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A Monitor for 7-Unit Synchronous Error-Correcting Systems for Use on Radio-Telegraph Circuits

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A monitor for measuring the character-error rate on working radio-telegraph circuits using 7-unit synchronous error-correcting codes has been developed and, after tests in the field, has been found to be satisfactory. A new style of unit construction has been employed which makes optimum use of the volume available for components and which materially reduced the amount of time taken in the construction and wiring of the circuit elements.

INTRODUCTION

IT has been shown[1] that the performance of a radio-telegraph system is best described in terms of the element-error rate. Unfortunately, the direct measurement of element-error rate on a working radio-telegraph circuit is not possible without accurate knowledge of the signal as transmitted. Field trials of working radio-telegraph systems are, therefore, of necessity conducted by comparing the performance of the system under test with that of a system working under the same conditions and whose performance is already known. Hitherto, this has been done by direct inspection of the printed copy at the telegraph terminal, but this is a cumbersome procedure and a simpler and more reliable system was required.

The great majority of long-distance radio-telegraph circuits carry time-division multiplex systems using error-correcting codes, and these systems require complex and expensive equipment to separate the channels and operate the automatic error-correcting equipment located at the telegraph terminal. In previous tests this equipment has been used either to permit errors to be observed from inspection of the printed copy, or to permit errors to be counted by observing the incidence of the special signal that is sent out when an error is detected.

To conduct a thorough field trial on this basis requires a large number of persons, and involves the use of v.f. channels between the radio station and the telegraph terminal as well as the multiplex equipment. Furthermore, since these trials are usually continued over a protracted period, changes of shift staff are probably involved at the terminal and this makes it very difficult to secure the precise co-ordination of effort that is essential if the trials are to be productive of useful information. Experience has shown that very often when the results are finally analysed it is very difficult to separate those errors arising from the transmission and those caused by faulty liaison between the various parties involved in the trials. If, therefore, it were possible to design a simple unit that could be connected to the output of a radio-telegraph receiver and which would read the number of characters in error in a known total number of characters sent, the whole procedure for conducting these trials would be much simpler and less liable to inaccuracy.

Such a device could also be of considerable value to the radio-station staff as a monitor for observing the grade of service on the working systems. With these requirements as a basis, the design of a monitor was undertaken which would comply with the requirements of the majority of 7-unit error-correcting systems in use. Fig. 1 shows the external appearance of the unit, which was designed to be compact, self-contained and portable.

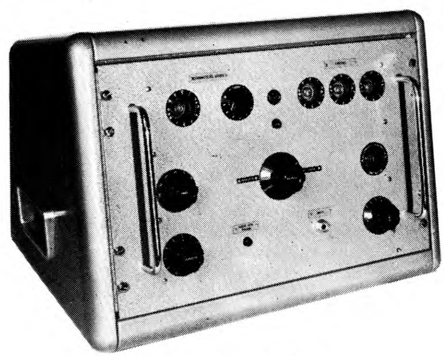

FIG. 1—THE MONITOR UNIT

DESIGN REQUIREMENTS

The time-division multiplex systems at present in use which operate using the 7-unit error-correcting code are divided into three groups. The first group consists of 2-channel character-interleaved systems operating at an

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aggregate telegraph speed in the range 85–100 bauds. The second group includes 2-channel element-interleaved systems also working at an aggregate speed of 85–100 bauds. The third group consists of 4-channel systems using a combination of character and element interleaving which have an aggregate speed in the range of 170–200 bauds. The monitor unit should be capable of use on all of these systems.

The terminal equipment that separates the channels and operates the error-correcting system involves a fairly complex system of speed control to keep the receiving equipment in synchronism with the transmission. In addition, the distributor which separates the channels acts as a regenerator and gives the system a margin of about 48 per cent. The monitor must also run in synchronism with the transmission, and regenerate the signals. Both the synchronizing circuit and the regenerator should, however, be as simple as possible if the equipment is to be portable. Subsequent to regeneration, it is necessary to detect the errors in the transmission, and this is done by checking the 3:4 mark-to-space relationship in each of the 7-unit characters. A more detailed description of the operation of these error-correcting systems is given elsewhere.[2]

Of the different kinds of error-correcting systems in use, the majority at the present time are 2-channel character-interleaving systems, and so it was decided to design the monitor in the first place to operate on this system and then to see how it could be adapted to work on the other and less commonly-used systems.

Considering a 2-channel character-interleaved system, the two channels (known as A and B) are identified by the polarity of the elements. The A channel is usually sent "erect," i.e. positive polarity for mark elements, and the B channel is "inverted," i.e. negative polarity for mark elements. In the monitor unit there is a common error-detecting circuit that inspects each of the two channels for the 3:4 relationship and so one of the channels must be inverted before it is checked for errors. This is done in a unit called the "commutator" which accepts all the A channel signals as they are but inverts B channel signals. By this means the ratio of positive to negative elements in both channels is 3:4, and a common error detector will work satisfactorily. This ratio is checked by means of a counter which closes a gate if three positive elements are received in any train of seven. If more or less than three are received, the gate will not close. The closing of this gate prevents a pulse, generated at the end of every seventh element, from reaching the error counter. The error detector will operate correctly only if the regenerator is correctly synchronized with the speed of the incoming transmission, and if the element examination is so phased with respect to the incoming elements that it checks the 3:4 ratio starting from the first element of each character. These two operations are commonly referred to in telegraph parlance as "synchronizing" and "phasing," but the more general expressions used in digital technique are "digit sync." and "frame sync.," respectively.

The necessity for the maintenance of digit sync. and frame sync. means that controls must be provided which enable the regenerator to be synchronized accurately with the speed of the transmission, and that the error detector is provided with an arrangement which will enable it to operate from the first element in each character.

With regard to digit sync., the difficulty arises that at the receiver the instants of modulation of the telegraph signals are displaced from their correct time relationship not only by speed difference between the transmission and the regenerator but also by telegraph distortion arising from fading and interference on the radio signal. The first of these effects is likely to be a steady difference in speed, either fast or slow, whereas the second is a random effect. The only way of controlling the speed of the regenerator is by inspection of the instants of modulation and interpretation of their displacement from the correct time as a speed error. If this alone were done a continuous succession of slow and fast correction pulses would be given as a result of fading. It is, therefore, necessary to adopt some system of integration so that these random effects are smoothed out and only the steady effects due to true errors of speed are allowed to affect the timing of the regenerator.

Considering frame sync., it would be ideal if the apparatus could automatically find its own frame sync. and, once having found it, maintain itself automatically in this condition. If this is not possible then the finding of frame sync. should be made semi-automatic, i.e. the apparatus should hunt for frame sync. on operation of an "auto-phase" button and once having found it the frame-sync.-control function should be inoperative until the button is again operated.

In semi-automatic frame-sync. conditions the stability of the unit is then the stability of the oscillator or multivibrator controlling the regenerator. On the error-correcting equipment, where the finding of frame sync. is usually a long process requiring the co-operation of both terminals, it is usual to provide very stable oscillators that can be relied on to maintain synchronism over a period of up to 15 minutes without correction. Under these conditions the equipment will hold both digit sync. and frame sync. during periods of interruption of the transmission and will not require frame sync. to be established again when transmission is resumed. With the monitor unit, however, the automatic or semi-automatic frame-sync. device enables frame sync. to be found comparatively rapidly, and, since loss of revenue earning traffic is not involved, it is quite feasible to restrict the time during which the regenerator must maintain synchronism to the sort of interruption period that can be expected as a result of propagation disturbances. This enables a simpler form of oscillator to be used, which is a considerable advantage in portable equipment.

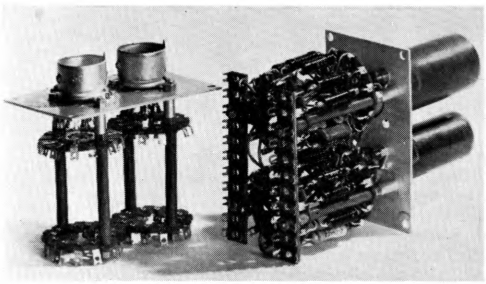
GENERAL DESCRIPTION

Only two external connexions to the monitor are required, one to the mains supply and the other to the source of the signal to be checked. A mains-voltage selector at the back of the unit enables the unit to work from any a.c. supply within the limits 200–250 volts. An interlock fitted to the voltage-selecting switch prevents the voltage selector being operated with the mains connected. This protects the unit against current surges which might rupture the mains fuses.

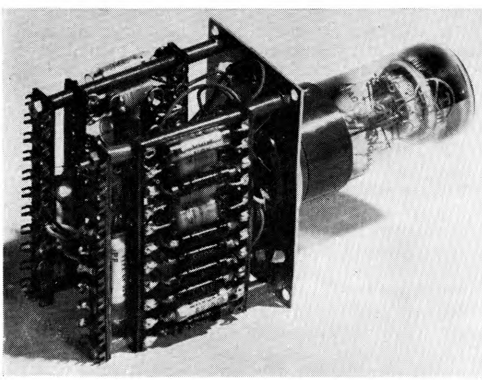
The front panel may be removed by unfastening four screws and lifting the panel clear by the front handles. A framework mounted on the back of the panel carries the circuit assembly for the unit, except the power unit which is mounted separately at the rear of the case. Connexions between the power unit and the rest of the unit are made by means of flexible cables and multi-way connectors.

Unit-Construction System

The complexity of the circuits, and the need to economize in space if the apparatus were to be portable, led to considerable thought being given to the best method of construction. Eventually it was decided to make the unit in small sub-assemblies that would be individually simple to make and wire, and could all be assembled into a common framework with tag blocks for inter-unit connexions. To reduce time and labour during assembly it was decided wherever possible to use standard components. The sub-assembly finally evolved is mounted on a small aluminium panel, approximately 3 in. × 2 in., and has accommodation for two valves (Types B7G or B9G) and about 20 resistors or capacitors (Fig. 2 (*a*)). A second type of sub-assembly (Fig. 2 (*b*)) of identical overall size accommodates a decade-counter tube with associated components.



(*a*) Sub-Assembly for Two Valves



(*b*) Sub-Assembly for Counter Tube
FIG. 2—TYPICAL SUB-ASSEMBLIES

The main unit consists of 14 of the sub-assemblies described above together with a special unit which houses the character and error counters. Of the 14 sub-units, seven comprise the synchronous regenerator and seven the error detector. The counter unit may readily be removed from the main framework, to which it is connected by a flexible cable and multi-way connector. Access to the connexion strips on the sub-assemblies is made by removing the front panel from the framework.

DETAILED CIRCUIT DESCRIPTION

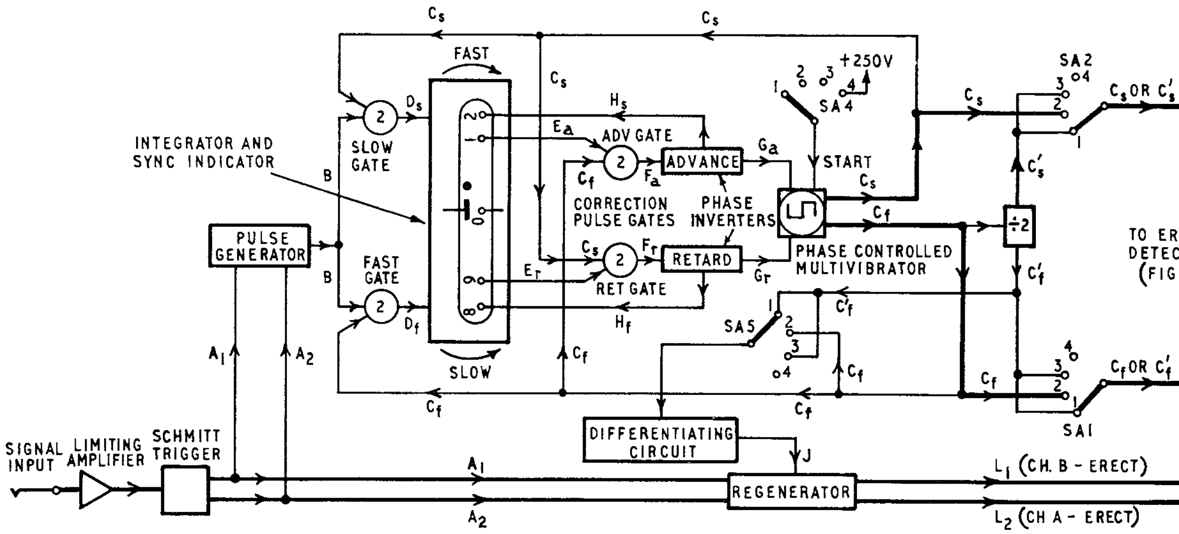
The Synchronous Regenerator

The aim of synchronous regeneration is, firstly, to reconstitute the received signal which may have been distorted and mutilated during its passage from the transmitter to the receiver and, secondly, to maintain the same relative timing sequence existing between the instants of modulation in the original signal at the transmitter. This means that the regenerator will have to cope, not only with the fluctuations of telegraph speed caused by instability of the telegraph sender, but also with the distortion introduced by fading and multi-path propagation.

The principle employed in the present regenerator is to inspect each telegraph element as nearly as possible at its centre where it is only rarely affected by distortion. The most likely cause of error is the presence of a "split" or an "extra" at the instant of inspection and by making the inspection period short the likelihood of error is kept to a minimum. Since there is no direct physical link between the transmitter and the receiver over which synchronism can be maintained, the regenerator must rely on its own internal stability to maintain digit sync. during periods of fading and during short-term interruptions of transmission such as may occur due to static. As already explained, it is not necessary to maintain digit sync. over protracted periods of interruption as the speed with which digit sync. and frame sync. can be regained after restoration of transmission renders this long-term stability unnecessary. The regenerator is in consequence controlled by a simple phase-controlled multivibrator whose stability is sufficient to maintain digit sync. during interruptions lasting up to 15 seconds. Fig. 3 shows the general circuit arrangements and Fig. 4 shows the waveforms at various parts of the circuit.

It is convenient, first, to consider the arrangement whereby digit sync. is maintained. The only information available from the incoming signal from which digit sync. may be achieved is the relative timing between successive transitions. Poor conditions of reception and bandwidth limitations in the system may cause a single telegraph element to be severely distorted in shape, and a preliminary "squaring up" of the signal is necessary before regeneration proper can proceed. This is done in a limiting amplifier followed by a Schmitt trigger. The limiting amplifier will accept signals of widely-differing amplitude down to a minimum of ±1 volt peak-to-peak without affecting the performance of the unit. This is a very valuable feature in portable test equipment which may have to work under widely-varying conditions of input signal. The output signal from the limiting amplifier is fed to the Schmitt trigger, which provides two outputs A_1 and A_2 of opposite polarity, as shown in Fig. 4, in which the original telegraph distortion as received still remains. These waveforms, A_1 and A_2, are differentiated in the pulse generator and the negative pulses suppressed. The positive pulses are then combined to produce waveform B, which gives a positive pulse at every transition in the incoming-signal train.

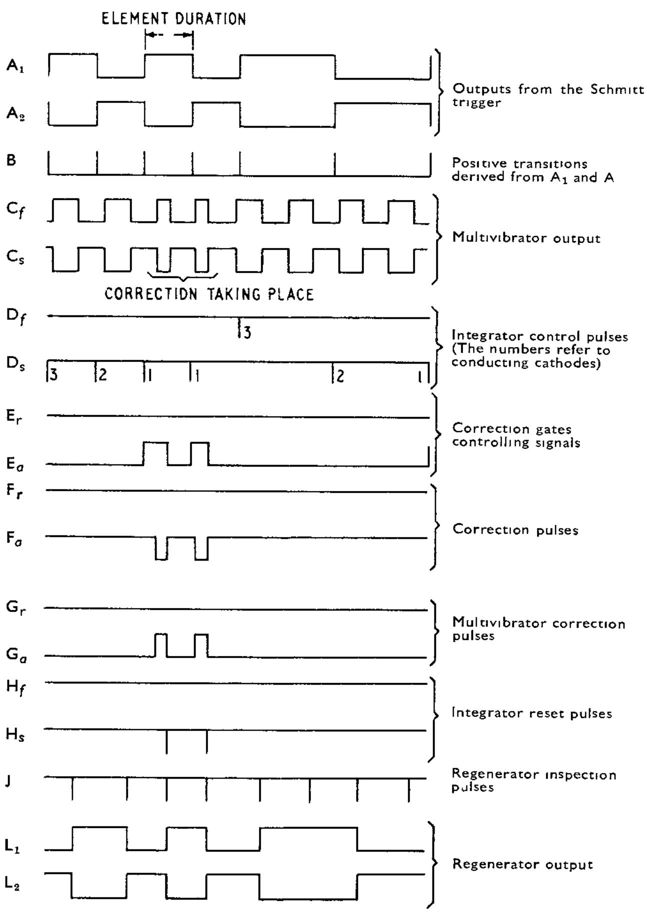
The multivibrator is set to relax at a frequency twice that of the fundamental keying speed of the incoming signals, and two waveforms of opposite polarity, C_f and C_s, are produced from its output signal. Waveform B is gated by the positive half-cycles of C_f and C_s in two gates designated the "fast" and "slow" gates, respectively, and, if the multivibrator is running fast with



SA is the multiplex system selector:
Position 1—4-channel character-interleaved system
Position 2—2-channel character-interleaved system, or reversals signal
Position 3—2-channel element-interleaved system

FIG. 3—SCHEMATIC DIAGRAM OF SYNCHRONOUS REGENERATOR

respect to the incoming signal, pulses D_f will be produced at the output of the "fast" gate. If the multivibrator is, however, running slow with respect to the incoming signal, pulses D_s will be produced at the output of the "slow" gate. These pulse trains D_f and D_s produce the fundamental information subsequently used to operate the phase-control element in the multivibrator.



Distortionless signals are shown to demonstrate the synchronizing system

FIG. 4—WAVEFORMS IN THE SYNCHRONOUS REGENERATOR FOR A 2-CHANNEL CHARACTER-INTERLEAVED SYSTEM

Waveforms A_1 and A_2 still contain any distortion that may be present in the incoming signal and so waveform B will also exhibit the characteristic time displacements of distorted signals. Telegraph distortion on a radio-telegraph system tends to be random in nature rather than having a steady bias, so that if the information from waveforms D_f and D_s is integrated over a suitable period of time, the random effects tend to nullify one another and the resulting signal will contain, mainly, information relating to the speed fluctuations in the transmission. The integrated signal may then be used to apply the phase correction to the multivibrator.

The integration process is carried out by means of a cold-cathode selector tube. Waveforms D_f and D_s are fed to the selector tube via two separate driving circuits which are arranged to cause the tube to step clockwise and counter-clockwise, respectively. Cathode 0 is left disconnected so that the discharge cannot progress beyond cathode 9 or cathode 1, according to the direction in which the tube is being stepped.

When the discharge steps to either cathode 1 or cathode 9, a positive pulse E_a or E_r is produced, respectively. This opens either the "advance" gate or "retard" gate and allows either waveform C_f or C_s to pass, after inversion, through to the phase inverters, from which the trailing edges of the inverted C pulses, i.e. pulses F_a or F_r, produce either resetting pulses H_s or H_f, which in turn transfer the discharge of the integrator tube to either cathode 2 or cathode 8.

Referring to the waveform diagram (Fig. 4), assume that the multivibrator is running slowly with respect to the incoming signal and the glow on the integrator tube is resting on cathode 3. The next transition of waveform B will be allowed to pass through the "slow" gate, and waveform D_s will be produced at the output of this gate; D_s will step the selector tube on and the discharge will transfer to cathode 2. Further drift occurs, and the next transition to appear in the "slow" gate will cause the discharge to be transferred to cathode 1.

The positive output (E_a) produced at cathode 1 opens the "advance" gate and allows waveform C_f to pass through. In its passage through the gate, C_f is inverted and appears at the output as F_a. Pulse F_a is now applied to the "advance" phase inverter where its polarity is corrected and appears at the output as G_a. The trailing edge of F_a gives rise to a negative pulse H_s which resets the discharge on the integrator tube to cathode 2 and, in so doing, closes the "advance" gate.

If the correction so applied is insufficient to restore synchronism the process described above will be repeated and the discharge on the indicator tube will oscillate between cathodes 1 and 2. On the other hand, if the correction so applied is greater than that required to restore synchronism the reverse process will be initiated, and the discharge will be transferred from cathode 2 to cathode 3, after which the procedure described above will be repeated. The waveform diagram shows this condition. If the multivibrator is running permanently slow, therefore, rapid correction will result. However, if the drift in the multivibrator should reverse, seven pulses of waveform D_f will be required before the discharge will reach cathode 9 and produce a retarding correction-pulse. The retarding pulses are produced by waveforms E_r, F_r and G_r, and waveform H_f transfers the discharge from cathode 9 to cathode 8 of the selector tube.

In general, the random nature of the distortion on waveform B tends to cause the selector-tube discharge to step in both directions at random; only genuine drift between the transmission speed and the multivibrator will result in positive stepping in one direction with resultant change in the multivibrator phase. To keep the distortion of the regenerated output to a minimum it is essential that the multivibrator phase correction does not exceed about 1 per cent per element. This is ensured by limiting the duration of the correcting pulses by using the timing pulses C_f and C_s derived from the multivibrator itself; the trailing edges of C_f and C_s determine the instants at which the "advance" and "retard" gates close. The cold-cathode selector tube used in the integration process also gives a useful display which indicates when digit sync. is obtained, thereby facilitating the adjustment of the "sync." control.

Initial setting-up of digit sync. is performed manually by setting the "bauds" control to the nearest figure appropriate to the received transmission speed. When this has been done the selector tube, at present serving as a "sync. indicator," will probably give a confused display. This is caused by the rapid slip in phase, which causes an apparently simultaneous discharge on four or more of the cathodes of the selector tube. The phase slip may now progressively be reduced by adjustment of the "correction-figure" control and by watching the display on the selector tube until the discharge is seen to oscillate slowly from side to side, finally settling at either cathode 1 or cathode 9; the regenerator is in digit sync. but the multivibrator will be continually corrected in one sense. If the sync. control is now adjusted it will be possible to get a display on the selector tube which will tend to oscillate about the central positions and only rarely step to the extreme positions at which correction pulses are given out.

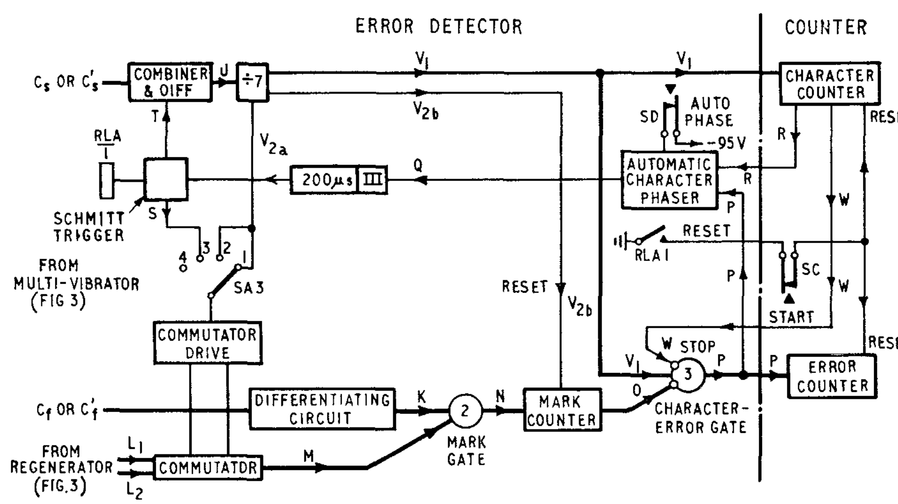
Referring to Fig. 4, it will be seen that if negative-going pulses (J), obtained as a result of differentiating waveform C_f, are used as inspection pulses for the regenerator, they fall in the centre of the incoming-signal waveforms. The regenerator stage will then produce waveforms L_1 and L_2 at its output, and these waveforms will reproduce the coded information in waveforms A_1 and A_2 with a maximum of 2 per cent element-by-element distortion and delayed in time by one half of a telegraph element.

Error Detector

The error detector has been designed to handle 2-channel and 4-channel character-interleaved systems as well as 2-channel element-interleaved systems using single-element interleaving. It also includes the necessary means for obtaining frame sync. Since, at the present time the majority of point-to-point circuits to this country employ 2-channel character interleaving (TOR) the operation of the error detector will be described in terms of this system. The method adopted to deal with the other two systems mentioned above will be described later.

In a 2-channel character-interleaved system the A channel is sent erect, and the B channel is sent inverted. This is done to preserve the balance of the mark-to-space ratio of the aggregate signal and also to provide a ready means of identifying the channels. For the characters in the A channel to be interpreted as correct each must contain three positive elements, whilst for the B channel each character must contain four positive elements. If, after regeneration in the monitor the polarity of the B-channel elements is inverted the checking stages will only have to interpret three positive elements in seven as a correctly received signal.

Referring now to Fig. 3 and 5, it will be seen that for the system under consideration switch SA should be in



SA is the multiplex system selector.
Position 1—4-channel character-interleaved system
Position 2—2-channel character-interleaved system, or reversals signal
Position 3—2-channel element-interleaved system

FIG. 5—SCHEMATIC DIAGRAM OF ERROR DETECTOR

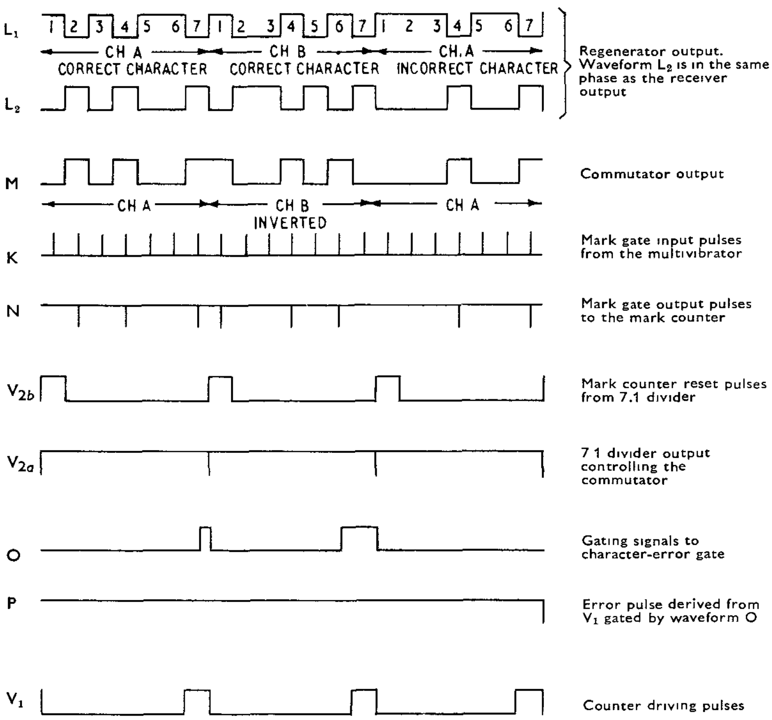


FIG. 6—WAVEFORMS IN THE ERROR DETECTOR FOR A 2-CHANNEL CHARACTER-INTERLEAVED SYSTEM

position 2. Four sets of signals are fed from the regenerator to the error detector, two sets of signals from the multivibrator, of opposite polarity (C_s and C_f), and two from the regenerator, of opposite polarity (L_1 and L_2); C_s and C_f are 1:1 square-wave reversals whose frequency is numerically equal to the signalling speed of the aggregate signal, and L_1 and L_2 contain the signal information.

Two such waveforms L_1 and L_2, fed from the synchronous regenerator to the error detector, are shown in Fig. 6. L_2 has the same polarity as the incoming signal but is delayed in time by half an element due to regeneration. Thus, the L_2 waveform has the A channel erect and L_1 has the B channel erect. These two signals are applied to a commutator (see Fig. 5) which, under the control of a train of V_{2a} pulses occurring at 7-element intervals and obtained by differentiating the output from the 7:1 divider, switches waveforms L_1 and L_2 alternately to the commutator output. Provided the switching pulse occurs at the end of each character an output will be produced in which both the A and B channels are erect.

The commutator output signal M is fed to a gate which allows the pulse train K to operate a counter whenever waveform M is positive; the pulse train K is obtained by differentiating waveform C_f. Since the gate opens when M is positive, i.e. for a mark, and the counter also only operates when M is positive, these two units are called the mark gate and mark counter, respectively. The counter is reset at the end of each train of seven elements by waveform V_{2b}. A second gate, the character-error gate, is closed when the mark-counter output waveform is positive. The mark-counter output is positive when it has received three positive pulses from the mark gate; that is, if three marks have been received in a train of seven elements a V_1 pulse is then prevented from reaching the error counter. If any number of marks other than three is counted during a train of seven elements the V_1 pulse will be allowed to operate the error counter. Waveform V_1 also operates a character counter. The character counter can be preset, by means of a count selector switch, to stop counting at any multiple of 1,000 characters up to 10,000, and to close the character-error gate at the same instant by a stop signal from the counter. Operation of the start button resets all the counters to zero and clears the stop signal.

The process of frame synchronization is semi-automatic. It is initiated by the operation of the "auto-phase" button SD, and once frame sync. has been obtained the automatic character phaser is locked out of service. During the phasing cycle the counters are reset to zero by removing the earth from the reset line at contact RLA1. Assuming that the input signals to the regenerator are free from error and also that traffic is being transmitted on both channels, then, unless frame synchronization is obtained, the character-error rate recorded by the instrument has been found by experiment slightly to exceed 60 per cent. The automatic character phaser is essentially a counter with a two-way drive. Operation of the button SD removes a holding voltage from the ninth cathode of the selector tube in the automatic character phaser and allows the discharge to be driven towards cathode 0 by the character-error pulses P. A second train of pulses R, occurring every third, seventh and tenth character out of each batch of ten, drives the discharge forward towards cathode 9. If the error rate is as high as 6 in 10, the selector tube will eventually register 0, thereby injecting a pulse Q to a Schmitt trigger via a delay network which ensures correct timing. The square-wave output from the trigger is differentiated and combined with the input signal to the 7 : 1 divider; this advances the frame by one element. This process is repeated until frame sync. is obtained and the discharge in the selector tube of the automatic character phaser reaches cathode 9 and locks out of service. When the incoming signal is subject to errors frame synchronization would take longer to achieve if the errors due to vagaries in the radio transmission path did not tend to occur in batches during deep fades interspersed with groups of error-free characters. As the signal/noise ratio deteriorates it takes longer to obtain frame synchronization and a point is eventually reached where it becomes impossible. However, the error rate of the incoming signal when this occurs is so high that the circuit would no longer be considered workable.

One difficulty does, however, arise with this method of synchronization when idling signals are being transmitted. With a repetitive signal the 3 : 4 mark-to-space ratio can be obtained if the ratio check is made starting on six out of the seven elements of the idling signal. Care must, therefore, be taken when using the equipment in the field to ensure that frame synchronization is initiated during the reception of traffic.

Counters

The counters are assembled as one complete unit, but only the final stage of the character counter is displayed through the front panel since it is only necessary to display the thousand count. A neon indicator, mounted just above the "start" button, flashes at every tenth character during the count to indicate that the counter is operating. When the count is complete the neon indicator glows continuously.

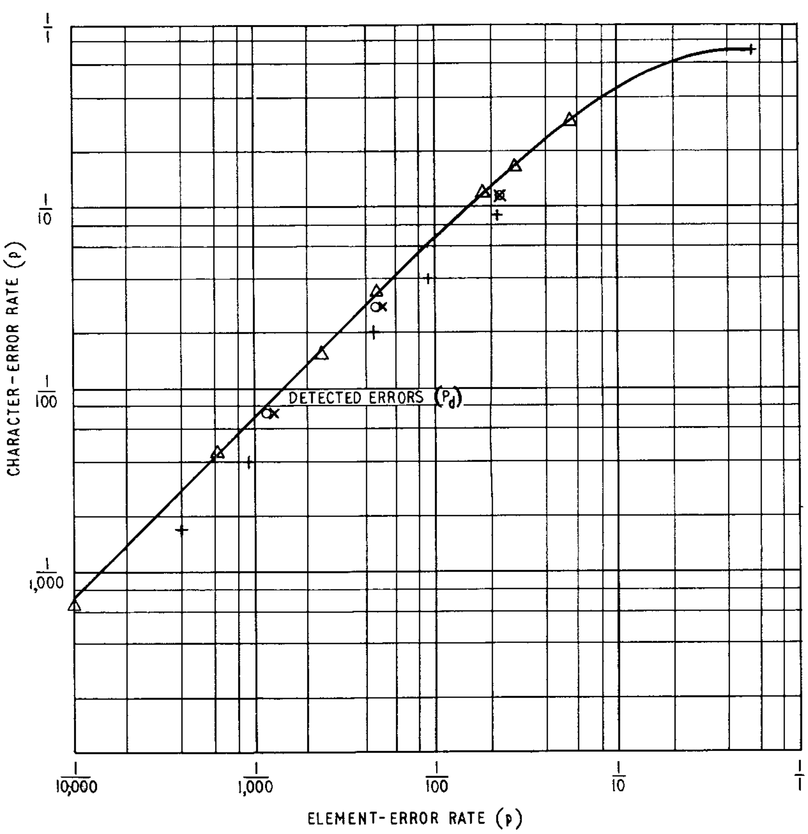
The counter units are conventional in design. A selector tube is used in the tens-character counter-stage to provide the pulse train R to the automatic character phaser, and the final stage employs a 12-way selector tube. Output signals from cathodes 1 to 10 of the thousands-character counter-stage are taken to a count selector switch to provide the stop pulse that closes the input-gate driving-valve and also the pulse W to close the character-error gate.

OPERATION OF THE UNIT

As already mentioned, the unit will work on 2-channel and 4-channel systems. The method of operation on a 2-channel character-interleaved system has already been described. With the system selecting switch (SA) set in position 2, a reversals signal can also be checked since any seven elements must contain either 3 marks and 4 spaces or 4 marks and 3 spaces. If the first seven has a 3 : 4 mark-to-space ratio the next seven must have a 4 : 3 mark-to-space ratio thus fulfilling the basic requirements of a 2-channel interleaved system.

To check a 2-channel single-element-interleaved system, the system selecting switch should be set to position 3. This halves the frequency of the regenerator inspection-pulse and the frequencies of waveforms fed to the 7 : 1 divider and to the mark gate. Under these conditions alternate elements of the incoming signal only are regenerated, i.e. the signals from only one channel are passed to the commutator. The commutator, under these conditions, operates only during the frame-synchronization process to provide a 3 : 4 mark-to-space ratio to the mark gate so that synchronization may be obtained. The counter display gives an answer in terms of character-error rate since the character counter and error counter are both driven by waveform V_1. No indication is given of the channel being checked.

Four-channel systems use a combination of character and element interleaving, and the method of combining the channels is as follows: $A_1\ C_1\ A_2\ C_2$ . . . . $A_7\ C_7\ B_1\ D_1\ B_2\ D_2$ . . . . $B_7\ D_7$, where channels A and D are erect and B and C inverted. The system selector should be set to position 1 for these systems. The frequencies of the control waveforms are halved, as for 2-channel element interleaving, so that the signals of only one pair of channels are regenerated and passed on as a normal two-channel character-interleaved signal to the commutator, which inverts the signal every seven elements. Again, no indication is given of the channels being checked.



Test conditions
Reversals were keyed and the signal was disturbed by white noise
△ Steady signal conditions
+ Flat fading conditions
○ Selective fading conditions
Signal received under selective fading conditions applied to element-error counter after synchronous regeneration
Detected errors, $P_d = 7p - 33p^2 + 95p^3 - 173p^4 + 195p^5 - 125p^6 - 35p^7$

FIG. 7—RELATIONSHIP BETWEEN CHARACTER AND ELEMENT ERRORS FOR A 3 . 4 RATIO CODE

PERFORMANCE

Three monitors have been constructed and have been in frequent use for about a year. During this period the design has been improved and the units are now considered satisfactory for extended field trial. They have been compared with the element-error counters used for testing receiver performance under laboratory conditions.[5] The results, shown in Fig. 7, are of interest as they show that under steady-state conditions the results confirm the relationship given for detected errors. Under fading conditions, however, assuming that the element-error rates were in every case correct, it is shown that the character-error rate was less than the theoretical value, the results for flat fading being further off than those for selective fading. Since precise agreement was obtained with steady signals the error counter was obviously working correctly. For fading-signal conditions it was shown that the relationship stated between the character-error and element-error rates no longer applies exactly. The reason for this is that the distribution of errors is different for the various conditions. With steady signals a random distribution of errors occurs, but with flat fading the errors tend to occur in batches at the trough of fades so that, although a number of consecutive element errors occur, this might give rise to only one or two character errors. Better agreement between measurement and theory was obtained with frequency-selective fading conditions because the receiver used for the tests was designed to make use of the frequency-diversity effect occurring under these conditions, thus reducing the incidence of batches of errors. To ensure that the synchronous regenerator of the monitor was having no effect on performance, a third test was carried out where the element-error counter of the laboratory test equipment used the output signal from the synchronous regenerator. The results obtained were the same as those obtained with the element-error counter checking directly the receiver output.

The character-error monitors were tested at the London International Telegraph Office on the various systems for which they were designed to operate. The three monitors operated correctly on 2-channel element-interleaved T.E.D. (Teleprinter Error Detection) systems and on 2-channel and 4-channel systems using character interleaving; the monitors were taken to Bearley Radio Station for field trials. These included acceptance testing of multi-channel equipment, comparison of aerial systems and general-purpose monitoring. When used for general-purpose monitoring the unit was operated by the radio-station staff. It was used to monitor the Sydney–London TOR (Teleprinter Over Radio) circuit; error rates obtained at half-hourly intervals were recorded in the station log. During the wave-change period when two receivers operating on two different frequencies were employed the monitor was used to select the better signal for traffic.

It must be emphasized that a certain amount of experience is required to operate the unit and interpret the results accurately. The method of obtaining correct digit synchronization has already been described and is relatively simple when receiving distortionless signals, but under poor-signal conditions some experience is required to interpret the sync. indicator display.

Subsequent tests on the multivibrator stage of the synchronous regenerator have shown that the frequency stability is dependent on heater-voltage variation. Provided the change in voltage is kept to within ± 5 per cent of nominal, and breaks in signal transmission are not greater than 15 seconds, digit sync. will be maintained over a number of days without attention. The problem of obtaining correct frame sync. when receiving idling signals could be overcome by fitting additional units capable of recognizing the correct sequence of marks and spaces.

If an additional commutator were provided a simple means of separating the multiplex channels for connexion to a 7-unit printer or an undulator would be available. If the principle of providing each radio receiver with a regenerative output stage were accepted, automatic monitoring of receivers operating on error-correcting codes would be relatively simple, as the timing signals for the error counter could be provided by the built-in regenerators. Frame synchronization, being semi-automatic, could be set in motion each time the monitor was switched to a receiver output. Counter read-out units have also been developed which would display the error rate for each receiver on the channel of a Foster Recorder chart.

ACKNOWLEDGEMENT

The authors would like to thank all past and present colleagues who were concerned with the development of this equipment, and the staff at Bearley Radio Station and the London International Telegraph Office who assisted with the field trials.

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Book Review

"Principles of Electronics." M. R. Gavin, M.B.E., D.Sc., F.Inst.P., M.I.E.E., and J. E. Houldin, B.Eng., Ph.D., F.Inst.P., A.M.I.E.E. The English Universities Press, Ltd. xii + 348 pp. 305 ill. 30s.

The co-authors of this book are the Professor of Electronic Engineering, University College of North Wales, and the Senior Lecturer, Department of Physics, Chelsea College of Science and Technology. The book is based on the teaching and industrial research experience of the authors and is intended to give students the general introduction to the subject of electronics necessary for a first degree or diploma course in physics or electrical engineering. It is stated that the standard of mathematics required seldom exceeds that of Advanced Level of the General Certificate of Education.

The introductory chapters are devoted to the behaviour of free electrons, including their motion in the presence of electric and magnetic fields, and electrons in matter which introduce semi-conductors and impurity semi-conductors and form a useful stepping stone to the later chapters dealing with transistors and transistor amplifiers. A short study of thermionic, secondary, photoelectric and field emission follows with two further chapters dealing with the fundamental characteristics of diodes, multi-electrode valves and transistors. The remaining 13 chapters—approximately half of the book—deal mainly with the use of these devices in amplifiers, oscillators, rectifiers and switches, and include a chapter on feedback and a useful but rather abbreviated chapter on special valves for very high frequencies.

The main emphasis throughout the book is on fundamental principles and, as the authors state, "no attempt is made to cover specific applications of electronics such as radio, television, radar, computers, instrumentation, etc." To supplement the work many useful references could have been included in the rather brief bibliography.

In some of the circuit diagrams a rather unconventional presentation of current flow has been adopted and, although not difficult to follow when considering valve circuits, the newcomer to transistors may well experience difficulty when attempting to determine the true direction of current flow. However, the authors have managed to concentrate a great deal of information into a reasonably priced book which is attractively and clearly laid out with liberal illustrations. A useful collection of 250 examples, grouped to cover each chapter of the text, is found at the end of the book. Many of these have been extracted from recent examination papers of the Institution of Electrical Engineers and the Institute of Physics. Although there is a complete absence of worked examples, a little guidance is given to the solution of some of the problems.

B. V. H.

The Repair of Shallow-Water Submerged Repeaters

B. K. MOONEY†

U.D.C. 621.315.287:621.375.2:621.395.64

The recovery of a faulty repeater located in shallow water and the process of repair are described. The type of repeater referred to is of an old design of which there are about 30 in service on various routes around the British Isles.

INTRODUCTION

THERE are in service on various routes around the British Isles nearly 30 shallow-water repeaters working in paragutta and polythene insulated cables. These repeaters* are of the old single-ended mechanical design which were manufactured under controlled conditions, but not in air-conditioned accommodation or to the high standards of modern repeaters. Fourteen spare repeaters of this type are stored at submarine cable depots, for use as replacements in the event of a working repeater becoming faulty.

Some of the earliest of these repeaters are equipped with standard commercial valves, and are still in service after nine years. Several have failed after a reasonable period in service, have been recovered and replaced by spare repeaters. The recovered repeaters have then been repaired to maintain the stock of spares.

RECOVERY AND REPLACEMENT OF A FAULTY REPEATER

In shallow water the recovery of a faulty repeater and the insertion of the replacement is now no great problem and can usually be completed in approximately 12–18 hours from the time the ship arrives on site. Normally a point some 200 yards from the repeater position is accurately located by the Decca navigational system. The ship grapples at this point and, when the cable has been picked up, it is under-run towards the repeater. When the repeater is up and under the bow sheaves (Fig. 1), the cables are secured and then cut away from the repeater, which is lifted inboard by the ship's derrick. If there is not sufficient slack cable to allow the replacement repeater to be jointed in, stock cable is spliced on to one end of the sea cable, and paid out to allow sufficient cable to be picked up on the other side to enable the repeater to be jointed in. The two joints to the repeater are then made in the jointing-chamber section of the repeater.

After jointing is completed, a radio message is sent from the ship to the controlling repeater station giving permission for power to be applied to the cable to energize the repeaters for testing. Tests are then made between the terminal repeater stations with the repeater still on deck. If these tests prove satisfactory the power is removed from the cable while the repeater is put over the side and lowered to the bottom by means of the ship's derrick. During the lowering, and for about ten minutes after the repeater reaches the bottom, the insulation resistance is monitored from one of the terminal stations. If this is satisfactory, the power is re-applied to the cable and overall tests are made to prove that the performance of the system has been restored to normal.

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

* HALSEY, R. J., and WRIGHT, F. C. Submerged Telephone Repeaters for Shallow Water, *Proceedings I.E.E.*, Paper No. 1633, Feb. 1954 (Vol. 101, Part I, p. 167).

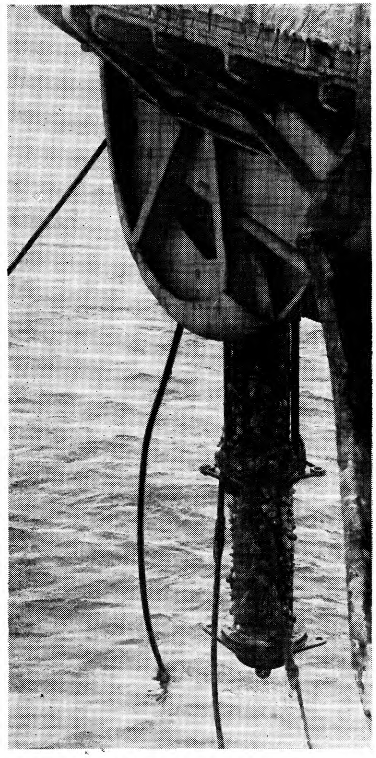


FIG. 1—RECOVERED FAULTY REPEATER UNDER BOW SHEAVES

DISMANTLING FROM THE PRESSURE HOUSING

The fault investigation and the repair of the recovered repeaters involves firstly proving that the fault condition still exists. Once this is proved the operation of the mechanical dismantling of the repeater from its housing is commenced. During the various stages of dismantling, the repeater is subjected to a considerable amount of handling, and the handling gear and trolleys are designed to prevent any mechanical shocks. Because there is always a risk of the fault condition changing or disappearing during these operations, which involve inverting the repeater several times, the repeater gain is monitored; knowledge of the repeater position at the time of a change in fault condition may give sufficient information to allow the repeater to be manoeuvred to restore the fault.

Because of the necessity to obviate any mechanical shock to the repeater the dismantling is carried out by skilled staff. This work is carried out at the Woolwich Submarine Cable Depot where a repeater dismantling

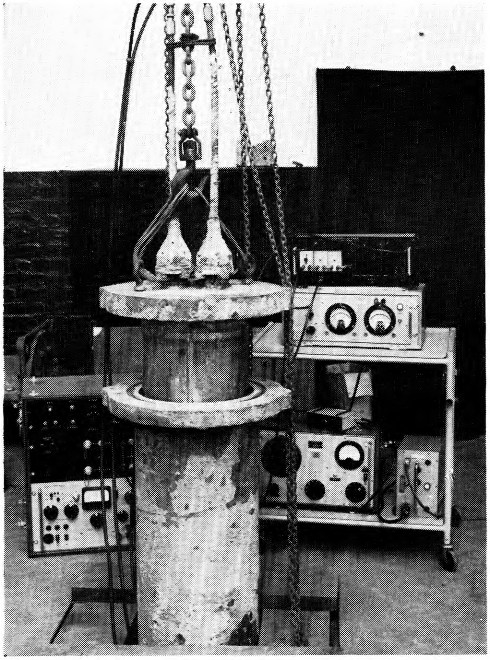


FIG. 2—LIFTING THE REPEATER UNIT FROM THE HOUSING

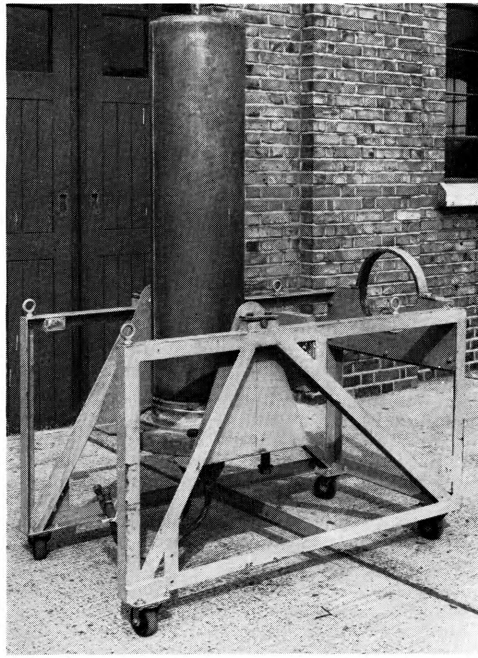


FIG. 3—REPEATER UNIT AND GLAND PLATE MOUNTED ON SPECIAL TRANSPORTING TROLLEY

pit and two sets of overhead lifting tackle have been provided. Special trolleys for handling the repeater at various stages of dismantling and repair, and for transporting the apparatus unit to the repair accommodation, have been designed and produced.

The first mechanical operation is the removal of the jointing-chamber section, after which the repeater housing is cleaned, so that dirt from the housing will not be transferred to the repair accommodation. The outer housing is then unbolted and the repeater unit with its gland plate and glands is lifted from the housing (Fig. 2) and inverted to allow the removal of the inner brass sleeve, which is soldered on to the gland plate. This is the final operation at the Woolwich depot, and the brass sleeve is fitted back over the repeater apparatus unit as a mechanical protection during transport.

TRANSPORT OF APPARATUS UNIT

The repeater unit is fitted into a special trolley (Fig. 3) for transport to the repair accommodation in the Main Lines Development and Maintenance Branch laboratory. Access to this accommodation, which is on the fifth floor, is difficult and for this reason the transporting trolley has been specially designed so that the repeater is held in a cradle, pivoted at the point of balance, thus allowing the repeater to be easily changed to either a horizontal or vertical position. The most stable position for transporting the repeater is horizontal, but on arrival at the laboratory, where lifting tackle is not available, the repeater is easily moved into a vertical position to allow it to enter the lift for transit to the fifth floor. There the fault investigation and repair is carried out in special accommodation to which only authorized staff have access.

FAULT INVESTIGATION AND REPAIR

The main object of the fault investigation is to establish and locate the fault condition with a minimum disturbance of wiring and units. In order to reduce the risk of the fault disappearing and to minimize the work required later, every possible test is applied and the results recorded before carrying out even the simplest operation on any component or unit.

When the fault has been located the remainder of the repeater is carefully checked and the results compared with the original manufacturing test results and specification figures; no changes are made to the remainder of the repeater if the results show agreement with the original figures. The object of the repair is to restore the repeater to its original working condition and no attempt is made to incorporate any modifications to improve the repeater performance. Any replacement component to be incorporated in a repeater is first subjected to rigorous tests and then aged, after which the component is retested for any change in performance. Thus several components must be tested and aged in order that a suitably stable and reliable component can be selected for use in the repeater. After the repair the tests normally applied to the repeater after manufacture are made, and on satisfactory completion of these the apparatus unit is given two weeks' "confidence run" during which its gain is monitored and recorded for one week in each direction of transmission.

REHOUSING

The gland plate has in the meantime been cleaned and treated with zinc-rich paint. The cable glands and gland plate are subjected to a water-pressure test of 500 lb/in^2 for 24 hours by means of a special pressure test bell. The apparatus unit when ready is mounted on its gland plate, the brass sleeve is soldered on and the repeater unit pressure-tested at 5 lb/in^2 with nitrogen (oxygen free). The gas is then passed through the apparatus unit for 48 hours to dry it out, after which the gas filler holes are sealed off and the repeater unit is ready for rehousing.

The seal between the gland plate and the housing is a tongue and groove type, formed by tightening down a projecting ring on the gland plate on to a gutta percha ring in the circular groove in the housing. In order to establish that the repeater unit will enter the housing without fouling when it is finally bolted down, it is lowered into the housing without the gutta percha sealing ring being fitted. With the repeater unit in its housing the tongue on the gland plate should enter the groove in the housing, thus ensuring that the strain will be taken entirely on the sealing ring when the repeater is finally sealed.

When the repeater is finally lowered into its housing the gutta percha sealing ring is fitted in the groove, and the cup in the end of the housing is filled with a mixture of glycerine and litharge. This mixture sets hard between the cup and the spigot and provides the necessary support for the far end of the repeater unit. The necessary pressure on the gutta percha ring is obtained by a set of bolts around the periphery which are slowly tightened down in turn until a gap of 0·160 in. between the gland plate and the housing is obtained all round.

On completion of the sealing-up operation the repeater is transferred to a storage tank filled with water. The water keeps the ambient temperature of the repeater down to a reasonable figure when run for long periods and also preserves the gutta percha sealing ring and the paragutta glands and tail cables used on some of these repeaters. When installed in the tank the repeater undergoes a full series of tests and a six-week confidence test. During this test the carrier-frequency gain is monitored for two weeks in each direction of transmission and the noise is monitored for one week in each direction. Having undergone these tests satisfactorily the repeater is regarded as a satisfactory spare and remains in the storage tank, where it is routine-tested annually.

Book Review

"Linear Network Analysis." S. Seshu and N. Balabanian. John Wiley & Sons, Inc., N.Y., and Chapman & Hall, Ltd. xiv + 571 pp. 268 ill. 94s.

"Linear Network Analysis" is intended for use as a text-book in the first year of a post-graduate course in electrical engineering at an American university, and aims at giving a fairly thorough treatment of the foundations of network theory from certain points of view which are currently considered important. The starting point of the book is well defined and is the conventional mathematical model adopted in network theory. For this purpose a network is considered as being an interconnexion of idealized elements, namely, resistors, capacitors, inductors and ideal transformers; the variables describing its behaviour are taken as the voltages across, and currents through, these elements, and the basic relations from which all else is deduced are the Kirchhoff voltage and current laws together with the equations relating voltage and current in the elements. From these postulates, network theory is developed to the point where the student is fully equipped to start reading the technical literature on network synthesis and the more sophisticated design procedures. None of this latter material is included in the book.

The first four chapters are concerned with the geometry of circuits (or, more precisely, their topology), and with the development of the mesh and nodal equations in a logical fashion from the Kirchhoff laws. These equations are solved with the aid of the Laplace transform, and chapter 4 ends at the point where the conventional network impedance functions are introduced. The next two chapters discuss, respectively, the steady-state response and the time response of networks, while chapter 7 describes the various relations between the real and imaginary parts of network functions. The initial concepts of two-port (or two-terminal-pair) networks and the different sets of parameters used for specifying them, with a few examples of applications, are the subject of chapter 8. A delightful 50-page discussion about the analytical properties of network functions, based on energy considerations, appears in chapter 9 and this, together with the first four chapters, forms the highlight of the book. The remaining two chapters on feedback and image-parameter theory, respectively, are good but relatively uninspired.

In general content the book is comparable with Professor Guillemin's "Introductory Circuit Theory," but it is more formal and concise. The whole treatment is essentially mathematical, and of a level which presupposes some familiarity with the elements of the theory of functions of a complex variable and with Laplace transforms. A 56-page appendix serves as an extended summary of what the intending reader should know of these topics. The mathematical arguments in the book are carefully reasoned and sufficiently rigorous to satisfy all but the most pedantic. Nowhere do the authors attempt to reconcile their theory with the behaviour of laboratory devices, and wisely so, for the book is suitable only for those who are already well aware of the discrepancies that exist.

Only one point was noticed which is considered to have been dealt with badly and this is the description of minimum-phase functions in chapter 7: this phrase was coined by Bode in connexion with (input/output)-type transfer functions but the authors explain it in terms of (output/input)-type functions and never quite recover from the confusion of sign. However, this is a very small flaw in an otherwise excellent book; it is written with an extremely clear style and it handles the subject in a businesslike manner. In this reviewer's opinion it is probably one of the best books on the subject to have appeared within the last decade and is wholeheartedly recommended to anyone wishing to make a serious study of network theory.

H. J. O.

Mechanization of the Initial Stages of Processing Mail

Part 2—Automatic Facing and Stamp Cancellation

G. P. COPPING, B.Sc., A.M.I.E.E., P. S. GERARD, B.Sc., A.M.I.E.E., and J. D. ANDREWS, A.M.I.E.E.†

U.D.C. 681.178

Part 1 of this article described the present manual method of preparing pillar-box collection mail for stamp cancellation and subsequent sorting and dispatch. This was followed by a description of the machinery at present under field trial at Southampton sorting office that automatically separates the mixed mail into groups of packets, large envelopes and small envelopes. It separates the latter into groups of long items and short items and arranges these groups into tidy stacks for further processing. The machine designed to perform this further processing, which is also under field trial at Southampton, forms the subject of the present part of the article. This machine rearranges the short and long items so that all addresses face the same way, cancels the stamps, and groups first-class and second-class mail separately. Together, therefore, the two machines automatically prepare small-letter mail for sorting.

PRINCIPLE OF OPERATION

The feature of each envelope which is used to achieve automatic facing is the postage stamp, whether this be adhesive, embossed or printed. Certain items are therefore handled inefficiently by the machine in their present form, e.g. business reply cards which carry no stamp, and the redesign of such items to facilitate their detection is now under consideration.

Correct operation of the machine depends upon the stamp being affixed in the top right-hand corner; only an insignificant proportion of stamps are affixed anywhere else. Accepting this as a criterion, it is possible to limit the areas over which each item must be searched for the presence of the stamp by arranging the items in the form of an evenly spaced stream wherein each is travelling in a direction parallel with its longer edges. If all items are so positioned there are only four instead of eight possible corner positions in which a stamp may appear. Square items, which appear in very small numbers, are handled with only 50 per cent efficiency because their aspect ratio renders it impossible to ensure automatically that they enter the machine resting on either the top or bottom long edge.

Possible Routing Systems

Fig. 4 illustrates a number of possible routing systems for an automatic facing machine; all are based on the essential requirement that items should move in single file in a direction parallel with their longer edges. In system A all four possible stamp corner positions are scanned more or less simultaneously for the stamp; if one is detected the resulting signal is stored and subsequently used to bring the appropriate twisting mechanism into operation when the particular item which has generated the signal has travelled from the scanning

† Post Office Research Station.

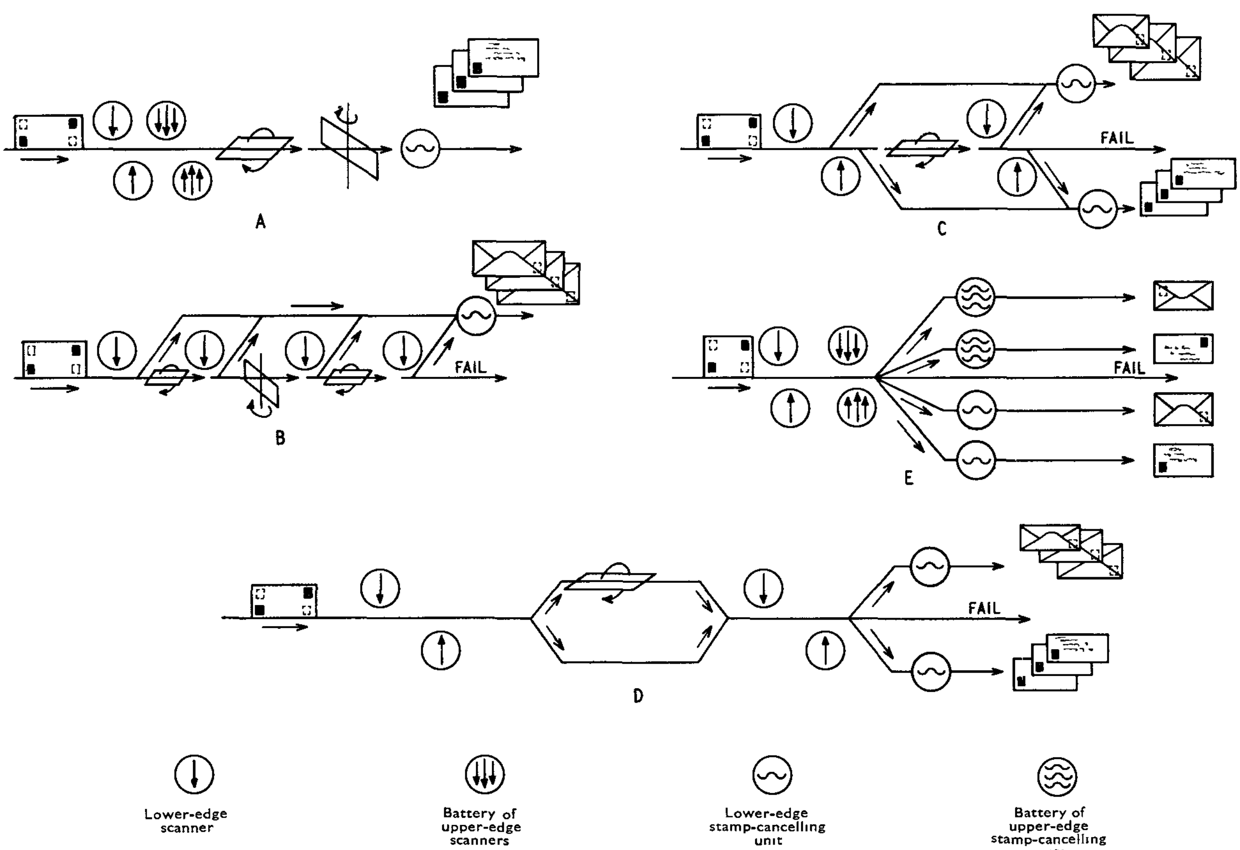


FIG. 4—POSSIBLE SYSTEMS FOR AUTOMATIC FACING

point to the repositioning mechanism. It will be observed that items have to be rotated about a vertical or horizontal axis or about both axes or allowed to pass undisturbed according to the position of the stamp on entry.

Systems B, C and D are other variants, whilst system E avoids the need for any repositioning mechanism by collecting the mail in four separate stacks, each stack containing items with the stamp in a common corner. Final alignment of all "stamp corners" is readily accomplished, manually in this instance, as each of the four packs is collected.

Facing System Adopted by the Post Office

On balance the most attractive system is D. Various serious disadvantages appear in the others, e.g. the difficulty of cancelling stamps near the top edges of items that vary in height, as would be required in the case of system E. The system which has therefore been adopted by the British Post Office is a version of system D, modified to offer two additional collecting points in order to provide the facility of segregating first-class and second-class mail. In this system items are first examined on both sides near their lower edge; if a stamp is detected the item is directed along a "straight-through" path. If no stamp is detected, implying that the stamp is located near the upper edge, the item is directed to the "twist" path along which it is inverted. After inversion, the two paths, which are identical in length, rejoin and the items reform into the original stream with the difference that all stamps are now near a common edge. A further scanning stage is next reached where the detectors have to note whether the stamp on each item is near the leading or trailing edge and whether it is a 2d stamp or combination of stamps. Electronic analysis of the generated signals then controls the routing of the items into the appropriate collecting box.

In practice the route is folded to economize in space, as can be seen from Fig. 5. In this photograph the input end of the machine appears in the left background and the collecting mechanisms for processed mail in the right foreground. Attention is drawn to the position of the scanning devices; these are located on the shelves in the centre of the figure and are therefore some distance from the diverting and inverting mechanisms. This layout introduces the need for some form of memory in which to store instructions for such components whilst items move from scanning positions to deflecting points. Any attempt to avoid completely the need for some form of memory increases the mechanical complexity to an unacceptable degree, and cold-cathode shift registers have been adopted for signal storage in the present machine; these are located with the other electronic control equipment at the rear of the structure.

The shift register is a follower type of memory wherein the "bits" of stored information keep pace in time with the items to which the information relates and, with such a system of control, it is of course essential for the stepping "bits" of information to maintain strict synchronism with the moving items. A positive grip must therefore be applied to all transit items and for this reason a twin-belt conveyor system has been adopted which transports the items sandwiched between the two strands for the majority of their journey through the machine.

Twin-belt conveyors frequently have the very serious disadvantage, when used for paper conveyance, of donating static charges to their load due to rubbing between the strands. To avoid this, the belt system has been very

FIG. 5—AUTOMATIC FACING MACHINE

carefully designed to ensure that no rubbing can take place at any point. This has been assured by employing a single endless belt to form the conveyor; the belt is 145 ft long and so routed that different portions come together over the necessary sections to form a twin system. All chance of rubbing is thereby removed because sections of the belt which are brought into contact are part of the same belt and must therefore move at exactly the same speed (unless the belt is stretching over some sections and contracting over others, which is unlikely).

At points where the letter route curves, the appropriate strand of the twin belt is deflected and the remaining strand transports the items between itself and the rollers over which it runs; the deflected strand rejoins after the curve. The belt can develop static charges where it bends at such rollers, but if the bend is not too sharp no trouble occurs.

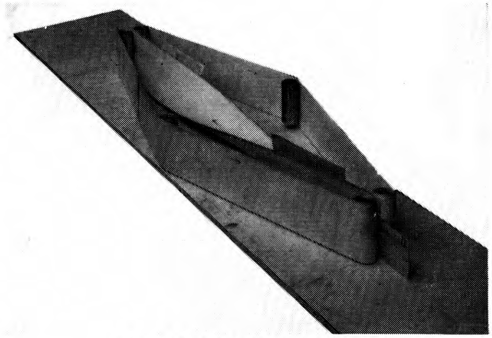


FIG. 7—UNBROKEN-LOOP INVERTER

Formation and Control of Single-File Stream

As described in Part 1, the segregating machinery collects long and short items of small mail in separate packs with all the long edges of the items parallel. These packs are therefore ready to be formed into the desired single-file stream if items can be separated one at a time from a pack and passed into the conveyor system. The development of a suitable mechanism has proved very difficult due to the wide variation in the physical characteristics of mail, and a successful device only appeared after continuous practical experiment. Fig. 6 illustrates the final form. A sprung plate urges the feed stack toward the separating point whilst the stack is supported on rotating rods in order to reduce the resistance of the stack as a whole to lateral movement. This permits the force applied by the plate to be kept to a minimum and leaves the stack desirably loosely compressed. Separation is effected by a downward-driving perforated belt through which suction is applied to the leading letter in the stack. The following letter is prevented from driving out with the first by a sprung restraining rubber pad set immediately below the stack floor; this action is assisted by warping the leading and second letters transversely by means of guides, which effectively increases their stiffness.

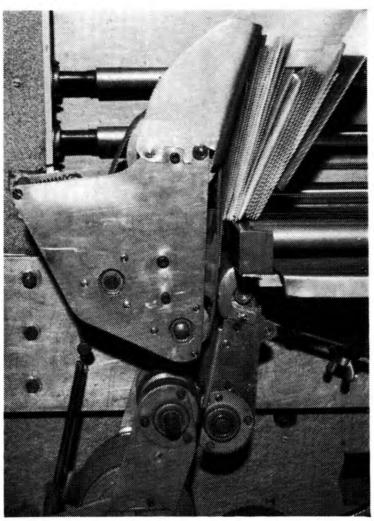


FIG. 6—LETTER-FEED UNIT

Letters issue head-to-tail at a speed somewhat lower than the machine conveyor speed so that, when they are snatched forward as they enter the conveyor system, gaps are formed in the stream; the gap length is directly proportional to the length of the snatched items. Therefore, to operate the machine in the most economical way, i.e. to load the belt fully by providing a minimum gap between letters, long and short items will not be processed intermixed. Instead, the feed unit will be fitted with a two-speed gearbox to allow the appropriate speed to be selected according to the lengths of the items to be processed and so achieve the desired maximum loading of the belt and maximum processing rate for a particular conveyor speed.

At present the conveyor speed is 330 ft/min and the minimum permissible gap length $2\frac{3}{4}$ in. This results in a handling rate of between 350–400 items/min for items 4–7 in. long. Although this figure is acceptable to the Postal Services, it is not necessarily the maximum attainable, and the question of handling rate is to be investigated in the course of the field trials.

Provision is made for detecting gaps less than the minimum and cancelling any signals relating to any two items too close together. This avoids the possibility of the too-narrow gap causing a jam at a diverting point but necessitates routing both items to the reject stack at the end of the machine.

The inversion of items that is required in system D is effected very simply by further careful routing of the belt. Fig. 7 illustrates how an endless belt can be arranged to form a twin-band conveyor and also effect inversion of the transported matter. In the example illustrated, a 360° twist must be inserted in the belt before joining the ends of the loop. This requirement is avoided, for the belt used on the facing machine, by cancelling out the inversion on an ineffective section of the belt run.

Diversion of transit items is achieved at the appropriate points on the machine by a form of butterfly "valve." This is pivoted in the plane of the stream and deflects items to one side or the other according to its setting. The twin conveyor bands are parted at diversion points and items are transported between sprung rollers as they pass the valve, care being taken in the positioning of the rollers at the branch to ensure that even the shortest items (4 in. long) are positively gripped throughout the deflecting action. Power to swing the valve blades is provided by the main belt-driving motor via half-revolution clutches, which are coupled to the motor and electromagnetically released under the control of the electronic control system described later.

Position-indicating photo-beams are fitted at various points along the letter path. These and the reasons for their presence are described later, but one appears immediately before each diversion point to ensure synchronism between the arrival of items and the operation of the diverter.

Before transporting items past any scanning point it is necessary to align them accurately. If this is not done the wrong area of envelope may be examined. This vital alignment is achieved by drawing apart the twin-band conveyor by approximately 1 in. for a distance of about 2 ft preceding each of the scanning sections, where the conveyor has been arranged to carry the letters resting in a vertical plane. Parting the belts for this short run allows the items to settle squarely on to a subsidiary horizontal belt installed closely under the lower edges of the twin bands. At the end of the spaced sections the bands are brought together again to re-grip the items which by this time have all their lower edges accurately aligned to the line of the subsidiary belt.

Segregation of First-Class and Second-Class Mail. In order to provide for the segregation of first-class and second-class mail, it has been necessary to modify system D (Fig. 4) by employing two distinct systems of scanning and by doubling the number of faced-letter output points to provide five outlets in all. Two outlets are for items bearing a stamp near the leading edge of the letter, one for first-class mail (3d stamp) and the other for second-class mail (2d stamp); a further two are similarly provided for items bearing a stamp near the trailing edge. The fifth collecting point is for those items which bear no stamp or otherwise defeat the machine.

Stamp Cancellation. Cancelling and date stamping are effected by printing dies which rotate once for each letter that passes. These are located in each of the four diversion paths and are controlled by photo-beams which are directed across each path and ensure that the cancellation mark is located accurately on the item. The dies are powered via a single-revolution clutch in a similar fashion to the diverters.

Stacking is achieved by ejecting the items on to sloping trays. The bottom of each resulting stack is supported by a sprung plate which moves downwards under the weight of the stack as it builds up. The effect is to maintain an open gap at the head of the stack into which entering letters are free to move. Entry is assisted by a constantly rotating star-shaped wheel.

Automatic Controls. As a precaution against the possibility of seriously damaging mail, an automatic machine shut-down system has been provided. This feature is introduced by employing the numerous photo-beams in an additional capacity. Electronic delay-circuits are associated with each beam unit and coupled in parallel to the main machine cut-out switch; if any beam remains broken for more than half a second the cut-out is automatically released.

Certain beams are employed for the further purposes of detecting too-narrow gaps and overlong or overlapping items. These uses will be described later.

SCANNING

Two systems of scanning are employed in the machine. One system is photoelectric and operates in the visible band; the other reacts to the presence of conductive lines printed on the back of the stamps.

Optical Scanning

An optical scanner comprises a light-tight box in one wall of which a narrow slit exists, an optical system and light source which are arranged to project a light-spot $\frac{1}{64}$ in. by $\frac{1}{4}$ in. centrally on to the slit, and lastly a photo-multiplier cell which is located inside the box near the slit. The cell is wrapped in an Ilford gelatine filter to render it sensitive only to light in the yellow-green range (5,500 Ångströms) and is so screened from and positioned relative to the light source that only light reflected from whatever surface is pressed against the slit on the outside of the box can reach the cell. The yellow-green band is used because the percentage reflectivities of the inks used in printing the lower denominations of stamps have a common low value at this wavelength and stamp signals are therefore brought to a common level.

The belt run and the boxes are so arranged that one strand of the twin belt is routed to the rear of each of the four scanning boxes on the table whilst the other slides the transit items across that side of each box which carries the slit. The slits are so sited in relation to the travelling items that the areas of each item which are swept across the slits are those wherein a stamp may be expected to appear.

The size and shape of the scanning light-spot has been carefully chosen to effect a compromise between rendering the scanner insensitive to printing and writing and yet ensure that some area of dense colour unrelieved by shading will be covered by the spot as each stamp passes.

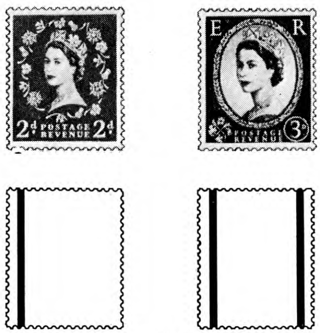
Detection is effected by noting whenever the reflected light energy falls below a predetermined minimum, as occurs whenever the light-spot impinges upon a stamp; the sensitivity of the system must therefore be very stable. This is achieved by stabilizing both the l.t. supply for the filament of the light source (a 36-watt 27-volt projector lamp) and the e.h.t. supply to the multiplier, and by under-running the light source. This protects the light source and at the same time prevents fatigue of the cell by limiting the anode current to approximately 20μA. It was also found necessary to solder the connecting wires to the projector lamp, as the contact resistance of the normal bayonet-socket varies widely.

Buff envelopes and other shaded envelopes reflect strongly in comparison with stamps and do not defeat the scanner; unfortunately, advertisement slogans, dirt marks, etc. can do so and this is one reason for the need to donate a special characteristic to stamps such as the printing of graphite lines on the rear surface, as described below.

Graphite-Line Detection

The graphite-line detector simply comprises two special rollers between which the items pass. One is made of some non-conductive material such as rubber and is sprung against its fellow; the other has a core of non-conductive material but is fitted with a number of metal tires or rings which are proud of the surface and spaced approximately $\frac{1}{8}$ in. apart. A steady potential of approximately 2,000 volts is applied by brushes between adjacent tires, alternate tires being connected internally.

The stream of mail is passed between the rollers and, whereas there is normally no reaction as the uncovered portion of the envelope touches the insulated tires, when a treated stamp appears the tire potential is sufficient to break down the paper of the stamp and drive a current path through the paper, along the graphite line and back through the paper to the adjacent tire. Passage of current is the indication of the presence of a graphite-lined stamp.



$\frac{1}{2}$d, 1d, 1$\frac{1}{2}$d and 2$\frac{1}{2}$d stamps have two graphite lines on the back similar to those on the back of the 3d stamp

FIG. 8—GRAPHITE-LINE MARKING OF REAR SURFACE OF STAMPS

Fig. 8 illustrates two of the special stamps with which the Southampton area is supplied; it is only when a twopenny stamp appears alone on an item that an isolated graphite-line signal will be recorded; all other stamps or combinations of stamps will generate two or more signals. This is the simple means of coding adopted to achieve segregation of first-class and second-class matter.

The efficiency of the system is quite acceptable but it has weaknesses; for example it has been noted that the public in affixing the stamp can inadvertently break a line if the stamp is heavily wetted and then put in position with a sliding action.

Alternative Detection System

A third system of detection, which will almost certainly replace the graphite system, is shortly to be introduced. This involves treating the stamps with a non-radioactive phosphorescent compound which is activated, immediately prior to scanning, by exposure to ultra-violet light. The same system of encoding the value as used with the graphite technique will be employed in this instance. It will be appreciated that the type of scanner in this case will be identical with the optical scanners, but no light source and no filter will be needed. Such a system of treating the stamps has been sought for many years but it is only recently that Post Office chemists have succeeded in producing a phosphor combining all the essential characteristics. Such a phosphor must be cheap to produce, non-toxic, virtually transparent, resistant to moisture and readily made up in ink form.

However effective a special treatment may prove, it will always be necessary to retain an optical scanning system on a facing machine in order to cater for the matter which does not bear an adhesive stamp. Unfortunately, the optical system also has its limitations such as its failure, unless provided in an extremely complex form, to distinguish between first-class and second-class mail and to cope with dirty marks or very pale stamps, such as the recently introduced 4$\frac{1}{2}$d stamp.

ELECTRONIC CONTROL SYSTEM

The control system has to provide for the following seven distinct functions:

(i) Letter position indication
(ii) Scanning-signal acceptance
(iii) Scanning-signal interpretation
(iv) Synchronous storage of scanning signals (shelf stores)
(v) Analysis of stored signals
(vi) Synchronous storage of analysed signals (diverter stores)
(vii) Diverter operation.

Letter Position Indication

In order to lessen the chance of accepting false signals from the scanner due to the existence of random marking, advertisements, etc., on the faces of envelopes, it is essential for the control equipment to be informed of the particular part of an envelope which a scanner is viewing at any instant. This indication is provided by nine photocell-light-beam units suitably positioned relative to the various scanners (Fig. 9). Similar units are used to indicate the positions in which the diverters are set at any instant, the arrival of a letter at a diverter, the arrival of a letter at a cancelling die and to generate stepping pulses for the information store or memory drive.

The units each comprise a 4-watt 6-volt light source spaced approximately 1$\frac{1}{2}$ in. from a phototransistor; no lens system is incorporated. The dark or light condition is noted by a hard-valve two-position trigger.

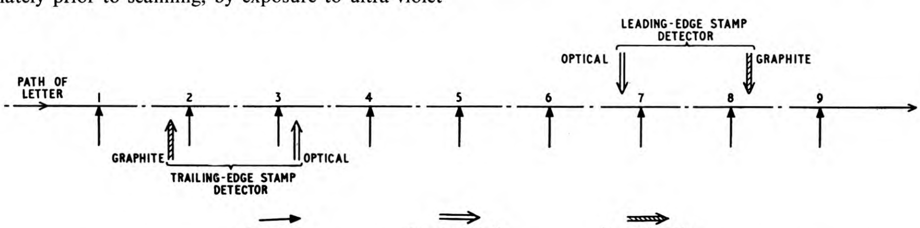
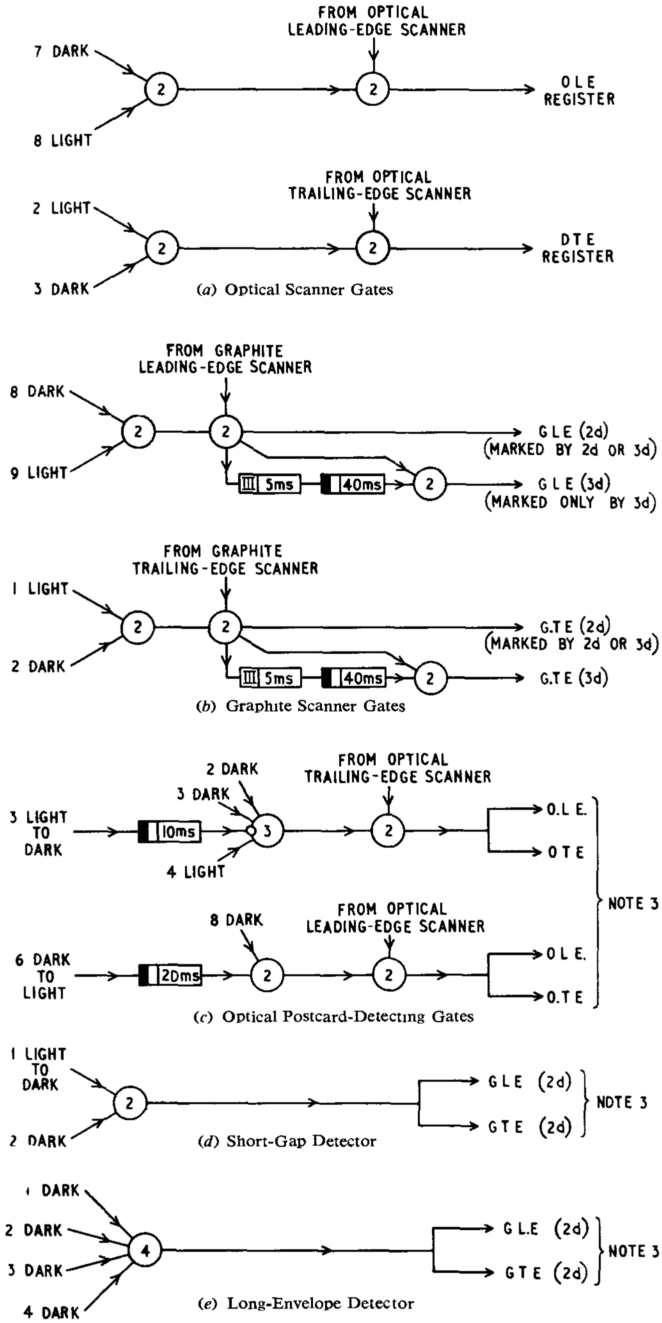


FIG. 9—SEQUENCE OF GATING BEAMS AND SCANNING POINTS ON SECOND AND FINAL SCANNING SECTION

Scanning-Signal Acceptance

Signals are only accepted from the permanently-operative scanners as indicating the presence of a stamp when what is termed a "stamp corner" is in view. This "corner" is deemed to include an area measuring $2\frac{1}{2}$ in. × $1\frac{1}{3}$ in. respectively along the long and short edges from the top right-hand corner of any item when viewed with the long edges horizontal. Acceptance or rejection of signals is achieved by associating two photobeams with each scanner so that one is broken whilst the other is unbroken when a "stamp corner" is in view. This lessens the effect of signal imitation which occurs frequently with optical scanners, much less frequently with graphite-line scanners and should be non-existent with the phosphorescent system of marking.



Notes:
1. The input signals on the left of the diagram are from gating beams 1–9 (see Fig. 9).
2. The outputs on the right of the diagram are connected to the shelf-store shift registers, which are designated as follows:
O.L.E.—Optical (leading edge)
O.T.E.—Optical (trailing edge)
G.L.E. (2d) and G.L.E. (3d)—Graphite (leading edge) 2d and 3d respectively
G.T.E. (2d) and G.T.E. (3d)—Graphite (trailing edge) 2d and 3d respectively
3. Both shelf-store registers are marked and this effectively erases all signals

FIG. 10—SCANNING-SIGNAL INTERPRETATION GATES

Scanning-Signal Interpretation

Incorporated in the signal-gating circuits of the graphite-line scanners on the upper shelf (the second scanning section) is a circuit for deciding whether there is one or more graphite lines on a stamp. This was originally achieved with a form of counter but, as "wrap round" of a letter on a detecting roller may prolong a signal and cause two signals to overlap and thus give a single continuous signal, a form of time-division test is now used: a signal persisting for, or occurring in, a period of 40 ms that commences 5 ms after the start of the signal, or the preceding signal, is deemed to be due to a second line and the appropriate shift-register store is marked (Fig. 10). There is no need to make this distinction for the bottom shelf as at this point only the presence or absence of a stamp is of interest, not its value.

If optical-scanner signals are received from both the leading edge and the trailing edge on the same side of the item it is assumed to be a picture postcard. In this case both optical signals are rejected. If one of the above optical signals is accompanied by a graphite signal the latter is accepted as authentic, because false signals from the graphite scanners are rare.

If two optical signals or two graphite signals are generated by a leading "stamp corner" on one side of the item and a trailing "stamp corner" on the other, then the item cannot be faced. This rejection results in the other edge being examined when the item reaches the second scanning section if the original signals were obtained on the first scanning section. If such signals appear on the second section, rejection of the signals causes the item to be routed to the reject stacker.

Facilities are provided in both scanning sections for detecting items which are moving so closely spaced that the speed of operation of the diverters might be insufficient to allow full operation within the gap and so result in chopping or jamming of the items. Two adjacent photobeams spaced $2\frac{3}{4}$ in. apart are employed for this purpose: if the condition of the first photobeam changes from light to dark while the later one remains dark, a short gap is indicated and a circuit is provided which causes the rejection of both letters. The rejection system is described later.

Facilities are also provided for detecting apparently overlong items. In view of the intention of handling two size ranges, the detecting arrangement must be capable of adjustment. The need to detect such items exists because an apparently overlong item is in fact formed by two overlapping items. These must both be rejected to avoid misfacing one of them due to the machine acting upon the presence of stamps on the other.

Four adjacent photobeams are coupled to provide the facility of detecting letters over $7\frac{1}{4}$ in. long whilst a fifth can be switched in to change the rejection length to $10\frac{1}{2}$ in.

Synchronous Storage of Scanner Signals

Reference has already been made to the physical impossibility of compressing all four scanners (two optical, two graphite) of a scanning section into the space occupied by the smallest letter plus its associated gap. Consequently, in order to avoid confusion with signals from other letters, it is necessary to store the interpreted signals from the various scanners and beams originated by a particular letter as they arrive and carry them in synchronism with the moving letter until all have arrived and an analysis can be made.

Shift registers employing cold-cathode triodes have been adopted to provide this storage. The registers are stepped once for every 2 in. of belt movement, i.e. about 30 steps per second. The stepping is controlled by a photobeam which is interrupted by a disk, suitably drilled, that is rotated by the letter-conveyor belt.

There are six shelf stores for the second scanning section whilst four suffice for the first, there being no need to discriminate between 2d and 3d stamped matter in the first section. The stores for the top shelf are listed in the table.

Top-Shelf Stores

Detector	Signal Position	Type of Signal	Interpretation	Comment
Graphite	Leading Edge	Single Signal	2d stamp	Combined in first section
Graphite	Leading Edge	More than one Signal	3d stamp or combination of stamps	
Graphite	Trailing Edge	Single Signal	2d stamp	Combined in first section
Graphite	Trailing Edge	More than one Signal	3d stamp or combination of stamps	
Optical	Leading Edge	Standard	Stamp, no details	
Optical	Trailing Edge	Standard	Stamp, no details	

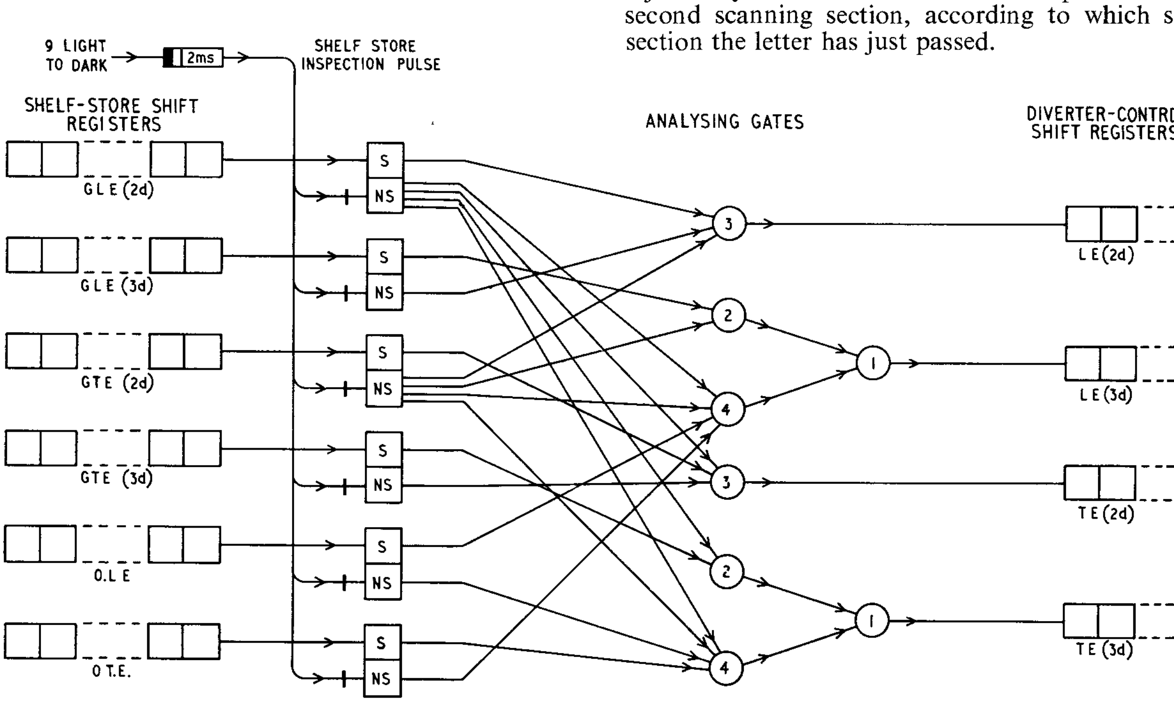
In addition to the primary purpose of the stores shown in the table they are also employed to record the presence of postcards, gaps that are too short and overlong items. The technique of signal analysis described later permits the registering of the above three events by the simultaneous marking of the leading-edge and trailing-edge optical-signal stores in the event of a postcard appearing and the simultaneous marking of the leading-edge and trailing-edge 2d graphite stores in the event of either a short gap or an overlong item appearing.

Analysis of Stored Signals

As signals issue from the various scanning-signal-interpretation gates they are fed to the proper point in the appropriate stepping store so that each item and all the signals relating to it arrive virtually simultaneously at the ends of the stores and the end of the scanning section respectively. Analysis of the complete information about the item is therefore possible at this point in time and it is carried out on the basis that the graphite sensing is more reliable than the optical so that if both an optical and a graphite signal exist the former is ignored. If no graphite signals are present then note is taken of the optical. Fig. 11 illustrates schematically how the analysis is made.

If a graphite signal is received from both the leading and trailing edges of a letter, confusing information appears at the analysing point. In such a case the analysing circuits reject both signals and the letter has to be regarded as unstamped although possibly one signal might be authentic whilst the other might be generated by a pin or staple inside a very thin cover.

Information indicating to which stack the letter should be routed is forwarded by the analysing section to further shift registers which control the operation of the various diverters on the machine. If no information is forwarded concerning a letter no store is marked, no diverter operates and the letter is either directed into the reject tray or taken in an inverted position into the second scanning section, according to which scanning section the letter has just passed.



Notes
1. The designations of the shelf-store shift registers are as indicated in Fig 10.
2. The shelf-store shift registers are stepped by signals from the signal-interpretation gates, as indicated in Fig. 10.
3. The stable states of the triggers are indicated by the letters S and NS, denoting "Stamp" and "No Stamp" respectively
4. The Diverter-Control Shift Registers are designated as follows:
L.E. (2d)—Leading Edge (2d)
L.E. (3d)—Leading Edge (3d)
T.E. (2d)—Trailing Edge (2d)
T.E. (3d)—Trailing Edge (3d)

FIG 11—SIGNAL ANALYSING SECTION

Synchronous Storage of Analysed Signals (*Diverter Stores*)

Cold-cathode shift registers, identical with those used for the shelf stores, are employed for carrying information between analysing-circuit outputs and the diverters. These registers also step once for every 2 in. of belt movement so that the "bits" of information remain synchronized with the movement of the letters.

Control of Diverters

In relation to the movement of the items of mail through the machine, the associated signals in the shift registers in effect jerk along in a series of 2 in. steps. The letters, which flow smoothly, are therefore only momentarily in perfect synchronism with their signals at some instant during each step. In order to achieve perfect synchronism between the arrival of a letter at a diverter and the operation of the diverter, the stored information is only used to prepare for the operation, leaving a signal from a photobeam sited some 2 in. in front of the diverter finally to effect operation when broken by the letter. This system also makes it possible to relax slightly the tight requirements regarding letter slip in the conveyors.

A further feature of the diverter-control circuit is that the diverter has no normal position and operates only when necessary. This reduces the number of operations as a diverter does not necessarily have to restore after the passage of each diverted letter.

Due to the mechanical design of the diverter drive, the control circuits are not automatically aware of the position of the diverter at any instant. A photobeam unit has therefore to be provided to transmit this information; the beam is broken in one setting of the blade and uninterrupted in the other. The final diverter-operate gate in the circuit is therefore controlled by three signals, one from the shift register, one from the letter-arrival beam, and a third from the diverter-position indicator beam. Disagreement between the instruction carried by the associated shift register and the position indicator together with a signal from the arrival beam effects change-over.

The functioning of the final scanning system is illustrated by tracing the passage of a well-spaced 6 in. dark picture-postcard bearing a graphite-marked 2½d stamp on the lower trailing corner. As this item enters the scanning section, beams 1, 2 and 3 (Fig. 9) are broken in sequence. When beam 3 is broken a 10 ms inhibit pulse is applied to the "3" gate‡ in the postcard-detecting section (Fig. 10 (*c*)). At this moment the three controlling latches of this gate are open and, but for the inhibiting pulse, the gate would open. After 10 ms, by which time the letter has moved into view of the optical scanner, the gate does open and prepares the following "2" gate for opening. The 10 ms delay is necessary to avoid a signal from the scanner resulting from a mark on the belt being accepted as a signal from the envelope. The slight displacement of the optical scanning point and beam 3 is intentional so that when the trailing corner of an item is being scanned, scanning can be discontinued by the clearing of beam 3 *before* the trailing edge of the letter clears the scan point and allows the scanner to "look at" the belt.

Assuming that the message writing on the sample item is very closely spaced and dark, a false stamp-signal may be generated whilst the leading corner is in view; that is, when the leading edge lies between beams 3 and 4 and the postcard detector "2" gate is prepared to open. If such a signal appears this "2" gate opens and both the leading and trailing optical shelf stores are struck at a point corresponding to the position of the leading edge of the postcard at that moment.

The length of the card will determine whether beam 2 will be cleared before beam 4 is darkened. Irrespective of which event occurs first, the occurrence of either will block further flow of optical signals through the postcard-detector circuit. When beam 2 clears, the first "2" gate in the trailing optical-scanner circuit will open, because beam 3 will be broken and beam 2 unbroken.

From this moment until the trailing edge of the letter clears beam 3, optical signals from the trailing stamp-corner, which in this instance is the true stamp corner, can flow through the second "2" gate in the optical-scanner circuit. When the stamp appears therefore, the trailing-edge optical store is marked. This marking must be such that the information is impressed on the store level with the position of the *leading* edge of the letter although the signal has arisen from a point near the *trailing* edge. This is achieved by marking several consecutive steps of the store simultaneously so that the effective position of the leading edge lies somewhere in the struck length of store. Attention is drawn to the fact that this optical signal from the stamp will be superimposed on the signal which was applied when both optical stores were struck to indicate the appearance of the earlier misleading signal.

Prior to the postcard clearing beam 2, beam 1 will have been cleared and this will have resulted in the opening of the first "2" gate in the trailing-edge graphite-signal-interpretation circuit (i.e. beam 1 light, beam 2 dark). From this moment until beam 2 is cleared any "graphite" signal will pass through the second "2" gate with the four following results:

(i) the release of a trigger designed to transmit a pulse 5 ms later,

(ii) the marking of a section of the 2d graphite-lined stamp trailing-edge store at a point corresponding to the approximate position of the leading edge of the letter,

(iii) the momentary preparation of the third "2" gate to open, and

(iv) the generation of a persistent pulse of 40 ms duration, upon receipt of the 5 ms delayed pulse mentioned in (i), which holds the third "2" gate prepared to open.

When a second "graphite" signal is generated, as will occur in this instance because the card is carrying a 2½d stamp, the third "2" gate will open because it is already prepared and because of the simultaneous receipt of a signal along the direct path between the two "2" gates. This opening results in a section of the 3d graphite-lined stamp shelf store also being marked at a point corresponding to the approximate position of the leading edge.

As the card proceeds it will be noted whether the item following it is closer than the spacing of beams 1 and 2 and whether the item is overlong and extends across beams 1, 2, 3 and 4.

When the picture side of the card is ultimately viewed, the dark picture will generate optical signals at both ends and again the leading and trailing optical shelf stores will be marked in a fashion similar to that already

‡ A device in which a signal appears on the output lead when control conditions are present on three inputs.

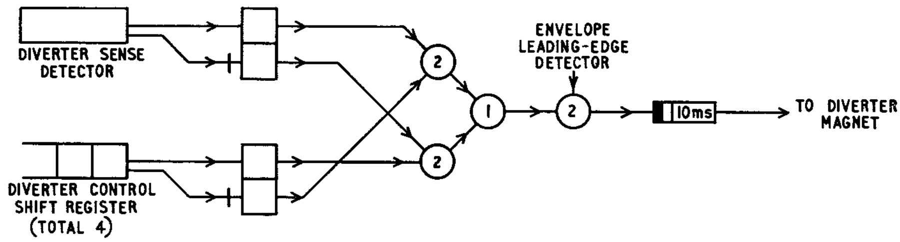


FIG. 12—DIVERTER CONTROL SCHEMATIC

described. In this case, however, as no graphite-lined stamp exists on the picture side none of the graphite stores will be marked or re-marked.

When the leading edge of the letter breaks beam 9, all relevant information will have arrived at the ends of the following stores: 2d and 3d trailing-edge graphite-signal stores and leading-edge and trailing-edge optical-signal stores. The breaking of beam 9 generates a 2 ms inspection pulse which unlocks each of the double gates which terminate each shelf store. This allows the gate pairs to set, one open one shut, indicating whether a stamp signal is present or not at the end of the various stores. The set of conditions existing on the double gates can now be analysed by the groups of "1", "2", "3" and "4" gates forming the analysing section (Fig. 11).

For the example being considered, both optical stores and both trailing-edge graphite stores carry signals whilst both leading-edge graphite stores are empty. The leading-edge 2d stamp store will therefore not be marked, for two of the inputs controlling the "3" gate at the head of this store are absent. The leading-edge 3d store will also not be marked because both inputs on the associated "2" gate and one on the associated "4" gate are absent. The trailing-edge 2d store will not be marked because only one latch on the associated "3" gate is open. However, the trailing-edge 3d store will be marked because both latches to the associated "2" gate are open—namely a stamp indication from the 3d trailing-edge graphite shelf store and a no-stamp indication from the 2d leading-edge graphite shelf store. Had a single false graphite signal been generated from the leading stamp corner on the test card the leading-edge graphite 2d shelf store would have been marked, with the result that neither the "2" nor the "4" gates controlling the trailing-edge 3d diverter store could have opened. No diverter stores would have therefore been marked and the card would have been designated unfaceable and directed to the reject stack.

As already stated, the diverter-control shift registers or stores are arranged to pass information to the diverters in synchronism with the letters. Operation of the diverters has been described and Fig. 12 illustrates the system schematically. Associated with each diverter there are two double gates, one indicating the existing position of the diverter, the other the direction in which it should be set. Two "2" gates react to a difference between settings of the double gates; if there is a difference a signal is passed through the "1" gate to prepare the following "2" gate for the appearance of the leading edge of the letter when this breaks the monitor beam. On receipt of this signal the "2" gate opens and the diverter changes position due to the operation of the associated release magnet, which is energized for 10 ms.

An item diverted from the main stream by the above action is conveyed towards the appropriate stack. In passage to the stack it passes a cancelling die which rotates once to leave an impression on the item as this breaks a controlling photobeam.

CONCLUSION

The facing machine described was installed in Southampton sorting office in December 1957 and has handled a large part of the daily facing load of that office for much of the time since then. The machine has been subjected to a large number of modifications which have improved its performance and provided the design team with valuable information.

The satisfactory performance during the field trial has resulted in the placing of a contract for the manufacture of three complete segregating and facing installations (each installation comprising one segregating unit and four facing machines) to allow for an extension of the field trials to include other sorting offices.

Frequency-Modulated Voice-Frequency Telegraph Systems for Radio Telegraph Services

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U.D.C. 621.376.3:621.394.441:621.371

One of the shortcomings of amplitude-modulated voice-frequency telegraph systems is the deterioration in performance caused by fluctuations in gain of the transmission path. These may produce either sudden or long-term changes in telegraph signal bias, depending on the nature of the fluctuations. The use of frequency-modulated voice-frequency (f.m.v.f.) telegraph systems largely overcomes this, and a brief description is given of the f.m.v.f. telegraph systems used between the London Overseas Telegraph Terminal and Post Office radio stations for the radio telegraph services.

INTRODUCTION

FOR several reasons radio transmitting and receiving stations are situated in places remote from centres of population and, in order to control the radio telegraph transmitters from the London Overseas Telegraph Terminal at Electra House, voice-frequency telegraph channels are provided to the transmitting stations at Bodmin, Criggion, Dorchester, Leafield, Ongar and Rugby. Similarly, v.f. channels convey to London the telegraph signals picked up at radio receiving stations at Bearley, Brentwood and Somerton.

A wide range of telegraph signalling speeds has to be catered for by the v.f. telegraph channels, as will be seen from the following list of signalling systems in use for radio telegraph services:

(*a*) Morse code at various signalling speeds

(*b*) Start-stop teleprinter signals at 45·5 and 50 bauds

(*c*) Synchronous multiplex systems having signalling speeds from 80 to 200 bauds

(*d*) Hellschrieber signals at 245 bauds

(*e*) Start-stop data transmission signals (approximately 75 bauds in one instance).

Advantages of Frequency Modulation

The improvements resulting from the use of frequency modulation instead of amplitude modulation for voice-frequency telegraph systems have already been described* for systems having 120 c/s spaced channels. An f.m.v.f. telegraph system is of special advantage where the transmission path suffers from level change and noise. The circuits which are provided between the London terminal and the radio stations are usually routed throughout on audio plant to avoid the transient effects which may occur on certain carrier and coaxial line plant. Audio plant also normally gives a lower noise level, except under fault conditions. However, level changes of 4 db have been recorded on such circuits, and the performance of amplitude-modulated voice-frequency (a.m.v.f.) telegraph systems deteriorates in such circumstances due to bias distortion. F.M.V.F. telegraph systems will however accept level changes of $\pm$ 15 db without appreciable deterioration in performance and this has two advantages: it not only gives a measure of protection against the effects of day-to-day level changes and against line faults resulting in noise or level changes, it also reduces the frequency at which periodic circuit maintenance checks need be made.

Hence the original network of a.m.v.f. telegraph systems for radio land-line extensions is being replaced by f.m.v.f. systems and, when the change-over is completed, there will be about 380 channels between Electra House and the radio stations to cater for the expanding use of radio telegraph services.

DESCRIPTION OF F.M.V.F. TELEGRAPH EQUIPMENT

General Features

The equipment to be described is manufactured by Siemens Edison Swan Ltd. but was originally designed by Cable and Wireless Ltd. specifically to meet the requirements of radio telegraph services, and some was already operating when the Cable and Wireless Ltd. radio stations in this country were transferred to the Post Office in 1950. It was decided to adopt this type of equipment to replace the amplitude-modulated systems, as it was at that time the only type of f.m.v.f. equipment available which covered the wide range of signalling speeds required. There are two versions of the equipment:

(*a*) *Twelve-channel equipment* for low and medium signalling speeds up to 120 bauds. The channel mid-band frequencies are spaced 240 c/s apart, starting at 360 c/s for channel 1 and extending to 3000 c/s for channel 12.

(*b*) *Six-channel equipment* (five high-speed channels and one medium-speed channel). The high-speed channels, for signalling speeds up to 260 bauds, are spaced 480 c/s apart, the mid-band frequencies starting at 840 c/s and extending up to 2760 c/s (channels 2 to 6). Channel 1 has the same characteristics as channel 1 on the twelve-channel equipment and provides only for medium signalling speeds (i.e. up to 120 bauds).

The equipment is housed in cabinet-type racks (Racks, Apparatus, No. 52) adopted as a standard for radio stations. Each terminal is composed of the requisite number of sending or receiving channel racks, a test rack and a power rack on which a number of power units are mounted; these supply stabilized h.t. and signalling voltages. In the London terminal both sending and receiving channel racks are installed, in separate groups, and are operated from centralized h.t. and signalling supplies.

Each send-channel rack comprises six oscillator-modulators, or "tone-senders," which generate the channel frequencies and, under the control of the double-current telegraph signals, deviate the frequency $\pm$ 50 c/s on medium-speed channels or $\pm$ 100 c/s on the high-speed channels. A line amplifier giving a variable gain in steps of 2 db from $-$ 2 to $+$ 38 db, a 6·3 volt heater-supply transformer and a h.t. distribution-fuse panel are also mounted on the rack. The channel band-pass filters are mounted at the rear.

On the receive racks the six tone-senders are replaced by six channel receive units, otherwise the same items

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* CHITTLEBURGH, W. F. S., GREEN, D., and HEYWOOD, A. W. A Frequency-Modulated Voice-Frequency Telegraph System. *P.O.E.E.J.*, Vol. 50, p. 69, July 1957.

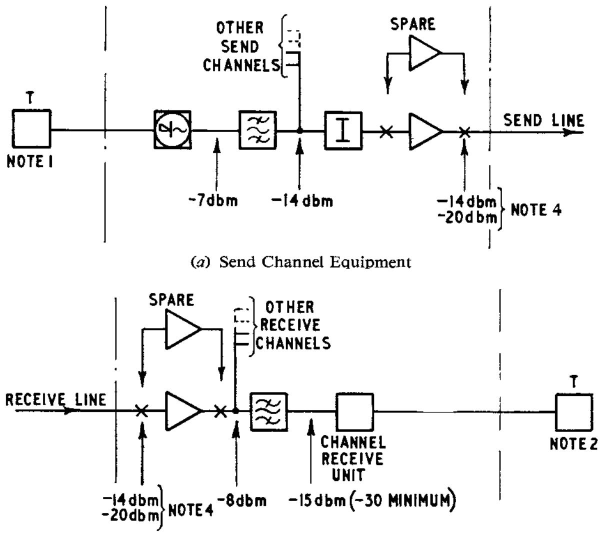
are fitted. A bias panel is also fitted which can be switched to any of the six channel outputs to determine its condition or to check for bias.

The power rack accommodates up to eight stabilized power-units, each with an output of 500 mA, five units for h.t. (240 volts) and three for signalling (110 volts), together with a patching field to enable any individual load to be switched to a spare supply unit when necessary.

The test rack layout is varied to suit the requirements of the station, but basically it consists of a 180-point jack-field through which the channel ends and audio circuits are wired for testing purposes. The remaining space is available for mounting six panels, which may contain a variety of items used for testing and monitoring purposes.

Circuit Operation

Fig. 1 shows the send and receive equipments in block-schematic form.



(*a*) Send Channel Equipment

(*b*) Receive Channel Equipment

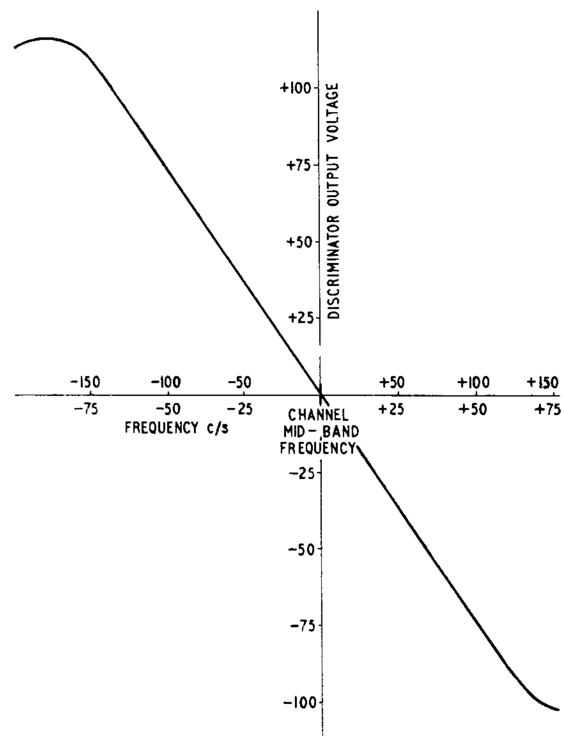
Notes:
1. On a channel outgoing from this country, this symbol represents the telegraph transmitter at the Overseas Telegraph Terminal or at a renter's premises. On an incoming channel it represents the telegraph signal output from the radio receiver.
2. On an outgoing channel this symbol represents the drive unit of a radio transmitter. On an incoming channel it represents the telegraph receiver.
3. dbm—decibels relative to 1 mW.
4. On 12-channel systems the level per channel is the lower level shown and on 6-channel systems it is the higher level.

FIG. 1—BLOCK SCHEMATIC DIAGRAM OF SEND AND RECEIVE EQUIPMENTS

Send Equipment. The tone-sender consists of a resistance-capacitance oscillator of the Wien-bridge type. The oscillator frequency is varied by the telegraph signal causing a modulating valve to vary the value of the resistive arm of the oscillatory circuit. The input signalling voltage is limited by a series diode arrangement so that for voltages above 25 volts the control exerted by the modulator valve remains virtually constant. A low-pass filter precedes the modulator valve to change the square-wave telegraph signals so that they approximate to the ideal trapezoidal waveform, eliminating the higher-frequency components of the original keying waveform. Following the oscillator is an amplifier and output-level control to adjust the tone level into the channel send-filter. The items preceding the send filter are shown collectively as the oscillator-modulator in Fig. 1(*a*). The outputs of the channel filters are commoned together and a 6 db pad provides a degree of impedance matching between the filter outputs and the input to the system amplifier which follows the pad. The output of the amplifier is applied to the audio line, and each tone is sent at − 14 dbm* for a six-channel or − 20 dbm for a 12-channel system.

Receive Equipment. At the receiving terminal the v.f. tones pass through a system amplifier to the receiving band-pass filters; each separate channel frequency then passes to a channel receive unit which converts the frequency-modulated signals to a double-current output. The channel receive unit includes a limiter stage in which a bi-stable d.c.-coupled multivibrator is driven by a preceding stage keyed by alternate half-cycles of the incoming channel frequency. The limiter produces no output until the signal input reaches threshold level, approximately − 30 dbm at the unit input. Above this level the limiter output is virtually constant and, after amplification, the signal is passed to the discriminator. This comprises two inductance-capacitance circuits in series, each tuned to resonate at + 75 (+ 150) c/s or − 75 (− 150) c/s on either side of the mid-band frequency. The first figure is for the medium-speed channels; those in brackets are for the high-speed channels for which the deviation is double that of the medium-speed channels. The rectified components of the potentials developed across the tuned circuits by the modulated channel-frequency are filtered and added in opposition, producing the response shown in Fig. 2.

The discriminator output voltage is applied to a d.c.-amplifier valve which, in conjunction with a second d.c.-amplifier valve working in antiphase, produces a double-current signal in the output load. At a radio station this load is the transmitter drive stage. In the



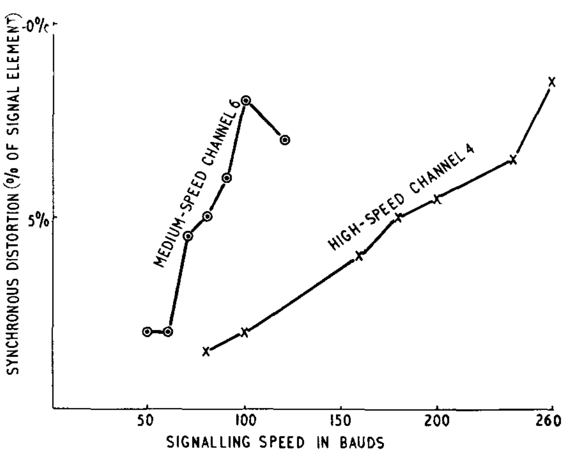
Note: The frequency deviation is ± 100 c/s for 260-baud channels and ± 50 c/s for 120-baud channels

FIG 2—TYPICAL DISCRIMINATOR CHARACTERISTIC

* dbm—decibels relative to 1 mW.

incoming direction, it is the receiving telegraph instrument. The output voltage varies with load and, at radio transmitting stations, the load is always arranged to be 1500 ohms. At Electra House however, where a variety of receiving instruments are used and where on some circuits the incoming signals are extended to renters' premises, polarized relays are inserted in the output circuit so that the standard signalling conditions of $\pm$ 80 volts from a low-impedance source can be used.

An indication of the performance of the equipment is given in Fig. 3.



Note In general, lower numbered channels have greater distortion and higher numbered channels have less distortion than the channels shown

FIG. 3—TYPICAL CHANNEL PERFORMANCE

Test Equipment

To facilitate setting-up and checking the channel frequencies a test oscillator is provided. It is of the beat-frequency type with crystal check points at the channel mid-band frequencies. A trimmer control is provided for precise adjustment of the frequency, and a calibrated dial gives a frequency range of 180 c/s either side of the mid-band frequency. The deviation frequencies are specially marked and given "click" or spring-locked positions for quick setting.

Automatic Telephone and Electric Co. Ltd. Telegraph Distortion Measuring Sets Type 5 are provided for the generation of low-distortion signals, the measurement of the margin of monitoring teleprinters and measurement of synchronous distortion. The same maker's Telegraph Distortion Measuring Sets Type 6 are also provided for the measurement of both synchronous and start-stop distortion. These telegraph distortion measuring sets were manufactured with three signalling-speed ranges covering 20–80 bauds but, to meet the wider range of signalling speeds required, they have been modified to cover the ranges 40–60, 85–105 and 170–190 bauds (Type 5), and 40–60, 170–190 and alternatively 190–210 or 235–255 bauds (Type 6). Telegraph distortion measuring sets designed by the Post Office and covering a continuous signalling-speed range of 40–400 bauds are available at Electra House and also in the Telegraph Branch Laboratory for special investigations.

Monitoring Equipment

The main items of equipment at radio stations for monitoring outgoing and incoming traffic are the teleprinter, the undulator, which produces an ink trace of the telegraph waveform on a moving paper tape, and the Hellprinter. All three are current-operated devices and direct connexion to the output circuit of the v.f. channel or radio receiver would impose an unusually heavy load and affect the operation of the circuit. Hence, electronic monitoring units termed monitoring bridges are provided which have high-impedance inputs and low-impedance outputs suitable for current-operated devices. The bridge used for driving an undulator, termed a check bridge, has a shaping circuit included which assists a quick change-over from one signalling condition to the other, thus helping to overcome the inertia of the pen moving across the paper tape.

FUTURE DEVELOPMENTS

Although the equipment described has proved reliable in operation, the power consumption and space requirements are high. Transistor equipment when available will reduce power consumption, occupy less than half the present space and may also set a new standard of reliability.

Book Review

"The Performance and Design of Direct Current Machines." Albert E. Clayton, D.Sc., A.K.C., M.I.E.E., and N. N. Hancock, M.Sc., A.M.I.E.E. Sir Isaac Pitman & Sons, Ltd. xx + 516 pp. 314 ill. 40s.

This is the third edition of the book, which was first printed in 1927. It is a textbook on d.c. machines, primarily for students working for B.Sc.(Eng.) degrees and Higher National Certificates. In this new edition, based on the rationalized m.k.s. system of units, certain sections have been re-written or amplified, and many illustrations replaced by modern examples.

The book commences with eight pages defining the various symbols used in the book. The first seven chapters deal very clearly, and in considerable detail, with the construction and theory of operation of the various parts and windings of d.c. machines, and with armature reaction, losses and commutation. Two chapters cover the load characteristics of motors and generators, whilst three others describe the methods of speed control and testing.

There is an interesting chapter on special machines which includes most of the less common types, amongst which are balancers, the continuous-current generator, welding generators, metadyne, amplidyne and magnicon. Adequate information on the practical mechanical details of d.c. machines is given, and the complete design theory is covered in the last five chapters. At the end of the book there are 167 examples covering every chapter, many of these examples being from London University and I.E.E. examination papers. Answers are given to all the numerical problems.

The book is well written, and very clearly printed and illustrated and will be of considerable value to engineers and students.

R. S. P.

A New Telephone for Deaf Subscribers—Handset No. 4

W. T. LOWE, A.M.I.E.E.†

U.D.C. 621.395:613.383:621.375.4:621.395.92

A telephone handset containing a single-stage transistor amplifier has been developed to provide amplified reception for deaf subscribers.

INTRODUCTION

THERE are several thousands of telephone subscribers in this country who are hard of hearing, and their need for amplified reception is catered for at present by a valve amplifier (Repeater, Telephonic, No. 17). It is, however, bulky and uses dry batteries, which necessarily require frequent replacement.

A new telephone, the Handset No. 4, has been developed which incorporates a transistor amplifier drawing power from the telephone line current. All the additional components required are contained within a standard telephone-handset case. This new item will supersede the present valve amplifier.

To illustrate more clearly the improvements provided by the new telephone, a brief description is first given of the Repeater, Telephonic, No. 17.

REPEATER, TELEPHONIC, NO. 17

The Repeater, Telephonic, No. 17 consists of a single-stage valve amplifier, together with its l.t. and h.t. dry batteries, within a wooden cabinet 14 in. × 10 in. × 5 in. It is used in conjunction with a special desk telephone on which is mounted a volume control and an on/off key. The maximum gain of the amplifier is approximately 18 db.

The valve amplifier has three main disadvantages:

(*a*) It is bulky and unsightly.

(*b*) Frequent replacement of the dry batteries is necessary and this results in high maintenance charges.

(*c*) A special telephone instrument must be provided in addition to the amplifier unit.

All of these difficulties have been overcome in the new design.

FIG. 1—HANDSET NO. 4

HANDSET NO. 4

The Handset No. 4 (Fig. 1) has been designed for use with the new standard Telephone No. 706.‡ No modifications are required to the telephone circuit and the Handset No. 4 simply replaces the standard handset (Handset No. 3). The external appearance of the new handset is identical to that of the standard handset except for the volume control, which protrudes unobtrusively through the body near the earpiece. In this position the control can be readily adjusted by the subscriber and yet its rim cannot be damaged if the handset is dropped on a flat surface. The control can be lifted out for maintenance simply by unscrewing the handset ear-cap.

All the amplifier components, with the exception of the volume control, are mounted on a strip of insulating material with printed wiring on the underside. The strip is shown in Fig. 2. The amplifier is inserted into the hollow handle of the handset via the cord entry hole and can be readily withdrawn for maintenance. To permit this, the moulded block for the cord entry hole is not cemented in position as in the Handset No. 3 but is held in position by a removable spring clip within the transmitter cavity.

The handset cord is terminated on the amplifier by three screw connexions, which are mounted on the tail of the amplifier strip. These screws lie within the transmitter cavity when the amplifier is in position inside the handset handle and are thus readily accessible for cord replacement.

The new instrument will be available in three colours —black, grey and ivory.

Transistor Amplifier

The circuit of the transistor amplifier (Fig. 3) consists of two parts: the power-feeding section and the single-stage amplifier section.

The amplifier employs one transistor used in common-emitter configuration, with the handset receiver as the collector load. Base bias is provided by resistor R4. The incoming signal is fed to the base via a matching transformer, series volume control, and coupling capacitor, C3.

The amplifier requires 3 mA collector current with a 3-volt supply and, assuming an α' of 50 for the transistor,* the maximum gain is approximately 25 db, whilst the maximum sound pressure developed by the receiver under these conditions is about 200 dynes/cm^2. Severe limiting occurs if the amplifier is driven beyond this point, giving protection to the user against high-level transient signals.

With the volume control in the minimum position, the received signal is approximately 6 db below that of a standard telephone.

The amplifier performs satisfactorily over a temperature range of +10°C to +50°C. When tested at 60°C the gain decreases considerably, but recovers when the temperature is reduced.

Power-Feeding Arrangements

D.C. power for the amplifier is drawn from the telephone line, using a non-linear resistor, MR1, in series with the telephone transmitter, and the potential drop across MR1 provides a nominal 3-volt supply for the amplifier. The non-linear resistor provides automatic

† Subscribers' Apparatus and Miscellaneous Services Branch, E.-in-C.'s Office.

‡ SPENCER, H. J. C., and WILSON, F. A. The New 700-Type Telephone—Telephone No.706. *P.O.E.E.J.*, Vol. 52, p. 1, Apr. 1959.

* α' denotes the small-signal current gain of a transistor used in common-emitter configuration.

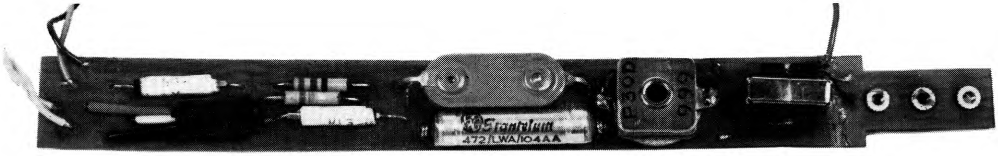


FIG. 2—TRANSISTOR AMPLIFIER COMPONENTS MOUNTED ON INSULATING STRIP

compensation for change of line current with change of line length. For example, in a 50-volt exchange network, the line current can vary from 30 to 100 mA depending on the total line resistance. The amplifier requires a minimum of 1·5 volts for satisfactory operation and the components in the supply circuit introduce a further potential drop of about 0·6 volt. Therefore 2·1 volts must be available at the lowest line current of 30 mA, which implies a value of 68 ohms if a fixed series resistor is used. With a line current of 100 mA this would give 6·8 volts, which is excessive for the amplifier. This wide variation in voltage is reduced by using the non-linear resistor MR1 in place of a fixed resistor. The forward current/voltage characteristic of MR1 is such that the amplifier supply voltage can be maintained between 2·8 and 3·8 volts for a line current range of 30–100 mA.

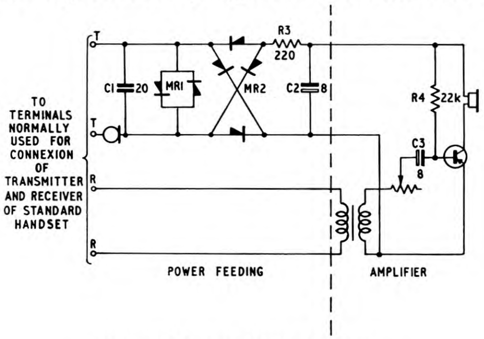


FIG. 3—TRANSISTOR AMPLIFIER CIRCUIT

MR1 consists of several small selenium rectifier plates in series. To cater for line reversals two such units are used, connected as shown in Fig. 3. MR1 is shunted by a 20 μF capacitor to minimize transmission losses.

The supply voltage to the amplifier is passed through a full-wave bridge rectifier, MR2, to ensure correct voltage polarity at the amplifier independent of line polarity. R3 and C2 form a filter network and decouple the amplifier output from the line.

CONCLUSION

The Handset No. 4 has been designed as a hearing-aid handset for use on 50-volt exchange lines, but it can also be used on any common-battery exchange where the line current is in the range 30 to 100 mA. A second version will be produced for use on installations where the line current is less than 30 mA.

The Handset No. 4 is less costly than the present valve amplifier and should prove to be a robust and reliable item.

ACKNOWLEDGEMENTS

Acknowledgements are due to Ericsson Telephones Ltd., who were mainly responsible for the design of the Handset No. 4.

Book Review

"Generation, Transmission and Utilization of Electrical Power." A. T. Starr, M.A., Ph.D., M.I.E.E. Sir Isaac Pitman & Sons, Ltd. 524 pp., 431 ill. 27s. 6d.

This is the fourth edition of a well-known book first published in 1937. This edition contains some new information on generation, a brief outline of the Calder Hall station and an appendix explaining the method of utilizing nuclear energy.

The book is intended to cover the "Electrical Power" syllabus of the engineering degree and as the title indicates it covers a very wide field. While some 282 pages are devoted to overhead and underground lines and cables and other aspects of power transmission and 124 pages to the utilization of power, there is only one chapter of 30 pages dealing with the whole question of generation. The eight appendices cover 100 pages and give some useful but brief information on a number of miscellaneous subjects including hyperbolic functions, a.c. theory, transformers, metering, converters, heating and welding plant, in addition to nuclear energy referred to earlier. It seems that some of the material in these appendices would be better in the main body of the book.

Such a wide field is covered and so little space devoted to some sections that it is not surprising that the treatment in places is very superficial. This is particularly so in the chapter on generation and some sections on utilization. The chapter on illumination is rather out-of-date in practice and contains only a half page on the important subject of fluorescent lighting. Again, in the chapter on industrial utilization, the section on lifts makes no reference to tandem motors or gearless motors, whilst a maximum lift speed of 350 ft/min quoted in this chapter has at least been doubled in this country for many years.

The appendix on converting plant deals at some length with the various valve rectifiers, but omits all reference to the important group of metal rectifiers that have been in use for many years.

A large number of examination questions, mainly from London University examination papers, are included at the end of each chapter and as the answers are also given at the end of the book these will be of great value to the student.

The book is very well produced, the diagrams and photographs are clear and it should be useful as a book of reference.

R. S. P.

The Design and Testing of Semi-Permanent Metallic Contacts for Use at Low Voltages*

ALAN FAIRWEATHER, M.Sc., Ph.D., A.M.I.E.E., and E. J. FROST, A.M.I.E.E.

U.D.C. 537.311.4: 621.3.066.6

The importance of surface contamination and the effects of different environments on various types of contact are discussed. Methods of contact testing including the use of artificial atmospheres to produce accelerated deterioration are also described.

INTRODUCTION

THE design and testing of a contact device for use in a particular circuit involve the specification and measurement of contact resistance. Unfortunately, this quantity is probably more widely misunderstood and wrongly measured than any other in electrical engineering. Two points must therefore be clearly established: first, a single measurement of the resistance of a single contact does not necessarily provide any useful information, especially regarding the behaviour of the contact during its life, and second, the behaviour of a single contact is not necessarily typical of the metal from which it is made.

Surface contamination by poorly conducting material is the main factor in any problem concerning the use of contacts at low voltages. Such contamination may consist of dust, grease or films produced by adsorption or corrosion. The applied voltage is regarded as "low" if it is too small to initiate conduction by any process analogous to breakdown. A contact which behaves as a disconnexion at a certain low voltage may still be able to provide a connexion if the voltage is raised sufficiently to break down the contamination. A measurement of resistance made subsequently at the low voltage may, however, be a record only of a condition obtained at the higher voltage. It is therefore essential, in testing, to ensure that the applied voltage never exceeds that at which the measurement is to be made. The test voltage will usually be either the minimum which is ever likely to be encountered in practice or a lower voltage related to this minimum by some arbitrary factor. A suitably low upper limit for most communication purposes is 0·1 volt.

An important structural difference often exists between "light" duty contacts, required perhaps to transmit "low" voltages and a negligible amount of power, and contacts required to perform "heavy" duties. The distinction in duty is roughly that between situations in which millivolts and milliamperes are involved and in which failure takes the form of disconnexion or noise, and situations in which amperes and inductive loads are involved and in which failure is a consequence of erosion. For light duties, in the interests of economy, plated contacts are frequently employed: they would not, however, in general have an adequate life for heavy-duty work. By implication, therefore, although not always explicitly stated, practical interest in materials for low-voltage contacts is largely directed towards base metals or plated coatings on base metals. Two aspects of the behaviour of such coatings thus present themselves: first, the intrinsic properties of the coating metal, supposing that it could be made to provide a near-perfect coating; and second, the properties of a practical coating, which may have imperfections resulting from thinness, non-uniformity, porosity or poor adhesion. These considerations inevitably influence the choice of testing procedures. For instance, hydrogen sulphide is a well-known cause of the tarnishing of silver contacts, but an accelerated test involving hydrogen sulphide might not necessarily provide the best means of testing silver-plated contacts.

CONTACT RESISTANCE

Practical Significance

Considerations of contact resistance often lead, quite rightly, to the conclusion that if this resistance does not exceed, say, one hundredth or even one tenth of the series circuit impedance, then all will be well. If the circuit impedance is 100,000 ohms, then the contact resistance could be 1,000 ohms. This conclusion does not, however, afford any justification for specifying, without more ado, that the contact resistance shall not exceed either this value or an arbitrary fraction thereof if some hypothetical factor of safety (or ignorance) is invoked. In practice, an exposed contact having a resistance of an order greater than that corresponding to metallic contact (milliohms) is likely to be in an unstable state and in a process of transition to disconnexion. Considerations of circuit impedance are not therefore relevant to the specification of contact resistance. Furthermore, whereas a contact resistance of higher than metallic order almost certainly implies instability, one of metallic order does not necessarily imply stability. The initial magnitude of a contact resistance is not, for instance, a reliable guide to its future magnitude. Information of this kind can only be derived from experiments in which the contact is subjected to natural or simulated atmospheric attack. The object of contact design should be to ensure that contact is initially metallic and that it remains so throughout the required life of the contact. The aim of contact testing should be to ascertain whether this has been achieved.

Environments

A contact may be required to spend its life in any of a variety of environments. On the one hand, it may be located in an atmosphere which is free from impurities of the kind found in industrial or marine towns. It may, additionally, be housed in a heated room and be provided with a dust cover. Moreover, both these enclosures may themselves be free of sources of contamination. On the other hand it may, either by accident or by design, be freely exposed in an industrial or marine atmosphere of high relative humidity. In between these extremes there are many environments intermediate in severity.

Corrosion films result from a reaction between contact metal and environment. An environment may be

* Taken from the paper of the same title presented by Alan Fairweather and E. J. Frost to the Third Electronic Industries Association Conference on Reliable Electrical Connexions held in Dallas, Texas, December 2, 3, and 4, 1958. Dr. Fairweather is at the Post Office Research Station and Mr. Frost was formerly there.

"natural" in the sense that it is one in which the contact will spend its working life. Alternatively, it may be "artificial" in the sense that it is one prepared specially for test purposes. Its temperature, relative humidity and pollution concentration may have been given values, either separately or jointly, greater than "natural" in order to accelerate deterioration.

Experience shows that in industrial areas atmospheric corrosion is brought about mainly by oxides of sulphur and, in particular, by oxides of sulphur in the form produced by the combustion of sulphur-containing fuels. Since sulphur dioxide is by far the major constituent, it is convenient and usual to describe natural and artificial atmospheric pollution in terms of sulphur-dioxide content. In doing so it must be remembered that sulphur dioxide when pure is a less potent cause of corrosion than it is when associated with other products of combustion, notably sulphur trioxide (this difference is, incidentally, very marked with textiles).

It is well known that metals differ widely in their resistance to chemical attack and, correspondingly, in their resistance to atmospheric corrosion. Only gold and certain members of the platinum group can, for most practical purposes, be regarded as completely corrosion-resistant. It is also well known that atmospheric corrosion can result in two different types of attack, described respectively as tarnishing and humid corrosion. Tarnishing can occur in air which is nearly dry, whereas humid corrosion ensues when the relative humidity exceeds a certain critical value. This value is about 70 per cent for copper or nickel in air contaminated with sulphur dioxide. The nature of the surface layer resulting from each type of attack is very different. Tarnishing produces a thin, fairly uniform, poorly-conducting film, whereas humid corrosion produces a relatively thick, patchy and also poorly-conducting film.

Films due to tarnishing usually consist of semiconducting oxides or sulphides or of mixtures of both constituents. Such films are most commonly encountered with silver and copper and with alloys containing them. The contact resistance associated with these films decreases rapidly with temperature and, therefore, with voltage. Breakdown can thus be brought about by a cumulative process once heating has become significant. Films due to humid corrosion in industrial environments usually consist of sulphates, while in predominantly marine environments they usually consist of chlorides: nitrates and carbonates are rare. The contact resistance associated with such compounds is sensitive to condensed water. In the absence of condensation the contact resistance is likely to be high and less dependent upon voltage than that corresponding to semiconducting compounds. In the event of initial condensation and subsequent drying-out, the contact resistance will increase.

The mechanical properties of the surface barriers produced by the various types and conditions of corrosion product are correspondingly different. Humid corrosion with condensation leads to the most readily penetrable barriers. Tarnishing and humid corrosion with drying-out lead to more robust barriers. Tarnish films, although likely to be intrinsically stronger, are much thinner than the products of humid corrosion.

Surface Distributions

In general, the properties of a corroded metal surface vary from point to point in the surface, and information derived from a single region on a specimen or from a single contact structure is not necessarily representative of the behaviour of the metal in a particular environment. The exposure of a metal surface to natural or simulated atmospheric attack thus leads to a distribution of surface properties and the form of this distribution varies for different rates and types of corrosion. If, as in accelerated life-testing, a comparison has to be made between data relating to distributions which are essentially different in form, then a choice of procedure presents itself. A detailed statistical analysis can be performed or, more simply, attention can be confined to one fraction of the test data, defining properties in a particular range or class. This class might be, for example, the one which from an engineering point of view implies either very good or very bad behaviour.

Classification of Contact Resistance

The surface property of practical interest is contact resistance for specified combinations of shape and force. Experience shows that contact resistance can conveniently be classified in orders of ten as shown in Table 1.

TABLE 1
Classification of Contact Resistance

	Class					
	g	w	x	y	z	p
Range (ohms)	$<$0 01	0·01 0·099	0·1 0·99	1·0 9·9	10 99	$>$100

The class designations "g" and "p" may, perhaps, be regarded as indicating "good" and "poor" respectively. For the best work, the g-class is the most significant one and interest is centred on resistance changes within this class and, in particular, from values less than, to values greater than, say, five milliohms. For other work, for instance some of that described in this article, it suffices to ignore the g-class and to include in the w-class all resistances less than a hundred milliohms.

Accelerated Deterioration

In specifying an environment for accelerating deterioration, several decisions have to be made. It is necessary, first, to decide upon the type of environment—industrial, marine or tropical—to be simulated. At the same time, it is necessary to determine roughly the extent to which deterioration is to be speeded-up. Then if, say, an industrial type of environment is chosen, it must be decided whether it shall be one which produces tarnishing or humid corrosion and, if humid corrosion is selected, whether or not there shall be condensation. Finally, it must also be decided whether acceleration is to be brought about by an increase in pollution or in temperature, or by a combination of both. If the preferred environment is similar to one also used in corrosion-testing for other purposes, then so much the better.

It seems reasonable to suppose that contact structures of the kind which remain closed during life are likely to be most severely attacked in the presence of condensation. It may also be reasonably assumed that structures which may be disturbed either accidentally or intentionally, and need to make a fresh closure at any time during their life, are likely to be most adversely affected by the more rugged films produced in the absence of condensation. Consequently, structures intended for general use should be required to behave satisfactorily in both conditions.

The likelihood of meeting both conditions in one type of environment, such as the industrial type, suggests the use of a pair of test chambers. The atmospheric pollution and temperature in each would be the same but, superficially, the interior of one would be wet and that of the other dry. Closed structures would be exposed in the "wet" chamber and open structures would be exposed in the "dry" one and subsequently closed once only for the measurement of resistance. But if continued usage were to show that one of these tests were always the more severe, then the less onerous one could be abandoned. It is not unlikely that testing would confirm that, almost always, a smaller force is needed to maintain a satisfactory connexion than to produce it.

Experience suggests that data relating to accelerated deterioration in an industrial type of environment are the most generally useful. Pollution of the artificial atmosphere by oxides of sulphur is best produced by the combustion of a sulphur-containing fuel such as coal-gas enriched with carbon disulphide vapour. For work at "room" temperature (say 20°C), a suitable concentration of oxides of sulphur, as measured in the atmosphere and reckoned as sulphur dioxide, is about 20 parts per million. This is about 20 times that encountered in the most highly polluted "natural" atmosphere found in an industrial town.

If an increase in temperature is also used as a means of acceleration, then enrichment of coal-gas may be unnecessary. If the wet chamber could be dispensed with, the possibility presents itself of devising a very simple test procedure employing only open structures and based on the use of a commercial gas convector-heater. The main combustion products from such a device are carbon dioxide and water vapour with small amounts of oxides of sulphur and nitrogen. These would provide an atmosphere which is not outrageously different from those encountered in service. The ready availability of such heaters would facilitate the provision of test equipment.

Contact testing is frequently done with the object of assessing the relative merits of several different models of the same device. The order of preference may well turn out to be the same, irrespective of the test environment. This is not surprising, and advantage can often be taken of such results to reduce the work involved in testing. It cannot, however, be assumed that this will always obtain. For instance it is well known that, simply as a protective coating, zinc is better than cadmium in an industrial environment, whereas it is worse in a marine one. It also follows that the relative severities of different environments may appear very different when assessed with respect to their effect on different combinations of contact metals.

CONTACT WETTING

The electrical breakdown of a corrosion film does not necessarily result in a contact resistance of the same order as that associated with simple metallic contact. The final resistance achieved after initial breakdown depends upon the current which has been allowed to flow. Milliamperes might suffice to attain a resistance of tens of hundreds of ohms, but tens of amperes might be necessary to reduce the resistance to one-tenth of an ohm. Electrical and mechanical breakdown are not therefore equivalent, but in practice they can be employed in a complementary way. "Borderline" situations exist in which an otherwise unsatisfactory contact can be made serviceable by the superposition of a steady current of a few milliamperes drawn from a supply having a potential of several tens of volts. This technique is useful in telephone work and is usually known as "wetting." It is not, however, always applicable or desirable. It is frequently essential with silver contacts at forces of the order of a few tens of grammes. For a worthwhile improvement to be obtained, the open-circuit voltage should not be less than about five volts and the closed-circuit current should not be less than about one milliampere. In practice, a wetting current of five milliamperes from a 50-volt exchange battery is frequently used.

CONTACT CONSTRUCTION

Operational Hazards

A broad distinction exists between the following two classes of hazard which are usually involved in contact operation:

(*a*) *Basic design hazards* which are always present and arise as a consequence of a reaction between contact metal and environment. Film growth by adsorption, tarnishing, or corrosion is a hazard of this class.

(*b*) *Random catastrophic hazards* of the kind which are either outside the control of the designer or which cannot reasonably be accepted as basic design hazards because it is impracticable (but not necessarily impossible) to secure immunity from them. The deposition of particulate material such as dust is a hazard of this class; so also is the occurrence of a flaw in a plated coating.

Basic hazards are, or should be, much more important than random ones and, in contact design, first attention should be given to overcoming them. Their effect, for a given material, depends primarily on contact force and shape. With low voltages and fixed total force, contact multiplication with its associated force subdivision may be desirable in systems subject to random hazards but, ideally, it is only permissible if the force per contact is sufficient to overcome the basic hazards. Thus, the means by which the effects of basic and random hazards are reduced are mutually opposed and, in practice, compromise is necessary. For a specified quality of service and a limited total force there is, in principle, an optimum number of contacts. More will increase the effect of the basic hazard by a greater amount than they reduce the effect of the random one and conversely.

Contact systems can be classified in a corresponding way: a basic hazard only is involved in a properly designed plug and socket, but both basic and random hazards are involved in an exposed relay contact.

In passing, it is desirable to mention briefly and without classification three rather subtle, incidental hazards. Onlv the first of them is specifically associated with contacts, but the others can be encountered in contact devices. With one exception, they are all sensitive to environment and arise because contact members require insulation and are often closely spaced.

The Effect of Organic Vapours. It has long been known that contact behaviour can deteriorate seriously in environments containing organic vapours. These vapours may be burned as a result of arcing or sparking. The consequences can be excessive erosion, carbonaceous deposits and increased contact resistance. In the absence of arcing or sparking, such vapours may also be polymerized as a result of contact sliding. The consequences can be surface contamination and high contact-resistance. Significant concentrations of organic vapours can be produced in sealed enclosures containing certain organic materials. These materials may be insulation of the kind, for instance, associated with relay coils, or they may be in the form of paint. Phenolic materials and paints not free from solvent are particularly undesirable.

Silver Migration. It is also well known that silver can migrate through certain insulating materials and give rise to poor insulation. The effect is, perhaps, most apparent with phenol formaldehyde-type and alkyd-type resins. It is accelerated by an electric field, by small electrode separation, by high relative humidity and by atmospheric pollution with sulphur dioxide and, possibly, hydrogen sulphide. Imperfect curing has a similar effect.

Whisker Growth. Experience has shown that metallic surfaces can produce both metallic and non-metallic whiskers. Several metals, including, for example, zinc, cadmium, tin, and their alloys, can produce metallic whiskers the growth of which is not very sensitive to environment. Silver can produce such whiskers in the presence of an electric field. Silver and copper can also produce sulphide whiskers in the presence of insulating material containing sulphur. Metallic whiskers have been known to attain lengths of the order of one centimetre and can introduce unwanted connexions having resistances of a few hundreds of ohms between components. Sulphide whiskers are much shorter and a less likely source of trouble. Exploratory experiments have been done on some specimens of this latter type of whisker discovered on silver-plated jack-springs. The results were as follows:

A piece of gold leaf was lightly pressed against the whiskers and the resistance between leaf and spring was measured. The value obtained was, however, unstable, and efforts to determine its variation with temperature were unsuccessful. An increase in applied voltage produced a decrease in resistance and vice versa. Actual values could not be reproduced, but a voltage cycle high–low–high invariably brought about a resistance cycle low–high–low. In these tests, the low voltage was 1 millivolt and the high voltage 4 volts. The corresponding resistance values were about 1 megohm and 50 ohms. Tests were also made for rectification effects: at 4 volts, a reversal of current-flow caused a change in resistance. In some instances, this change corresponded to a factor of three, but more often it was masked by fluctuations.

Materials and Forces

It has been emphasized that the object of contact design should be to ensure that contact is initially metallic and that it should remain so throughout the required life of the device. It has also been recognized that this desirable target has frequently not been reached in the past and is unlikely always to be reached in the future. It has also been stressed that the attainment of an adequate quality of service has often relied and may continue to rely on the use of voltages large enough to secure some measure of electrical breakdown or "self-wetting" or on the provision, either intermittently or continuously, of separate wetting arrangements. In any guide to contact design it is therefore necessary, however repugnant it may be as a matter of principle, to take account of two kinds of contact which can be described, somewhat loosely, as "metallic" and "wetted" respectively.

The information in this section is essentially a statement on the contact design of plugs and sockets. It is based partly upon experience with existing designs and partly upon recent experiments carried out on copper, brass, nickel-silver, stainless steel, gold and silver. The primary object in these experiments was to ascertain the effect of oxygen and of sulphur compounds on contact behaviour.

Type of Contact Required. The desirable contact force depends upon the electrical conditions and requirements of the associated circuit. In some circuits, for example amplifier-input circuits, the power handled by the contact is very small, so that in order to establish a connexion any films present on the contact surfaces must be penetrated entirely mechanically. In others, for example telephone switching-circuits, the film is also subject to electrical breakdown. Thus, two types of contact can be recognized:

Type (*a*), which relies on contact force and shape to provide metallic contact (despite the possible existence of films).

Type (*b*), which depends upon a combination of mechanical and electrical breakdown.

It is evident that the first type is the more difficult to design and more costly to make. For both types a high reliability is commonly expected, in the sense that the probability of a contact having a resistance greater than, say, 10 ohms must be very low (1 in 10^4?). For type (*a*) contacts this criterion usually necessitates a force sufficient to ensure that at least 90 per cent of the contacts have a resistance of less than 100 milliohms. For type (*b*) it requires that the majority of the contacts have a resistance of less than 1 ohm. As the value of maximum tolerable contact resistance is reduced, it becomes increasingly necessary to use type (*a*) contacts, unless the current handled is very high, i.e. of the order of 1 ampere. Contact-noise (especially microphonic noise) requirements may also necessitate the use of metallic contacts.

Protection of Contacts. With a given component of sound construction, reliability depends upon the maintenance of metal surfaces free, or nearly so, of tarnish films and corrosion products. In turn, this depends upon the working environment and, generally speaking, this can be improved by restricting the flow of air and dust near the contacts. In particular, contacts which are normally open should be protected by simple covers.

There is evidence to show, as would otherwise be expected, that hard surfaces such as hard rhodium plate are more susceptible to dust faults than are soft surfaces such as soft gold. Particulate material, even if crushed, remains on a hard surface, whereas it is submerged in a soft one.

Design. The overall shape of the contacts is primarily determined by the desirability of concentrating the available contact force into a limited apparent contact area. For example, plate contacts can be made less susceptible to dust and film debris by doming one plate to form a contact pip, or one contact member may be formed from round wire. No long-term advantage can be gained by the use of sharp edges or points. If electroplated contacts are used, smooth contours and relieved edges are required, for otherwise the basis metal may be prematurely exposed.

In the absence of comprehensive data, it is sometimes difficult to decide whether, with a fixed overall force, it is better to use single or independent multiple contacts.

The principles involved have already been discussed. For ordinary base metals and silver, single contacts are better for plugs and sockets, particularly if metallic contact is required. Twin contacts are, of course, successful in telephone relays.

A wiping action is essential to all types of contact.

Typical Data. Possible combinations of contact metal and force are shown in Table 2. In this table it has been

TABLE 2

Combinations of Contact Metal and Force Required for Reliable Contact

Type (*a*) Contacts (metallic)		Type (*b*) Contacts (open-circuit voltage >5V: closed-circuit current >1 mA)	
Metal	Force (grams)	Metal	Force (grams)
Gold	30	Silver	30
Palladium	30	Nickel-Silver	100
Platinum	30	Brass	100
Rhodium (see text)	30	Nickel	100
Silver	300		
Nickel-Silver	1,000		
Brass	1,000		
Nickel	300		

assumed that reliable contact (as already defined) is required over a period of years in industrial atmospheres and that each connexion is made by a single contact, both members being of the same material. It is also assumed that the contact design is in accord with the principles outlined earlier, the dimensions approximating, say, to those of a hemisphere of radius 1 mm.

The specification of forces for reliable contact operation is not an easy matter. Any material left long enough in a suitably adverse environment will, for several reasons, become unserviceable for all reasonable contact forces. Noble metals such as gold, platinum, palladium and rhodium are, for most practical contact purposes, almost entirely corrosion resistant. Exposure, however, of the kind encountered in service, and in the absence of sliding, results in the formation of surface films which are often visible as a "bloom". They seem to consist only partly of dust, and their mechanical behaviour is rather like that of a grease. They do not form to the same extent on all metals; their effect on contact behaviour is adverse and similar in kind to that of films produced by corrosion. They differ however in one important respect from corrosion films; most of the film can usually be rubbed-off with a dry cloth. When this is done, there is, from a practical point of view, little to choose between the metals mentioned. But if it is not done, and if good behaviour on a first closure is all-important, then large differences are at once apparent.

The data in Table 2 relate to contacts which have been serviced to the extent of being rubbed with a dry lint-free cloth. If, however, they have not been so treated, the situation is very different. Of the plated finishes, rhodium will not provide 90 per cent w-class contacts for any reasonable force. Gold continues to do so at 30 grams, and palladium will also do so if the force is raised to 100 grams. No material is known which is superior to gold for use at low voltages. The behaviour of silver is, for several reasons, somewhat variable and little influenced by rubbing with a cloth. The minimum force quoted in the table is rather complimentary: in conditions conducive to severe tarnishing, silver will not provide 90 per cent w-class contacts for any reasonable force. Other experiments have shown, however, that silver-sulphide films tend to break down if the force is maintained for a long period (days). For this additional reason, silver is likely to be much better if the contacts remain closed during their working life.

Concentrated forces higher than 30 grams are not desirable with rhodium, especially if the contact is vibrating.

The forces quoted for brass, nickel and nickel-silver are considered sufficient to break down the oxide films which develop when these metals are exposed to air. Such films become significant in a period of weeks and provide some protection to the metal. It must be emphasized, however, that, under conditions of high humidity, complete failure may result even if the force is high (1 kg) and the voltage large (330 volts). As a working rule, contacts of these metals are not suitable if easily visible tarnishing is probable.

Copper contacts do not appear to offer any advantages over those of, say, brass if the current is limited to milliamperes. When oxidized at 200°C, they show a much higher breakdown voltage (50 volts) than brass or nickel-silver contacts, and this difference may persist at lower temperatures.

Some work has recently been carried out on contacts of stainless steel and of chromium (plated). These metals rapidly form a highly protective oxide film and in this respect are similar to aluminium. Both require large contact forces, and, of the two, stainless steel appears the more promising. Thus, on a sample of a particular molybdenum stainless steel the contact behaviour was not modified by long (years) exposure in a "wet" (industrial) chamber. It formed a reliable type (*b*) contact at a force of 300 grams.

The successful use of stainless steel in practice evidently depends upon the setting-up and maintenance of high contact-forces. The wide manufacturing tolerances at present used on, for example, silver-plated contacts would be quite unsuitable for those of stainless steel.

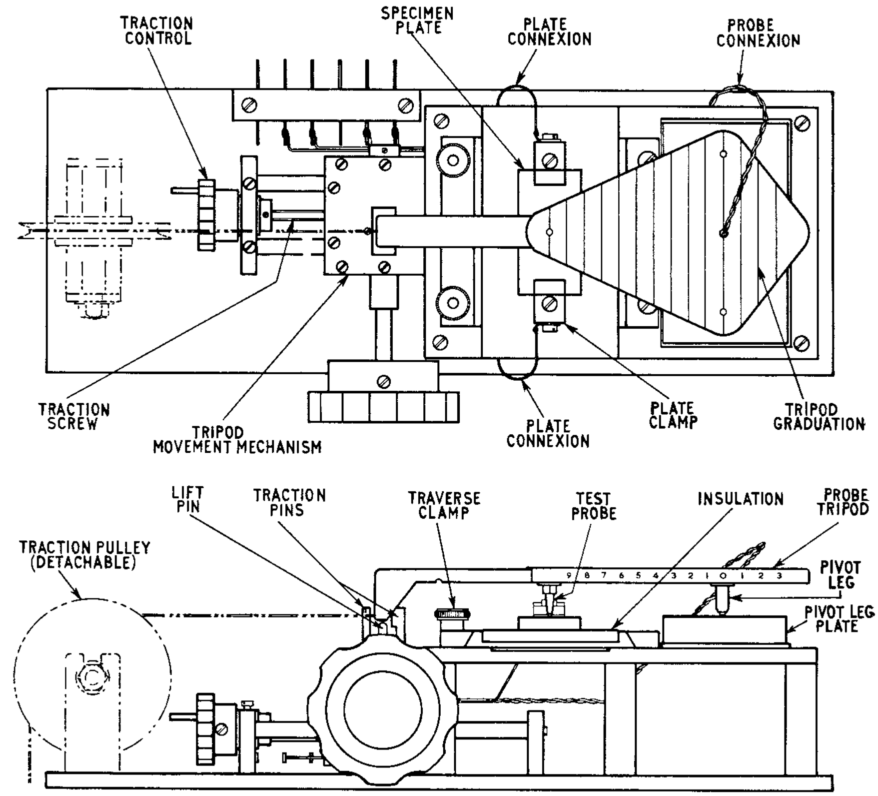
CONTACT TESTING

Aims and Requirements

Contact studies are undertaken with a variety of aims. For instance, the ultimate objective may be the provision of a contact device. Alternatively, there may be no such practical end in view, and the objective may be the solution of a problem in surface physics. Practical contact testing is usually done for one of two purposes, either to obtain basic data relating to materials and forces necessary to the design of a new contact device, or to ascertain the behaviour of an existing device. This behaviour depends, amongst other things, on the choice which has been made of material and force, so the tests required are similar to, but more limited in scope than, those involved in the collection of basic data. Tests for this purpose are best done with elementary structures such as crossed-rods or hemispheres-on-planes. But whatever the purpose of practical testing may be, it needs to be related to the conditions encountered in service.

Contact service falls into one of two classes, according to whether the contacts spend most of their life open or closed. All contacts deteriorate electrically as a consequence of environmental attack. They may also do so as a result of mechanical wear, if intermittent operation is involved. Intermittent operation may be a design feature or it may be an accidental consequence of disturbance. A metallic connexion should be obtainable on a first closure at any time in the specified life of the contact and it should be continuously maintainable for the whole of this life. Resistance tests are necessary therefore with contacts exposed both in the open and closed condition in appropriate environments. Such tests should be preceded (not followed) by any mechanical wear treatment or "conditioning" which is necessary. This may be either a few operations performed in order to detect springs worked beyond their elastic limit, or it may be many operations corresponding to the number expected in service multiplied by some arbitrary factor of "safety."

The essential information needed for a material is simply a statement of the way in which, for a typical contact shape, the change in contact-resistance distribution with life depends upon contact force. When practical applications are in view, less comprehensive data often suffice, the information required being, perhaps, a statement of the force needed to ensure that, during life, not more than a certain fraction of a set of contacts shall have a resistance greater than that corresponding to metallic contact, say five milliohms. Interest is, of course, centred on the (possibly few) potentially bad contacts and not on the good ones.



ELEVATION WITH PLATE CLAMP REMOVED

FIG. 2—CONTACT BALANCF

Techniques and Apparatus

Information is required for a closed structure affected by condensation, and for the first closure, both with and without wipe, of an open structure not affected by condensation. The closed structure is of the crossed-rod type illustrated in Fig. 1 and not less than ten are used at each force. The material being studied is in the form of wires welded or otherwise attached to supporting springs. The contact force can be adjusted by means of a screw. With the necessary exception of the contact region, the metal parts of the structure are protected by paint. The open structure is of the hemisphere-on-plane type, and only the plane portion is exposed to atmospheric attack. The plane is a plate usually 2 in. long, 1 in. wide and about $\frac{1}{4}$ in. thick; it may be solid or plated. The hemisphere is nominally clean and is about $\frac{1}{16}$ in. or $\frac{1}{8}$ in. in diameter. It is of the same material as the surface of the plate. For any normal force, there are only two practical situations of interest: one is when wipe or surface traction is absent and the other is when the tractive force is unlimited. Two measurements of contact resistance are made in succession, therefore, at each test-spot. The first is on closure and the second after wiping. For each load or normal force the test-plate is sampled at a hundred spots distributed more or less uniformly over the surface of the plate. A similar procedure is followed in the collection of data for the wetted type of contact.

The contact resistance associated with any spot on the surface of the plate can be measured for various combinations of normal force and surface traction force with the aid of the contact balance shown in Fig. 2. This device is an example of the use of intrinsically stable, three-legged structures in contact research. The balance is essentially a tripod, one leg of which constitutes the test probe and the other two serve both as pivot and slider. The tripod can be loaded on both sides of the pivot legs and can be lowered gently towards the specimen plate by means of the knob-operated lift-pin and cam. It can also be dragged parallel to the surface of the specimen plate, either by means of the knob-operated traction-screw or, if a knowledge of the tractive force is required, by means of a weighted cord over the traction pulley.

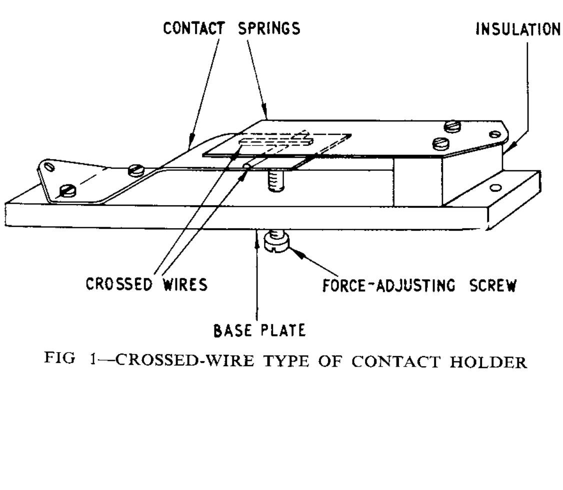


FIG 1—CROSSED-WIRE TYPE OF CONTACT HOLDER

Developments are in progress in the authors' laboratory as a result of which it is hoped to supplement and for some purposes to replace the manually-operated contact-balance by a fully automatic device. When associated with automatic measuring apparatus, it should make the whole process of collecting basic design-data almost entirely automatic.

For components the general procedure is essentially the same. Interest is again directed towards the worst situation which can arise. The detailed technique may therefore depend on the knowledge available regarding mechanical tolerances imposed in manufacture and also, perhaps, on the number of specimens supplied for examination. For instance, consider a socket (e.g. in a valveholder) intended to accommodate a plug (e.g. a valvepin) and let it be supposed that limits have been specified for the diameter of the pin. The most adverse combination of circumstances is encountered when a socket has been subjected to repeated insertions of a maximum diameter pin and is then required to make contact with a minimum diameter pin (if limits have also been specified for the aperture of the socket, then consideration must be given to the possibility that a socket initially of minimum aperture may be more adversely affected by such mechanical "conditioning" than one initially of maximum aperture).

Thus, when mechanical tolerances are known, the worst situations can be assessed immediately. If data have already been collected for the materials employed, then only a measurement of normal (not withdrawal) force is necessary. Otherwise, tests are done, using for the plug clean dummies specially selected or made (from similar material) instead of a production item chosen at random. A set of dummies joined by a flexible lead is used for a multi-way closed structure: the results are then truly representative of the contact members and are not influenced by inaccuracies in the relative spacing of pins and sockets. One dummy, used repeatedly, suffices, of course, for a multi-way open structure.

If, however, no mechanical tolerances have been specified, then production items are used at all stages in the test and in sufficient quantity to ensure that the worst situation has been identified and its significance assessed correctly.

In the routine practice of component testing, as well as in the collection of design data, no opportunity is lost in the authors' laboratory to obtain information of more general or basic value than that needed for the solution of an immediate problem. One aim is always to relate the results of accelerated and natural corrosion; another is to develop the simplest possible test-procedure. Accordingly, whatever the objective of the work, not less than four sets of specimens are employed so as to provide one set of closed structures and three sets of open ones. The closed set is exposed in a "wet" industrial chamber and one open set in a "dry" chamber; another open set is exposed in the laboratory and the remaining open set in an experimental "gas-fire" chamber.

When testing specimens involving, say, a hundred test contacts, it is convenient to use a multi-point selector switch of the kind used in the Strowger system of automatic telephony. The contacts of such a switch must, of course, be above reproach and to this end both wiper and bank contacts are gold-plated. The bank-contact assembly of this switch can readily be detached from the switch mechanism, and so each set of test contacts is wired permanently to its own bank and is associated with the switch mechanism only when measurements are made. The bank, but not the insulated wiring, is protected from the atmosphere in the test chamber by means of a sealed polythene bag. With specimens having fewer test-contacts, such as plugs and sockets, smaller selector switches with non-detachable banks are sometimes employed. In such circumstances, the complete switch and wiring is enclosed in a painted metal container of the kind used for syrup or paint, and the specimen is attached to the ouside.

Test Chambers. Chambers of the kind envisaged earlier cannot, of course, be completely sealed. Leaks are necessary to permit the entry of air required for combustion (when such air is not introduced for other purposes) and also to prevent the build-up of excess pressure inside the chamber. Water is most simply introduced as a mist produced by a device similar to the familiar scent-spray and driven by compressed air. Some water condenses on the walls of the chamber and also on any objects inside the chamber. Some of the oxides of sulphur resulting from combustion are taken up by the water. Excess air and water are allowed to escape and, as a consequence, the pollution of the artificial atmosphere is less when the spray is employed than when it is not. In the authors' test chambers, which have a volume of about 26 cu. ft, the spray reduces the concentration in the atmosphere by approximately one half. Specimens are attached to rotating arms and the movement serves to stir up the atmosphere in the chamber. It also ensures that a specimen is not confined to one region only in the chamber. The working cycle involves exposure for 8 hours/day and 5 days/week, with the chamber open at other times. This is continued for 60 working days and the whole test thus occupies about three months.

The experimental "gas-fire" chamber has so far taken the form of a gas-heated room having a volume of about 1,500 cu. ft. The concentration of sulphur dioxide in the vicinity of the specimens is about 1·5 parts per million and the corresponding temperature about 70°C. Components for use at "abnormal" temperatures are sometimes classified according to the upper limit which has been fixed for the temperature of their environment. The lowest of such upper limits is 70°C. Work has been done with exposure periods of the order of one-tenth of that standardized for the "wet" and "dry" industrial chambers. But further data need to be obtained on the effects of longer exposures before a suitable test period can be standardized.

Electrical Techniques. The results discussed in this article were obtained with the aid of two basic instruments; a four-terminal bridge and a "wetting" circuit. In the bridge, the voltage at the "unknown" terminals, when these are open, is limited to 100 mV, and the current through the specimen cannot exceed 20 mA. Thus, the specimen contact is not electrically disturbed during the measurement, and its resistance will depend primarily upon the mechanical breakdown of any films, dust particles, etc. which may be present on its surfaces. However, in some experiments, some degree of electrical breakdown is required immediately before the measurement of contact resistance, and the "wetting" circuit is designed to fulfil this requirement. It makes available at the specimen a known maximum voltage attained when the specimen is open-circuited, and a known maximum current which is substantially independent of the contact resistance, provided this is generally less than 100 ohms, or. for heavy-current conditions, less than 10 ohms.

The supply for the wetting circuit is, of course, d.c., but a low-frequency (219 c/s) a.c. supply is used for the low-voltage measurements. Experience has shown this to be desirable and many troublesome errors can thereby be avoided, for example those caused by thermo-electric potentials and by cell action at insulator surfaces. But it is still necessary to shield or separate the bridge and the specimen undergoing test from extraneous sources, particularly heavy-current switching circuits such as those used in telephone switching. Induced transients of even short duration may otherwise seriously affect the behaviour of the contact.

Both circuits are flexible enough to be used in the statistical type of experiment on several hundred contacts as well as in experiments which require the accurate measurement of the resistance of relatively few contacts or the observation of contact-resistance changes. In particular, the bridge has been specially adapted for the statistical type of experiment and it then provides means for the automatic classification and counting of test results at a rate exceeding one hundred per hour.

Current and potential leads between specimen and apparatus are used for all measurements and, consequently, leads may be some yards in length. If necessary, manually-operated selectors may be inserted between the apparatus and a group of specimens.

By the addition of two units to the bridge and detector, the order of the resistance of a contact is measured and classified automatically. A single test-cycle takes between one and two seconds and commences when a "start" button is depressed by the experimenter and ends when the result has been recorded on a counting-meter as an occurrence in one of five class-intervals. Thus, the final result of a test on several hundred contacts is shown by the meters in terms of class-frequency. Alternatively, a single contact may be continuously monitored automatically.

In essence, a switching unit takes the place of the variable arm in the bridge and substitutes, in turn, one resistor from a group of five; simultaneously, corresponding meter circuits are made dependent upon a differential relay in the detector. Each of the five resistors is switched as a four-terminal resistor. Their resistances, with the exception of the last, correspond to the upper limits of the class intervals, which might be 0·1, 1·0, 10·0, 100 and 1,000 ohms. Operation of a meter occurs only if a start signal has previously been given and when a resistor of value greater than that of the specimen is substituted in the variable arm of the bridge or when the specimen has been found to be greater than 100 ohms. It cannot occur until the bridge has reached a steady state because a delay period follows resistor substitution.

CONCLUSION

Commonly accepted standards for contact behaviour are too low and a general improvement in performance is both possible and desirable. A widespread need exists for the standardization of adequate design and testing procedures. Some basic principles have been discussed and a test procedure recommended which involves exposure of the contact in an artificial environment polluted with the products of combustion of a sulphur-containing fuel.

Book Reviews

"Whittaker's Arithmetic of Electrical Engineering." Fourth Edition revised by A. T. Starr, M.A., Ph.D., A.M.I.R.E. Sir Isaac Pitman & Sons, Ltd. 194 pp. 22 ill. 10s.

The publishers of this little book have produced many technical works for elementary engineering students, amongst them being various text books suitable for young telecommunications engineers training for Ordinary National Certificate or an Intermediate Group Course Certificate of the City and Guilds of London Institute.

However conscientiously a student may read, and make notes on, the subject matter of a book, he will not train himself adequately for an examination unless he works solutions to appropriate numerical examples. "Whittaker's Arithmetic of Electrical Engineering," first published in 1908 and subsequently revised four times, must have been one of the first books ever written as a guide to the working of numerical examples. The fourth edition is intended for the young electrical engineer of first- or second-year National Certificate standard, at which level there is little difference between power engineering and telecommunications. This is the part of the National Certificate syllabus that used to be covered by the general term "Magnetism and Electricity." The basic principles which it embraces are divided into 16 chapters with a brief, but adequate, explanation of the fundamental formulae and their meaning at the head of each. The rest of each chapter is devoted to examples and their solutions; there are about ninety worked exercises in the book. Some three hundred unworked problems are also given, with numerical answers at the back of the book.

The scope of the problems is fairly wide and they have been chosen as typical of the principles involved rather than as a "cram" for a specific examination. This greatly increases the range of students to whom the book will appeal and at the same time makes it of interest to advanced sixth-form science students at schools.

The present publication is a reprint of the 1934 edition and no attempt has been made to change the text to the M.K.S. system. The C.G.S. system of units is used throughout. Despite the time that has elapsed since the last revision of the book, there is no suggestion that the text is out of date; the fundamentals of electrical engineering and the methods of teaching them have remained unaltered for many years. This is one of the better of the "cramming" books, and, bearing in mind the limited range of such a work, is good value. C. F. F.

"Fundamentals of Radio and Electronics." Edited by W. L. Everitt. Second Edition. Constable & Co., Ltd. xiv + 805 pp. 592 ill. 57s. 6d.

The scope of Everitt's well-known book, "Fundamentals of Radio", first published in 1942, has in this second edition been extended to include electronics. The book has thereby been greatly enlarged and, with the help of five contributory authors, Everitt ably touches on most fields in which electronics have made an impact.

The presentation is at an intermediate level and, hence, is largely descriptive. It will not satisfy the advanced student because the coverage is so wide that each of the 22 chapters would need treatment in a separate book to fulfil such an aim. In some places the text shows evidence of the purely academic approach rather than that of the experienced engineer. For example, in Fig. 14–12 the curve given as a relation between the audio voltage output plotted against the frequency deviation in an f.m. detector is

(*Continued on p.* 35)

A Vehicle for Radio Investigation Work

G. H. SLATER, A.M.I.E.E.†

U.D.C. 629.114.7:621.391.823:621.396

A description is given of a new vehicle for use on radio investigation duties. The vehicle is based on an existing standard type, the Area Planning and General Purpose Vehicle.

INTRODUCTION

THE first type of vehicle specially developed for radio investigation (R.I.) work and capable of transporting two men with their equipment was introduced in 1935. It was an adaptation of a postal van and was known as the 8 cwt R.I. Vehicle. It had a non-metallic body—a feature then thought essential—and could mount an external aerial. This type of van remained the standard vehicle for radio interference work until 1947 when the Morris R.I. Car (Fig. 1) came into service. This vehicle, like its predecessor, had a non-metallic body and was based on a Morris 8 cwt chassis. One hundred and sixty-five of these R.I. Cars were provided and they proved to be a marked improvement on the previous type. In addition, modified Minor Vans were introduced to meet the greatly increased need for vehicles for the radio investigation service.

FIG. 1—MORRIS R.I. CAR

Experience with these vehicles under a wide range of conditions, however, naturally revealed scope for further improvements. In particular, the roof sockets for aerials were difficult to keep weather-tight, and the need for less-cramped operating conditions and better stowage arrangements for the apparatus became apparent. The security of the apparatus itself also presented problems. Since a non-metallic body was no longer considered essential, it was possible to base the design of a new vehicle on an existing standard type—the Area Planning and General Purpose Vehicle*—which seemed likely to provide the facilities required.

THE NEW VEHICLE

The general appearance of the new vehicle is shown in Fig. 2. The large side-windows and glazed pockets for the sliding side-doors help to give a good all-round view from the operator's position, so enabling him to pass instructions to the driver when they are "homing" on a source of interference.

FIG. 2—THE NEW VEHICLE

Interior Fittings

In addition to the usual seats for the driver and passenger, a bench seat is provided on the near side as an operating position. The space beneath this seat provides convenient stowage for batteries, for which rubber trays are provided, and a cabinet on the offside provides a table on which apparatus may be mounted (Fig. 3). The table is lit by a lamp fitted over the near-side door pocket. A 5-amp socket-outlet over the table is connected to the vehicle battery.

A folding table is fitted in front of the passenger seat to provide additional writing space.

A combined heater and demister is provided, and blinds are fitted to the side windows for use as required when operating within the vehicle.

Stowage and Security of Apparatus

To provide security for the apparatus carried in the vehicle an expanded-metal screen is used to divide the cab from the rest of the interior of the body. Since it is necessary to provide access from the cab to the rest of the interior, the screen is arranged in the form of two fixed panels, one on each side, and a folding door hinged to the near-side panel. When open, this door folds flat against the fixed near-side panel, as can be seen from Fig. 3. The side panels themselves are formed from two smaller panels, the upper parts being detachable to give access to the glazed door-pockets for cleaning purposes. Hinged flaps are provided at the bottom of the off-side

† External Plant and Protection Branch, E.-in-C.'s Office.
* SLATER, G. H. An Area Planning and General Purpose Vehicle. *P.O.E.E.J.*, Vol. 48, p. 112, July 1955.

FIG. 3—INTERIOR OF VEHICLE SHOWING OPERATING POSITION, APPARATUS CABINET AND AERIAL SUPPORT

fixed portion and at the bottom of the folding door to permit a ladder to be carried, as shown in Fig. 3.

Both the screen and the rear doors can be padlocked, while the opening side-windows are, of course, secured on the inside by window catches.

The full security provided enables the stowage facilities for the radio apparatus to be combined with the bench space required to mount the apparatus when it is in use. No separate locked accommodation is therefore required. The apparatus storage takes the form of a cabinet divided into compartments. Access to the compartments is obtained via sliding panels which form the top of the cabinet and provide the bench space. Apparatus mounted on the panels may be secured in position with elastic luggage-cords anchored to flush-fitting anchor pins inserted in the panels. By leaving one panel free it is possible to gain access to any of the compartments by sliding the panels as required without it being necessary to disturb any apparatus set up for use on the bench space. Flush-mounted bolts enable the panels to be locked in position to prevent any uncontrolled movement when the vehicle is in motion.

Aerial Mounting

To avoid the difficulties experienced with aerial sockets on previous vehicles, the aerial support on the new vehicle transmits no stress from the aerial to the vehicle roof and at the same time provides a weathertight mounting. The mounting consists of a tubular support extending from a batten on the vehicle floor to the roof and terminating at each end in a socket. This tubular support provides a direct channel for water entering at the roof end to a hole in the floor beneath the lower socket. The sockets are so arranged that the support can be rotated either directly by hand or by remote control from the cab. The remote-control gear, which enables the aerial to be rotated through 400° if required, is operated by a handle fitted behind the driver's seat; this handle is connected to the tubular support by flexible steel wires encased in steel conduit. The conduit and the control gear are fixed to a detachable batten to facilitate vehicle maintenance.

A junction box with a hinged flap carrying a coaxial connector is fitted to the tubular support to enable the coaxial lead from the aerial to be connected to the apparatus. The hinged flap of the junction box is fitted with a gasket to provide a watertight joint when the flap is closed.

To mount an aerial it is only necessary to insert the stub end into the open end of the tubular support on the vehicle roof. The stubs of the various types of aerial are slotted to engage with a pin fitted to the tubular support just below the underside of the roof. This pin projects outside the tubular support and provides an indication of the direction to which the aerial has been rotated.

The aerial support is fitted at the rear of the vehicle to enable the operator to mount the aerials while standing on the vehicle floor.

ACKNOWLEDGEMENTS

Acknowledgement is made to the members of the Motor Transport Branch, the Inland Radio Planning and Provision Branch, and the External Plant and Protection Branch who co-operated with the author in the development of the vehicle.

Book Review

"Fundamentals of Radio and Electronics"—

continued from p. 33

inaccurate; for the condition shown it will be a positive-going signal without an upward trend near the origin. It must not be thought, on the other hand, that all the material is sketchy or inaccurate. The explanation of P-type and N-type operation of semi-conductors on page 159, and the description of diversity reception on page 473, are good examples of the clear and concise styles adopted. The description of the magnetron on page 159 is disappointing, but the subject is pursued again on page 603 in a more satisfying manner. The information on microwave aerials is also rather haphazardly scattered.

The retention of Chapter 1 on mathematics, introduced in the first edition, is difficult to justify. It covers arithmetic from addition and subtraction to logarithms, simple algebra and trigonometry. The editor's claim is to make the text self-contained. The advances in educational facilities for engineering trainees and the essential mathematical "stock-in-trade" possessed by all electronics engineers nowadays makes this chapter superfluous. In other respects the book covers quite well the fundamentals of electricity, amplification up to microwave frequencies, basic radio, television, radio propagation and radar, the principles of electronic instruments and industrial applications.

W. A. R.

The Drum-Type Machine for Cleaning Mail Bags

F. G. CUMMINGS, A.M.I.E.E.†

U.D.C. 681—25:648:656.85

With nearly five million mail bags in use in the British Post Office the task of cleaning them is one of considerable magnitude. Based on previous experience, gained by using machines to clean mail bags, the drum-type machine has been developed. With this machine it is possible to clean to an acceptable standard either 50 letter bags or 30 parcel bags in a machine-operating time of 10 minutes.

INTRODUCTION

THE British Post Office has in service nearly five million mail bags which, in the interests of efficiency and hygiene, must be kept in a satisfactory state of cleanliness. Mail-bag cleaning is, therefore, a task of considerable magnitude, and the latest type of machine which has been developed for the purpose is described in this article.

Under the auspices of headquarters committees set up in 1936 and 1945, consideration was given to improvements in the bag-cleaning organization, and the methods used in other countries were studied. The Engineering Department was able to proceed with the design and ordering of machines for installation at bag-cleaning centres at selected large offices in various parts of the country. There are now installed 27 machines of the latest pattern and a further 14 will be provided over the next two years; in some cases these will replace equipment of an earlier pattern which is at present in service.

It would be as well to explain that mail-bag cleaning does not include washing, the use of solvents, or other normal laundering processes. The laundering of mail bags is practised by certain overseas administrations although in some cases this is confined to exceptionally dirty bags which in this country would be scrapped. It is considered that mail-bag washing has a number of disadvantages, including high cost, deterioration of bag fibres, substantial reduction of bag capacity due to shrinkage, the necessity for bag re-stencilling, etc., and the process favoured here is the removal of dust by mechanical methods.

According to medical opinion, the ordinary dust present when mail bags are being handled is not injurious to health as it consists mainly of vegetable and carbon particles, not in themselves harmful unless inhaled in sufficient quanties to cause irritation and congestion of the mucous linings of the air passages. In the normal process of mail transportation, bags have many opportunities to acquire dust from surfaces with which they come in contact. Some of this dust becomes embedded in the canvas fabric of the bags and may be released into the atmosphere when the bags are subsequently handled. The object of mail-bag cleaning is, therefore, to reduce to a minimum the amount of dust retained by the bags by subjecting them to a tumbling process at fairly frequent intervals.

Machines for cleaning mail bags have been in use by the Post Office since 1910. It is a tribute to the workmanship of these early machines that some of them are still giving useful service.

Broadly speaking, the machines installed can be grouped under three headings, as follows:

(*a*) Beater machines.
(*b*) Vacuum machines.
(*c*) Drum machines.

The main disadvantage of types (*a*) and (*b*) was that bags had to be individually treated. Also, considerable brush wear occurred with beater machines, as a result of which they became less effective. Vacuum-type machines, which have been previously described in the Journal,* were at one time highly thought of; in fact, they were standard equipment for some years after their introduction in 1932 as it was considered that their use would result in a higher standard of cleaning than was obtainable with other available types. Considerable muscular effort was required for continuous use of these machines, however, and as a result of a series of tests carried out at the request of the 1936 committee, it was conclusively demonstrated that drum-type machines not only cleaned more bags per man-hour but cleaned them more effectively. The committee therefore decided to install no more vacuum-type machines but to proceed with a program of providing drum machines. The war inevitably interrupted this program, and by the time installation could again proceed the machines had been virtually redesigned, using, however, the same fundamental cleaning principle.

THE DRUM-TYPE MACHINE

In drum-type machines, dirty bags are loaded into an octagonal drum which is then rotated at about 15 rev/min for a prescribed period. The tumbling which the bags receive loosens the dust from the bag fabric and the dust-laden air is drawn away to a textile filter where the dust is trapped, the filtered air being exhausted to the atmosphere. It must be emphasized that this type of machine is not intended for the treatment of badly soiled or contaminated bags—in the British Post Office these are separated and destroyed.

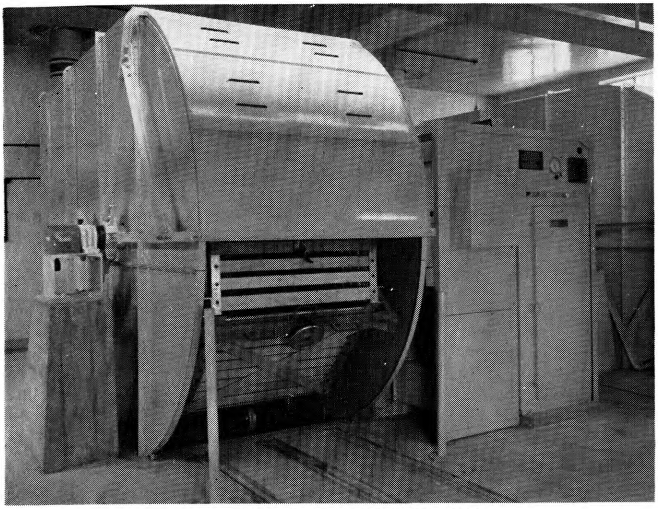
For descriptive purposes the modern drum-type machine (Fig. 1) may be considered as being composed of several basic components.

The Drum

The drum is generally in the shape of a hollow octagonal prism measuring 7 ft 4 in. externally across each pair of parallel sides. The metal framework of the drum is formed with 2 sets of radial spokes of 4 in. × 2 in. channel section, connected at their extremities by 2 in. × 2 in. angle-section framing and, at the hub, to centre bosses. These bosses are keyed to a 3 in. diameter steel shaft passing through the drum. To the framework of the drum are attached slats of well-seasoned timber, spaced about 1 in. apart, forming the ends and periphery of the prism. Care is taken to ensure that there are no projecting bolts, etc., inside the drum which might damage mail bags being cleaned. To aid the tumbling action of the bags, sets of wooden beater bars are fitted along the centre line of some of the sides of the drum, parallel to the drum axis.

The drum is constructed in two unequal sections, the division occurring in a horizontal plane 1 ft 6 in. below

† Power Branch, E.-in-C.'s Office.
* SNELL, W. S. A New Mail Bag Cleaner. *P.O.E.E.J.*, Vol. 27, p. 272, Jan. 1935.



The radial door is open and the truck is in position
FIG. 1—GENERAL VIEW OF BAG-CLEANING MACHINE

the drum axis (assuming the drum to be in its normal "at-rest" position). The lower, and smaller, portion of the drum is in the form of a truck with wheels, and can be removed from the drum for loading or transportation of bags. When in position for the bag-cleaning process the truck portion is securely locked to the upper portion of the drum. Two trucks are normally supplied with each machine.

Earlier machines were notable for very heavy drum construction, but efforts have recently been made to reduce the weight, and hence the kinetic energy, of the drum to minimize stresses set up during acceleration and deceleration, and to achieve more accurate levelling on stopping. The majority of the metal used in the drum framework is now aluminium alloy and the total weight of the drum (including the truck) has been reduced from 10½ cwt (or more on earlier equipment) to about 6¼ cwt.

One of the problems in drum design has been to prevent bags becoming tangled around the shaft. At one time, in fact, it was thought that the solution lay in dispensing with the shaft, and machines were installed in which the drum was supported on trunnion bearings. This design led to structural weaknesses and these machines were subsequently fitted with shafts. In machines of current design, a slotted "half barrier" is fitted inside the drum, radial with the shaft. The effect of this is to scoop bags up from the bottom of the drum during rotation and cause them to slide over the shaft at an appropriate point in the drum's revolution. It has proved to be very satisfactory in practice.

The complete drum, including truck, is balanced by weights added to the outer edges of the octagon to ensure, as far as possible, freedom from stress and vibration during rotation. The exterior surfaces of the drum are fitted with two sets of rubber sweeping strips so that the whole of the inner surface of the drum casing is swept continuously as the drum revolves.

The Drum Casing

The drum casing is of cylindrical form, and is constructed of 12-gauge steel-sheet fastened to an angle-iron framework. Its function is to confine the dust-laden atmosphere. Access for engaging and removing the truck is provided by means of a counter-balanced radial door. The counter-balance weights are supported on cranked arms, which are arranged so that the door moment is greater than the counterbalance moment in the door-closed position and vice versa in the door-open position. The door is provided with louvres through which air is drawn into the casing by the fan. At the rear of the drum casing access to the filter compartment is provided by an aperture 10 in. high, extending the width of the casing. Dust-laden air is drawn through this aperture by the fan, while the heavier dust is swept through the aperture by the rubber sweepers attached to the outside of the drum.

Filter Compartment

The filter compartment (Fig. 2) is a metal cubicle built on to the rear of the drum casing. It contains 12 flannel-fabric stocking-type filters, which, at

FIG. 2—FILTER COMPARTMENT

their lower ends, are clipped around spigots by webbing belts and are fitted so that the raised nap of the cloth is facing the direction of the air flow. The upper ends of the filter stockings are secured to a framework terminating in a shaker handle, normally held in a clip. The bottom of the filter cubicle has two hoppers each terminating in a replaceable dust-collecting bag. By releasing the shaker handle from the clip, dust trapped in the filter stockings may be shaken into the dust bags; this is done about once each day. A metal grille is provided at the bottom of the filter compartment to trap any undetected mail which may have been retained in the bags. The extractor fan is usually mounted close to the filter compartment. Suitable access doors are provided at the rear of the compartment.

The Fan and Ducting

Air is drawn into the drum casing by means of a centrifugal fan connected at the top, and to the rear, of the filter compartment. After passage through the filter stockings, the air is discharged into the atmosphere outside the building via galvanized-iron ducting containing suitable canvas sections to minimize noise due to vibration. The fan is capable of discharging not less than 1,800 cu. ft. of air per minute against a static head of $2\frac{1}{2}$ in. water gauge.

Drum Driving Gear

The drum driving gear is the heart of the bag-cleaning machine, and the type of drive now employed is the product of considerable development work. The drum is rotated by an electric motor through a worm reduction gear. On some earlier equipments the gears were required to be self-sustaining to maintain the drum stationary when the supply to the motor was disconnected. It was found that this could not be achieved after initial running-in, and holding brakes had to be fitted to these machines. The self-sustaining gear gave rise to other difficulties because it was irreversible, at any rate when new, and if a torque reversal occurred, e.g. during the slowing-down period of the drum, there was a tendency for the gear to lock-up, throwing considerable stress on the gear thrust bearing. A self-sustaining gear is no longer called for and a more robust gear is now employed having a two-start worm with a lead angle of $8^\circ 20'$ and a calculated efficiency of 83 per cent. A flexible coupling was at one time used between the worm gear and the drum shaft, but this produced torsional oscillation and a solid coupling is now employed.

Truck levelling has been a major problem in bag-cleaning machine development; with all drum-type machines in which a truck is incorporated as part of the drum, it is necessary to bring the truck to rest in a level position, so that it can be readily withdrawn and replaced. On modern machines levelling is performed automatically, although to cater for incorrect operation a levelling handwheel is provided. The handwheel is normally inaccessible to the machine operator, thus ensuring that faulty levelling is investigated and corrected. On some earlier machines slip-ring a.c. motors were used, the levelling being achieved by introducing rotor resistance and oscillating the drum between limits at a slow speed until it came to rest. Present practice is to use a 350-volt d.c. motor, reduce its speed by lowering the voltage to 60 volts and finally level the drum as described under "Control Equipment." The driving gear is fitted with a spring-operated, "normally-on" electromagnetic brake which finally brings the drum to rest. With this system, levelling within limits of $\pm\frac{1}{2}$ in. (measured at the drum periphery) is achieved.

Control Equipment

A simplified diagram of the control equipment is given in Fig. 3. The motor is of the separately-excited type, the field of which is energized from a 350-volt d.c. supply. This voltage is also applied to the armature for normal running but a supply at 60 volts d.c. is used for slowing the drum. The control equipment operates at 200 volts d.c. The d.c. supplies are obtained from selenium rectifiers incorporated in the control equipment.

Mounted side-by-side at the end of the worm-wheel shaft are two cams whose angular dispositions around the shaft can be independently varied. Each cam engages with an associated roller; these two cam rollers control the operation of switches SL and STL, which are associated, respectively, with the slowing and the stopping of the drum. When the drum is rotating during a normal run, the cam rollers are held out of contact with the cams by the zoner solenoid Z, but when stopping is initiated zoner solenoid Z is de-energized, allowing the cam rollers to operate their associated switches. The normal disposition of the cams is such that there is about 120° angular displacement between the two, the stopping cam being the last one to operate.

The duration of a run is determined by an adjustable synchronous timer. Depressing the start button on the synchronous timer energizes the motor of the timer and operates contact T1; contact T1 operates relay ZR. Relay ZR then operates the main contactor relay, MC, and energizes zoner solenoid Z, which lifts the cam rollers away from the cams. The electromagnetic brake is energized via contact MC3, freeing the worm shaft. Relay F is also operated by relay ZR and connects the motor armature to the 350-volt d.c. supply via the starting resistors; these resistors are successively switched out as relay R operates, and the drum runs up to speed.

On completion of the scheduled time, the synchronous timer releases contact T1, causing zoner solenoid Z to be de-energized after the release of relay ZR. The cam rollers then re-engage with the cams so that at the appropriate point in the drum rotation springs SL close, operating the interlock relay INT. Relay INT releases relay F at contact INT3, and energizes the slow-to-operate relay SR at contact INT4. The release of relay F reduces the armature voltage to 60 volts. After a delay of a second or two, relay SR operates and connects the slowing resistor across the armature to act as a divertor. At the same time a buzzer is operated, via contact SR1, to indicate to the operator that the cleaning process has been completed. The drum continues to rotate until the stopping cam opens springs STL. These springs release contactor relay MC and, hence, apply the electromagnetic brake to bring the drum to rest and restore the circuit to normal.

Electrical interlocks are provided on the truck-locking handwheel gear, the radial door, the hinged box which permits access to the handwheel, and the handwheel engaging mechanism. These interlock contacts are shown in Fig. 3 as contacts TD, DD, HWB, and HW1, respectively.

The circuit also arranges for the brake magnet to be energized by the closure of contacts HW2 when the

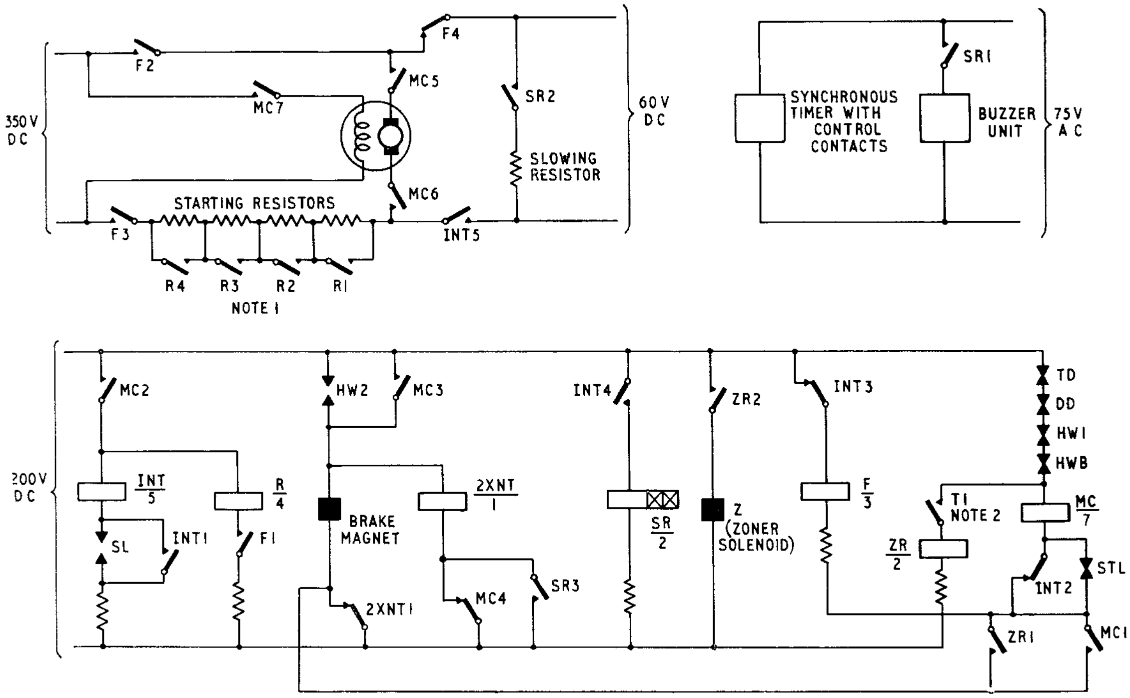


FIG. 3—SIMPLIFIED SCHEMATIC DIAGRAM OF CONTROL EQUIPMENT

Notes 1 Contacts R1–R4 are closed in sequence by operation of Relay R.
2 Contact T1 is controlled by the synchronous timer

handwheel is engaged for manual truck levelling. As the brake coil is not continuously rated, the 2XNT relay (a nomenclature derived from lift control equipment) is energized at the same time, limiting the hand-levelling period to about 80 seconds. Relay 2XNT also operates and applies the brake if, due to a fault, the controller remains in the slow-speed condition for the same period.

MACHINE LOADING AND RUNNING TIME

One of the major problems associated with drum-type bag-cleaning machines is the specification of machine loads and running times. There are two main classes of mail bag in use in the British Post Office: the letter bag, 44 in. long by 26 in. wide and weighing (new) 1 lb 14½ oz; and the parcel bag, 48 in. long by 20 in. square, weighing (new) 3 lb 10 oz. Cleaning-machine loads are specified in terms of both types of bag.

Before the investigation of the 1945 committee, large loads and long running times were favoured. An exhaustive series of tests was carried out in 1945–46, however, and as a result operating conditions were revised. The most striking conclusion which resulted from these tests was that smaller loads gave better cleaning. With regard to running time, from consideration of the principle of operation of drum machines it will be appreciated that, in addition to removing dust, small particles of the canvas-bag fibre—generally referred to as "fluff"—will also be removed. This represents undesirable wear and tear and, quite apart from considerations of operating economics, it is necessary to curtail running time for this reason alone. In general, the heaviest fall of dust occurs in the first 10 minutes of the running period, after which, although dust continues to be extracted, the rate of extraction falls and the proportion of fluff extracted increases.

It will be seen from the above that the specification of machine-operating conditions represents a compromise between conflicting considerations. Bearing all relevant factors in mind the following operating conditions were specified for drum-type machines, giving an acceptable standard of cleaning at reasonable cost without appreciable bag wear.

Operating Conditions for Drum-Type Machines

Type of Bag	Load	Duration of Run
Letter	50	10 minutes
Parcel	30	10 minutes

CONCLUSION

The methods to be employed for mail-bag cleaning offer considerable scope for technical ingenuity.

The material from which the bag is made has a very important bearing on the problem, and if a non-fibrous and impervious material was available, comparable in durability and cost to the flax canvas at present used, the situation would, without doubt, change significantly. Continued research will, perhaps, make such a material available in the course of time. With the existing type of mail bag, however, the equipment described above represents a satisfactory and economic solution to the problem arising from the conditions in the United Kingdom.

An Improved Trigger-Type Dial—the Dial, Automatic, No. 21

J. L. BELK, Assoc.I.E.E.†

U.D.C. 621.395.636.1

A new telephone dial is being introduced in matching colours for use with 700-type telephones. The basic trigger mechanism of the earlier type of dial has been retained but the use of a different form of construction and different materials has enabled an improved appearance and performance to be obtained at reduced cost.

INTRODUCTION

THE development of the 700-type telephone* necessitated some redesign of the dial so that its appearance would be in keeping with the new telephone. The opportunity was also taken to reduce the cost of the dial whilst improving its reliability. Development of the dial followed that of the telephone, and the existing type of stainless-steel dial with a figured number-ring has therefore been used on the first issues of the new telephones. The general appearance of the new dial is shown in Fig. 1.

FIG. 1—GENERAL APPEARANCE OF THE NEW DIAL

FEATURES OF THE NEW DESIGN

Interchangeability

When large numbers of an item of apparatus are in use it is essential that the normal economic life of the item shall not be curtailed by the introduction of new components which are not interchangeable. Thus, with seven million telephones already in service, the new dial had to be suitable for use both on existing telephones and the new telephone. This meant that the three fixing lugs used on the earlier dial had to be retained on the new dial, although a new method of fixing, by means of a clamp around the body of the dial, was to be used on the new telephone.

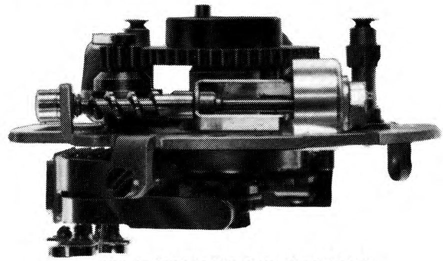


FIG. 2—BASE PLATE AND MECHANISM

Reliability

The reliability of a dial mechanism can be proved only by prolonged field trial. Accelerated life tests may show possible faults but a satisfactory life test on a mechanical component which is affected by ageing is only a preliminary step to a field trial if performance is to be proved conclusively before introduction. Thus, although new designs of mechanism were considered for the dial, they were rejected in favour of the trigger mechanism which has been used by the Post Office since 1948.

Mechanical Details

The most expensive component of the earlier dial was the metal case that housed the mechanism. Economy has been obtained with the new dial by mounting the mechanism on a flat steel base plate (Fig. 2) and completing the body by means of a moulding (Fig. 3). The flat plate has provided improved accessibility and the use of steel has provided greater support for the centre bearing. The centre bearing of the older dial could be distorted, due to the brass case buckling, if excessive pressure was put on the edge of the finger plate, e.g., when the dial was dropped or forced into a telephone case or dial mounting.

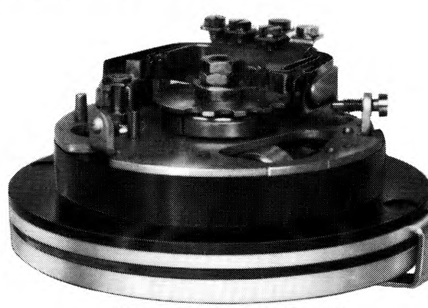


FIG. 3—BACK VIEW OF NEW DIAL

† Subscribers' Apparatus and Miscellaneous Services Branch, E.-in-C.'s Office.

* SPENCER, H. J. C., and WILSON, F. A. The New 700-Type Table Telephone—Telephone No. 706. *P.O.E.E.J.*, Vol. 52, p. 1, April 1959.

The material for the bush of the centre bearing has also been changed and it is now made of steel, although trials of different materials have not established any particular superiority. This provides the more conventional combination of brass and steel for this type of bearing. In addition, the centre spindle and the governor gear pinion and its shaft have been provided with a coating of dry graphite to assist in preventing dial failure due to deterioration of the lubrication at these points. Dry lubrication, which will not be affected by ageing, has been investigated for use in other parts of the dial mechanism, but a fully satisfactory and cheap method of providing dry lubrication for all bearing surfaces has not yet been found.

Spring-set Design

Palladium has been used in preference to silver for the pulsing contacts. Silver contacts used in the existing types of dial have occasionally developed a high contact resistance which can affect pulsing, and cause noise in the line. Although not widespread, these troubles have occurred on the earlier slipping cam type of dial, the contacts of which had a wiping action, and also on the trigger-type dial the contacts of which have very little wiping action. The use of palladium may prevent or reduce these faults at little extra cost.

Appearance

It was originally hoped that a single type of dial would be acceptable for use on all the different coloured telephones. Early consultation with the Council of Industrial Design indicated that polished stainless steel was not favoured and, as the Post Office did not favour a satin finish for the heavily used finger plate, alternative materials were investigated.

P.V.C. appeared to be ideal material in that it was cheap and could be made with a variety of colours and finishes. The appearance of the complete telephone was much improved by having a dial coloured to match the telephone and, not withstanding the increased overhead costs of having more than one dial, a full range of seven colours was introduced. The colours are listed in Table 1. Also, because of its resilience, a finger plate made of this material was pleasant to handle and risk of damage to the centre bearing, by excessive pressure applied off-centre on the front of the dial, was reduced.

TABLE 1
Colours Used for the Finger Plate and Number-Ring of the New Dial

Abbreviated Colour Description (used in titles of telephone, dial, finger plate and number-ring)	Actual Colour of Finger Plate	Actual Colour of Blank "Number-Ring"
Black	Black	Black
Blue	Concord blue	Concord blue
Green	Aircraft grey-green	Forest green
Grey	French grey	Elephant grey
Ivory	Light ivory	Light ivory
Red	Lacquer red	Lacquer red
Yellow	Topaz yellow	Topaz yellow

Note: The green and grey number-rings, which are darker than the green and grey finger plates match the colour of the telephone handsets. The finger plates match the colour of the telephone covers.

The formed p.v.c. construction enabled the front of the dial to have an unbroken contour because the dial centre label and its protective window have been sunk into the finger plate. The resilience of the finger plate has been used to retain the label protector by gripping three pips on the periphery of the protector and so providing a snap fit. The protector has to be released by using a rubber suction disk (Extractor No. 29), or by inserting a small screwdriver (Screwdriver No. 1) under an ejector plate beneath the protector.

To match the appearance of the dial, the finger stop and the dial centre label have also been redesigned as shown in Fig. 1. The centre label is grey with white printing on the top half, and white with black printing on the bottom half and is suitable for all colours of dial. The appearance of the dial, in its association with the Telephone No. 706, has been approved by the Council of Industrial Design.

Dust Exclusion

The dial "number-ring" was designed to prevent it collecting dust and providing a point of entry for dust into the mechanism. Thus, instead of fitting the number-ring into a recess as on earlier dials, it now overlaps the body of the dial. Part of the body has been left exposed so that when the dial is gripped with the hand, as for instance when it is fitted in a switchboard dial mounting, pressure can be taken directly on to the dial body. When the dial is fitted in the new telephone the body is not seen because the dial is sunk so that the top surface of the dial number-ring is coincident with that of the outer number-ring.

A thin polythene seal has also been provided between the dial number-ring and the boss of the centre spindle. This seal is a floating fit in the number-ring, to enable it to be self adjusting for eccentricity between the number-ring and the centre spindle. A dust cover has been included in the Telephone No. 706 to protect the back of the dial.

FURTHER WORK

The modifications necessary to provide a new range of dials for other purposes are now being investigated. For use on 200-type and 300-type telephones, as a maintenance replacement item, the only change that will be required in the new dial will be replacement of the plain number-ring by one carrying letters and figures. It is hoped that the new dial with letters and figures will also be suitable as a switchboard dial, and a field trial is being arranged. Trials of an earlier design of p.v.c. finger plate, which was based on the shape of the stainless-steel finger plate, failed due to breakage across the thin bridge between the finger holes. The finger plates of the latest design are of greater depth and should prove to have sufficient strength to withstand the hard use encountered on switchboards. On the other hand, trials leave little doubt that a stainless-steel finger plate will still be necessary in call offices if excessive damage is to be avoided.

ACKNOWLEDGEMENT

The author wishes to acknowledge the development work done on this item by the liaison manufacturer, The General Electric Co., Ltd.

Proposed Commonwealth Pacific Telephone Cable System

U.D.C. 621.315.28:621.395.5(265/266)

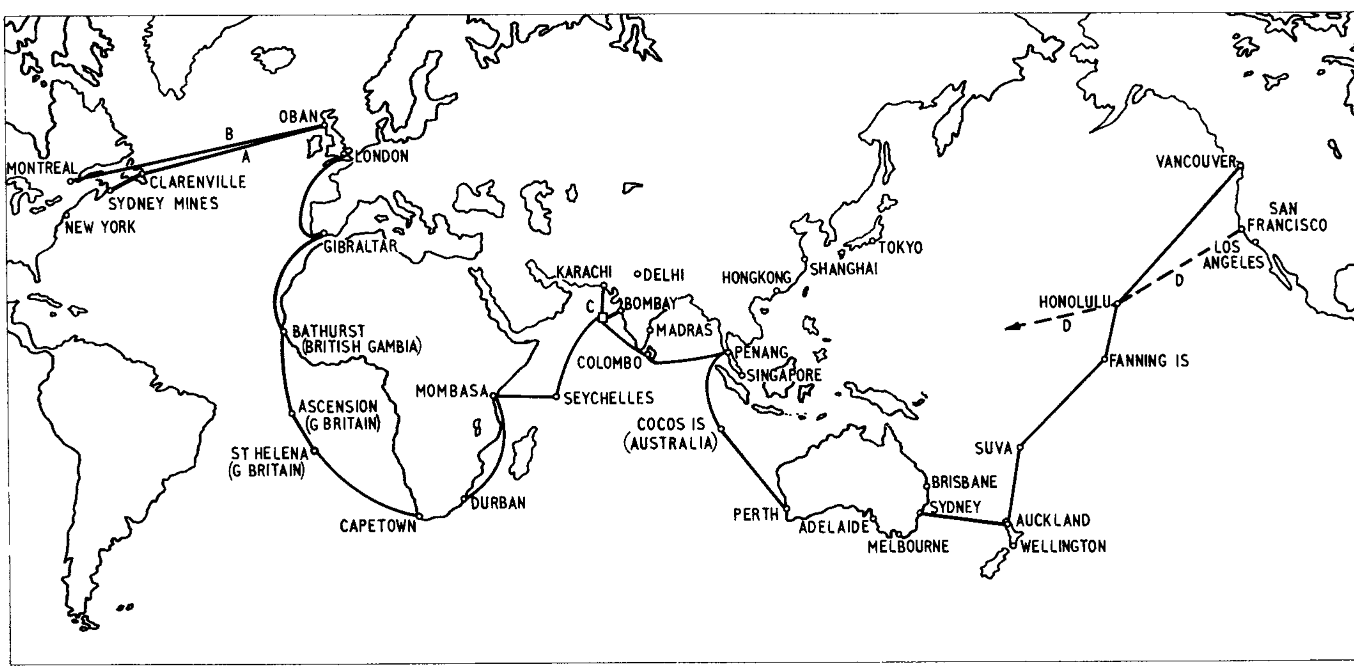
PRIOR to the opening of the first transatlantic telephone cable (TAT-1)[1] in September 1956, telecommunication facilities between Commonwealth countries were provided by the 140,000 nautical miles (n.m.) of submarine telegraph cables of Cable and Wireless, Ltd. (C. & W., Ltd.)* and by radio telephony and telegraphy. TAT-1 provided, initially, six telephone circuits and 11 telegraph circuits between the United Kingdom and Canada; the present facilities are provided by 13 telephone circuits, 20 80-baud and two 50-baud telegraph circuits.[2]

In April 1957 at Ottawa[3] it was agreed, subject to the consent of Governments, to provide a direct telephone cable between the United Kingdom and Canada. This was to be based on the development by the United Kingdom Post Office of a system providing a bandwidth of 240 kc/s in each direction over a single cable of novel construction,[4] the strength member being in the middle and torsionally balanced and the external sheathing being polythene. The system would be owned jointly by C. & W., Ltd., and the Canadian Overseas Telecommunication Corporation (C.O.T.C.). The agreement was subsequently ratified by Governments and provision of the system (CANTAT), involving about 93 rigid repeaters, is now in hand. Using high-efficiency 3 kc/s-spaced channel equipment, developed at the Dollis Hill Research Station,[5] the system will have a capacity of 80 telephone circuits or their equivalent, without using T.A.S.I.[5,6] It is due for completion in September 1961.

* Owned entirely by the United Kingdom Government.

In July 1958, the Commonwealth Telecommunications Conference agreed, in London, to recommend to Governments the provision of a complete "round-the-world" telephone cable system (Fig. 1), generally to the CANTAT pattern. The estimated cost was about £88 million, including CANTAT and the United Kingdom–Canada circuits in TAT-1, which would become the first link in the "round-the-world" system. This recommendation was accepted in principle by Commonwealth Governments at the Commonwealth Trade and Economic Conference[7] held in Montreal in September 1958, the United Kingdom Government undertaking to provide up to 50 per cent of the total capital. It was left to countries immediately concerned to initiate action in respect of individual links.

In June 1959 the Australian Government advised the Commonwealth Relations Office that "in its view it was desirable that construction of a large-capacity trans-Pacific cable, immediately to follow completion of CANTAT in 1961, should now be considered by the Governments directly concerned" and proposed a Pacific Cable Conference in Sydney, to start on 28 September. The primary invitations went to the Governments immediately concerned—the United Kingdom, Canada and New Zealand—though representation from all Commonwealth countries was invited. The agenda included the revised wayleave and accounting arrangements necessitated by the participation of other Commonwealth countries in the ownership of the system. In the event, only the four particpating countries were represented, together with Sir Ben Barnett, Chairman of the Commonwealth Telecommunications Board. The



A—TAT-1; B—CANTAT; C—Proposed underwater connexion point; D—A T &T.Co. Pacific cables

It was originally proposed (at the 1958 Conference) that the Australia–New Zealand cable should land near Wellington but in 1959 the Sydney Conference agreed that the cable would land near Auckland, thus avoiding the internal New Zealand link, Auckland–Wellington

FIG. 1—PROPOSED COMMONWEALTH ROUND-THE-WORLD TELEPHONE CABLE SYSTEM

Seated at centre table (from left, next to pillar, to right): Sir Giles Chippindall (Vice-Chairman, O.T.C.(A); Sir Ben Barnett (Chairman, Commonwealth Telecommunications Board); Rt. Hon. R. G. Menzies (Prime Minister of Australia); Hon. C. W. Davidson (Postmaster-General, Australia—Conference Chairman); S. F. Kellock (Chairman, O.T.C.(A)); M. R. C. Stradwick (Director-General, Postmaster-General's Department, Australia).

FIG. 2—SIR ROBERT HARVEY ADDRESSING THE OPENING SESSION OF THE CONFERENCE

United Kingdom delegation, headed by Mr. R. J. P. (now Sir Robert) Harvey, Deputy Director General, included representatives of the Post Office, C. & W., Ltd., and the United Kingdom High Commissioner in Canberra.

The conference chairman was the Australian Postmaster General, the Hon. C. W. Davidson, and the Vice-Chairman was Mr. S. F. Kellock, Chairman of the Overseas Telecommunications Commission (Australia)—O.T.C.(A). The Conference was an outstanding success right from the opening session (Fig. 2), when the Australian Prime Minister, the Rt. Hon. R. G. Menzies, gave the proceedings a flying start with his exhortation and encouragement; Mr. Menzies is truly cast in the Churchillian mould!

The proceedings were extremely cordial and, while a few differences in viewpoint had to be reconciled in the inevitable compromise, the result was never in doubt. It is gratifying indeed that representatives of four independent Commonwealth countries bound only by common descent, tradition and purpose were able to reach rapid and unanimous agreement on such a large and novel project.

The scheme recommended to Governments involves the provision of a Commonwealth Pacific Cable (COMPAC), conforming closely to the CANTAT pattern and connecting Sydney to Vancouver via Auckland, Suva (Fiji), Fanning Island and (probably) Honolulu, on the Hawaiian island of Oahu; with the last exception all landings will be on Commonwealth territory. While it is now considered technically feasible to span the 3,500 n.m. between Fanning Island and Vancouver without an intermediate landing, there are obvious technical and traffic advantages in a landing near Honolulu, which is already connected by an American Telephone and Telegraph Company (A. T. & T. Co.) telephone cable to San Francisco; A. T. & T. Co. have also announced plans for telephone cables onward to Japan and other Far East countries. However, an Hawaiian landing has not yet been agreed with the United States Government authority though discussions have been initiated.

The plan is essentially that agreed at the 1958 Conference, departing from it only in detail. Thus:

(*a*) the Australia–New Zealand cable will land near Auckland instead of Wellington and the internal New Zealand link, Auckland–Wellington, will thus be avoided, and

(*b*) the cable leaving Canada will be in two sections for power feeding; Vancouver–Port Alberni (on Vancouver Island), 100 n.m., and Port Alberni onwards to Honolulu or Fanning.

Approximate distances, maximum depths and numbers of repeaters are given in the table.

In the words of the Conference Report "the system will provide transmission bands 240 kc/s in width in each direction over the sections Vancouver–Honolulu–Fanning–Fiji–Auckland–Sydney. These bands would normally be available as five 48 kc/s bands in the range 60–108 kc/s at the above points, but could if necessary be divided in a different manner. The 48 kc/s bands would be equipped to provide telephone, telegraph (including telex), program, facsimile and data transmission circuits as required. Within the band-width limitations of the system other telecommunication services which may be developed in the future could also be provided. Conventional television will not be practicable."

The system will be connected to the CANTAT cable via the trans-Canada microwave radio-relay system (a Bell TD2 System) and will—again in the words of

Composition of Pacific Telephone Cable System

Section	Distance (n.m.)		Max. Depth (fathoms)	Re-peaters	Equal-izers
	Map	Cable			
Vancouver–Pt. Alberni	100	106	Mostly Overland	6	0
Pt. Alberni–Honolulu	2,310	2,444	3,400	93	9
Honolulu–Fanning	1,044	1,110	3,100	42	4
Fanning–Suva	1,890	2,002	3,000	76	7
Suva–Auckland	1,146	1,214	2,500	47	5
Auckland–Sydney	1,172	1,242	2,600	48	5
TOTAL	7,662	8,118	—	312	30

the Conference Report—"provide a major link in the Commonwealth round-the-world system, and it will enable all normal telecommunication services of modern standards to inter-link with other international and national systems, both inside and outside the Commonwealth". It will be planned as part of a connexion of a notional length of 25,000 km, i.e. a 20,000 km global circuit with a C.C.I.T.T. "circuit fictif" of 2,500 km at each end. The transmission objectives for such a connexion are the subject of a current question by a C.C.I.T.T. study group; the objectives recommended by the technical committee at the Conference conform closely with those proposed to the C.C.I.T.T. by the United Kingdom Post Office. They include zero (4-wire) transmission loss between international switching centres in the "via" or through condition, with a standard deviation for overall circuits (including London–Sydney, over 16,000 route miles) not exceeding 1·8 db. The mean circuit noise should not exceed 1 pW/km at a point of zero relative level.

In the knowledge that, in the matter of switching over international networks, there is a wide diversity of practice between Administrations, it was recommended that signalling and switching objectives should generally be as agreed between the United Kingdom Post Office, A. T. & T. Co. and C.O.T.C. for transatlantic circuits.

The importance of through-group working with overall group-reference pilots was stressed and this must inevitably lead to some modification of the high-efficiency 3 kc/s-spaced channel equipment as now being manufactured. The difficulties of through-group working with this equipment have been set out in an earlier note[2] and a modified design is now in hand.

Detailed planning of the system will be controlled through Joint Technical Meetings; the execution of the plans will be the responsibility of C.O.T.C. in Canada and Honolulu, O.T.C.(A) in Australia, the New Zealand Post Office in New Zealand and C. & W., Ltd., in Fanning and Fiji; these four bodies will own and operate the system.

A joint United Kingdom P.O./C. & W., Ltd., unit now being set up at Dollis Hill under Mr. R. J. Halsey, Director of Research*, will be responsible for engineering the submarine cable sections to the agreed requirements. The project generally will be under the control of a Management Committee of high-level representatives of the Commonwealth Partners.

C.O.T.C. will have undivided ownership of the system between Vancouver and a point south of Hawaii; the remainder will be owned jointly by the other three partners on an indivisible basis.

A tentative construction program, aiming at a "ready-for-service" date of April 1964 for the entire system, involves laying the Sydney–Auckland and Auckland–Fiji sections in 1962 and the Fiji–Fanning and Fanning–Honolulu–Vancouver sections in 1963–4. H.M.T.S. *Monarch* will be the only cable laying ship available in 1962 when she will operate in conjunction with a supply ship; in 1963, a new cable layer planned by C. & W., Ltd., is expected to be available to assist *Monarch*.

The Conference Report has now been accepted by all four Partner Governments and the Management Committee will have its first meeting, in London, in April 1960.

R. J. H.

* Also a director of C. & W., Ltd.

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[2] Increasing the Traffic Capacity of Transatlantic and Other Submarine Telephone Cables. *P.O.E.E.J.*, Vol. 52, p. 140, July 1959.

[3] A Proposed New Telephone Cable between the United Kingdom and Canada. *P.O.E.E.J.*, Vol. 50, p. 104, July 1957.

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[6] O'Neill, E. F. TASI (Time Assignment Speech Interpolation). *Bell Laboratories Record*, Vol. 37, p. 83, Mar. 1959.

[7] Commonwealth Trade and Economic Conference: Report of the Conference, Cmnd. 539 (Her Majesty's Stationery Office), p. 16.

An Answering Set for Telephone Subscribers

F. L. RANDALL†

U.D.C. 621.395.9:621.395.625.3

Design requirements are suggested for a device which will answer a telephone call and give a recorded message when the called subscriber is absent. The way in which these requirements are met by the Post Office Answering Set No. 1 is described.

INTRODUCTION

FOR many years it has been possible for subscribers connected to certain exchanges to arrange for incoming calls to be intercepted at a manual board and for callers to be referred to an alternative number. This service is particularly valuable to subscribers such as doctors, who can expect to receive urgent telephone calls at any time and who are thus relieved of the necessity of ensuring that someone is always available to answer them.

Unfortunately, this transfer-of-calls service cannot be made available to all subscribers who might wish to use it, and there is a need for an automatic answering device which can be associated with the telephone installation whenever it is not convenient for calls to be answered personally.

GENERAL DESIGN CONSIDERATIONS

It was considered that an answering machine for subscribers' use should provide the following facilities:

(*a*) The user should be able to record the message he wishes the caller to hear, and change it as required.

(*b*) The subscriber's telephone should be used to record the messages, and the recording process should be no more difficult than making a telephone call.

(*c*) The user should be able to check the recording he has made by listening to it in the telephone receiver.

(*d*) The message capacity of the machine must be adequate, but not greater than can conveniently be used fully. To help in this respect, there should be an indicator showing the time available throughout the recording process.

(*e*) A caller should be able to hear the whole message at least once, even if part of its transmission is interrupted by pay tone from a pay-on-answer coin box.*

(*f*) Connexion of the machine must not interfere with normal use of the subscriber's installation, and all incoming calls should ring a telephone bell.

The machine described in this article is not required to record the caller's message; other approved machines are already available which will do this.

ANSWERING SET NO. 1

Physical Features

An answering device, developed commercially to meet a Post Office performance specification, has been adopted and coded as "Answering Set No. 1". It is an a.c. mains-operated machine using standard tape-recording techniques and is shown in Fig. 1 together with a Telephone No. 706.

The moulded case of the answering set, which follows the general configuration of the Telephone No. 706, is approximately 12 in. wide, 6 in. high and 9 in. deep; it is two-tone grey in colour.

Only two controls are needed to operate the set; these are a function-selector switch having the four positions "Off", "On", "Check" and "Record", and a press button which starts the machine when a recording is to be made or checked. Three indicators are provided. One of the two small circular windows shows a pilot light when the mains supply is connected, the other shows a moving

† Subscribers' Apparatus and Miscellaneous Services Branch, E.-in-C.'s Office.

* BASTOW, F. J., COLLINGWOOD, J. D., NEWELL, E., and PRICE, C. K. The Pay-on-Answer Coin-Box System, *P.O.E.E.J.*, Vol. 51, p. 343, Jan. 1959.

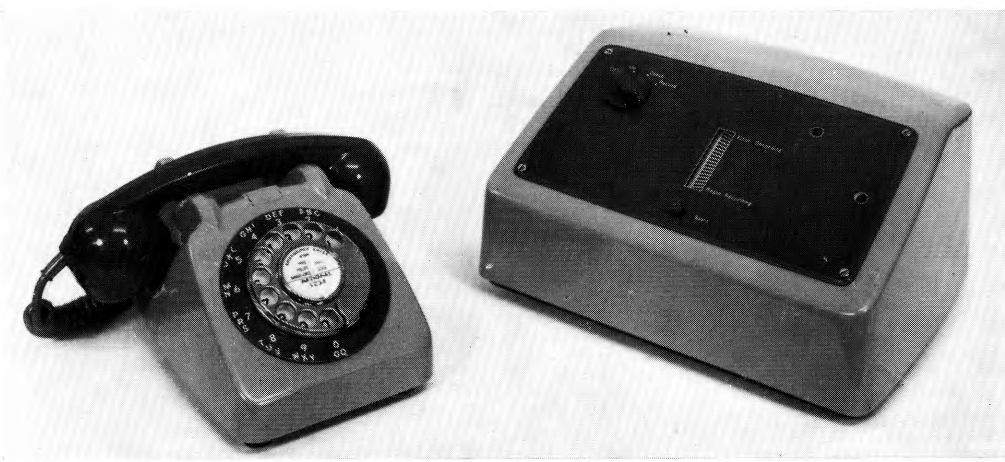


FIG. 1—ANSWERING SET NO. 1 WITH TELEPHONE NO. 706

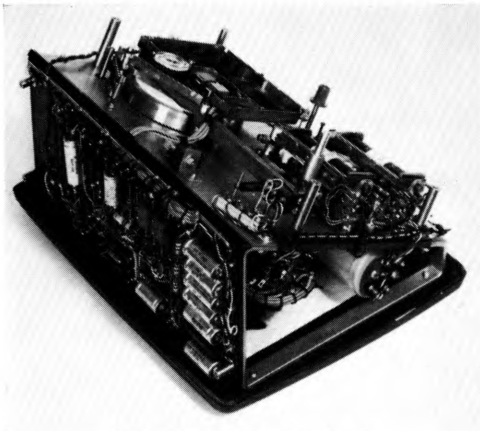


FIG. 2—CHASSIS OF ANSWERING SET

pattern when the tape driving system is in motion and so acts as a warning against switching the set to a new function before the previous one is completed. The third indicator is the central rectangular window, showing an edge-lit scale marked "Begin Recording" and "Finish Recording"; a pointer moves between these marks during the recording process.

Fig. 2 shows the machine's wedge-shaped chassis, with the cover removed from the tray in which the tape is stored. The sloping panel carries most of the components for the control circuit, and the vertical rear member carries the electronic circuits. A conventional driving system is used for the tape, giving a linear speed of $1\frac{7}{8}$ inches per second. The loop of tape is slightly longer than is necessary for a 20-second message and the excess portion is thickened so that it displaces the tape pinch-wheel at the end of each cycle of operation. The pinch-wheel is mounted at one end of a pivoted lever, so that a small movement of the wheel is mechanically magnified and operates two microswitches held in contact with the other end of the lever. The pinch-wheel also carries a pattern which can be seen through one of the windows in the control panel.

The flywheel of the tape driving system carries a concentric plastic disk in which is moulded a spiral groove running from the centre to the rim. A nylon stylus tracks this groove and, by a cranked lever system, moves the pointer linearly over the time-indicator scale.

To prevent electrostatic attraction between the convolutions of tape in the storage tray, the tape is wiped immediately after passing the pinch-wheel by a metal strip solidly bonded to the chassis.

The set is connected to the associated telephone and exchange line by a 6-way cord terminated on a strip, which is exposed when the base of the set is removed.

Electrical Features

Electrically, the set is in three parts:

(*a*) *The answering circuit*, which includes the function-selector switch and control relays

(*b*) *A record/replay amplifier*, together with the h.f. bias oscillator and the erase and record/replay heads

(*c*) *A power unit*, which supplies h.t. and l.t. to the record/replay amplifier, smoothed d.c. of 50–60 mA for the telephone transmitter and partially smoothed d.c. for relay operation.

Facilities

The Answering Set No. 1 can be associated with most of the telephone instruments used by the British Post Office and can be directly connected to any type of exchange service line except C.B.S.1 and shared-service lines.

Incoming calls are answered about 7 seconds after the receipt of ringing current; it is undesirable for the machine to answer too quickly. Calls are answered by the connexion of a transformer winding having a resistance of 120 ohms and presenting an impedance of about 600 ohms to the exchange line. Transmission of the recorded message begins immediately after answering, and a 20-second recording is played twice. If the recording capacity has been fully used, the second transmission begins within 2 seconds of the end of the first. After the repetition, the machine disconnects itself from line and is immediately ready to answer the next call.

The message is recorded by speaking normally into the handset, and it is desirable to use the whole of the recording capacity by talking until the time indicator disappears from view. The recorded message can then be played back into the telephone receiver.

When automatic answering of calls is not required, the set can be disconnected by switching to "Off". In all positions of the selector switch, it is arranged that a telephone bell is included in the line circuit.

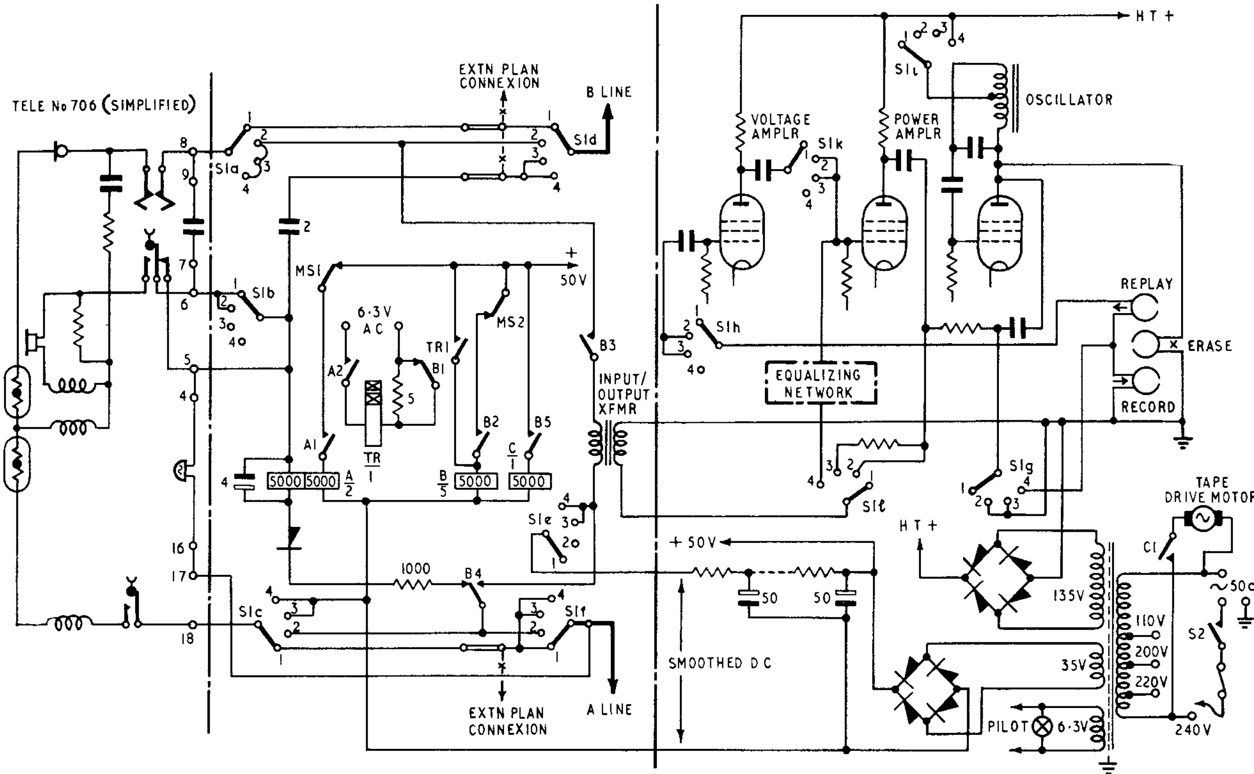
Circuit Description

Fig. 3 is a simplified diagram of the circuit of the Answering Set No. 1. The set is shown associated with a Telephone No. 706.

For automatic answering, the multiple-wafer selector switch is turned to "On". This connects mains to the set, via switch S2, and S1 connects relay A in parallel with the windings of the telephone bell. A small proportion of ringing current is rectified to operate relay A, which locks over its own contact via a microswitch, MS1. Contact A2 applies 6·3 volts a.c. to a thermal relay, TR, which operates in 5–7 seconds so providing the required pre-answering delay. The thermal relay contact operates relay B, which in turn operates relay C, so starting the tape drive motor. B3 and B4 connect the 120-ohm winding of the transformer to line to give the answering condition; B2 provides a holding circuit for B via the second microswitch, MS2. The tape is now in motion past the replay head, and the recorded message is transmitted.

When the tape loop completes its first cycle and the message has been transmitted once, the thickened portion of the loop causes both microswitches to open momentarily. The locking circuits of relays A and B are broken, but the latter relay remains operated because the thermal relay contact TR1 is still closed. As relays B and C remain operated, the tape motor continues to run until the microswitches are again opened by the thickened tape at the end of the second message transmission. Relay B now releases because TR1 has opened and there is no alternative holding path. The output transformer is disconnected from line by B3 and B4. When, in turn, relay C releases, the motor stops and the set is ready to receive the next incoming call.

While the set is switched to "On", normal telephone service is available from the associated instrument.



The function-selector switch S1 positions are 1—OFF, 2—ON, 3—CHECK, 4—RECORD

FIG 3—SIMPLIFIED CIRCUIT OF ANSWERING SET NO 1 ASSOCIATED WITH TELEPHONE NO 706

Making a Recording

The selector switch is turned to the "Record" position and connects the whole of the telephone transmission circuit to the input of the amplifier. It also switches smoothed d.c. to the transmitter. The user gets normal telephone speech conditions, including some side-tone, while recording and he unconsciously adjusts his voice to normal level without the aid of a volume indicator. The ringing circuit is switched via a 2μF capacitor in the set in order that ringing current from an incoming call can be applied to the telephone bell even if the switch is left in the "Record" position. While a recording is being made there is no connexion between the speech circuit and the exchange pair. In the amplifier, the selector switch applies h.t. to the bias oscillator, connects the input transformer to a power amplifier and connects the amplifier output, together with bias current, to the record/replay head of the tape system. At the same time, bias current is applied to the erase head to remove the previous recording.

The recording process commences when the "Start" button is pressed. This action sets the indicator pointer at the beginning of the time scale, and also operates relay B mechanically. As before, the tape drive motor is switched on, cycling the tape once until the micro-switches are opened; when this occurs, relay B releases and relay C cuts off the motor.

Checking the Recording

In turning the selector switch from "Record" to "Check", the only circuit changes are in the amplifier unit where the record/replay head is now connected to the input of a high-gain voltage amplifier, and h.t. is disconnected from the bias oscillator. Operation of the "Start" button, as before, causes the tape to make one cycle during which the recording is heard in the telephone receiver but, because an attenuator is added to the amplifier output in this switch position, the recording is 3 or 4 db below the level which is available for transmission to line. By this means the user is able to hear the message at about the same volume as a local caller will hear it, and can satisfy himself as to its volume and clarity.

When standard direct-exchange-line service is required, the function switch is turned to "Off", disconnecting the mains supply, providing through circuits from the exchange pair and electrically dissociating the set from the telephone circuit.

Use of the Answering Set with Multi-Instrument Installations

To avoid complications in the wiring of extension-plan and similar systems, straps are provided in the set so that the exchange line can be intercepted when the function switch is at "On," while in all other switch positions the exchange pair is routed straight through the set. In these circumstances, a separate telephone instrument is provided for recording and checking.

Characteristics of the Record/Replay Amplifier

The recording amplifier can accept peak input signals of about 2 volts without distortion, i.e. it can accept the maximum speech voltage likely to be developed in the transmission circuit of a modern telephone; an equalizing network is included to reduce over-emphasis of sibilants.

The replay amplifier contains a compensating network giving a generally rising gain/frequency characteristic which tends to offset loss of higher speech frequencies due to the comparatively low tape speed. The overall effect gives a substantially smooth frequency response over the range 600–2,200 c/s, falling by about 8 db at the extremities of the speech range of 300–3,400 c/s.

The speech voltage output to line closely follows the input level from the transmission circuit of the recording telephone, the variation being of the order of $\pm$ 2 db. The caller thus hears the recorded message at about the same strength as he would hear the called subscriber if the call were answered personally.

Power Consumption

The power consumption of the answering set has been kept low—a desirable feature since the set may be connected to answer calls over a long period and since the subscriber provides the power. The consumption is approximately 15 watts in the standby condition and reaches a maximum of 36 watts when a recording is being made.

CONCLUSION

The Answering Set No. 1 caters for those subscribers who require a simply operated device which, in their absence, will give callers a message saying where or when they can be located.

ACKNOWLEDGEMENT

The author wishes to thank Sontranic, Ltd., of Edgware for their co-operation in the development of the answering set.

New Test Jacks for Telephone Exchange Equipment

U.D.C. 621.395.655

INTRODUCTION

TEST JACKS giving multi-point access to equipment have been fitted on selectors and relay-sets since the introduction of automatic telephone exchange equipment. A range of jacks, with an increased number of access points and space for supervisory lamps and labelling, was introduced with the 2000-type selector and although a number of minor changes have been made from time to time, the low and reliable contact resistance which is desirable could not always be ensured with a basic design employing single-contact springs. Furthermore, loss of tension in the contact springs has sometimes resulted in the links becoming loose, this looseness being accelerated by vibration in the case of selectors. This difficulty could become more serious on the 4000-type selector in which part of the test jack is mounted horizontally and part vertically.

Accordingly, a design employing twin-contact springs in the jack has been developed and the following paragraphs describe a new series of test jacks that are physically and electrically interchangeable with the corresponding items in the current series.

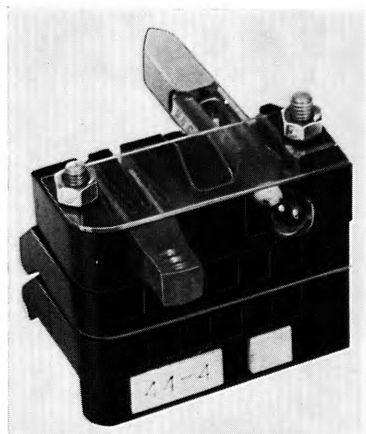


FIG. 1—TEST-JACK ASSEMBLY

THE NEW TEST JACKS

There are three separate phenolic mouldings, as shown in Fig. 1, which can be assembled in various combinations to produce a wide range of test jacks. The three mouldings cater, respectively, for a test and lamp jack providing two test points and an indicating lamp; six test points; and six test points combined with labelling facilities. For selectors all three mouldings are combined in one assembly, this combination giving indicating lamp and labelling facilities together with a total of 14 test points.

The limitation of space between the shelves of relay-set racks results in insufficient room to accommodate test jacks assembled with all three mouldings. For these, combinations of only two mouldings are used. Either the test and lamp jack together with the six-point test jack providing an indicating lamp, labelling facilities and a total of eight test points; or an assembly with two mouldings providing labelling facilities, but without an indicating lamp, and a total of 12 test points can be used. When the number of test points required is large, two assemblies can be fitted, one on each side of the relay-set. The maximum number of test points that can be provided on a relay-set is 24.

The mouldings are designed so that the contact springs are recessed from the front surface of the jack and the test plug is therefore guided by the moulding before contact is made with the test springs. It is therefore impossible to make contact incorrectly with other springs when inserting the test plugs.

Labelling facilities are now provided on the lower moulding of a test-jack assembly instead of on the upper or lamp-jack moulding as in the existing type.

The contact springs are manufactured from 35 S.W.G. nickel-silver of a temper grade sufficiently high to maintain a satisfactory spring tension. Each contact spring consists of two individual parts which when

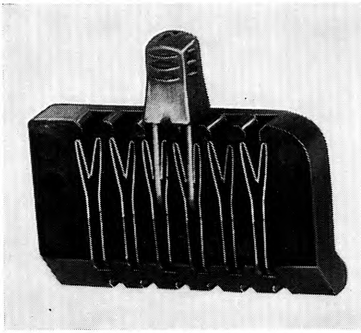


FIG. 2—SINGLE TEST-JACK MOULDING SHOWING CONTACT SPRINGS

assembled take the form of the letter "W" (see Fig. 2). Two contact surfaces are therefore provided for each of the test-plug contact blades. In the existing test jacks only one side of the test-plug contact blades engages with the contact springs, the other engaging the side of the moulding.

Silver plating the contact springs was considered but, due to the fact that the contact springs are contained in a phenolic moulding in fairly close proximity to each other and may be connected to a standing potential, the possibility of silver migration and subsequent breakdown of insulation ruled out its use. Tests have shown, however, that nickel-silver contact springs, used in conjunction with a test plug having silver-plated contact blades, result in a contact of very low resistance. It is proposed, therefore, to introduce test plugs having silver-plated contact blades.

Labels made of white polystyrene having a moulded-in metal pin are located in a recess and lie flush with the surface of the test-jack moulding. The metal pin, which is split, is pushed through a hole in the moulding and then splayed out at the rear to prevent the label falling out. The labels are made in two sizes, 0·220 in. and 0·480 in. in length, both being 0·220 in. wide, and can be used in various combinations to give the required designation within a maximum length of approximately 1 in.

CONCLUSIONS

The new test jacks will supersede the existing types for all new work and for maintenance replacements. It is not intended to take retrospective action to replace jacks on existing equipment.

The improvements referred to have been obtained without changing the physical size or method of mounting the test jacks, and therefore no apparatus mounting changes are necessary. The test jacks are suitable for use on both 2,000-type and 4,000-type selectors.

The development work on this item was carried out by the Automatic Telephone and Electric Co., Ltd., on behalf of the British Telephone Technical Development Committee.

F. B.

Book Review

"Control Engineering." G. J. Murphy, Ph.D. D. Van Nostrand Co., Inc. xii + 385 pp. 246 ill. 56s.

This is the second book by Dr. Murphy on this subject; the first, "Basic Automatic Control Theory," was published in 1957 (reviewed in this Journal, July 1958). It is natural to wonder in what way this book differs from its predecessor; briefly, the treatment is less advanced but wider in scope.

The new topics are: systems with dead time, i.e. with pure delay; sampled-data systems, including *z*-transforms; noise in control systems; non-linear systems. This last topic is dealt with in two ways: by means of describing functions, and by means of the phase plane. Topics which are common to the previous book are: descriptions of various electrical, magnetic, mechanical, hydraulic, and pneumatic components, with suitable specifications (approximate if appropriate) of their behaviour, and the essential basic theory of control systems and their stability in particular. Control systems are dealt with from several points of view. The time-response is investigated using the Laplace transform, leading to synthesis and analysis of systems in terms of the locations of poles and zeros of transfer functions. The frequency-response point of view deals with Bode diagrams (i.e. gain/frequency plus phase/frequency curves), Nyquist diagrams, and so on. Each chapter concludes with collected references (in addition to footnote references on specific points) and problems (without answers). There are tables of Laplace and *z*-transforms.

This is a textbook; although it has a strong practical flavour, it is intended to provide engineering students (who have "studied previously, at an elementary level, differential equations, electric circuit theory, and mechanics") with the theoretical foundations of the subject. Dr. Murphy evidently believes that the way to do this is to begin the study of each topic with a logical, exact, thorough, theoretical treatment of a suitable mathematical model, and then to go on to practical applications and rules-of-thumb. These theoretical sections are excellent and refreshingly free from loose statements. The section on sampled-data systems is a particularly good example of the approach in its patient build-up of the mathematical model and its clarification of the assumptions and approximations that are—quite understandably—taken for granted in most papers on the subject.

A few errors were noted. There is an arithmetic slip in Example 2, page 64, the correct table being the exceptional type with an all-zero row. The angle ϕ_1, as illustrated in Fig. 5–10, differs from the definition in the text. The references to Fig. 5–17 on pages 156–7 should be to Fig. 5–18. The definition of the unit-step implicit in equation 8–25 differs from that of equation 2–6; the point at issue here is the definition of the value of a function at a discontinuity, and it would have been in keeping with Dr. Murphy's usual thoroughness if this point had been tidied up. There is one paragraph on signal-flow graphs; this is obviously inadequate and would have been better omitted; moreover, the conventions of Fig. 2–21 differ from the accepted conventions.

All these points, however, are comparatively unimportant. The combination of sound theory and a practical approach should make this an excellent text book.

W. E. T.

A Magnetic-Drum-Type Automatic Traffic Equipment with Transistor Switching Elements

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The introduction of high-speed switching elements using transistors can lead to more efficient use of space and power supplies. To enable a field trial of such switching elements to be undertaken, an automatic traffic equipment was constructed using a magnetic drum for storage of relevant information. The facilities provided with the equipment are relatively simple but are sufficient for it to be used to test the magnetic-drum-type register-translator in use at Lee Green exchange. The performance to date has been satisfactory and has provided useful information for application in new designs.

INTRODUCTION

UNDOUBTEDLY the solution to many of the economic problems of telephone switching lies in the exploitation of electronic techniques and, even at this early stage, it is evident that these techniques can compete successfully with existing practices. More important perhaps, they give the designer the means of attacking switching problems much more effectively than hitherto. Thus, while the future telephone exchange may be entirely electronic,[1,2] present electromechanical systems can be supplemented very successfully by electronic equipments such as the magnetic-drum register-translator. The reliability of drum-type telephone switching equipments installed in Strowger electromechanical exchanges has been established by a field trial of a register-translator at Lee Green exchange[3] (in the London Telecommunications Region South-East Area). This equipment is handling normal traffic 24 hours a day and is being maintained by the maintenance staff already employed in the exchange. The results so far obtained have demonstrated that equipment of this type is capable of satisfactory service, and the production-line version will be used for register-translator installations in the London and other director areas to provide for subscriber-dialled trunk traffic.

In contemporary electronic equipment the chief hazard to reliability arises from the use of thermionic valves, not necessarily because of their inherent failure rates even in the long term, but rather from mounting them in relatively large numbers in as small a space as possible. The resulting problems of heat dissipation together with those of providing auxiliary power supplies are, of course, well known, and some four or five years ago it was realized that, even though little development work on high-speed transistor elements had been done, such elements would make more efficient use of space and power supplies. Subsequent investigation led to the design of circuit elements capable of operating in the 100 kc/s pulse-repetition-frequency range with a performance which appeared to be at least as good as that of the valve circuits they would eventually replace. No claims could be made in respect of long-term reliability as performance data had only been obtained by the application of stringent laboratory tests intended to ensure that the design margins were adequate to withstand any condition which might conceivably be encountered. Certainly, the tests imposed were more exacting than those originally applied to the equivalent valve circuits because, during the intervening period, a better understanding had been gained of how best to select the most critical combination of factors likely to cause failure.

The next step was the incorporation of the transistor elements in a field-trial magnetic-drum-type machine, with the ultimate objective of determining the practicability of constructing telephone switching equipment using transistor high-speed switching elements. A register-translator seemed an unnecessarily large piece of equipment for such a purpose and an automatic traffic equipment using similar circuit elements, but physically smaller, was therefore chosen.

After the necessary development work an automatic traffic equipment was constructed and installed at Lee Green exchange in February 1959. The equipment is associated with the field-trial magnetic-drum-type register-translator and continuously checks the performance of that equipment.

THE AUTOMATIC TRAFFIC EQUIPMENT

Facilities

Since the object of constructing the machine was primarily that of testing the transistor elements the facilities are relatively simple and by no means exhaust the possibilities of this type of equipment.

A program of test calls is stored on the magnetic drum in a section referred to as the library. Each test call may comprise a normal directory number such as ABB 6814 (i.e. 222 6814) plus the appropriate translation, which might be typically 2985 6814. Storage space for 20 such test calls is utilized on the drum (though there is capacity for many more) together with "typing-in" arrangements for inserting any required program of calls or making changes to the program.

In general, testing is initiated by sending trains of pulses from the automatic traffic equipment in accordance with the drum-library data relevant to the particular test being performed (see Fig. 1). These trains of pulses are received by the exchange register-translator which responds by returning the translation pulse trains to the traffic equipment. Whether the test has been successful or not is determined by a comparison between the incoming pulse trains and the drum-library data relative to the test. When correspondence exists between these a "check-correct" signal from the comparison circuit marks the completion of the test by initiating a relay switching sequence. This sequence, interposed between the completion of one test and the commencement of the next, gives an inter-test pause of approximately one second. During this time clear-down takes place of all circuit conditions relevant to the test just completed and of all drum data recorded in both traffic and register-translator equipments during the test.

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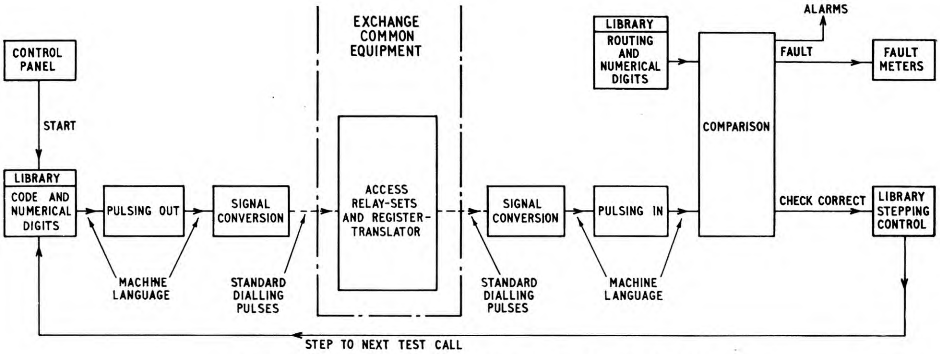


FIG. 1—BLOCK SCHEMATIC DIAGRAM OF THE TESTING SEQUENCE

An unsuccessful test is detected by the fact that the comparison circuit does not find correspondence between the library data and the incoming pulse trains and, consequently, does not give the check-correct signal within the time required to register the successful completion of the longest possible test. The procedure which follows this failure to complete the test successfully in the specified time depends upon the setting of a key on the control panel. With the key operated, a failure results in a single actuation of the total-faults meter and of the individual-test fault meter corresponding to the test in progress, and testing is resumed after an inter-test pause. On the other hand, with the key normal a failure leads to the cessation of further testing and, in addition to the operation of the fault meters as mentioned above, the operation of audible and visual alarms. Maintenance attention is thus directed to the fault. Provision is also made for the connexion of external indicators on which outgoing and incoming information can be displayed as an aid to diagnosing faults.

Test calls are normally applied to the exchange register-translator via each of its access relay-sets, but provision is made for the repeated application of any test call to any relay-set, or all relay-sets, or all test calls to any one relay-set. Each test call applied to the register-translator results in the single actuation of the total-calls meter during the inter-test pause period.

Certain test calls are reserved for testing the automatic traffic equipment quite independently of the register-translator, the performance of the equipment being recorded on a group of resettable meters provided for the purpose. These self-routine test calls normally precede the application of each cycle of test calls to the register-translator, but it is possible to set the machine so that, when not required for exchange-equipment purposes, it can continuously undergo the self-routine test-call cycle.

Physical Construction

The complete equipment, which is mains operated, measures 6 ft 6 in. × 21 in. × 12 in. and is shown in Fig. 2. The various component sub-units which make up the equipment are also indicated in that figure. The logical-circuit system consists of an assembly of printed-wiring boards, and one such board is shown in Fig. 3. Each board is supported by runners and is connected to the rack wiring by a plug and socket to facilitate removal and replacement for maintenance purposes. When it is required to inspect, under working conditions, some

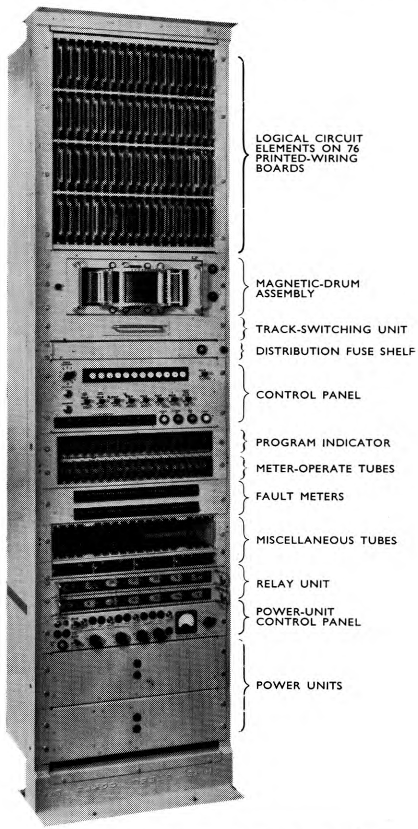
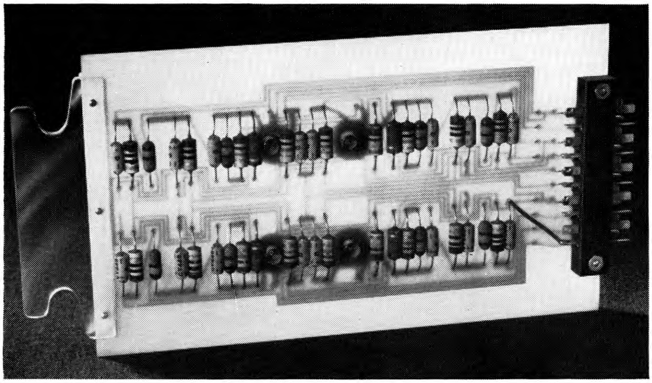


FIG. 2—THE AUTOMATIC TRAFFIC EQUIPMENT



The board measures 8½ in. × 4½ in.

FIG. 3—ONE OF THE PRINTED-WIRING BOARDS USED FOR THE LOGICAL CIRCUIT ELEMENTS

point in a circuit element not brought out to a plug terminal the appropriate board can be stood out from its working position by means of a jig, the connexions being completed via jig wiring.

The drum is 6 in. in diameter and is fitted with special bearings to ensure long life. It is mounted with its axis vertical and the bearings are grease packed. The drum speed is servo-controlled by a magnetic amplifier, but in the event of an uncorrectable fall in speed the drum power supply is automatically cut off until maintenance attention is given. The complete drum assembly can be jacked out of position for maintenance purposes.

The control panel accommodates all the keys necessary for setting the machine into the required mode of operation, and provides arrangements for typing-in the test-call program or amendments. Supervisory lamps, alarm lamps and alarm-reset keys are also provided on this panel.

Twenty meters are fitted, on the basis of one per test call, for registering faults found by the traffic equipment. The total-faults and total-calls meters are also fitted on the meter panel.

The traffic equipment is not entirely electronic and certain functions are carried out by relays. They are mounted on an assembly which can be withdrawn after removal of interconnecting multi-way plugs from their corresponding sockets within the machine. A uniselector is used to select any one particular register-translator access relay-set for test purposes and is mounted on the relay-set rack.

A cold-cathode-tube ring-counter is used to control the registration of fault pulses on the appropriate fault meter. These tubes are arranged to be visible at the front of the machine and indicate the test in progress. The meters and some relays are operated by other, larger, cold-cathode tubes also mounted to be visible from the front of the machine, thus assisting the maintenance staff to diagnose any incorrect operation of the machine. Each tube element is mounted on a plug-in card unit behind a Perspex protective front panel. A perforated metal backing is fitted to prevent the accumulation of static charges on the Perspex so that proper operation of the tubes is not jeopardized. Furthermore, since the consistency of cold-cathode-tube characteristics is dependent upon a minimum level of illumination, lamps have been provided within the cabinet to fulfil this requirement.

The simple and compact power units, mounted at the bottom of the rack, provide all d.c. power supplies from a filtered mains supply. The usual protective fuses are provided but, in addition, a power-unit failure causes immediate disconnexion of the mains supply to the equipment pending maintenance attention. A multi-way rotary switch connects a meter, scaled to indicate the nominal voltage $\pm$ 10 per cent, to each output-voltage supply busbar, as required, and all voltages measured are normally expected to lie within this range; the equipment can tolerate voltage variations of this order without risk of misoperation.

Alarm-type distribution fuses are located in a hinged shelf above the control panel, a visual indication being given when any fuse blows.

The total power consumption, including that for all lamps and relays, is less than 200 watts and no special ventilation aids are necessary.

Susceptibility to High-Frequency Transient Interfering Signals

Undoubtedly one of the biggest problems facing the electronic-equipment designer is how to counter the effects of interference when the equipment is finally installed, particularly when the site is an electromechanical exchange. At the present time it is a problem which may only be resolved on site after installation. This was demonstrated at Lee Green when the traffic equipment was installed. It was found that the suppression devices incorporated in the equipment during development were effective in ensuring that the machine, considered on its own, would function satisfactorily even in the "noisy" environment of an electromechanical exchange. After the equipment had been cabled to the exchange apparatus to be tested, however, it became apparent that the machine was not immune to interference, a few misoperations still occurring at a rate which varied with the volume of traffic through the exchange. Eventually this residual susceptibility to interference was eliminated by refinements in the filtering and decoupling arrangements.

Similar refinements have since been incorporated in the designs for new equipment but it will only be possible to establish the efficacy of these measures when this equipment has been installed and tested under working conditions. Experience has shown that, so far, it has not been possible to devise comprehensive tests for reproducing adequately the conditions liable to be encountered in the field. In the meantime, a program of investigation into the nature of interference is being carried out.

CONCLUSION

Considerable development work preceded the actual construction of the automatic traffic equipment which, in itself, is a comparatively simple machine. The elements developed and the element-interconnexion rules evolved, however, have made the design of other machines, some much more complex, a relatively straightforward design process. Other projects utilizing the same circuit elements are now in hand and the performance of the equipment at Lee Green exchange gives support and encouragement to this new work.

The traffic equipment has also proved of real practical value as a maintenance aid since it can be used to assist the maintenance staff to investigate suspected poor register-translator performance. In fact, several somewhat obscure faults in the register-translator equipment, which would not have been easy to locate otherwise, have been brought to light by the operation of the equipment.

ACKNOWLEDGEMENTS

The development work was carried out by British Telecommunications Research, Ltd., in co-operation with the Telephone Exchange Systems Developments Branch, Engineering Department. The authors wish to thank all who contributed to the design, construction and installation of the equipment, and record their appreciation of the co-operation given by members of the staff of the London Telecommunications Region South-East Area. The photographs for Fig. 2 and 3 were supplied by British Telecommunications Research, Ltd., to whom acknowledgement is made.

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[2] Model Electronic Exchange in Dollis Hill Laboratories. *P.O.E.E.J.*, Vol. 52, p. 260, Jan. 1960.

[3] MARWING, K. G. Design Features of the Lee Green Magnetic-Drum Register-Translator. *P.O.E.E.J.*, Vol. 51, p. 137, July 1958.

The Administrative Radio Conference, Geneva, 17 August to 21 December, 1959

U.D.C. 061.3:341.226:621.396

IN considering the work of the Administrative Radio Conference (A.R.C.) held in Geneva in 1959 it is useful to look briefly at the earlier history. At the A.R.C. in Cairo, 1938, new International Radio Regulations, including a frequency allocation table covering the range 10 kc/s to 200 Mc/s, were agreed. Radio developments during the war were such that it became apparent in the immediate post-war years that provision would have to be made for new services, including radio navigational systems, and also for an increase in long-distance fixed, broadcasting, aeronautical and maritime mobile radio services.

These issues were considered in 1947 at the Atlantic City A.R.C. where the Cairo Regulations were brought up-to-date and the frequency allocation table was revised. At Atlantic City the Regulations were largely re-written; the table was extended from 200 to 10,500 Mc/s; the International Frequency Registration Board (I.F.R.B.) was set up as a permanent organ of the International Telecommunications Union to examine and to record frequency assignments and to advise members of the Union on the more effective use of the frequency spectrum; it was decided that the C.C.I.R.* should have a full-time director and vice-director and a permanent secretariat. It was also agreed that the new frequency table would be implemented below 27·5 Mc/s after detailed frequency plans for the several services concerned had been accepted at subsequent conferences.

Despite repeated efforts, however, acceptable plans for the broadcasting and fixed services operating in the range 4–27·5 Mc/s were not produced and it was necessary to convene an Extraordinary Administrative Radio Conference (E.A.R.C.) in Geneva in 1951 to approve a method by which the various services would be fitted into the Atlantic City frequency bands. Such a method was evolved and in the main the services were accommodated in band by about 1956. It then became clear that the time would soon be opportune to look at the Atlantic City Regulations in the light of new operating procedures, types of service and requirements, and it was finally decided to hold another A.R.C. in Geneva during 1959.

* International Radio Consultative Committee.

The meeting opened on 17 August; it was attended by upwards of 700 people, including representatives of many international organizations. The United Kingdom delegation of 45 included representatives of various Government Departments and the Armed Forces, as well as a number of advisers from operating agencies and other organizations.

It was clear that the 12-year period which had elapsed since the Atlantic City Conference was too long in view of the major advances in the radio field during the interval and that the many difficult problems facing the Conference included the need for:

(*a*) a decision whether or not there should be a major redistribution of spectrum space between the maritime, aeronautical, fixed and broadcasting services in the range 4–27·5 Mc/s;

(*b*) frequency allocations for ionospheric and tropospheric scatter, for radio astronomy and for research on space systems; and

(*c*) a large extension of the upper frequency limit of the table.

There was clearly a will by all delegations to facilitate the work of the Conference, which quickly got into its stride. The work was divided among seven committees dealing respectively with credentials, finance, the frequency table, the I.F.R.B. and the notification and registration of frequencies, technical characteristics and definitions, operational questions and the drafting of the new regulations. In turn these committees were further sub-divided into sub-committees, working groups, etc., so much so that the United Kingdom delegation, large as it was, found itself fully stretched in providing adequate representation. The three key committees were those dealing with the new frequency allocation table, with the I.F.R.B. and the notification and registration of frequencies, and with operational questions.

Apart from the work of the Drafting Committee, which went on until the end of the Conference, the committee stage of the work was completed by early December. After this, plenary meetings were held on most days, and frequently well into the night, until 18 December. At these meetings the draft Radio Regulations as submitted by the several committees were approved. The formal signing and closing ceremony was held on 21 December when the new Radio Regulations were accepted by the delegates of the 84 countries who signed the agreement; there were a few reservations, mainly in respect of some parts of the frequency table. It was agreed that the Regulations should come into force on 1 May 1961.

It may be thought by those not directly concerned that four months is an unduly long time for the review of the Radio Regulations. However, it must be appreciated that the new regulations cover all aspects of radio usage on which international agreement is necessary and occupy over 600 printed pages, that upwards of 6,000 written proposals were examined, that the new frequency table covers the range 10 kc/s to 40,000 Mc/s, some 200 times the band-width of the Cairo table prepared 21 years earlier, and that to achieve agreement major compromises on many aspects had to be negotiated. Furthermore, besides the Atlantic City Radio Regulations, the Conference had to take into account the complicated provisions of the Agreement that had resulted from the E.A.R.C.

It is not possible in this short review to discuss the new regulations in any detail, and brief reference will be made only to a few of their more important aspects. No major changes have been made in the Atlantic City table below 27·5 Mc/s, i.e. the bands in this range allocated to the fixed, broadcasting, aeronautical, maritime, land mobile, standard frequency and amateur services, and for industrial, scientific and medical purposes, are not modified to any extent. Appropriate provision has been made for services employing ionospheric and tropospheric scatter propagation, due care having been taken with the former to ensure that it shall not cause undue interference to other services. Frequency allocations for radio astronomy and space research have been included. Closer frequency tolerances and spurious radiation limits are to be applied to radio transmitters. The procedure for the notification and registration of frequencies as defined at Atlantic City has been modified with a view to the evolution of a more realistic International Frequency List. A frequency management procedure has been adopted for the high-frequency broadcasting service. Agreement was also reached upon new procedures for maritime radio-telephone operation. The functions and duties of the I.F.R.B. have been expanded to enable it to play a more effective part in improving spectrum usage, and in assisting the newly developing countries to solve their frequency assignment problems. At the Conference the eleven I.F.R.B. members were elected and it was agreed that the new Board would take over from the old Board on 1 October 1960.

In considering the use of the frequencies in the range 4–27·5 Mc/s it was clearly demonstrated that the congestion was becoming such that positive steps would have to be taken during the next few years to reduce demands. It was pointed out that this could be achieved by the use of alternative means of communication, of improved technical characteristics and by the rationalization of circuit usage. It was agreed that the matter would be studied by the I.F.R.B. and a small panel of experts, and that their report would be submitted to the Administrative Council for action.

Only experience can prove the wisdom of the many decisions taken at the Conference, but looking back it can be said that all the countries present showed a desire to co-operate and, as a result, much was achieved.

C. F. B.

Book Review

"Higher Electrical Engineering." J. Shepherd, B.Sc., A.M.I.E.E., A. H. Morton, B.Sc., A.M.I.E.E., A.M.Brit.I.R.E., and L. F. Spence, B.Sc.(Eng.), B.Sc.(Econ.), A.M.I.E.E. Sir Isaac Pitman & Sons, Ltd. 566 pp. 350 ill. 40s.

This book of 21 chapters covers the course for the A1 and A2 years of the Higher National Certificate in Electrical Engineering and also includes a great deal of the Part 2 and Part 3 syllabuses of the London B.Sc.(Eng.) examination. The authors are members of the teaching staffs of the electrical engineering departments of three well-known technical colleges and, as they have had considerable experience in teaching H.N.C. classes in electrical engineering, are well qualified to write on this subject. Throughout, the rationalized M.K.S. system of units has been used.

The first six chapters deal with symbolic notation, circuits, a.c. theory and measurements, harmonics and transients, and the next three with electric and magnetic fields, transformers and the various types of three-phase windings Four chapters are devoted to the construction, characteristics and speed control of synchronous machines and induction motors. The subject of voltage surges and protection against short-circuits are well treated whilst there are some excellent chapters on vacuum and gas-filled valves, amplifiers, feed-back, and the various types of oscillators.

The layout of the material, the clearness of the type, and all the numerous diagrams are excellent and reflect credit on the authors and the publisher.

A most useful feature, particularly to students, is the large number of questions produced throughout the book, most of which are from past Higher National Certificate and London University examination papers. Each chapter contains some well chosen, fully worked-out examples and also a number of others to which the answers are given and in some cases hints on how they should be solved.

The book can be strongly recommended as being of good value and of considerable assistance to all students of electrical engineering.

R. S. P.

Trial of a New Type of Wall Telephone

U.D.C. 621.395.721.3

THE Post Office is obtaining limited quantities of a new wall telephone which will be used in selected areas to test customers' reaction to a wall telephone available in a wide colour range. This telephone, coded Telephone No. 1/706 and illustrated in Fig. 1, is a modified version of the table telephone, Telephone No. 706, which has already been described in an earlier article.* To make it suitable for mounting on a wall, the table telephone has its dial turned through 180° and the cradle extended to retain the handset. Means are also provided for fixing the telephone to the wall.

FIG. 1—THE WALL TELEPHONE: TELEPHONE NO. 1/706

To enable the dial to be reversed, additional cut-outs have to be made in the telephone cover and the outer number-ring clip to accommodate the new position of the dial finger stop. Also, the mounting ring within the telephone that clamps around the dial has to be slightly modified to give clearance for the new position of the dial governor-bearing screw. These changes, which neither affect the use of the parts in the table telephone nor increase their cost, are already incorporated in a proportion of table telephones.

The modification to the cradle consists of replacing the two small metal plates that surround the plungers in the table telephone by a chromium-plated cradle extension held by the two cover-fixing screws, which pass down through the normal cradle close to the plungers. The plungers in the telephone are actuated by the side of the handset by a wedging action.

The telephone is fixed on the wall by means of two subsidiary parts. The first of these is a narrow bracket that is mounted horizontally on the wall, using a screw through the central fixing hole. The ends of this bracket are formed into hooks; the telephone is hung on these hooks using the holes in the base into which the two front rubber feet are fitted for the table telephone. The second part is a small oval plate with two holes in it. The plate is fastened to the wall telephone with a screw, which is passed through a "knock-out" hole in the telephone base and into the threaded hole in the plate. The other hole is used to fix the plate to the wall and is large enough to accommodate possible inaccuracies in the wall fixing. This mounting arrangement has the advantage that it eliminates the need to hold up the weight of the telephone while the sometimes difficult wall fixings are made. Also, the telephone can subsequently be very easily removed, and changed if necessary, without interference with the wall fixings. This method of fixing the telephone to the wall by two screws only, in a vertical line, has been adopted because in some forms of house construction only vertical timbers in the walls, spaced some distance apart, give the firm screw fixings needed to support the weight of a telephone.

The wiring of the wall telephone is identical with that of the table telephone, except that it has no line cord or terminal block; it may, therefore, be substituted for a single-button table telephone in any extension-plan arrangement. As the changes involved are slight it would be possible to convert some table telephones into wall telephones locally if kits of the necessary extra parts were provided. However, because of the very limited use envisaged for this telephone and the limited availability of table telephones suitable for the conversion, this will not be done, and completely assembled wall telephones will be supplied.

The development of the wall telephone described above was carried out by Ericsson Telephones, Ltd.

H. J. C. S.

* SPENCER, H. J. C., and WILSON, F. A. The New 700-Type Table Telephone—Telephone No. 706. *P.O.E.E.J.*, Vol. 52, p. 1, Apr. 1959.

The SCOTICE/ICECAN Submarine Cable Projects

U.D.C. 621.315.28:621.395.5(261)

PLANS are in hand for the laying of submarine cable systems linking the United Kingdom, the Faroes, Iceland, Greenland and Canada (Newfoundland). The cable system between the United Kingdom and Iceland has been given the code name SCOTICE and that between Iceland and Canada the code name ICECAN. The systems will enable important requirements of the member countries of the International Civil Aeronautical Organization (I.C.A.O.) to be met. With the advent of high-speed jet aircraft they require very reliable speech and telegraph communication between Air Traffic Controllers dealing with aircraft flying across the North Atlantic. These Air Traffic Controllers are situated in Eire, Scotland, Iceland, Greenland and Canada (Newfoundland). Sufficient circuit capacity is being provided to meet all other likely telephone and telegraph requirements over the route for a number of years to come.

It is expected that the facilities provided on the submarine cable systems will conform to those of the TAT/CANTAT type systems in that, in addition to the traffic circuits, special telephone and telegraph circuits will be provided outside the normal transmission band for engineering maintenance purposes. Omnibus speech and telegraph circuits will be set up between London and Cornerbrook (Newfoundland) via the submarine systems to enable speedy location of faulty sections to be made. The engineering of the system is such that restoration of all the civil aviation circuits can be effected within a short time of a reported fault by re-routing via other submarine systems such as the new CANTAT[1] system.

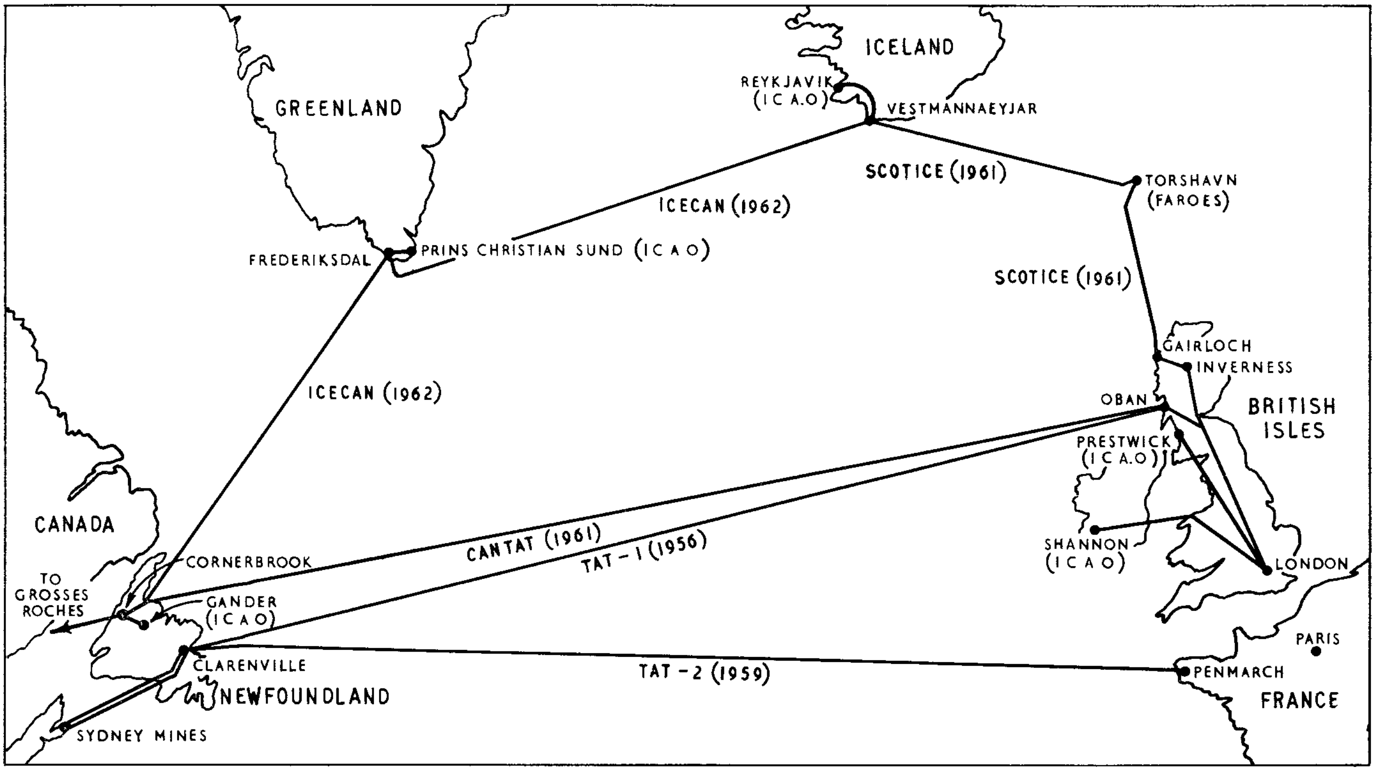
The SCOTICE submarine system, which is to be provided as a joint undertaking between the United Kingdom Post Office, the Great Northern Telegraph Co. of Denmark, the Danish P.T.T. and the Iceland P.T.T., will be laid by H.M.T.S. *Monarch* immediately after completion of the laying of CANTAT in September 1961 and should be available for service in December of that year. It is being designed to provide twenty-four 3 kc/s-spaced telephone channels between Gairloch in Scotland, Torshavn in the Faroes and Vestmannaeyjar in Iceland, the lengths of the respective sections being 290 nautical miles (n.m.) and 408 n.m. The Gairloch–Torshavn section will be equipped with 10 submerged repeaters at a spacing of approximately 26·5 n.m. and the Torshavn–Vestmannaeyjar section with 15 submerged repeaters and one submerged equalizer. The gain of the submerged repeaters will be about 60 db at 192 kc/s.

The submarine cable will be a single conventional 0·46 in. diameter polythene-insulated coaxial cable, similar in nature to a scaled-down version of the 0·62 in. diameter cable used on the TAT systems[2] except that the copper tapes around the centre conductor will not be provided. The cable and repeaters will be laid at depths of up to 1,000 fathoms (approximately 1 mile). The transmitted frequency bands will be 24–96 kc/s in the A–B direction of transmission and 120–192 kc/s in the B–A direction, the A terminal for both sections of SCOTICE being located at Torshavn. A special 6 kc/s band in each direction of transmission will be provided for engineering maintenance purposes. Repeater monitoring equipment of the loop-gain type will be provided at Torshavn and will be suitable for use on both sections. The repeater line current will be 316 mA, provided by constant-current master/slave type power units[3] similar to those on the TAT Clarenville–Sydney Mines system. The power units will be installed at Gairloch, Torshavn, and Vestmannaeyjar, the "master" units being located at Torshavn. In the United Kingdom the routing will be audio to Inverness and then on London–Inverness carrier groups, which will be equipped with 84·08 kc/s group reference pilots and automatic gain regulators. These will be installed at the terminals of the group to reduce loss variation to a minimum.

The SCOTICE system is unique in that it is the first submarine system landing in the United Kingdom to use 0·46 in. diameter polythene-insulated coaxial cable and also the first submarine system to be equipped from the start with the new 3 kc/s-spaced channel equipment which has been designed by the British Post Office for use on long submarine cable systems. This new channel equipment[4] will provide sixteen 250–3,050 c/s band-width channels in the normal carrier-group band 60–108 kc/s, compared with the twelve 300–3,400 c/s band-width channels normally provided in a group band. Of the available 24 cable circuits, 16 will be United Kingdom–Iceland circuits and will pass via a through-group filter at Torshavn whilst the remaining eight channels will terminate at Torshavn to provide outlets from the Faroes to both the United Kingdom and Iceland. Frequency-modulated voice-frequency-telegraph terminal equipment will be provided at London, Torshavn and Reykjavik (Iceland) to provide the necessary telegraph channels on the system.

The complete submarine system between group-distribution frames will be designed and engineered by Standard Telephones and Cables, Ltd., who were awarded the contract for the project against keen international competition.

The ICECAN system, in which the United Kingdom will have no ownership interest, is expected to be laid in the summer of 1962, and the civil aviation authorities will lease one speech and four telegraph circuits in the system. They require that their speech circuit shall link Air Traffic Controllers at Shannon (Eire), Prestwick (Scotland), Reykjavik (Iceland), Prins Christian Sund (Greenland) and Gander (Newfoundland) on an omnibus basis. The overall circuit will be some 4,000 miles long and is required to operate on a 24-hour basis, and consequently they have requested re-routing facilities, in the event of failure of any section of the route, within five minutes from the time at which a failure is reported. In order to effect this re-routing the circuit to Prestwick will be routed via the London International Maintenance Centre (I.M.C./A)[5], which is staffed 24 hours a day. Since the circuits in the CANTAT systems will also terminate at I.M.C./A, re-routing via the CANTAT system to Cornerbrook can be effected almost immediately since both I.M.C./A and Cornerbrook will be connected to the two separate speaker systems linking these stations, one via CANTAT and the other via SCOTICE and ICECAN. Five stations are to be interconnected



I.C.A.O. indicates location of International Civil Aeronautical Organization Air Traffic Controllers

CIVIL AVIATION REQUIREMENTS AND THEIR RELATION TO TRANSATLANTIC SUBMARINE CABLE SYSTEMS

on the omnibus speech circuit and special two-tone selective signalling will be employed using dialled pulses of alternate 600 and 1,500 c/s tones. Four-digit dialling will be used, separate codes being allocated to the respective Air Traffic Controllers both at a particular station and for different stations.

The civil aviation authorities also require four telegraph circuits linking the Air Traffic Control Stations and certain meteorological and aircraft-movement control stations. In Greenland and Newfoundland these latter stations are situated reasonably near the Air Traffic Control Stations but in the United Kingdom and Iceland some of the circuits will have to be extended over inland voice-frequency telegraph systems to their desired terminations. Initially, all the circuits will operate at a speed of 50 bauds but eventually 75-baud working will be employed. Omnibus working on some of these circuits is also required. Due to the number of voice-frequency telegraph systems through which these circuits will pass, regenerative repeaters will be required at several intermediate points in order to meet the stipulated distortion requirements.

The map shows the location of the Air Traffic Controllers and their relation to the various transatlantic submarine cable systems.

P. T. F. K.

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Retirement of Brigadier Sir Lionel H. Harris,

K.B.E., T.D., M.Sc., F.C.G.I., M.I.E.E.

BRIGADIER SIR LIONEL HARRIS retired on 31 January 1960 after 37 years in the Post Office, having been Engineer-in-Chief since October 1954; previous to this he had been Controller of Research. The details of his career have often been given in this Journal, and it must suffice to say that he had a wide experience of the Post Office. Besides the Research Branch he served in the Telegraph Branch; as Superintending Engineer, Midland District; and as Regional Director, Scotland.

The post of Engineer-in-Chief is of course an extremely important one and it would be almost impossible in this short review to catalogue the commitments that it carries. Perhaps this is not so important as placing on record the direction in which the development of the Engineering Department has been steered and the esteem and prestige in which it is held among all other departments and organizations.

For some years prior to his departure from the Research Branch, sufficient progress had been made to show the future of electronic devices in the development of telephone exchanges. Sir Lionel, however, realized the great technical effort which would be necessary by the Post Office and its contractors, and largely due to his patient negotiation the Joint Electronic Research Committee was set up in 1956. This committee unifies the efforts of the Post Office and switching contractors in the electronic exchange field. He recently opened the small trial exchange at Dollis Hill, which is to be the forerunner of the Highgate Wood exchange.

Sir Lionel was a Senior Executive Engineer and an Assistant Staff Engineer in the Telegraph Branch and he continued to retain his close personal contact with telegraph developments. In accordance with his policy of keeping in mind the well-being of the industry as a whole, as well as the Post Office, he ensured that new equipment made use of the most modern devices and techniques. Many examples of this could be quoted.

His policy for the trunk network was to provide a balanced network of wideband radio and cable channels capable of being used for telephony and television with adequate capacity for future development and maintenance, and although he left too soon to see this achieved, the Engineering Department is in the course of building it up. Our modern wideband transmission systems are probably second to none in the world. A good deal of his time has been spent grappling with the problems of television, in the capacity of Chairman of the Television Advisory Committee Technical Sub-Committee.

In the field of long-distance submarine-cable telephony he has been at pains to ensure the development of a first class British system and he took a direct personal interest in the cable fleet and its equipment. The British principles of lightweight cable and rigid two-way repeaters seem likely to be adopted widely.

We have often remarked on the endurance of the standard 3,000-type relay with which we were both associated in 1931. His invention of rectified reaction in 1932 enabled a valve to operate a relay with unheard-of speed in those days. The "static relay" used in voice frequency telegraph systems sprang from his fertile mind.

Sir Lionel has been associated with the army from the age of 18 and was on General Eisenhower's staff in charge of the Telecommunications Section of S.H.A.E.F. His interest was of the widest and any help which could be given to the Services by the Post Office was always unstintingly given, and his many associates at home and abroad made liaison particularly easy.

Of particular interest to members of the Institution of Post Office Electrical Engineers and readers of the Journal were the 50th Anniversary Celebrations in 1956, in which Sir Lionel took a leading part, and members will remember with pleasure and pride his address giving the achievements of the Institution.

Sir Lionel was an ideal Chief in that he knew his staff and their capabilities intimately, and never called for unnecessary briefing. He liked to be kept informed of important matters and would always give help and advice when needed: he was always accessible. In his dealings with staff he was just, straightforward and honest and, as in all his work, to the point; he always considered the relative effects of any changes on staff at Headquarters and in the Regions.

The prestige of the Department was foremost in his mind; the event which has probably given him most pleasure was when he was knighted in the Birthday Honours of 1957, and which he regarded as a tribute to the Department. He was interested in every facet of its work.

He has said that he and Lady Harris are looking forward to retirement with pleasure and excitement. All their many friends will wish them a retirement which is full, long and happy.

H. W.

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

MR. A. H. MUMFORD joined the Engineering Department as a Probationary Assistant Engineer (old style) in 1924 and it soon became apparent to his immediate colleagues in the old Wireless Section that he was well equipped to work on radio development, and, as he obtained experience of organization and management, that he would rise to high office. That these early forecasts have been fully borne out is shown by his distinguished career, and we now have much

pleasure in extending to him our sincere congratulations on his appointment as Engineer-in-Chief, following the retirement of Brigadier Sir Lionel Harris.

In his early days at Dollis Hill Mr. Mumford demonstrated his flair for development work and his ability to build up a loyal and happy team which he imbued with a will to get things done. At Dollis Hill he made important contributions both in the radio and the coaxial cable fields and also played a major part in laying down the broad pattern of radio development, and this has influenced to a considerable extent the Department's national and international radio systems. His return to the City in 1938 as Staff Engineer was of special importance in that he was destined to guide the Radio Branch through the war years. His load during that time was extremely heavy; much of it had to be carried personally and it says much for his ability and stamina that he kept going. All his colleagues and friends were delighted when his personal contribution was recognized by the award of an O.B.E. in the New Year Honours of 1946.

In the early post-war period Mr. Mumford was concerned as a senior member, and later as the leader, of United Kingdom delegations in a series of international conferences drawing up new Radio Regulations, including a new frequency allocation table. In the course of this work, he attended meetings in Moscow, Paris, Atlantic City and Geneva, at which he was soon recognized as an authority and achieved an international reputation. In between his international meetings he spent 1948 on a course at the Imperial Defence College.

On his promotion to Assistant Engineer-in-Chief in 1951, Mr. Mumford undertook new responsibilities on engineering organization and staff work, in which fields he was able to display his talents, particularly his humanity and understanding. This work included the chairmanship of the Boards dealing with promotions to Area Engineer/Senior Executive Engineer and above and to Motor Transport major grades, negotiations with Staff Associations, membership of the Engineering, Factories and Supplies Departmental Whitley (E.F.S.D.W.) Council as well as of the Engineering Department Engineering Whitley Committee, and Chairmanship of the Standing Joint Committee on grading questions affecting Post Office Engineering Union grades. On becoming Deputy Engineer-in-Chief in 1954 Mr. Mumford continued his responsibilities on organization and staff matters, including membership of the committee set up by the E.F.S.D.W. Council to review the promotion procedures for engineering and allied grades. As the senior engineering member of the Standing Telecommunications Advisory Committee he was directly concerned with financial policy.

In addition to his official load Mr. Mumford has somehow found time to contribute extensively to the work of the Institution of Electrical Engineers. He was a member of the Radio Section for many years, and Chairman of the Section in 1945–46. Later, he was elected to the Council of the Institution, and he became Vice-President in 1958. Throughout this period he has been an active member of many Institution committees and has presented several papers to the Institution. He has also contributed papers to the Institution of Post Office Electrical Engineers, acted as Chairman of the London Centre and served on the Board of Editors of this Journal.

It has been a matter of wonder to many of his colleagues how, with all his responsibilities, Mr. Mumford has retained his youthful outlook and buoyancy. No doubt he has been assisted in this by his several activities outside the technical field, by the interest and concern he has always displayed in the well-being of his colleagues, particularly that of the more junior members, and by his enjoyment of social occasions.

Mr. Mumford follows a line of distinguished Engineers-in-Chief, and like them he will have to grapple with many new problems. In facing these his leadership, his ability to reduce a problem to its essentials and his inborn cheerfulness will stand him in good stead. Those who are close to him well know that he will add lustre to his distinguished office. With his many friends, both at home and abroad, we tender to him our best wishes for the future.

C. F. B.

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:

Aberdeen Telephone Area	W. A. Smith	Technical Officer	British Empire Medal
Centre Telephone Area, London Telecommunications Region	J. Hartigan	Technician, Class I	British Empire Medal
Engineering Department	F. A. Loomes	Technical Officer	British Empire Medal
Engineering Department	W. J. Marshall	Senior Executive Engineer	Member of the Most Excellent Order of the British Empire
Liverpool Telephone Area	J. H. Kirk	Executive Engineer	Member of the Most Excellent Order of the British Empire
Long Distance Area, London Telecommunications Region	T. H. Godfrey	Leading Technical Officer	British Empire Medal

Special Commendation

The Board notes with pleasure that the Postmaster-General has personally commended Mr. G. S. Walker, Senior Draughtsman, Engineering Department, to whom the Royal Humane Society has awarded its Testimonial on Parchment for rescuing a boy from drowning in the Grand Union Canal at Alperton, Wembley, on 22 June 1959.

D. A. Barron, M.Sc., M.I.E.E.

The appointment of Mr. D. A. Barron as Deputy Engineer-in-Chief on 1 February 1960 will be welcomed by his many friends and colleagues.

Mr. Barron entered the Post Office in 1927 after graduating with honours at Bristol University. Between 1927 and 1940, when he came to the Telephone Branch in the Engineering Department, he obtained a wide experience of both internal and external works in the Technical Section of the old South Western Engineering District at Bristol, in the Plymouth Section and as Sectional and Area Engineer at Liverpool. Shortly after joining Telephone Branch, Mr. Barron was promoted Assistant Staff Engineer in charge of circuit and apparatus design and took charge of the Circuit Laboratory.

In 1945, Mr. Barron was selected for a special appointment as chief consultant to the Indian Posts and Telegraphs Department to plan the conversion of the Calcutta area to automatic working. His selection for this task was a recognition of the wide and specialist knowledge that he possessed in both the internal and external fields.

Mr. Barron returned to the Post Office in 1947 and was shortly afterwards selected to lead a working party whose task was to survey automatic switching methods and plant throughout the world, and to examine the engineering aspects of subscriber trunk dialling for Great Britain. In the course of this work, he took a small party to the U.S.A. to study their telephone switching practices. This work culminated in "a report on the extended mechanization of the telephone network in the United Kingdom, with particular reference to national subscriber-to-subscriber dialling," which was issued in 1949, the year in which he was promoted to Staff Engineer. This report was to form the basic study for the S.T.D. system which has now reached an advanced stage of development. The opening of the Bristol installation in December 1958, which included the first introduction of fully electronic apparatus into our switching system, was a happy and successful termination of the first stage of this work, with which Mr. Barron has been so closely connected. The other major project in the home technical field with which he has been concerned is the development of the fully electronic telephone exchange, as a member of the Joint Electronic Research Committee, which combines the research efforts of the Post Office and industry.

Apart from developments in the home field, Mr. Barron has been closely connected since 1948 with dedevelopment and procedures in international switching and signalling techniques through membership of C.C.I.T.T. study groups. He was chairman of the Commission for the Field Trials of Semi-automatic Operation in Europe and is chairman of the 11th C.C.I.T.T. Study Group on International Switching and Signalling Systems.

In 1954, Mr. Barron was promoted to Assistant Engineer-in-Chief and shortly afterwards visited Switzerland, Holland and Germany as a member of a small team charged to study ways and means of reducing the cost of provision of telephone service.

Mr. Barron has always been an active member of the Institution of Post Office Electrical Engineers. He was Treasurer from 1951 to 1955 and has been Chairman of Council since 1955. He was a member of the Board of Editors of this Journal from 1949 to 1954 and has been chairman of the Board since 1955.

With his promotion to his present duties, Mr. Barron will inevitably have to give more attention to matters of general administration in the engineering field at the expense of his devotion to the technical development of the telephone system. We know that he will bring to bear on those problems the qualities of good sense and sound reasoning that are characteristic of him.

R. E. J.

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

After six years as Assistant Engineer-in-Chief, Capt. C. F. Booth took up his appointment as Deputy Engineer-in-Chief on 1 February 1960. His promotion will cause no surprise to those acquainted with him, for his conscientiousness and industry are apparent to all.

Like Sir Lionel Harris and the new Engineer-in-Chief, Capt. Booth started his career in the Post Office Engineering Department in the Research Branch in 1923. He soon made his entry into the study of quartz crystal techniques, for I remember he consulted me soon after on contact materials for crystal holders. This was the

start of a long and distinguished career, and apart from a short time in the External Telecommunications Executive he has been entirely concerned with radio in the Engineering Department. Over this period the importance of radio, like the range of frequencies employed, has steadily mounted, until we are now speaking of tens of thousands of megacycles per second. Frequency generation and stability are the essence of many of the problems and in these Capt. Booth is an acknowledged expert. Many new methods of generation to fantastic accuracies of stability have been devised in recent years and he has seen to it that the Post Office is not lagging behind. The Engineering Department has particular interests because, besides developing and operating many radio links, it takes a primary part in the control and allocation of frequency bands. The arguments on these matters are not always entirely technical so that negotiations have to be carried out by particularly able and astute engineers, and Capt. Booth has spent many years on these and allied matters.

Capt. Booth was the first Staff Engineer to take charge in 1949 of the Radio Laboratories at Dollis Hill when they were formed into a separate Branch. They have now been made two divisions of Research Branch, each headed by a Staff Engineer. In 1951 he left Dollis Hill and took over the Radio Planning Branch, and on the setting up of the External Telecommunications Executive in 1952 he was made Deputy Director. He was promoted to Assistant Engineer-in-Chief in January, 1954.

He has been a great supporter of the Institution of Electrical Engineers, having been a member of the Radio Section Committee for many years, and Chairman in 1950–1951. He has written many papers, for which he received prizes and premiums. He has also made many contributions to the Institution of Post Office Electrical Engineers.

The C.C.I.R. has also claimed a great deal of his time for he led the United Kingdom delegation at the Plenary Meetings at Stockholm in 1948, Geneva in 1951, Warsaw in 1956 and Los Angeles in 1959. 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 delegation. In 1959 also, there was an Ordinary Administrative Radio Conference in Geneva at which he led the technical delegation, and which lasted many months. He is now Chairman of the General Purposes Committee and Study Group XI, and of the Ad Hoc Television Committee.

He received the O.B.E. in 1947 and the C.B.E. in 1956 and these were obviously well merited, and well appreciated by Capt. Booth and his staff.

As may be judged by this short account, Capt. Booth is a glutton for work, and may be relied upon to uphold the prestige of the Department in all his enterprises. He is extremely powerful in committee work and organizational problems. As a member of the Television Advisory Committee Technical Sub-Committee his advice will be eagerly sought on a subject which is likely to become extremely important. In addition to this and the more orthodox developments in radio, we have propagation by waveguide, scatter and satellites, all needing urgent investigation. To cover and co-ordinate the field of radio, a man of exceptional calibre is evidently needed and we have him in Capt. Booth. His colleagues at home and abroad are delighted at his success and spur him to even greater efforts.

H. W.

C. E. Calveley, O.B.E., E.R.D., B.Sc.(Eng.), M.I.E.E.

With his appointment as Assistant Engineer-in-Chief, Mr. Calveley returns to the telephone field after some years as Chief Motor Transport Officer.

He first joined the Engineering Department as a Probationary Inspector in 1928 and later passed the open competition for Assistant Engineers (old style) in 1930. There followed a period when he gained wide experience of internal and external plant both in London and in the provinces. In 1938 he was promoted to Executive Engineer in the Engineering Organization and Efficiency Branch of the Engineering Department, and perhaps it was here that his interest, which he still retains, was first aroused in problems of organization, staff relationship and training.

As a member of the Royal Corps of Signals he served with the British Expeditionary Force in France and later was appointed a liaison officer with the Canadian Corps. In 1942 he joined the staff of the Supreme Allied Commander as major and the following year took command

of No. 2 War Office Signals at Portsmouth, where he was concerned with the preparation for the Allied invasion of Europe. Later, as a full colonel, he accompanied the invading forces, restoring telecommunications services.

On returning to civilian life he was appointed, in 1946, as the first principal of the Engineering Department's Central Training School near Stone, and its early success was largely due to Mr. Calveley's initiative, determination and tact. In 1954 he was appointed Staff Engineer in charge of the Telephone Branch of the Engineering Department at a time when many new development projects in the switching and signalling field were just getting under way. He applied his characteristic enthusiasm and energy to help forward such schemes as semi-automatic working on international circuits to the continent and the early introduction of S.T.D.

Two years later he was appointed Chief Motor Transport Officer. In that capacity he successfully grappled with a different set of problems and introduced a new range of motor vehicles specially adapted to Post Office requirements.

In 1947 Mr. Calveley was awarded a Commonwealth Fellowship and spent a year in America studying personnel selection and training with the American Telephone and Telegraph Company and its associates. He also attended an advanced management course at Harvard Business School.

His colleagues and numerous friends wish him well in his new appointment. H. E. F.

Institution of Post Office Electrical Engineers

Increase in Annual Subscriptions

No objections were received from the Corporate Membership to Council's proposal to increase the annual subscriptions to cover the increase in the cost of *The Post Office Electrical Engineers' Journal.* A ballot of the Corporate Members was thus not required and the proposed change to Rule 13, Subscriptions, to cover the increase is now operative. The increased annual subscriptions are as follows:

Corporate Members		
Member	£1 3s.	(formerly £1 1s.)
Associate Member	£1	(formerly 18s.)
Affiliated Member	£1	(formerly 18s.)

The increased subscription will start on 1 April 1960, and arrangements have been made with the Accountant-General's Department for the increased deduction from salary to be made without requiring fresh forms of consent to be signed by members.

The annual subscription of Corresponding Members (Non-Corporate Members) will also be increased, from £1 1s. to £1 3s., starting 1 April 1960.

Associate Section members who purchase *The Post Office Electrical Engineers' Journal* by deduction from salary as part of their I.P.O.E.E. subscription will note that the cost of the Journal will be increased from 2s. to 2s. 6d. per copy commencing with the April 1960 issue. The Institution is investigating the procedure to be adopted for such Associate Section members to cover the increase, and Associate Section Centres should take no action until informed by the Institution.

Retired Members

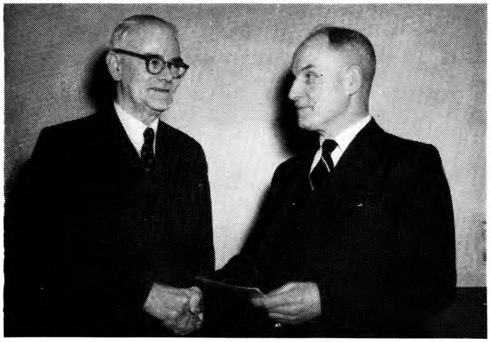
The following members, who retired during 1959, have retained their membership of the Institution under Rule 11(*a*):

F. S. Padgham, 8 Brockenhurst Road, Aldershot, Hants.
F. E. Wallcroft, 2 Betys-y-coed Road, Cyncoed, Cardiff, South Wales.
C. H. Lewis, 26 St. Edyths Road, Sea Mills, Bristol.
F. T. Perkins, 183 Langley Way, West Wickham, Kent.
H. G. Davis, 17 South Cliff Avenue, Eastbourne, Sussex.
C. H. Wright, 41 Dallinger Road, Lee, London, S.E.12.
W. Williams, 26 Rocky Lane, Childwall, Liverpool, 16.
A. C. Warren, 35 Beacon Way, Banstead, Surrey.
C. W. Arnold, 9 Russell Road, Moor Park, Northwood, Middlesex.
L. Mickler, "Roseworth," Holeyn Hall Road, Wylam, Newcastle-on-Tyne.
J. J. Wilton, 258 Tamworth Road, Newcastle-on-Tyne, 4.
F. J. Christopher, "Chez Nous," Great Preston Road, Ryde, Isle of Wight.
T. C. Loveday, M.B.E., 114 Cambridge Road, Gt. Shelford, Cambridge.
E. H. Jolley, O.B.E., 7 Bridle Road, Eastcote, Pinner, Middlesex.

Retirement of Mr. T. E. Walker

Mr. T. E. Walker, Honorary Local Secretary of the North Eastern Centre of the Institution, retired on 6 January 1960, his 65th birthday, after 46 years' Post Office service, the last 30 years having been spent as a Leading Draughtsman at N.E. Region Headquarters, Leeds.

The success of the Institution's activities depends on the enthusiasm and service of individuals, particularly of the local centre officers, and Mr. Walker is an outstanding example. He accepted the office of Honorary Local Secretary of the North Eastern Centre in 1930 and held it for an unbroken 30 years until his retirement. The undoubted strength and success of the North Eastern Centre is due in no small part to Mr. Walker's untiring work and



By courtesy of the *Yorkshire Evening Post*

devotion to the objectives of the Institution during his long service. He became well known to, and friends with, a very wide circle of members during the war years when the Engineering Department contingent at Harrogate often took advantage of the open invitation to attend the meetings of the North Eastern Centre at Leeds.

The Council of the Institution has great pleasure in recording its sincere appreciation and thanks to Mr. Walker for his long and meritorious service and expresses its warmest wishes for a long and happy retirement.

Many tributes were paid to Mr. Walker by his colleagues at a farewell gathering held at Leeds to mark his retirement. The photograph shows the presentation made to Mr. Walker (left) on their behalf by Lt.-Col. J. Baines, O.B.E. (right), Chief Regional Engineer, N.E. Region, and Chairman of the North Eastern Centre of the Institution.

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.

2558 *Mitchell's Elementary Building Construction.* Ed. D. Nield (Brit. 1959).
Gives the up-to-date practice, with emphasis on those techniques likely to be the subject of future development.

2559 *Principles of Transistor Circuits.* S. W. Amos (Brit. 1959).
Covers the basic principles of the transistor and its application in amplifiers, receivers and other circuits.

2560 *Radio Studies of the Universe.* R. D. Davies and H. P. Palmer (Brit. 1959).
Aims at making the achievements in this field of research more widely known and understood.

2561 *Mathematics for Telecommunication Engineers.* S. J. Cotton (Brit. 1959).
Covers the syllabus of the fourth and fifth years of the C. and G. course in telecommunications and tries to bridge the gap between the maths reached in courses such as H.N.C. and that required to understand the articles in professional journals or to solve many problems facing, in particular, telecommunications engineers.

2562 *Facilities for Data Transmission.* G.P.O. (Brit. 1959).
Describes the facilities offered by the Post Office in the United Kingdom for the transmission of data for digital computers.

2563 *Wiring Circuits.* E. Molloy (Brit. 1959).
Designed as an aid to electrical contractors, installation engineers and electrical maintenance engineers.

2564 *Stereophonic Sound.* N. H. Crowhurst (Amer. 1957).
Gives a general review of the subject, and covers domestic and theatre systems.

2565 *Electron Physics and Technology.* J. Thompson and E. B. Collick (Brit. 1959).
A concise but comprehensive account of the modern theory of the electron, including critical surveys of construction techniques and the applications of electronic devices.

2566 *High-Speed Computing.* S. H. Hollingdale (Brit. 1959).
For the educated general reader who may wish to use these machines.

2567 *Nuclear Power Plant.* E. O. Taylor (Brit. 1959).
Provides a view of the basic ideas underlying nuclear power generation; sixth-form science level is assumed.

2568 *The Practical Hi-Fi Handbook.* J. G. King (Brit. 1959).
A general view of the subject—the enthusiastic amateur and the service engineer both being catered for.

2569 *Magnetic Sound Recording.* D. A. Snel (Dutch 1959).
The theory and practice of magnetic sound recording and reproduction.

2570 *Electronic Circuit Theory.* H. J. Zimmermann and S. J. Mason (Amer. 1959).
Deals primarily with the methods of analysis of electronic circuits.

2571 *Transistor Circuits.* K. W. Cattermole (Brit. 1959).
An introductory account of the principal functions and circuit arrangements in which transistors can be used, together with brief descriptions of the devices themselves and of certain major applications.

2572 *A First Course in Television.* "Decibel" (Brit. 1958).
Assumes a reasonable knowledge of wireless.

2573 *Electricity and Magnetism.* A. W. Hirst (Brit. 1959).
Limited to those portions of the subject which form the basis of electrical engineering practice; a textbook for students entering the Electrical Engineering Department of a University or Technical College.

2574 *Dynamics.* A. E. Short (Brit. 1959).
Makes full use of vector analysis, and includes such relatively advanced topics as central orbits without adopting the mature standpoint of the university textbook. No previous knowledge of the subject is assumed.

2575 *Transistors in Radio, Television and Electronics.* M. S. Kiver (Amer. 1959).
For the radio and television technicians and all technical workers who desire to gain a working knowledge of transistors and transistor circuits.

2576 *Principles of Frequency Modulation.* B. S. Camies (Brit. 1959).
Intended for students, radio engineers and radio amateurs; gives a reasonably comprehensive account of the fundamentals of f.m. and its applications in radio transmitters and receivers, and in radar systems.

2577 *Transistor Electronics.* A. Lo, etc. (Amer. 1958).
A thorough study of both the theory and practice of transistors and transistor circuits.

2578 *Heating & Ventilating.* O. Faber (Rev. L. N. Doe) (Brit. 1959).
An introduction to the subject; gives a broad general survey of the principles and practice without entering into too much detail.

W. D. FLORENCE,
Librarian.

Regional Notes

Northern Ireland

CARLISLE–BELFAST BROADBAND RADIO-RELAY SYSTEM

A broadband radio link (Radio System 10/10) between Carlisle and Belfast was brought into service on 31 October 1959, in order to extend the commercial television service to Northern Ireland. The radio link operates in the 4,000 Mc/s band with a transmitter power of 5 watts, and uses paraboloid aerials of 10 ft diameter, connected to the radio equipment by wave-guides of 2 in. × 0·66 in. cross-section. Dry air is circulated through the wave-guide system to prevent the ingress of moisture, which would lead to corrosion and resultant attenuation.

The radio terminals are situated at Ballygomartin (Belfast) and Harraby (Carlisle); a note on the erection of the tower at Ballygomartin was given in the Regional Notes in the *P.O.E.E.Journal*, Vol. 52, p. 227, Oct. 1959. In order to meet the required opening date, service is being given temporarily by means of outside broadcast transmitters at Harraby, and these will remain in service until the permanent equipment has been installed in the new building. The three non-demodulating radio-relay stations are situated at Riddingshill (near Dumfries), Cambret Hill (near Gatehouse of Fleet) and Enoch Hill (near Stranraer). The total route mileage is 132·7, of which nearly 40 miles are over the North Channel.

By the opening date, equipment for two channels in the direction Carlisle to Belfast had been provided, each channel having a band-width of about 5 Mc/s; one channel carries the I.T.A. program, whilst the other channel is a standby. At Carlisle the input video signal is fed simultaneously to both channels by a resistive splitting network and 20 db wideband amplifiers, and at Ballygomartin the radio-channel outputs are connected to the video circuits to the television control at Telephone House, Belfast. Both channels are monitored by synchronizing-pulse detectors, and either channel may be selected as the main program channel, depending upon the quality of the picture as displayed at the Belfast television control.

It is expected that work on equipping the link for telephony will start in the near future, and it will then be extended to provide three channels from Great Britain, one for television, one for telephony, and one standby or protection channel. In the direction Northern Ireland to Great Britain two channels will be provided, one for telephony and one standby.

The radio link is designed to provide up to a total of six channels in each direction, each channel being capable of carrying a video signal, or one direction of transmission of a 600-circuit telephony system. As a common aerial system is used, the combining and separating of channels is achieved by means of branching filters in the wave-guides. Modulators, repeaters and demodulators can deal with either television or telephony signals without requiring adjustment, and at each station the channels will be used on the basis of one common standby channel for every five working channels; the standby channel, which is continuously operated, will be switched into service upon failure of a working channel, by baseband switching equipment at the radio terminals under the control of continuity pilot tones and detectors, but facilities will also be provided so that this automatic protection can be overruled by manual selection.

On the oversea path Enoch Hill–Ballygomartin, height-diversity reception is provided in order to combat the effects of reception of unwanted signals reflected from the surface of the sea. The equipment for this purpose comprises, at each of these stations, an additional receiving aerial and wave-guide feeder situated at a carefully selected height above the main aerial. At Ballygomartin, the difference in height is 45 ft. Bearing in mind that the radio wavelength is 7·5 cm, it will be appreciated that signals arriving at the main and diversity aerials at the same instant will differ in phase, and the aerial spacing is so chosen that, under normal conditions of fading, a fade on the main signal is compensated by a peak on the diversity signal, and automatic-control circuits are provided to ensure that the two signals always combine in phase. The essential parts of this control system are:

(*a*) A ferrite modulator which phase modulates the signal from the diversity aerial.

(*b*) A motor-driven phase-shifting device which operates mechanically and ensures that the combination of the signals from the two aerials is continuously maintained at optimum.

A point of interest is that this radio link is the first in service in the United Kingdom to be provided with this particular height-diversity reception facility, and experience since the link was opened has indicated that a very steady signal can be obtained in this way.

The television signals are conveyed from Ballygomartin to Telephone House, Belfast, by unbalanced video transmission on 375E coaxial pairs equipped with 20 db video amplifiers. The main signal is transmitted to the Ulster Television Centre, Mavelock Street, Belfast, for editing and onward transmission, via Telephone House, to the I.T.A. transmitter at Black Mountain; these circuits are provided by unbalanced video transmission on 375E coaxial pairs equipped with video amplifiers and waveform correctors, hum balancers and longitudinal chokes as appropriate.

To guard against loss of program due to Post Office line-equipment failures, standby video amplifiers are provided at Ballygomartin, Telephone House and Black Mountain. The amplifiers at Ballygomartin and Black Mountain can be switched into service by remote control from the television control at Telephone House.

R. A. D. W

Scotland

OVERHEAD RECOVERY UNIT

Recently, when it was necessary to recover a 10-mile overhead route in Scotland West Area, the opportunity was taken to mechanize the work using a "route-recovery unit."

The unit consists of a framework into which is fitted a petrol engine (from a recovered trailer winch). The engine is connected by a shaft and vee-belt to a 15 : 1 ratio gearbox (from a recovered trailer pump) which transfers the horizontal drive to a vertical shaft, and the end of this shaft is fitted into a collapsible reel. A further vee-belt drives a compressor (from a recovered paint sprayer). Both the compressor and reel are controlled by adjustment of the jockey pulleys, which can allow the vee-belts to slip. An impact spanner is also part of the unit; this tool looks not unlike a household power drill, and is connected by an air line to the compressor. Its function is to unscrew arm bolts, which it does very successfully even when the threads are firmly held by rust. The entire unit fits along the nearside of a 2-ton vehicle which is fitted with a turntable extending ladder and platform. One 4-man gang is necessary for the work, the duties of each man being: vehicle driver, reel operator, ladder operator and foreman.

The method of operation is as follows. The vehicle is driven to the first pole. The ladder operator positions and ascends the turntable ladder, and cuts down the wires at the insulators. The wires are caught and bunched by the foreman waiting below. The ladder is then restored to the driving position and the vehicle moves to the next pole. On arrival there the ladder operator cuts down the wires on each side of the insulators, and the span, of up to eight 150 lb/mile wires, is fed into the reel by the foreman. The reel is controlled by the operator inside the vehicle, who weighs and stows each coil as it is completed. The time for the recovery of each span can be reduced to about eight minutes, after the gang have had a day's experience.

Where recoveries of complete routes are being carried out, the wire recovery unit is followed by a 3-ton slewing-jib crane, borrowed from the Glasgow Area, which extracts the poles very quickly. Some 40 miles of route have been recovered by this means and the unit is now regarded as a normal mechanical aid.

Since using this technique, performance ratings have varied from 16 to 40, depending on the gauge of wire handled. The staff appeared somewhat sceptical initially but they are now very enthusiastic. Great credit is due to the Glasgow Telephone Manager's Area workshop staff who constructed the unit and displayed endless patience during the experimental period.

D. B.

OPENING OF AIRDRIE NON-DIRECTOR EXCHANGE

Nearly 1,700 Scotland West Area subscribers previously connected to Airdrie exchange (a U.A.X. No. 7) and its relief, Wayside exchange (a U.A.X. No. 13), were introduced to the code "100" for operator assistance at the opening of Airdrie non-director exchange.

For the first time in the Area, acceptance of the new equipment was made jointly by engineering and traffic divisions without further tests by the traffic staff. Pre-transfer testing of the junction routes, involving over 170 junctions, was also carried out on a joint basis. As a result of these successful joint acceptance tests, the transfer to the new 2,600-multiple exchange took place on 14 January 1960, a week earlier than the agreed ready-for-service date; an earlier transfer date could have been achieved if the Christmas and New Year holidays had not intervened. Experience of these joint tests, carried out in close liaison between traffic and engineering staffs, indicated that a considerable saving in manpower was possible without prejudice to the satisfactory operation of the exchange equipment. In addition, the time saved should, in future cases, help towards achieving a transfer date coincident with the ready-for-service date.

R. B.

Midland Region

PROVISION OF EMERGENCY TELEPHONES ALONG THE LONDON–YORKSHIRE MOTORWAY IN THE COVENTRY AREA

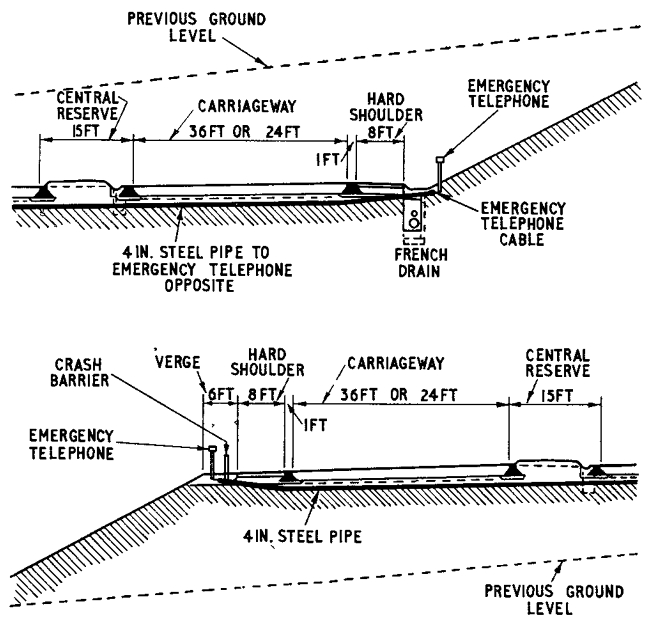
The provision of the emergency telephones along the London–Yorkshire motorway involved the Midland, Home Counties, and London Telecommunications Regions. In order to ensure uniformity on a new project it was decided to place contracts at Headquarters for the work involved and to provide direct engineering control of the work in the field by the External Plant and Protection Branch of the Engineering Department.

The emergency telephones along the London–Yorkshire motorway* are spaced at 1-mile intervals on both sides of the motorway and are positioned so that each telephone on the east side is opposite a telephone on the west side. Following a comparative-costs study of providing such a network, it was decided that cable should be laid along the motorway with connecting cables to the appropriate police headquarters. This gives each police headquarters control of the section of motorway in its own territory. As far as the Coventry Area is concerned this required the provision of the largest and smallest control centres for the motorway—the Northamptonshire County Police control with 54 telephones in six groups, and the Warwickshire County Police control at Rugby with two groups of two telephones each.

During the planning stage the consulting engineers for the motorway set up a large office near the line of the new road, and this enabled an Area planning Assistant Engineer to maintain close co-operation, and to establish with the consulting engineer's staff personal contacts which were valuable throughout the work, particularly as the road construction was organized in 4-mile sections each with its own labour force and supervising staff.

There were eight such sections in the Coventry Area and, as cabling was at one time proceeding in all sections, it became necessary to appoint a full-time works Assistant Engineer to ensure common methods of cable laying and protection throughout. This officer controlled four Post Office works supervisors on the cabling contract, and also a group of Post Office jointers who followed closely behind the cabling parties and inserted loading coils in joints at 1,760-yard intervals. The jointers also prepared the cable tails at each telephone point; the tails were then buried pending the delivery and erection of the pillars by the contractors. A Land Rover was used to maintain contact between sections separated by an unlevelled length of road. It was only by adopting such methods that the necessary rate of progress was obtained; in fact, the schedule was so tight that the final tests were completed only 60 hours before the motorway was officially opened.

Typical cross-sections of one carriageway of the motorway are shown in the first figure, indicating the cable position stipulated by the consulting engineers—13 ft back from the concrete haunch, on the outside of the French drain in cuttings and on the outside of crash barriers on embankments.

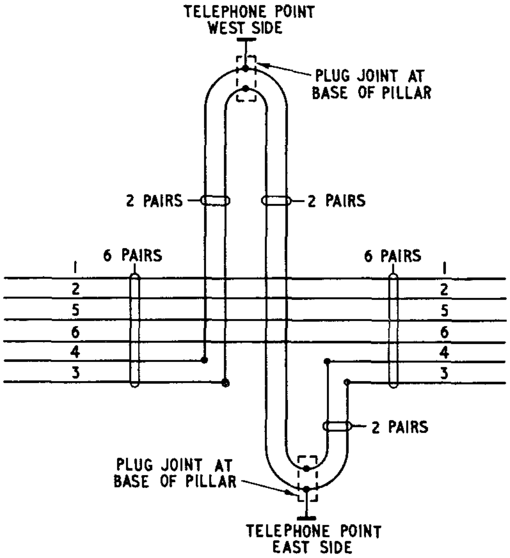


TYPICAL CROSS-SECTION OF MOTORWAY SHOWING POSITION OF CABLE

Only 1½ miles of cable trench were excavated mechanically, the main length of 29½ miles being hand dug to minimize disturbance of recently-graded embankments and to avoid the use of mechanical diggers or moledrainers on the recently formed and seeded hard shoulders. In this trench a polythene-sheathed 40 lb/mile quad-type cable was laid at a depth of 12 in. with a 3 in. surround of sand. A 6-pair cable was used in the sections having more than one group of telephones, and a 2-pair cable provided for each final section and in the tail to each telephone. The positions of every two telephones opposite each other, at the 1-mile intervals, were linked under the motorway by 2-pair cables laid in 4 in. steel pipes and jointed as shown in the second figure.

Where rock or retaining walls were encountered in

* TURNER, G. Emergency Telephones for the London–Yorkshire Motorway. *P.O.E.E.J.*, Vol. 52, p. 243, Jan. 1960.



SCHEMATIC ARRANGEMENT OF PILLAR CABLING

cuttings the cable was run in 2 in. asbestos-cement pipes to the top of the cuttings. Under the 33 bridges 2 in. asbestos-cement pipes were used for the full width of the abutments, and through stone revetments this type of pipe was further protected by a 4 in. steel pipe used as a sleeve, thus avoiding difficult joints between pipes. On the 21 viaducts the cable was passed through one of five 3 in. earthenware ducts laid directly under the paving slabs.

Daily tests were made on all cables laid, and faults were cleared as they occurred. The faults were all due to mechanical damage; most of them were caused by the use of earth augers for digging post holes for signs and crash barriers, and by bulldozers carrying out final grading on embankments. There is, however, no doubt that the cables were saved from many faults by being laid as late as possible.

For maintenance purposes two 1,800-yard lengths of 6-pair cable and of 2-pair cable are held in the Area in addition to short lengths for patching. The long lengths are only for interruption purposes and will be laid overground between adjacent telephones should it be obviously impracticable to make a quick permanent repair of a fault. Although east-side and west-side telephones opposite one another are connected to different groups, it is possible to test both their cable pairs by opening the plug joint at the base of either telephone pillar (see second figure). This facility is valuable owing to the prohibition on vehicles making U-turns and on pedestrians crossing the motorway; in the worst condition an 18-mile journey is necessary to get a vehicle to the opposite side of the motorway.

With the opening of the motorway the telephones were immediately in demand, and for the first few days the Northamptonshire control was handling about 100 calls a day. Now, after three months, the figure is about 20 a day. Right from the start the police have given the utmost co-operation at all times. Initially they carried out a daily check of all telephones, but this has been reduced to a daily test of the last telephone in each group. When a telephone is reported faulty the police patrol first makes a check at the pillar before calling the Post Office. Two Post Office engineers, one at the control and one visiting the pillars, carry out a check of all the equipment once a month to ensure satisfactory working, the work being completed in one day.

In two months there were three cable faults: one due to low insulation in a joint, another caused by damage during roadworks and the third due to subsidence. On one occasion a lorry, running off the road, dragged the cable out of the ground but caused no fault. The only control-apparatus faults were due to the tapped battery being unequally discharged, and this has been cleared by a circuit modification. Of four telephone faults reported, one was due to a faulty selector resistor and the three others were caused by receivers being left off by users.

The most serious maintenance problem is the amount of travelling involved, as a linesman operating from Northampton has to travel 40 miles to clear a fault at any telephone north of Heyford, owing to the previously-mentioned restriction on U-turns.

For the protection of the maintenance staff and road users the problem of safety precautions is being discussed by the Engineering Department with the police authorities, with a view to standardizing emergency-warning signs and the lighting of such signs and obstructions in each county.

H. H.

S.T.D. AT EVESHAM

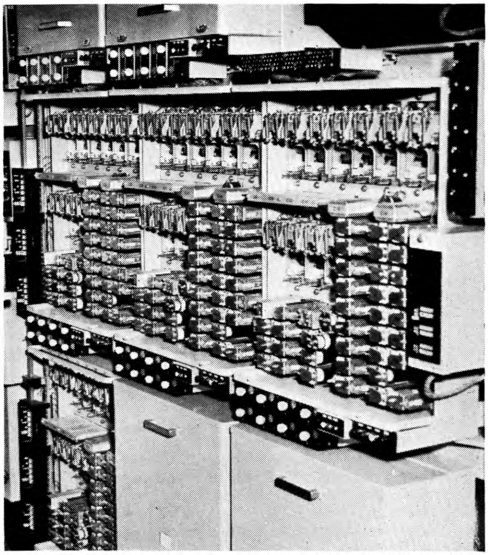
The third S.T.D. installation in the country, and the first in the Midland Region, was successfully brought into operation at Evesham, at 3.0 p.m. on Wednesday, 6 January 1960. Before an assembled company of the prominent citizens of Evesham, including the Mayor, the Deputy Director General, Mr. R. J. P. (now Sir Robert) Harvey, C.B., made the inaugural call to London, to Sir Rupert de la Bere, ex-M.P. for Evesham and Freeman of Evesham; the Mayor later gave the signal for the service to be opened to the public. Before 3 p.m. Evesham subscribers had dialling access to 18,000 subscribers in their own and adjacent charging groups—they now have dialling access to 2½ million subscribers.

Evesham is a non-director exchange with some 1,300 exchange lines, and apart from the town-business load there is a seasonal load associated with the market-gardening trade, which at this time of the year is at its lowest level. The number of trunk calls originating from Evesham and the surrounding exchanges which were handled each day by the operating staff during the summer months was about 2,400, of which 1,000 were from Evesham subscribers and including 100 from public call offices, which now await the new coin-box before being given S.T.D. facilities. It is estimated that S.T.D. will allow approximately 65 per cent of the 900 remaining calls to be dialled by the subscribers, i.e. 590 per day.

The equipment was installed by the General Electric Co., Ltd.; it is of the electromechanical type, and is comprised mainly of 40 register-access relay-sets, and 12 registers with two translators. The electromechanical registers are shown in the photograph. The trunk circuits are terminated on the banks of two racks of motor uniselectors, one rack being accessible from the manual board and the other from the S.T.D. equipment. Trunk routes link Evesham with London, Cardiff, Bristol, Gloucester, and Birmingham. The Birmingham route, which occupies a 40-availability group (23 actual circuits) on the motor uniselectors, is to Birmingham Anchor trunk tandem exchange, and as well as providing access to the Birmingham director exchanges also takes the calls from Evesham to Edinburgh, Glasgow, Manchester, Liverpool and other large centres in the north.

Beside the normal supervision of the installation and the acceptance testing of the equipment, the Department's work in Evesham exchange included a certain amount of rearrangement of the existing equipment in connexion with the observation circuits, traffic recorder, manual-board circuits, and with the changing of selector levels for the adjacent exchanges.

Modifications to suppress the dial tone on incoming junctions were necessary at all U.A.X.s No. 12 and 13 accessible from the S.T.D. equipment. This involved a fairly extensive modification of the selectors at the U.A.X.s No. 12, but there were only two such exchanges, with 20 selectors between them. At the U.A.X.s No. 13 the incoming-junction relay-sets had to be modified and separate 1st selectors had



ELECTROMECHANICAL REGISTERS AT EVESHAM EXCHANGE

to be fitted; there were 16 of these exchanges with 142 relay-sets. At both groups of exchanges the multi-metering straps were rearranged to cater for the change of dialling codes in the main exchange. Altogether the work in the U.A.X.s occupied 3,000 man-hours.

G. A. P.

North-Western Region

MANCHESTER TRUNK MECHANIZATION

The opening of the first trunk non-director exchange in Manchester, "Guardian," was described in the Regional Notes in the *P.O.E.E.Journal*, Vol. 52, p. 77, Apr. 1959. The second and larger unit, "Pioneer," was brought into service in November and December, 1959. The equipment includes 101 racks of motor uniselectors, 92 racks of 2,000-type selectors and 219 relay-set racks. A new intermediate distribution frame of 175 verticals was installed in Telephone House, on the same floor as the existing trunk director exchange. A new suite of 12 trunk-test positions was installed on another floor.

Installation commenced in August 1957, and in view of the size and complexity of the job it was controlled by a combined Area and Regional committee on which the contractors were represented, and which supplemented site meetings at Area level. A considerable amount of work had to be carried out by the Area staff in conjunction with that carried out by the contractor's staff, particularly in view of the planned integration of the new trunk non-director installation with the existing trunk-director installation beyond the 1st selector levels. Some details of this work are described below.

In November 1958 the incoming cables to the trunk director exchange 1st code selectors were ready for change-over to the new Pioneer intermediate distribution frame. New relay-sets for all trunk director circuits had been provided as part of this contract. The process of transferring the working circuits from old relay-sets to the new ones was completed by taking out of traffic 20 circuits at a time on a scheduled time-table. Approximately 1,000 circuits were involved and this operation was spread over a period of about three weeks. The old relay-sets were modified, shifted to their ultimate positions and then re-cabled to the new intermediate distribution frame. Over the next few months a number of other miscellaneous relay-sets were dealt with in a similar manner.

The lining-up program progressed in step with the main-exchange installation and was completed in seven months. By this time, the 2-wire ends were being connected, via the new trunk-test racks, to the exchange. As two-thirds of the circuits over 20 miles in length were being transferred from other exchanges, switching facilities had to be provided. Spare disconnexion-type jacks on the old and new trunk-test racks were used for this purpose. The circuit arrangements were complicated for the old routing of the switched circuits was via any one of seven distribution frames existing in Telephone House.

The majority of switched circuits originally terminated on the manual board and, consequently, considerable rearrangement of the 600 positions concerned was required. Because of this and traffic-routing problems, a decision was made to carry out the transfer at night, on 13 and 14 November.

For the transfer itself the circuits were divided into nine groups with approximately equal numbers in each; four groups were transferred on the Friday night and five on the Saturday night. The engineering tests commenced at 10.15 p.m. and, by using all trunk-test positions, it was possible to carry out dialling and speaking tests on each circuit prior to traffic testing. The engineering operations lasted approximately one hour for each group of circuits and were followed by traffic tests. Very little trouble was experienced, and out of 4,800 circuits transferred only 13 faults were found, of which two were on the Pioneer equipment, eight on distant-exchange equipment, and three were caused by switching operations.

Coincidental with the Pioneer transfer, circuits on level 2 of the trunk-director exchange 1st code selectors were transferred to an "accommodation" level and the job of integrating the two outgoing-junction multiples commenced. New cabling between the 1st code-selector banks and the intermediate distribution frame, via a new test-jack frame, was completed, and the ultimate grading and routing of the level 2 outlets to the trunk 2nd selectors were finished. Director translations were changed, and work on integrating the circuits on the next level commenced. By the middle of December all trunk-director traffic was flowing through the Pioneer outgoing-junction multiple and trunk mechanization at Manchester was complete.

GROUND-LEVEL LEAD-IN AT ALTRINCHAM AUTOMATIC TELEPHONE EXCHANGE

As previously reported in various publications, considerable savings have been made in the design of Altrincham telephone-exchange building due to the work of the Joint Post Office and Ministry of Works Research and Development Group.* A significant proportion of the cost of building a telephone exchange is in the excavation and construction of the underground cable chamber. At Altrincham costs have been greatly reduced by designing the 48-way duct lead-in to the new 10,000-line exchange to enter the apparatus room at ground level. The geographical conditions at the site were helpful in as much that the road level outside the site was 3 ft higher than the proposed foundation level.

It was agreed that the Ministry of Works would be responsible for not only the building of the exchange but also the provision of the pipes and construction of the lead-in. As the work on site was scheduled to commence in October 1959 all duct work in the road outside was completed before that date.

Prior to the laying of the duct the architect made arrange-

* MACKENZIE, W. K. The Work of the Joint Post Office and Ministry of Works Research and Development Group. *P.O.E.E.J.*, Vol. 52, p. 251, Jan. 1960.

ments to peg out the proposed lead-in centre line. The new exchange manhole, sited on this line, was of the RT8 type suitably modified to fit the actual site and duct requirements. A "window" of suitable size to take the lead-in ducts was left facing the new exchange, and it incorporated a 6 in. p.v.c. water barrier to provide a good water seal between the manhole and duct block. The aperture was temporarily filled in with $4\frac{1}{2}$ in. brickwork. To complete the work in the road outside, 18-way and 12-way multiple-duct tracks were laid to adjacent manholes, with provision for laying a further 18-way multiple duct into the exchange manhole at a future date.

Octagonal and asbestos-cement duct had been considered for the lead-in, but in conjunction with the Ministry of Works it was finally decided that more efficient jointing could be effected by the use of pitch fibre pipes; these pipes, 8 ft in length and a $\frac{1}{4}$ in. thick. have a $3\frac{1}{2}$ in. internal diameter. The joints are made by tapping the spigot end of a pipe into the conical collar of the preceding pipe. Horizontal and vertical staggering of joints was attained by cutting short lengths of pipe on site, the spigot end being cut by a special tool supplied by the manufacturer.

Early in the building operations a sloping excavation was cut along the proposed duct line to the exchange-manhole wall, and the temporary brickwork removed from the aperture. The standard practice of constructing a U-trough was considered unnecessary by the Ministry of Works for the laying of this type of duct. The timbered trench sides were lined with a waterproof paper to prevent moisture in the concrete from seeping away during the laying process. It was, however, necessary to use shuttering for the portion of the block which came above ground level.

A standard duct seal seemed unnecessary as the duct entered the apparatus room above the surrounding ground level, but as the road outside had a general rise it was possible that water might be forced into the exchange by the natural hydraulic gradient. It was, therefore, decided that a lead duct-seal should be fitted at the manhole end. At the exchange end each pipe was fitted with a special collar to provide a $\frac{1}{4}$ in. shoulder required as a bearing for a compound gas-seal. In connexion with the lead seal, an angle-iron frame was made by the Post Office, as a mounting for the duct-seal fixing bolts; this was later placed in the concrete surrounding the lead-in pipes.

Two timber templates of the 48-way formation were constructed on site, the manhole end having the standard $5\frac{1}{8}$ in. duct centres, whereas at the exchange end the vertical spacing was increased to 6 in. to correspond with the normal cable bearer-bracket fixing holes.

With the templates and duct-seal mounting-frame in position a mesh-reinforced concrete base (6 in. thick) was laid in the trench and the layers of pipes concreted into position in the usual way, using 1 : 2 : 4 small-aggregate mixture. The correct line and vertical spread of each pipe was achieved by stretching a cord between the templates above each pipe. As the eighth and final layer was laid, two ladder hooks were placed above the pipes in the surrounding concrete where it entered the apparatus room. They are designed to support a removable bar and roller device by which means the cable can be supported at the duct lip during drawing-in operations, so removing the possibility of sheath chafing.

The completed lead-in rises from the exchange manhole at a gradient of 1 in 12 over a distance of 88 ft, and is below ground level except where it crosses the narrow path surrounding the exchange. Continuing through the test room as a bulkhead, it enters the apparatus room at floor level. Cables within the exchange will be supported on standard cable bearers and brackets secured to a rolled-steel joist within the outside wall, the whole being encased in a removable timber cover.

Cabling will commence from the wall-side lower duct, and the cables will pass over the first bracket. curve down to the floor of the $10\frac{1}{2}$ in. deep cable trench and then turn towards the main distribution frame. Joints between the external cables and the 400-pair p.v.c. terminating-type cable will be placed diagonally on the floor of this trench, which will be 10 ft wide. Subsequent cables will, in turn, take up the wall-side position before dropping down from the bracket levels on to the floor and then turning towards the main distribution frame. The separation between the cabinet enclosing the cables and the fuse mountings on the main distribution frame will be 5 ft.

D. J. M.

Associate Section Notes

Huddersfield Centre

A meeting was held in the Friendly and Trades Club on Wednesday, 28 October 1959, when Mr. G. Howarth of Kershaw's Nurseries, Slead Syke, Brighouse, gave a talk entitled "Everyday Gardening." The member's questions which followed were many and varied; the advice and information received was most interesting and instructive, and very much appreciated by the 20 members present.

On the evening of Tuesday, 24 November 1959, a party of members went to the West Riding Constabulary C.I.D. Block at Wakefield. The visit to this "Scotland Yard of the North" consisted of a tour round the M.O. (Modus Operandi), photographic and fingerprint departments, and gave us an insight into some of the many ways in which criminals are caught. The 26 members of the party were left in no doubt that crime does not pay.

On Tuesday evening, 8 December 1959, Mr. G. Mallinson (maintenance staff) presented his talk, "An Outline of Amateur Radio," in which he described the qualifications, aims and achievements of radio "hams." This was followed by a practical demonstration in which contacts were made with several local "hams." Mr. M. Firth (P.A.B.X. construction staff) then briefly described the types of aerial used and the circuit operation of the transmitter and receiver. The meeting proved both interesting and enjoyable, and was attended by 24 members.

D. B.

Hull Centre

The current session commenced on Thursday, 8 October 1959, with a 16 mm sound-film show, by Mullard, Ltd., on transistors and transistor circuits. Other films included one of the new techniques of radio astronomy.

We are very much indebted to members of the Institution who have travelled long distances to give us interesting papers on such subjects as "The Fundamentals of Telephone-Cable Design," by Mr. A. C. Holmes, Training Branch, Engineering Department, and "The B.P.O. 700-Type Telephone," by Mr. H. J. C. Spencer, Subscribers' Apparatus and Miscellaneous Services Branch, Engineering Department. Both these talks were very well illustrated with lantern slides and transparencies. Another paper on "Subscriber Trunk Dialling," was given by Mr. T. A. Barker of the North Eastern Regional Office.

A joint meeting was held with the Kingston-upon-Hull Electronic Engineering Society, when an admirable paper on "Radio Transmission through Space" was given by Messrs. Humphreys and Webster, Chief Engineer and Senior Design Engineer of Pye Telecommunications, Ltd., respectively. Members have also been invited to attend a meeting of the Hull and East Riding Branch of the British Computer Society, Ltd., on "Ernie," to be given by Mr. W. E. Thomson, Dollis Hill Research Station.

Our 1959–60 session ended with a dinner on Thursday, 10 March 1960, at which Mr. H. V. J. Harris, M.B.E., Telephone Manager, Hull Corporation Telephones, was the guest speaker, and the annual general meeting in April.

The committee and officers thank members for their support and look forward to a good 1960–61 session.

L. J.

Leeds Centre

On Wednesday, 18 November 1959, 30 members travelled to Blackburn to spend a day at the valve factory of Mullard Ltd. The party were welcomed by the resident visits organization officer, Mr. Swain, who, in an introductory talk illustrated by photographs and diagrams, described the development of the organization. In the lecture theatre a film on the manufacture of high-quality valves was then shown; it explained in detail how each component is fitted in the assembly line to build up the complete valve, and concluded with illustrations of the numerous tests to which the various types of valve are subjected. The tour of the factory commenced with a most interesting visit to the wire plant. This was followed by an excellent lunch in the visitors' dining room. After lunch the tour continued with visits to the assembly departments and the glass-tube department The visit concluded with tea, after which the chairman thanked the Mullard organization and staff for a most instructive and interesting visit.

On Thursday, 3 December 1959, we held our Annual Dinner and Dance at the Ringway Restaurant, Whitehall Road, Leeds; 102 members and guests attended. The guests included Lt.-Col. J. B. Sutcliffe (Telephone Manager, Middlesbrough), Mr. F. Wood (Telephone Manager, Leeds) and Mrs. Wood, Mr. E. Hopkinson and Mr. P. D. Gilbey (Area Engineers, Leeds) with Mrs. Hopkinson and Mrs. Gilbey, and Mr. A. K. Robinson (Regional Liaison Officer). At 7.15 p.m. members and friends assembled and introductions were made before dinner was announced. It was stimulating to hear the pleasant sound of conversation during this excellent and well-served meal and to realize that all were enjoying themselves. The resident quartet played light music during dinner, after which the chairman, Mr. C. Baker, proposed a toast to the guests of the evening, referred briefly to the future policy of the Centre and thanked members for their wonderful support throughout the year. He concluded with good wishes to all for the festive season. After Mr. F. Wood had replied the remainder of the evening was taken up with dancing. During the interval a floor show was presented by television personalities Leslie and Bowland, with Robert Sinclair, magician, and was thoroughly enjoyed by all.

C. B.

Sheffield Centre

Three particularly successful meetings were held during the final quarter of 1959. At the first meeting, on 27 October, a lecture was given by Mr. E. L. Davey of British Insulated Callender's (Submarine Cables), Ltd., on the 138 kV submarine power-cable between British Columbia and Vancouver Island. A brief talk by the lecturer was followed by an excellent colour film of the whole project from the cable-manufacturing stage through to the switch-on of power. On view were many photographs of the scheme, and models of the scow, cable-laying gear and other equipment used during the operation. In spite of a local transport strike we had a large audience which included Associate members from the Leeds and Doncaster Centres, and members of the local Electricity Authority.

"The 250-foot Radio Telescope at Jodrell Bank" was the subject that attracted an audience of well over one hundred on 24 November. The speaker was Mr. C. M. Kingston of Husband & Co., the Sheffield firm of consulting engineers responsible for the design and construction of the instrument. After giving a simple outline of the principles of radio-astronomy the lecturer mentioned some of the factors to be considered when selecting a site for the telescope. Altitude and freedom from abnormally high-force winds were highly desirable features, and past weather records of possible sites were studied before the final choice was made. A film, "The Inquisitive Giant," showed the construction of the telescope, and was augmented by slides to illustrate some of the more detailed points. After the lecture Mr. Kingston answered questions as fully as the preservation of trade secrets would allow, and hinted at some possible future uses of the instrument such as the tracking of guided missiles.

Our annual Christmas social was held on 12 December and this year it took the form of a party, with a break during the evening for an excellent meal. We are indebted to Mr. A. Knowles and his wife for preparing and organizing the fun and games and, as those present included all age groups from six upwards, it was no mean feat to keep everyone entertained all the time. Our Telephone Manager, Mr. E. S. Loosemore, was once again our very welcome guest.

J. E. S.

York Centre

The York Centre was re-opened for the 1959–60 Session, after a lapse of seven years, with the following officers present: *Chairman:* Mr. L. Chapman; *Secretary:* Mr. B. C. Jackson; *Assistant Secretary:* Mr. M. Watson; *Treasurer:* Mr. H. C. Johnson; *Committee:* Messrs. D. Bellwood, P. Dring, R. Jackman, A. S. Shirley, A. Steventon and J. Varlow.

The session was opened by a member of the senior section, Mr. N. Heaton, who gave a lecture on "Subscriber Trunk Dialling," with particular reference to its application at York and Bridlington. The attendance at the meeting was very encouraging to the committee and augured well for the future.

Mr. A. C. Holmes of the radio interference section at Scarborough, gave a practical demonstration and lecture on "Stereophonic Sound Reproduction" and undoubtedly showed the value of this medium as opposed to straight monaural reproduction.

Messrs. Hubbard and Mack, Telephone Exchange Standards and Maintenance Branch, Engineering Department, provided an exceptionally interesting evening by dealing with "Optical Aids to Development and Maintenance." This lecture showed how optics and, in particular, the use of the high-speed camera play their part in shaping the design of Post Office equipment, and the discussion continued until quite late.

The "Film Show" in January proved to be the worst attended of the meetings, due, no doubt, to the foggy weather. Nevertheless, an attendance of 22 was highly commendable in the circumstances and the meeting was thoroughly enjoyed by those present. Four films were shown: "Modern Gears," "Under the River," the story of the Severn Tunnel, "Radio-isotopes in Industry," an interesting picture by the U.K. Atomic Energy Commission, and "Antarctic Crossing."

Up to now a very successful session has been held, and the committee are well pleased with the results following the re-opening of the Centre.

B. C. J.

Edinburgh Centre

It is gratifying to be able to report that the average attendance at meetings this session has increased, although there is still room for improvement.

On 17 November 1959 the secretary again presented a program of films, including "The Rival World," by courtesy of Petroleum Films Bureau, and "Pan-Tele-Tron," by courtesy of Philips Electrical, Ltd.

At our meeting on 24 November 1959, Messrs. Hubbard and Mack, Telephone Exchange Standards and Maintenance Branch, Engineering Department, presented a lecture with illustrations, entitled "Optical Aids to Development and Maintenance." This proved most interesting and the members present, especially those on automatic exchange maintenance duties, were fascinated by the demonstration of films which concluded the lecture. These films consisted of photographs of the vertical and rotary stepping of the shaft and wipers of a 2,000-type selector which had been filmed by a high-speed camera at 3,500 frames/second.

During the course of the evening the Chief Regional Engineer, Mr. R. J. Hines, presented a Certificate of Merit to one of our members, Mr. W. Morrison, in recognition of his essay entitled "Printed Circuits."

D. M. P.

Chester Centre

The newly formed Chester Centre held its inaugural meeting on 15 April 1959 and was addressed by the Area Liaison Officer, Mr. T. A. P. Colledge, and Mr. Warren, Regional Engineer, Wales and Border Counties Headquarters.

Membership of the Centre now totals 88 and the following officers were elected: *Chairman:* Mr. D. Simmonds; *Secretary:* Mr. E. M. Walsh; *Treasurer:* Mr. D. B. Hickie; *Librarian:* Mr. M. Jones; *Committee:* Messrs. T. Parsonage, E. Whitley, A. Fleet, S. Hoyle, J. Crewe and T. A. Rogers.

Our program opened with an interesting paper, "Area Organization, Planning and Finance Control," presented by Mr. T. A. P. College. In November we welcomed Mr. K. Gray, who gave his illustrated talk, "Recent Developments in Auto Telephony." A good attendance was recorded at both meetings and lively question times followed.

The visit to British Insulated Callenders Cables, Ltd., Helsby, proved very popular, and our hosts showed us all the intricacies of a cable works.

Twenty members, drawn by ballot, paid a visit to Granada T.V. Studios, Manchester. Mr. Paul Rycroft conducted us on a most interesting and enlightening visit, and described the control equipment and studio techniques required in television productions.

We are looking forward to the other lectures and visits on our program, and new members, particularly from the external staff, are always welcome.

E. M. W.

Hereford Centre

An inaugural meeting was held at Hereford, on 17 October 1959, with a membership of 30. The following officers and committee were elected: *Chairman:* Mr. E. Wellington; *Vice-Chairman:* G. Jenkins; *Secretary:* Mr. E. A. Talboys; *Treasurer:* Mr. H. D. Goodman; *Committee:* Messrs. D. C. Booton, A. T. Daniels and F. E. Page. Following the meeting an interesting paper, "A Subscriber Trunk Dialling Digest," was given by Mr. J. C. Price of Shrewsbury; it was much appreciated by our members.

On 24 October 1959, a film, "Diesels in Industry," was shown. This was followed by a talk by Mr. McCrone of Lister-Blackstone, and discussion went on into the late hours of the evening.

Weather conditions on 14 January were at their worst for a visit from Mr. A. H. C. Knox, President of the Associate Section, Mr. Harrison, Liaison Officer, Home Counties Region, Mr. Lamping, Liaison Officer, Post Office Headquarters, Wales and Border Counties and Mr. L. G. W. Barnsdall, Area Engineer, Shrewsbury Area. A talk on "Appraisements and Promotions," by Mr. Knox, was received by a small but very appreciative audience. Our visitors are to be congratulated on setting a fine example to members, by attending our meeting in such adverse weather.

The rest of the program for the session included the following:

2 March 1960: Mullard Film Show, "Conquest of the Atom" and "From Us to View."

29 March 1960: "Telecommunications within the C.E.A.," by Mr. Crofts, Central Electricity Generating Board.

Visits were arranged to R. A. Lister, Ltd., Dusley, T.R.E., Malvern, and a convenient power station.

Magazines are now circulating smoothly, books are being requisitioned from the I.P.O.E.E. Library and members are making use of the other facilities offered. May I, in conclusion, appeal to interested non-members to join the Associate Section and increase the strength of this Centre.

E. A. T.

Shrewsbury Centre

In June 1959 a tour of Goodyear Tyre Co., Ltd., Wolverhampton, was arranged to foster the interest of the existing members and potential members.

The following month we were extended an invitation from the Radio Retail Trades Association to see two films from Mullard, Ltd., at the Shrewsbury Technical College.

At the annual general meeting held on 30 July the following officers were elected: *Chairman:* Mr. F. I. Roberts; *Secretary:* Mr. H. Christmas; *Treasurer:* Mr. R. G. Paulson; *Committee:* Messrs. J. Callear, K. Nicholson, E. Dodd, R. A. Jervis, G. R. Ridgway, A. Fieldon and J. Fleming.

Since then we have had a varied and full program.

September 1959: A lecture on "Subscriber Trunk Dialling," given by Mr. J. C. Price.

October 1959: Tour of the new automatic telephone exchange.

November 1959: Film show. Four films from the I.C.I. and Aims of Industry film libraries.

December 1959: A talk on "Road Navigation and Rally Experiences," given by Mr. C. Vincent.

January, 1960: A lecture on "Optical Aids to Development and Maintenance," given by Messrs. Hubbard and Mack, Telephone Exchange Standards and Maintenance Branch, Engineering Department.

The membership has doubled since June which is very encouraging. In the meantime we hope to continue with many more items of interest.

H. C.

Cornwall Centre

The 1959–60 session commenced with a paper on "Recent Developments in Aerial Cables," by Mr. J. Bluring, of Reading. The paper dealt in detail with the various methods of construction and the types of cable encountered. The paper was illustrated by some very interesting films and slides including some showing tests on aerial cables in the wind tunnel at Farnborough.

For our October meeting we were fortunate to have a paper from Mr. Hodge who was with the Whittle jet-engine development team in the R.A.F. Mr. Hodge, who has recently returned to Cornwall to develop gas-turbine compressors for a Cornish firm, gave a historic account of the gas-turbine engine and illustrated his paper with actual parts from a jet engine.

One of the most interesting papers that the Centre has yet heard was given in November by Mr. Proctor, O.B.E., Chief Regional Engineer, London Telecommunications Region. This paper was entitled "Bits of Information: an Introduction to Digital Computers." Mr. Proctor put this complex subject into everyday language so that all members felt they had some knowledge of how a computer works. The lecture was illustrated with a large number of pieces of apparatus, including cold-cathode counting tubes. Mr. Proctor was assisted by Mr. Paynter. The Centre hopes Mr. Proctor will pay it another visit during 1960.

One of our members, Mr. K. Barlow, gave a paper on "The New Coin-Box for S.T.D." at the December meeting and brought along a new coin-box as well as many other pieces of apparatus, including a tape recording of pay tone, etc.

Our lectures for the remainder of the 1959–60 session were:

January 1960: Mr. Bayley of Bristol gave a paper on "Telex."

February 1960: Mr. H. J. C. Spencer, Subscribers' Apparatus and Miscellaneous Services Branch, Engineering Department, gave an illustrated lecture on "700-Type Telephones."

March 1960: Lecture by Messrs. Little and Hix, External Plant and Protection Branch, and Telephone Exchange Standards and Maintenance Branch, Engineering Department, respectively, on "Subscribers' Line Protection and the M.D.F."

April 1960: Annual general meeting and a talk from our Telephone Manager, Mr. H. C. O. Stanbury.

A. R. B.

London Centre

It was with great satisfaction that the London Centre learned at Christmas that two of its members had received awards for papers they had read during the 1958–59 session. Mr. J. L. Garland, a Technical Officer in Long Distance Area, received his award for a paper on "The Transatlantic Telephone Semi-Automatic Switching Equipment," read before the Chatham Centre, and Mr. D. C. Greenaway, of the Telephone Exchange Standards and Maintenance Branch, Engineering Department, received his award for a paper "Mobile Artificial Traffic Equipment," read before members of the Centre.

The November lecture of the present session was also given by Mr. Garland, his subject on this occasion being "The Continental Semi-Automatic Switching Unit." His lucid lecture and the accompanying slides made an interesting subject. This paper was also read before Associate Section members of the Sheffield Centre in January 1960. The technical film show in December 1959 proved popular; it ranged from the heat of a glass-works, the Dutch film "Glass," which won an International scientific film award in 1958, to the cold of Antarctica, "Antarctic Crossing," by the Shell Film Unit. We were also indebted to Unilever, Ltd., for lending us one of the only two copies of their film "The Electronic Computer in Commerce," a fascinating introduction to computer techniques.

The penultimate lecture this session, "Overseas Telecommunications," will be given by Mr. A. P. Hawkins, who will talk about the work of the Cable and Wireless organization. For the annual general meeting at the end of May our guest speaker will be Mr. W. S. Proctor, Chief Regional Engineer, London Telecommunications Region, who will give his talk "Automatic Aids in Telephone Maintenance" at the Institution of Electrical Engineers. To supplement this talk the Telephone Exchange Standards and Maintenance Branch of the Engineering Department are kindly lending their display of latest developments, including the redesigned main distribution frame, solderless connexions and the Type 4 uniselector, among other exhibits.

The opening rounds of the inter-Area technical quiz were held before Christmas with East Area beating South-West Area by 52½ to 45½ points, and London Test Section beating Centre Area by 49½ to 41½ points. West and City Areas had byes from their respective contestants, North and Long-Distance Areas, who were unable to enter teams. It is hoped that the semi-final will have been played by Easter, enabling the final to be played during May and the quiz trophy to be presented at the annual general meeting by our President.

Following a suggestion from the Centre committee that there might be scope for an Associate Section film unit to further the objects of the Associate Section, Centre Area have decided to form the nucleus of this project. The first venture will be the filming of the cable and duct reroutings resulting from the Marble Arch road-redevelopment scheme, which takes place this year, and will be a 16 mm black-and-white film. Mr. S. Challoner (Balham A.T.E., 49 Upper Tooting Road, Tooting, S.W.17, Telephone BAL 4063), the librarian of the London Centre committee, is the chairman of the sub-committee organizing this project. He would be interested to hear of the experiences of any other Centre in this field.

The Radio group of the Centre have recently purchased a Taylor 68 A/M signal generator with a Centre loan. It will be available to the seven radio groups in the London Telecommunications Region who are contributing to its cost.

D .W .W.

Hitchin and Luton Centre

The annual general meeting of the Hitchin and Luton Centre was held at Hitchin on 28 October 1959. The meeting was well supported and the chairman's report of the year's activities was favourably received. The following officers were elected for the ensuing year: *Chairman:* Mr. L. V. Little; *Treasurer:* Mr. M. W. Hardyman; *Secretary:* Mr. E. T. Nicholls; *Committee:* Messrs. J. Addie, S. J. Watts, R. N. Alston, P. C. Shaddick, L. W. Munday and D. W. Edwards.

The draft constitution was presented by the secretary, and after discussion it was prepared in its final form. The program for the session was agreed with the final arrangements left in the hands of the secretary. The chairman's report showed that the centre had a steady increase in membership during the whole of its first year.

E. T. N.

Tunbridge Wells Centre

We are pleased to hear that Mr. C. D. Wickenden, of the Tunbridge Wells underground staff, has received one of the five awards for Associate Section papers for the session 1958–59 for his paper on "Gas Pressurization of Cables," which he read before the Centre on 29 January 1959.

At the October 1959 meeting of the Centre, Mr. Blue, of British Railways, gave a talk on "Developments of British Railways," with particular regard to the Southern Region. On 4 November 1959 Messrs. Pope and Jury, of the local external planning group, told us something of the work that is going on in connexion with the opening of the new Tunbridge Wells exchange. Three exchanges will be merged into this new exchange, namely, Tunbridge Wells Main, Tunbridge Wells Relief and Southborough, and by 1965—two years after the opening of the new exchange—it is expected that over 11,000 lines will be required.

On 18 November 1959 we visited Lancashire Dynamo (Nevelin), Ltd., at Hurst Green, Surrey, where we saw the assembling of several large control consoles and many types of switchgear. We were shown, also, the making of mercury-arc rectifiers, from the glass blowing and forming to the final testing.

Mr. Cheale gave a paper at the December 1959 meeting entitled "The A.N. Minor Works Party," and Mr. Crockett read his paper on "Metals" on 13 January 1960.

The next item on our program is a talk by Mr. Newman of the London Telecommunications Region on the television switching centre at Museum telephone exchange.

R. A. D.

Staff Changes

Promotions

Name	Region, etc.	Date
Deputy Engineer-in-Chief to Engineer-in-Chief		
Mumford, A. H.	E.-in-C.O.	1.2.60
Assistant Engineer-in-Chief to Deputy Engineer-in-Chief		
Barron, D. A.	E.-in-C.O.	1.2.60
Booth, Capt. C. F.	E.-in-C.O.	1.2.60
Chief Motor Transport Officer to Assistant Engineer-in-Chief		
Calveley, C. E.	E.-in-C.O.	1.2.60
Executive Engineer to Senior Executive Engineer		
Yeo, B. F.	E.-in-C.O.	18.11.59
Executive Engineer (Open Competition)		
Claydon, D. J.	E.-in-C.O.	11.1.60
Assistant Engineer to Executive Engineer		
Janes, A. L.	H.C. Reg.	23.10.59
Newman, J. I.	S.W. Reg.	23.10.59
Cox, D. S.	E.-in-C.O.	23.11.59
Roach, J. D.	W.B.C.	17.11.59
Elkins, A. H.	E.-in-C.O.	18.12.59
Jeffery, N. E.	E.-in-C.O.	18.12.59
Lumber, A. L.	E.-in-C.O.	18.12.59
Roberts, M. E.	E.-in-C.O.	31.12.59
Day, H. B.	E.-in-C.O.	1.1.60
Jefferys, J. G.	E.-in-C.O.	29.1.60
Assistant Engineer (Open Competition)		
Adams, A. R.	E.-in-C.O.	11.1.60
Watson, R. J.	E.-in-C.O.	11.1.60
Mullins, B.	W.B.C.	7.9.59
Inspector to Assistant Engineer		
Stone, C. W.	L.T. Reg.	12.11.59
Buck, W. G.	L.T. Reg.	6.11.59
Bower, F.	E.T.E.	30.10.59
Waldron-Kelly, H. C.	N.W. Reg.	22.10.59
McIntosh, D. T.	Scot.	7.12.59
Taylor, F. J. R.	L.T. Reg.	21.12.59
Truman, A. C.	H.C. Reg.	20.11.59
Palmer, C. J.	L.T. Reg.	30.1.60
Technical Officer to Assistant Engineer		
Outhwaite, S. O.	N.E. Reg.	22.9.59
Andrews, T. G. G.	N.W. Reg.	1.10.59
Boughey, C. J.	E.-in-C.O.	23.11.59
Livinstove, D. V.	Scot. to E.-in-C.O.	23.11.59
Stalker, R. J. C.	N.E. Reg.	16.11.59
Gardener, W. D.	S.W. Reg.	4.11.59
Metz, A. R.	L.T. Reg.	6.11.59
Glover, T. F.	L.T. Reg.	6.11.59
Care, J. L.	L.T. Reg.	6.11.59
Simmons, D. P.	L.T. Reg.	6.11.59
Hair, J. A.	S.W. Reg.	4.11.59
Wiper, H.	N.W. Reg.	19.10.59
Whittaker, R. D.	N.W. Reg.	19.10.59
Storey, J.	N.W. Reg.	16.11.59
Christie, W. C.	Scot.	30.11.59
Wright, F. E.	H.C. Reg.	17.12.59
Short, G. V.	H.C. Reg.	17.12.59
Wait, C. H.	H.C. Reg.	17.12.59
Stammers, R. J.	H.C. Reg.	11.1.60
Luke, A. E.	H.C. Reg.	17.12.59
Rice, W. S.	E.T.E.	21.12.59
Hall, E. R.	E.T.E.	21.12.59
Struthers, J.	Scot.	12.12.59
Brown, R. T.	Scot.	14.12.59
Jones, A.	E.-in-C.O.	31.12.59
Gauntlett, D.	L.T. Reg.	11.1.60
Douglas, H. J.	L.T. Reg.	21.12.59
Davies, L. A.	L.T. Reg.	21.12.59
Irish, L. W.	L.T. Reg.	21.12.59
Doherty, A.	N.E. Reg.	23.12.59
Curran, W.	N.W. Reg.	4.12.59
Goodrick, A. L.	N.W. Reg.	21.12.59
Stammers, R. J.	H.C. Reg.	11.1.60

Name	Region, etc.	Date
Technical Officer to Assistant Engineer—continued		
Whiteside, L. B.	H.C. Reg.	12.11.59
Ashman, D. E. C.	H.C. Reg.	19.11.59
Broom, L. G. C.	Mid. Reg.	13.1.60
Rogers, J. O.	E.T.E.	13.1.60
Wood, F. W.	E.-in-C.O.	11.1.60
Lake, A. G.	S.W. Reg.	4.1.60
Murphy, R. J.	S.W. Reg.	22.1.60
Middleton, J. L.	N.W. Reg.	11.1.60
Draughtsman to Assistant Engineer		
Mitchell, H. L.	L.T. Reg.	6.11.59
Gore, T. L.	L.T. Reg.	6.11.59
Technical Officer to Inspector		
Edmunds, A. H.	L.T. Reg.	6.11.59
Nokes, F. T.	L.T. Reg.	6.11.59
Olley, S. A.	L.T. Reg.	1.1.60
Hocking, J. L.	L.T. Reg.	1.1.60
Moody, J. J.	L.T. Reg.	1.1.60
Raison, W. G. W.	L.T. Reg.	30.12.59
Lowry, G.	Scot.	8.1.60
Spearing, W. W.	Scot.	25.1.60
Shearer, J. M.	Scot.	11.1.60
Technician I to Inspector		
Williams, J. D.	W.B.C.	8.12.59
Bennett, W.	L.T. Reg.	23.11.59
Smith, W. H. F.	E.T.E.	23.11.59
Hislop, G. D.	S.W. Reg.	14.12.59
Chapman, R. E.	W.B.C.	14.12.59
Parfitt, W.	W.B.C.	10.12.59
Haslehurst, H. J.	N.E. Reg.	23.12.59
Williams, T. D.	W.B.C.	4.1.60
Rogers, H.	W.B.C.	1.1.60
Gaudion, T. L.	W.B.C.	11.1.60
Mullinex, H. J.	W.B.C.	11.1.60
Smith, H. I.	N.E. Reg.	11.1.60
Magrath, F. M. C.	L.T. Reg.	1.1.60
Fielding, H. E.	N.W. Reg.	19.1.60
Hoyle, D.	N.W. Reg.	19.1.60
Carr, G. R.	N.W. Reg.	19.1.60
Hall, A.	N.W. Reg.	19.1.60
Senior Experimental Officer to Chief Experimental Officer		
Bowcott, H. J.	E.-in-C.O.	23.12.59
Taylor, P. E.	E.-in-C.O.	23.12.59
Senior Scientific Officer (Open Competition)		
Champion, J. A.	E.-in-C.O.	1.12.59
Scarbrough, R. J. D.	E.-in-C.O.	31.12.59
Experimental Officer (Open Competition)		
Fiddyment, D. G.	E.-in-C.O.	23.11.59
Scientific Officer (Open Competition)		
Meadows, R. G.	E.-in-C.O.	24.11.59
Assistant Experimental Officer (Open Competition)		
Cross, A. C.	E.-in-C.O.	30.10.59
Haggett, M. E.	E.-in-C.O.	9.11.59
Royle, R. J.	E.-in-C.O.	31.12.59
Assistant (Scientific) (Open Competition)		
Philpotts, C. A. (Miss)	E.-in-C.O.	27.1.60
Technical Assistant II to Technical Assistant I		
Hide, M. G.	E.-in-C.O.	10.12.59
Smith, P. F.	London Reg. to E.-in-C.O.	10.12.59
Yaxley, A. E.	H.C. Reg.	10.12.59
Potts, A.	N.E. Reg. to E.-in-C.O.	10.12.59
Miles, S. B.	N.E. Reg. to E.-in-C.O.	10.12.59
Shipway, A. R.	H.C. Reg.	10.12.59
Pickles, A.	E.-in-C.O.	10.12.59

Promotions—*continued*

Name	Region, etc.	Date	Name	Region, etc.	Date
Workshop Supervisor I to Technical Assistant II			*Workshop Supervisor II to Technical Assistant II—continued*		
Parker, H. K. A.	S.W. Reg. to E.-in-C.O.	10.12.59	Bryce, R.	N.E. Reg.	10.12.59
Beveridge, S. R.	Scot. to London Reg.	10.12.59	Clench, E. A.	E.-in-C.O.	6.1.60
Wood, G. H.	Mid. Reg. to N.E. Reg.	10.12.59			
Workshop Supervisor II to Technical Assistant II			*Draughtsman to Leading Draughtsman*		
Raymond, G. H.	H.C. Reg. to N.I.	10.12.59	Lewis, G. W. F.	L.T. Reg.	16.10.59
Harris, R. J.	H.C. Reg. to E.-in-C.O.	10.12.59			

Retirements and Resignations

Name	Region, etc.	Date
Engineer-in-Chief		
Harris, Brig. Sir L.	E.-in-C.O.	31.1.60
Senior Executive Engineer		
Young, J. S.	E.-in-C.O.	31.12.59
Marshall, W. J.	E.-in-C.O.	31.12.59
Prichard, F. E.	N.E. Reg.	1.6.59
Executive Engineer		
Hardy, J.	Mid. Reg.	29.9.59
Arthur, R.	Scot.	30.11.59
Ditchfield, J. A.	N.W. Reg.	11.11.59
Rayns, F. H.	E.-in-C.O.	7.12.59
Saunders, C. T.	E.-in-C.O.	31.12.59
Woodley, E. T. M.	S.W. Reg.	18.12.59
Steedman, C. A.	S.W. Reg.	31.12.59
Chapman, C. W.	H.C. Reg.	1.1.60
Nicholls, P. A.	E.-in-C.O.	1.1.60
Assistant Engineer		
Peterson, G. H.	N.W. Reg.	30.9.59
Sutcliffe, E.	N.W. Reg.	11.10.59
Johnson, F.	N.W. Reg.	16.10.59
Linney, J.	N.W. Reg.	17.10.59
Hilsden, H. E.	L.T. Reg.	11.11.59
Hingley, H.	E.-in-C.O.	27.11.59
Atherton, W.	N.W. Reg.	9.12.59
Cumming, W.	Scot.	12.12.59
Hoare, J. H.	S.W. Reg.	14.12.59
Everson, W. E.	H.C. Reg.	18.12.59
Trew, H. W.	L.T. Reg.	18.12.59
Grimston, W. T.	L.T. Reg.	21.12.59
Smiddy, F. L.	N.E. Reg.	31.12.59
Hagon, W. R.	E.T.E.	31.12.59
Ganderton, W. G.	Mid. Reg.	31.12.59
Joannou, A. (*Resigned*)	E.-in-C.O.	31.12.59
Loveday, R. C. H. (*Resigned*)	E.-in-C.O.	31.12.59
Price, R. J. (*Resigned*)	E.-in-C.O.	8.1.60
Thompson, G.	N.W. Reg.	31.12.59
Rothwell, A.	N.W. Reg.	31.12.59
Graham, H. E.	H.C. Reg.	31.12.59
Assistant Engineer—continued		
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Billman, B. C.	H.C. Reg.	29.1.60
Hobley, H. F. G.	L.T. Reg.	29.1.60
Price, R. J. (*Resigned*)	E.-in-C.O.	8.1.60
Inspector		
Culshaw, T. J.	N.W. Reg.	31.10.59
Brown, W. T.	L.T. Reg.	22.1.59
Gomm, F. J.	S.W. Reg.	7.11.59
Woods, D. T.	S.W. Reg.	12.11.59
Evans, A. E. W.	W.B.C.	15.11.59
Denman, J. H.	N.W. Reg.	27.11.59
McQuarrie, J. J.	Scot.	28.11.59
Frost, F. W.	L.T. Reg.	30.11.59
Hall, A. R.	H.C. Reg.	30.11.59
Pickford, F. W.	W.B.C.	7.12.59
Wormald, A. R.	N.E. Reg.	13.12.59
Osman, A. S.	S.W. Reg.	15.12.59
Ward, A. B.	L.T. Reg.	15.12.59
Eadie, S. T.	N.W. Reg.	15.12.59
May, G.	S.W. Reg.	20.12.59
Frater, L. S.	N.E. Reg.	31.12.59
Preston, J. J. P.	W.B.C.	31.12.59
Williams, R. S.	W.B.C.	8.1.60
Brunton, N.	N.E. Reg.	14.1.60
Scientific Officer		
Brook, V. S. (Miss) (*Resigned*)	E.-in-C.O.	5.11.59
Assistant Experimental Officer		
Davis, P. (*Resigned*)	E.-in-C.O.	20.11.59
Assistant (Scientific)		
James, P. M. (Miss) (*Resigned*)	E.-in-C.O.	4.12.59

Transfers

Name	Region, etc.	Date
Area Engineer		
Dolan, W. H.	W.B.C. to Malaya	19.10.59
Executive Engineer		
Rimmer, E. G.	E.-in-C.O. to N.W. Reg.	9.11.59
Partridge, J. G	Cyprus to E.-in-C.O.	30.11.59
Neill, T. B. M.	Approved Employment to E.-in-C.O.	14.12.59
Executive Engineer—continued		
Ephgrave, E. V.	E.-in-C.O. to Min. of Supply	16.11.59
Lang W. N.	Scot. to Malaya	1.9.59
Assistant Engineer		
Sheldon, W.	E.-in-C.O. to Scot.	14.12.59
Feldon, B. R.	E.-in-C.O. to H.C. Reg.	4.1.60
Mullins, B.	W.B.C. to E.-in-C.O.	4.1.60

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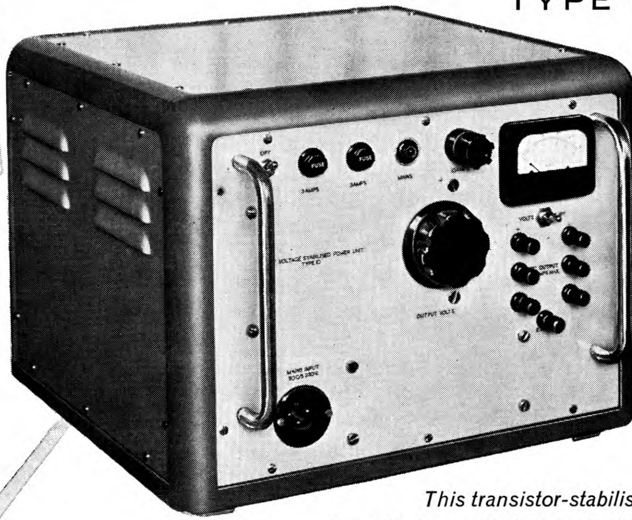

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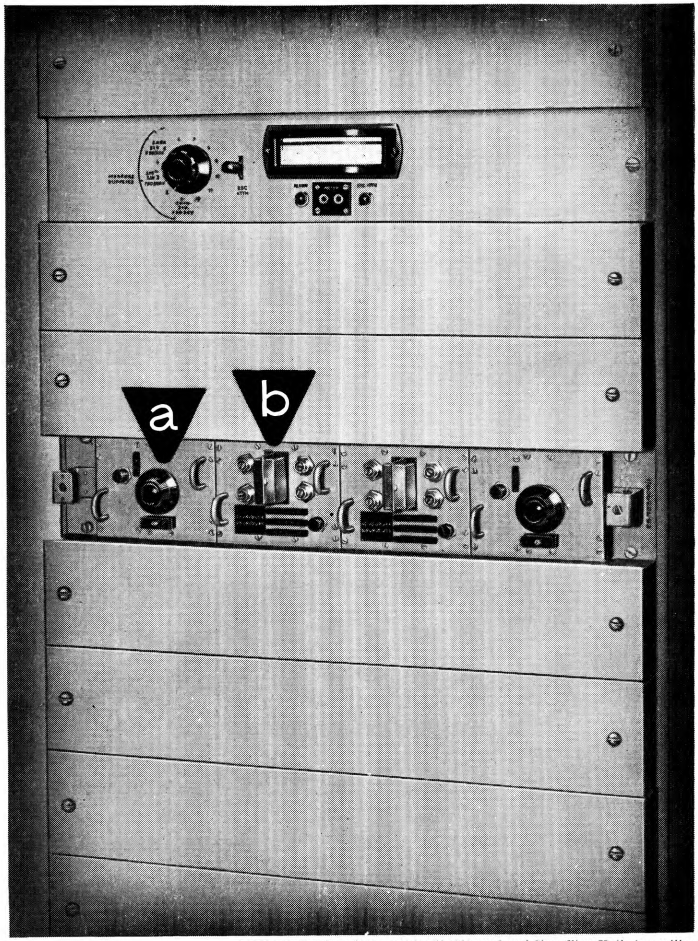

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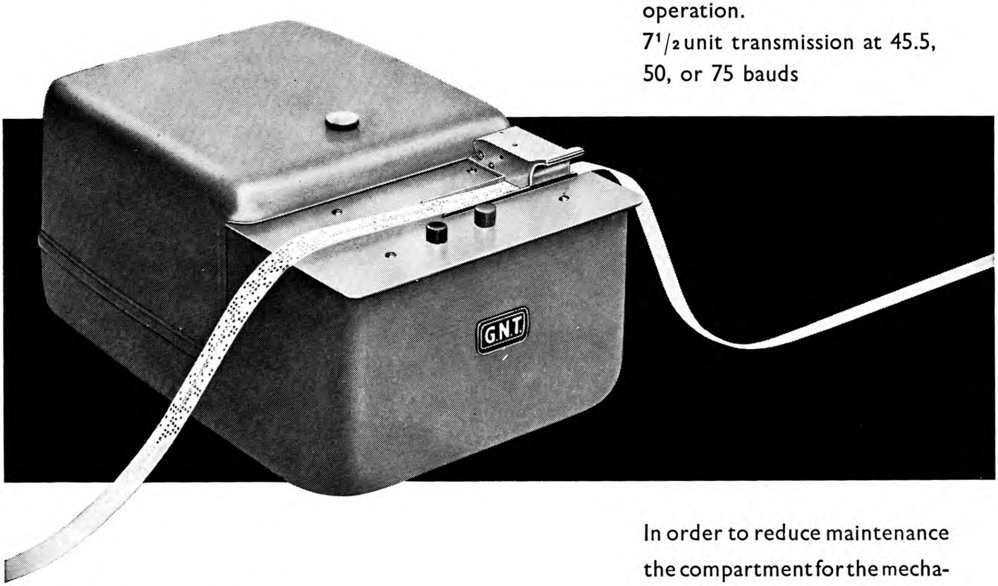

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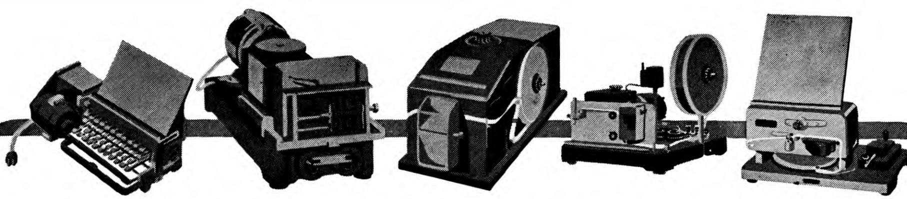

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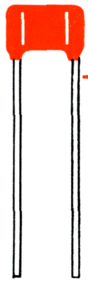

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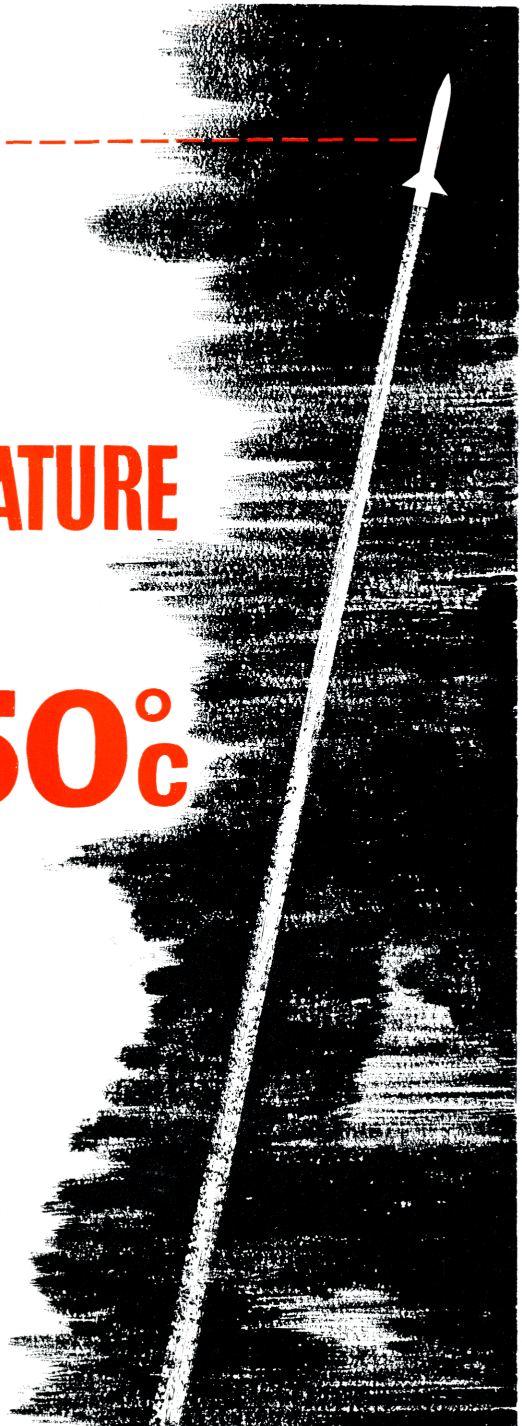

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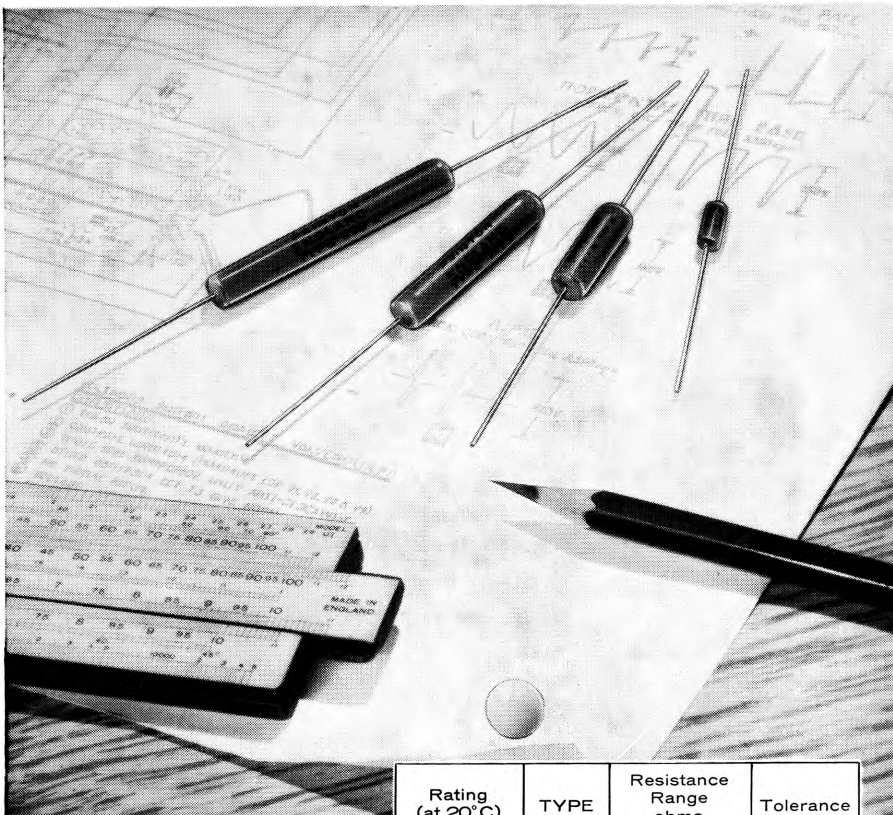

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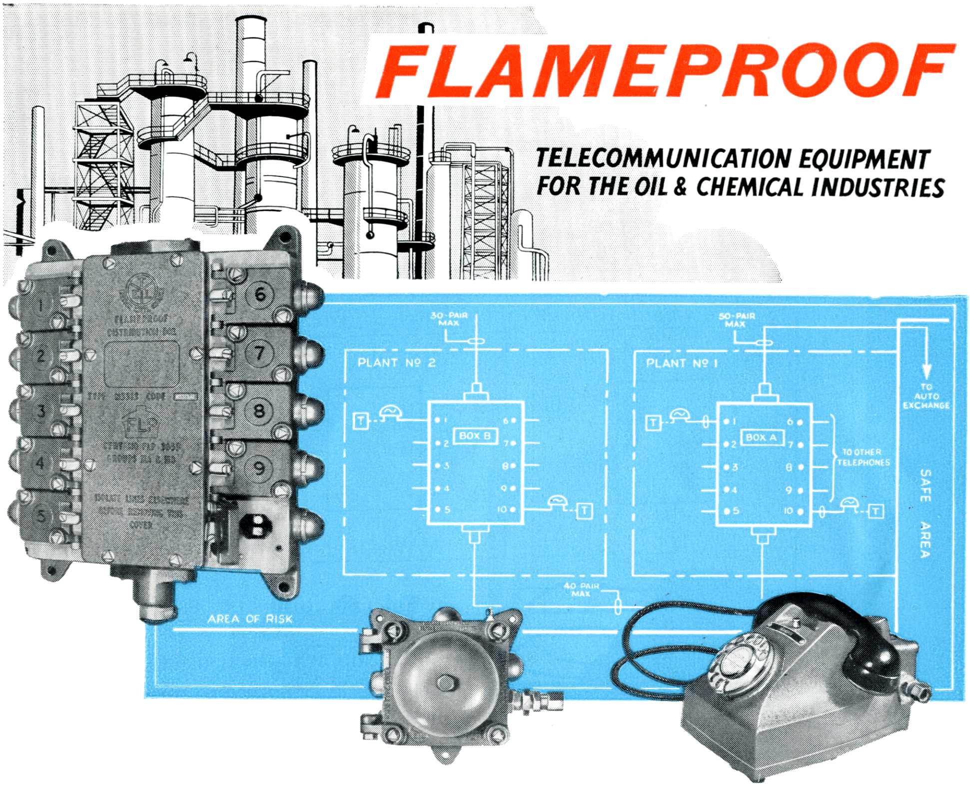

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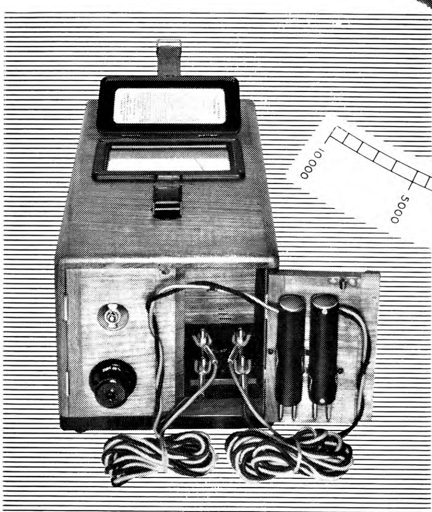

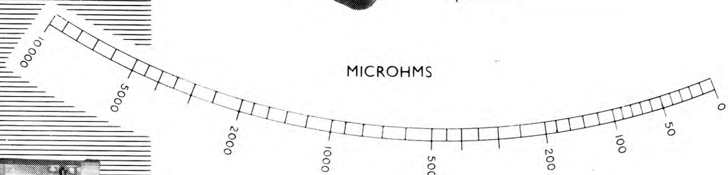

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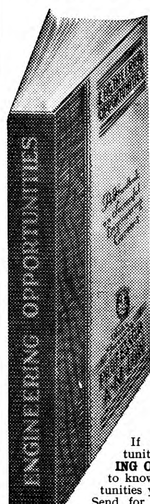

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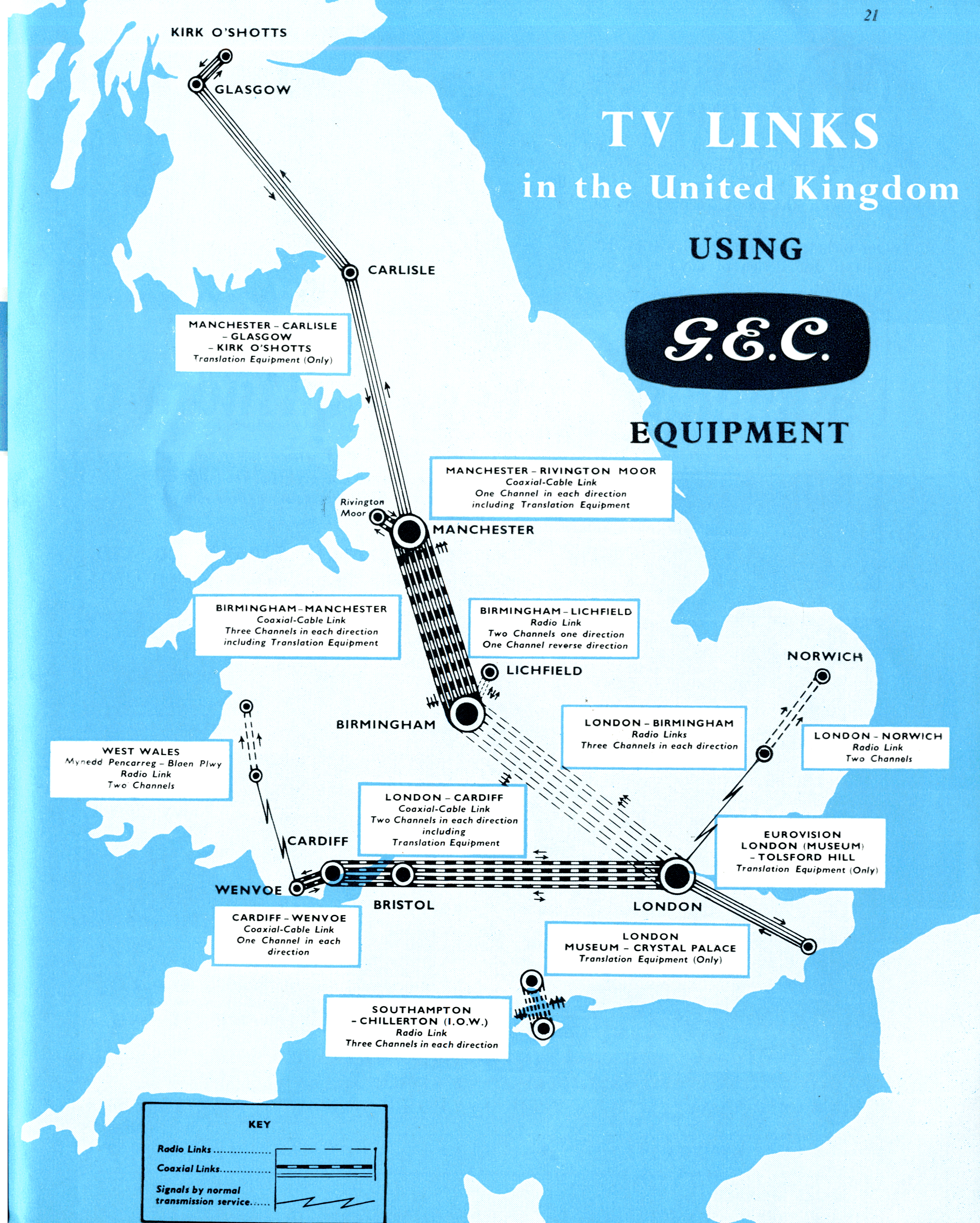

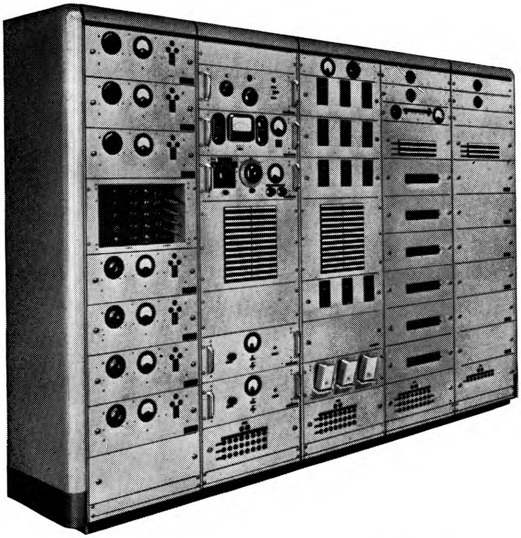

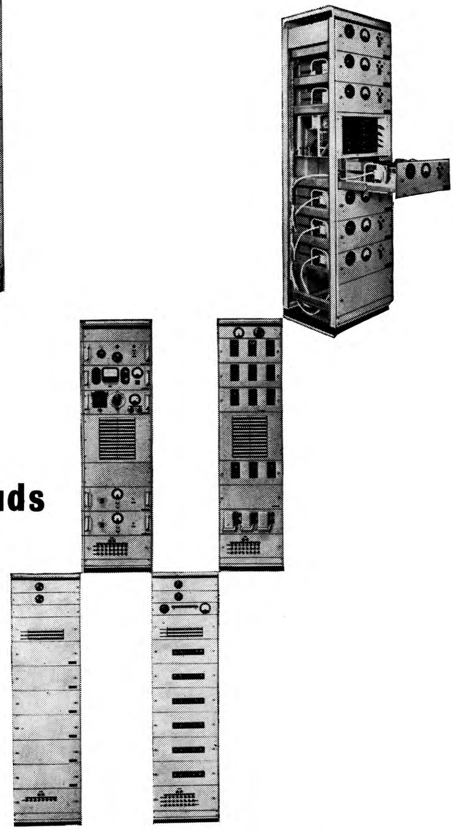

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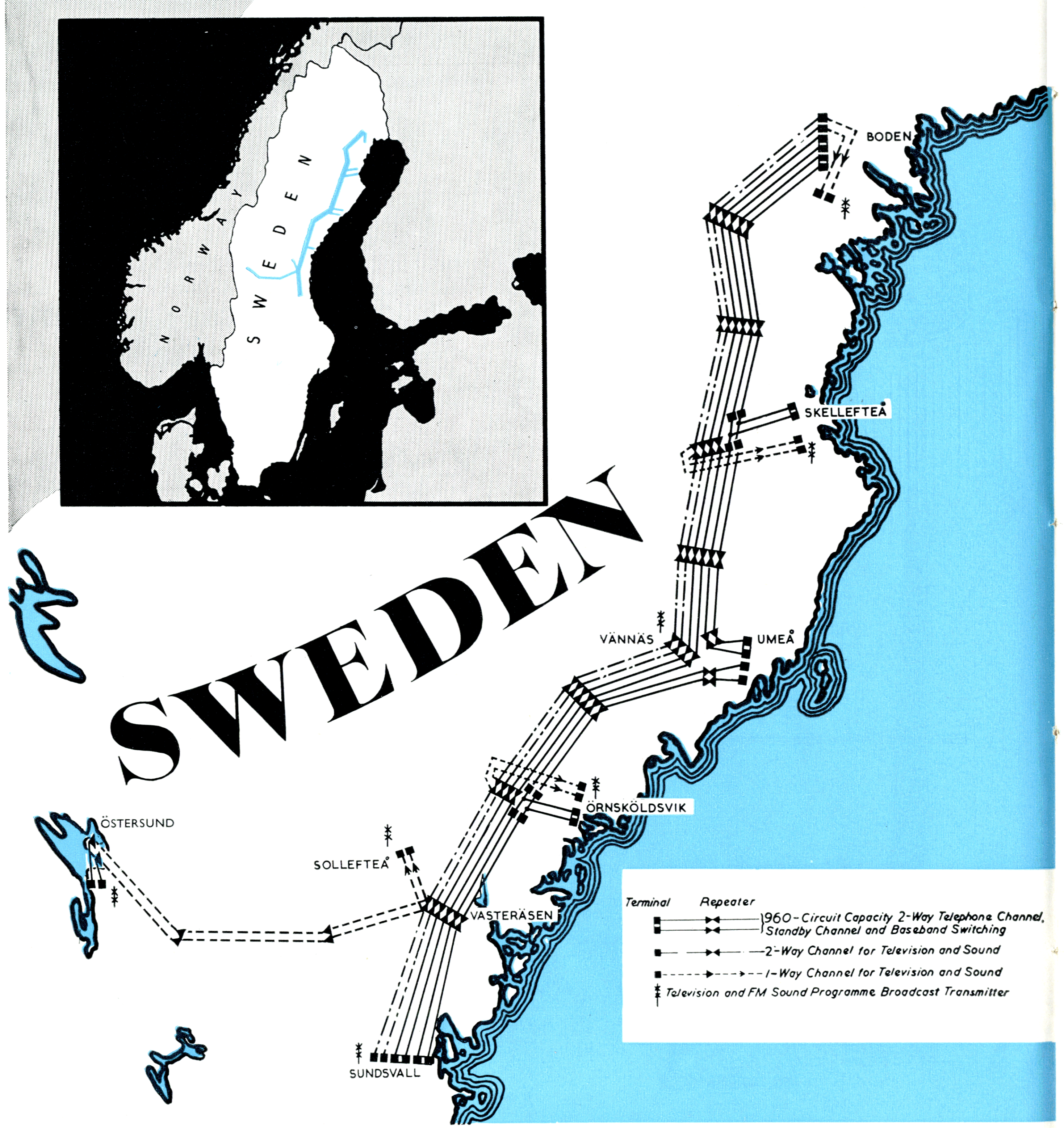

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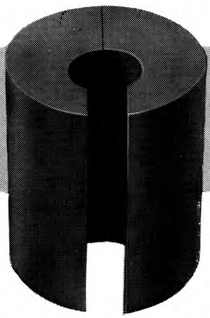

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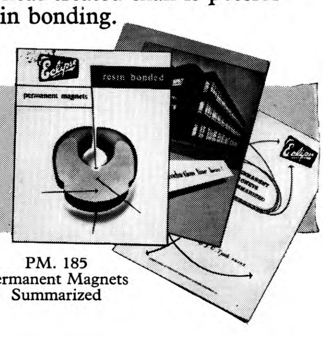

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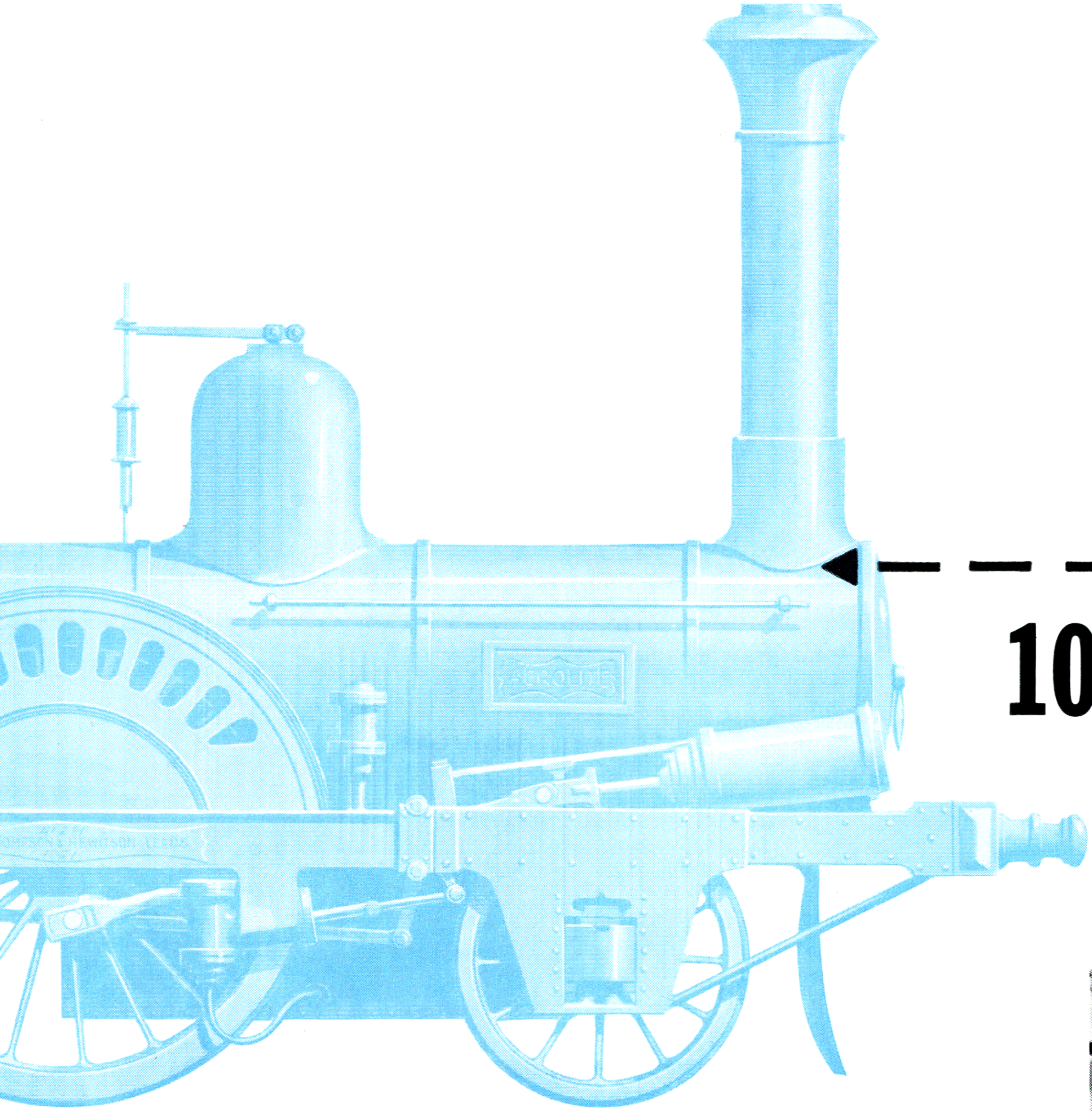

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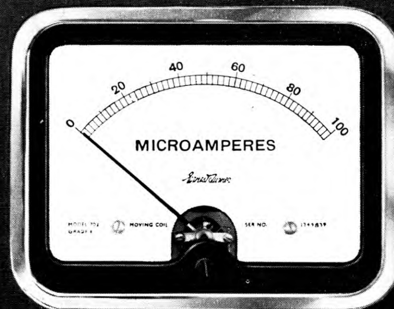

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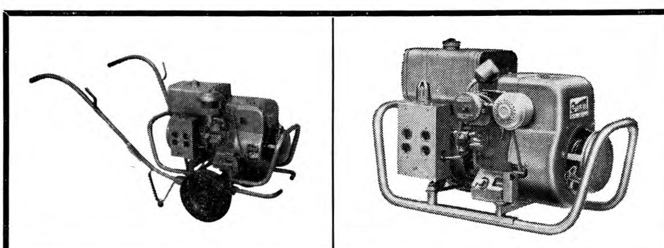

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