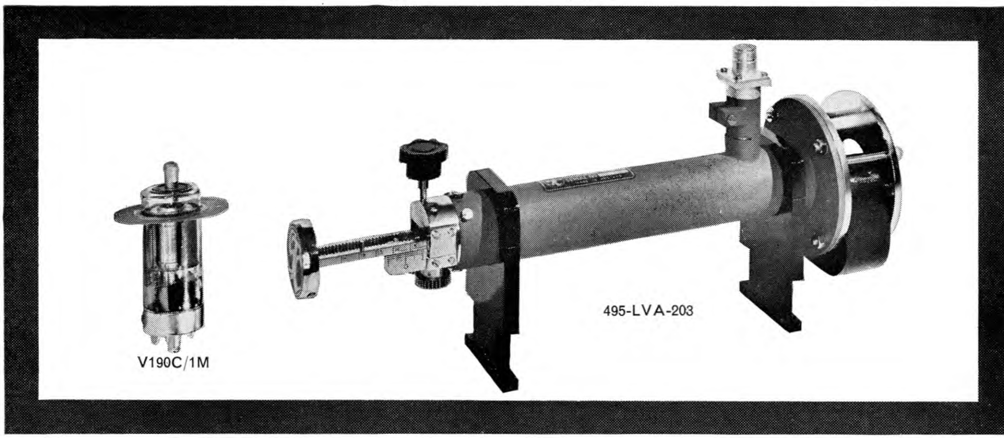
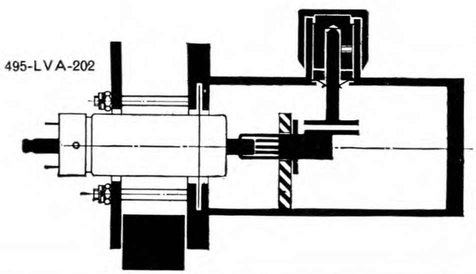


BANDS IV & V

Coaxial line oscillators have the high frequency stability and efficiency associated with the multi-resonator Klystron combined with the advantage of having only one cavity to tune. For Type V190C/1M, which operates in L-Band, this cavity normally takes the form of a coaxial line which is an extension of the resonator structure within the tube.

A cavity of this nature is simpler and easier to use than that required with UHF triode valve. Also, frequency modulation can be easily effected by varying the drift tube voltage of the coaxial line valve.

The performance of the tube is determined by the cavity in which it is used and type 495-LVA-202, which is a compact capacitance-loaded coaxial type, enables it to cover BANDS IV AND V.



V190C/1M ABRIDGED DATA

CAVITY		**495-LVA-202**	**495-LVA-203**	**495-LVA-203A**
Frequency	Mc/s	500—925*	800—1100	900—1250
Output	W	0·3—1·0	2	2
Resonator voltage		280	> Drift tube voltage	150—400
Drift tube voltage		75—250	150—400	150—400
Electronic tuning	Mc/s	4	3	—
Screen voltage	V		Adjusted for beam current	
Beam current	mA	45	70	70

**Type 495-LVA-202A tunes from 515 to 1015 Mc/s*

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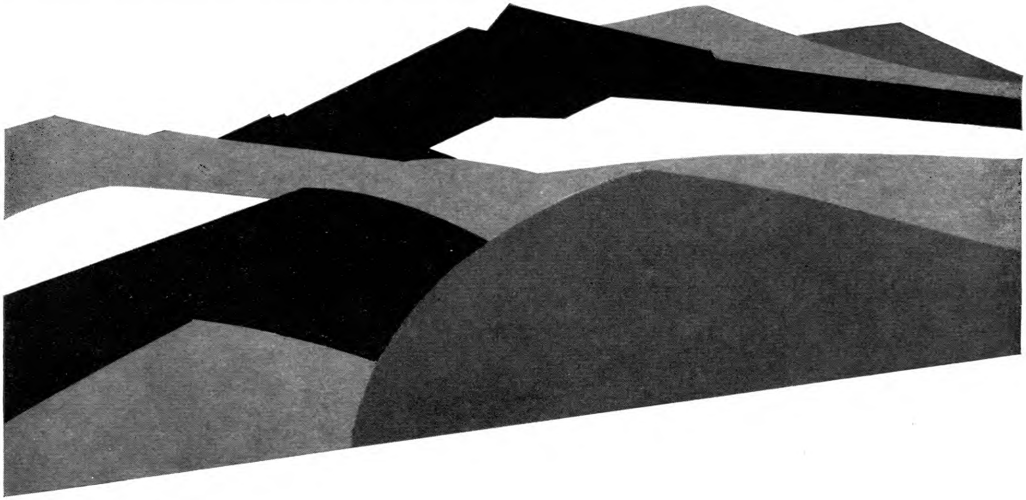
63/14MS

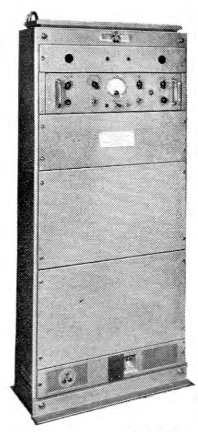
Improved 'Rural Radio' for versatile Cross-Country Communications



Type 800 UHF/VHF Radio Telephone Systems

The Type 800 single channel radio telephone system is an improved version of the well-known AT&E 'Rural Radio' and offers substantial economies both in installation and maintenance costs wherever the terrain prohibits the use of cables or overhead lines. The equipment is completely compatible with the existing range of AT&E telephone equipments, and signalling and relay sets are available which permit suitable termination of virtually any type of telephone, exchange or switchboard.
The equipment is contained in a single terminal rack and operates in the UHF and VHF bands with a maximum frequency of 500 Mc/s. The power output ranges from 6 watts to 150 watts according to requirements. The equipment is narrow band apparatus and high stability performance permits operation on adjacent channels spaced only 25 kc/s apart. Normally the use of aerial diplexers permits single aerial operation.
The Type 800 equipment is just one of a wide range of communication equipments built by AT&E, who also offer a comprehensive planning, surveying and installation service.
If you would like more details, please write to:

AT&E (Bridgnorth) Ltd · Bridgnorth · Shropshire · England



ATE(B)1

LOW BUDGET
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with the NEW MARCONI
AUTOSPEC

AUTOMATIC SINGLE PATH ERROR CORRECTION

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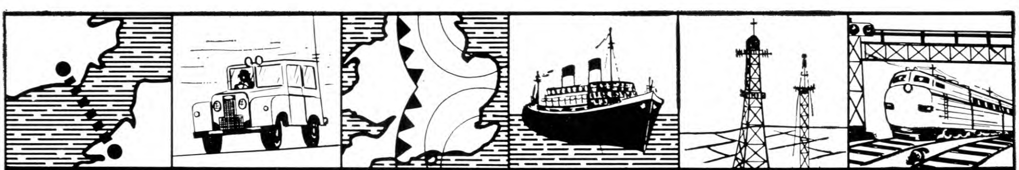
AUTOSPEC is the first single path error corrector to include automatic correction without the need for repetition

AUTOSPEC is a product of the same design team responsible for the production of the world famous AUTOPLEX



MARCONI'S WIRELESS TELEGRAPH CO. LIMITED · CHELMSFORD · ESSEX · ENGLAND

TRANSISTORIZED WAVE ANALYSER 74199-A SLMS

This is a portable transistorized set for making frequency selective level measurements in the audio-frequency range. It measures over an extremely wide level range and is capable of analysing the harmonic performance of audio circuits.

ABBREVIATED TECHNICAL DATA

Performance

Frequency Range:
30 c/s — 19 kc/s.

Measuring Range:
Through and terminated levels on balanced and unbalanced 600Ω circuits:-

As a selective receiver: +25 dbm to — 95 dbm.

As a harmonic analyser: Measures discriminations up to 60 db.

Dimensions & Weight

$16\frac{3}{4}$ x 13 x $6\frac{3}{8}$ in. (425 x 330 x 162 mm)
21 lb (9,6 kg)

63/1CT

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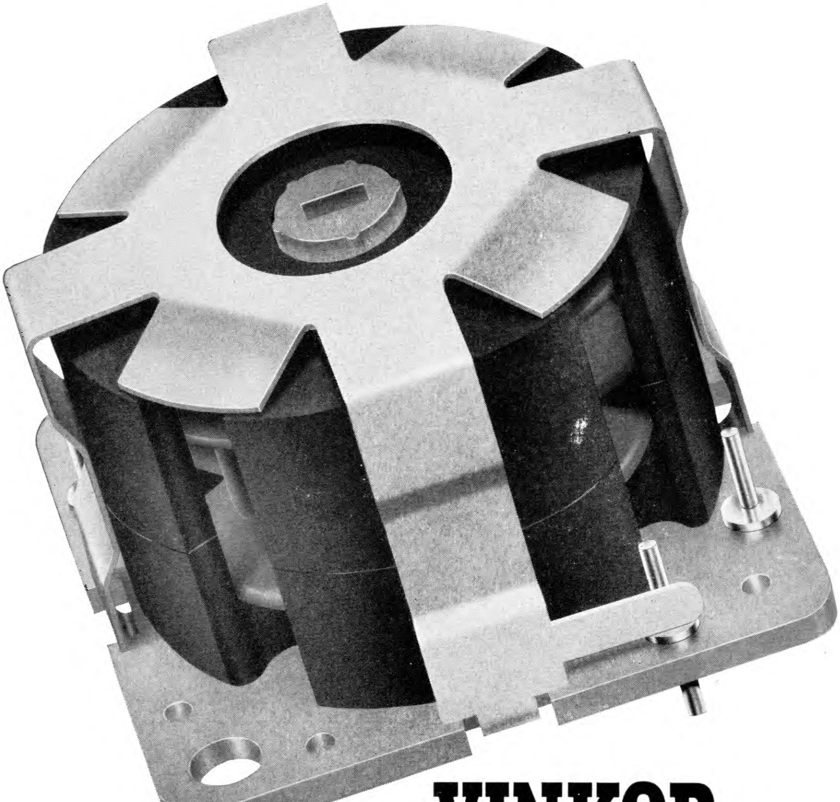
Standard Telephones and Cables Limited
TRANSMISSION SYSTEMS GROUP
North Woolwich · London, E.16
Telephone ALBert Dock 1401 · Telex 21645



VINKOR-

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SAVES SPACE—One-third reduction in height

SAVES WEIGHT—Approx. 50% reduction

SAVES TIME—Easier assembly

SAVES MONEY—Simplified construction

Vinkors with the new clip mounting are offered as an alternative to the standard range of Vinkors.

The new clips show a marked reduction in both size and weight and are ideal for applications requiring a simple but effective mounting arrangement.

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Full technical details of both clip and standard housing Vinkors are available on request to Mullard House. Please quote reference Z/1004/4

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MC1004

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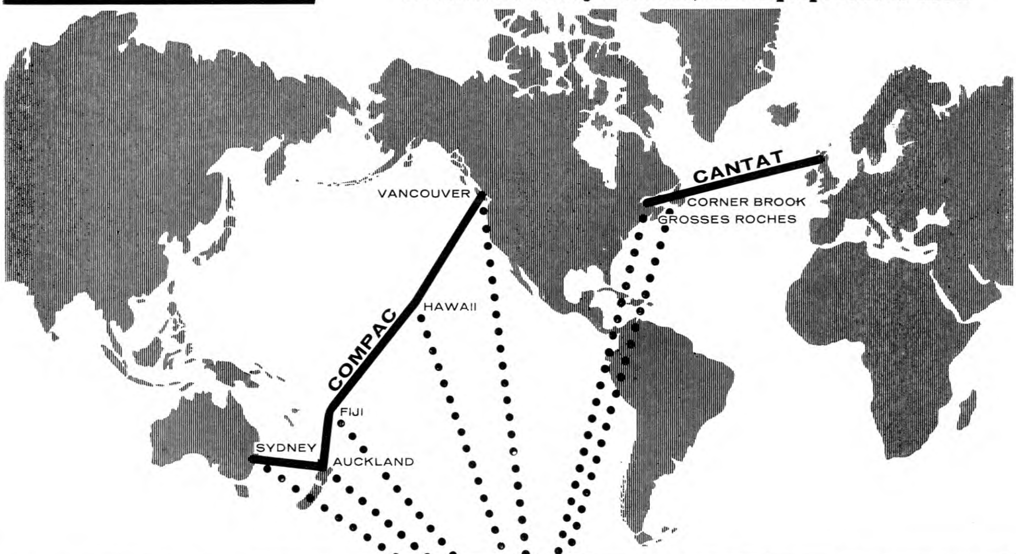
EXPERIENCE SPANS THE WORLD

For more than a century the Telecommunications Division of AEI has played a part in pioneering major telecommunications projects and has to its credit technical achievements of the highest order in this very specialised field. Since its formation in 1935, the Transmission Department has supplied and installed a wide range of multi-channel telephone and telegraph systems to administrations throughout the world.

It is this background of experience, gained over the passage of a hundred years, that has enabled AEI and Submarine Cables Ltd to contribute towards the success of the round-the-world cable scheme, first with CANTAT and now with COMPAC.

When reliability matters, AEI equipment is used



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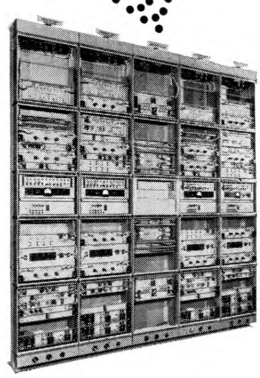


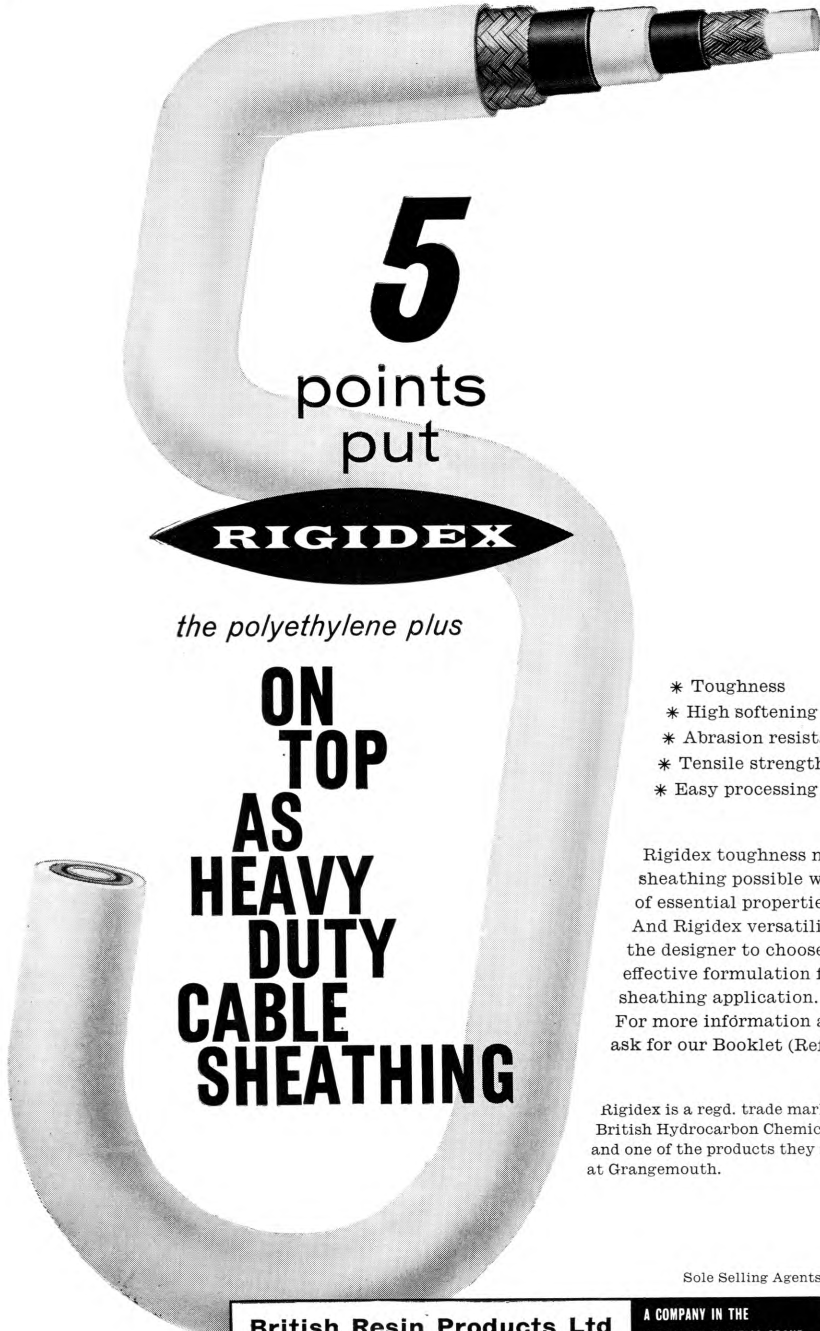
DIRECTIONAL FILTER AND CABLE-FREQUENCY TRANSLATING EQUIPMENT

AEI

Telecommunications Division

Transmission Department
Woolwich, London SE18

Associated Electrical Industries Limited



STC LIGHTWEIGHT HEADSETS, designed for use by private and public telephone operators and approved by the British Post Office, are fast superseding the use of the older breast type instruments.

The main advantages of this STC product are extraordinary light weight, a high degree of comfort, stability and manoeuvrability and constant level of transmission regardless of head movement. The headsets are made in black, grey or ivory nylon plastic which is virtually unbreakable.

The "Rocking Armature" principle—an important STC development in telephone receiver design—which gives improved sensitivity and frequency response has been incorporated into these instruments.

Write for leaflet D/104

Standard Telephones and Cables Limited

TELEPHONE SWITCHING DIVISION

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Published by *The Post Office Electrical Engineers' Journal*, G.P.O., 2-12 Gresham Street, London, E.C.2
and printed in Great Britain at The Baynard Press by Sanders Phillips and Co., Ltd., Chryssell Road, London S.W.9

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Soldering Instruments for Vital and Exacting Work

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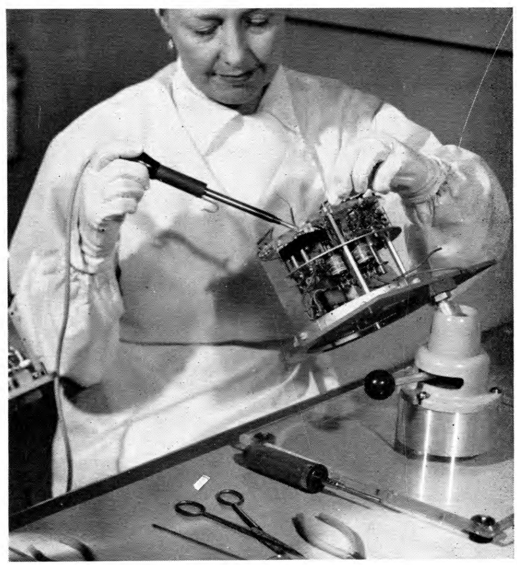

Photograph by the courtesy of Submarine Cables Ltd.

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