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THE Post Office Electrical Engineers' Journal

START-STOP PRINTING TELEGRAPH SYSTEMS.

(*Continued.*)

A. E. STONE, A.R.C.Sc.

(III.). THE TELEPRINTER NO. 3A.

THE generic name of "Teleprinter" has now been allotted to all types of start-stop telegraph apparatus. The Morkrum Teletypes No. 1A and No. 2A, described in previous issues of this Journal, are now designated Teleprinters No. 1A and No. 2A respectively, while the title Teleprinter No. 3A has been given to a start-stop instrument, designed by Messrs. Creed and Co., the use of which is being greatly extended by the Department.

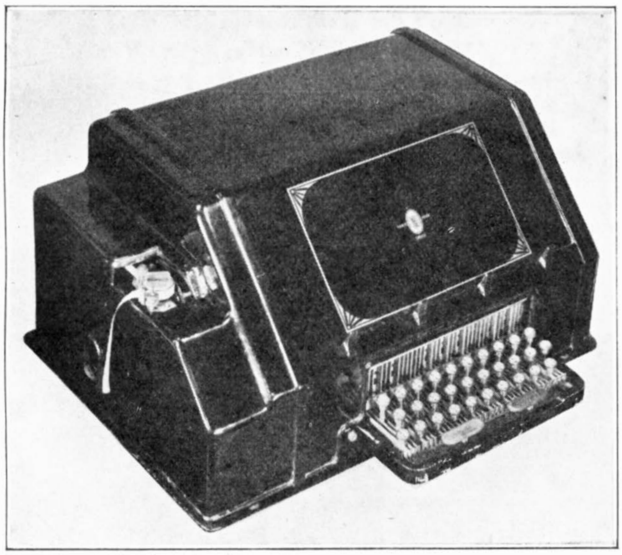


FIG. 1.—TELEPRINTER NO. 3A.

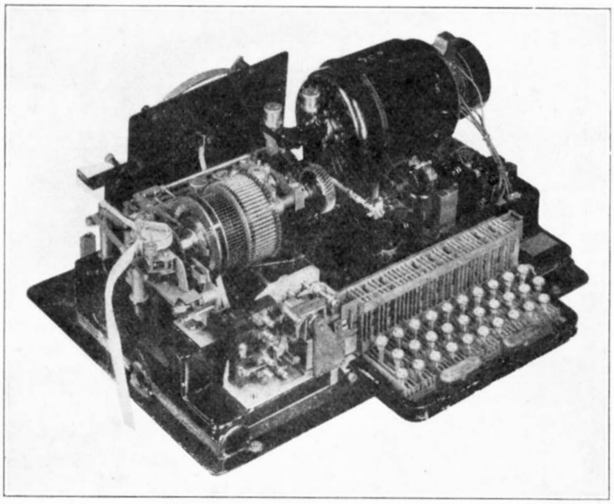


FIG. 2.—TELEPRINTER NO. 3A WITH COVER REMOVED.

Fig. 1 is a general view of the Teleprinter No. 3A, and Fig. 2 shows the arrangement of the mechanism. It consists of a typewriter keyboard transmitter and a tape-printing receiver, independently driven by a single shunt-wound motor of 1/12th H.P., but mounted on the same base. The motor runs continuously, but the transmitting and receiving mechanisms are at rest when signals are not being transmitted over the circuit. The operating speed is 60 words per minute.

SIGNALLING CODE

LTRS	FIGS	UNITS 1	2	3	4	5	LTRS	FIGS	UNITS 1	2	3	4	5
A	:	●	●	○	○	○	Q	1	●	●	●	○	●
B	?	●	○	○	●	●	R	4	○	●	○	●	○
C	(	○	●	●	●	○	S	'	●	○	●	○	○
D	2	●	○	○	●	○	T	5	○	○	○	○	●
E	3	●	○	○	○	○	U	7	●	●	●	○	○
F	1/	●	○	●	●	○	V	)	○	●	●	●	●
G	3/	○	●	○	●	●	W	2	●	●	○	○	●
H	5/	○	○	●	○	●	X	£	●	○	●	●	●
I	8	○	●	●	○	○	Y	6	●	○	●	○	●
J	7/	●	●	○	●	○	Z	.	●	○	○	○	●
K	9/	●	●	●	●	○	/	/	○	●	○	○	○
L		○	●	○	○	●	✳	✳	●	●	●	●	●
M	'	○	○	●	●	●	–	=	○	○	○	●	○
N	–	○	○	●	●	○		+	○	●	○	○	●
O	9	○	○	○	●	●	LETTER SPACE		○	○	●	○	○
P	0	○	●	●	○	●	FIGURE SPACE		●	●	○	●	●

SHADED CIRCLES DENOTE MARKING SIGNALS.

FIG. 3.

Fig. **3** shows the arrangement of the five-unit code used, and it will be seen that, apart from a few secondary characters, it is the same as for the Morkrum instruments. The start signal, however, which precedes a character combination, is a marking impulse and the stop signal a spacing impulse, *i.e.*, just the opposite to the Morkrum apparatus with which the start and stop signals are *spacing* and *marking* impulses respectively.

Transmitter Clutch Trip Mechanism.—A cam sleeve, which is at rest normally, controls all the mechanical operations of the Transmitter. When any key lever of the keyboard is depressed, a motor-driven spindle causes the cam sleeve to make one revolution and then stop. This is effected as follows:—

Referring to Fig. **4**, RW is a Ratchet Wheel driven continuously by the motor in the direction shown. Pivoted on the Cam Sleeve, which surrounds RW, are two Pawls P. The Pawl Abutment PA holds these pawls, normally, in such a position that their hooked ends do not engage with the teeth of RW.

On depressing a Key Lever, the Trip Bar TB moves downwards, causing the upper end of TL to move the Cam Trip Lever CTL to the right. The latter engages with the lower end of PA, thereby lifting the upper extremity away from the Pawls. Immediately this occurs, the Pawl Spring PS, encircling the Cam Sleeve, forces the hooked ends of the Pawls into engagement with RW and the Cam Sleeve with its various Cams commences to rotate. One of the Cams, C, as it rotates, pushes CTL down until it disengages from the forked end of PA; the latter is then restored to its original position by the Spring S1, so that its upper end is in position to intercept the pawls, withdraw them from RW and thus stop the Cam Sleeve at the end of one revolution.

Keyboard Locking Arrangement.—In order to ensure that the proper sequence of impulses shall be sent when a key lever is operated it is necessary (*a*) to prevent another key from being operated when one key is already depressed, and (*b*) to prevent a depressed key from rising until the signal combination has been transmitted.

For this purpose two Locking Bars, LB1 and LB2, are provided as shown in Fig. **4**. LB2 is pivoted at Y and normally its front edge is just clear of the extremities E of the key levers. When a key lever is depressed, the Trip Bar TB turns about its pivot X, and the lower end of *m*, which is attached to X, moves downwards. Spring S4 then pulls the end of *n*, which is fixed to the pivot Y, downwards, thus causing LB2 to move forward under the extremities of all the remaining key levers, in which position it prevents them from being depressed. As soon as the key lever is released, TB will rise under the action of Spring S3, and LB2 will be restored to its original position by the action of the upper end of *m* on *n*. The Locking Bar LB1 is controlled by the Reset Lever RL. Immediately the Cam Sleeve starts to rotate, Cam C, which controls RL, allows LB1 to move to the right under the action of Spring S6 and one of its projections *h* enters a hole in the depressed key lever, holding it down until the Cam Sleeve has completed a revolution and Cam C has restored LB1 to its original position.

Transmitting Mechanism.—Underneath the Key Levers and at right angles to them are the Locking Bar LB1 and the five Combination Bars

CB1 to CB5, as shown in Fig. **5**. The upper edges of the latter have a series of projections arranged according to the signalling code and normally the bars are held to the left against the tensions of the Springs S, by the lower end of the Reset Lever RL, so that the projections do not come directly under the key levers. A key lever when depressed can therefore enter a set of notches between the projection of the Combination Bars. This is shown in Fig. **5** (Plan) where the black parts of the Combination Bars denote projections. The projections correspond to spacing units of the code, and the code for any particular key lever may be ascertained from the projections immediately to the left of it. Thus for A, the code is 1, 2, marking, and 3, 4, 5, spacing; and for Q, 1, 2, 3, 5, marking, and 4 spacing.

Each Combination Bar has a vertical extension E and associated with it is a Selecting Lever L, which is constrained by spring S7 to ride on the surface of a Cam on the Cam sleeve. There are five Selecting Levers, L1 to L5, and five Cams, C1 to C5, corresponding to the five Combination Bars. In addition there is a sixth Selecting Lever L6 operated by a sixth Cam C6, but there is no Combination Bar associated with L6. The function of L6 is to send the " Start " impulse. The lower ends of all the Selecting Levers bear against the upper part of the Actuating Lever AL, the forked end of which embraces the insulated end of the Transmitting Tongue TT. The latter plays between the contacts S and M, which are connected to the line battery, and normally it rests against S. (See also Fig. **6**).

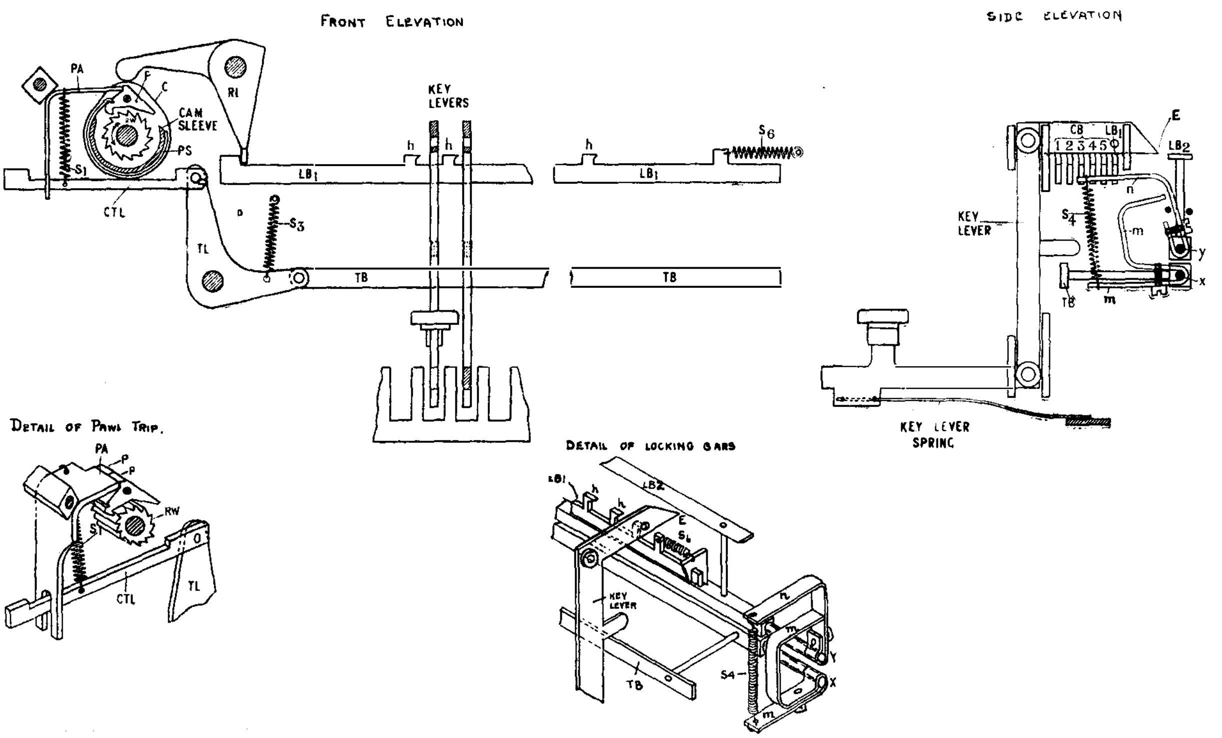


FIG. **4**.

The action of the Transmitter may be best explained by considering the following sequence of events occurring during the transmission of the letter Y, say, the code for which is 1, 3, 5, marking, and 2, 4, spacing:—

(*a*) When Key Lever Y is depressed it enters the notches in the Combination Bars, operates the Trip Bar which releases the Cam Pawls P (Fig. **4**), and the Cam Sleeve starts to rotate.

(*b*) Cam C (Figs. **4** and **5**) allows RL to release the Combination Bars, and also LB1 which when it moves to the right locks the key lever Y. Of the Combination Bars, only 1, 3 and 5 are pulled to the right by their springs; CB2 and CB4 are held in their normal positions because the projections on them butt against the depressed key lever. Accordingly extensions E1, E3 and E5 will move from under the ends of L1, L3 and L5, but E2 and E4 will remain under the ends of L2 and L4.

duration of which is fixed by the length of the indent in C6.

(*d*) Just as L6 is about to be restored to normal by C6, L1 falls into the indent in Cam C1, because it is free to do so, as E1 has moved to the right. Consequently TT will remain on the "Marking" Contact. Immediately L1 rides out of the indent in C1, L2 tends to drop into the indent in C2 but is prevented from so doing by E2, which is in its normal position directly under

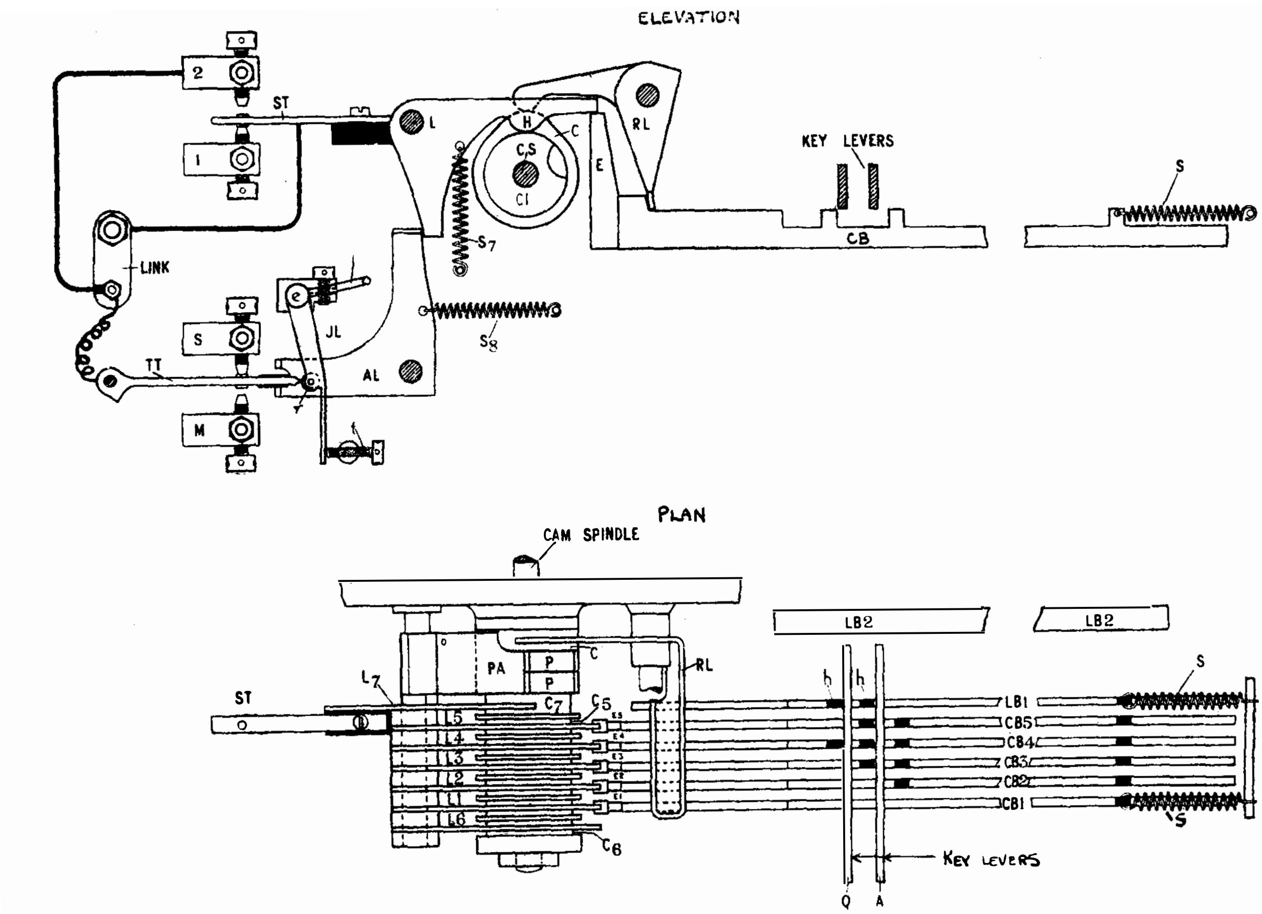


FIG. 5.

(*c*) As the Cam Sleeve rotates, the projection H on L6 will drop into the indent in Cam C6. The lower end of L6 will therefore move to the left, causing AL to turn anti-clockwise so that the upper part of its forked end will move TT to the "Marking" Contact M. This gives the "Start" impulse, the

the end of L2. As a result, since L1 is now restored to its normal position, Spring S8 will cause AL to move clockwise and its forked end will move TT to the "Spacing" Contact S. Similarly, Cams C3, C4 and C5 will, in turn, cause AL to move TT to M, S and M respectively.

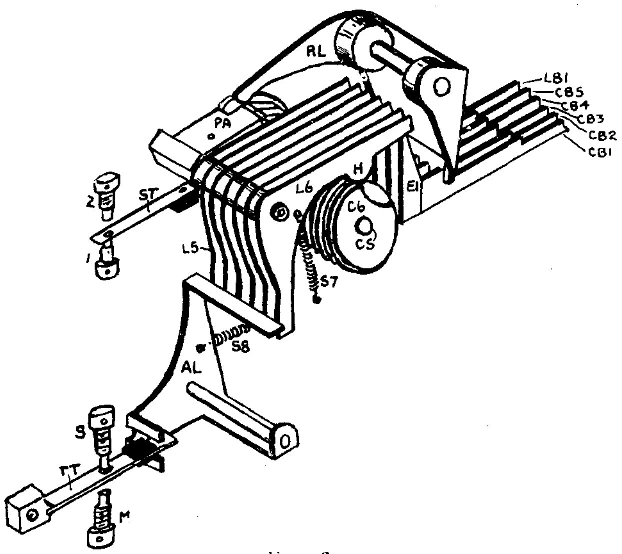


FIG. 6.

(*e*) When L_5 rides out of the indent in C_5, TT moves to " Spacing," and shortly afterwards Cam C operates RL, restoring LB_1 which releases the key lever, and moving those Combination Bars that were pulled to the right, back to their normal positions.

(*f*) Finally the Clutch is disengaged and the Cam Sleeve comes to rest after making one revolution.

A Jockey Roller *r* mounted on the Lever JL, exerts sufficient pressure on the end of the Transmitting Tongue to give it a quick decisive movement from one contact to the other. The indents in the six transmitting Cams C6 and C_1 to C_5 are staggered to ensure that signals are sent out successively.

Printer Clutch Trip Mechanism.—The incoming signals from the distant station operate a Creed polarised relay mounted on the base of the instrument. This relay controls a " mechanical relay " which operates the Selecting and Printing mechanisms.

Referring to Fig. **7**, the motor spindle drives the disc *d*, the gear wheels W_1, W_2 and the Ratchet Wheel RW, which is fixed on the spindle of W_1, continuously. Mounted freely on the motor spindle is an Eccentric *e* carrying the Detent D. The friction between D and *d* is such that D, if unobstructed, would rotate with *d*; it is held in one of two positions, however, by the projections X and Y of the pivoted lever L which is controlled by the link attached to the relay armature. The arrangement is, in effect, an escapement and allows D to rotate half a revolution each time the relay armature moves from S to M or from M to S. The eccentric *e* turns with D and as it is embraced by the end of the rod H, it moves the latter first in one direction and then in the other as D completes the two halves of one revolution. Associated with the Ratchet Wheel RW is a Cam Sleeve upon which are pivoted two Pawls P as in the case of the Transmitter. These Pawls do not engage with the teeth of RW, normally and the Cam Sleeve is then stationary.

The first impulse received on the Creed Relay, being the " Start " signal, moves the relay armature to " marking " and the top of L will be moved to the left allowing D to rotate for half a revolution until it is stopped by the projection Y. This causes rod H to move to the right, turning the Trip Shaft TS, withdrawing the Trip Link TL and Pawl Abutment PA, so that the Pawls P can be forced, by the Pawl Spring, into engagement with RW. The Cam Sleeve accordingly starts to rotate. The final impulse in any character combination being the " Stop " signal moves the relay armature to " spacing " thus displacing L to the right and allowing D to rotate for half a revolution to the position shown in Fig. **7**, when it is stopped by the projection X which has been moved into its path

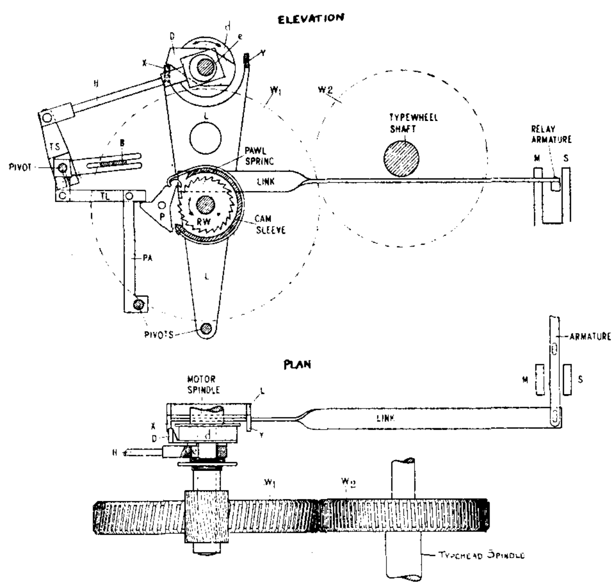


FIG. 7.

by L. Rod H is thus moved to the left and acting through TS and TL moves PA into such a position that the Pawls P are tripped out of engagement with RW at the end of one revolution of the Cam Sleeve which then comes to rest.

The Trip Shaft also controls the position of the Striker Blade B, the function of which will be described later. B is in the position shown when the relay armature is to " Spacing," and is tilted downwards when the armature moves to " Marking."

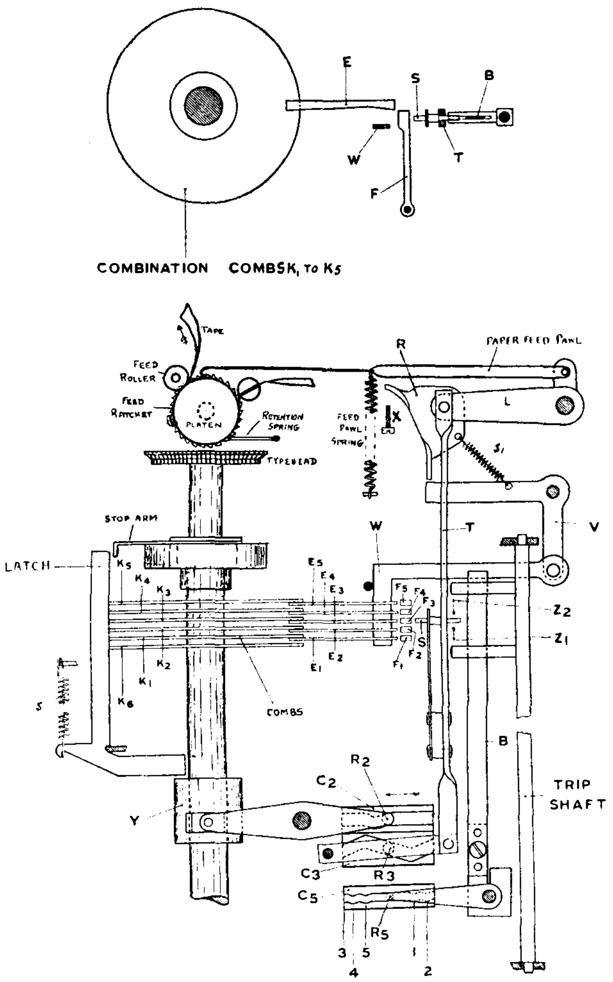


Fig. 8.

Selecting Mechanism.—In Fig. 8 K_1 to K_5 are five circular Combs each of which has a horizontal extension arm E. Directly in front of the extension arms are five Selecting Fingers F_1 to F_5. The Combs are mounted side by side on a drum and each can turn slightly if its extension be pushed upwards by the corresponding Selecting Finger. Opposite the Selecting Fingers is the Striker Pin S which is carried by the Traversing Link T.

The whole of the operations of the Printer are performed by five cams mounted on the Cam Sleeve. Three of these cams are shown in development in Fig. 8 and their functions are as follows :—

C_2 operates the Sliding Sleeve Y for a purpose to be described later.

C_3 controls the motion of the Traversing Link T, which carries the Striker Pin S backwards and forwards across the front of the Selecting Fingers.

C_5, which has five indents in its track, causes the free end of the Striker Blade B to make successive movements towards the Pin S. These five indents are positioned relatvely to the track of C_3 that the forward movements of B take place at such times as S is successively opposite each of the Fingers F_1 to F_5.

The normal positions of the three cam rollers R_2, R_3 and R_5 on the cam tracks are as shown and the Pin S is opposite F_3. The Cams move in the direction of the arrow. As already explained, the receipt of the " Start " signal sets the Cam Sleeve in rotation and C_3 acting on roller R_3 causes T to move in the direction of arrow Z_1 so as to bring Pin S opposite F_1 just as roller R_5 moves into the first indent in C_5. The free end of B will accordingly move towards S and will strike it, if the first impulse following the " Start " signal is a marking unit, but will miss it, if it is a Spacing unit, because the relay armature will then be on the Spacing side and B will be tilted upwards. When R_5 moves into the second indent, S will be opposite F_2 and so on for each successive indent in C_5. When S is pushed forward by B, it moves the Selecting Finger F, immediately in front of it, underneath the corresponding extension arm E. In this manner as S traverses the front of the Selecting Fingers in the direction Z_2, the latter are either pushed under the extension arms or remain *in situ* according to the position of the relay armature, and the selection is thus set up on the Fingers.

Printing.—Passing freely through the centre of the Combs is a continuously rotating spindle,

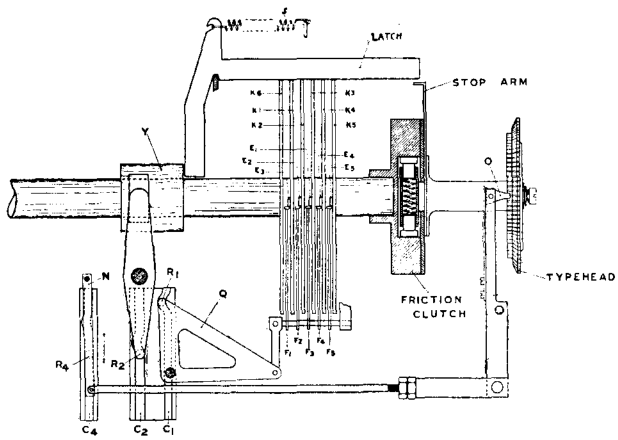


FIG. 9.

see Fig. 9, carrying at one end a friction clutch which communicates the motion, normally, to a Typehead and Stop Arm. The Typehead consists of a number of small typebars mounted in the form of a vertical circle in which the letters of the alphabet alternate with figures and other characters as shown in Fig. 10. Each Comb is slotted on its edge in a definite manner and can occupy one of two positions, one of which, in combination with any other combs that may have been moved, puts a set of slots in the five combs into alignment and allows one of a number of latches (depending on the character selected) to be pulled in under the action of a Spring $ (see Fig. 9). The disposition of the latches and the combs is shown in Fig. 11. If for example, Combs 3 and 5 are slightly displaced to the left, a set of slots is aligned in the five combs which allows latch H to be selected (the code for H is 1, 2, 4 spacing, and 3, 5, marking). When a latch is thus selected it acts as a lock to the Combs, and its free end projects into the path of the rotating Stop Arm (see Fig. 9). The motion of the latter, and therefore that of the Typehead is arrested, the Clutch slipping to allow of this. When this occurs the required typebar of the typehead has been brought directly in front of the Printing Hammer O. Actual printing does not take place until near the end of the next revolution of the Cam Sleeve, when S is moving from F5 to F3. At a particular instant during this movement, the indent in Cam C4 operates lever N and cause the Hammer O to strike the selected typebar and thus record the character on a paper tape. The faces of the typebars are inked by contact with inked rollers. Immediately after printing, the indent in Cam C2 (Figs. 8 and 9) moves sleeve Y forward and lifts the selected latch clear of the combs allowing any of the latter that were displaced to return to their normal positions under the action of springs. Finally just before the Cam Sleeve comes to rest, the indent in C1 (Fig. 9) moves lever Q which raises the Selector Fingers. Those fingers that were pushed under the extension arms during the passage of S from F1 to F3 will accordingly lift the corresponding arms

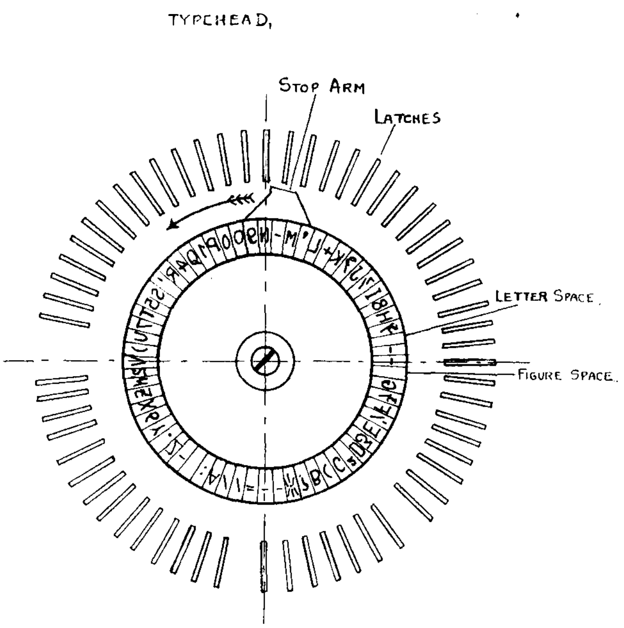


FIG. 10 (a).

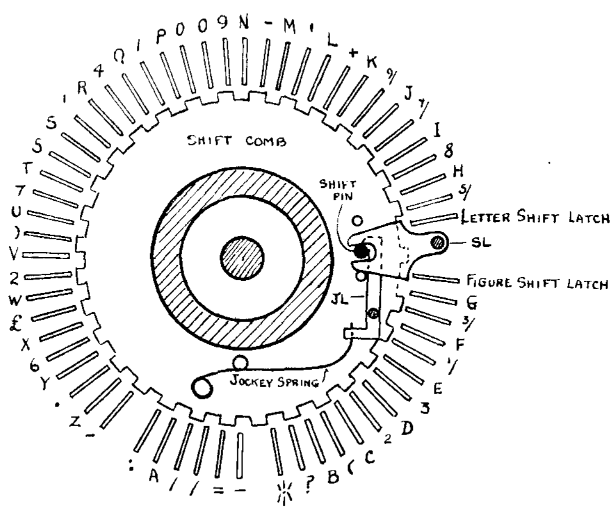


FIG. 10 (b).

and transfer the selection to the Combs. The printing of the character thus selected takes place near the end of the next revolution in the manner described.

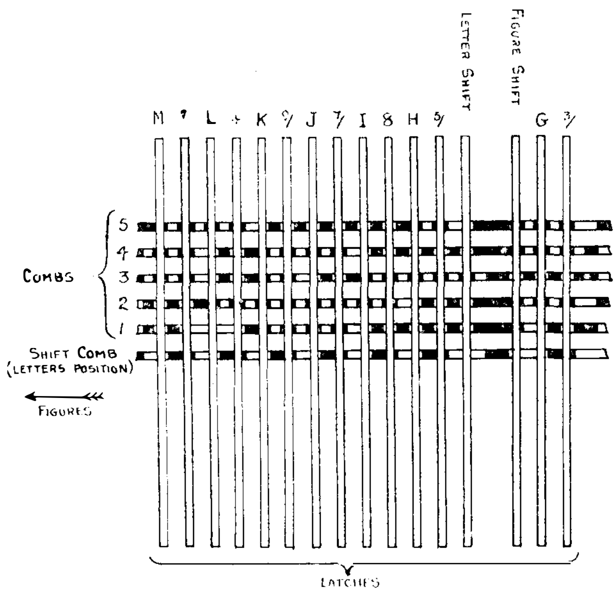


Fig. 11.

Finger Resetting Mechanism.—While S is moving from F_3 to F_1, Cam C_1 (Fig. **9**) causes lever Q to lower the Selector Fingers which were raised to set the Combs just before the end of the previous revolution. At the same time the Selector Fingers that were pushed forward are restored to their normal positions so that they may be reset when S moves from F_1 to F_5. This resetting is effected as follows, Fig. **8** refers :—

The Resetting Link Lever V is held, normally, against the end of the bellcrank R by the spring S_1. R is pivoted on the end of T and as the latter moves in the direction Z_1, R will push against the end of V and move it to such an extent that the link W will push any Selector Fingers, which were set during the previous revolution, from under the Extension Arms E. Before T reaches the end of its stroke, the other extremity of R strikes the stop screw X and R is thrown out of engagement with V. As a result spring S_1 turns V clockwise and W is thrust to the left so that it will be clear of the Selector Fingers when the next combination is being set up as T moves from F_1 to F_5. R is carried with T during this movement and ultimately its extremity again falls behind V.

Paper Feed Mechanism.—A roll of paper tape is mounted on a holder fixed inside the cover to the back of the Instrument. The paper is fed round a platen and led through an aperture in the left side of the cover. Fixed on the platen spindle is a Feed Ratchet which is driven by a Feed Pawl pivoted on the Bell Crank L (see Fig. **8**). The Traversing Link T operates L and when it moves in the direction Z_1 the Feed Pawl is pushed forward and slips over one tooth of the Feed Ratchet; the Retention Spring holds the latter steady and prevents it from moving backward. The Feed Pawl engages with the Ratchet when T moves in the direction Z_2 and turns the Platen so that the tape is fed forward one letter space. The Feed Pawl regains its normal position when T reaches its position of rest opposite F_3.

Shift Mechanism.—Referring to Fig. **11** it will be seen that in addition to the five Combs

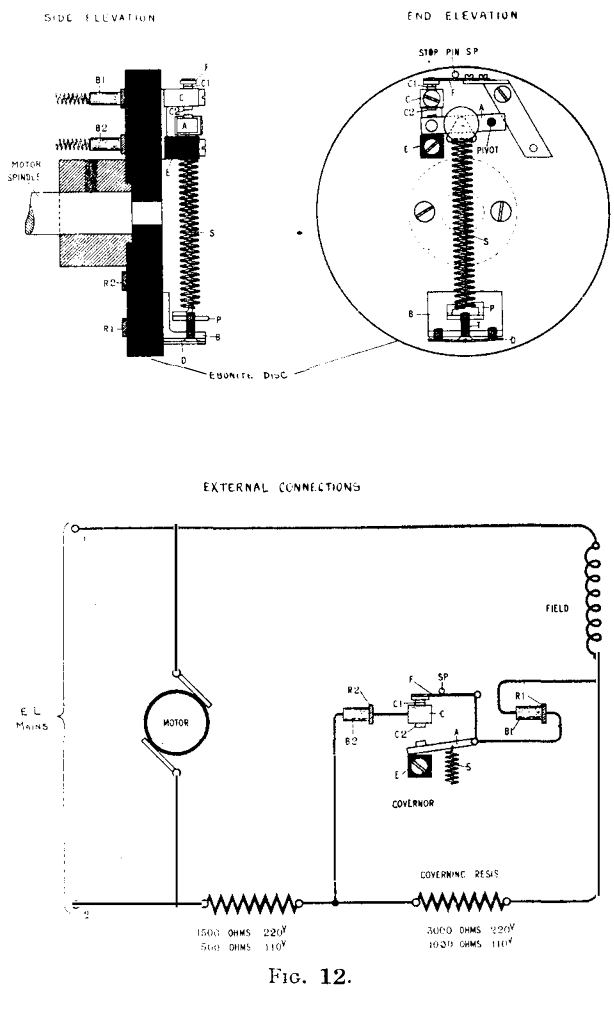


Fig. 12.

there is a Shift Comb (K6 in Figs, **8** and **9**) which can also occupy one of two positions. The blocked-in parts of the various Combs denote projections, and with the Shift Comb in the " letters " position shown, the projections on it allow only Primary character latches to be selected when the other five Combs are set. If the Shift Comb is displaced slightly to the left

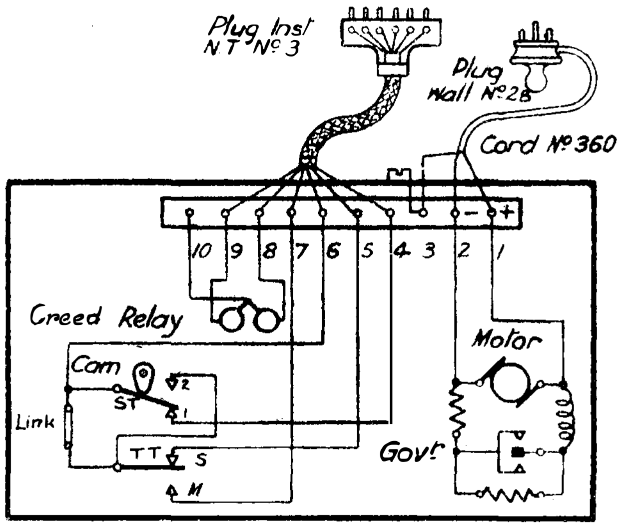


FIG. **13**.

(" figures " position), the projections on it move under the Primary latches and allow only the selection of the secondary character latches. For instance, with the Shift Comb in the " letters " position, if the incoming combination is 1, 2, 4 spacing, and 3, 5 marking, latch H will be selected, while if the Shift Comb is in the " figures " position, latch $^{5}/$ will be selected. Fig. **12** shows the Shift Mechanism. The forked end of the Shift Lever SL engages with a Shift Pin fixed to the Shift Comb. If the distant station sends the Figure Shift combination, which is 1, 2, 4, 5 marking and 3 spacing, the combs 1, 2, 4, 5 move to the left, slightly, and the Figure Shift Latch enters the notches thus aligned and operates SL. The forked end of the latter in acting on the Shift Pin turns the Shift Comb anti-clockwise to the " figures " position and all selections following this will give secondary characters. The change back to " letters " occurs when the Letter Shift Latch is selected and operates SL.

Governor.—The Creed Governor is of the centrifugal type and is fixed on one end of the spindle of the Driving Motor as shown in Fig. **12**. It consists of an ebonite disc on one side of which are mounted the Contact Arms A and F, and the contact block C, etc. On the other side are two brass rings, R1 and R2, upon which ride the carbon brushes, B1 and B2, for making the connections to the motor circuit. The Contact Arm A is controlled by the Spring S and is normally held against the insulated block E, so that the contacts C2 are open. F is a flat spring weighted at its free end and normally closing the contacts C1. A and F are both electrically connected to R1, and the Contact Block C is connected to R2.

When the motor is not running, the Contact Arms rest as shown and F short-circuits the Governing Resistance, thus ensuring a large starting current through the Motor Field Windings. When the Governor commences to rotate, F flies outwards and in opening contacts C1 switches the Governing Resistance into the Field circuit, thus causing the Motor speed to *increase*. A also moves outwards and eventually closes contacts C2; this short-circuits the Governing Resistance, thereby causing the speed to decrease so that A opens the contacts C2, switches in the Governing Resistance and again causes the speed to increase. This making and breaking at C2 takes place very rapidly and an average speed is maintained, depending on the Governing Resistance and the tension of S. The lower end of S is fixed to a plate P which engages with a fine screw T by means of which the tension of S may be altered.

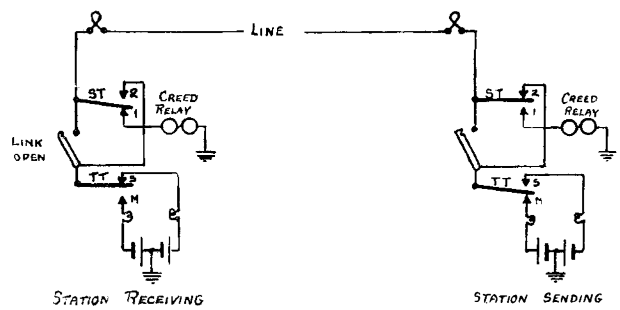


FIG. **14**.

The stroboscopic method of checking the speed is used.

Circuit Connections.—The internal connections of the Teleprinter 3A are shown in Fig. **13**. For Up and Down D.C. Simplex Working, shown diagrammatically in Fig. **14**, use is made of the "Send Receive" switch ST (see also Fig. **5**). The function of this switch is the same as that of the switch on a D.C. key, *i.e.*, it cuts off the battery when receiving and substitutes the receiving apparatus. The movement of ST is controlled automatically by a cam on the Transmitting Spindle, and when this spindle

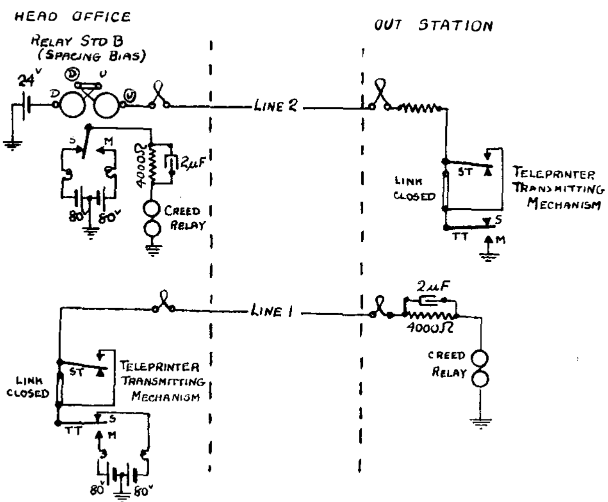


FIG. **15**.

is at rest ST is against contact 1, thus joining the Creed Relay direct to the line. As soon as the spindle starts to rotate, the cam allows ST to move over to contact 2, disconnecting the relay and joining the Transmitting Tongue TT to the line. The Link between TT and ST must be opened with this method of working; when it is closed it short-circuits ST.

Two Line Simplex working is often used on short routes from a Head Office in order to allow balancing apparatus and batteries to be dispensed with at the Out Station. Fig. **15** shows the arrangement, and it will be seen that the Head Office works double current over Line 1 to the Creed Relay at the Out Station. The latter sends over Line 2 to the Head Office by making and breaking the circuit. The circuit is disconnected while the Transmitting Tongue TT at the Out Station is on the Spacing Contact, and is earthed when it moves to the Marking Contact. The Head Office Relay is set with a "spacing" bias, which is overcome when a line current flows, and the Creed Relay in the local circuit is operated. Only one Teleprinter is used at each office.

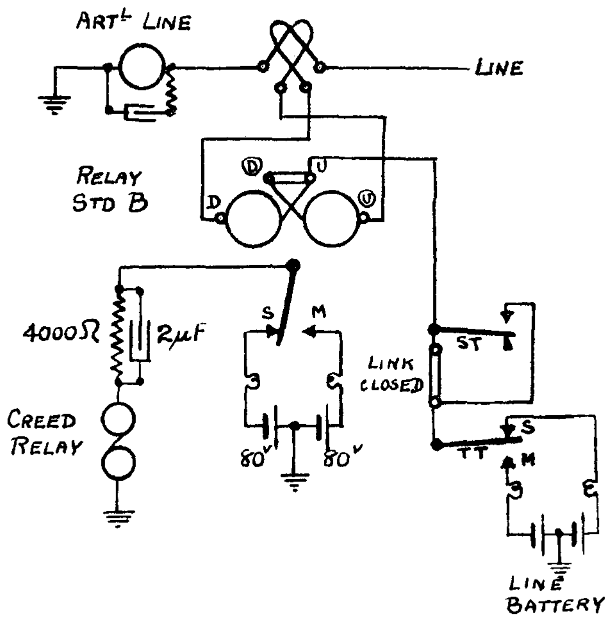


FIG. **16**.

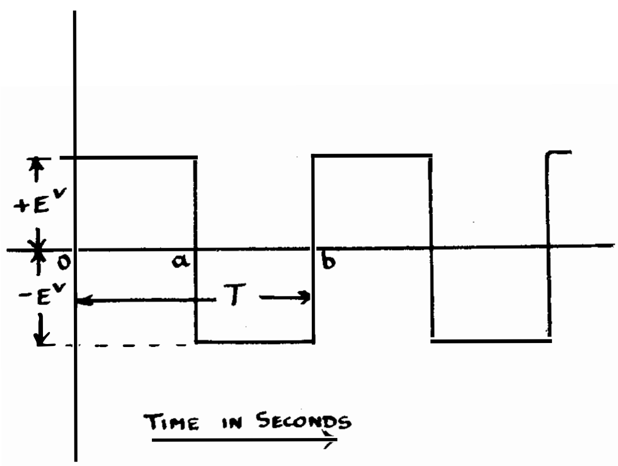
The connections for duplex working are shown in skeleton form in Fig. **16**, and are sufficiently obvious to require no comment. Both stations are joined up alike.

THE END.

TRANSMISSION SPEEDS OF TELEGRAPH APPARATUS.

A. E. Stone, A.R.C.Sc.

On all telegraph lines of any importance double-current working is adopted because of its advantages from a transmission point of view as compared with single current working. These advantages are well known and need not be detailed here. In the double current system the series of "dots" represented in Fig. 1 is formed by applying at the sending end of the line the opposite poles of a battery alternately for equal lengths of time. The time interval from 0 to a, or from a to b, may be termed a dot unit; the interval from 0 to b, *i.e.*, two dot units, is termed the period, and if it be denoted by T seconds the number of dots that is sent per second, called the "dot" frequency, is given by $f = \frac{1}{T}$. The zig-zag curve of Fig. 1 may be represented by the complex alternating e.m.f.



$$e = \frac{4E}{\pi}\left[\sin 2\pi ft + \tfrac{1}{3}\sin 6\pi ft + \tfrac{1}{5}\sin 10\pi ft + \ldots\ldots\right]$$

where E is the e.m.f. of the sending battery and f is the dot frequency.

In actual signalling, whatever the apparatus used, a regular sequence of dots rarely occurs for any length of time; for instance, in Morse signalling dashes and letter spaces must necessarily be sent at frequent intervals. An approximate idea of the transmission of signals over telegraph lines may be obtained, however, by considering the case of "dot" signals only and, incidentally, it may be mentioned that the transmission problems are simplified by the fact that on long, well-insulated lines worked at high speed only the first term in the complex expression given above, viz., sin $2\pi ft$, need be considered, because the currents at the receiving end resulting from the harmonic components sin $6\pi ft$, etc., are attenuated to such an exent as to be negligible in comparison with that resulting from the fundamental, sin $2\pi ft$.

In dealing with the transmission speeds of telegraph apparatus, there are obvious advantages in considering the rate of signalling as so many cycles per second (*i.e.*, the dot frequency) as against the usual practice of so many words per minute. To state the speed of a circuit in words per minute conveys nothing that is intelligible for transmission purposes unless the type of apparatus used is also stated. For instance, if the maximum working speed of a circuit with Wheatstone Apparatus is 125 words per minute, it could be worked at a speed of approximately 200 words per minute with apparatus using a five-unit code; the vital factor governing the working speed of the apparatus is the maximum permissible number of cycles per second, and this for the example given is 50 for both the Morse and the five-unit code at the quoted speeds.

From a commercial point of view it is desirable of course to know the speed in words per minute, and the following shows the methods of obtaining the speed in cycles per second corresponding to speed in words per minute for the principal types of telegraph apparatus.

(1) *Wheatstone Morse System.*—The Morse code is made up of two elementary signals, which are distinguished from each other by their duration. One signal, called a "dot," is taken as the unit; the other signal, which is called a "dash," is three times as long. Each letter of the alphabet is represented by a particular combination of dots and dashes. The spaces between the elements forming a letter are each

equal in length to one dot, while the spaces between the letters of a word are each equal to three dots, and between words five dots.

The various characters in the Morse code differ widely in length, but on an average may be assumed to be equal to eight dot units. The length of an average word (this is independent of the code used) is taken to be five characters plus one letter space, or six characters, and as the length of the average character is eight dot units, the average word consists of 48 dot units in the Morse code.

Now in sending a series of dots, each marking current, which has a length of one dot unit, is followed by a spacing current of the same length and this combination forms one reversal of current.

Accordingly 48 dot units represents 24 cycles of current, and this is the number of cycles per average word. If W be the speed in words per minute, the number of cycles per minute is 24 W. Hence

$$\text{The Transmission speed} = \frac{24W}{60}$$
$$= 0.4W \textit{ cycles per second.}$$

Thus if the speed W be 125 words per minute, the Transmission speed is $.4 \times 125 = 50$ *cycles per second.*

(2) *Duplex Multiplex Type-printing Systems.*—In the five-unit code used with these systems, each character has a length of five dot units and the space between words has the same length.

If S be the number of segments on the sending ring of the distributor and alternate segments are connected to the positive and negative poles of a battery, respectively, it is possible to send $\frac{S}{2}$ cycles of current per revolution of the brush arm. Accordingly if N revolutions per minute be the speed of the brush arm, the number of cycles per minute is equal to $\frac{SN}{2}$. Therefore:

$$\text{The Transmission Speed} = \frac{SN}{2 \times 60}$$
$$= \frac{SN}{120} \text{ cycles per second} \quad \ldots\ldots\ldots\ldots (1)$$

As previously stated, the length of the average word is six characters. Now, one revolution of the brush arm is necessary for sending one character per channel, hence six revolutions are required for sending six characters, *i.e.*, one word. If, then, the working speed of a channel be W words per minute, $W = \frac{N}{6}$. Substituting the value of N obtained from this in Equation (1) gives:

$$\text{The Transmission Speed} = \frac{S \times 6W}{120}$$
$$= \frac{SW}{20} \text{ cycles per second} \quad \ldots\ldots\ldots\ldots (2)$$

If c be the number of channels, then in the Baudot System

$$S = 5c + 2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

because each sending channel has five segments, and two additional segments are required for correction purposes.

If, however, correction from signals is used, the two correcting segments are not required and then

$$S = 5c \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Substituting (3) and (4) in (2) gives

Transmission Speed (Baudot System)
$$= \frac{(5c + 2)W}{20} \text{ cycles per second} \quad \ldots (5)$$

Transmission Speed (Correction from Signals)
$$= \frac{5cW}{20} \text{ cycles per second} \quad \ldots\ldots\ldots\ldots (6)$$

It will be seen that for a given speed per channel, the transmission speed using correction from signals is less than that for the Baudot System, and the advantage of the former is greater the smaller the number of channels.

By putting $c = 4$, 3 and 2 in equations (5) and (6) the following formulæ may be obtained for the transmission speeds of Quadruple, Triple and Double Multiplex installations, respectively:—

Installation	Transmission Speed in Cycles per sec.	
	Baudot System	Correction from Signals
Quadruple Duplex	1.1W	W
Triple Duplex	.85W	.75W
Double Duplex	.6W	.5W

From these formulæ the following table has been prepared:—

Installation	Speed per Channel W	Transmission Speed in Cycles per second.		Total Output in Words per Minute (w×c)
		Baudot System	Correction from Signals	
Quadruple ($c=4$)	30	33	30	120
Quadruple ($c=4$)	35	38.5	35	140
Quadruple ($c=4$)	40	44	40	160
Triple ($c=3$)	40	34	30	120
,,	47	39·95	35·25	141
,,	50	42·5	37·5	150
,,	53	45·05	39·75	159
Double ($c=2$)	50	30	25	100
,,	55	33	27·5	110
,,	60	36	30	120

To illustrate the importance of correction from signals, consider the case of a line the maximum working speed of which is 40 cycles per second. Taking triple duplex multiplex installations as an example it would be possible to work—

(1) Triple Baudot at 47 words per minute per channel, giving a total output of 141 words per minute; or

(2) Triple Multiplex (correction from signals) at 53 words per minute per channel, giving a total output of 159 words per minute.

Clearly if both systems were worked at a speed of, say, 45 words per minute, the correction from signals' method would give the wider working margin, because its transmission speed would only be 33.75 cycles per second compared with 38.25 cycles of the Baudot installation. The lower transmission speed of the former would allow of satisfactory duplex working with a less accurate balance than would be demanded by the higher transmission speed of the latter.

The advantage of the five-unit code as compared with the Morse code will be apparent by referring to the following table which shows the respective transmission speeds for a working speed of 120 words per minute:—

Installation.	Total Output Words per Minute	Transmission Speed. Cycles per sec.
Wheatstone.	120	48
Quadruple Duplex (*a*) (Baudot System)	120	33
Quadruple Duplex (*b*) (Correction from Sigs.)	120	30
Triple Duplex (*c*) (Baudot System)	120	34
Triple Duplex (*d*) (Correction from Sigs.)	120	30

(3) *Teleprinter Systems.*—Teleprinters use a five-unit code for the actual character combinations, but employ in addition a start signal of length one unit and a stop signal of length $1\frac{1}{2}$ units, so that from a transmission point of view each character has a length of $7\frac{1}{2}$ units, *i.e.*, $3\frac{3}{4}$ cycles.

If t secs. be the time of one revolution of the Transmitting Cam spindle, then in this period of time $3\frac{3}{4}$ cycles can be sent. Hence:

The Transmission Speed $= \dfrac{3\frac{3}{4}}{t} = \dfrac{15}{4t}$ cycles per second.

For the Teleprinter 1A, which has a maximum operating speed of 40 words per minute, $t = .25$ second.

$\therefore$ The Transmission Speed $= \dfrac{15}{4 \times .25} = 15$ cycles per sec.

In the Teleprinters 2A and 3A, each of which has a maximum operating speed of 60 words per minute, $t = .154$ second, hence:

The Transmission Speed $= \dfrac{15}{4 \times .154} = 24.4$ cycles per sec.

It is interesting to note in connection with the latter that Wheatstone working at 60 words per minute is equivalent to a transmission speed of 24 cycles per second; hence from a transmission point of view the Teleprinters 2A and 3A are slightly worse than Wheatstone working at an equivalent speed.

WESTERN EXCHANGE, LONDON.

F. P. Dumjohn, A.M.I.E.E.

WEStern Automatic Exchange, forming another link in the " Director " network of London, was successfully brought into service at 4 p.m. on Saturday, January 5th last, and the old C.B. manual equipment cut out of service. The time chosen for the change-over certainly has its advantages judging by the views of those present who had past experience of midnight transfers.

The excellent work done by the Department's officers in organising and preparing all " preliminaries " was markedly exemplified in the fault returns available after the " all-clear " of the old exchange was reported. The analysis of these showed less than 1% P.Gs., six subscribers' apparatus faults, no junction faults and four switching equipment faults. The latter favourable result may be justifiably credited to

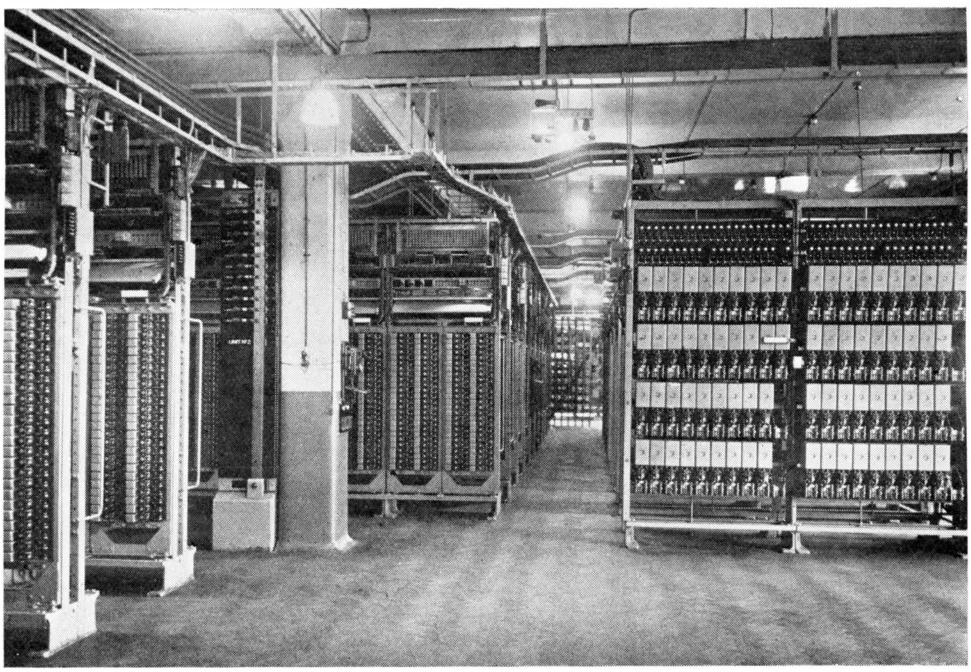


Fig. 1.—Line Units and 1st Code Selectors.

the Contractors, Messrs. Siemens Brothers & Co., Ltd., of Woolwich, and, as this is the first London exchange to be supplied by this firm in the London auto network, a brief review of some of its features may be of interest.

The initial equipment provides for 7,100 lines (preselectors), 7,400 multiple numbers and 300 auxiliary numbers for P.B.X. groups exceeding 11 lines. Switch equipment is provided for 6,800 lines and spare banks enable additional circuits to be fitted to serve for the 7,100 working lines.

Although the exchange serves the busy shopping district of Kensington, its traffic load is relatively light in comparison with Metropolitan exchanges. The originating traffic for which provision is made is about an average of 0.036 traffic units per line, whereas densities of about 0.7 to 0.9 and more occur in Meropolitan exchanges. There are 388 First Code Selectors for originating subscribers' traffic and only a little over 10% of the traffic is between WES subscribers, routed from level " 0 " to 64 First Numerical Selectors. Part of the outgoing traffic is routed direct from four levels of the First Code Selectors and the remainder *via* 352 Second Code Selectors. Incoming traffic from the Trunk Exchange, Automatic and Manual Exchanges, is completed over 591 Junctions passing through a 11-position Cordless " B " Board to First Numerical Selectors.

All Manual Services, comprising assistance " 0 " calls, Information, Service P.B.X., Interception and Supervisors, are dealt with at a 20-position Manual " A " Board. Trunk calls to subscribers found engaged at the Cordless " B " Board are transferred and completed at the Manual " A " Board.

There are 71 Line Units, each fully equipped for 100 preselectors, but only two have the full equipment of 32 final selector banks. The remaining 69 are partially equipped with 16 final selector banks. Separate Test and Trunk Offering switches are provided to which access is obtained from 8 Test Distributors and 6 T.O. Distributors respectively. The Line Units (Fig. 2) differ in design from those in London Exchanges already in operation, principally in the mounting of the preselectors. These are mounted horizontally and arranged in four vertical panels of 25 divided on two gates. The multiple on the banks is neatly splayed out so as to facilitate access to the soldered joints on the bank contacts. The terminal assembly at the top provides for separate terminals for the preselector arms and the final selector multiple so as to enable multiple numbers to be cross-

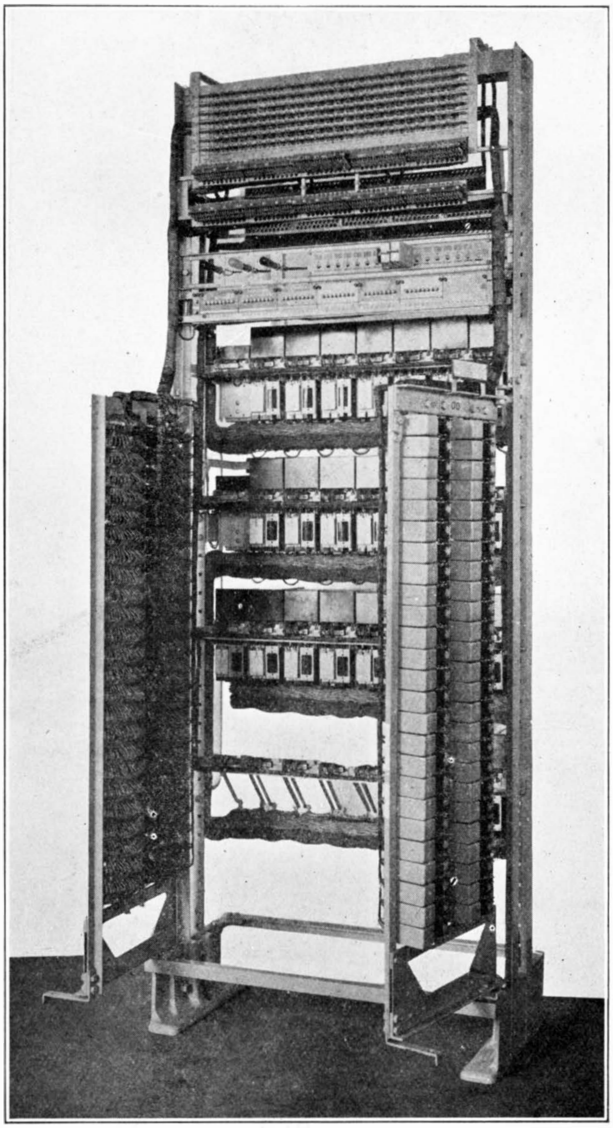


FIG. 2.—LINE UNIT.

connected with the minimum of limitation to particular preselectors. A run for jumper wires for this purpose is arranged between line units.

There are 65 " A " digit selectors with the usual grouping arrangements to 111 Directors. Each Director is a self-contained unit arranged

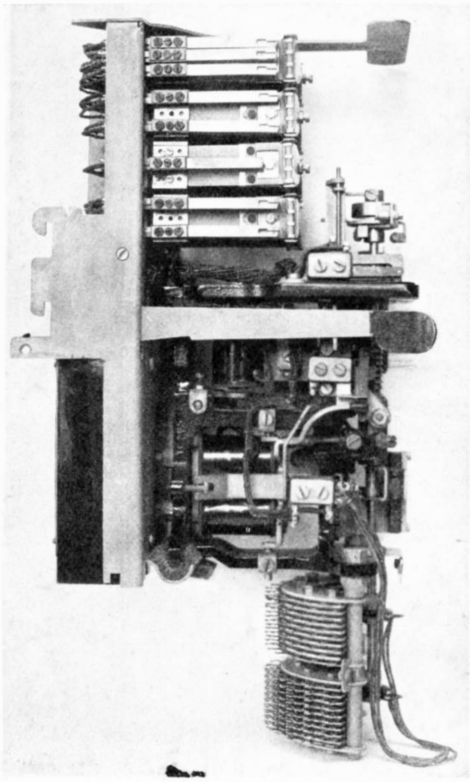


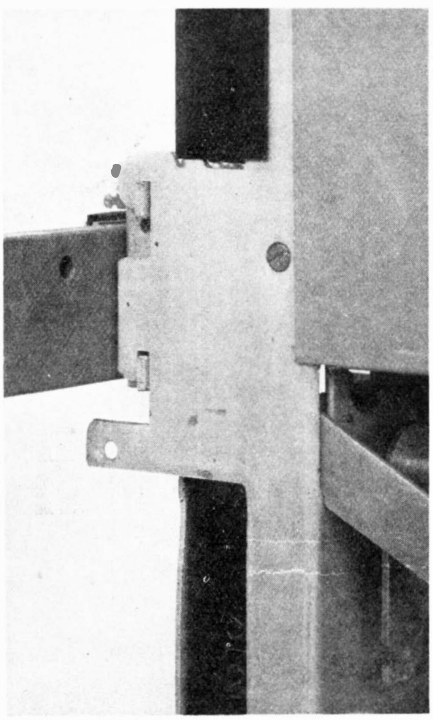
Fig. 3.—" A " Digit Selector
Showing Lever Arm raised to " disconnect " position.

for jacking-in, but in view of the weight of such a unit consideration is now being given to separating it into two units so as to facilitate easy removal.

The selectors are mounted on racks arranged in U formation with a terminal assembly at one end as in other London Exchanges. The selector mechanism and associated relays for each type of selector are mounted on one plate, with jacking-in points and wired complete as a "Circuit Unit." (Fig. 3). The advantages of this unit arrangement are well-known, but it may be as well to stress one in particular, namely, the interchangeability of selector units wherever the external panel and rack wiring can be so arranged.

A feature on the selector units is a lever connected with the contact blades, by means of which the contact blades can be lifted from their sockets, so that by raising the lever a faulty unit can be disconnected, or isolated from battery potentials before making adjustments. The end of the lever is painted red and in the " disconnect " position it is readily seen projecting from the switch.

The method adopted for the suspension of



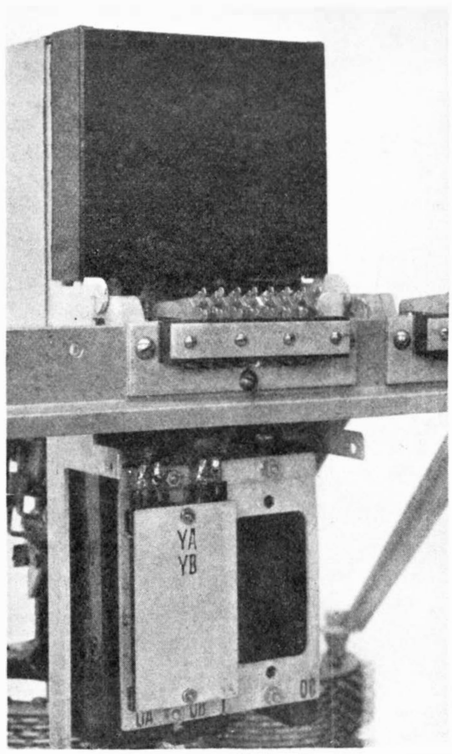
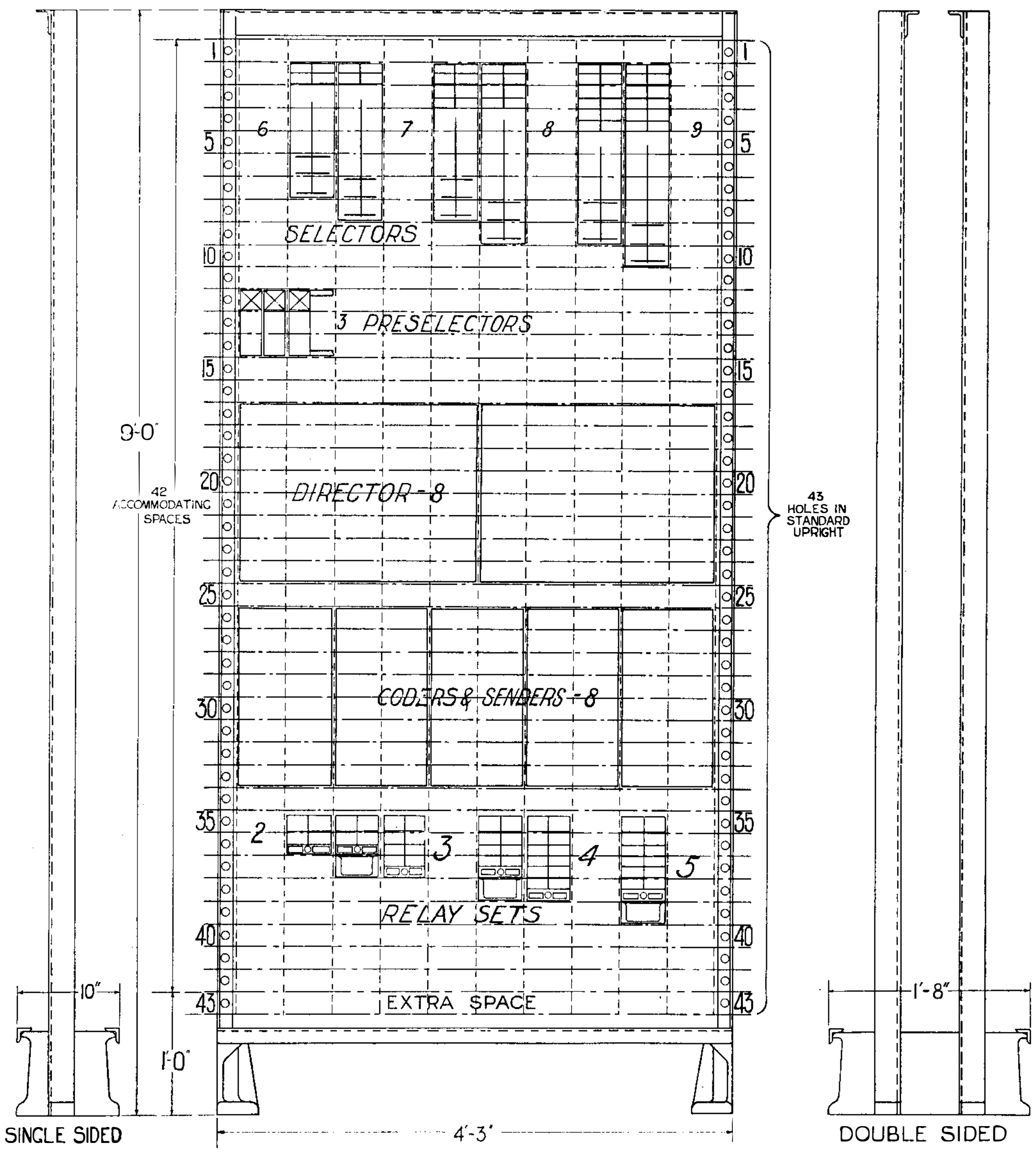


Fig. 4.—Single Member Suspension.

selector and relay set units is an innovation which claims attention. All sizes of units are suspended on a single angle iron member (Fig. **4**) between the uprights of a rack. Stamped metal cradles with two pairs of projecting ears are fixed to the angle iron, having the ears arranged to engage with slots on either side of the unit mounting plate.

Fig. **5.** DIAGRAM OF UNIVERSAL RACKS



A universal design of rack (Fig. **5**) has been provided, akin to a "Meccano" design, in which all uprights are drilled with holes at such centres as to permit one type of rack to be utilised for any type of apparatus units. It not only facilitates economy in manufacture, but has obvious advantages in facilitating re-arrangements in the exchange.

Three types of P.B.X. final selectors are fitted to provide for groups of 2-10 lines, 11-20 lines and groups over 20 lines. The 2-10 P.B.X. groups provide the same facilities and features as those originally introduced in Messrs. Siemens Brothers' No. 16 Auto Equipment and enable ordinary lines to be connected to any number not reserved for a P.B.X. line. The 11-20 groups provide for P.B.X. lines only of this size and have the same operating conditions as in other London Exchanges. The "over 20" type, although embodying the basic principles of the 11-20 type (with which it has been designed to be interchangeable), has special features of its own. It is fitted with a 200-point bank and any number of P.B.X. groups of lines can be connected from 10 of 20 up to 1 of 200 lines. The banks of the 11-20 and over 20 P.B.X. groups are cabled to the Manual I.D.F., where they are cross-connected to tie-cable circuits to the Line Units on which the associated preselectors are mounted, the facilities being such that about 5% of the preselectors on each line unit are assigned for P.B.X. lines.

Improvements have been made in circuit design, *e.g.*, a rotary magnet make contact is employed for the drive of selectors, delayed metering is used so that no lock-up contact on subscribers' meters is required and the way is prepared for the ready introduction of multi-metering. Space does not permit of enumerating other features except the one particular economy made in the number of relays used in earlier circuits, *e.g.*:—

Group Selectors	have	4	relays	instead of	5
Ordinary Finals	,,	7	,,	,, ,,	8
2-10 P.B.X.	,, ,,	8	,,	,, ,,	9

Automatic routiners are fitted for testing First Code Selectors, Coders, Senders, Directors, C.C.I. Repeaters and "B" Position Junction Relay Sets.

Duplicate batteries of 25 cells are provided, plated for 3,930 and box capacity for 5,502 amp. hours and are designed for 24 hours exchange consumption. A set of 11 C.E.M.F. cells provides for 30 volt P.B.X. power leads, but C.E.M.F. cells for regulating the exchange busbar voltage are not fitted. Duplicate motor-generators of 51 K.W. output serve either for operating the plant on a charge-discharge basis or with either battery floating. The power circuit provides for single pole switching as now standardised by the Department, and the simplifications thereby effected are noticeably apparent in the size of the power board, which measures only 8 feet in length, including the ringer panel.

The ringing machines and interrupters are in duplicate, one driven from the public supply and the other from the battery. Whilst the mains driven ringer is in use, arrangements provide for its disconnection on failing from any cause to switch in the battery ringer automatically.

The writer is indebted to the Engineer-in-Chief of the Post Office for permission to publish this brief outline and to the courtesy of the Board of Editors for its publication.

RELAY AUTOMATIC SYSTEM IN CZECHO SLOVAKIA.

R. Mordin.

The Great War destroyed many things and created some others, among them the Republic of Czecho Slovakia, having a population of about 14 millions and an area about equal to that of England and Wales.

By the end of the War, the people of Bohemia, Moravia and Slovakia had been brought to the verge of starvation. Thanks, however, to the statesmanship of Dr. Masaryk and Dr. Benes exerted at the Versailles Peace Conference, the State of Czecho Slovakia, combining the three countries mentioned, was constituted and recognised by the Allied Powers. By 1921 it had become one of the most stable and prosperous territories in Europe exhibiting a phenomenon at that time unique in Central Europe, to wit, a balanced Budget. Since then the country has developed progressively and on account of its natural resources bids fair to become one of the most important industrial areas in Central Europe.

Czecho Slovakia has not been slow in recognising the benefits of Automatic Telephone Service, and an interesting Relay Automatic Public Exchange network has recently been brought to completion at Moravska Ostrava, perhaps its most important industrial city.

The various exchange equipments were designed by the Engineers of the Relay Automatic Telephone Company to the specification of the

Department of Posts and Telegraphs, C.S.R., and the equipment was manufactured under licence from the Company by the firm "Telegrafia," of Prague, who also carried out the work of installation under supervision by the Relay Company's engineers.

The network is illustrated diagramatically by Fig. **1**, and consists of a main exchange initially equipped for 2,500 subscribers' lines, to which are connected six automatic satellites. A number of manual exchanges are also provided with junction service through the main exchange, whose design provides for the gradual conversion of the manual satellites to automatic working in the future.

precisely similar to those employed in the well-known P.A.B.X switchboards supplied by the Relay Automatic Telephone Company to the British Post Office, and have in all cases the following characteristics:—

	Minimum.	*Normal.*	*Maximum.*
Armature Stroke ...	28	30	32 mils.
Contact Pressure— "make" contacts ...	$1\frac{3}{4}$	$2\frac{1}{8}$	$2\frac{1}{2}$ ozs.
Contact Pressure— "break" contacts...	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$ ozs.

. The gap in the magnetic circuit when relays are operated is fixed precisely at 2, 6, 12, or 24 mils, depending on the function of the relay.

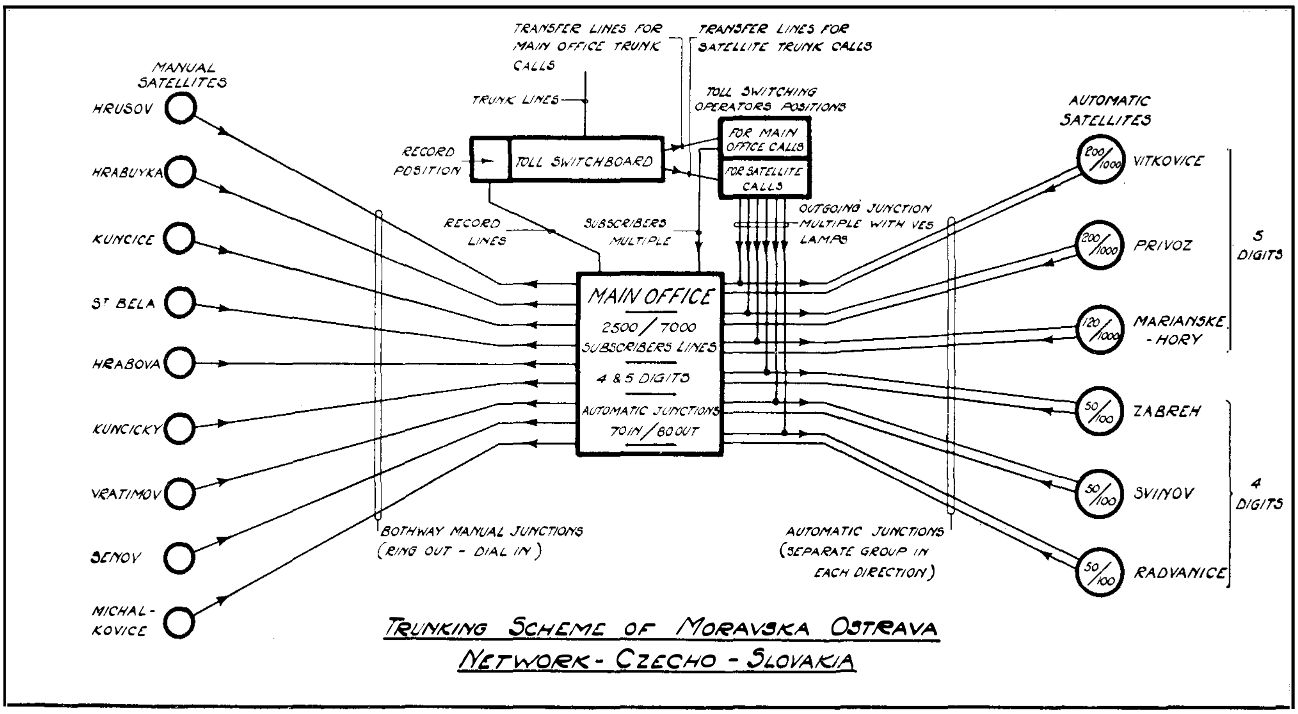


FIG. **1.**

The number of lines to be connected ultimately to the main office remains indeterminate, and is only limited by the floor space that can be made available in the future. The ultimate equipment will certainly reach 7,000 lines, and may be expected to extend beyond that figure. The layout of the equipment in the main office is shown in Fig. **2**.

General Characteristics.—All selecting and connecting operations are performed by relays

It is of interest that the Main Office contains 21 relays per line based upon the initial equipment of 2,500 subscribers' lines and 150 junctions, a figure only very slightly in excess of the relays per line in small P.A.X.'s and P.A.B.X.'s.

Numbering Scheme and General Operation.—The numbering scheme of the network is as follows:—

	1	Not used. Equipment rejects " 1 " as a false impulse.
Main Office	2,000 etc. 3,000 etc. 4,000-4499	Initial equipment 2,500 subscribers' lines.
	4,500 etc. 5,000 etc. 6,000 etc.	Initially dead levels available for extensions.
	71,000 etc. — 70,000 etc.	(Maximum 15,000 subscribers' lines.)

Special Services.

Trunk Record	04	Other " 0 " two figure numbers available for further special services.
Enquiries ...	00	
Telegrams ...	08	

The Main Office equipment consists of two " Subscribers' Divisions," each containing equipment for 950 lines, one " Subscribers' Division " with equipment for 600 lines, and a " Junction Division " dealing with the traffic to and from the automatic satellites as shown in the Floor Plan, Fig. **2**.

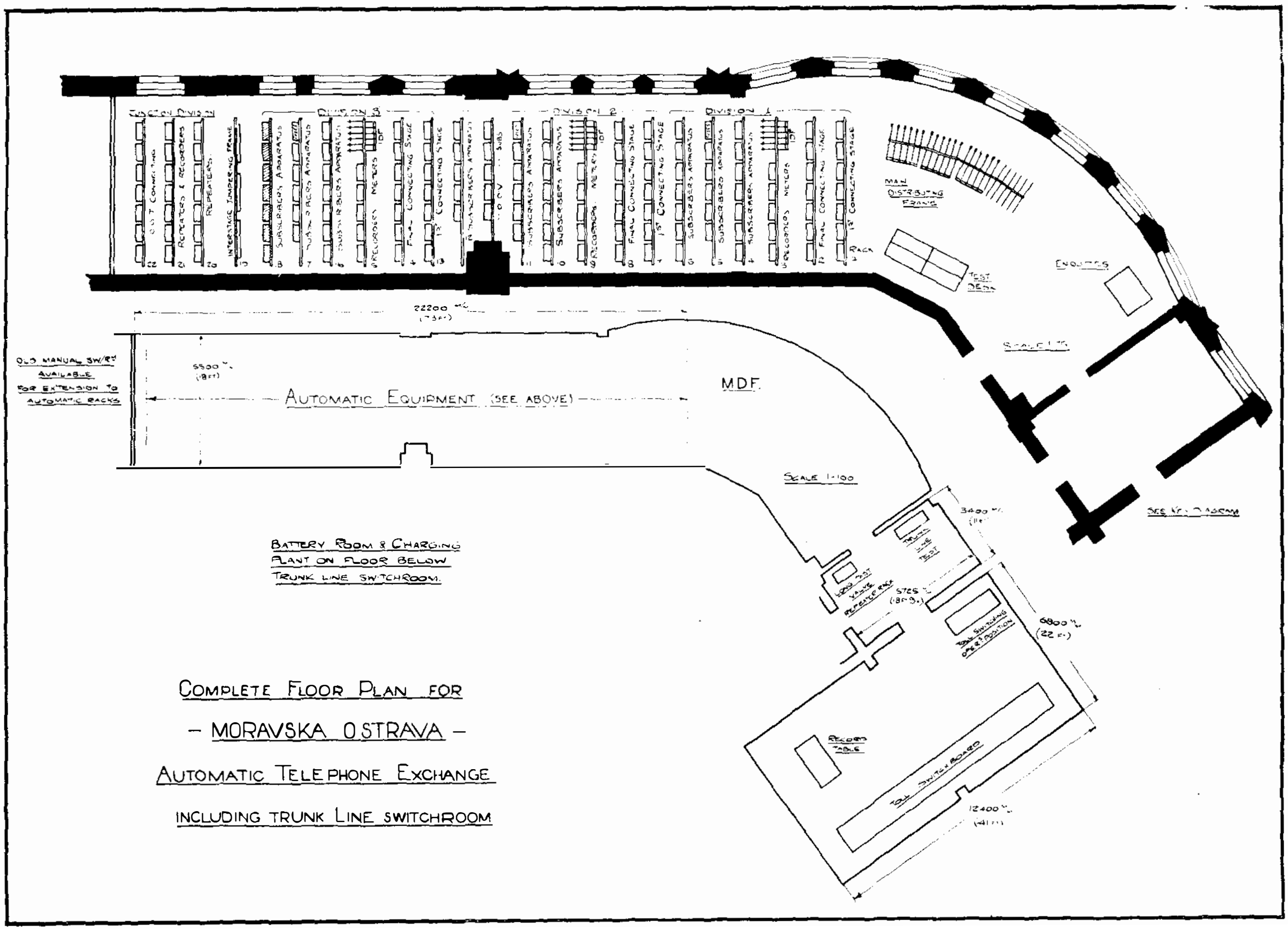


Fig. 2.

Automatic Satellite Subscribers.

Vitkovice	82,000	etc.	Automatic satellites initially installed.
Mar. Hory	83,000	,,	
Radvanice	84,000	,,	Remaining " 8 " and " 9 " five figure numbers available for further automatic satellites.
Zabreh	85,000	,,	
Svinov	86,000	,,	
Privoz	97,000	,,	

A " Subscribers' Division " includes its own IDF and is capable of accommodating 1,000 lines, but on account of ceased services, removals, numbers in reserve for additional P.B.X. lines and other contingencies incidental to public exchange service in general, the whole of the 1,000 numbers would never be simultaneously in use. On this account, and since the

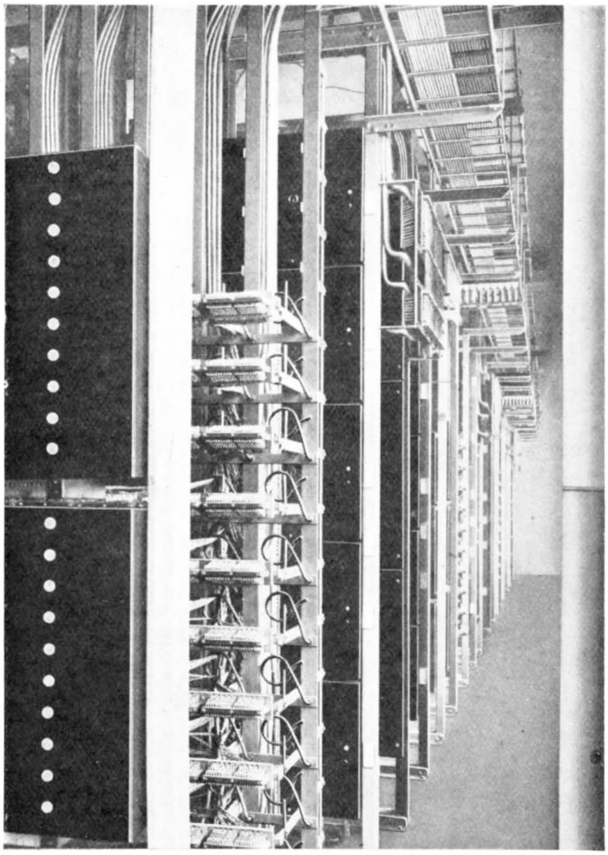


FIG. 3.—VIEW DOWN CORRIDOR FROM INTERMEDIATE DISTRIBUTING FRAME, SUBSCRIBERS' DIVISION 11. (Rack 9 of Floor Plan).

" Relay " System normally provides that the full range of 1,000 numbers is always available, the actual equipment per " Subscribers' Division " at Moravska Ostrava is reduced to 950 lines in order to avoid waste.

Apart from the apparatus individual to subscribers' lines, each " Subscribers' Division " contains a First Connecting Stage for distributing the originating traffic and a Final Connecting Stage for connecting the terminating traffic for the whole of the lines in the Division.

The trunking stages are of the usual " Trunk Line " type employed in the Relay System* and are controlled by a group of selective circuits (Recorders) associated with each.

Referring to the numbering scheme given above, the First Stage Recorders only accept the first digit dialled (except when the latter is " 7 " when a further digit is accepted) and then cause the call to be extended through the First Connecting Stage into the Final Connecting Stage of the Division in which the required line is located, the final three digits being accepted by the Recorders in the latter and resulting in the desired connection.

In the case of calls for Satellite Subscribers, the first digit dialled (8 or 9) extends the call into an Outgoing Junction Connecting Stage located in the Junction Division in which the Recorders accept the 2nd digit and extend the call to a particular satellite, leaving three digits to be dialled into the Recorders therein for the purpose of finding the required line.

The Satellite Subscribers are connected to a

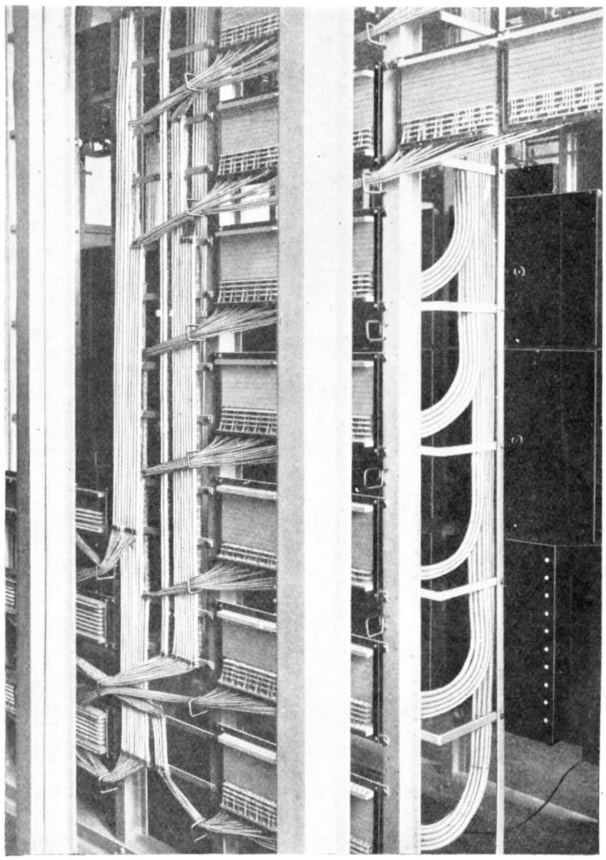


FIG. 4.—DISTRIBUTION OF TRUNKS FROM FIRST CONNECTING STAGES AND REPEATER CONNECTING STAGE TO FINAL CONNECTING STAGES, AND OUTGOING JUNCTION CONNECTING STAGE.
(Rack 19 of Floor Plan).

* *See P.O.E.E.J., Vol. 13, Part 1, and Vol. 15, Part 4, and also " The Relay System of Automatic Switching " by H. W. Dipple (Paper read before I. of P.O.E.E.)*

Repeater in the Main Office immediately on taking off their receivers. The Connecting Stage and Recorders associated with the Repeaters distribute the incoming Satellite traffic to the Final Stages of the " Subscribers' Division " and to the Outgoing Junction Connecting Stage (for through traffic), so that the function of the Repeater Connecting Stage resembles that of the First Stages in the " Subscribers' Division," with the exception that if the first two digits dialled by the Satellite Subscriber determine the call to be one local to the satellite, the junction is dropped and, for the first time, a Recorder is brought into circuit at the Satellite, which accepts the final three digits and finds the required line therein.

General Facilities.—The following general facilities characterise the automatic equipment:

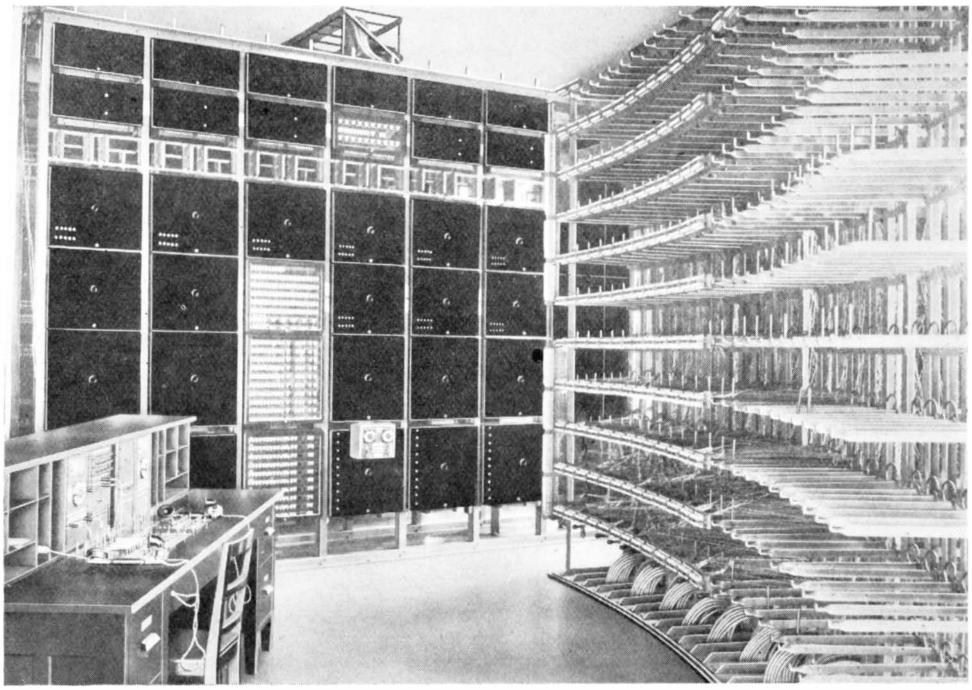
(*a*) Dialling, Busyback and Number Unobtainable tones in accordance with British Post Office practice.

(*b*) The calling subscriber controls the connection, but in all cases a thermostatic back-release and alarm is provided in the event of slow clearing by the calling subscriber.

(*c*) Line faults and subscriber's irregularities are prevented from engaging common apparatus for more than one minute.

(*d*) Ineffective calls do not occupy trunks in connecting stages or junctions between exchanges.

(*e*) The correct operation of subscribers' meters is automatically supervised. Failure of the meter causes the connection to be held up and an alarm given.



TEST DESK. FIG. 5. MAIN DISTRIBUTING FRAME.
Rack 1. A & B Feeds and First Connecting Stage, Subscribers' Division 1.
(Covers removed from 4 Relay Groups).

(*f*) The " Search " for an idle trunk or junction is practically simultaneous and extends over the whole group of circuits concerned, without regard to their number.

(*g*) No restriction in the number or distribution of lines constituting a P.B.X. Group.

Trunk Traffic.—Moravska Ostrava was already an important trunk line centre before the introduction of automatic working, and the conditions specified for the operation of the trunk traffic were somewhat exacting.

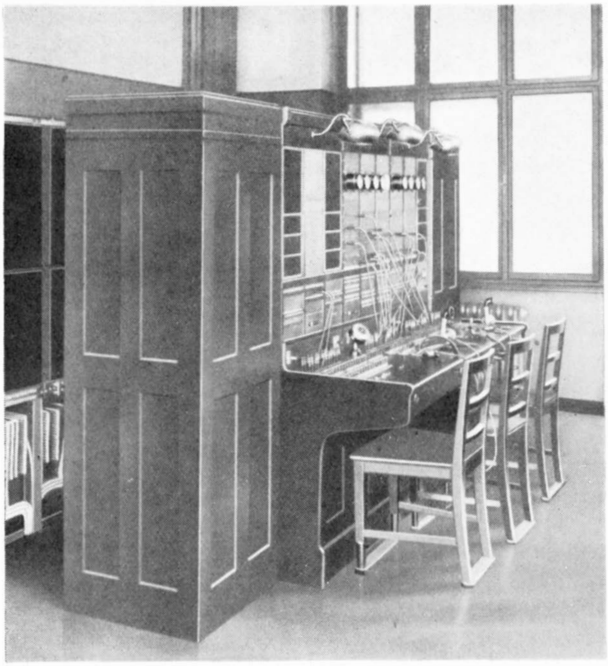


FIG. 6.—TOLL SWITCHING OPERATORS' POSITIONS FOR ROUTING TRAFFIC BETWEEN ALL AUTOMATIC SUBSCRIBERS IN NETWORK AND THE TOLL SWITCHBOARD PROPER.

It was required, and it has been provided under the new system, that the operators on the existing Toll Switchboard should

(*a*) be given direct access to every automatic subscriber in the network;

(*b*) be able to enter any engaged subscriber's line for the purpose of offering a trunk call;

(*c*) be able to effect the trunk connection over the same circuit by which it was offered, at the same time breaking down any other connection on which the subscriber may have been engaged at the time.

(*d*) For the purpose of the above facilities, in connection with satellite subscribers, the Toll operator should be able to use the ordinary outgoing junctions to the satellites and appropriate any junction if they should all happen to be engaged.

(*e*) In the latter case be able to discriminate before appropriating a junction between those engaged on trunk and ordinary traffic in order not to interfere with existing trunk calls.

(*f*) Positive lamp supervision is to be given to the Toll Operator.

In order to give effect to these arrangements a small manual switchboard for "Toll Switching," as shown in Figs. **2** and **6** and a Record Table, was installed in proximity to the existing Toll Switchboard.

The Main Office subscribers' lines and also the outgoing junctions to the automatic satellites are multipled before the Toll Switching Operators, who are provided with two groups of plug-ended lines from the Toll Switchboard proper,

(*a*) for trunk calls to Main Office subscribers and

(*b*) for trunk calls to Automatic Satellite subscribers.

The routing of the traffic is indicated by the arrows in Fig. **1**.

To effect a trunk call the automatic subscribers dial 04 and details are taken by the Record Operator.

When the call matures it is reverted to the originating subscriber by the Toll Operator through the medium of the Toll Switching Operator, who completes the connection either through the Main Office Subscribers' Multiple or by dialling out over an outgoing junction to a Satellite subscriber.

In the latter case the operator puts out a discriminatory condition when plugging into the junction and when dialling she omits the first two digits of the number. Connection is obtained to the required line whether it is engaged or not, without requiring any special operation by the Toll Switching Operator. Engaged lamps are provided on the O.G.J. multiple and junctions engaged on Trunk Calls have in addition a tone on the sleeve of the jacks in order to comply with condition (*e*) referred to above.

The sole function of the Toll Switching Operator is to obtain connection to the line on behalf of the Toll Operator proper, who afterwards takes complete control of the call. The operation of a trunk call by the Toll Operator is precisely the same for calls to Main Office or Satellite subscribers.

AUTOMATIC ROUTINE TESTERS FOR AUTOMATIC TELEPHONE EXCHANGES.

W. E. Chinn, A.M.I.E.E., and J. S. Young.

It is unnecessary to stress the important bearing that high grade maintenance has upon the efficiency of the telephone service and routine testing is one of the essential operations. In manual exchanges, faults that occur between routine tests are not allowed to affect the service because the presence of an operator ensures the discovery of the faults and the consequent diversion of traffic to other channels. In an automatic exchange, however, the human element is to a great extent replaced by mechanical switching devices which necessarily have but a limited ability to discriminate between normal and abnormal conditions.

It follows therefore that service could be seriously degraded by the continuance for long periods of undiscovered faults on automatic systems. To avoid this state of affairs, as far as possible, and to obtain early advice of the existence of faults, it is necessary to carry out exhaustive routine tests at comparatively frequent intervals: on the apparatus used in automatic exchanges.

The methods of routine testing employed vary in accordance with the requirements of particular exchanges and are divided under two heads, as follows:—

(1) Manual Testing involving the constant attendance of maintenance officers for the manipulation of the manual and semi-automatic testers employed and for the purpose of associating them with the apparatus to be tested. This method is used extensively in exchanges where only small numbers of each type of apparatus are involved.

(2) Automatic Testing which normally requires attention only when a fault has been discovered in any piece of apparatus under test. This method is used where, owing to the large numbers of each item of apparatus or the complexity of the tests required, it would be uneconomical to employ manual methods.

It is intended in this series of articles to deal with the routine testers which are included under heading 2, giving a general description of the functions applying to all routiners and of certain individual circuit features which are considered to be of special interest.

The routiners to be described are those at present installed in the earlier London Exchanges and, if space permits, others for which access equipment has been, or is being, provided.

Those routiners fitted as part of the main installation are designed for testing the following apparatus:—

(1) Subscriber's and Incoming 1st Code Selectors.
(2) Directors.
(3) C.C.I. Repeaters.
(4) C.C.I. Coders.
(5) Senders.
(6) Keysending "B" Position Apparatus.

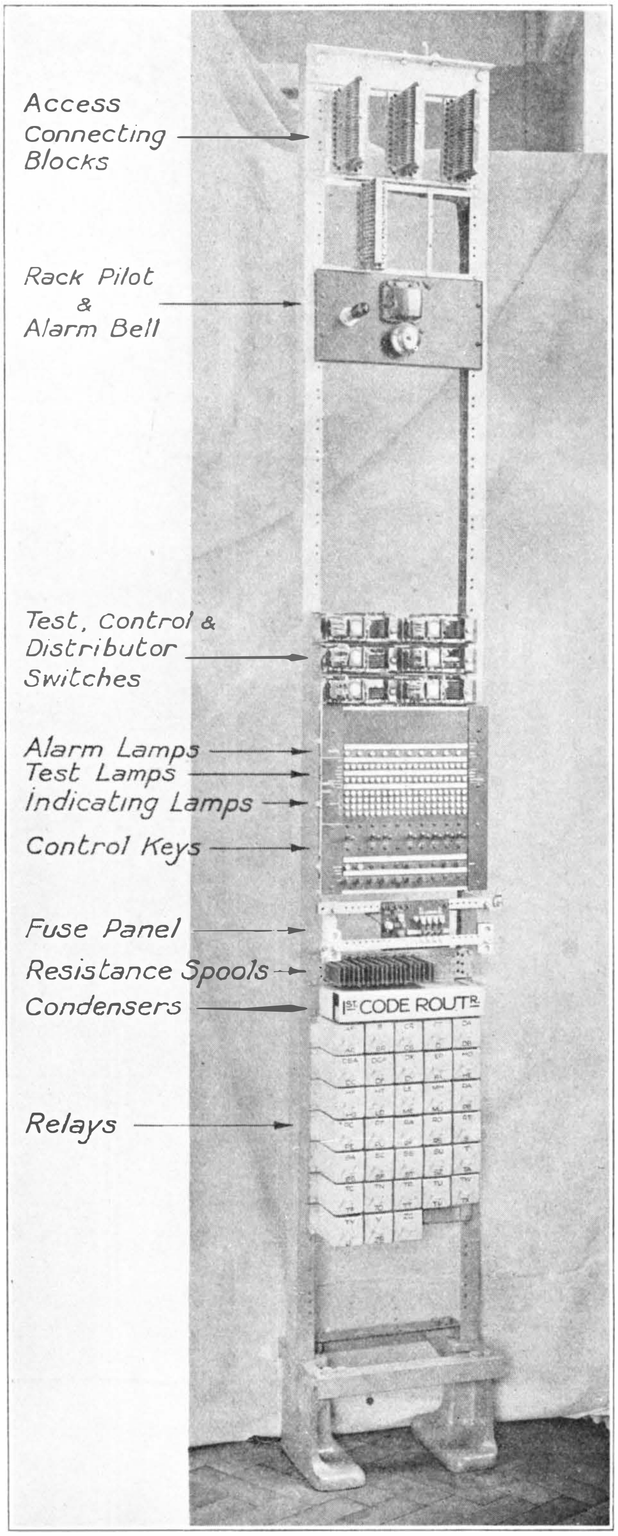
Three other routiner circuits have been designed and are undergoing circuit laboratory trials. These are for testing:—

(1) 11-20 line P.B.X. Final Selectors.
(2) Large Group P.B.X. ,, ,,
(3) C.C.I. Junctions.

Routiners are composed of two main parts: the test and control apparatus, and the access equipment.

The test and control apparatus is generally mounted on a special rack located near the equipment it is intended to test and consists of switches, relays and keys for controlling the sequence of tests to be applied and for changing the circuit conditions as required.

The access equipment consists of a primary distributor (in a few exceptional cases there are also secondary distributors) and access switches. The latter are in most cases mounted with the apparatus to which they afford access, while the former are mounted on the routiner rack. Generally, only 20 contacts of the access switch bank are used; this is in order to give a better numbering and cabling scheme.



1ST CODE SELECTOR ROUTINER.

The functions which are common to most routiners are summarised as follows:—

(1) Afford, in cyclic order, access to the apparatus to be tested, as shown in Fig. 1.

(2) Step over contacts of the access switch associated with unequipped apparatus. The stepping is effected in various ways. In some cases by self-interrupted drive; in others by a relay connected to the unequipped contacts, which provides an additional step to the access switch and delays progress of the routiner tests during the stepping; and in other cases by a battery connected to the unequipped contacts to operate a relay in the routiner which is switched into circuit for a given period.

(3) Step over contacts of the primary distributor when no equipped apparatus is connected to the access switch. This is effected as mentioned in (2).

(4) Step the access switch after satisfactory completion of the cycle of tests on one set of apparatus.

(5) Step the primary distributor to the next equipped access switch when all the apparatus associated with the previous access switch has been tested.

(6) Effect stepping of the access equipment manually by means of push type keys to any required set of apparatus for the purpose of continuously routining same.

(7) Routine test continuously any required set of apparatus and ensure adequate guarding of same between the test cycles. A key designated "Continuous Routine" is provided for the purpose of disconnecting the normal access equipment stepping circuits, thereby causing the tests to be repeated on the same set of apparatus.

(8) Afford indication, by means of lamps on the routiner rack, which set of apparatus is being tested. In some cases an individual lamp is associated with each set of apparatus to be tested; in other cases shelf lamps with a common set of access switch lamps are provided; and in the remaining cases one set of lamps and a lamp indicating key are

provided, the key being employed for the purpose of associating the lamps with the access switches or the primary distributors as required.

(9) Afford lamp indication of the particular test in progress. These lamps also afford indication of the test which failed when a fault is encountered. One level

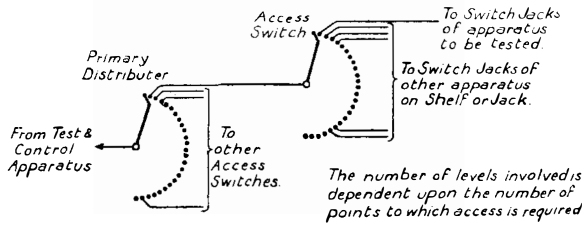


FIG. 1.

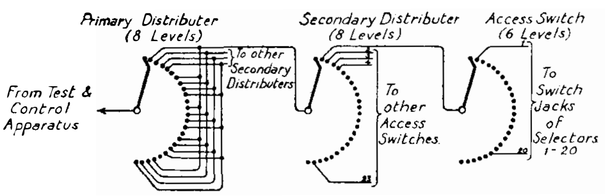
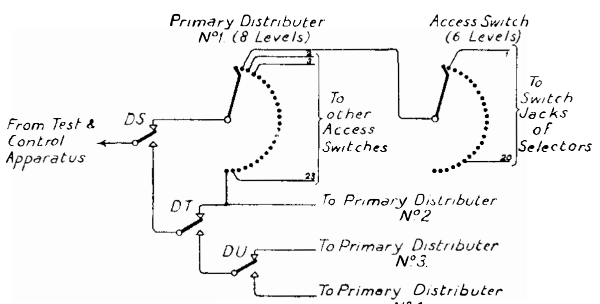


FIG. 2*a*.



Contacts DS, DT, & DU are contacts of the switching relays used to switch the testing connections through when making a continuous routine test

FIG. 2*b*.

of the test switch, where fitted, has its relevant bank contacts connected to these lamps. Where a test switch is not fitted, contacts of the relays controlling the test are used.

(10) Stop the routiner when a fault is encountered and give an alarm. In most cases an alarm is given after the expiration of a certain period from the commencement of each test, if the test has not been satisfactorily completed within that period. In a few cases an alarm is given if the whole test cycle is not completed within a certain time. The routiner stops due to the fact that the application of the following test depends upon the satisfactory completion of the test in progress.

(11) Provide by means of a key restoration to normal of the testing equipment and a re-test of the same set of apparatus when a fault occurs. A key, " Reset," is provided by which a " Reset Relay " is operated, the contacts of which are connected in such a manner that they disconnect the holding circuits for alarm relays, provide a release or homing circuit for each testing switch and operate a relay to delay the restart of the test cycle. The operating circuits of relays associated with the test switch are disconnected during the homing of that switch.

(12) Provide remote control of the " Reset " facility. Jacks, spaced at convenient distances, are provided on the racks of the apparatus to be tested and connected to the " Reset Relay." With each routiner a plug, cord and pear push are provided and by inserting the plug into any one of the jacks mentioned above the " Reset Relay " in the routiner may be operated by the maintenance officer while observing any set of apparatus on which a fault exists.

(13) Provide, by means of a key, stepping to the next set of apparatus and restoration to normal of the testing equipment when a fault occurs. A key, " Step On," is connected in such a manner that it performs similar functions to those provided by the " Reset Relay " and in addition operates the relay which would normally operate at the finish of the test cycle in order to step the access equipment.

(14) Provide fault imitation keys to check that the routiner will give an alarm when particular faults are encountered. Keys are connnected in such a manner

as to simulate faults which would seriously interfere with the general service either in the normal way or when the routiner is in use.

(15) Provide an indication that tests on all associated equipment have been completed. A " Routine Finished " relay is connected to the contact of the primary distributor following the last equipped contact. The operation of this relay gives lamp and alarm indication.

A general outline of the operating procedure may be of interest at this stage.

Before commencing a routine test, it is essential that certain tests shall be applied to ascertain that the routiner will function correctly when certain faults are encountered. In order to do this a " Fault Imitation " key is thrown and then the start key. The routiner will commence operating and when the particular test is made the simulated fault should cause the routiner to stop and give an alarm. The reset key may then be thrown, one fault imitation key restored and another operated, when on release of the reset key the routiner will recommence. This procedure is followed until all the fault imitation keys have been operated in turn.

To start the routiner for a normal test of the whole of the associated sets of apparatus the " Start Key " is thrown. The routiner will then proceed with the testing until it encounters a fault, when an alarm will be given by means of a local trembler bell and the main alarm system which includes the rack pilot lamp.

Particulars of the fault as indicated by the test lamp, and the switch or set of apparatus being tested are recorded. The latter is indicated by the lamps associated with the access equipment.

The maintenance officer may now investigate the fault if he considers that additional information would be helpful or that it may be readily cleared. If the fault is cleared the " Reset Key " should be momentarily operated for sufficient time to allow the test switch to return to normal. The same set of apparatus will then be re-tested. If the fault has not been cleared the " Step On Key " should be momentarily operated, after which tests will commence on the next set of apparatus.

On completion of the normal routine test an alarm is given. The maintenance officer may now use the routiner for the purpose of continuously routine testing those sets of apparatus in which faults have been discovered and not cleared during the normal routine test. In this connection the " Continuous Routine Key " is thrown and then the " Primary Distributor Stepping Key " manipulated until the primary distributor reaches the access switch with which the particular set of apparatus is associated. The " Access Switch Stepping Key " should now be operated to step the access switch to the required set of apparatus. The associated lamps indicate the positions of the distributor and access switch as they are moved. Should the routiner have two primary distributors and the required apparatus be associated with the second, the " Distributor Selecting Key " should be thrown prior to the manipulation of the stepping keys, thus giving direct stepping to No. 2 distributor. The " Start Key " should now be operated and the set of apparatus will be continuously routined.

The apparatus being tested may be observed throughout the tests and, when a fault occurs, the routiner may be " Reset " by means of the pear push and cord previously mentioned, without the necessity for the observing officer's return to the routiner.

It may so happen that the fault is only connected with one test of the routiner; in this case certain other tests may be cancelled by throwing the relevant " Test Cancel Keys " where fitted. These may also be thrown when making a general routine test to reduce the testing time, or when it is desired to locate faults of a definite nature.

While the officer is in attendance the main alarm system is disconnected from the local routiner alarm (trembler bell) by the operation of the " Main Alarm Key."

There are other uses for the " Continuous Routine Key." For instance, if during a general routine a fault is located which has previously given trouble (a fault of an intermittent nature) the continuous routine key may be operated previous to the reset key and the fault investigated as in the case of a continuous routine test. Afterwards the continuous routine key may be restored and the general routine resumed. Another use is to enable the routiner to test a particular group of switches. In this case the routiner is stepped to a particular switch as for a continuous routine test and after the test cycle has commenced the continuous routine key is restored.

First Code Selector Routiner.

In this routiner a " Control Switch " and a " Test Switch " are fitted. The Test Switch changes the tests to be applied in the required sequence while the Control Switch changes the conditions to the access leads as the tests progress.

Where two primary distributors are fitted, a " Distributor Selecting Key " is provided to switch the primary distributor stepping circuit direct to No. 2 distributor when manually stepping prior to a continuous routine test. If three primary distributors are fitted, two keys would be provided.

Where more than three primary distributors would be required, one primary distributor and four or more secondary distributors are fitted as required. This arrangement, as shown in Fig. **2**a, avoids the use of a large number of switching relay contacts, as shown in Fig. **2**b, which are potential points of failure.

In view of the difficulty of automatically busying outlets on selector levels, the vertical and rotary stepping tests are usually made by manual routine testers, which are associated with the necessary points by means of the test jack provided on each selector. In some of the earlier exchanges, however, all the points required for this purpose were not provided and it was therefore necessary to seek some alternative means of access. Since the auto routiner access points are similar to those required for the manual tester, a test jack is fitted common to the access equipment and can thereby be associated with each selector in turn, or with any particular selector as required. The points of access on each selector are P, +, − ingoing connections, the meter connection and the K relay.

Before the cycle of tests is commenced, it is necessary to ascertain whether or not the selector position is equipped. Various methods are employed to effect this. In some exchanges the meter connection of equipped selectors is continuously earthed except for the metering period during which battery is applied. This fact is utilised to determine that the position is equipped. A differentially wound relay, with the coils normally in opposition is so connected to the selector meter lead (see Fig. **3**a) that if either earth or battery is found the relay will operate and cause the routiner to proceed with

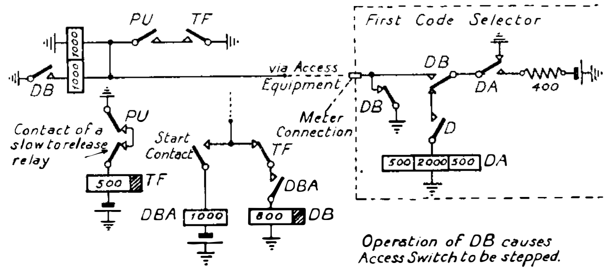


FIG. **3**a.

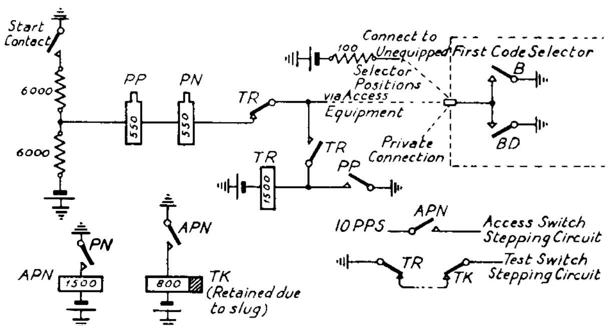


FIG. **3**b.

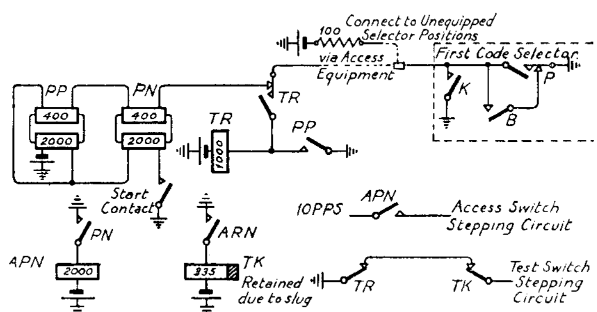


FIG. **3**c.

the tests. If the differential relay does not operate, the release of a slow relay steps the access switch to the next position. The " Unequipped " test is followed by the " Selector Busy " test, for which conditions are applied to the private to determine whether or not this is earthed. Should the private remain earthed for more than 2—4 mins. an alarm is given. In many other exchanges the " Position Unequipped " and " Selector Busy " tests are applied simultaneously during the releasing period of a slow relay, as shown in Figs. **3**b and **3**c, where polarised relays are used. In these cases the two polarised relays are connected on the one side to the centre point of a battery and

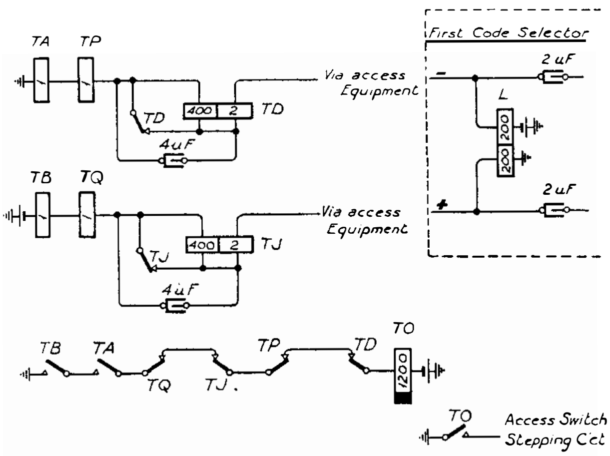


FIG. **4**a.

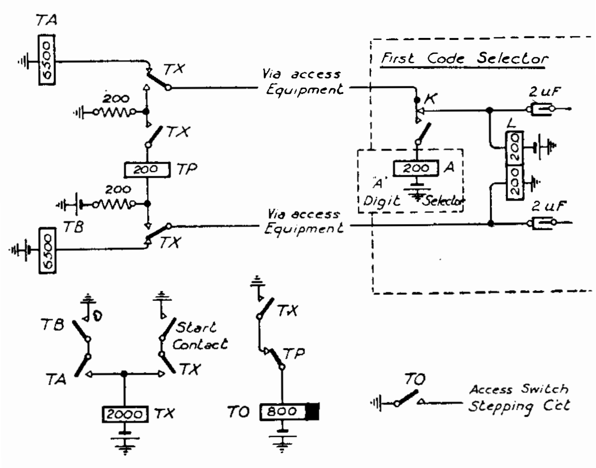


FIG. **4**b.

earth-connected resistance and on the other to the private. These relays have been arranged to discriminate between earth (busy), battery (unequipped) or disconnected (free) conditions. If battery be found, the operation of relay PN causes the access switch to step to the next position, while if PP operates, further tests are delayed until the selector becomes free or if still busy after 4½ mins. an alarm is given.

It will be noticed that all negative conditions are tested during delay periods.

Having determined that the selector position is equipped and the selector disengaged the private of the selector is earthed by the routiner while the ingoing lines are tested. The latter is accomplished by connecting three relays (in some cases two) to each line, as shown in Fig. **4**a. TD or TJ operate should direct battery or earth, respectively, be found; TP or TQ if the potential is abnormal due to contacts on the banks of the preceding switches; and TA and TB only if correct potentials, with the usual margins, are obtained. Where split loop impulsing, involving switching operations on the ingoing leads when the selector L relay is operated, is employed, the test is as follows:—A high resistance relay is connected to each line to test for continuity without operating the "L" relay, after which a Wheatstone network is applied, see Fig. **4**b, to test for any out-of-balance conditions.

The " L " relay of the selector having been operated, the private should be earthed. This is verified by a simple test at this stage.

In the case of " Forced Release " of the selector, earth is removed from the holding circuit of the K relay and hence in order that the routiner may determine that " Forced Release " has occurred this is made an access point. It is also used to determine when a free " A " Digit Selector has been found. The latter test has made it necessary in some exchanges to use the connection between the K relay and the rotary switch drive magnet for the access point. This is due to the K relay being held from the First Code Selector instead of the " A " Digit Selector. The respective access points and associated routiner connections are shown in Figs. **5**a and **5**b. It will be seen from Fig. **5**a that if after a given delay period (this allows ample time for the hunting of the " A " Digit Finder and the resultant switching operations) relay TE is not operated then earth is not being returned from the " A " Digit Selector. In Fig. **5**b relays TE and TES will operate while the " A " Digit Finder is hunting and, when hunting ceases, relay TES will release due to the absence of direct earth and thus operate TER. If the " A " Digit Selector has not been seized, this will be proved in the next test by relay TE

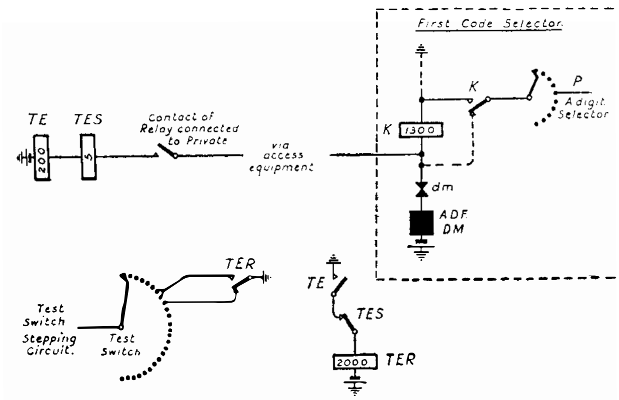


FIG. 5*a*.

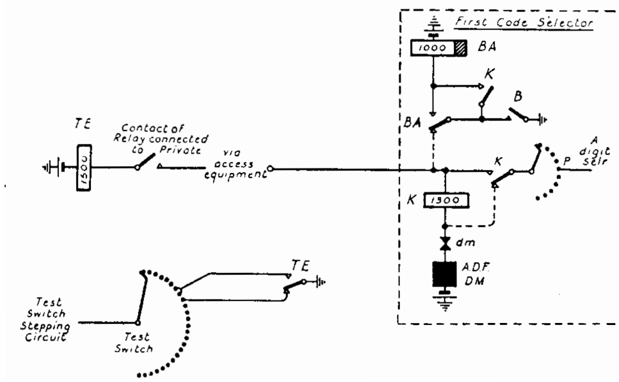


FIG. 5*b*.

remaining operated when it should have been released due to " Forced Release " condition.

After the " Forced Release " test has been applied the ingoing loop is opened for a given period to allow the selector to restore to normal. The private is guarded by the routiner during this period. The selector is then re-seized and a single digit sent to the " A " Digit Selector. The " Forced Release " from the Director is then tested in a similar manner. Owing to the length of time required to ascertain that " Forced Release " conditions are received from the " A " Digit Selector and Director respectively, cancel keys are fitted in order that either or both of these tests may be cancelled if so required.

A 50-point sending switch is used in this routiner. The connections of one level of the switch are wired to a tagblock as shown in Fig. **6** and the sending control relays are commoned on this tagblock as required for the sending of the predetermined four digits, a single digit to test the Director " Forced Release " and a train of three digits to set up " Through " conditions. Keys are not used for setting up the digits as only specially allotted digits may be sent. The " Through " conditions are established *via* a spare selector level, usually " Second Code," back to the routiner and so are under the control of the routiner.

The " Manual Holding " feature of the selector is tested by connecting battery to the outgoing positive lead while two slow relays release in tandem, the ingoing leads being disconnected at the same time. When both relays have released, the private is tested to ascertain if it be still guarded by the selector. In some equipments the period of relay release is augmented by a 1.5 sec. stepping pulse to the test switch. This period is designed to allow full release of the selector, before the private is tested, should the " Holding " feature be faulty.

The application of the next test is delayed while the selector is allowed ample time to restore to the normal " Through " conditions. The battery and earth connections of the outgoing leads are reversed and the meter connection tested for the metering condition. Resistances equal to the test or adjust figures may be introduced into the outgoing leads by key operation previous to commencing the routine. This feature is used in conjunction with continuous

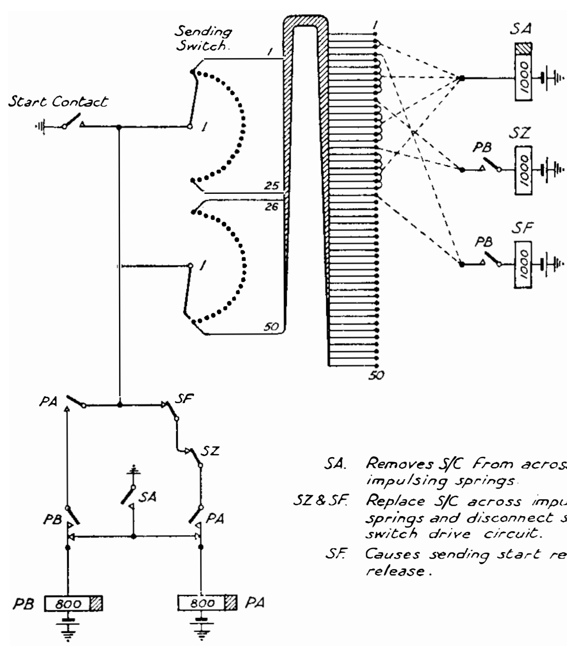


FIG. **6**.

routine testing to ensure that the selector D relay is in correct adjustment and remains so during several consecutive tests. Experience has shown that this feature is not warranted and hence it will not be included in future routiners.

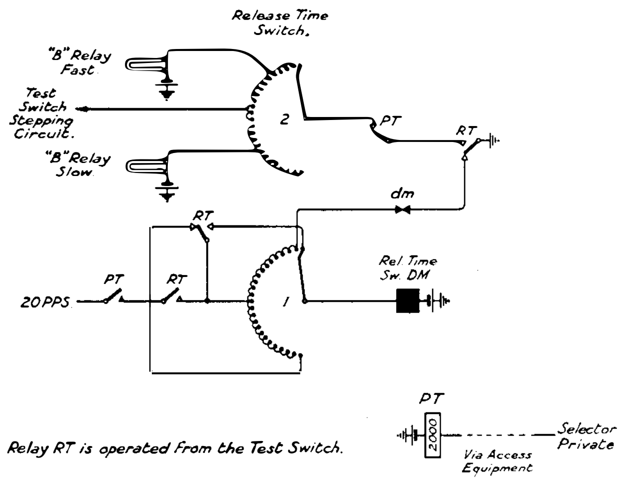


FIG. **7**.

Pulses are now connected to the Release Time Switch (see Fig. **7**) and at the same time the selector ingoing loop is opened in order that the period during which earth is retained on the private may be timed. When the earth is removed from the private by the selector an alarm operates if the period is longer or shorter than normal.

In this routiner the fault alarm is given after $4\frac{1}{2}$ mins. A Time Check Relay (Relay No. 192A) is stepped by 1.5 sec. earth pulse. The relay commences to operate as each test is applied and is released when the test proves satisfactory. The period of $4\frac{1}{2}$ mins. is chosen as this is required for the " Selector Busy " test. The release alarm is given after 9 secs., a Time Alarm Relay (Relay No. 157A) being stepped by 1.5 sec. earth pulses. In some exchanges, Relay No. 157A is used for both alarms and is stepped by $\frac{1}{2}$ min. earth pulses for the fault condition, while in other exchanges the S and Z schemes are employed.

" Fault Imitation " keys are fitted in this routiner to simulate the following conditions:— " Direct Earth " or " Battery Contact " on either ingoing line, " Selector Position Unequipped," " Selector Busy," " Meter Fail " and " Private Disconnected."

Indication of the selector being tested is given by a shelf lamp and a shelf position lamp.

In order that traffic statistics on Directors may be more accurately analysed, a meter is arranged to record the number of times that Director meters are operated due to the functioning of this routiner.

AN ARTIFICIAL TRAFFIC MACHINE FOR AUTOMATIC TELEPHONE STUDIES.

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Engineering Department Standard Telephones and Cables, Ltd.

[*Reprinted from " Electrical Communication," October, 1928.*]

DESIGNERS of automatic telephone exchange equipments have at all times felt the need for positive data to enable them to provide the most economical, yet adequate, quantities of equipment for efficient service. Consequently close attention has been given to the theory of probability by means of which fundamental formulæ and curves have been devised, enabling the equipment engineer to determine readily the equipment quantities required to carry any known traffic with a particular switching arrangement and a specified grade of service. Various investigators engaged in probability research have produced basic formulæ, which, while being approximately in agreement for general traffic conditions, are nevertheless at variance in certain respects owing, in some cases, to the different physical assumptions made, and in other cases, to the different methods of interpreting these assumptions in developing formulæ. Each has in turn resorted to experiment to justify assumptions and to obviate laborious or impracticable mathematical work. In these experiments different methods have been employed to reproduce physically a sequence of events governed by the laws of pure chance and analogous to those obtaining in telephone traffic. So far as the writers of this article are aware, all the methods hitherto adopted required a long period of time for one experiment, and involved careful plotting on graphs of a very large number of points. As a test, the method often adopted, of obtaining from a telephone directory a random series of four-digit numbers representing the times of call originations in ten-thousandths of the busy hour,

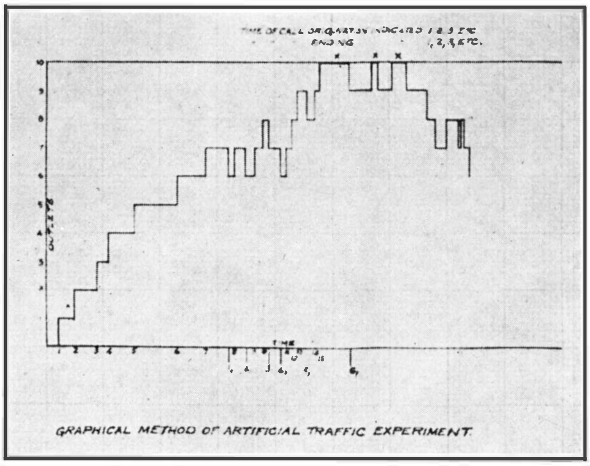


Fig. 1.—Simultaneous Calls in progress at any Interval.

was tried and it was found that with two men employed on the work there was an average interval of 20 seconds between the recording of two successive call originations on a graph. In this method each originating call is assumed to continue for a constant holding time—usually 2 minutes—and the number of simultaneous calls in progress at any interval is indicated as shown in Fig. **1**. If ten switches are being considered, any call arriving whilst ten simultaneous calls are in progress is lost. This condition is reached at points " X " marked on the graph. To obtain reliable results the experiment should be continued until about 20 lost calls are recorded so that to verify conditions with a grade of service of 1 in 1,000 (P = 0.001) it would be necessary to record 20,000 calls on the graph. This, at the rate indicated, would occupy 222 man-hours and even if by practice this time could be reduced it will be seen that one experiment involves a considerable amount of labour and time.

The object of this article is to outline a development which has been undertaken with a view to producing a machine for the production, distribution and analysis of artificial traffic so that experiments may be carried out within a reasonably short period of time and with a considerable reduction of the tiresome work involved in graphical methods. Whilst the design of the machine described here is limited to the study of the comparatively simple trunking arrangement known as two-group grading, the principle involved readily admits of an extension of its application to more general cases.

Two main requirements have to be met in the machine:

1. It must produce a random time distribution of originated calls.
2. It must give facilities for applying the traffic so produced to particular switching arrangements, in such a manner that the traffic distribution through the system is readily obtained.

Production of Artificial Traffic.

The time distribution of call originations is arranged to satisfy the following conditions:

1. Calls must originate in a purely chance manner.
2. The calling rate taken over a long period must be uniform.
3. A large number of call originations per holding time must be possible. This means that the traffic must represent that which would originate from a large number of subscribers.

To obtain numerical results readily, steel balls such as are used in ball bearings are utilised to represent calls, thereby giving each originated call a physical identity. The random traffic distribution is obtained (Figs. **2** and **3**) by directing a stream of balls from a funnel on to a large steel ball placed above the centre of a wire grid which supports a small number of funnels connected to rubber tubes leading to the lower part of the machine. The balls, after striking the deflecting ball, are scattered in a random manner over the grid as indicated in Fig. **2** and a small proportion at chance intervals enters one or other of the funnels, which are spaced irregularly over the grid. These balls now represent originated calls, and the remainder which have fallen through the grid are directed by means of

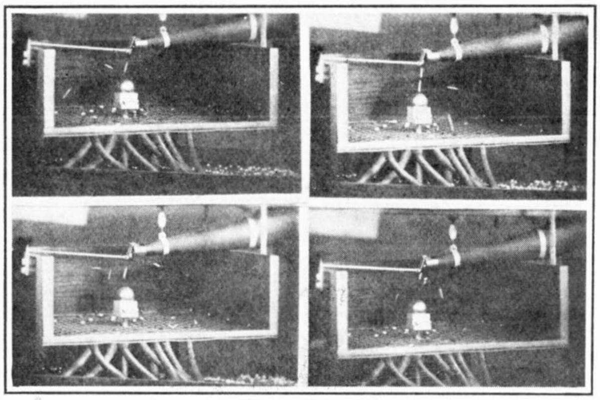


FIG. 2.—RANDOM TRAFFIC DISTRIBUTION ILLUSTRATING STREAM OF BALLS, LARGE STEEL DEFLECTING BALL, WIRE GRID AND RUBBER TUBES LEADING TO LOWER PART OF MACHINE.

an inclined plane to a container fixed on the outside of the cabinet. The balls collected in this container are regularly transferred to the main supply at the top of the cabinet. The box containing the supply of balls is provided with an inclined glass-lined base so that an even flow of balls is supplied to the funnel. The funnel adopted, after several experiments with different shapes and types, consists of a loud-speaker horn which is hinged to the supply box so that the slope may be adjusted to the best value for an even flow. A baffle plate is fitted at the outlet from the funnel, and is operated by means of a shaft terminating in a milled nut at the side of the cabinet. This baffle plate serves to direct the stream of balls on to the deflector. The deflector is provided with both horizontal and vertical adjustments. The distribution of the balls can therefore be adjusted to cover the whole area of the grid over which they are scattered.

METHOD OF SETTING UP SWITCH ARRANGEMENTS.

The balls which enter the rubber tubes are led through the inclined plane on which the other balls fall. They then drop into a wooden runway which directs them to the lower part of the machine representing the switching equipment. The original design represented two switching stages—a 24- or 25-point line switch stage followed by a 10-point selector stage. The arrangement is shown in Fig. 3, and although this has been modified in the later design it is described here to indicate the facilities which may be provided.

In Fig. 3 the multipled 25 outlets from a group of line switches is represented by an inclined aluminium runway with 25 holes, each hole being provided with a "busying" device arranged to close it for a period equal to a call holding time whenever a ball drops into it. A ball starting from the beginning of the runway proceeds along it, passes all busy outlets and enters the first free one, thus giving a mechanical representation of a call hunting by means of a line switch for a free outlet. Before they enter the line switch runway, the balls from the wooden runway pass through a separating device which ensures a certain time interval between the arrival of two balls in the line switch runway. This is done to prevent the mechanical equivalent

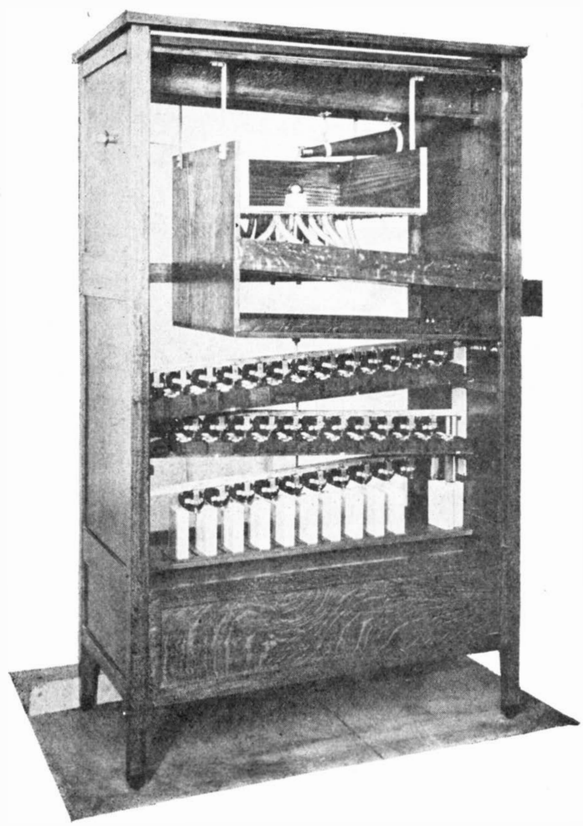


FIG. 3.—ARTIFICIAL TRAFFIC MACHINE. LOWER PART OF MECHANISM REPRESENTS SWITCHING EQUIPMENT.

of a double connection, which would otherwise occur in the machine more frequently than in actual practice. A ball which finds all line switch outlets engaged falls through a hole at the end of the runway into a tube leading to an overflow bin. This represents a call which has failed to find a free outlet on the first half-revolution of a line switch; but since a line switch continues to hunt till a free outlet is found, this ball must immediately be transferred to the beginning of the line switch runway and must be allowed to hunt again.

For convenience in designing the cabinet, the 25 outlets representing the line switch multiple are arranged in two groups, one of 13 and one of 12—the upper two runways in Fig. **3**. If it is desired to represent the 24-point multiple of the homing line switch, one of the 25 outlets is permanently "busied."

The outlet "busying" device shown in Fig. **3** consists of an ebonite roller mounted below the outlet. Attached to the side of the roller is a short glass tube the bore of which is slightly greater than 5/16″. A 5/16″ diameter steel ball is enclosed in the tube; the remaining space is completely filled with a mixture of glycerine and water, and both ends of the tube are sealed. In the free condition, the tube takes up a vertical position due to the weight of the steel ball, and in this position the roller presents a pocket to the outlet in the runway. A steel ball on reaching a free outlet, drops into the pocket, turns the roller over and drops into a runway below, parallel to the first, and leading to the next switching stage. Meanwhile the roller having been turned over is prevented from returning to the normal position by a pin which engages a pawl, the arrangement being such that the roller can rotate in one direction only. In the locked position, the roller closes the runway outlet while the glycerine tube is held in a position slightly inclined to the horizontal. In Fig. **4** the first three outlets are shown engaged. The ball enclosed in the tube rolls slowly down, the motion being restricted by the glycerine. When the ball has passed the centre of the tube its weight turns the roller over to a second normal position 180° removed from the first. In this position a second pocket is presented to the outlet which is, therefore, free again. The time taken for the roller to leave one normal position and restore to the second represents the holding time of the call. The average value of this time should be the same for all rollers to reproduce conditions corresponding to those assumed in theory.

In the original design, a ball having taken a line switch outlet is carried by means of the runway below the rollers to the top of a similar runway equipped with 10 outlets representing the multipled outlets from one level of a group of selectors. The delay between the seizure of a free line switch outlet and the subsequent seizure of a selector outlet is somewhat longer in the traffic machine than in actual automatic switching. The runways are, however, arranged so that the time between the commencement of hunting at the line switch stage and the commencement of hunting at the selector stage is the same for all calls. Thus the slower hunting speed and delay between stages does not affect the traffic distribution.

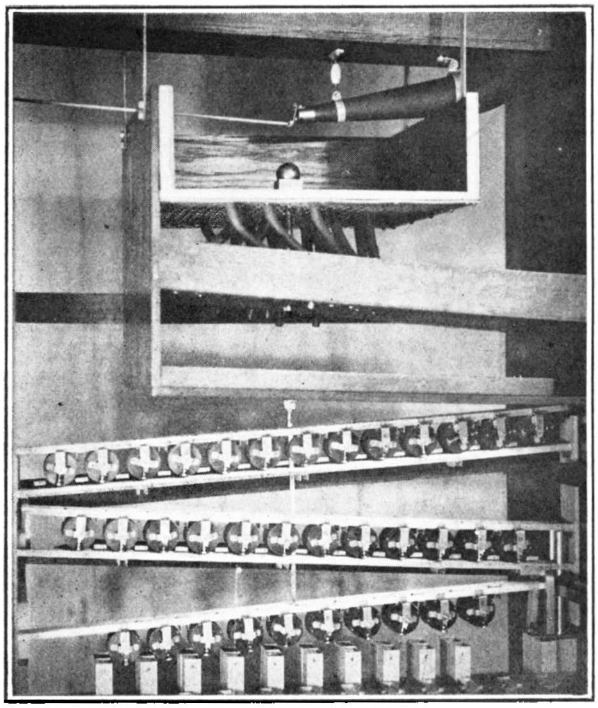


FIG. **4**.—ARTIFICIAL TRAFFIC MACHINE. FIRST THREE OUTLETS SHOWN ENGAGED BY MEANS OF "BUSYING" DEVICE.

Since the traffic from subscribers' line switches is not all routed over the same level of first selectors, the artificial traffic machine must be arranged to satisfy this condition. For the purpose of traffic experiments it is not necessary to study more than one level; traffic to the other levels need not be analysed. A mixture of two sizes of balls is, therefore, used and, after leaving the line switch runway, the balls pass a separating device which routes the larger size to the selector runway and the smaller size, representing traffic to other levels, to an analysis bin. The mixture of the two sizes thus controls the average value of the fraction of the total traffic routed over the level which is being studied.

The outlets in the selector runway are tested in turn in exactly the same manner as already indicated, and when a free outlet is found, the ball, having turned the roller over, is dropped into an analysis bin placed below the roller. If all 10 outlets are busy the ball drops through a hole at the end of the runway into a separate bin. Thus the number of calls received by any one outlet or the number of lost calls is given by the number of balls found in the corresponding bin at the end of the test.

In order to carry out tests on the distribution of traffic at the line switch stage, two sets of analysis bins, corresponding to the two halves of the line switch runway, are provided. These analysis bins can be seen in Fig. **3**, numbered 1, 5, 10, 15, 20 and 25. When these bins are placed in position alongside the runways, the balls which take line switch outlets drop into short channels each leading to a bin corresponding to a particular outlet.

Facilities for two-group grading are provided by duplicating the whole of the mechanism representing the switching arrangements as described above. The rubber tubes from the wire grid are divided into two groups leading to two wooden runways which serve the two sets of line switch and selector runways. Each of the duplicate line switch and selector runways consists of two channels fitted close together and equipped with one set of rollers double the width of the first rollers so that the two outlets controlled by one roller may be " busied " by a ball from either channel. The double runway is mounted alongside the first, and the partition between the single runway and the adjacent channel of the double runway is provided with a series of gates, one between each pair of outlets. The arrangement is shown in Fig. **5**. At the beginning of the line switch or selector runways, the balls enter the two outer of the three channels so that if it is desired to run the two groups of outlets with no grading, the centre channel is not used. If some of the outlets in the two groups are to be graded, the gate before the first graded outlet is thrown across the single runway, so that a ball finding the individual outlets in that runway engaged, is deflected into the centre channel and proceeds to test the outlets which are also being tested by balls in the outer channel of the double runway. A trunking arrangement with individual outlets following graded outlets (called " reversed grading " by the British Post Office) can be provided by setting the gate after the last graded outlet across the centre channel, so that a ball which finds the graded outlets in the centre channel engaged, is returned to the single runway to test the last group of individual outlets.

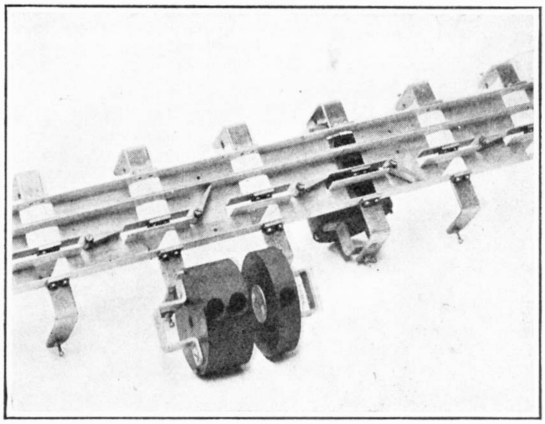


FIG. **5**.—DOUBLE RUNWAY PROVIDED FOR TWO-GROUP GRADING.

Arrangements are also provided in the machine for enabling a call to be routed from either of the two line switch multiples to either of the two selector groups. Thus, a ball having taken a particular line switch outlet, may either drop into the channel immediately below it and leading to one selector runway, or, by means of a deflector which clips on to the channel below the roller, the ball on falling out of the roller may be deflected to the runway which leads to the other selector group.

The trunking scheme of the machine as described above is shown in Fig. **6**.

It was proved that with the design of " busying " device described above, owing to the difficulty of adjusting all rollers to have the same average holding time, it was not possible to obtain any accurate results from tests. This difficulty was caused by the slight differences in

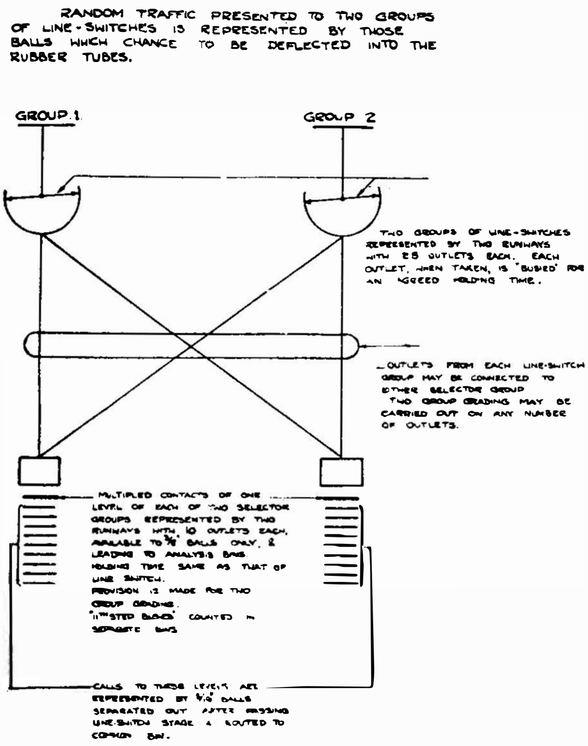


FIG. **6**.—TRUNKING SCHEME OF ARTIFICIAL TRAFFIC MACHINE.

the several timing devices and the individual adjustments which were necessary for each. It was, therefore, decided to introduce a timing device with a common control, the arrangement being such as to utilise the first model as far as possible.

The timing arrangement adopted is shown in Fig. **7**, and consists of a series of shafts, one running below each set of rollers, and all shafts being driven through gearing from a small electric motor fitted inside the cabinet. Each shaft carries a number of wheels (one per roller) which are driven through a friction clutch. The glycerine tubes are removed from the rollers, and one of the two pockets is filled in to load the roller, so that normally it takes up a position with the other pocket open to the runway. In this free position, the corresponding wheel on the rotating shaft is prevented from turning by means of a pawl which engages with a notch in the wheel. When the outlet is taken, the roller turns over as before, and in doing so, a pin, fitted in the side, strikes the pawl, and raises it out of the notch in the wheel, which immediately moves away from the normal position. The ball having dropped out of the roller, the latter tends to return to normal, but is prevented by the pawl, which now rests on the rim of the wheel against which it is forced, both by its own weight and by the roller. The outlet is thus held "busy" until the notch in the wheel has made a complete revolution, when the pawl drops in and releases the roller, and at the same time locks the wheel again.

One complete turn of the shaft, therefore, represents a call holding time, and since all shafts are controlled by the same motor, the holding

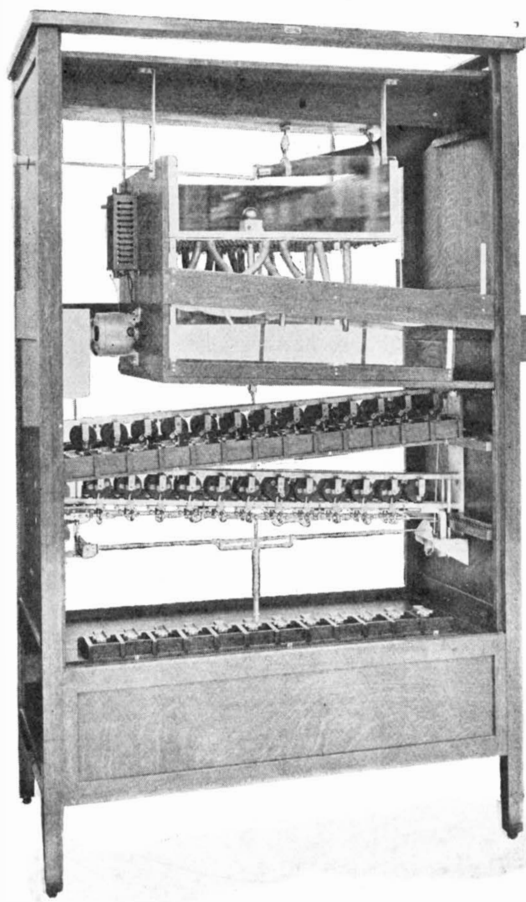


FIG. **7**.—ARTIFICIAL TRAFFIC MACHINE WITH COMMON CONTROL "BUSYING," DEVICE.

time of all outlets is the same. By varying the speed of the motor, the holding time may be adjusted within limits to any desired value.

The introduction of this type of " busying " device in the original model permits the use of only 23 of the 25 outlets in each line switch group (in Fig. **7**: outlets 12, 13 and 25 are shown permanently " busied "). The capacity of the machines, therefore, reduced for the present to one switching stage with facilities for studying the traffic distribution in two groups of outlets, each group consisting of any number of outlets up to 22. The arrangement for direct or reversed grading between these groups remain unchanged.

Although the reduction to one switching stage reduces the scope of the machine, it is possible with the single stage to study problems associated with the standard 10-group selector or with the 20-group selector. In this way the accuracy of the underlying principle of the machine may be tested and the machine may then be applied to the solution of problems such as arise, for example, with reversed grading. If required, arrangements can be made for adding the second stage.

Method of Making Tests.

Before a test is run on the machine, a preliminary experiment must be made to ascertain that a satisfactory volume of traffic is being obtained. The balls are allowed to run from the funnel, and the baffle plate and deflecting ball are adjusted to give a satisfactory distribution over the grid. The wooden runways leading to the lower part of the machine are closed to prevent the balls from proceeding further, and the time taken for a number of calls to originate is measured. From this the number of calls per holding time —*i.e.*, the traffic—is obtained, and if any change is required to the value given, this can be effected either by adjusting the number of rubber tubes or by altering the position of some of them on the grid.

To commence a test on both line switch and selector stages, the required grading and cross-connecting arrangements are made, and the balls are allowed to run through the machine until a number of calls are in progress. During the preliminary run all the balls are collected in a common bin placed below the selector runways. These calls do not count in the test. The test interval commences from the time when all the analysis bins, mounted on a platform at the bottom of the machine, are pushed forward into position below the rollers.

At the end of the test period, the platform with the analysis bins is withdrawn and the common bin is replaced. The aperture between the baffle plate and the funnel mouth is then closed to stop the flow of balls.

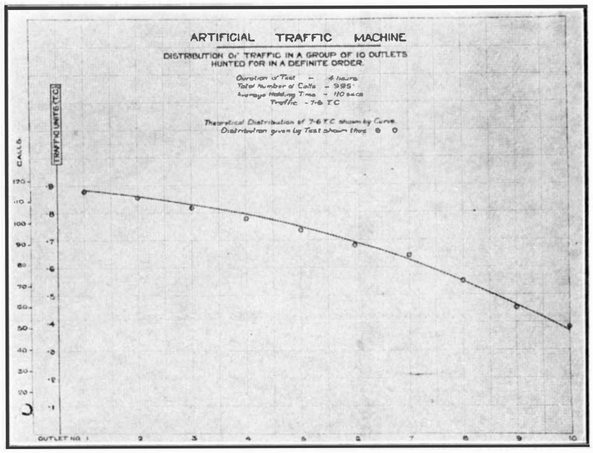


Fig. **8**.

A test on the line switch stage only, is carried out in the same manner except that during the preliminary run the balls are allowed to proceed to the selector stage, or in the present model, to a common starting bin. The test period commences when the group of wooden analysis bins is placed up against the runway and ends when these bins are withdrawn.

Results of Tests.

The machine in its modified form has been employed to determine the distribution of traffic in certain simple cases where the solution can also be derived mathematically. Results of such experiments are reproduced in graphical form in Figs. **8** and **9** and in tabular form in Tables I. and II. It will be seen that in Fig. **8** the mechanical analysis closely approximates to that deduced by theory; the machine, therefore, furnishes a direct means of solution for the complex cases where precise mathematical solutions are too laborous or are impossible.

Table I.

Test of Distribution of Traffic in Group of Ten Outlets Hunted for in a Definite Order.

Summary of Results.

Duration of Test	4 hours.
Total Number of Originated Calls	995.
Average Holding Time of Calls	110 seconds.
Traffic (a)	7.6 T.C.

Distribution.

Outlet No. (r)	Calls	Traffic Units (T.C.) Test	Traffic Units (T.C.) Theoretical (a_r)	Calls Test	Calls Theoretical
1	115	.879	.884	115	115.6
2	112	.856	.860	112	112.5
3	107	.817	.828	107	108.3
4	102	.779	.796	102	104.3
5	96	.734	.748	96	98.0
6	89	.680	.692	89	90.6
7	84	.641	.625	84	81.8
8	72	.550	.548	72	71.8
9	59	.451	.461	59	48.3
10	50	.382	.369	50	60.4
O/F	109	.833	.789	109	103.1
Totals...	995	7.602	7.600	995	994.7

Table II.

Test of Distribution of Traffic in a Two-Group Grading with Two Individual and Nine Common Outlets.

Summary of Results.

Duration of Test	5 hours.
Number of Calls to Group 1	475
,, ,, ,, ,, ,, 2	971
Total Number of Calls	1,446
Average Holding Time of Calls	104.6 seconds.
Traffic to Group 2	2.82 T.C.
Traffic to Group 1	5.78 T.C.
Total Traffic	8.6 T.C.

Distribution.

Outlet No.	Calls	Traffic Units (T.C.) Test	Traffic Units (T.C.) Theoretical	Calls Test	Calls Theoretical
1 Grp. 1	124	.737	.739	124	124.1
1 ,, 2	146	.868	.852	146	143.1
2	145	.862	.860	145	146.0
3	142	.844	.838	142	140.9
4	137	.815	.803	137	135.0
5	128	.761	.761	128	128.0
6	124	.737	.708	124	119.0
7	113	.672	.643	113	108.0
8	99	.589	.570	99	95.8
9	83	.493	.490	83	82.4
10	67	.398	.400	67	67.3
O/F	138	.821	.927	138	155.9
Totals...	1,446	8.597	8.600	1,446	1,445.5

The points through which the theoretical curve in Fig. 8 is drawn are those given in column 4 of Table I. and are derived from the formula:

$$a_r = \frac{\dfrac{a^{r-1}}{r-1!}}{1 + a + \dfrac{a^2}{2!} + \ldots + \dfrac{a^{r-1}}{r-1!}} - \frac{\dfrac{a^r}{r!}}{1 + a + \dfrac{a^2}{2!} + \ldots + \dfrac{a^r}{r!}}$$

where a_r = traffic carried by the rth choice switch of a fully available group hunted for in a definite order, and

a = total traffic approaching the group.

The expression:

$$\frac{\dfrac{a^r}{r!}}{1 + a + \dfrac{a^2}{2!} + \ldots + \dfrac{a^r}{r!}}$$

represents the probability that a group of r switches is completely occupied and can be denoted by p_r. The formula for a_r can, therefore, be expressed as:

$$a_r = a(p_{r-1} - p_r).$$

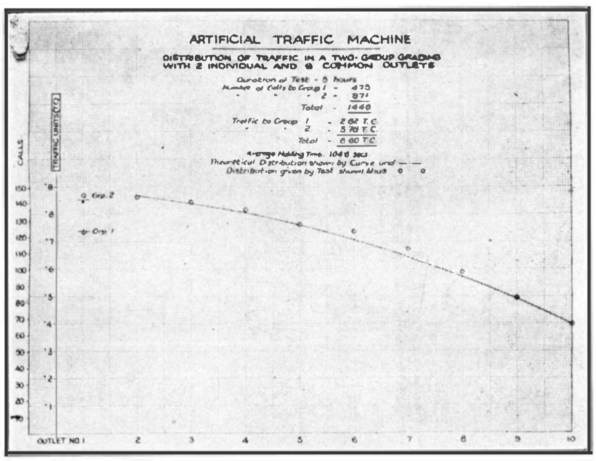


Fig. 9.

The theoretical curve in Fig. 9 is deduced in a similar manner. The traffic carried by each individual first choice is calculated from the formula, and the total overflow to the common second choice is then known. The total traffic which, presented to the first choice of a single group of ten outlets, would give the same overflow to the second outlet can then be determined.

This traffic is then substituted for the term "*a*" in the above formula to give the approximate theoretical traffic distribution over the common outlets. Fig. **9** indicates the extent to which the experiment agrees with the approximate mathematical method.

FURTHER DEVELOPMENTS.

The development of this model has led to the proposed design of an electrically controlled system in which the present arrangements for giving a random time distribution of originated calls would be retained while the switching arrangements would be represented by groups of relays and message registers, the latter giving the traffic analysis by direct readings. Such a scheme would be more flexible than the mechanical arrangement; and with the provision of a small distributing terminal assembly, would give facilities for studying any trunking arrangement.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST DEC., 1928.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
613,408	517	3,975	51,625	122	London	24,728	72,930	2,404,162	112,209
79,224	2,184	20,639	65,796	2,634	S. East	4,058	53,144	211,831	28,342
82,345	4,414	31,135	57,062	3,236	S. West	20,398	12,677	159,220	60,457
64,901	6,040	38,214	60,631	4,693	Eastern	24,116	40,116	122,600	68,312
98,244	8,408	45,308	59,410	3,843	N. Mid.	30,830	55,522	250,055	109,136
80,732	4,798	30,176	73,298	4,471	S. Mid.	12,147	24,175	192,946	87,515
58,743	4,730	29,871	52,928	3,311	S. Wales	6,461	26,312	124,233	71,918
105,632	8,027	26,456	50,337	4,281	N. Wales	13,687	41,089	280,174	61,604
160,362	1,481	16,409	43,641	2,511	S. Lancs.	13,849	79,155	478,925	49,265
93,962	6,225	30,838	46,888	3,018	N. East	11,715	46,380	244,011	74,617
64,859	3,893	24,521	38,080	2,134	N. West	8,661	34,851	172,339	31,548
47,863	2,523	16,127	25,687	2,702	Northern	4,909	16,335	110,801	49,163
21,666	4,566	8,404	13,782	542	Ireland N.	134	2,326	43,428	1,581
66,723	5,517	26,431	38,045	1,472	Scot. East	4,518	13,675	156,105	45,832
89,016	7,281	24,509	43,146	971	Scot. West	12,149	24,952	226,565	36,779
1,727,680	70,604	373,013	720,356	39,941	Total	192,360	543,639	5,177,395	888,278
1,693,618	70,466	371,339	713,439	40,038	Figures as at 30th Sept., 1928.	188,621	527,235	5,001,532	886,386

PROBABLE LOSS IN AUTOMATIC SWITCHING SYSTEMS WITH DOUBLE PRESELECTION.

VERY little has been published in the past on the theoretical aspect of this subject. Mention should be made, however, of articles by McHenry (*P.O.E.E.J.*, January, 1922) and Dumjohn and Martin (*P.O.E.E.J.*, July, 1922).

The following article is an abstract of a thesis by Dr. Baltzer, of Germany, dealing with the problem of loss in such a system.

Synopsis.—Brief description of Siemens system of Preselection, introducing the term "group control."

Probability that exactly 1 or 2, or 3, etc., groups of second preselectors are fully occupied.

Comparison of theoretical and practical results, as regards the effect of "group control."

Total loss in first preselector stage, excluding group control effect.

Total loss in first preselector stage, including group control effect.

Examples of the use of the formulæ for the purpose of comparison of various schemes of double preselection.

Criticism of Dr. Baltzer's Theory.

Further work by Dr. Baltzer.

(*a*) *Double preselection schemes with direct and indirect connections to group selectors, from first preselectors.*

(*b*) *Suggested law of the distribution of holding time.*

Most of the work published in the past, in connection with the determination of lost calls, has dealt with the loss of that traffic which arrives at a group of switches when all the available circuits from it are engaged on actual calls. This subject has been extended, however, by McHenry (*P.O.E.E.J.*, 1922), and lately by Dr. Baltzer, of Germany (extracts from whose work have appeared in "Zeitschrift Für Fermeldetechnik" of March and April, 1928), to the question of loss in double preselection systems, where additional calls fail due to the "group control" of first preselector outlets, an explanation of which is given below.

This system is, of course, the well-known one of Siemens Bros. An example of it is described in the next paragraph, the switch quantities being those made use of by Baltzer in his work. As nothing of a theoretical nature has apparently been published in the past on this particular subject, except the work of McHenry, it is thought that an abstract of the new theory of Baltzer may be of interest, especially as important problems arise in connection with the choice of the number of preselector contacts, the system of cross-connections, etc.

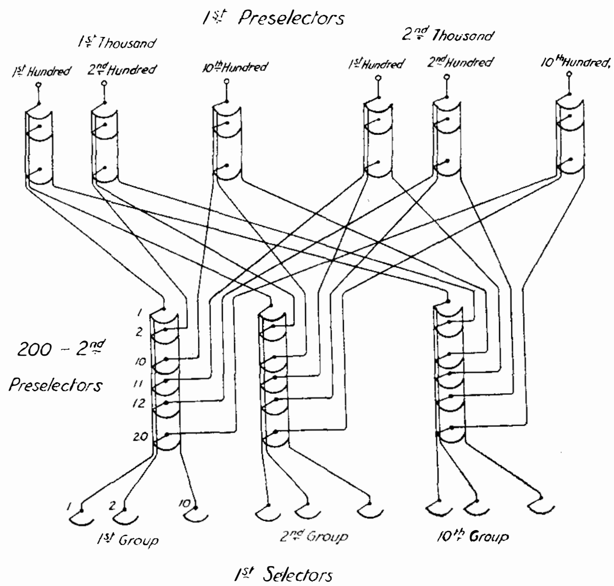


FIG. 1 Scheme of Interconnecting 1st & 2nd Preselectors.

Fig. 1 represents the system considered in the thesis. The 2000 lines are divided into 20 groups of 100 lines each. From the 100 first preselectors of one group, 10 circuits multipled to the banks of all these preselectors connect to the second preselectors, which in turn are divided into 10 groups A-K. The first circuit from the first group of first preselectors goes to a second preselector in group A, the second circuit from this group to a second preselector in group B, and so on. The banks of each group of 20 second preselectors are multipled, and connected to 10 circuits to first selectors. It may thus be seen that, if this group of 10 circuits to first selectors is in use, 10 out of the 20 second preselectors are "group controlled," *i.e.*, they cannot obtain an outlet to a first selector. Traffic testing these group controlled preselectors must thus be diverted to those groups that are not in the same condition, and, if all groups are thus controlled, the traffic is lost.

Deduction of an equation for the probability of group control among Z groups of second preselectors.

It is evidently possible that, at any instant, either no group, or only 1 group, or 2 groups, or only "Z" groups of second preselectors are fully occupied, and at most, "m" groups can be fully occupied.

Let P_0 represent the probability of complete engagement of 0 groups.

Let P_1 represent the probability of complete engagement of 1 group.

Let P_z represent the probability of complete engagement of z groups.

so that ΣP must be equal to 1.

P_z is clearly dependent on the three following variables:—

(1) The number of simultaneous engagements of the second preselectors = g (varying according to the laws of probability).

(2) The number of groups of second preselectors = m (fixed by trunking scheme).

(3) The number of outlets from each group $= q$ (fixed by trunking scheme). In the above system of connections $m = q = 10$.

The probability of exactly g connections

$$= W_g = e^{-y}\frac{y^g}{g\,!} \text{ (Poisson Function) } \quad \text{..........(1)}$$

where y = number of traffic units concerned.

Let Wq_1, be the probability that, with g simultaneous connections, exactly 1 group of second preselectors is fully occupied. Wq_2 the probability of full occupation of 2 groups and generally, Wq_z, the probability of full occupation of z groups

$$\text{Then } P_z = \Sigma\, W_g.\, W_{gz}. \quad \text{........................(2)}$$

Determination of W_{g1}.

The index numbers 1, 2, 3, etc., are used to denote the single groups of second preselectors, and the following symbols are introduced:—

In the symbol $W_{12}{}^{345}$. the lower index figures represent groups fully occupied, while the upper figures represent groups not fully occupied, the groups having no part in the symbol, being in any condition.

Thus $W_{12}{}^{345}$ is the probability that groups 1 and 2 are fully engaged, 3, 4, and 5 are not fully engaged, groups $6 - m$ being in any condition.

Evidently $W_1{}^{23\cdots m}$ is the probability that only group 1 is fully occupied, and since all single groups are considered similar, $W_1{}^{23\cdots m} = W_2{}^{13\cdots m} =$ etc.

Thus the total chance that only one group is

$$\text{engaged} = \binom{m}{1} W_1{}^{23\cdots m} \quad \text{.......................(3)}$$

$W_1{}^{23\cdots m}$ must now be found.

(1) There are mq outlets in all and thus if there are g connections, they may be divided amongst the outlets in $\binom{mq}{g}$ different ways.

(2) If all q outlets from group 1 are engaged, then there are $(m - 1)q$ free outlets among which the remaining $(g - q)$ connections may be divided, in $\binom{(m-1)q}{g-q}$ ways. But this is the number of cases favourable to the full engagement of group 1.

$$\therefore \quad W_1 = \frac{\binom{(m-1)q}{g-q}}{\binom{mq}{g}}$$

In a similar way, the following general equation can be developed:—

$$W_{123\,\ldots\,x} = \frac{\binom{(m-x)q}{g-xq}}{\binom{mq}{g}} \quad \text{..................(4)}$$

The full engagement of group 1, the remaining groups being in any desired condition (probability = W_1), can evidently occur in the two following ways:—

(1) Group 1 is fully engaged, group 2 also fully engaged and the remaining groups in any condition. The corresponding probability = W_{12} and its

magnitude is known from the foregoing.

(2) Group 1 is fully engaged, group 2 free, and remaining groups in any condition, the corresponding probability being W_1^2. Its magnitude is unknown at the moment, while W_1 is known.

$$\therefore\ W_1 = W_{12} + W_1^2 \quad \text{and} \quad \therefore\ W_1^2 = W_1 - W_{12}$$

Considering the first three groups we find from similar considerations

$$W_1^{23} = W_1 - 2W_{12} + W_{123}.$$

Correspondingly we find the general equation

$$W_1^{23\cdots m} = \binom{m-1}{0} W_1 - \binom{m-1}{1} W_{12} \pm \cdots \pm \binom{m-1}{m-1} W_{12\cdots m}$$

$$= \sum_{x=1}^{x=m} (-1)^{x-1} \binom{m-1}{x-1} W_{12\ldots x} \quad \ldots\ldots(5)$$

Combining equations 3, 4, and 5, we obtain

$$Wq_1 = \frac{\binom{m}{1}}{\binom{mq}{g}} \sum_{x=0}^{x=m-1} (-1)^x \binom{m-1}{x} \binom{mq-(x+1)q}{g-(x+1)q} \quad \ldots\ldots\ldots\ldots(6)$$

In the same way, it can be shown that

$$Wq_z = \frac{\binom{m}{z}}{\binom{mq}{g}} \sum_{x=0}^{x=m-z} (-1)^x \binom{m-z}{x} \binom{mq-(x+z)q}{g-(x+z)q} \quad \ldots\ldots\ldots\ldots(7)$$

Now, substituting $(m - n)$ for z, it can be understood that exactly $(m - n)$ groups may be engaged, only if there are more than $(m - n)q$, and less than $(mq - n)$ connections at once. A test of equation (7) gives this result.

Equation for P_z or P_{m-n}.

In equation (2), if z is made equal to $(m - n)$, as a basis for simplification of calculations, the combination of (2) and (7) results in

$$P_{m-n} = \sum_{g=(m-n)q}^{g=mq-n} \left[\frac{e^{-y} y^g \binom{m}{m-n}}{g!\,\binom{mq}{g}} \sum_{x=0}^{x=n} (-1)^x \binom{n}{x} \binom{nq-xq}{g-(x+m-n)q} \right] \quad \ldots\ldots\ldots\ldots(8)$$

This can be given the following form :—

$$P_{m-n} = \binom{m}{n} \frac{e^{-y} y^{mq-n}}{mq!} \sum_{x=0}^{x=n-1} (-1)^x \binom{n}{x} \frac{(nq-xq)!}{[(n-x)q-n]!} (1+S)$$

$$\text{where } S = \sum_{r=1}^{r=(n-x)q-n} \frac{[(n-x)q-n]!}{[(n-x)q-n-r]!\ y^r} \quad \ldots\ldots\ldots(9)$$

An artificial traffic test made by Messrs. Dumjohn and Martin (in *P.O.E.E.J.*, of July, 1922) with this switching system gave the results shown in column III. of Table I., with values of m, q and y, = 10, 10 and 75 respectively. Column II. gives the results obtained by Baltzer, using Equation (9). The other columns show the results obtained, using the theories of various other experts.

I	II Equation (9)	III. Dumjohn & Martin	IV. McHenry	V. Lubberger	VI. Lubberger
P_0	0.441	0.4287	0.3504	0.766	0.05
P_1	0.262	0.2554	0.3874	0.188	0.16
P_2	0.149	0.1460	0.1927	0.038	0.25
P_3	0.076	0.0827	0.0568	0.013	0.25
P_4	0.041	0.0445	0.0110	0.007	0.16
P_5	0.022	0.0201	0.0014	0.0047	0.13
P_6	0.011	0.0135	0.0001	0.0032	0.06
P_7	0.0051	0.0049	0.00008	0.0022	0.01
P_8	0.00206	0.0019	—	0.0017	0.00
P_9	0.00131	0.0012	—	0.0012	—
P_{10}	0.00092	0.0002	—	0.00092	—

Total... ... 1.014

The figures in column II. seem to compare very favourably with the results of column III., though I have, even after repeated calculations (for P_4, P_5, P_6, P_8) failed to obtain these results, the values obtained for these numbers being approx. 0.022, 0.011, 0.0061, and 0.00218. Baltzer claims that the formulæ can be easily evaluated, but the calculations are very tedious especially for large values of n, and the fact that our numerical results do not agree probably shows that a slight lack of accuracy somewhere in the working out of the formulæ is responsible for large errors.

It may be stated here that a rough idea of the average number of circuits unavailable through group control may be found by use of the

$$\text{mathematical expectation} = \mathrm{D} = \sum_{z=0}^{z=m} \mathrm{P}_z z (e-q)$$

In the example quoted before, $m = 10$, $q = 10$, $e = 20$, $y = 75$ and hence D = 12 ccts. (approx.).

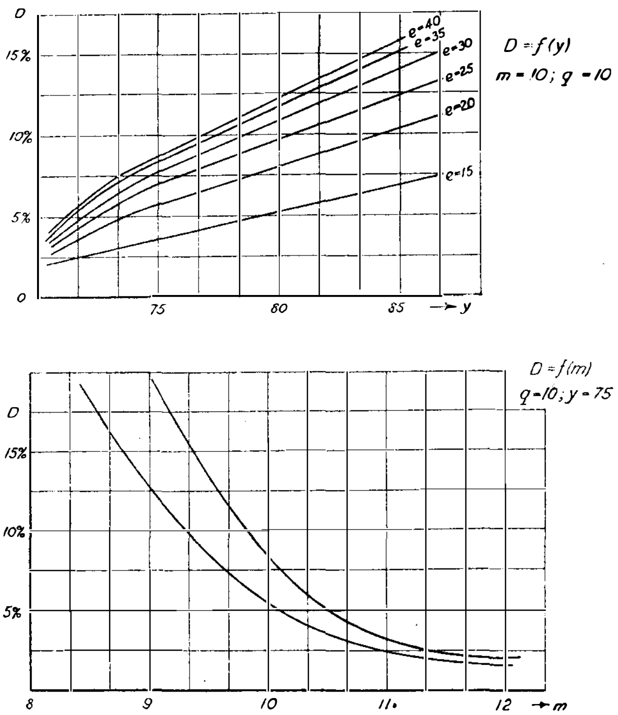


FIG. 2. D = f(y) & D = f(m)

In Fig. **2**, the upper curve shows the relation between D and traffic for various values of e, and the lower curve, the relation between D and m.

Loss in First Preselector Stage, excluding group control effect.

In order to find the probability of lost calls in this case, it is necessary to know the traffic per group of first preselectors. This can only be taken as $\lambda\, y/n$ where λ is a constant introduced to allow for the fact that all the single groups do not have their busy periods at once.

Using one of Lubberger's formulæ for this constant, Baltzer calculates that in the case of $y = 75$ T.Us, $\lambda = 1.27$ and hence the traffic per group $= y_k = 1.27 \times 3.75 = 4.76$.

The loss in the first preselector stage excluding group control effect is then obtained from the following formula (Lubberger & Ruckle):

$$\mathrm{R} = \mathrm{W}_v \left(1 - e^{-(\mathrm{C}_k - v)\mathrm{W}_v}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

where $\mathrm{W}_v = e^{-y_k} \dfrac{y_k^{\,v}}{v\,!}$, and C_k = number of calls per group busy hour, per group.

In our example, $y_k = 4.76$, $v = 10$, and hence $\mathrm{W}_v = 0.014096$.

The call duration is taken as $1\frac{1}{2}$ minutes (German).

Hence R = 0.013.

Loss in First Preselector Stage, including group control.

The formula developed here, strictly speaking, holds good only for systems in which all circuits outgoing from a group of first preselectors are to be considered as similar, and where, therefore, the preselectors do not return to a home position on completion of the engagement. In systems such as that of Siemens in which the first circuits are always tested first, the equations only hold strictly when by special cross-connections the similarity of the various circuits is artificially restored, since the greatest percentage of engagements occurs on the first choice circuits.

Consider group I. of first preselectors; what holds for this group will hold for every other group on account of the symmetry of the arrangement. Symbols A, B, - - - K, are used to designate the 10 outlets from this group.

P_1 is the time during which any desired group of second preselectors is engaged. $\mathrm{P}_\mathrm{A} = \dfrac{\mathrm{P}_1}{\binom{m}{1}}$ is the time during which only group A of second preselectors is completely engaged. Now, how great is the fraction of time during which circuit A_1 is engaged by group control? There are, in all, 20 circuits to group A of second preselectors. In time P_A, 10 circuits are engaged by calls and 10 by group control. If A_1 is engaged on a call, there are still 19 circuits among which the remaining 9 calls can be divided in $\binom{19}{9}$ ways. $\binom{19}{9}$ is therefore the number of favourable cases. The total number of possible cases in the time P_A. = $\binom{20}{10}$ ways of distributing the calls. The required probability is therefore $= \dfrac{\binom{19}{9}}{\binom{20}{10}} = \frac{1}{2}$. Thus the time during which A_1 is engaged by group control $= 1 - \frac{1}{2} = \frac{1}{2}$.

Similarly, circuits B_1, C_1, etc., have probabilities $= \frac{1}{2}$ since $P_A = P_B =$ etc., $= \dfrac{P_1}{\binom{m}{1}}$

Consider the time P_{AB}, $= \dfrac{P_2}{\binom{m}{2}}$, in which groups A and B are completely engaged. By similar reasoning, in 2/4 of the time P_{AB}, one of the 2 circuits A_1 and B_1 is engaged by group control; in $\frac{1}{4}$ of the time, both are engaged by group control; and in $\frac{1}{4}$, none is engaged by group control. Hence $P_{AB} = P_{AC} =$ etc., $= \dfrac{P_2}{\binom{m}{2}}$. That is to say, in 2/4 of the time P_2, some single circuit in group I is engaged by group control. Similar reasoning for P_3, P_4, P_5, etc., shows that the total time during which 1 circuit is revertively engaged.

$$= Wr_1 = \tfrac{1}{2}\, P_1 + \frac{\binom{2}{1}}{2^2}\, P_2 + \frac{\binom{3}{1}}{3^2}\, P_3 + \ldots \text{etc.}$$

$$= \sum_{z=1}^{z=m} \frac{\binom{z}{1}}{2^z} \,.\, P_z. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

The general formula becomes, for x circuits group controlled

$$Wr_x = \sum_{z=x}^{z=m} \frac{\binom{z}{x}}{2^z} \,.\, P_z.$$

It should be emphasised here that this equation only holds for the scheme of connections of Fig. **1**.

The appropriate equations can be determined by the method shown, but will not, in all cases, give such a simple law.

Now, in the time W_{r_1}, in which any given circuit in group I. is engaged revertively, the danger of loss exists when $(v - 1) = 9$ connections exist among the unblocked circuits.

According to Poisson, that is the case during the time $e^{-y_k} \dfrac{y_k^{9}}{9\,!}$

Thus the danger period $= e^{-y_k} \dfrac{y_k^{9}}{9\,!}\, W r_1$

In time, W_{r_2}, the danger period is $= W_{r_2}$ $= W_{r_2} e^{-y_k} \dfrac{y_k^{8}}{8\,!}$

Generally, the danger period

$$= W_{r_x} = W_{r_x} \cdot e^{-y_k} \cdot \frac{y_k^{v-x}}{(v-x)\,!} \quad \ldots\ldots\ldots\ldots(12)$$

Lost calls occur according to equation 10, when in the time W_{r_x}, still further calls originate, *i.e.*, for $y_k = C_k t$

$$R_x = W_{r_x} \left(1 - e^{-(C_k - v - x) W_{r_x}}\right) \quad \ldots\ldots\ldots\ldots\ldots(13)$$

and $R = \Sigma R_x$

With $y = 75$, $m = v = 10$, $c = 20$, $y_k = 4.76$, $t = 1/40$, $C_k = 190$, we get $R = 1.62\%$.

We obtaned 1.3% neglecting group control and thus this has raised the loss by 0.3%. Such a large loss as 1.62% in the cheap preselector stage would not be economical, it being preferable to have part of this loss over the selectors

As examples of the use of the foregoing calculations for the purpose of comparison, two further schemes are compared below.

(*a*) 200 lines per group of 20 contact first preselectors, the second preselectors remaining as before. $R = 0.000515$, the loss due to group control being 0.000409.

(*b*) 10 contact first preselectors, 20 contact second preselectors, the latter being in 10 groups of 40. $R = 1.305$; loss due to group control $\rightarrow 0$.

To give some idea of the effect of group control as the traffic varies, the graph is shown of loss plotted against traffic, in Fig. **3**.

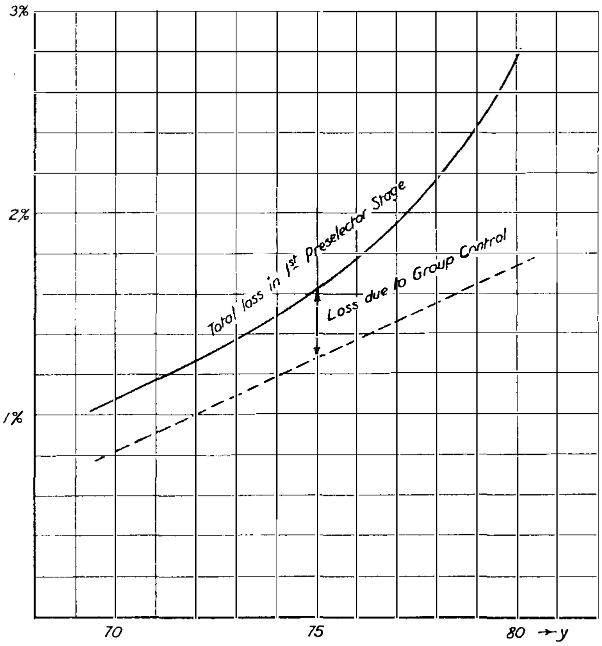


FIG. 3 Loss in the 1st Preselector Stage showing the effect of Group Control.

The author concludes that with large traffic densities, it will be economical to use greater numbers of contacts than 10 on first preselectors.

With small traffic densities, a 10-contact field is suitable. He notes, however, that the whole question turns on economical values and the question of standardisation.

Notes on the above theory.

(1) There are two drawbacks to the practical use of this theory—

(*a*) The calculations are very lengthy, even though several terms in the various series may be dropped as the values fall.

(*b*) A new formula must be constructed for W_{r_x} for every different arrangement of cross-connection.

(2) The Poisson formula has been used throughout, which is not strictly correct, as the number of circuits is not unlimited, though it is fairly accurate for large numbers of switches.

(3) This formula does not apply, as stated before, to the case of homing preselectors.

(4) It is not thought that Lubberger's' formula (Equation 10) is theoretically sound, when used in the way Baltzer uses it, and thus, the use of Erlang's would be preferable, in its place.

A small 100 hours artificial traffic test was made, assuming 3-contact first and second preselectors, 6 groups of the former, and 3 of the latter, as a severe test (owing to the small number of switches, etc.).

In this test, a total value of 3 traffic units was taken, for which value Erlang's and Poisson's formulæ give approximately the same results.

The resultant theoretical and practical values of P_x are shown below.

	P_0	P_1	P_2	P_3
Artificial Traffic Result	0.8819	0.1044	0.0127	0.0011
Theoretically	0.8643	0.1161	0.0153	0.0027

These results compare very well, under the circumstances.

Further work by Baltzer.

This author in later numbers of the same journal deals with several of the associated probability problems.

In one of them ("Zeitschrift Für Fernmeldetechnik," September and October, 1928), he treats the question of double preselector schemes in which some of the first preselector outlets are connected directly to the first selectors, the rest being connected *via* second preselectors. A simple 2-group grading of the trunks to second preselectors is also introduced, though its effect does not form part of the calculations.

A formula for the probability that x of the 10 outlets from a group of 50 lines are engaged by group control is given, which, though interesting, does not seem to be of much practical use at present, owing to the fact that doubtful assumptions are made which a practical test might show to be quite inaccurate.

In a further article ("Zeitschrift Für Fernmeldetechnik," November, 1928) Baltzer deals with the law of the distribution of holding times. He suggests a Gaussian Law foundation with origin moved to the left, and with an additional peak due to very short calls.

The Gaussian Law would suggest that the holding time denoted by the peak of the curve (*i.e.*, excluding the very short calls denoted by the sharp peak) is such that the numbers of calls having greater and smaller holding times are equal.

The Law hitherto used by several is of the form $\phi(u) = e^{-u}$ where u = holding time.

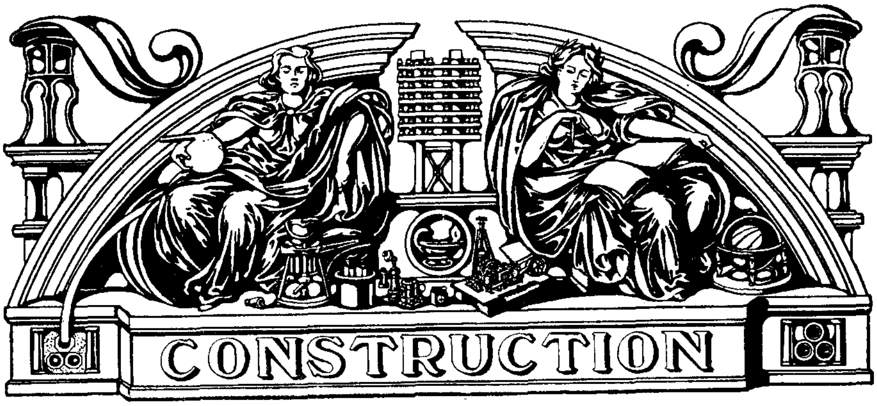
H. T. W. Millar.

[*A copy of this article was sent to Dr. Baltzer before publication, when he made the following comments:—*

(1) *He has found a simple method of calculating the values of P_z which he intends to publish in detail in a future article.*

(2) *While he agrees that the Poisson formula is unsuitable to the extent suggested in the article, he considers Erlang's formula equally so.*

(3) *He considers that Lubberger's formula* (10) *is fundamentally right, but states that he hopes to publish in the future a new loss formula which will be correct for large and small values of traffic.*]



THE HOLBORN GAS EXPLOSION.

O. P. Moller, A.M.I.E.E.

When, in 1862, a Company called the Pneumatic Dispatch Coy. constructed a tube between St. Martins-le-Grand and Euston Sation for the purpose of conveying parcels between those points, the promoters little dreamed of the amazing happenings that, 66 years later, would centre about that portion of their tube which lies—or did lie until recently—between Kingsway and Tottenham Court Road.

On a bleak morning in December last a section, three eighths of a mile long, of one of London's main thoroughfares was, within a few minutes, converted from a solidly built and level roadway into a chaotic ruin of tilted flagstones, upturned blocks of concrete, cavities and fissures, leaning lamp-posts and zig-zag kerbs. Heavy manhole covers were shot high into the air and during the explosions the whole roadway rose and fell with a wave-like motion. A taxi-cab was overturned, windows were broken and underground cellars blown in. Flames broke out at many points and the terrified onlookers might have been pardoned for refusing, on this occasion, to believe their senses. Even the

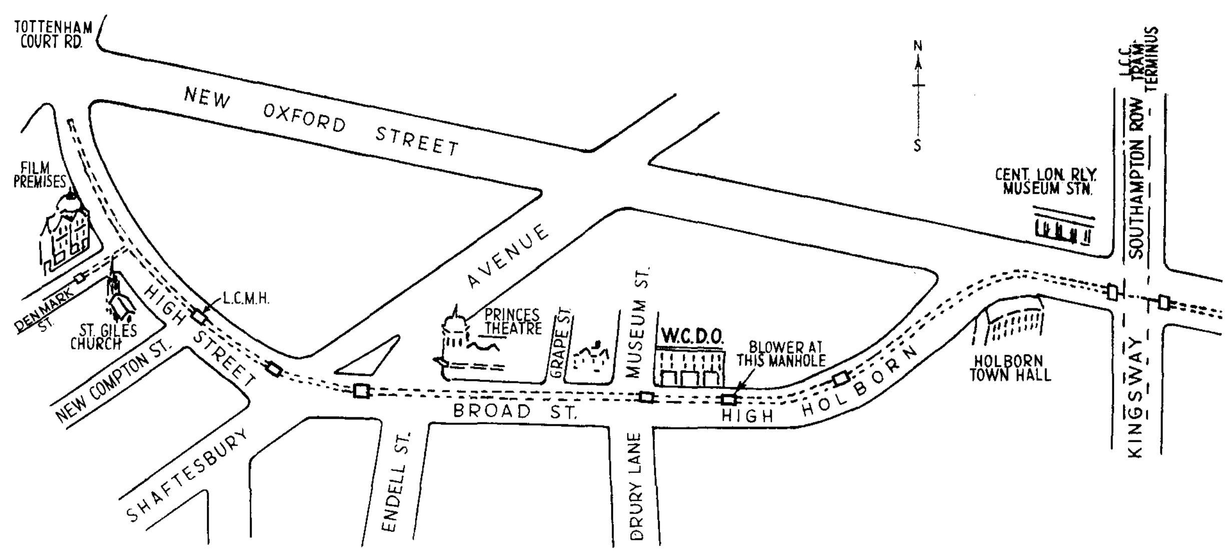


Fig. 1.—Plan of Tube Route.

newspaper reporters were unable to do much more than report the solid truth!

The old parcels tube, as it is called, in which the gas that did the mischief seems to have collected, was built of cast iron lengths, of "D" section, jointed with lead and yarn, the flat part forming the floor and the upper portion the arch. The tube is 4′ 6″ wide and 4′ 3″ high. It carries only Post Office cables and these are arranged on either side with a gangway down the centre. A detailed description of the tube is given by Mr. H. R. Kempe in Paper No. 32, "Pneumatic Dispatch," Institution of P.O. Electrical Engineers.

The history of the tube is interesting. Built, as has been said, in 1862, it was abandoned after two or three years' working on account mainly of the difficulty of keeping it airtight. It lay derelict until 1921, when the local authorities having control of the streets traversed suggested to the Post Office authorities that if underground cables were required in those streets they should be laid in the derelict tube. Owing to the congestion of traffic in Holborn, it was desired that this thoroughfare, especially, should not be opened up. The Post Office considered the possibilities of the tube as an underground cable route and ultimately decided to purchase it, the owners having been traced. From that time cables have been laid in various sections, and in the half-mile section between Kingsway in Holborn and Tottenham Court Road there were approximately 26 cables in use when the explosion occurred in this length in December last.

FIG. 2.—OUTSIDE MANHOLE WHERE FIRST EXPLOSION TOOK PLACE.

For purposes of access, drawing in cables, jointing, and housing loading coils, a number of manholes had been constructed at intervals. These are indicated on plan in Fig. **1**.

It was found that gas, on occasions, accumulated in certain portions of the tube and in order to remove this the Post Office found it necessary to install electric blowing plant for the purpose of pumping in fresh air at one manhole while adjacent manholes were opened to let out the gas. This blower was worked from power points arranged in connection with circuits provided for lighting the tube.

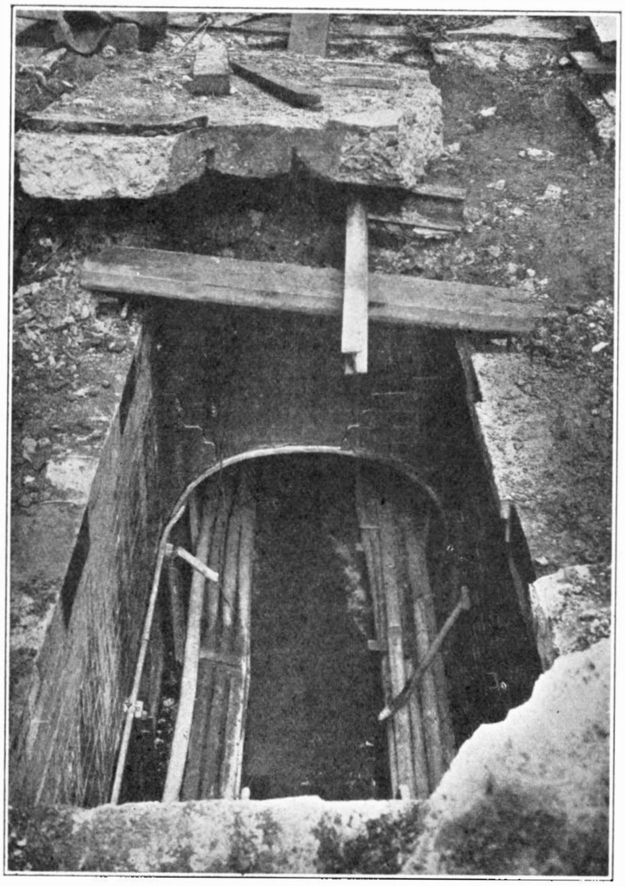


FIG. **3**.—INTERIOR OF MANHOLE AFTER ROOF HAD BEEN REMOVED.

At 7.45 a.m. on the morning of Thursday, 20th December, 1928, Post Office workmen arrived at the manhole near the West Central District Office and made preparations for blowing-out preparatory to entering the tube. A smell of gas was noticed as soon as the manhole was opened. One of the men went down with the lead, but before he could connect it an explosion occurred in the tube, and before he could get up the ladder and out of the manhole another explosion occurred. While he was head and shoulders out of the manhole this second explosion blew him out on to the roadway in flames. He died 10 days later in Charing Cross Hospital.

Gas mains and water mains were fractured, and as a result of the gas escaping a further explosion took place about 12.30 a.m. at the end of Denmark Street in High Street, setting fire to a building occupied by firms in the cinema film trade, and although a very large number of fire engines were on the site the building was burned out in a very short time.

Fig. **1** is a plan of the area concerned.

Fig. **2** shows the manhole at the rear of the W.C.D.O. where the first explosion took place.

Fig. **3** shows the interior of the manhole outside W.C.D.O. immediately after the roof and debris had been removed. An iron ladder normally rested in the centre of the wall facing the photographer.

Fig. **4** shows the roadway outside the Princes Theatre.

Fig. **5** shows the Gas Light & Coke Co.'s excavation outside the Princes Theatre, where repair work on a 48″ High Pressure Gas Main had been carried on.

Fig. **6** shows an 8″ bend on the gas main, which was over 40 years old. The metal, which was thick on the inside of the bend, had run out thin on the outside and the hole, showing black, in the fore-ground was $1\frac{1}{2}''$ long by 1″ wide. On the broken pipe next to the bend was a $\frac{1}{2}''$ hole in thin metal. With a pocket knife blade it was possible to make another hole close by. On breaking off a piece of the cast iron it was possible to cut it easily with an old pocket knife as in the locality of the break it was composed partly of graphite.

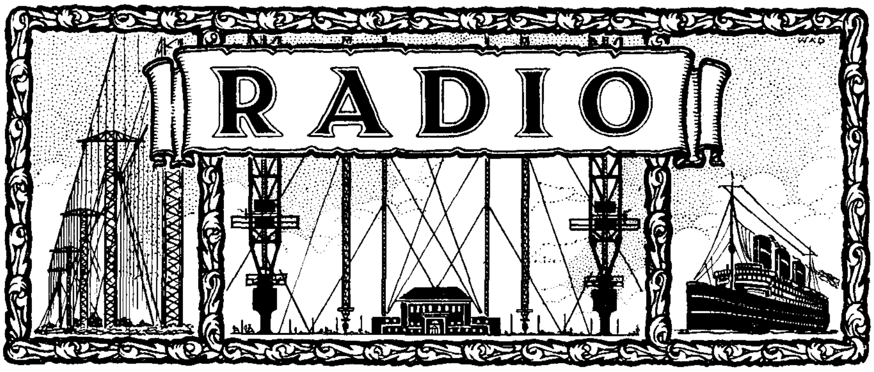
Fig. **7** shows the wrecked roadway with Loading Coil Manhole opposite New Compton Street in High Street.

It has been decided to rebuild the destroyed route in standard octagonal duct work, the whole of the partly destroyed iron tube being taken out.

The remaining portions of the old tube between St. Martins-le-Grand and Kingsway and between Tottenham Court Road and Euston Station are still in use.

Fig. 4.—Roadway near Prince's Theatre.

FIG. 6.—BEND ON GAS MAIN.



VARIATIONS IN SIGNAL STRENGTH FROM AUSTRALIA.

THE Australian Beam service was opened for traffic in April, 1927, the wave-length used by the Australian transmitter being 25.728 metres or 11,660 kilocycles. After the initial stages were over and the service had settled down to normal running conditions, systematic records of the signal strength and the conditions existing on the service were instituted.

These records were commenced in June, 1927, and sufficient time has now elapsed to show that the variations in signal strength apart from magnetic storms and other irregular interruptions are cyclical.

The method adopted for keeping these records is for the attendant on the receiver at Skegness to record hourly his impressions of the signal strength at the first listening position on the receiver, allowances of course being made for the couplings, etc., in use at the time so that the values obtained are entirely empirical. These hourly readings are plotted daily on a time basis, the signal strength being graded from 0 to 6, one chart being used for one month's readings. At the end of the month there are thus 30 or so readings at each hour; these are evaluated and a curve constructed from the results obtained. This curve represents the average value of the signal strength at each hour of the day for that month. The series from June, 1927, to July, 1928, are shown in full line in Fig. 1, those for June, 1928, to November, 1928, being shown dotted. The curve for December, 1928, has been omitted as changes were made in the Australian transmitter during that month which had the effect of increasing the received signal strength at Skegness. The daylight darkness conditions on the great circle paths are also shown.

During January good signal strength is obtained from 0900 till 1800 with a slight diminution at 1100. The gradual weakening of signals at 1100 and the increasing time during which this weakening is experienced can be seen through February, March, April and May until its maximum is obtained in June and July. Thereafter this gap closes up gradually until January, when it has again almost disappeared. In the same way the growth and decline of signal strength during the evening and early morning periods can be seen to repeat over each year.

The Australian service is worked on two routes, westward from England from approximately midnight till noon, and eastward from England during the remainder of the day. These two great circle paths differ in length, the westward or long route being about 23,000 kilometres, and the eastward or short route about 17,000 kilometres.

Sunrise and sunset do not show any effect on the average signal strength when the service is worked on the long route. Any possible effect is masked by the fact that the sun has risen in Australia before it has set in England on this route.

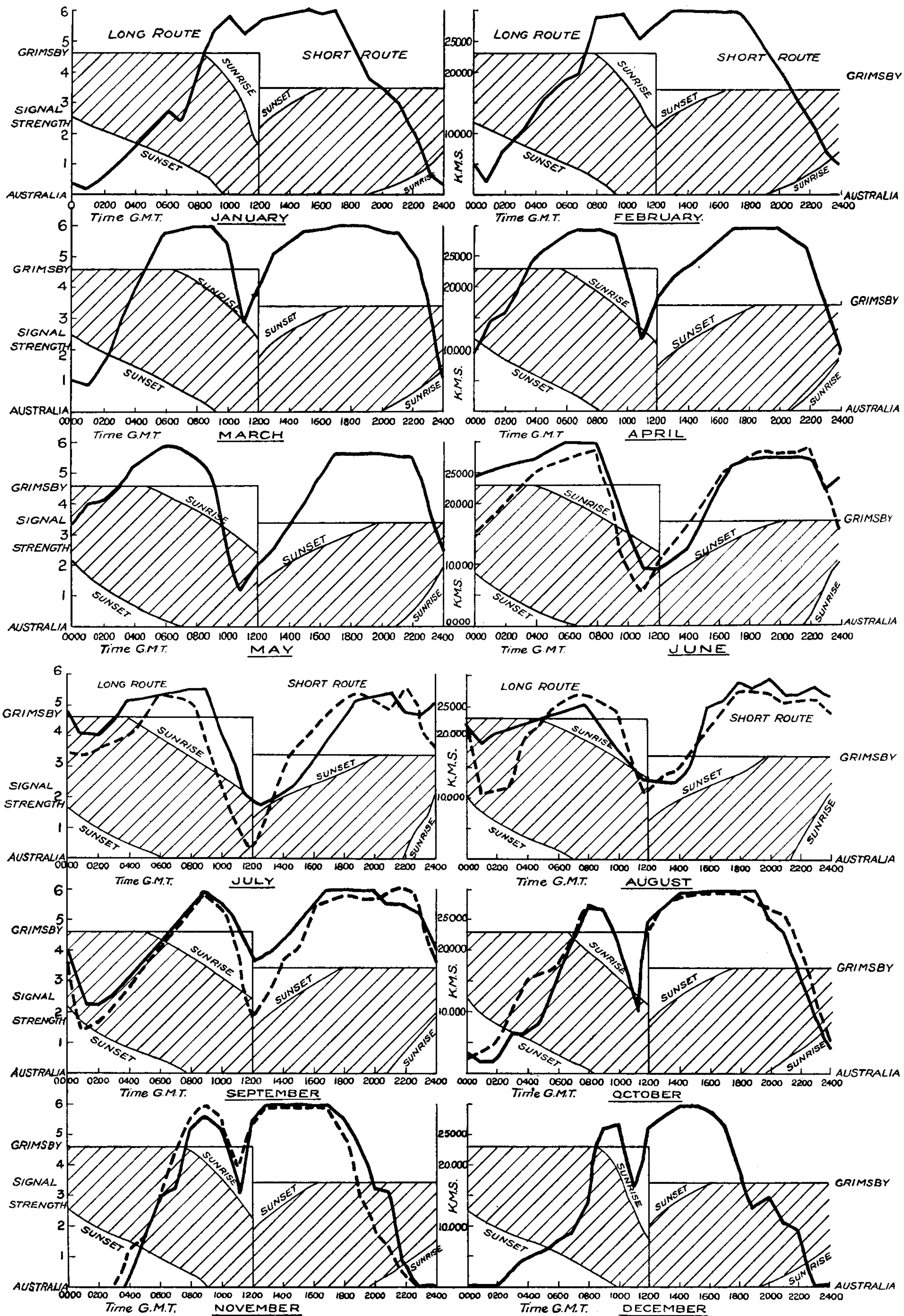

LONG ROUTE
SHORT ROUTE
SIGNAL STRENGTH
GRIMSBY
AUSTRALIA
SUNRISE
SUNSET
K.M.S.
25000
20000
10000
Time G.M.T.
0000 0200 0400 0600 0800 1000 1200 1400 1600 1800 2000 2200 2400
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIG. 1.

A slight weakening of signals is, however, noticed at Skegness at the English sunrise, but the effect only lasts for a short time so that the average strength curves are not seriously affected.

The Australian sunrise on the short route does, however, have a very marked effect on signal strength at certain periods of the year. This effect is definitely seen in each month, except May, June, July and August; even in these months it may be the cause of the slight drop in signal strength noticed about this time, but, as the English sunset occurs about the same time, it is difficult to establish definitely whether the former or the latter is responsible, especially in view of the peculiarity observable with the Australian sunrise in other months. In January the effect of the sunrise is noticeable two hours before the sun actually rises at the transmitting station. In February the period is also two hours, but in March it is one hour, in May half an hour, in September and October it is again half an hour, increasing to one hour in November and two in December.

This appears to be a peculiar effect, but in the light of experience obtained on the Indian beam service it is suggested that an explanation may be found in the difference existing in night conditions in winter and summer. On the Indian service a 16 meter wave is used for daylight communication, and it is found that, during the winter, signals fade out, at the latest, two hours after sunset in India; that is, after there is more than two hours of darkness on the path. In summer, however, this period is extended and it frequently happens that good signal strength is

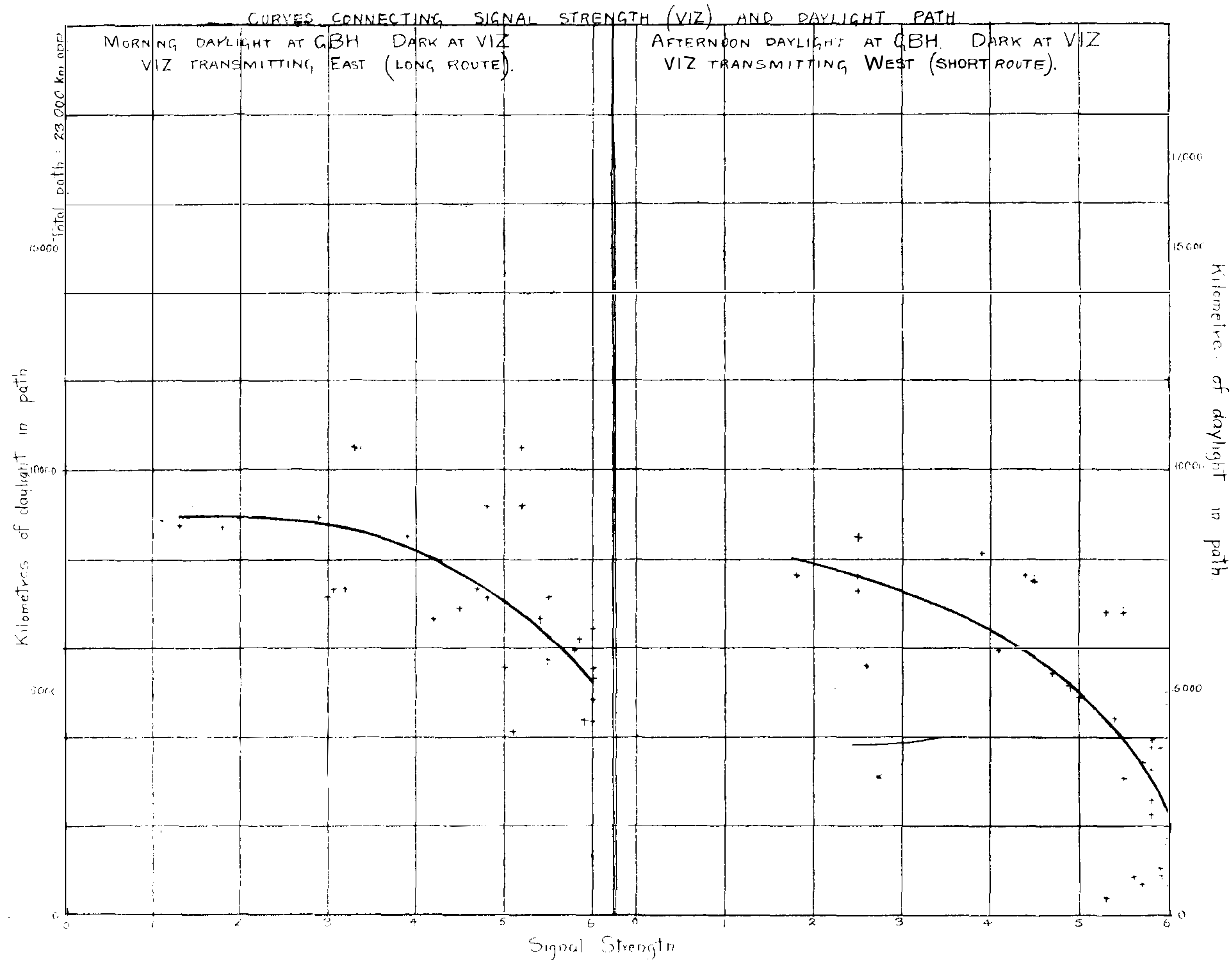


Fig. 2.

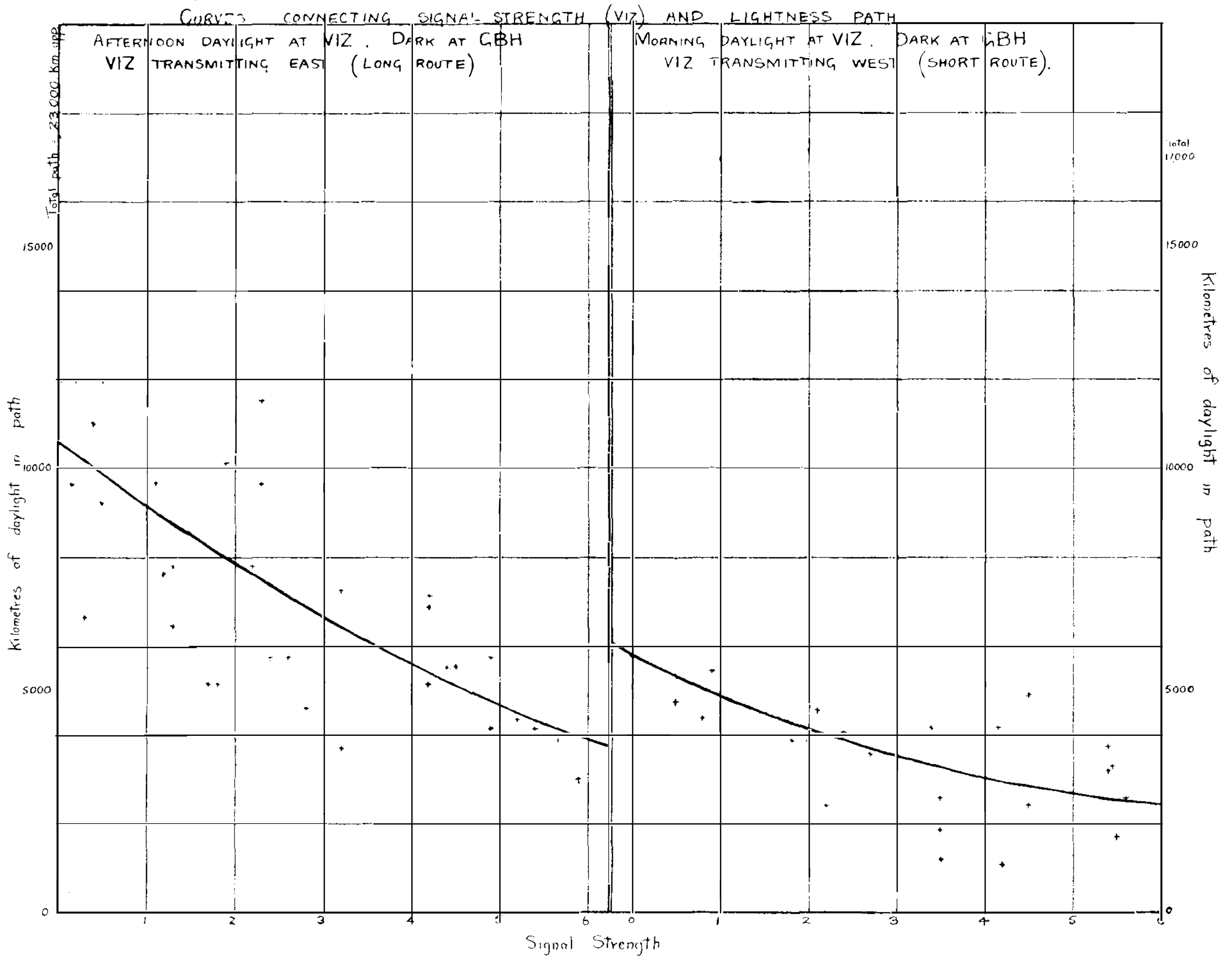


FIG. 2.

obtained when the whole of the path is in darkness. This would suggest that for some distance at least on the dark side of the daylight-darkness path the summer night conditions obtaining on the Heaviside layer approach day conditions. Night conditions approaching day conditions would thus obtain on the great circle path for some time before actual sunrise at the Australian transmitter and would produce a diminution in signal strength, as the wave used is primarily a darkness wave. This effect is apparent on the Indian service in summer and it would consequently appear to be due to the altitude of the sun; therefore the premature sunrise effect on the Australian service should be at a maximum during the Australian summer, as is actually the case.

There are four daylight-darkness conditions obtaining on this service; two on the long route and two on the short route. In the former there is, firstly, afternoon daylight at Australia and darkness in England and, secondly, darkness in Australia and morning daylight in England. In the latter there is, firstly, afternoon daylight in England and darkness in Australia and, secondly, morning daylight in Australia with darkness in England. From a first inspection of the average curves, it is apparent that the effects of these four conditions are not similar, and curves connecting the length of the path in daylight with the signal strength obtained under the four conditions, are shown in Fig. **2**. There appears to be a very marked difference in the effect of morning daylight at Australia when compared with the other three conditions, the attenuation of signals being much greater, even though this condition occurs on the short route. Signal strength fades from maximum to zero when—

1. The daylight path length is increased by 3,500 kilometres with morning daylight in Australia.
2. The daylight path length is increased by 7,000 kilometres with afternoon daylight in Australia.
3. The daylight path length is increased by 6,000 kilometres with afternoon daylight in England.
4. The daylight path length is increased by 4,000 kilometres with morning daylight in England.

Maximum signal strength is obtained when—

1. Under 2,500 kilometres of the path is in daylight under morning daylight conditions at Australia.
2. Under 4,000 kilometres of the path is in daylight under afternoon daylight conditions at Australia.
3. Under 5,000 kilometres of the path is in daylight under morning daylight conditions at England.
4. Under 3,000 kilometres of the path is in daylight under afternoon daylight conditions at England.

These curves are average curves and of course take no account of seasonal variations, which, it is well known, have a marked effect on the attenuating effect of daylight.

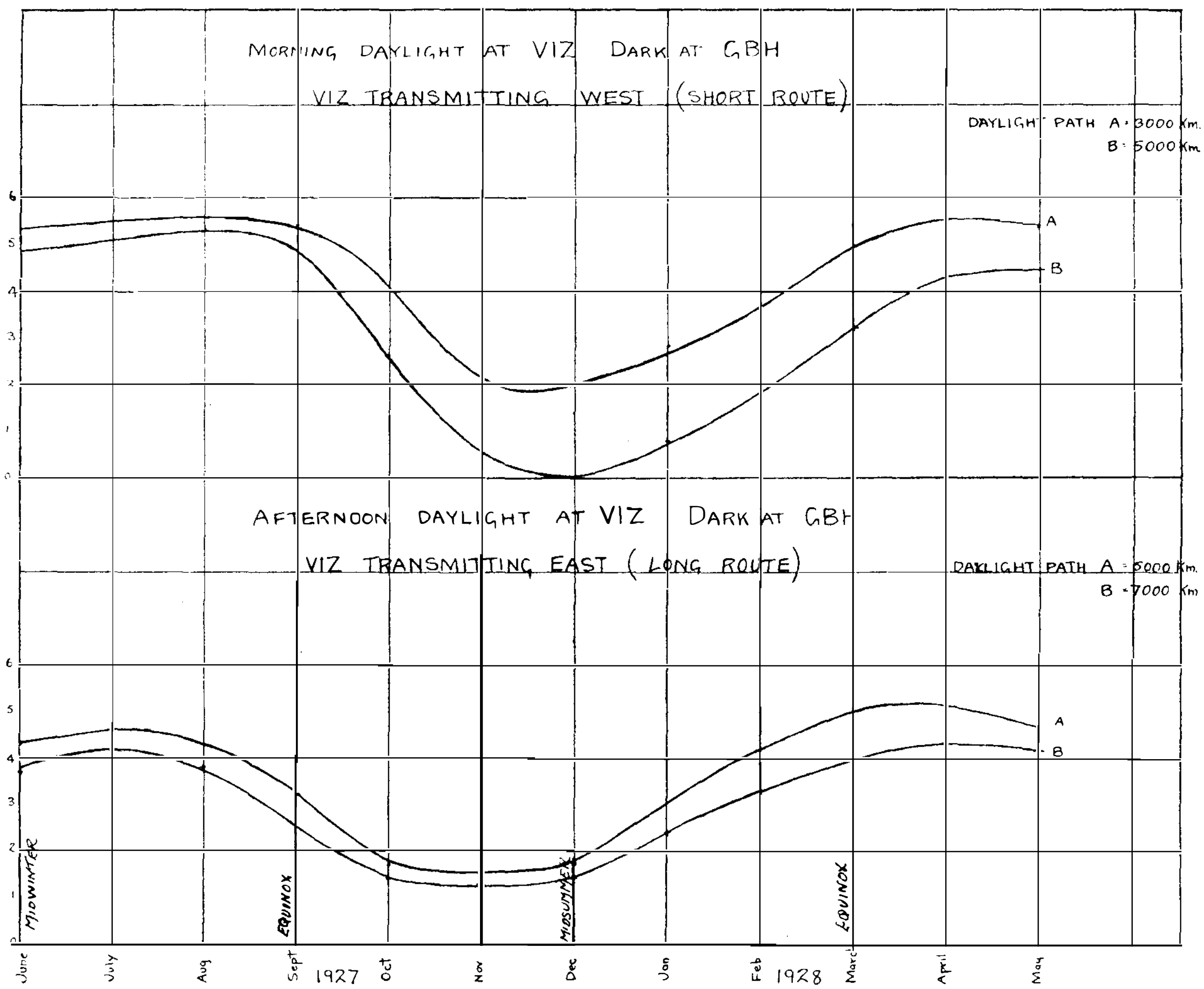


Fig. 3.

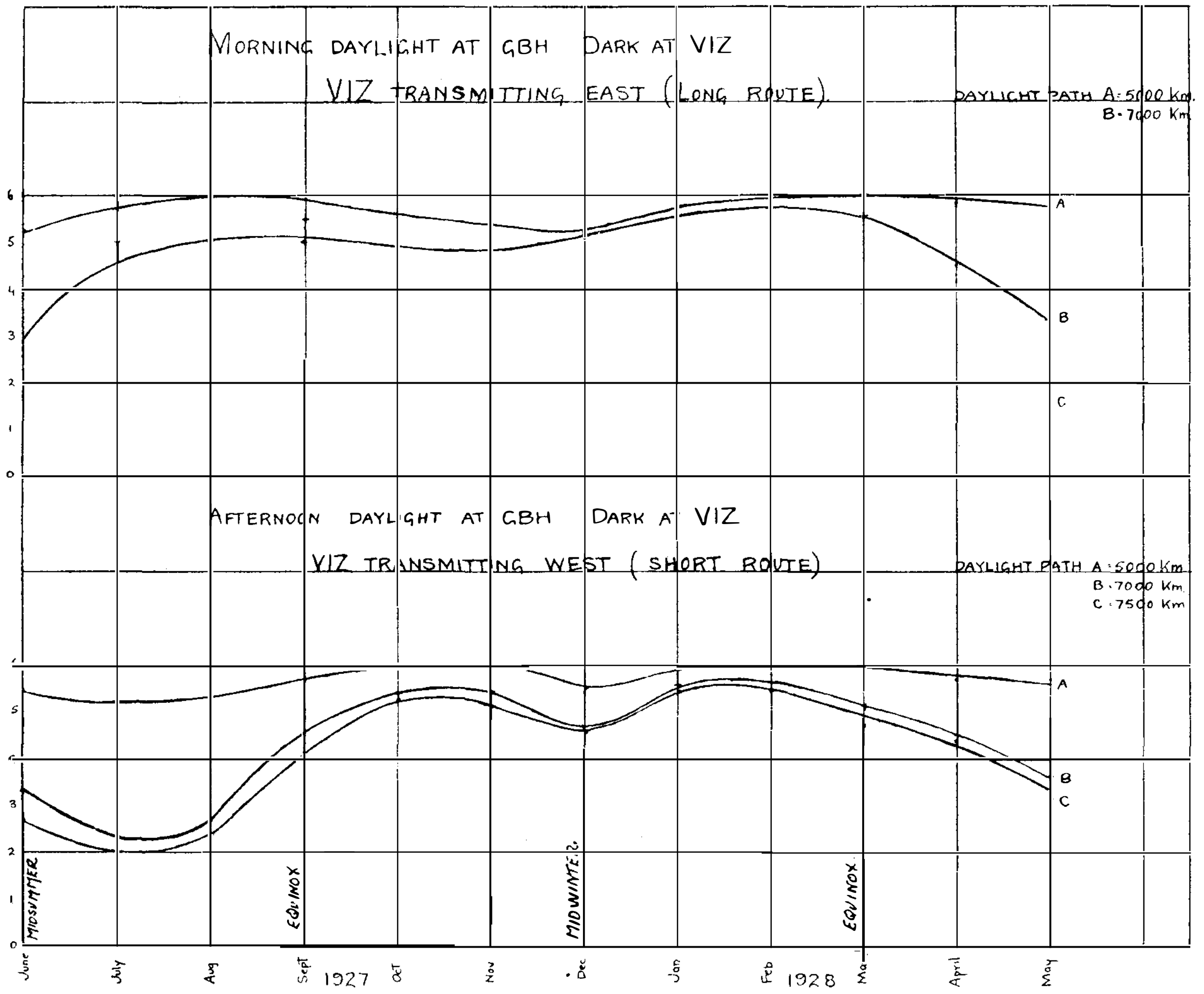


Fig. 3.

To show this seasonal effect the curves shown in Fig. 3 have been prepared. In these curves the signal strength obtained with a definite amount of the path in daylight under the four different conditions have been plotted on a monthly basis. With afternoon daylight at Australia on the long route, the greatest signal strength is obtained in the Australian winter, April to July, falling to a minimum during the Australian summer. This curve is fairly symmetrical about these two seasons.

The curve for the Australian morning daylight shows a greater signal strength in the Australian winter and a smaller strength in summer than the corresponding curve for Australian afternoon daylight, and the strength falls rapidly to the summer condition during the spring, but only rises slowly during the autumn.

The curves for the English daylight conditions show no serious change in signal strength for the shorter distances under winter and summer conditions, but definite minima occur at the English summer on the longer distances. The curves also appear to be fairly symmetrical.

There is considerable difference in the attenuation produced under the differing daylight and seasonal conditions and the figures have been tabulated to show those differences. The Australian figures have been rearranged so that a direct comparison between similar seasonal conditions at both ends of the service may be made.

Length of Light Path 5000 Kilometres.

English.			Australian.		
Month	Morning daylight (long route)	Afternoon daylight (short route)	Month	Morning daylight (short route)	Afternoon daylight (long route)
Jan.	5.6	5.9	July	5.1	4.6
Feb.	5.9	6.0	Aug.	5.3	4.3
Mar.	6.0	6.0	Sept.	4.9	3.2
April	5.9	5.8	Oct.	2.5	1.8
May	5.7	5.6	Nov.	0.5	1.1
June	5.2	5.4	Dec.	0.0	1.8
July	5.7	5.2	Jan.	0.7	3.0
Aug.	6.0	5.5	Feb.	1.7	4.2
Sept.	5.9	5.7	Mar.	3.2	5.0
Oct.	5.4	6.0	April	4.3	5.1
Nov.	5.3	6.0	May	4.5	4.8
Dec.	5.2	5.5	June	4.9	4.4

Length of Light Path 7000 Kilometres.

Jan.	5.5	5.5	July	no figures	4.1
Feb.	5.8	5.6	Aug.		3.8
Mar.	5.5	5.1	Sept.		2.5
April	4.5	4.5	Oct.		1.4
May	3.3	3.6	Nov.		1.2
June	3.0	3.3	Dec.		1.4
July	4.5	2.3	Jan.		2.4
Aug.	5.0	2.7	Feb.		3.3
Sept.	5.0	4.5	March		4.0
Oct.	4.9	5.4	April		4.3
Nov.	4.8	5.4	May		3.8
Dec.	5.1	4.6	June		4.1

These figures show that, under similar seasonal conditions, daylight at the Australian end has a worse effect on signal strength than daylight at the English end. Unfortunately, similar figures for the English transmissions to Australia are not available, so that it is not possible to say whether daylight at the transmitting end of a service has a greater attenuating effect than daylight at the receiving end, or whether the effect of Australian daylight on signals received there would show the same greater attenuation when compared with English daylight. If the latter be the case, it may be that the differing latitudes of the two stations is the deciding factor.

In all these curves the readings an hour before the normal route changing times of noon and midnight have been omitted as this change is not made exactly at the specified time throughout the year.

R. G. de Wardt.

NOTES & COMMENTS

IN the New Year's Honours List, the issue of which owing to the regrettable illness of His Majesty the King had been postponed till March 1st, every officer in the P.O. Engineering Department and his numerous friends outside the service were delighted to see in the list of Knights Bachelor the name of Colonel Thomas Fortune Purves, O.B.E., Engineer-in-Chief of the Post Office. Since 1922, the year in which he was appointed to the Chief's chair, Colonel Purves has been responsible for many developments in the art of electrical communications, a few of which may be enumerated here: Completion of Trunk underground cable and repeater station system; introduction of lead-covered paper-core loaded submarine telephone cables to the Continent; Trans-Atlantic Radio Telephone Service, which now covers all North America and practically all Europe except Russia and Turkey; the Beam Radio Services to India, Australia, South Africa and Canada; the extension of Automatic telephone service to many industrial and residential centres in the provinces and an excellent and promising start made with the conversion of the London system to Automatics; the opening of the London P.O. Tube Railway, etc. Such are a few of the achievements carried out by the Department over which the new knight has presided with his customary grace and skill for some six years, and surely he thoroughly deserves the honour the King has bestowed upon him and indirectly bestowed upon the Department he represents.

Of his work before 1922, we would refer our readers to the July, 1922, issue of this Journal. The appreciation given there terminates as follows:—"The staff has received the announcement of Major Purves's appointment as their chief with unanimous approval and the keenest satisfaction. Their confidence in his scientific and engineering ability and in his established reputation as a broad-minded and sympathetic administrator will act as an effective inducement to all to place their best efforts at the service of the Department, and foster the feelings of mutual trust between the staff and the Administration without which it is not possible under present day conditions to carry on a great industrial concern efficiently and satisfactorily. The new Chief is a strong man—literally, and in the later meaning of the word—and with an immense enthusiasm for his profession. Yet withal he is ever genial and kind-hearted. For the past twenty years, during which period the writer has been closely associated with him, he has never been known to lose his temper with a subordinate." And still, despite alarums and excursions, setbacks and triumphs, overwork and worry, he remains the same. We are sure we express the wishes of every member of the staff when we offer here our heartiest congratulations to the Engineer-in-Chief upon the well-earned honour now conferred upon him.

THE P.O. COMMERCIAL ACCOUNTS, 1927/8.

The contents of this valuable annual publication can best be summarised from the Explanatory Memo, which appears after the contents page. "The accounts bring together the revenue, capital expenditure and operating expenditure from the various accounts and returns in which they are accounted for to Parliament. The cash figures so obtained are adjusted to the income and expenditure basis, except where the variation is unimportant. Provision is made for the reserves for depreciation, pensions, etc., which are necessary to exhibit the commercial results of operation. Interest is charged on all loan capital or moneys treated as loan capital. In addition to the General Account for the P.O. as a whole, separate accounts are prepared for the three main services, postal, telegraph and telephone. . . . The surplus or the deficit on the year's working is regarded as paid to the Exchequer or made good by the Exchequer, as the case may be, and is not carried forward to the next year's account."

The capital assets of the P.O. consist of—

(*a*) Engineering plant and stores for the telegraph, telephone and electric light, etc., services.

(*b*) Land and buildings.

(*c*) P.O. (London) Tube Railway.

Smaller assets are charged against revenue as they are purchased.

The total capital liabilities shown in the Balance Sheet under General Account are given as £124,548,488, and are made up of (*a*) Loans raised under the Telegraph Acts 1892-25 £69,045,374; (*b*) Exchequer Bonds £1,179,900; (*c*) Exchequer Advances £48,179,373 and (*d*) Sundries £6,143,841. The total Telephone Capital raised to date amounts to £99,699,482, but of this amount £31,562,384 has been redeemed. The interest payable on this capital has varied from 3½ per cent. in 1913, up to 6 per cent. in 1921/22 and in 1928 5 per cent.

The certified assets in the above Account are as follows:—

	£
Freehold Land and Buildings ...	17,510,781
Leasehold ,, ,, ,, ...	1,439,073
Plant	96,501,600
Engineering Stores in Stock ...	3,241,688
Sundry Debtors for revenue ...	3,296,284
Cash: On Revenue A/c and Subscribers' Deposits ...	2,559,064
	£124,548,488

After making provision for depreciation, pensions, and interest on capital the accounts show a loss of £1,380,829 on Telegraphs and a profit of £107,391 on Telephones for the year.

It might be stated here that the prospects of an increase in Telephone profits are distinctly favourable for this year.

TELEPRINTERS.

In an article on the possibilities of Teleprinters for public use in the *Telegraph and Telephone Age* of January 1st, 1929, Mr. E. Kleinschmidt finds Europe progressive in matters telephonic, but that it lags behind America in telegraph practice. Nevertheless he admits that Europe had seen the possibilities of the adoption of the Teleprinter system and is endeavouring to establish subscribers' exchanges for inter-communication by the use of Keyboard Telegraph apparatus. Such a system has been provided for the use of the Berlin police on a fairly large scale.

The German Telegraph administration is also interested in telegraph exchange systems, and they have plans in hand for the supply of a public service.

The French Telegraph Administration has started a Teleprinter Exchange known as the "Telemixte." This is fully described in *Le Matin* of September 1st, with costs for rental and calls. The system operates on a telephone subscriber's circuit, but is not planned for simultaneous telegraph and telephone working. The subscriber asks for a teleprinter connection by phone and switches over to his telegraph instrument.

The British Post Office is also considering the matter.

The High Commissioner for Canada in London has communicated the following paragraphs prepared by the Canadian Government Information Bureau at Ottawa:—

CANADIANS THE GREATEST TELEPHONE CONVERSATIONALISTS IN THE WORLD.

Canadians are the world's greatest telephone conversationalists. A recently issued official bulletin dealing with telephone statistics shows that on a per capita basis an average of 221 conversations per year were held by the people of Canada, compared with 205.4 in the United States, the next highest, and 137 in Denmark, which is given third place.

The bulletin shows that there were at the end of 1927 a total of 1,259,987 telephones in Canada, an average of about one 'phone for every eight persons in the Dominion. Canada has 2,462 telephone system with a wire mileage of 3,591,035. The Province of Ontario leads in the number of 'phones with 558,468, an average of 17.5 per 100 of population. Quebec is next with 255,970, an average of 9.8 per 100; then British Columbia with 113,051, or 19.7 per 100; Saskatchewan 107,782, or 12.9 per 100; Manitoba 74,032, or 11.4 per 100; Alberta, 73,407, or 11.9; Nova Scotia, 41,219, or 7.6; New Brunswick, 31,254, or 7.6; Prince Edward Island, 4,669, or 5.4, and the Yukon Territory, 136, or 3.9 per 100 of population.

FURTHER TELEPHONE EXPANSION IN EASTERN CANADA.

The Bell Telephone Company of Canada contemplates an expenditure of $27,000,000 during 1929 on construction and expansion of facilities on its lines in eastern Canada. This will be the largest appropriation in the history of the Company, comparing with $22,000,000 for the current year, which in turn was $4,000,000 larger than the 1927 amount.

Of the $27,000,000 for next year, $7,000,000 will be for extending long distance lines, including expenditures on new carrier current facilities, new cables, etc. Part of the total is for the new headquarters building in Montreal, which will be ready for occupation in five or six months. Eleven major building projects are under way.

OVER 250,000 RADIO LICENCES IN CANADA.

More than a quarter of a million Canadians holding radio receiving sets had paid the Government tax of $1 up to the end of November, 1928, an increase of 17,000 as compared with the end of November, 1927.

The returns indicate that there are 226,240 private radio receiving licences, although it is believed that more than 100,000 sets exist on which no license has been issued. The revenue from the issue of licenses is devoted by the Department of Marine and Fisheries to the improvement of radio services, about a score of radio interference cars being in use.

We regret to record the death of Mr. C. W. V. Schaefer, M.I.E.E., Electrician-in-Chief of the Eastern Associated Telegraph Companies. Mr. Schaefer entered the service of the Eastern Telegraph Company as a probationer at Malta in September, 1884, his father being in the service of the company at that station. In 1887, Mr. Schaefer was transferred to Gibraltar, remaining there until 1890, when he joined the electrical staff of the cable-ship "Electra." He subsequently served afloat in the cable-ships "Chiltern, "Great Northern," the old "Mirror," "Amber," and the "John Pender," in which ship he took over electrical charge from Mr. F. Ryan in February, 1902. Mr. Schaefer left the cable-ship "John Pender" upon his appointment to the H.O. Staff in April, 1906, and was promoted to the position of Electrician-in-Chief upon Mr. F. Ryan's retirement in March, 1923. The long practical experience in cable construction, laying and repairing, gained by Mr. Schaefer especially fitted him for his position as head of the department responsible for this work, and he was a recognised authority on cable engineering in all its branches. The benefit of this experience, too, is reflected by the utility of his various tests for the localisation of breaks and faults in submarine cables, the well-known "Schaefer" break test being practically universally adopted by the cable community at large, and he leaves behind most valuable data in the field of cable engineering.

Electrician-in-Chief of the Eastern Associated Telegraph Companies for six years, he was instrumental in arranging for a complete change in the method of cable working over the very large network of cables controlled by them. The introduction of the Regenerator revolutionised cable working, all in this relatively short period. The first trials were not completed until 1924. Up to that time it was unsatisfactory to work with more than two relay stations between terminals; now, in one instance, as many as eleven relay stations are interposed. On this particular circuit this number of relay stations fulfils the traffic requirements, but it has been proved that this is by no means the limit. Signals have, in fact, been passed satisfactorily from London to Penang (Straits Settlements) and back through twenty-one relay sets.

Loaded cables were also introduced during Mr. Schaefer's term of office. These introduced several new problems for solution and new methods of working had to be developed. Another introduction was the use of thermionic valves to serve the purpose of magnifying cable signals, resulting in higher speeds with increased stability.

Keenly interested in all branches of Electrical Engineering, Mr. Schaefer made many friends in the profession. To those who worked with him he was always cheerful, encouraging, and beloved by all.

Sir John Denison-Pender, Chairman of the Eastern and Associated Cable Companies, died at his home at Eaton Place, S.W., on the 6th ult. He was seventy-three years of age.

Sir John was brought up in the cable business, for his father, Sir John Pender, was one of the pioneers of the earliest submarine cables and founded the Eastern Telegraph Company. He was created a K.C.M.G. in 1901 and G.B.E. in 1920.

He was buried at Slaugham, Sussex, on Saturday, the 9th March, and a one-minute stoppage of circuits throughout the world-wide system of the Companies took place at 12.15 p.m. to allow the staff on duty to stand in silence in honour of the dead baronet.

The following notice is taken from the *Electrical Review* of the 4th January :—The death of Mr. John Lee, C.B.E., M.A., etc., occurred suddenly on December 24th while on board the "Laconia" on his return journey from New York, where he had been on a visit connected with the business of the Automatic Telephone Co., of which he became a director when he retired last year from the post of Controller of the Central Telegraph Office. Mr. Lee was born in 1867, and as a boy he entered the Post Office service at Liverpool, subsequently rising from the position of telegraphist to assistant superintendent, assistant traffic manager for telephones (1907) and in 1916 being promoted to the post of Inspector of Telegraph and Telephone Traffic. Three years later, after a brief period as Postmaster at Belfast, he came back to London as Controller of the Central Telegraph Office. He had a very full, varied and efficient life in the service. A mere list of the matters in which he was called to figure more or less prominently emphasises the valuable work which an enthusiastic and able man can render during 40 to 45 years. His record comprises the reorganisation of the Indian Railway Telegraph system, membership of the Committee on High Speed Telegraphy, and membership of various delegations to the U.S.A. and to the Continent, including the International Telegraph Conference in Paris over which he presided. He wrote a number of books on telegraph and telephone practice and other subjects, was interested in the principles of scientific management, was profoundly concerned with religious questions and modern movements connected therewith, attended many industrial conferences, was a most acceptable speaker and lecturer and a writer for the Press, while administrative and organising ability and a striking personality also form parts of the outline record of the interests and achievements of one who, according to those who knew him best, was a remarkable man, whose ceaseless industry unfortunately permanently impaired his health, so that he has passed away as a result of a heart attack at the age of 61 years. A Memorial Service was held at Christ Church, Newgate Street.

We regret to record the death on the 21st February of Mr. Edward Raymond Barker, M.I.E.E. He had been ill for many years. Mr. Raymond Barker was born in 1857 and entered the London School of Submarine Telegraphy in 1875. He received appointments later with the Eastern and Brazilian Submarine Telegraph Companies. He became first Assistant Chief Electrician at the submarine cable works of the I.R., G.P. and Telegraph Works in 1891 and remained with that company until he retired in 1912. He saw service in many submarine cable-laying expeditions, invented a calculator board for cable ships and the multitone transmitter, wrote many articles in the *Electrical Review* and published various books and pamphlets regarding the apparatus and methods so closely related to his submarine cable career.—*El. Review, 1-3-29.*

We have received from Mr. Weaver a copy of the Annual Reports for the year ended 31st December prepared for the Advisory Committees for Birmingham District and for Chester, North Wales and Hanley Districts.

HEADQUARTER'S NOTES.

EXCHANGE DEVELOPMENTS.

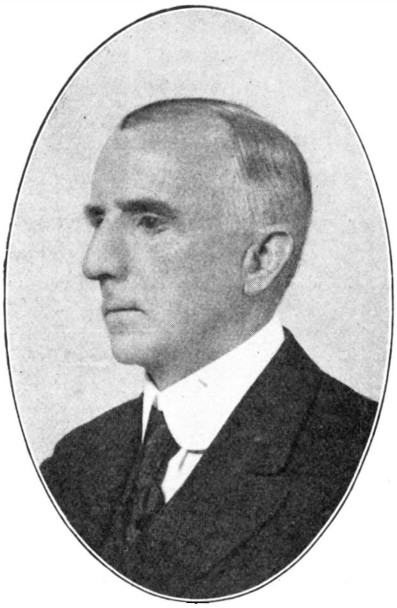
The following works have been completed :—

Exchange.	Type.	No. of Lines.
Ainsdale	New Auto.	618
Bath	,,	3040
Batheaston	,,	130
Cowley	,,	200
Dringhouses	,,	180
Headington	,,	200
Hipperholme	,,	350
Leicester	,,	8600
Sloane	,,	8000
Sowerby Bridge	,,	440
Halifax	Auto Extn.	Junction Equipt.
Cobham	New Manual	600
Connahs Quay	,,	440
Hornchurch	,,	880
Molesey	,,	2280
Petersfield	,,	500
Sutton	,,	4880
Valentine Relief	,,	1500
Anfield	Manual Ext.	1140
Brixton	,,	800
Ryde	,,	240
Speedwell	,,	2480
Winchester	,,	400
Bristol Tramways	P.A.B.X.	210
Clark Chapman & Hall	,,	30
Davis Theatre	,,	30
Dudley Board of Guardians	,,	30
Dunlop Rubber Company	,,	10
Edwards Ringer & Brigg	,,	30
Garner & Son	,,	30
Lloyds Packing Co., Ltd.	,,	30
Manchester Corporation	,,	20
Newcastle-on-Tyne Corpn.	,,	Junction Equipt.
Preston Corporation	,,	30
Rochdale Co-op.	,,	30
Southern Oil	,,	20
Wiggins Teape	,,	30

Orders have been placed for the following works :—

Exchange.	Type.	No. of Lines.
Aldridge	New Auto	135
Aylesford	,,	180
Barming	,,	100
Benton	,,	665
Bearstead	,,	280
Birmingham : Victoria	,,	2815
Birmingham : Harborne	,,	1290
Birmingham : Midland	,,	Positions
Birmingham : Northern	,,	5280
Boughton Monchelsea	,,	200
Davidson's Mains	,,	615
East Newcastle	,,	1520
Fairfield	,,	2700
Felling	,,	285
Gateshead	,,	1900
Gosforth	,,	1615
Hunton	,,	100
Jarrow	,,	570
Kenton	,,	105
Low Fell	,,	950
Maidstone	,,	2100
Newcastle-on-Tyne	,,	9200
Otham	,,	100
Wallsend	,,	800
Wateringbury	,,	200
West Newcastle	,,	1520
Whickham	,,	190
Burslem	Auto Extn.	250
Edinburgh Central	,,	1460
Edinburgh Morningside	,,	870
Edinburgh Murrayfield	,,	650
Edinburgh Newington	,,	660
Longton	,,	95
Newcastle-under-Lyne	,,	160
Park Mechanical Order Wire	,,	—
Swansea	,,	1000
Stockport	,,	360
Stoke	,,	110
Western Mechanical Order Wire	,,	—
Bexhill	New Manual	1460
Bourne End	,,	880
Egham	,,	780
Farnborough (Hants.)	,,	1020
Hazel Grove	,,	900
Herne Bay	,,	1240
Hitchin	,,	570
Sydenham	Manual Ext.	2040
Cheshire Joint Sanatorium	P.A.B.X.	20
Clarke Chapman & Hall	,,	30
Newcastle-on-Tyne Cprn.	,,	Modfn.
Rochdale Co-op.	,,	30
Shell Mex (Southampton)	,,	30
Society L'Ouest Africa	,,	20
Uxbridge Guardians	,,	20

WILLIAM MASTERMAN FRANCE, M.I.E.E.



W. M. FRANCE, M.I.E.E.

MR. FRANCE retired on the 31st October after 45 strenuous years in the Telephone Service.

He entered the business in the electrical department of the Lancashire and Cheshire Telephone Coy. in Liverpool in March, 1883. In 1889 he was placed in charge of erection and maintenance of exchange equipment in the Liverpool District, and on reorganisation following the amalgamation with the N.T. Co. in 1893 he was appointed Chief Electrician of the same district. In the following year he was transferred to the E.-in-C's Staff, but with headquarters at Liverpool, and for five years he was engaged in cable apparatus and materials testing at contractors' works and dealing with any special difficulty in connection with cables *in situ*.

Up to this time the manufacture of switchboard equipment in this country was carried out on a very small scale, and great credit is due to Mr. France for the advice and assistance he rendered to both the Company and the manufacturers in the initial stages of this class of work.

In 1899 he came to London and supervised the erection of the more important exchange equipments throughout the country.

In 1903 the Equipment Section was formed at H.Q. and Mr. France was placed in charge. During these early days his work was of great importance to the Telephone Co. and was done with conspicuous success. He remained in this position until 1915, when he was transferred to the Local Lines Section. In 1917 he was appointed S.E., N. Midland District, and in 1919 he returned to London to take charge of the Telephone Section.

In 1921 he was transferred to the Lines Section, where he remained in charge till his retirement.

In connection with the transfer of the National Telephone Co.'s undertaking to the Post Office he rendered most valuable service, more particularly in respect of the valuation of exchange equipments and internal plant. He attended all the sittings at the Law Courts during the Arbitration proceedings, his services being retained by the Company until the completion.

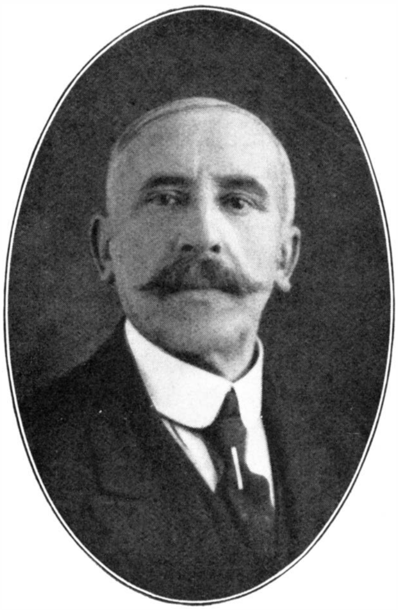
He was Chairman of the I.P.O.E.E. during the session 1926/7.

During his 45 years' service he has had only two days' sick leave and that in the very early days. The short absence was due to continuous work of two days and three nights restoring service at Liverpool Central Exchange after a fire.

He is a prominent Freemason and takes special interest in the Telephone Lodge, of which he was a founder in 1908 and Hon. Treasurer since 1920.

Of the man himself: he has a personality which has endeared him to all who have had the privilege to be associated with him. His prevailing characteristics are thoroughness and modesty; whatever he undertook was well done and his conclusions were sound and well balanced. At the same time he was always anxious to give the credit to those working under his direction rather than to assume it for himself and would make herculean efforts to assist those who required help. He has never allowed his true self to be buried in the hard crust of officialism—a real humanitarian and such a gentleman!

MR. ARTHUR CROTCH.



ARTHUR CROTCH.

ON the 31st December last, Mr. Arthur Crotch retired from official duty, having completed 45 years' service. Born and educated at the old cathedral city of Norwich, he entered the telegraphs there in 1883, and later was one of the early workers in the technical movement which brought about so great a change in the character of the telegraph staff of the Kingdom. He joined the engineering side in 1896, commencing at East Dean Repeater Station, was transferred thence to Lowestoft and to headquarters clerical establishment in 1900. Since that time he has been responsible for many works on technical subjects, the best-known, perhaps, being his first venture, "Elementary Telegraphy and Telephony." This was followed by his "Telegraphic Systems" and others, the latest being his "Automatic Telephony." These have been justly praised for their simplicity of treatment and clarity of expression.

For many years he was responsible for the exhibition of patterns and drawings in connection with the placing of orders for telegraph and telephone apparatus. This necessarily brought him into touch with the electrical manufacturing world, and his alert figure and never-failing courtesy will be greatly missed by the representatives of the firms with whom he was for so many years in daily contact.

Mr. Crotch was a man of many parts and always had a multitude of irons in the fire. Organ building (and an organist to boot), Egyptology, Biblical research, architecture, matters ecclesiastical and historical, and above all, literary humorists were his delight and the great love of his life was Charles Dickens, in whose writings he was fairly steeped. Very rare was the occasions which he could not cap with a suitable Dickens' story! He was also a great London-lover, and is on the lecturing staff of the L.C.C. for London history.

At a large gathering in the Designs Section he was the recipient of a suitable presentation subscribed by his many friends. In the absence of Colonel Purves, Mr. J. R. Gall presided and made feeling reference to Mr. Crotch's qualities. Many other speakers testified to his inveterate love of story-telling and his other humorous qualities. In retirement he will have the opportunity to "go-in" thoroughly for many subjects very near his heart, which have been previously kept out by lack of time. We wish the genial, happy Arthur many years of health and happiness to enjoy the fruits of his labours.

FREDERICK WILLIAM FRANCIS.

Mr. Francis, who retired on the 30th November, started business in 1884 in the office of the Telegraph Superintendent of the L.B. and S.C. Railway, and in the same year he entered as an evening student at Finsbury Technical College, taking the full electrical engineering course under Profs. Ayrton and Perry and then under Prof. Sylvanus Thompson.

Three years later he joined the United Telephone Coy. and was appointed to the experimental and testing branch, then under the control of the late Mr. I. W. Ullett, which maintained the London junction wires, tested cables, wire and apparatus in addition to experimental work. When the various companies amalgamated in 1890, the testing branch was shut down for a time, and after a short period in the office Mr. Francis was transferred to Exchange maintenance work. Single-handed for several years he kept in order all the six London City exchanges, except Avenue.

In 1894 he was appointed one of two Cable Inspectors, the other being Mr. W. M. France, who took over the northern half of the country. Their duties were to test all cables, principally the new paper core cable, at contractors' works and when laid. The inspectors were under the control of the Test Department, with Mr. J. R. Gall in command, but with only one other assistant. From this small beginning the Test Department grew with the increase in the Company's business until it performed the functions, or part of the functions, now administered by several Sections in the P.O., viz., Test, Designs, Construction, Power, and Office of Works.

At the transfer Mr. Francis was appointed Asst. Staff Engineer in the Designs Section, then under Mr. Purves, but later under his old chief, Mr. Gall, with whom he has served as principal assistant for nearly 30 years.

Mr. Francis is a delightful conversationalist, full of quiet humour and with a wonderful gift for mimicry. A more even-tempered man no one could wish to know. Widely read, there is no subject, either scientific or social, upon which he could converse without profit to the listener. He has learned how to assimilate those intellectual foods which ensure peace and happiness within and at the same time form an effectual bulwark against strife without. A real good fellow, modest almost to a fault, his cheerful countenance has always been a tonic to his colleagues.

RETIREMENTS.

In our quarterly return of Staff Changes several well-known names appear under the above heading, amongst them being those of Mr. R. McIlroy, I.S.O., Superintending Engineer of the London District, who bade his colleagues an official farewell on the afternoon of the 27th March; Mr. E. J. Ivison, the head of the Telephone Section at Headquarters; Mr. J. Richardson, Assistant Superintending Engineer, South Eastern District; Mr. W. H. Powning, of Swansea, a stalwart of the early days of the Society of Post Office Engineers and of the I.P.O.E.E., and Mr. W. J. Gwilliam, of the Test Section, Studd Street.

As time goes on, retirements of higher officials have become increasingly frequent and while the process opens vistas of promotion for the younger men one cannot fail to sense a feeling of regret as the veterans who were present practically at the founding of the Department lay down their harness and depart. They set a high standard of duty, these men; it is for the younger men who take up their jobs to maintain that standard.

DEATH OF MR. E. J. WHIBLEY.

WE regret to record the death of Mr. Edward James Whibley, which occurred at Boscombe on 13th February. He retired some six years ago, owing to ill-health, and by his absence for this period from the scene of active life, he has faded from the remembrance of many. But to a large number of his old friends still in the service, the news will come with regret.

His record is briefly given below. He entered the C.T.O. as a telegraphist in 1884 and in 1891 he was transferred to the Engineering Branch and took up duty at Cambridge, in the office of the Superintending Engineer (then Mr. Jenkin). In 1899 he was appointed to the Engineer-in-Chief's Office, where he graduated successively as third, second and first class clerk, retiring as we have said, in 1922.

My acquaintance and friendship with our friend began in 1900. Generally bubbling over with high spirits, he infected us all with his great good-nature. He was responsible for all apparatus received and sent out from headquarters, and he had the nose of a ferret for articles borrowed, mislaid or lost. Circulars sent round "as to" the whereabouts of a piece of apparatus produced the usual result, "could not be traced," etc. Then Whibley began his "researches"; and the chagrin of the man in whose possession it was found—at the back of a cupboard, forgotten—can only be imagined by those who have been the unwitting detainers of loans! Sometimes, his keenness and his "D Notes" gave occasion for strong language; but everyone agreed that, if he were a nuisance, he was a very necessary one! And, the search ended and the object found, the matter was finished with. Whibley had "got" it, and there was an end to it!

Of his happy good nature, one could give many instances. He would lend you £1 to £10 for the asking. And we often wondered at the amount of cash he carried about. But if you used a cheque of his, he would religiously demand the 2d.! He loved a joke: that it was against himself mattered not. As a teller of tales he was a failure; indeed, it was borne in on him so often that he found a unique way of amusing us. He would ask, "Did I tell you the tale of the two painters?" and on getting the negative, he would start on some rigmarole, knowing that we would stop him (forcibly if necessary) and not allow him to proceed. And he loved this as much as if he were a born raconteur! But I think the great characteristic of the man was his unfailing good temper. However busy, however worried, he would turn for a moment with that boyish laugh of his.

He lost his only son in the war, and he now leaves his wife and two daughters. To them, so bereaved, we offer our heartfelt sympathy. We laid him to rest in Mitcham Cemetery on a day such as he loved, a day flooded with the February sunshine and in harmony with his happy nature.

A.C.

LONDON DISTRICT NOTES.

Telephones.—The following figures show the changes in the number of exchange lines, extensions and stations during the three months ending and the totals at 31st December, 1928:—

	Increase.	Total.
Exchange Lines ...	7,895	355,493
Extensions ...	9,183	301,353
Stations	14,747	598,314

External Plant.—During the same period the changes shown below have occurred in mileage:

Telegraphs.—A nett decrease in open wire of 1 mile and a nett increase of 206 miles in underground.

Telephones (Exchange).—A nett increase in open wire of 50 miles and a nett increase of 88,205 in underground.

Telephones (Trunk).—A nett decrease in open wire of 68 miles and a nett increase of 3,981 in underground.

Pole Line.—A nett increase of 9 miles, the total to date being 5,896 miles.

Pipe Line.—A nett increase of 219 miles, the total to date being 10,260.

The total single wire mileages at the end of period under review were:—

Telegraphs	25,985
Telephones (Exchange) ...	2,456,562
Telephones (Trunk) ...	78,100
Spares	112,331

Telephone Exchange Progress.

During the month of January the following new Manual Exchanges were opened, viz.:—Molesey, Hornchurch and Sutton. These Exchanges, which are of the C.B. No. 1 type, were equipped with an initial capacity of 2,280, 880 and 4,880 lines respectively.

Other new Manual Exchanges recently completed are:—Pollards, with an equipment for 1,800 lines, which was opened on February 27th, and Valentine, with an equipment for 1,500 lines, which was opened on February 28th.

The following additions to plant are in hand by the Department's staff:—

Exchange.	No. of Lines.
Malden	1,560
Wimbledon	1,080
Hounslow	1,780

The General Electric Company is carrying out an extension of 1,200 lines at the Greenwich Exchange, which it is anticipated will be completed early in May.

New Manual Exchanges are in the course of erection at Thames Ditton (Emberbrook) and at Upminster; both Exchanges are being installed by the Standard Telephone and Cable Co., Ltd.

Automatic Exchanges.

Further progress has been made in the conversion to automatic working by the opening on January 5th of the new Western Exchange (7,100 lines), on March 2nd of Temple Bar (7,700 lines), and on March 9th of Archway (3,100 lines).

Installation work is in hand at the following Automatic Exchanges:—

Exchange	No. of Lines	Exchange	No. of Lines
Shepherds Bush	4000	Edgware	1300
Primrose Hill	6900	Hendon	3100
Beckenham	3000	Flaxman	9900
Reliance	2700	Fulham	7500
Metropolitan	9500	Mitcham	1480
National	9500	Hillside	2350
Maida Vale	7500	Ilford	3000

Sites.

The purchase of sites for the undermentioned Telephone Exchanges has been completed during the past three months:—

Ewell (Manual).
Stamford Hill (Auto.)
Surbiton (Manual).

Area Correction Transfers.

17,134 Area Correction Transfers were carried out in conjunction with the March issue of the London Telephone Directory.

Telegraphs.

Teleprinters.—Testing sets have now been provided which will enable instruments to be tried by working through to each other on an artificial line. The arrangement provides for testing Teleprinters Nos. 1-A, 2-A and 3-A.

The experimental working at Knightsbridge with alternating motors on No. 3-A machines still continues. It has been found desirable to fit signalling apparatus, consisting of generator and bell, to several Teleprinter circuits, and thus obviate the necessity for continuous running of the motor.

Three sets of the Siemens Halske type of apparatus have been installed for working to Norway. There are now five sets working at the C.T.O.

TUBES.

Power-worked tubes are now being fitted between the Counter and Instrument and Delivery rooms in important Branch Telegraph Offices.

Fans with press-button starters fixed adjacent to the Terminals are being successfully used, and are found to be a great improvement on the old hand-pump system.

The C.T.O. House-tubes are being converted to single-way working. Hitherto power has been supplied at one end to two or three tubes placed in series, with the result that if a block occurs in one Section, all three Sections are liable to be stopped. The new system should effect a considerable improvement, as the transit time will be much reduced and the working be of a very simple character.

The very cold weather in February caused trouble on some of the street-tubes. Moisture which condensed in the pressure tubes, accumulated and froze, thus causing a stoppage. Considerable difficulty was experienced in clearing away the ice which blocked the passage of the carriers.

TELEPHONE CABINETS.

A suite of Cabinets in which the folding doors are of teak and the bodies of hardwood, has been made at Cornwallis Road and erected at Mansion House Station. This follows the precedent set at Goodge Street, Bond Street, Charing Cross, etc. A pair made of old bodies with oak exteriors has been erected in Kensington High Street Arcade, and has evoked appreciative remarks.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

LOCAL CENTRE NOTES.

LONDON CENTRE.

The third meeting of the Session was held on December 11th, when Mr. A. J. Gill, B.Sc., M.I.E.E., gave a lecture " Radio Communication on Short Wave-lengths." The lecture was illustrated and at the close Mr. Gill gave a demonstration of the directional properties of a short wave aerial.

On Jan. 8th Mr. R. W. Palmer, A.M.I.E.E., gave a lecture, " The Measurement of Relay Times." The paper dealt comprehensively with the many types of apparatus which have been developed and was illustrated by lantern slides and demonstration apparatus.

On Feb. 12th Mr. A. J. Aldridge, A.C.G.I., A.M.I.E.E., gave a lecture on " The Measurement of Sound and its Application to Telephony." The lecture was illustrated and a good discussion ensued.

On March 12th, Mr. W. G. Radley, B.Sc. (Hons.), A.M.I.E.E., gave a lecture, " X-rays and the Structure of some Engineering Materials." The lecture was illustrated and the attention of the audience and the interesting discussion showed that keen interest had been aroused.

INFORMAL MEETINGS.

The third Informal Meeting was held on January 22nd, when Mr. H. E. Morrish, A.M.I.E.E., opened a discussion on " Jointing and Testing of Cables." The discussion aroused the keenest interest and Mr. Morrish ably replied to the many questions raised.

At the meeting on February 26th, Mr. W. Dolton, M.I.E.E., opened a discussion on " Inspection of Wireless Stations in the London Engineering District." In the course of an instructive discussion Col. Angwin and Mr. Matthews, of the Radio Section of the Engineer-in-Chief's Office, paid a tribute to the work of the Inspecting Officers.

VISITS.

Successful visits have been made to the Repair Depot of the London General Omnibus Co., Ltd., at Chiswick. The extent of the Works made one realise how much skill and organisation is devoted to the Bus Services, whilst the courtesy and hospitality shown were much appreciated.

Visits to the Barking Generating Station have also been made. This Generating Station, owned by the County of London Electric Coy., Ltd., is said to be the largest in the Country. The size and efficiency of the Steam Plant; the apparent absence of switches in the switch room; the fire extinguishing plant, and the intricacies of the control room, made the visit interesting and instructive. T.H.

NORTHERN CENTRE.

Mr. Thos. Davidson read a paper on "Underground Breakdown Organisation" before a well-attended meeting on the 21st December.

The subject was dealt with under the following headings:—

(1) The method of advising faults.
(2) The provision of testing apparatus.
(3) The recording of alternative routes to each main cable, to provide speakers and testing wires for localising complete breakdowns, and to afford provision for crossing over important circuits in the faulty cable.
(4) Provision of emergency tool kits and materials necessary for the temporary repair of faults to be stored at some point easy of access.
(5) Method of obtaining staff to deal with the breakdown.
(6) Provision of the necessary transport for staff and materials.

In his paper, Mr. Davidson suggested, among other things, that:

(*a*) A cable testing officer should be allocated to each Engineering Section, to be responsible for the localising of all main cable faults in the section.

(*b*) A service telephone should be installed at the residence of the testing officer for use in the event of faults occurring outside normal hours of duty. Each testing officer should be supplied with a Bridge Megger, which should be in his personal custody. Copies of the alternative routes to main cables should be supplied to each Test Room.

(*c*) An Emergency Tool Kit (the composition of which was given in an appendix to the paper) should be held at the Section Headquarters, where it would be readily accessible at all times, all breakdown apparatus and tools being painted red or other distinctive colour in order to be easily recognisible. The provision of emergency rations, where necessary, for men when engaged on breakdown work.

(*d*) The use of a $1\frac{1}{2}''$ semi-rotary pump on stand was advocated in place of the floodgate pump generally used on ground of portability.

(*e*) The earmarking of a ton van for breakdown work in each section, the van being employed on short journey work when not in use on breakdowns. The provision of motor cycle combinations for the use of testing officers was also suggested.

The paper concluded with a detailed description of the methods adopted in dealing with faults and returns to be made, the forms to be used, and the steps to be taken in special cases (*e.g.*, Electrolysis).

SCOTLAND WEST CENTRE.

Following is a cutting from the "Glasgow Herald," of the 4th February, dealing with a lecture held under the auspices of the Scientific Society of the Royal Technical College, Glasgow, to which members of the Scotland West Local Centre were invited. Many members of the Local Centre availed themselves of the invitation to be present:—

"PICTURES BY WIRELESS.

"POSSIBLE EFFECT ON NEWS TRANSMISSION.

"THE 'GLASGOW HERALD' SYSTEM.

"The various systems of picture telegraphy which are now in use in newspaper offices and elsewhere were described in full technical detail by Mr. E. S. Ritter, the London G.P.O. specialist in this form of transmission, at a meeting of the Scientific Society of the Royal Technical College, Glasgow, on Saturday night. The meeting was held in the College, and Professor Mellanby, president, was in the chair.

" G.P.O. Specialist Explains.

" Mr. Ritter defined picture telegraphy as the transmission of print, drawings, and sketches in black, white, or facsimile, and also the transmission of photographs, half-tones, etc., either over a telephone line or by radio circuits, or by a combination of the two. With the aid of photographs—originals, transmitted, and reproduced in newspapers—and of specimen parts of the transmitting and receiving systems, in addition to a number of lantern views and diagrams, he gave a full explanation of the working of the Siemens, Bell, Belin, Bart Lane, Marconi facsimile, and the Fultograph systems.

" At the close of the lecture a short discussion took place, in the course of which Mr. Ritter elaborated some of his remarks regarding various parts in the instruments.

" Future of Picture Telegraphy.

" On the invitation of the chairman, Mr. A. M'L. Ewing, manager of Messrs. George Outram and Co., Ltd., referred to the success that has attended the operation of the Siemens system of picture telegraphy since it was installed some time ago at the Glasgow and London offices of ' The Glasgow Herald ' and its associated newspapers. Since it had been installed, he said, very little trouble had been experienced in its working. He believed there were even greater possibilities in this form of transmission than had yet been attained—that the day might come when they might not only have pictures transmitted but also a very much speedier transmission of news. At present, with two telegraph lines in use, a speed of about 300 words a minute was attained. He understood that developments which were now under consideration by the Post Office would increase that capacity very greatly and possibly provide for the transmission of pictures at the same time, or at any rate, over the same wire. One estimate placed the output at very much higher than the 300 words a minute obtained just now. If they got news transmitted with as great accuracy and regularity as they got pictures at the present time he did not think they would have anything to complain about.

" Reproduction the Better Picture?

" Alluding to two views of the King which had been shown on the screen, and which had been sent by means of ' The Glasgow Herald ' apparatus, Mr. Ewing remarked that he had asked the London staff to transmit the picture and to send on the original of it. A slide had been prepared of the two, and the reproduction had been so fine that he thought there would be some difficulty in distinguishing the one from the other. On the screen it appeared to him that the transmitted picture was really the better of the two. (Laughter.) Possibly, however, that was because of the character of the paper on which it was printed.

" Mr. Percy Morris, ' The Scotsman,' spoke of the working of the Belin system, which has been installed in the offices of that newspaper, and indicated that some slight improvement might be effected in the matter of synchronisation and in the size of the picture. He was confident, however, that Belin had the right idea in regard to reception.

" A vote of thanks to Mr. Ritter was moved by the Chairman, and Mr. Ewing, in seconding, expressed appreciation of the co-operation and assistance that the Post Office had given in this new form of transmission of pictures to newspapers."

The third meeting of the current session was held on 4th February, when the lecturer was Mr. F. G. C. Baldwin, M.I.E.E., Assistant Superintending Engineer of the Northern District, and the subject " Scientific Organisation and the Post Office Engineering Department."

The paper having already been printed and issued to the members, the lecturer confined himself to certain portions of the paper and some considerations which arose since the paper was printed. With the aid of lantern slides the ground was covered in an instructive and interesting fashion and a good discussion ensued.

Under the auspices of the Scottish Centre of the Institution of Electrical Engineers a meeting was held in the Royal Technical College on

Tuesday, 12th February, when a paper by Mr. W. B. Woodhouse on "Overhead Electric Lines" was presented by Major H. Carter. Members of the I.P.O.E.E. were specially invited and there was a good response. The paper dealt specially with strength tests, carried out by the British Electrical and Allied Industries Research Association in regard to single "A," and "H" poles used in connection with overhead power lines. The methods of making the tests was illustrated by means of a cinematograph film and lantern slides.

On conclusion of the paper a discussion took place which was taken part in by several representatives of the Department.

H.C.M.

NORTH WESTERN CENTRE.

A meeting of the Centre was held in St. George's Hall, Preston, on the 15th January, 1929, when a lantern lecture entitled "The Early Development of Telephone Switching" was delivered by Capt. F. G. C. Baldwin, M.I.E.E.

The Chairman (Mr. J. M. Shackleton, M.I.E.E.) presided.

Capt. Baldwin, after his opening remarks, described the earliest telegraph switching appliances and the origin of the telephone exchange and proceeded with a description of the first telephone exchange in 1879. He then traced the evolution of the various switching devices up to the present day explaining the salient points of each system in passing. The lecture was illustrated by upwards of 50 interesting lantern slides.

On the 4th March, 1929, Mr. C. Coward contributed a paper entitled "Unit Construction and Maintenance Costs (External) from Fundamentals."

The subject was approached from the point of view of the actual work rather than from the final statistics and the paper was broadly divided into two sections, viz.:—Maintenance and Construction. Mr. Coward traced the system from its inception to the form in which it is now known and dealt at length with various aspects of the subject, relating actual experiences and suggesting improvements. The paper was followed by a discussion and in view of the interest aroused by the lecture and the paramount importance of the subject at the present time it was decided to postpone the proceedings and arrange a further meeting to continue the discussion.

D.B.

NORTH WALES CENTRE.

The Session was opened on 10th October, 1928, when Captain J. Coxon, M.I.E.E., read a paper entitled "Secondary Batteries." This paper had been specially asked for by the local Committee and was designed to assist members in charge of this class of plant. After a brief reference to the earlier types of secondary cell, Captain Coxon devoted himself to the types used in this Department, their installation and layout, their methods and rates of charging. In addition to a fine collection of slides there were many exhibits including specimen cells and plates of acid and also of nickel-iron-alkali cells. The paper was followed by a discussion.

The second meeting was held on 14th November, 1928, when Mr. A. S. Renshaw (E.-in-C.O.) contributed a paper entitled "Some considerations relating to the Clerical Organisation of the Engineering Department." Mr. Renshaw commenced at the year 1912 by describing the conditions existing at the time of the telephone transfer, which gave rise to the appointment of the Walkley Committee (1914) and he outlined the methods of investigation adopted by that Committee and the results which were achieved. The ratio of clerical staff to workmen was shown to have been considerably reduced in subsequent years, and at the same time the delay in furnishing the various monthly accounts had been greatly reduced. Mr. Renshaw then referred to standardisation, co-ordination and inspection, to the policy of devolution, recruitment, training and future developments, and he had in the subsequent discussion a long list of eager enquiries to meet.

The third meeting was held at the Central Cinema on 11th December, 1928, when the programme was of an unusual character, consisting entirely of technical films. There was an attendance of over 200, including visitors from the Surveyor's and Head Post Offices, Shrewsbury Technical College, Shrewsbury Secondary Schools and the Shropshire Philosophical Society. The programme commenced with the film "Voices across the Sea," followed by six other films lent by the Standard Telephones & Cables Ltd. illustrating telephones and cables, manufacture and development, broadcasting and receiving, valve repeaters, telephone transmission and switching, and the operation of the thermionic valve. The projection of the films was followed with great interest and this variant from the usual programme was voted a success.

The fourth meeting was held at Fordrough Lane Stores Depot, Birmingham, on 10th January, 1929, and prior to the meeting members were conducted in parties over the Stores Depot, Factory and Testing Branch, officers of the various staffs acting as guides, and explaining the different operations carried out. At the meeting Captain Cave-Brown-Cave, B.Sc., read a paper on "Modern Views on the Structure of Matter," in which he mentioned one by one the famous figures in the scientific world during the past 300 years, side by side with their most important discoveries, thus showing the steps by which scientific knowledge has advanced to its present position, which was fully outlined. Finally in dealing with present day knowledge Captain Cave-Brown-Cave gave a short talk on "Relativity" and described some of the methods by which scientific experiments are brought to proof. After an interesting discussion and votes of thanks to the lecturer and to the Controller, Stores Department, for his kindness in allowing the visit, the members inspected a collection of microscope slides illustrating experiments carried out by Captain Cave-Brown-Cave, Mr. W. J. Eves and Mr. P. C. Martin.

The fifth meeting was held at Shrewsbury on 6th February, 1929, when Mr. E. J. Jarrett read a paper entitled "Director Working." At the outset Mr. Jarrett exhibited a number of slides showing early switchboards of the flat magneto type and the various improvements leading to the present day C.B. switchboard, and indicated the devices by means of which in each successive stage, the time of operating was reduced, until, eventually the operators cord circuit was cut out altogether in the automatic exchange. The various operations in automatic apparatus and the designing of auto exchanges were then touched upon and the conversion of the Birmingham Exchange and the lay-out of plant in that area were outlined. In conclusion, the Tandem Exchange and Coder Call Indicator Exchange were described, and Director Working fully explained.

The sixth meeting was held on 27th February, 1928, and the members heard Mr. E. J. Woods, A.M.I.E.E. (E.-in-C.O.), read his paper on "The Main Underground Trunk Cable System of the British Isles." The paper has already been summarised in connection with Mr. Woods' visits to other Districts, and its reading on this occasion was followed by a long and interesting discussion.

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CAPTAIN J. P. PRICE.

Captain J. P. Price.

Captain J. P. Price attained his official majority in January last with 45 years' P.O. service to his credit. This record began in December, 1883, at Chester as a Telegraph Learner and in his earlier years of service he shared with others the unique experience of telegraphing the speeches of the late Rt. Hon. W. E. Gladstone in the North Wales Area as a member of the Special Service Staff set up for the purpose.

In 1896 he was appointed a Telephone Instructor for the taking over of the Telephone Trunk Service from the late National Telephone Company, visiting 62 towns in the British Isles in connection with this work. He also shared in the trunk transfer arrangements to Post Office control and the opening of many new Trunk Exchanges. At the finish of this work he was appointed to the Engineering Department in the N. Wales District as Sub-Engineer. Whilst in this district he began his well-known interest in paper dry core cables, and was early instrumental in getting the standard of insulation resistance raised above that then accepted for them, and specifications were adjusted to correspond.

He was transferred as a 2nd Class Engineer to the Engineer-in-Chief's Office, London, in 1898, taking up the work of testing and examining cables, wires and apparatus at manufacturers works, thus getting a valuable experience which stood him in good stead later.

In 1900 he joined in the work of telephoning London, and controlled duct and pipe laying, cabling, jointing and exchange equipment works in the Metropolitan (S) District, in an area which embraced the S., SW. and W. postal districts and the Thames Valley districts of Kingston, Putney and Wimbledon.

Following his promotion in 1901 to a 1st Class Engineership, he assumed the chargeship of the Wandsworth Section of London. He was responsible for much important work of a construction and maintenance character in modernising this area, including the provision of many miles of air-space paper-core cables for the service of all the National Telephone Exchanges there. Later he took over the control of the Holborn External Section of the Central London Area and from thence was transferred to the Engineer-in-Chief's Office again.

In March, 1911, he was appointed to the South Eastern District as Assistant Superintending Engineer, a post which he held for nearly 18 years. His former experiences of construction works and maintenance methods proved very valuable assets, for they enabled him to deal efficiently with the many difficulties he was called upon to dispose of, and to the credit of the district.

During the late War he was appointed P.O. Engineering adviser to the 2nd Army Home Defence, the Southern Army and the Kent Independent Force, with the rank of Captain. He was also Brigade Signal Officer to the South London Volunteer Regiment.

He was educated at the Chester Diocesan Training College, where he first became interested in electrical subjects. This interest he kept going throughout his service, keeping himself well informed at all times of the changes and advancement of them, by reading, lectures and classes. This spirit he was always inculcating into the members of the Staff, encouraging them to extend their knowledge in every way open to them. For the I.P.O.E.E. he had a very warm attachment and was never weary in advocating its usefulness.

All this, and much more, was testified to by many of his old colleagues who met at Croydon in December last to bid him " au revoir." The occasion was used by the Superintending Engineer, G. F. Greenham, Esq., in a happily-phrased speech, to present Mr. Price with a gold watch as a token of esteem and regard, subscribed for by his many friends in the district.

Mr. Price has left us in good health and vigour and with faculties as keen as ever, from which it can be deduced he will not " rust " in retirement. On the contrary, he is to take an active interest in motor cruising on an extensive plan, as skipper of the motor launch " Aloha Oe," in which he proposes to visit many of the rivers, creeks and canals of these islands and possibly continental ones as well. This is an excellent way of spending one's retirement and we feel sure he will enjoy it—he deserves to. We sincerely hope he will and cordially wish him " all the best " for a very long time to come.

G.

BOOK REVIEWS.

" Electrical Transmission and Distribution." Edited by R. O. Kapp, B.Sc. Sir Isaac Pitman & Sons. Volumes I. and II. 6/- each.

These are the first two volumes of a series of eight in which it is proposed to treat the problem of electrical transmission and distribution in its entirety. The book is divided into various sections, each written by a specialist on the particular subject dealt with.

Volume I. deals with the construction, erection and maintenance of overhead lines and concludes with a section on distribution in rural areas. The matter is dealt with throughout in a rather popular manner, but the details regarding the construction of overhead lines are set out very clearly and the matter represents a very up-to-date summary of modern practice. The section dealing with " Maintenance " is written largely from the view point of organization of the work. The section dealing with " Distribution in Rural Areas " is written by Mr. Borlase-Matthews. It is not surprising to find that the views on the Overhead Lines Association are very prominent.

Volume II. deals with power cables. It is divided into four sections entitled " Manufacture of Power Cables," " Cable Laying Methods," " Underground Cables " and " Consumers' Connections." The first section gives a very complete outline of manufacturing methods, with many excellent photographs of works and plant of a type not usually shown in technical works. The second section illustrates very clearly the various standard methods in use, together with methods adopted in a number of unusual cases. Many of the illustrations are easily recognisable, as examples of work by the Standard Telephones and Cables, Ltd. The third section deals with testing and maintenance. It contains a brief but very clear exposition of the problems of chemical and electrolytic corrosion.

H.C.

We welcome the arrival of the first number of " Civil Service Arts Magazine," which will be published quarterly, price sixpence. The editor, Mr. S. McKechnie, assisted by a weighty and influential committee, has produced a very good number to begin with, and it is understood there will be no lack of first rate material in the future. In the present issue Drama and Opera, Photography, Art, Music as pursued and practised in the Civil Service are adequately dealt with.

Commissioned agents are wanted for the magazine. Subscriptions sent direct to the Circulation Manager, " Civil Service Arts Magazine," Room 208, Treasury Chambers, Whitehall, S.W.1, should be accompanied by sevenpence in stamps. Yearly subscriptions are invited.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to	Date.
Gomersall, E., O.B.E.	Deputy Suptg. Engineer, London District.	Suptg. Engineer London District.	1-4-29
Cornish, H. V.	Assistant Suptg. Engineer, London District.	Deputy Suptg. Engineer, London District.	1-4-29
Hedley, J.	Assistant Staff Engineer, Telephone Section, E.-in-C.O.	Staff Engineer, Telephone, Section, E.-in-C.O.	1-4-29
Preston, E. L.	Assistant Engineer, Bristol Section, S.W. District.	Executive Engineer, Swansea Section, S. Wales District.	To be fixed later.
Cowburn, W.	Assistant Engineer, Liverpool Int. South Lancs. District.	Executive Engineer, Blackburn Section, N.W. District (vice Mr. R. C. Balcombe, transferred to Taunton, headquarters of a new section).	To be fixed later.
Pratt, A. J.	Assistant Engineer Liverpool External Section, S. Lancs. District.	Executive Engineer, Liverpool External Section, S. Lancs. Dist.	21-12-28
Linch, R.	Chief Inspector, Testing Branch, London.	Assistant Engineer, Testing Branch Birmingham.	13-1-29
Glover, D. W.	Unestablished Skilled Workmen. E.-in-C.O.	Inspector, E.-in-C.O.	15-12-28
Collinette, L. T.	Skilled Workmen, Class I., London Engineering District.	Inspector, London Eng Dist	
Humphreys, L. H.	,, ,,	,, ,,	
Moore, B. J.	,, ,,	,, ,,	
Robbins, E. H.	,, ,,	,, ,,	
Maggs, C. W.	,, ,,	,, ,,	
Sell, S. F.	,, ,,	,, ,,	
Hutchings, E. J.	,, ,,	,, ,,	
Peel, W.	,, ,,	,, ,,	
Barber, A. W.	,, ,,	,, ,,	
Mallows, F. J.	,, ,,	,, ,,	
Thompson, L. M.	,, ,,	,, ,,	
Hall, H. C.	,, ,,	,, ,,	
Phipps, G. R.	,, ,,	,, ,,	
Wheatley, J. J.	,, ,,	,, ,,	
Hutchinson, C. H.	,, ,,	,, ,,	
Sharp, J.	,, ,,	,, ,,	
Norfolk, E. W.	,, ,,	,, ,,	
Stuart, J. F.	,, ,,	,, ,,	
Brock, W. P.	,, ,,	,, ,,	To be fixed
Bydawell, P. J.	,, ,,	,, ,,	later.
Evans, W. A. A.	,, ,,	,, ,,	
Swan, G. E.	,, ,,	,, ,,	
Sallnow, C. B.	,, ,,	,, ,,	
Barnes, F. L.	,, ,,	,, ,,	
Howard, A. A.	,, ,,	,, ,,	
Maynard, W. F.	,, ,,	,, ,,	
Benham, F. W.	,, ,,	,, ,,	
Wills, H. H.	Skilled Workman, Class II., London Engineering District.		
Sly, R. C.	,, ,,	,, ,	
Richards, H.	,, ,,	,,	
Pettitt, V. R.	,, ,,	,,	
Bull, W. J.	,, ,,	,, ,,	
Hills, J. A. E.	,, ,,	,,	
Dutton, E. S.	,, ,,	,,	
Hart, S.	,, ,,	,, ,,	
Rolin, F. W.	,, ,,	,, ,	
Doubrowsky, T. L.	,, ,,	,, ,,	
Rumary, F. J.	Skilled Workman, Class I., Radio Branch.	Inspector, Radio Branch.	
Rhodes, W.	,, ,,	,, ,,	
Bailey, A. J.	,, ,,	,, ,,	
Stewart, T.	,, ,,	,, ,,	To be fixed
Mitchell, H. T.	,, ,,	,, ,,	
Cooper, W. D.	,, ,,	,, ,,	later.
Thomsett, H. S.	,, ,,	,, ,,	
Lynes, F. A.	,, ,,	,, ,,	

APPOINTMENTS.

Name.	From	To	Date.
Millen, G. J.	Probationary Inspector E.-in-C.O.	Inspector, E.-in-C.O.	1-1-29
Perryman, C. F.	Probationary Inspector E.-in-C.O.	,, ,,	
Hibbs, A.	Probationary Inspector, S. Mid. Dist.	Inspector, S. Midland District.	
Chandler, R. W.	Probationary Inspector, Grimsby Radio.	Inspector, Grimsby Radio.	
Salt, R. S.	Probationary Inspector, Eastern Dist.	Inspector, Eastern District.	
Bavin, A. E.	Probationary Inspector, London Engineering District.	Inspector, London Engrg. Dist.	
Seymour, E. H.	Probationary Insp., S. Lancs. Dist.	Inspector, S. Lancs. District.	
Hayes, H. C. S.	Probationary Insp., E.-in-C.O.	Inspector, E.-in-C.O.	
Buck, G. L. N.	Probationary Insp., E.-in-C.O.	,, ,,	
Roberts, J. H.	Probationary Insp., Ldn. Engr. Dist.	Inspector, London Engrg. Dist.	
Coleman, W. L. A....	Probationary Insp., S. West Dist.	Inspector, S. West District.	
Neale, J.	Probationary Insp., E.-in-C.O.	Inspector, E.-in-C.O.	
Styles, G. E.	Probationary Insp., Ldn. Engr. Dist.	Inspector, London Engrg. Dist.	
Knox, A. H. C.	Probationary Insp., E.-in-C.O.	Inspector, E.-in-C.O.	
Lowne, W. R. J.	Probationary Insp., S. East Dist.	Inspector, S. East District.	

TRANSFERS

	Rank.		To	Date.
Tattersall, J. T.	Executive Engineer	N.E. District.	S. West District.	27-1-29
Cresswell, H. G. B.	Assistant Engineer	London Engr. District.	E.-in-C.O.	1-10-28
Garnett, J. A.	,,	Scot. West.	London Engr. Dist.	8-1-29
Govett, C. W.	,,	London Engr. District.	E.-in-C.O.	13-1-29
Hobson, J. W.	,,	Scot. East.	Northern District.	6-2-29
MacDermott, C. N.	,,	E.-in-C.O.	Met. Police Dist.	1-1-29
Marsden, W. H.	Chief Inspector	N.E. District.	S. West District.	1-1-29
Crank, F. G.	Inspector	Devizes Radio.	Portishead Radio.	1-2-29
Turvey, G. H.	,,	N. Midland Dist.	Eastern District.	9-12-28
Coleman, W. L. A.	,,	S. West District.	London Engr. Dist.	10-2-29
Seymour, E. H.	,,	S. Lancs. District.	,,	10-2-29
Sims, A. E.	,,	S. West District.	E.-in-C.O.	20-1-29
Ingram, C. P.	,,	N. Midland Dist.	,,	27-1-29
Gilby, F. W.	,,	N. Midland Dist.	,,	27-1-29
Gambier, J. E.	,,	S. West District.	,,	3-2-29
Anderson, E. W.	,,	S. West District.	,,	3-2-29
Couch, P. R.	,,	S. West District.	,,	3-2-29
Sheriff, L.	,,	N. Wales.	,,	7-2-29
Chapman, R. H.	,,	N. Wales.	,,	10-2-29
Ellis, H. O.	,,	S. West District.	,,	10-2-29
Brock, P. R. W.	,,	London Engr. District.	,,	10-2-29
Missen, H.	,,	London Engr. District.	,,	10-2-29
Markey, J. M.	,,	Northern District.	,,	3-3-29
Longmore, F. W.	,,	Northern District.	,,	3-3-29

RETIREMENTS.

Name.	Grade.	Districts.	Date.
McIlroy, R., I.S.O.	Superintending Engineer.	London.	31-3-29
Ivison, E. J.	Staff Engineer.	E.-in-C.O.	31-3-29
Richardson, J.	Assistant Suptg. Engineer.	S. East.	7-3-29
Powning, W. H.	Executive Engineer.	S. Wales.	15-2-29
Gwilliam, W. J.	,, ,,	Testing Branch.	31-3-29
Sirett, C. J.	Assistant Engineer.	S. Midland.	24-3-29
Stewart, J. H.	,, ,,	London.	31-12-28
Tanner, L.	,, ,,	N. East.	31-1-29
Jessup, H. W.	Chief Inspector.	Testing Branch.	18-3-29
Collyer, A. J.	Inspector.	S. Midland.	17-12-28
Parvin, J.	,,	S. Wales.	31-12-28
Berry, A.	,,	S. Wales.	31-12-28
Kitcheman, S.	,,	N. East.	31-12-28
Halmshaw, C. A.	,,	N. East.	5-1-29
Hooper, C. F.	,,	S. East.	28-2-29

Deaths.

Name.	Grade.	District.	Date.
Barker, A. J.	Chief Inspector.	Testing Branch.	28-1-29
Hill, P. W. R.	,, ,,	S. West.	5-2-29
King, I.	,, ,,	London.	5-2-29
Dowdall, F. F.	Inspector.	London.	15-2-29
Ashworth, J.	,,	S. Lancs.	23-2-29

CLERICAL ESTABLISHMENT.

Promotions.

Name.	From	To	Date.
Stephenson, W. H.	Acting Staff Officer. E.-in-C.O.	Staff Officer, E.-in-C.O.	3-1-29
Ramsay, J.	,, ,,	,, ,,	31-1-29
Hoggarth, H. J.	First Class Clerk. E.-in-C.O.	Acting Staff Officer. E.-in-C.O.	3-1-29
Davidson, R. S.	Acting Executive. Officer E.-in-C.O.	Executive Officer, E.-in-C.O.	31-1-29
Ost, H. J.	,, ,,	,, ,,	31-1-29
Gordon, F.	,, ,,	,, ,,	31-1-29
Hamilton, C. J.	Clerical Officer E.-in-C.O.	Acting Executive Officer E.-in-C.O.	22-9-28
Emmett, H. H.	Clerical Officer, London District.	Higher Clerical, London District.	13-1-29
Frewin, W. D.	Clerical Officer, London District.	,, ,,	13-1-29
Hamilton, C. J.'	Acting Executive Officer, E.in-C.O.	Executive Officer, E.-in-C.O.	10-2-29
Bate, F.	Clerical Officer, N. Mid. District.	Executive Officer, E.-in-C.O.	10-2-29
Aspden, S. C.	Clerical Officer, E.-in-C.O.	Acting Executive Officer.	10-2-29

Retirements.

Name.	Grade.	Date.
Simms, J. T.	Higher Clerical Office (Ireland, N.)	22-2-29
Swansborough, R.	Higher Clerical Officer (London District).	31-3-29
Copp, S.	Higher Clerical Officer (London District).	31-3-29

Appointments.

Name.		Date.
Manning, W. J.	To Executive Officer E.-in-C.O. from Open Competition.	14-1-29

COMMUNICATIONS.

All Remittances and Communications should be addressed to the Managing Editor, P.O.E.E. Journal, Engineer-in-Chief's Office, Alder House, London, E.C.1.

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