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TELEGRAPH INSTRUMENT ROOMS. ADOPTION OF NEW METHODS.

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A DEPARTURE from the standard instrument room arrangements for telegraph circuits in this country has been authorised as a result of recommendations made by a Commission of enquiry into the organisation and methods of working the Telegraphs in America. The "Simon" Commission recommended that all apparatus other than that actually required by the operators should be removed from instrument tables and accommodated in test rooms or other suitable positions. (Incidentally, the suggestion to segregate apparatus other than manipulative units was made by the Engineer-in-Chief as far back as 1923, but its adoption has been postponed for various reasons).

Leeds H.P.O. was selected for an experimental application of the suggestion, and the telegraph instrument room at this office has been completely rearranged. Auxiliary apparatus for Morse and Teleprinter circuits has been mounted on racks, double tables have been introduced, with operating positions face to face. Timing stamps for use on busy circuits, and Vee belt conveyors for collecting received messages have also been installed. These features are new to the telegraph service in this country; a detailed description may be of interest, therefore, and useful in the event of further offices being similarly equipped.

Designs for the racks, apparatus, and riser belt conveyors were prepared by the Engineer-in-Chief and the manufacture of the whole equipment, except the conveyor system, was undertaken by the P.O. Stores Department at Holloway Factory. The re-organisation was completed by the Superintending Engineer early in October.

Initially, rack accommodation for 48 Teleprinter duplex, and five Morse duplex circuits has been provided. Concentrator and Wheatstone circuits are not included in the scheme, in view of the probability of their early inclusion in the Teleprinter or Phonogram programmes.

A space 32′ 6″ × 18′ was made available for the erection of three rows of bays, with a maximum capacity of 72 circuits. Fig. 1 shows the instrument room lay-out as regards segregated apparatus, telegraph test case, instrument tables, and belt conveyors.

The rack mounted apparatus is assembled on unit type bays, measuring 6′ $2\frac{3}{8}$″ × 1′ $8\frac{1}{2}$″. They consist of a frame of channel, 3″ × $1\frac{1}{2}$″ × 5/16″ m.s., fitted with a base of angle, 6″ × 6″ × 7/16″ m.s., drilled $\frac{1}{2}$″ clear to take Lewis bolts for floor fixing. Stays being undesirable on account of appearance, individual bays are drilled $\frac{3}{8}$″ clear and bolted together to give the required degree of stability. Mounting plates of $\frac{1}{4}$″ mild steel,

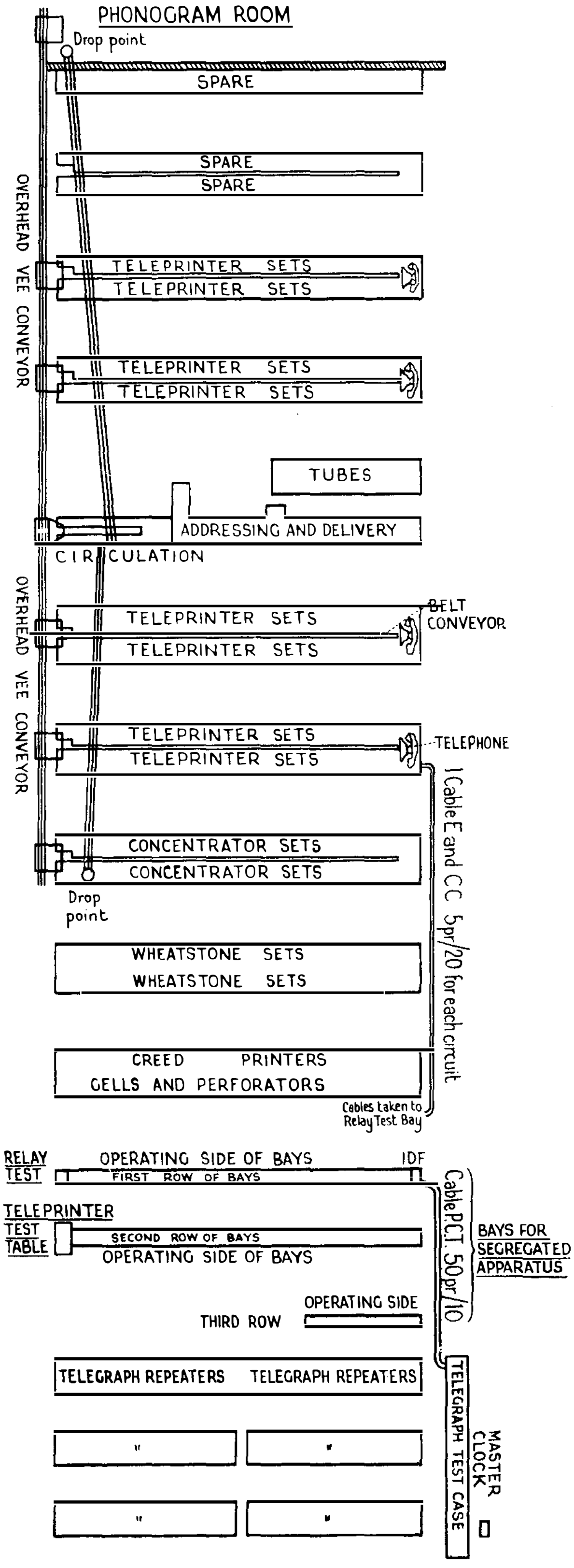

FIG. 1.—INSTRUMENT ROOM LAY-OUT.

cold rolled, are fitted to the frames by means of Whitworth hexagon head set screws. The plates are spaced to meet the dimensions of the apparatus employed. Fig. **2** shows a unit type bay fitted with apparatus, in position on the concrete foundation.

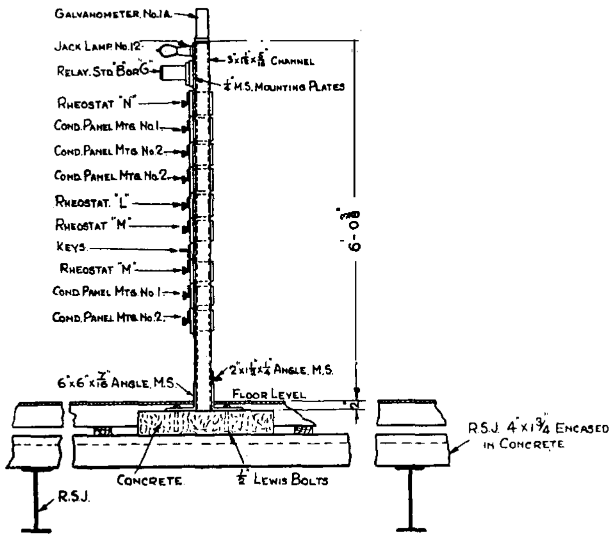

FIG. 2.—APPARATUS BAY IN POSITION.

P.O. standard telegraph apparatus is not suitable for vertical mounting as the plugs employed with rheostats, condensers, and other units are liable to be dislodged. Special apparatus having dial adjustment has therefore been designed and, where plugs are necessary, they take the form of a wire U link with one leg tethered. The opportunity has been taken to provide improved condenser units for the duplex balance, giving small gradations in values. The following new items have been introduced :—

Condenser, Panel mounting, No. 1, giving 9.9 μF in steps of 0.1 μF.

Condenser, Panel mounting, No. 2, giving 5.9 μF in steps of 0.1 μF.

Rheostat L, giving 830 ohms in steps of 10 ohms.
,, M, ,, 4350 ,, ,, ,, ,, 10 ,,
,, N, ,, 8430 ,, ,, ,, ,, 10 ,,
,, P, ,, 12430 ,, ,, ,, ,, 10 ,,

Coil Shunt, Panel mounting, giving 14,000 ohms in steps of 2,000 ohms.

The relays employed are of the standard P.O. rectangular base type; they are placed in position by insertion under clips carried by a baseboard mounted vertically on the bay and are therefore readily removed for adjustment or test. Experiments carried out recently demonstrated that these relays are most sensitive when in a horizontal position with the tongue pointing upwards. This position has consequently been adopted for rack mounting. The weight of an individual bay, complete with apparatus, is approximately as follows:—

Test Bay 272 lbs. Power Bay 300 lbs. Apparatus Bay 252 lbs. The total weight of the with the bays. Excluding the relay test bay three types of bay are provided.

Apparatus Bays. Fig. **3**. These accommodate the apparatus for two circuits. A galvanometer of the standard P.O. pattern, connected in the line circuit, is mounted above each apparatus set. It may be turned slightly to give any required angle of vision. Lever keys of the standard type are provided which enable the testing officer to:—

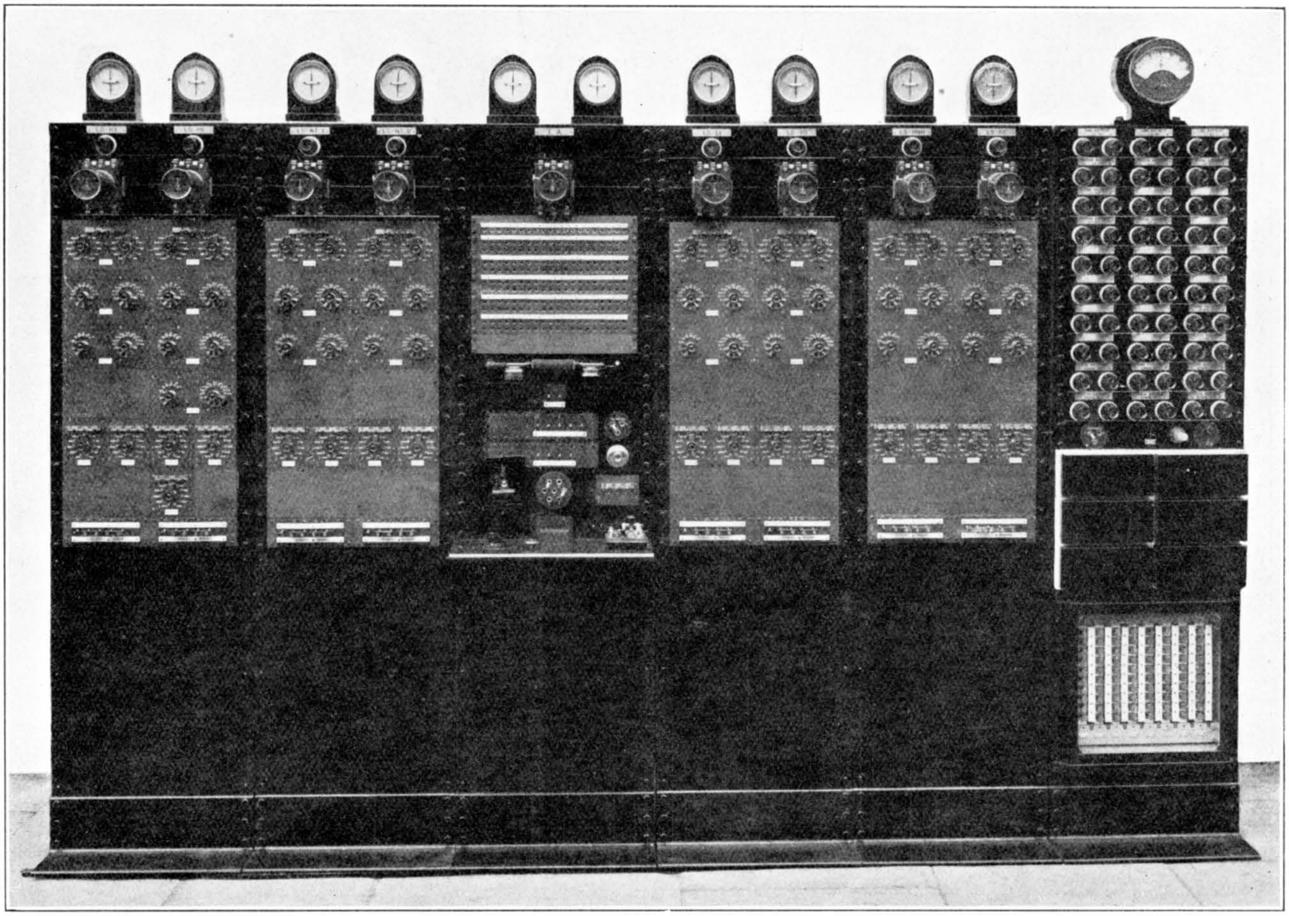

Fig. **3**.—Section of Bays. Reading from left: 2 Apparatus Bays, Test Bay, 2 Apparatus Bays, Power Bay.

racks concentrated upon a small area necessitated the addition of a rolled steel joist to strengthen the floor.

The bays are secured by Lewis bolts to a bed of concrete built up to 2″ below the floor level. Two rows of 17 bays each, and a section of six bays in the third row, were provided in the first instance. A small I.D.F., a relay test bay and a testing table for Teleprinters are also associated

(*a*) Balance the circuit.
(*b*) Work Morse duplex to the out-station.
(*c*) Work Teleprinter duplex to the out-station.
(*d*) Work Teleprinter duplex to the instrument table.

A key is provided to break circuit between the line relay local battery and the Instrument Table, also a battery cut-off key in the auxiliary circuit where a relay of the vibrating type is employed.

Power Bays. Fig. **3**. These are provided with jacks for 60 Lamps, Resistance, covering the requirements of 12 circuits. Immediately below the jacks, a small lamp, fuse-mounting and tumbler switch are fitted to form a circuit for testing the 1-amp fuses employed. Cut-outs No. 1 (modified for rack mounting) bay which is paralleled to a similar tablet on the Test bay. At the latter position voltage tests of the universal batteries are made, while loop batteries are tested at the Power bay tablet which is not earth connected.

Test Bays. Fig. **3**. These are equipped with jacks and apparatus enabling any one of eight circuits to be dealt with for testing.

FIG. **4**.—PART OF INSTRUMENT ROOM, SHOWING THREE SECTIONS OF BAYS IN BACKGROUND.

carrying 10 fuses each, for use with independent batteries and a Cut-out No. 3, accommodating 80 fuses for use with the universal battery supply, are mounted below the lamps where, by means of a plug and cord connection, a change of voltage may be made. Above the bay a centre-scale Voltmeter, reading 150-0-150 volts, is mounted, having connections to a 3-hole tablet fitted on the A test bay is placed in the middle of four apparatus bays and associated with a power bay on the right hand side of the group. Fig. **4** shows the first row of bays, comprising three sections, in position. It will be observed that the three tables immediately in front of the bays are occupied by the concentrator and Wheatstone sets not yet replaced. The apparatus sets are numbered from left to right, A1 to A4 being to the left of a test bay, and A4 to A8 on the right. The number of circuits connected to a test bay is limited to eight to minimise delay should two or more circuits require attention simultaneously, a situation liable to arise when daily tests, prior to opening the circuit, are carried out. A further limiting factor is the distance a testing officer can comfortably reach from the test bay in order to make adjustments of the balancing units on the apparatus bay.

The top jack strip provides jacks for cross connection to other test bays, a 40 volt battery for testing in conjunction with a 7-hole test tablet, and jacks for earth connections. The next four rows have two jack strips of 20 jacks each, coupled; 10 upper and 10 lower jacks are allotted to each Teleprinter to enable tests to be made on the artificial line, A and B lines, "go" and "return" receiving circuit, Teleprinter transmitting line, Teleprinter and line relay batteries. The bottom double jack strip is utilised to provide testing points for the testing apparatus, which comprises a jack to connect the test Teleprinter, socket to connect power for motor, leak galvanometer and relay. A Morse key and a polarised sounder are carried on a fibre-covered wooden shelf projecting 9″ from the bay.

When the testing officer receives an intimation that a circuit requires attention, a Teleprinter mounted on a portable table is wheeled to the position and connected to the jack and plug provided. If the distant office has complained of faulty signals from line, the relative leak key on the test bay is thrown and a duplicate of the signals being sent to line is obtained through a high resistance leak. Faulty transmission would thus become apparent. The circuits include aerial lines, underground screened conductors, underground loops, and earthed circuits superposed on loop circuits, so that the line voltage employed may be as low as 24 v. or as high as 120 v. It is essential therefore that the shunt resistance should vary with the circuit under test and the shunt coil already described is employed for this purpose. If there is difficulty in reception, the test teleprinter is placed in series with the teleprinter at the instrument table by means of a plug and cord connection on the jack strips so that signals from the line relay operates both. A fault may thus be located to the distant station's transmission or to the home station's reception. Incidentally, the arrangement of two teleprinters joined in series demands a high degree of efficiency as regards their adjustment and any weakness in a particular instrument is revealed. Telephonic communication between test bays and the instrument tables for the convenience of supervising officers is provided on the basis of one telephone for each 12 teleprinter circuits. At Leeds this involves provision of a telephone on each double table. To call the testing officer, the telephone is lifted; this causes a lamp and bell on the test bay to give visual and aural warning. The officer answers by operating key switches to join up the telephone set.

The height of the bays was determined by the area required to accommodate apparatus for an underground loop circuit working with a vibrating relay. An apparatus set associated with an aerial circuit requires only five balancing units, an underground loop circuit requires seven, whilst a circuit with a vibrating relay requires seven and four additional units for the vibrating circuit. A minimum height of six feet is required therefore since, with this provision, where a vibrating relay is employed, the lowest unit is only 1′ 4″ from the floor. It is not practicable to reduce this distance, owing to the inconvenience of the position and to the risk of damage to the apparatus by moisture during cleaning operations.

Wire FP, 1 pr/12½, red and blue, is employed for wiring the bays. Connection strips are fitted at the foot of the bays and leads for internal and external connections are taken from this point. Cables from bay to bay are carried on a small shelf made up of angle, 1½″ × 2″ × ¼″ m.s., attached to the frame.

From the bays, five wires for each Teleprinter are taken to a small Intermediate Distribution Frame, where a jumper field allows any necessary re-arrangement of lines in relation to bays to be made. The five wires then pass to the instrument table *via* double jack strips on the relay test bay. At this point, by means of five pin plugs and cords, a working line can be transferred to any Teleprinter set in the instrument room as desired. Facilities for the concentration of working sets are thus available, simplifying supervision, and enabling sections of the room to

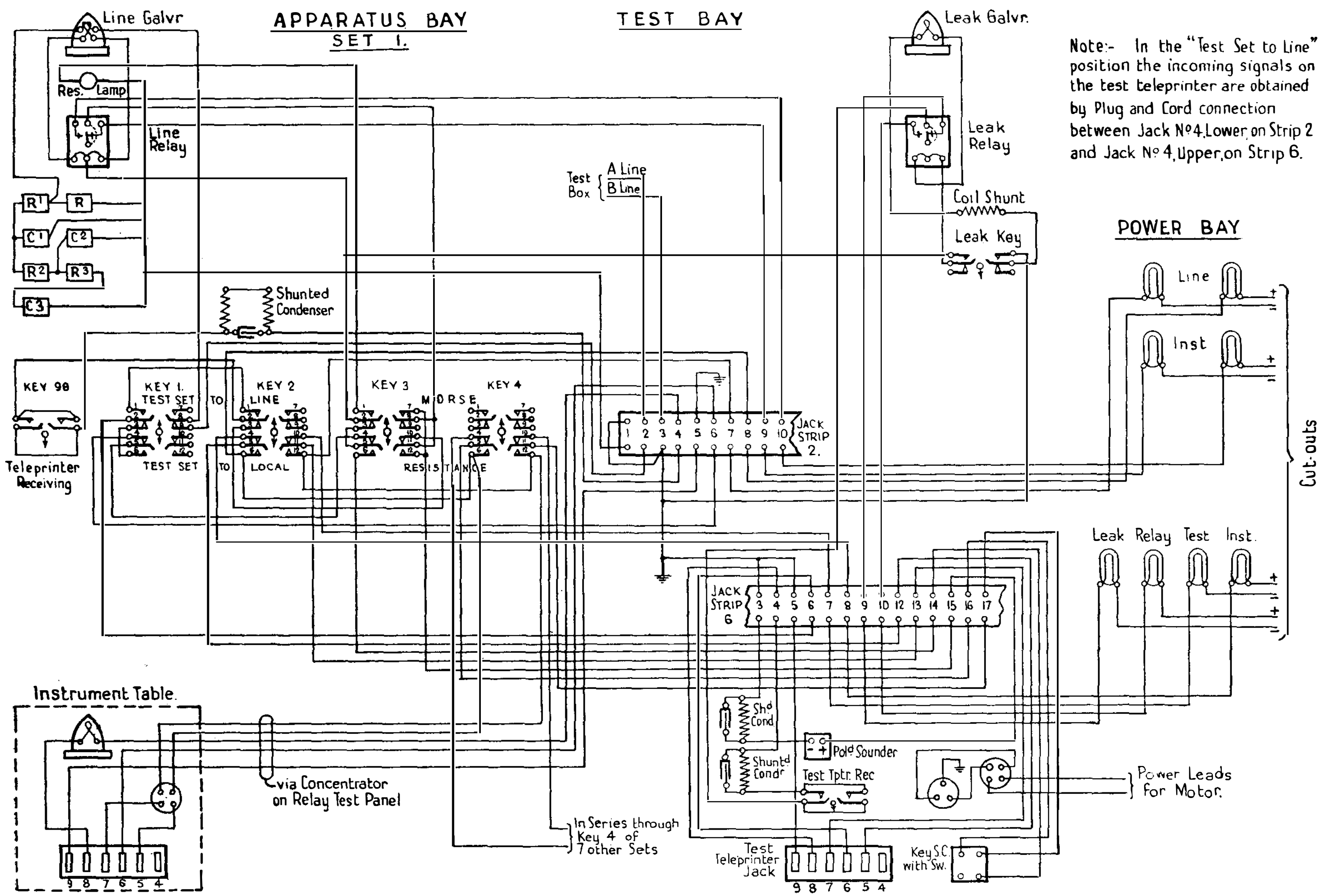

FIG. 5.—SCHEMATIC DIAGRAM OF A TELEPRINTER CIRCUIT.

be closed as the number of working circuits is reduced. The circuit connections are those in use for the standard Teleprinter duplex installation. The schematic diagram, Fig. **5**, allows the circuits made in the various positions of the key switches to be traced. The instrument table apparatus is confined to a Teleprinter with socket and battery cut-off switch for the motor circuit; a galvanometer in the receiving circuit, and a battery cut-off switch in the line battery circuit.

A section of bays to accommodate Morse circuits is provided. The general arrangement follows that of the Teleprinter Sections, the principle difference being that a less complicated system of key switches is required. At the instrument table a Morse key, sounder and tumbler switch are installed. The circuit may be worked either duplex or simplex, according to the position of a key on the relative apparatus bay.

Relay Testing.—The Relay Test Bay, Fig. **6**, closely follows a design produced by the P.O. Research Section. Its function is to secure an exact and uniform adjustment of the P.O. standard relays by means of measurements taken with sensitive instruments instead of depending upon visual examination of the operating parts. A standard relay is supplied with the bay, also a baseboard to accommodate the relay under test. By manipulating key switches the following tests may be made:—

(1) Calibration test of the standard relay to ensure that its behaviour is correct and that the adjustment is good.

(2) Sensitivity test. A current of one milliampere is passed through the relay coils and then reversed; the milliammeter should follow the change of direction.

(3) Neutrality test. Alternating currents at a speed of 50 p.p.s. are passed from the standard relay through the coils of relay under test, causing the latter to send reversals through the neutrality indicator. Any mechanical bias on the relay will be shown by the indicator and may be rectified by means of the biassing screw of the relay.

(4) Armature travel test. Alternating currents as in (3) are passed through the relay under test. The same pole of the battery is joined to both local contacts of the relay under test, whilst the tongue is joined to the coils of the

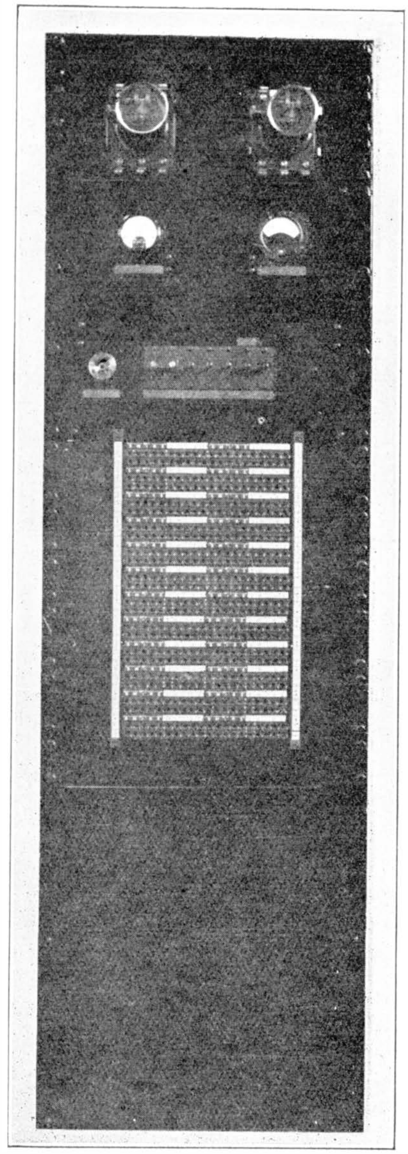

FIG. **6**.—RELAY TEST BAY.

neutrality indicator. If the relay tongue were at rest a full scale deflection would be produced on the indicator, irrespective of the contact engaged. When the relay tongue is vibrating, the full scale deflection is reduced by an amount dependent upon the width of the gap through which the tongue has to travel. If, therefore, a full scale deflection is regarded as 100% contact time, the actual reading observed on the indicator may be taken as the percentage contact time. It is thus possible to grade individual relays according to the efficiency required for any given circuit.

(5) Measurement of speed of telegraph signals.

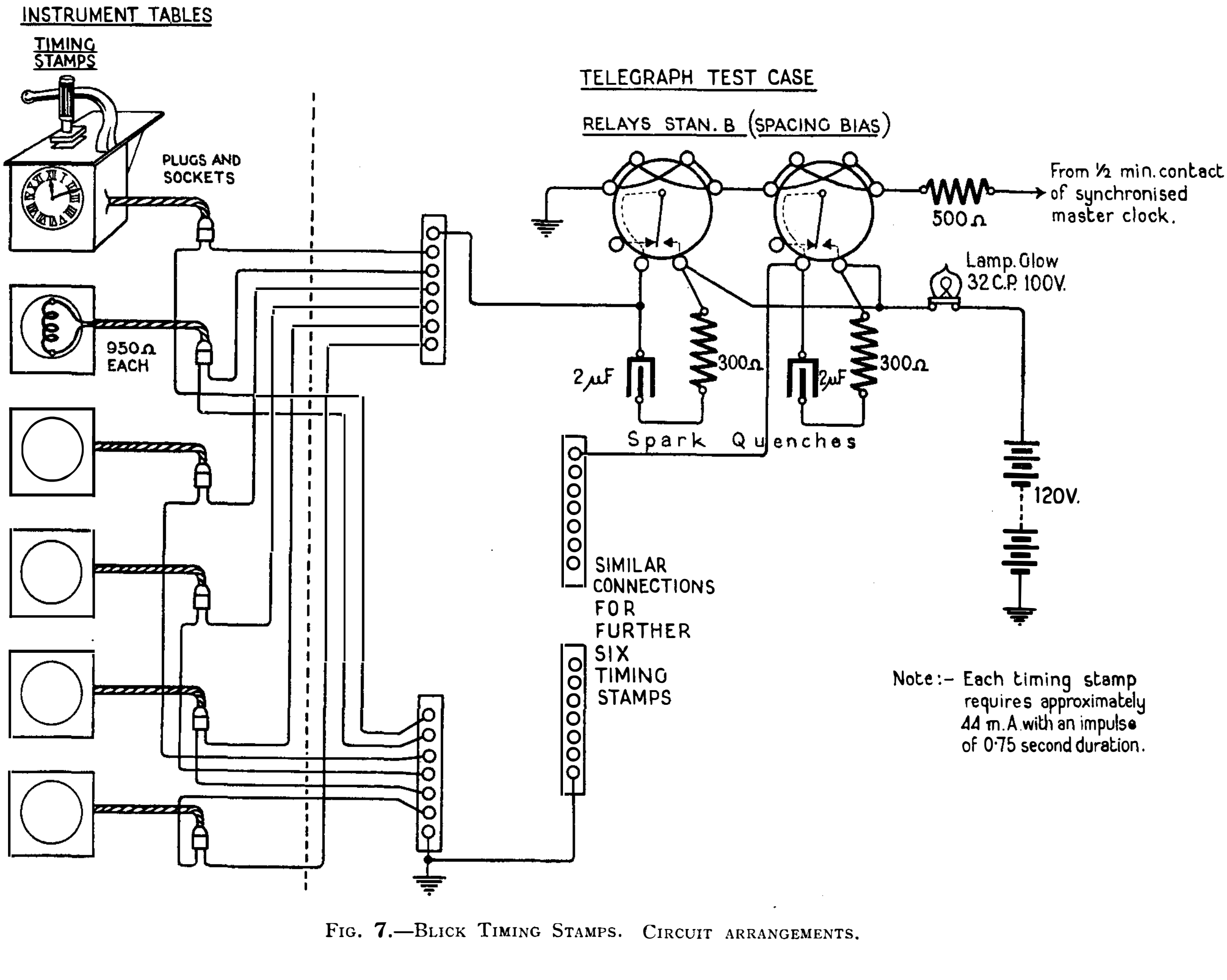

FIG. 7.—BLICK TIMING STAMPS. CIRCUIT ARRANGEMENTS.

The speed of reversals on a circuit may be measured by making a plug and cord connection to a jack on the bay; the reversals then pass through the coils of the standard relay. The tongue of this relay is joined to a condenser which is charged when the tongue makes contact on the marking side and discharged when it makes contact on the spacing side. The deflection on the speed indicator is approximately proportional to the speed at which the relay tongue is vibrating and, by the use of suitable values of resistance and capacity, the speed indicator is calibrated to give a direct reading of words per minute on one scale and periods per second on another. This test is useful for checking the speed of vibration of a Standard " G " relay.

The lower portion of the relay test bay is occupied by 24 rows of jacks arranged in pairs, five pairs being allotted to each Teleprinter set, providing for concentration as already mentioned.

Timing stamps.—Twelve Blick timing stamps have been installed on the receiving side of the busiest teleprinter circuits. The stamps are operated manually and give an impression upon the message form, (which is placed in position with face downwards) of the hour, minute, a.m. or p.m., and the circuit designation. The stamps have been designed to operate with a current value of less than 50 mA, which is given at half minute intervals from a synchronised Master clock of the Post Office pattern. Fig. **7** shows the circuit details.

Conveyors.—The instrument tables are 1′ 9″ wide, with the exception of one wider table in use experimentally. They are placed in pairs with a space of 2″ between each table and a gangway of 5′ between each pair of tables. Five double tables are provided with conveyors which run between and below the level of the tables. Access to the conveyors is obtained by means of a "Vee"-shaped channel, $1\frac{7}{8}''$ wide at the top, narrowing to $\frac{7}{8}''$ at a depth of 5″. The sides of the channel are of No. 16 S.W.G. sheet steel. Fig. **8** shows a photograph of a double table and

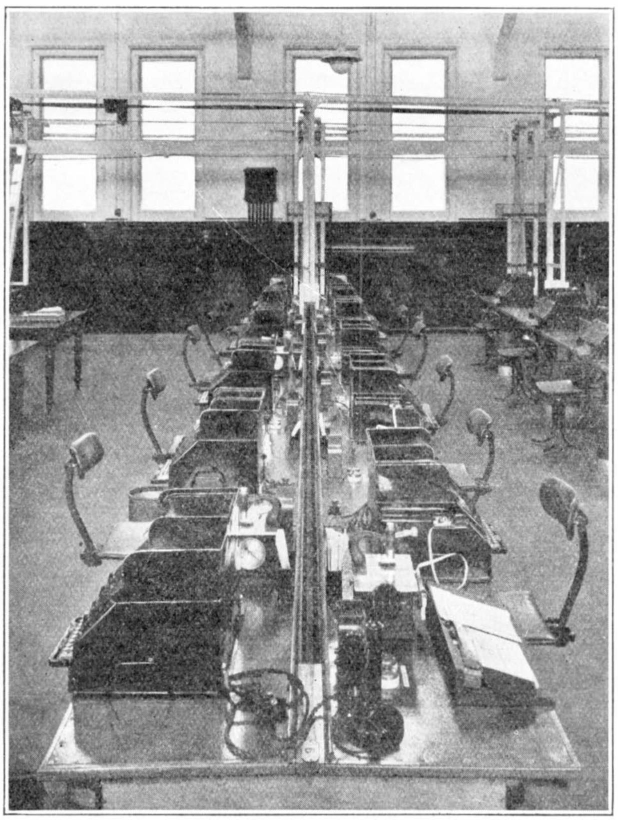

Fig. 8.—Instrument Table with Conveyor.

Fig. **9** a sectional view of the conveyor. At the base of the channel a continuously running

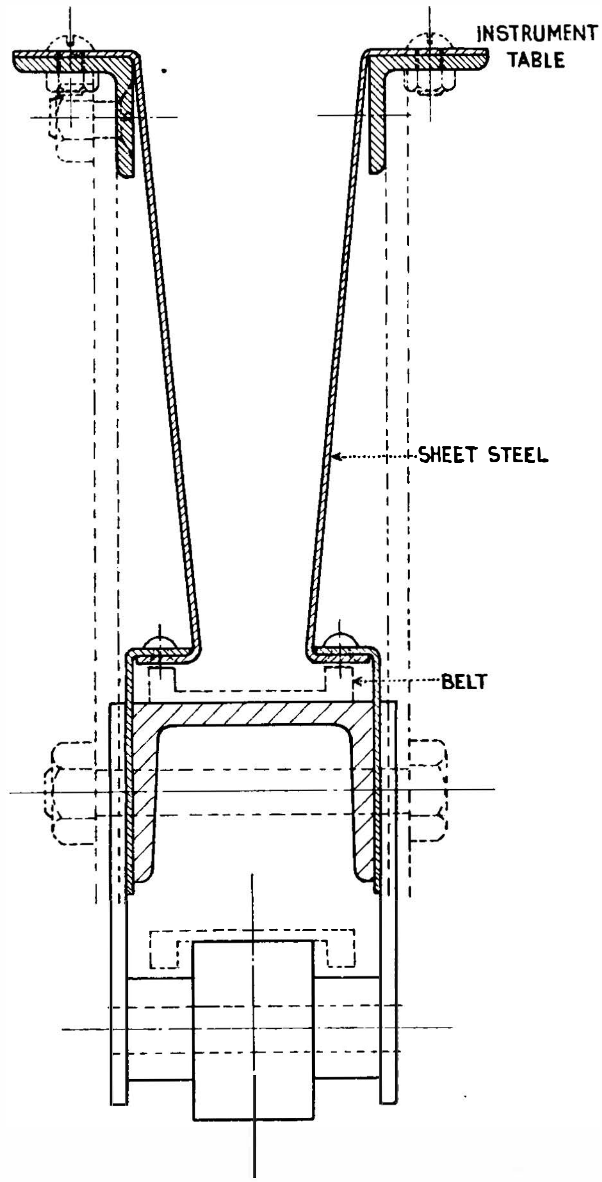

Fig. 9.—Conveyor in Section.

belt, $1\frac{7}{8}''$ wide, travels at a speed of 180 feet per minute. A separate motor is provided to drive each belt. The message forms are dropped into the channel and travel on edge to the end of the table where they are discharged into a riser belt, Fig. **10**.

The rollers of a riser belt are arranged in such a manner that the messages are taken from the table "Vee" conveyor in a vertical position, are then turned into a horizontal

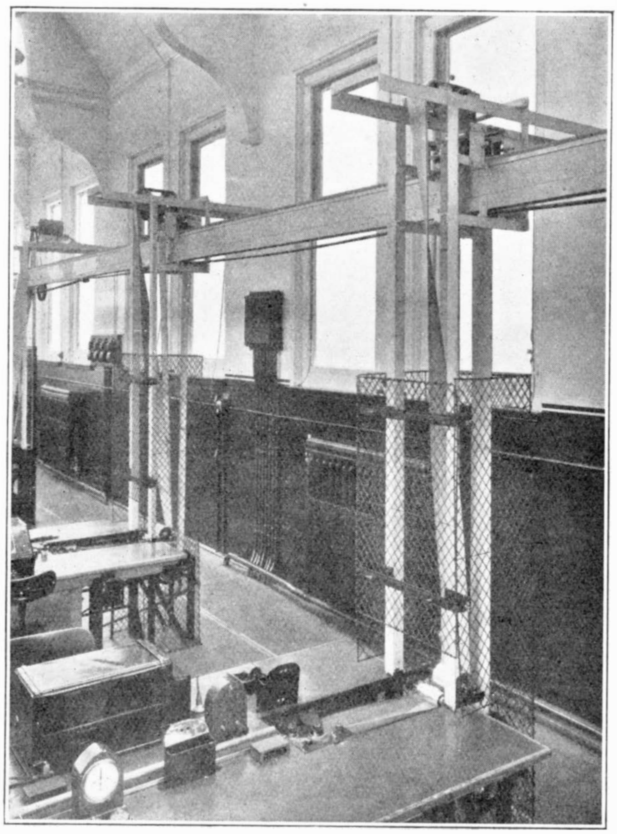

FIG. 10.—RISER BELT TO OVERHEAD CONVEYOR.

position, and delivered by rollers as shown in Fig. 11 into an overhead "Vee" conveyor. Two overhead "Vee" conveyors, each fed by

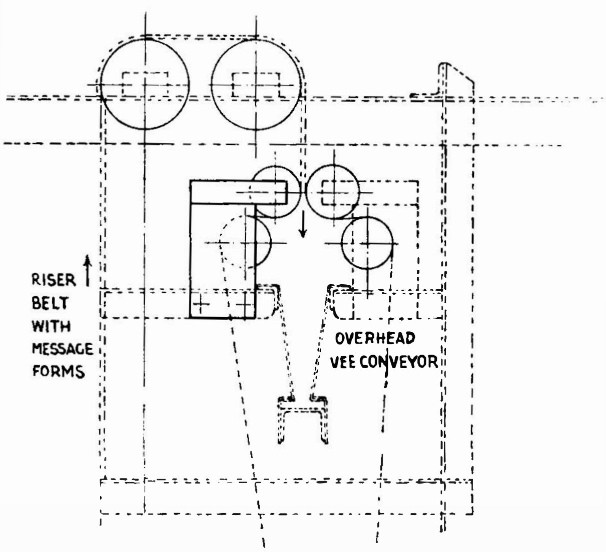

FIG. 11.—DETAILS OF DELIVERY TO OVERHEAD CONVEYOR.

three riser belts, run at right angles to the instrument tables at a height of 9′ from the floor level and converge at the circulation table, where the messages are delivered *via* a reinforced glass chute, with hinged front, on to a slow moving band, 9″ wide, travelling along the centre of the table.

In addition to the system for collecting received messages, messages for despatch are conveyed from the circulation table to two drop points, the Phonogram Room and the Concentrator. The two riser belts serving these points are fed by hand through chutes at the bottom of which the messages are gripped between two belts and are conveyed vertically to a height of 10′ and then horizontally to the points mentioned. The belts release the messages above a chain curtain chute down which they fall on to the table. Messages for dispatch on Teleprinter circuits are conveyed from the circulation table by hand as the circuits are grouped in close proximity. The introduction of the conveyors has reduced delay in circulation to a minimum.

The advantages arising from the re-arrangement, from an engineering point of view may be summed up as follows:—

(1) Economy of space. The same number of circuits have been accommodated in approximately two-thirds of the instrument room.
(2) Economy of apparatus, *e.g.*, only one Morse key and sounder is required for each group of eight Teleprinter circuits.
(3) Rapid and accurate localisation of faults on the instrument side by means of the interpolation of jacks in each instrument lead.
(4) Concentration of the testing of lines, instruments, and batteries at one point.
(5) The wiring at an Instrument table is reduced to a minimum.
(6) Any engineering work required can be carried out without impeding the Traffic staff.
(7) Facilities for observing the signals in both directions.
(8) Reduced risk of faults arising from wires making bad connection with screw terminals or being broken at the tables.

TELEGRAPH INTERNATIONAL 5-UNIT CODE.

A. C. BOOTH.

IN the issue Vol. 15, Part 3, of October, 1922, the position in regard to this subject was explained with a suggestion that endeavours should be made to obtain one 5-unit code instead of the three that were then in use. Subsequent to that article the Comité Consultatif International des Communications Télégraphiques, known as the C.C.I.T., was formed to deal with all subjects that had a bearing on international telegraphy. Among other matters, this subject of the 5-unit code was included for consideration and was dealt with at the meetings of 1926 and 1929 in Berlin. As was to be expected, there was considerable opposition to the slightest alteration in the Baudot code, but at the second meeting a few alterations were accepted. These modifications were not sufficient to admit of the use of one 5-unit code for different systems and the net result is that there are still two 5-unit codes, as shown in the accompanying diagram, Fig. 1. These two codes have not yet been finally accepted by all Administrations, but it is expected that there will be no opposition.

The endeavour to induce the users of the Baudot code to make sufficient alteration to admit of the use of the simplest form of alphabetical keyboard, whether perforator or direct sender, was with a view to retain the Baudot code if at all practicable. The difficulties of making the required changes are well recognised, but it is considered that the change would have been worth while. However, the endeavour failed, and, although the second code is based on the Baudot code, it will be seen that it is almost completely reversed, thus constituting an entirely new 5-unit code from the operator's point of view, both in regard to a perforated tape and from the action of the " marking " currents on the electro-magnet or magnets.

This result is the best that it has been possible to obtain after nearly eight years of discussion, and it is rather a pity in some respects that the Baudot code is thus doomed to disappear entirely in the course of the next few years, as it must do with the rapid growth of the modern systems of

ALPHABET No. 1.
For Multiplex Service.

No. of Signal			1	2	3	4	5	
1	A	1	o					
2	B	8			o	o		
3	C	9	o		o	o		
4	D	0	o	o	o	o		
5	E	2		o				
6	F	x)		o	o	o		
7	G	7		o		o		
8	H	+	o	o		o		
9	I	x)		o	o			
10	J	6	o			o		
11	K	(	o			o	o	
12	L	=	o	o		o	o	
13	M	)		o		o	o	
14	N	x)		o	o	o	o	
15	O	5	o	o	o			
16	P	%	o	o	o	o	o	
17	Q	/	o		o	o	o	
18	R	–			o	o	o	
19	S	.			o		o	
20	T	x)	o		o		o	
21	U	4	o		o			
22	V	'	o	o	o		o	
23	W	?		o	o		o	
24	X	,		o			o	
25	Y	3			o			
26	Z	:	o	o			o	
27	LTR SPACE	LTR SPACE					o	
28	FIG SPACE	FIG SPACE				o		
29	✱	✱				o	o	
30	REPOSE							
31	CARRIAGE RETURN		o	o				xx)
32	LINE CHANGE		o				o	xx)

NOTES:- o indicates a Negative impulse and perforations when tape transmission is used.

x) is Reserved for Interior service.

xx) is Reserved for column printers.

For Anglo-Continental Teleprinter service the Start signal is a negative impulse and the Stop signal is a positive impulse.

On Central Battery circuits the signalling is done by breaking the positive spacing current. Hence the code representation of the small circle will mean "no current" or "zero current" and not a negative

✱ Indicates an erasure signal.

ALPHABET No. 2.
For Teleprinter Service.

No. of Signal			1	2	3	4	5	
1	A	:		o	o	o	o	
2	B	?	o	o			o	
3	C	(		o			o	
4	D	,					o	
5	E	3	o		o	o	o	
6	F	/	o				o	
7	G	x)	o		o		o	
8	H	+			o		o	
9	I	8	o			o	o	
10	J	Bell		o	o		o	
11	K	x)		o	o			
12	L	=			o			
13	M	'	o		o			
14	N	–	o					
15	O	9				o	o	
16	P	0	o	o	o			
17	Q	1		o				
18	R	4	o	o				
19	S	x)	o	o		o		
20	T	5		o		o		
21	U	7		o		o	o	
22	V	)				o		
23	W	2	o			o		
24	X	x)	o		o	o		
25	Y	6	o	o		o	o	
26	Z	.			o	o		
27	LTR SPACE	LTR SPACE	o	o	o	o		
28	FIG SPACE	FIG SPACE	o	o	o		o	
29	✱	✱						
30	EFFACEMENT		o	o	o	o	o	
31	CARRIAGE RETURN				o	o	o	xx)
32	LINE CHANGE			o	o	o		xx)

FIG. 1.—TELEGRAPH INTERNATIONAL 5-UNIT ALPHABETS (1929).

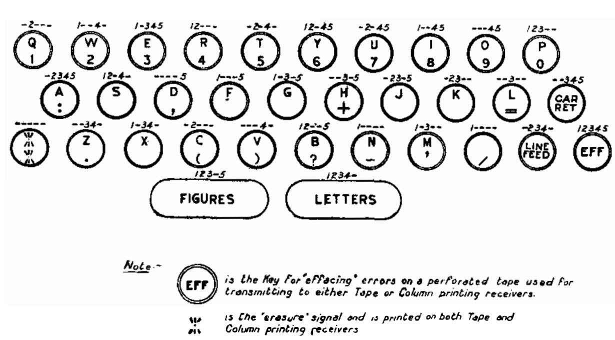

FIG. 2.—TELEPRINTER KEYBOARD FOR CONTINENTAL CIRCUITS. INTERNATIONAL ALPHABET No. 2.

telegraphy. Admirers of the Baudot system would certainly have preferred to have seen its code brought up to date, rather than to see it displaced by an entirely new one.

The keyboard lay-out for the British apparatus that will use the second code is arranged as shown in Fig. 2. It explains the use of the two erasure keys, one of which is marked with the well-known erasure signal and the other with EFF. The three keys, Carriage return, Line feed and Effacement need not be used until column printers are fitted at the receiving end.

APPLICATIONS OF THE THERMOSTAT TO TELEGRAPH CIRCUITS.

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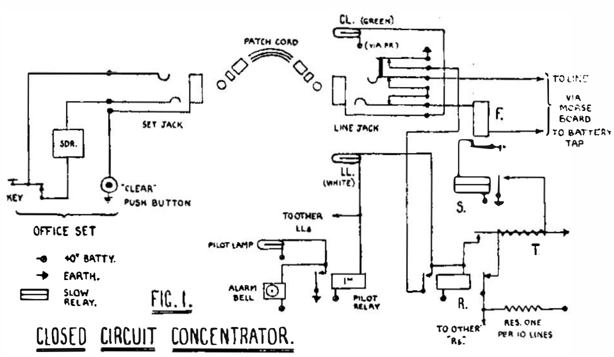
The use of the thermostat as a means of time control in automatic telephone circuits is well known. The following applications of the device for providing calling and alarm signals in various types of telegraph circuit may be of interest :—

(1) *Closed Circuit Morse Lines.* — A concentrator switchboard for use on closed circuit lines is illustrated in Fig. 2. The switchboard shown is arranged for concentrating ten lines, and is fitted with strips of ten line jacks, line lamps, set jacks and "clear" lamps. Fig. 1 shows the line circuit. A fast low-resistance relay F, which responds to the line signals, is interposed between the line and the battery tap. In the local circuit of F is a high resistance slow relay S, permanently operated, and controlling the thermostat T and a locking relay R. When signals are being sent between any two stations on the line, F responds, but S only gives



occasional flicks. If, however, F is given a prolonged release, S is de-energised, the thermostat heats and operates, closing the circuit of R. R is arranged to open the thermostat circuit, light the line lamp, pilot lamp, and operate the alarm bell, locking to an earth on the line jack. The calling signal remains locked therefore until the

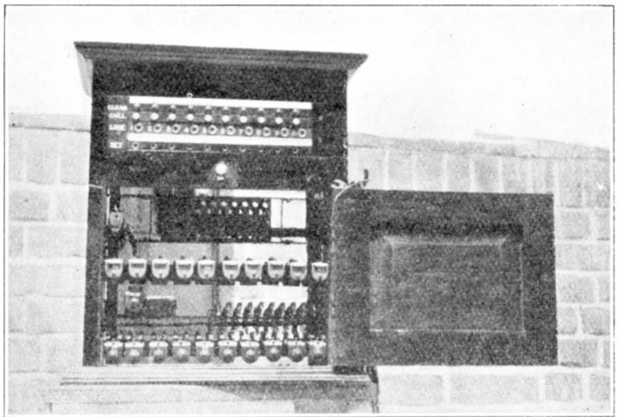


Fig. 2.—10-Line closed Circuit Concentrator.

call is answered, *i.e.*, until a patch-cord is plugged into the line jack. The other end of the cord is plugged into the office set jack on which the section traffic controller wishes to work the calling station.

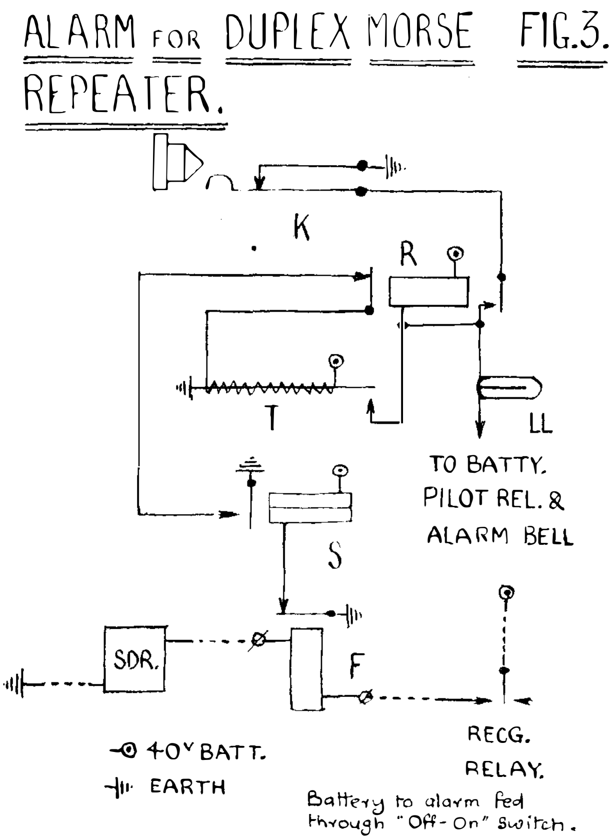
In practice, out-stations on the closed circuit lines are instructed to call the central station by holding the key down for thirty seconds. The thermostat is arranged to operate after twenty seconds, allowing a safe margin.

When the telegraphist has finished working with the out-station, he gives the "Clear" signal by pressing a push-button fitted on the set. The lamp CL lights, *via* the sleeve conductor of the patch cord, and operates the pilot relay and alarm bell.

Should the telegraphist forget to clear (or the patch cord is not removed to clear the connection) and an out-station endeavours to call, as can be seen from the line circuit diagram, the thermostat will operate and give an intermittent flashing and ringing signal to call attention.

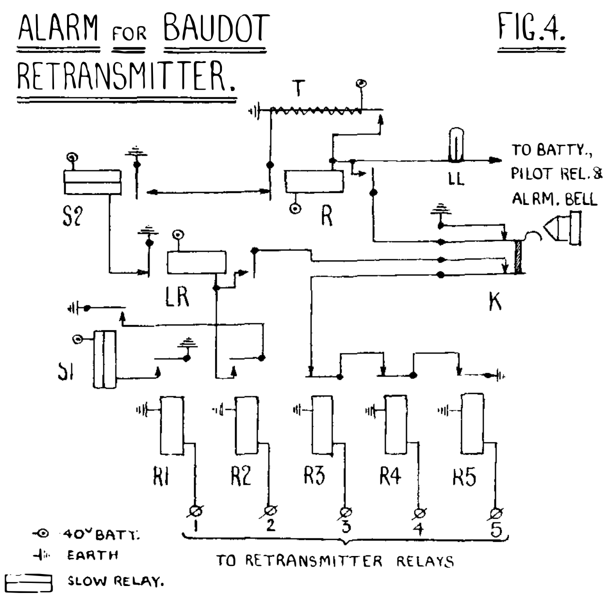
The device can of course be adapted to act as a calling alarm on closed circuit lines apart from the use for concentrator working cited above.

(2) *Duplex Morse Repeaters.*—Fig. **3** shows the calling device as arranged for calling Morse duplex repeater stations into circuit. The alarm circuit used is similar to that of Fig. **1**. F is introduced into the receiving circuit of the duplex repeater and the operation of F, S, T and R is similar to that already described. Two alarm units are used on the repeater set so that either



terminal station operator by holding his key down for thirty seconds can give the alarm signal on the repeater, and call the attention of the repeater supervisor. The release of the R relay in this circuit results from the operation of the push-button type key K.

(3) *Baudot Re-Transmitting Repeater.* — A modified form of the same alarm circuit for use on Baudot re-transmitting repeaters is shown in Fig. **4**. In this case five low resistance relays,



R1—R5, are arranged to work in parallel with the re-transmitting relays and respond to the same signals. A slow relay S1 is energised by the operation of R1, and earths the lever of R2. When R2 operates, this earth energises a locking relay LR. If R3, R4, or R5 operates after R2, LR is immediately unlocked and owing to the rapidity of the action of the relays the slow relay S2 is not released. If, however, no third, fourth or fifth impulse follows the first and second for some time, S2 releases and the thermostat operates after twenty seconds, as in the circuits previously described. In other words, for all combinations of the five units except for " Firsts and Seconds " (" É " in the letter column, or " & " in the figure column) the alarm will not respond, but in response to a succession of " És " or " &s," the thermostat operates, and the alarm lamp and bell call the attention of the Baudot supervisor. The alarm is released by the operation of the push-button key K which unlocks both locked relays. This device has the advantage of giving a positive calling signal and also eliminates the necessity of continuously running receivers on re-transmitting sets.

VOICE FREQUENCY KEY-SENDING FROM "A" POSITIONS.

I. H. Jenkins, M.I.E.E.

THE installation of an automatic exchange, whether in a single exchange area or in a large multiple exchange area such as London, necessitates provision for handling traffic originating in contiguous or distant manual exchanges, and flowing into the automatic exchange. This has constituted a problem of some dimensions ever since the introduction of automatic switching equipment. The comparatively simple case of the single exchange area with very small groups of incoming lines to the automatic exchange involved designing "tricky" circuits (see *Post Office Electrical Engineers' Journal* of October, 1925) both for accommodation of the dial at the manual end and for linking up the line to the selectors at the automatic end. The large area involving large manual exchanges, however, constitutes a bigger problem with wider economic possibilities. In these areas the use of dials on the manual exchange A positions becomes too costly because of the high call value of calls to automatic exchanges. The only permissible scheme is the use of key-sending equipment with digit keys, operated either on the A position or on a B position interposed between the manual exchange and the automatic exchange. The placing of the digit keys on the A positions is recognised as being the best arrangement and much work has been done during the past few years in endeavouring to evolve a satisfactory solution along these lines. A scheme which does accomplish this, satisfactorily employing voice frequency alternating currents for transmitting code impulses to the sender storage relays, has recently been evolved and it is the purpose of this article to describe it in outline.

In order to put it in its proper setting it is desirable to review briefly the schemes which have been used and tried out, and which have led to the evolution of this method.

Order wire key sending positions are well known, having been installed in all the automatic exchanges yet opened in London. In this method the equipment and operation at the manual end is precisely similar to that used for manual to manual order wire working. The A operator orders up the connection on an order wire and plugs into a junction assigned by the B operator at the automatic exchange end. The B position accommodates some 30 to 35 incoming junctions appearing in lamps and keys. The B operator allots the junction for each call, presses an assignment key and keys up the number required on a strip of digit keys, the clearing being in the hands of the A operator.

An early attempt to place the digit key on the A position is represented by the Museum Exchange equipment, which was described in the *Post Office Electrical Engineers' Journal,* April, 1926, by Mr. J. Hedley. This equipment, while being satisfactory from a traffic point of view, has distinct limitations in that the outgoing lines cannot be multipled and a very large quantity of automatic apparatus is required in the manual exchange.

The next development to be considered is the straight-forward junction scheme which, as worked out by Post Office engineers, has been installed at Manchester and Birmingham. In this scheme, the keying is not placed in the hands of the A operator, but the unsatisfactory order wire working is replaced by a new method. The A operator selects an idle junction and plugs into it. This action causes an available B operator from a group of positions to be automatically associated with the junction at the automatic exchange end. The A operator is advised by a "zip-zip" signal that the B operator is ready to take the demand, the B operator takes the call and keys up the number required. She has no assignment keys to operate and is automatically released from a call and lined up for the next call.

Straight forward junction working is referred to in the July, 1930, issue of *The Post Office Electrical Engineers' Journal* by Mr. L. F. Morice in an article dealing with "Manchester Automatic Telephone System." Fig. **8** is reproduced from that article and shows clearly the circuit lay-out. It was realised when this scheme was worked out for Manchester that there were possibilities, if satisfactory circuits could be devised, of placing the digit key on the A position and so eliminating the B operator. An attempt was later made to accomplish this in the design of mechanical order wires. In this system a 4-wire order wire is used and arrangements are made to associate it automatically with the digit key at the manual exchange and with the senders in the automatic exchange. Two forms of this scheme have been worked out. In the first one, now some years old, designed by Messrs. Siemens, and described by Mr. D. A. Christian in *The P.O.E.E. Journal* of July, 1928, a display panel was fitted on the A operator's position, the A operator pressing the order wire button and the automatic apparatus causing the display panel to indicate the junction assigned. She then plugged into the junction and keyed up the number on the digit key strip. A variation of this scheme still using an order wire was also worked out by Messrs. Siemens, somewhat on the lines of straight-forward junction working, the A operator plugging into an idle junction and on the receipt of a "zip-zip" signal keying up the number. These schemes, whilst being very satisfactory from a traffic point of view, still had the disadvantage of being complicated and requiring a large amount of apparatus at the manual end.

At this juncture, whilst considering mechanical order wire circuits, it was suggested that a separate order wire for passing impulses might be avoided by using four frequencies of AC current within the voice range, which could be coded to give all the signals required for 10 digits, and passed over the talking circuit. A system, the basic principles of which could be adapted to this purpose, already existed in the Standard Telephones & Cables scheme designed by them for key-sending over trunk lines, and shortly to be placed in service on the Leeds-London trunks. The scheme, however, as now

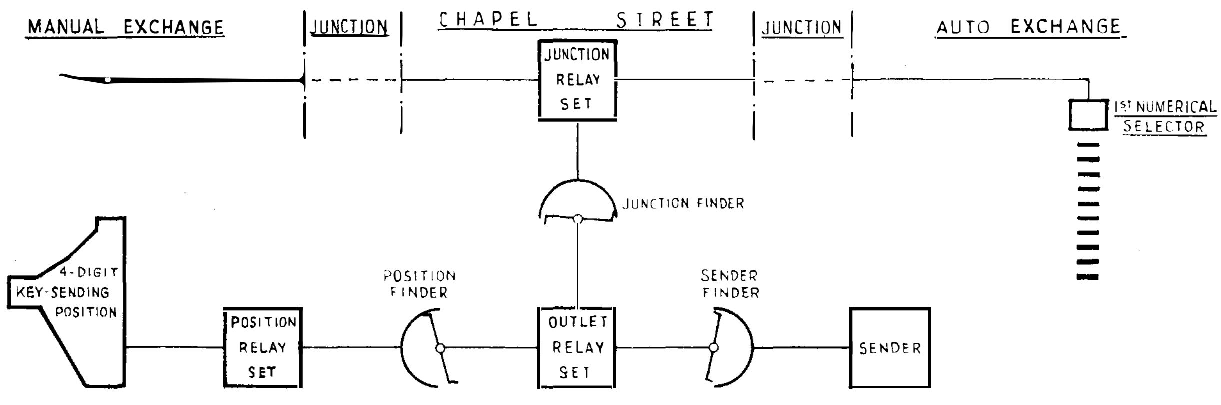


FIG. **8** FROM "MANCHESTER AUTO TELEPHONE SYSTEM" (*P.O.E.E. Journal*, July, 1930).

applied to short distance junction working, differs from that designed for long trunk operation in that a direct current is used over the junction to control the signals and hold the selectors. The voice frequency signals are used only to set up the storage relays in the sender at the automatic exchange. Any device for preventing interference from actual speaking currents on the line is avoided by arranging the circuit so that, after the automatic apparatus has lined up the digit key at the manual exchange with the receiving apparatus at the automatic exchange, a signal is sent over the line by depression of the cancel key to ensure that the storage relays in the sender are set at zero before actual digiting takes place. The advantage of this scheme is that the equipment at the manual exchange becomes very simple. A source of supply for voice frequency currents and its connection to the commons of the digit keys, together with some modifications to the A cord circuits, which are not of a formidable nature, is all that is required. Further, the Post Office standard straightforward junction circuits, as used in Manchester and Birmingham, can be readily adapted for voice frequency key sending. Reference to the Figure will show that it is a simple matter to replace the position relay set and operator's position itself by a voice frequency receiving set, which will perform the functions of the B operator by accepting the voice frequency coded impulses and translating them to the storage relays in the sender.

A trial equipment of this scheme has been working for some months in London and has proved very promising. Further development will be necessary to perfect the system, but sufficient has been done to make it quite clear that it has important possibilities and will be extensively employed in local and toll area networks. It will also in all probability be extended to longer trunk lines.

In a future article further details will be given.

PROBLEMS IN AUTOMATIC TRUNKING—LAST CONTACT TRAFFIC.

N. A. Hawkins, A.M.I.E.E.

Outline of Contents.

(*a*) Introduction.
(*b*) Theoretical considerations,
  (1) The case of full availability.
  (2) The case of grading.
(*c*) Some practical applications with examples.

(*a*) *Introduction.*

The trunking aspect of automatic telephony has been described in detail in a number of articles written by Mr. G. F. O'dell, of the Engineer-in-Chief's Office, and others, so that the majority of the readers of this journal are familiar, to a greater or less degree, with the principles of this branch of telephony. The purpose of this article is not therefore to repeat, except in a few details, what has already been written but rather to introduce another phase which is not generally known.

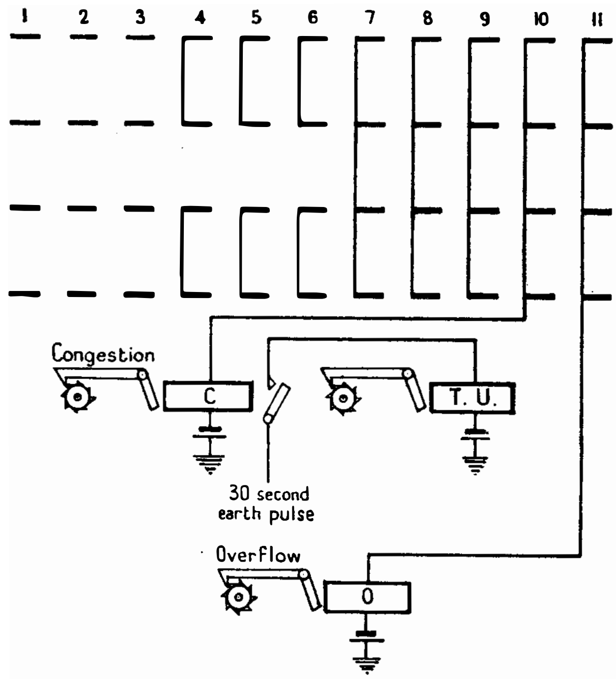
Before presenting the mathematical treatment on which this article is based, it is necessary to describe briefly a portion of the traffic metering facilities which have now been standardised in automatic exchanges. There are two types of traffic meters in practical use (*a*) overflow meters and (*b*) congestion meters. The latter consists of a set of two meters, one recording calls and the other being operated in a local circuit of the former by a 30 seconds earth pulse.

These meters fulfil the following functions:—

1. Overflow meters. Being associated with the 11th or 21st contact in the private bank of all switches having access to a full availability or graded group of outlets, dependent upon the size of the bank, record all calls, which, by virtue of the traffic passing through the particular route, are unable to seize an idle outlet in the next rank.
2. Congestion meters. The congestion call meter records the total number of times the last choice in a full availability or

graded group of outlets is brought into use. The meter associated with this, called the traffic unit meter registers by means of the 30 second earth pulse the time the last choice is in use.

Fig. 1 shows the method of connecting traffic meters to a typical grading.



Note:- The meter connections are associated with the private bank contacts.

Fig. 1.

Considering the traffic unit meter, and bearing in mind that one traffic unit is equivalent to one call hour or 120 call-half minutes per hour, it is apparent that by dividing readings obtained on the meter during one hour by 120 we obtain directly what traffic is being carried by the last choice of a particular group of outlets.

It is desirable to mention something about "grade of service." Grade of service is the proportion of calls which are allowed to fail during the busy hour, owing to the limitation, for economic reasons, of the amount of switching plant, the Post Office standard for which can be stated as follows:—

"When the traffic is normal, the grade of service per switching stage shall not be worse than 1 in 500. If the traffic increase temporarily by 10 per cent., the grade of service per switching stage shall not fall below 1 in 100."

The value of the grade of service being definite, the switch quantities required for given values of traffic are determinate from theories adopted as standard in Post Office design and generally the arrangement of the switches or rather the "trunking" in the exchange follow standard lines. The traffic tables used for automatic exchange design are given in Technical Instruction XXV., Part 12A.

(*b*) *Theoretical Considerations.*

The mathematical treatment which follows is subdivided into the cases of (1) full availability and (2) grading. It is thought that such elementary terms as these are so well known that it is not necessary to discuss their meaning.

(1) *Full availability.*

The theory adopted by the Post Office for design purposes is that of A. K. Erlang, of the Copenhagen Telephone Co., which states that if A is the total traffic offered to a group of x switches, the proportion of lost calls or grade of service P_x is given by the following expression:—

$$P_x = \frac{\dfrac{A^x}{x!}}{1 + A + \dfrac{A^2}{2!} + \ldots\ldots + \dfrac{A^x}{x!}} \quad \ldots\ldots\ldots(1)$$

Direct reasoning from this indicates that the proportion of calls P_{x-1} passed on from the $(x-1)$th switch will be

$$P_{x-1} = \frac{\dfrac{A^{x-1}}{(x-1)!}}{1 + A + \dfrac{A^2}{2!} + \ldots\ldots + \dfrac{A^{x-1}}{(x-1)!}} \quad \ldots(2)$$

It will be evident from first principles that traffic carried by last switch or contact = traffic offered to last contact − lost traffic or last contact traffic $= AP_{x-1} - AP_x$

$$= A(P_{x-1} - P_x) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Transposing expressions (1) and (2) we have

$$P_x\left[1 + A + \frac{A^2}{2!} + \ldots\ldots \frac{A^{x-1}}{(x-1)!}\right] = \frac{A^x}{x!}(1 - P_x) \quad \ldots\ldots\ldots(4)$$

$$P_{x-1}\left[1+A+\frac{A^2}{2!}+\ldots\ldots\frac{A^{x-1}}{(x-1)!}\right]=\frac{A^{x-1}}{(x-1)!}\quad\ldots\ldots\ldots(5)$$

Dividing (5) by (4) the following results

$$\frac{P_{x-1}}{P_x}=\frac{\dfrac{A^{x-1}}{(x-1)!}}{\dfrac{A^x}{x!}(1-P_x)}$$

$$\text{or}\quad P_{x-1}=\frac{xP_x}{A(1-P_x)}\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Substituting the value of P_{x-1} from (6) in expression (3) it is seen that

$$\text{last contact traffic}=A\left[\frac{xP_x}{A(1-P_x)}-P_x\right]$$

$$=P_x\left[\frac{x}{(1-P_x)}-A\right]\ldots\ldots(7)$$

$$=P_x(x-A)\ \text{approximately}$$

since for a good grade of service P_x is small compared with unity.

The theory of W. H. Grinsted, which is an approximation to that of Erlang, is very nearly true for good grades of service and is expressed as

$$P_x=\frac{\dfrac{A^x}{x!}}{e^A}\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

where P_x, A and x have the same significance as before, e being the base of Naperian logarithms.

Similarly it is seen that the proportion of calls P_{x-1} passed on from the $(x-1)$th contact is

$$P_{x-1}=\frac{\dfrac{A^{x-1}}{(x-1)!}}{e^A}\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

From (3) results

$$\text{last contact traffic}=A(P_{x-1}-P_x)$$

and therefore in this case

$$\text{last contact traffic}=A\left[\frac{\dfrac{A^{x-1}}{(x-1)!}}{e^A}-\frac{\dfrac{A^x}{x!}}{e^A}\right]$$

$$=\frac{\dfrac{A^x}{x!}}{e^A}[x-A]$$

$$=P_x(x-A)\quad\ldots\ldots\ldots\ldots\ldots(10)$$

a result which is in agreement with the approximation to that deduced from Erlang's theory for a good grade of service.

Analysing expression (7) it is seen that since last contact traffic = traffic offered to last contact − lost traffic

$$\text{Traffic offered to last contact}=\frac{P_x x}{1-P_x}\ldots.(11)$$

From this it is apparent that providing the grade of service is stated we can always determine the traffic offered to the particular outlet without knowing directly the value of the total traffic offered to the group. The application of this will be considered in a later portion of this article.

(2) *Grading.*

The case of grading does not admit of easy mathematical treatment. Though the problem has been attacked by several investigators, their results are too complicated to be of practical service.

In determining the traffic carried by each contact in a grading, therefore, use has been made of a theory published by Dr. Lubberger in Germany in 1924, and developed independently in the Post Office Engineering Department. This assumes that the traffic carried by each contact is the same as it would be if the same amount of traffic were offered to the corresponding contact in a full availability group. It therefore follows that if the traffic giving the same loss in a full availability group is determined for any given traffic offered to the grading, the traffic carried by the last common contact of the grading will be the same as the traffic carried by the last contact of the full availability group.

In the following paragraphs concerning grading use is made of the term "equivalent full availability traffic." This term is applied to an amount of traffic which, if offered to a full availability group with the same availability as a given grading, will result in the same amount of lost traffic as is actually experienced with the grading for a given total traffic offered. Thus in a particular case it was found that with a 10-contact grading of 30 switches the lost traffic was .082 traffic unit when 14.8 traffic units were offered. With a full availability group of ten circuits, 4.91 traffic units would need to be offered to give this loss. Then 4.91 traffic units is called the " equivalent full availability traffic " to 14.8 traffic units actual traffic for this particular grading.

The condition which must be fulfilled is that the lost traffic for the graded group must be equal to the lost traffic for the equivalent full availability traffic. Hence, if A' is the actual traffic and A is the equivalent full availability traffic, and B' and B the respective grades of service,

then $BA = B'A'$ ....(12)

Now for a full availability group

$$\text{last contact traffic} = P_x\left[\frac{x}{(1-P_x)} - A\right]$$

(See expression (7).

$$= P_xA\left[\frac{x}{(A-P_xA)} - 1\right]$$

$$= \text{loss}\left[\frac{x}{(A-\text{loss})} - 1\right] \quad ..(13)$$

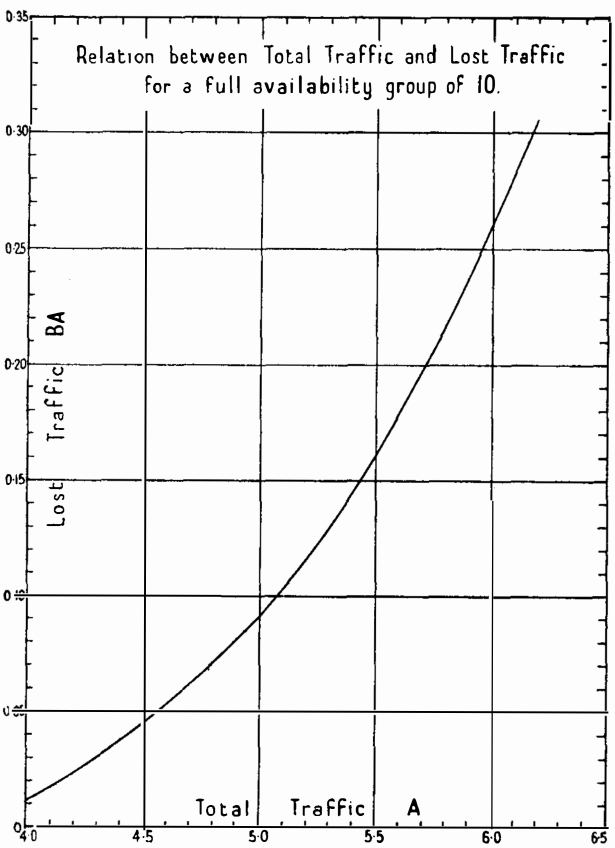


Fig. 2.

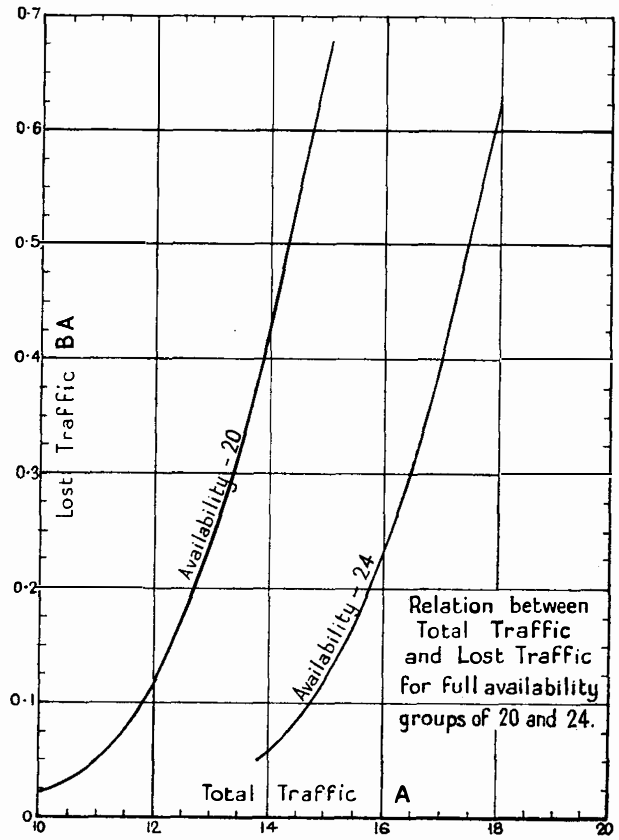


Fig. 3.

which is a convenient alternative to expression (7) and by substituting the value of A gives the last contact traffic for the equivalent full availability traffic.

On the theory mentioned above this will also be the last contact traffic for the grading when traffic A' is offered to it. In this case, however, the lost traffic cannot be neglected in comparison with the equivalent full availability traffic A, since their ratio is above 1 in 500 and for large graded groups may be above 1 in 100.

The only unknown quantity in expression (13) is A, that is, the equivalent full availability traffic. Curves have been prepared and are shown in Figs. **2** and **3**, giving the relation between lost traffic and traffic offered to full availability groups of 10, 20 and 24. These are the only availabilities at present in use and therefore we can determine from these curves what will be the equivalent full availability traffic to give the same value of lost traffic as would be obtained from a graded group. Then by substituting the relative values in expression (13) the last contact traffic is obtained. There is an approximation to expression (13) which is rather useful for checking purposes, but has only a limited application as indicated later.

Repeating expression (13)

$$\text{last contact traffic} = \text{loss}\left[\frac{x}{(\text{A} - \text{loss})} - 1\right]$$

It is found by substituting N, the number of switches in the graded group for x the availability and A′ the traffic offered to the former for A, the equivalent full availability traffic, the value of last contact traffic obtained is very nearly equal to the correct value. This of course will only be nearly true when $\frac{x}{\text{A}}$ is approximately equal to $\frac{\text{N}}{\text{A}'}$.

It is therefore apparent that the approximation, namely,

$$\text{last contact traffic} = \text{loss}\left[\frac{\text{N}}{(\text{A}' - \text{loss})} - 1\right] \quad ..(14)$$

must be nearly true under certain conditions. These conditions are dependent upon (*a*) the availability; (*b*) the grade of service and (*c*) the number of switches in the graded group.

These are summarised as follows:—

1. *Availability 24.*

For a grade of service 1 in 200 the upper limit or highest value for which the approximation (14) can be used is 70 switches. For a grade of service of 1 in 500 the upper limit is 150 switches.

2. *Availability 20.*

For a grade of service of 1 in 200 the upper limit is 80 switches.

For a grade of service of 1 in 500 the upper limit is 100 switches.

3. *Availability 10.*

For a grade of service of 1 in 200 the upper limit is 50 switches.

For a grade of service of 1 in 500 the upper limit is 50 switches.

As an example of the error involved:—

When $\text{N} = 150$ $\text{A}' = 96.67$ for $\text{B} = \frac{1}{500}$ $x = 24$

$$\text{Then lost traffic} = \frac{96.67}{500} = 0.1933$$

The approximation gives

$$\text{last contact traffic} = \text{loss}\left[\frac{\text{N}}{(\text{A}' - \text{loss})} - 1\right]$$
$$= .1933\left[\frac{150}{96.67 - .1933} - .1933\right]$$
$$= .1072 \text{ traffic unit.}$$

It is found from the relative curve that for a loss of 0.1933 traffic unit $\text{A} = 15.67$.

The correct value is therefore

$$\text{last contact traffic} = \text{loss}\left[\frac{x}{(\text{A} - \text{loss})}\right] - 1$$
$$= .1933\left[\frac{24}{15.67 - .1933}\right] - 1$$
$$= 0.1064 \text{ traffic unit.}$$

The error in this case is only 0.8 per cent.

(*c*) *Practical Applications.*

It is proposed to arrange the subject matter under this heading in the order (1) existing uses and (2) suggested uses.

1. *Existing uses* (A). The foremost application of the principles given in the earlier portions of this article was, in reality the cause of a detailed investigation of the subject. The use of the congestion meter set to determine the last contact traffic has been mentioned previously. The present method of interpreting the meter readings so obtained is to compare them with values determined theoretically, which should not be exceeded. These values are such that the worst grade of service permissible, viz., 1 lost call in 200 is being given. Form T.E. 440 is used for the purpose of recording the differences between meter readings for each hour of the period 10 a.m.—12 noon on a representative day in the week agreed with the Traffic Department. The top of the form is divided in order to give the following headings of the columns:—

(*a*) Level or Group; (*b*) Number of trunks; (*c*) Average duration in minutes; (*d*) Critical connections and (*e*) Critical T.U. meter reading.

The first three terms are self-explanatory, (*d*) is the permissible number of calls taken by the last choice, at the given average duration and

(e) is the total duration in half-minutes of the engagement of the last choice when the grade of service has fallen to the lowest permissible figure. These figures apply to the busy hour.

Obviously $2\ (c) \times (d) = (e)$.

We have seen that the last contact traffic at any reasonably good grade of service can be determined in the case of full availability from

$$\text{last contact traffic} = \mathrm{B}\ (x - \mathrm{A})$$

and for graded groups from

$$\text{last contact traffic} = \text{loss} \left[\frac{x}{(\mathrm{A} - \text{loss})} - 1 \right]$$

In the latter case, an even distribution of traffic is assumed, but, should this not obtain, the unevenness will be indicated by the meters when a sufficient volume of traffic is passing.

In an earlier paragraph it has been stated that one traffic unit is equivalent to 120 call-half minutes. Hence by multiplying the last contact traffic determined for the grade of service of 1 in 200, by 120 we get the critical traffic unit meter reading which it will be seen is independent of the average holding time of a call. The critical connections are therefore

$$\frac{\text{critical T.U. meter reading}}{2 \times \text{average holding time}}$$

TABLE 1.

No. of switches.	Traffic Unit Meter Reading.	Congestion Meter Reading.
1	0.60	0.12
2	1.13	0.22
3	1.60	0.32
4	1.98	0.40
5	2.32	0.46
6	2.64	0.53
7	2.90	0.58
8	3.16	0.63
9	3.40	0.68
10	3.62	0.72
11	3.83	0.77
12	4.03	0.80
13	4.22	0.84
14	4.42	0.88
15	4.57	0.91
16	4.74	0.95
17	4.90	0.98
18	5.05	1.01
19	5.20	1.04
20	5.34	1.07
21	5.48	1.10
22	5.62	1.12
23	5.75	1.15
24	5.87	1.17

Note :—Average duration = 2.5 minutes.

Table 1 shows the critical connections and traffic unit meter readings for an average duration of 2.5 minutes for the case of full availability, and Table 2 shows similar values for the case of gradings serving third and subsequent 10-contact selectors, *i.e.*, where the traffic may be assumed to be pure chance.

TABLE 2.

No. of Switches.	Traffic Unit Meter Reading.	Congestion Meter Reading.	No. of Switches.	Traffic Unit Meter Reading.	Congestion Meter Reading.
10	3.62	0.72	40	11.54	2.31
11	3.96	0.79	45	12.60	2.52
12	4.28	0.86	50	13.64	2.73
13	4.60	0.92	55	14.65	2.93
14	4.92	0.98	60	15.62	3.12
15	5.23	1.05	65	16.57	3.31
16	5.53	1.11	70	17.47	3.49
17	5.83	1.17	75	18.30	3.66
18	6.13	1.23	80	19.09	3.82
19	6.42	1.28	85	19.84	3.97
20	6.71	1.34	90	20.59	4.12
25	8.05	1.61	95	21.33	4.27
30	9.26	1.85	100	22.03	4.41
35	10.44	2.09			

Note :—Average duration = 2.5 minutes.

When comparing the meter readings obtained in practice with the values determined theoretically for a 1 in 200 loss, it is necessary to average the former over a period dependent upon the size of the group of switches and to omit from the average, all values which are due to known or suspected faults. The result will then give a fairly reliable indication of the condition of the service on the particular route. These readings are usually further compared with the results of traffic records before any definite action is taken. This is of course necessary to guard against (a) unevenness in the distribution and (b) a greater smoothness or peakiness of traffic than is allowed for by the design tables.

(B) As an extension of the above application it became necessary quite recently to determine the critical connections and traffic unit meter readings for the peculiar case of gradings of outlets from 25-point uni-selectors.* This type of switch is used in the Middlesboro' and Hanley satellite exchanges.

The useful information available consisted of a series of values of traffic offered to the 25th

* *This is the B.E.S.A. term for what was formerly known as preselector or its equivalent.*

choice in a full availability group for various values of total traffic. It was required to determine the 25th contact traffic. The following method was adopted:—

From expression (11) traffic offered to 25th contact $= \dfrac{P_x \times 25}{1 - P_x}$ where P_x is the proportionate loss at the 25th contact.

But traffic offered to 25th contact = traffic carried by 25th contact + traffic offered to 26th contact.

Knowing the value of the traffic offered to 25th contact the value of P_x can be determined, and from it the value P_xA which is the traffic offered to the 26th contact for the given value of total traffic A.

As an example, for a total traffic of 18 traffic units offered to a full availability group, it is known that

traffic offered to 25th contact = 0.6346 traffic unit.

$$\text{Hence } 0.6346 = \frac{P_x \times 25}{1 - P_x}$$

$$\text{from which } P_x = \frac{0.6346}{25.6346}$$

$$\text{and } P_xA = \text{traffic offered to 26th contact}$$
$$= \frac{18 \times 0.6346}{25.6346}$$
$$= 0.4456 \text{ traffic unit.}$$

Hence traffic carried by 25th contact

$$= 0.6346 - 0.4456$$
$$= 0.189 \text{ traffic unit.}$$

A series of values was obtained and curves plotted showing the relation between total traffic and lost traffic, and traffic carried by 25th contact and total traffic. From these the values of last contact traffic for different sizes of groups at a 1 in 200 grade of service were obtained and, finally, the critical connections and traffic unit meter readings in the same manner as before.

2. *Suggested Uses.*

(*a*) It has been shown that for both graded and full availability groups

$$\text{last contact traffic} = \text{loss}\left[\frac{x}{(A - \text{loss})} - 1\right]$$

where x and A for the case of grading refer to the equivalent full availability traffic.

The above expression can be written

$$\text{Congestion call meter reading} = \text{overflow meter reading}\left[\frac{x}{(A - \text{loss})} - 1\right] \quad \text{.......(15)}$$

If now the lost traffic is negligible compared with A, then (15) reduces to

$$\text{Congestion call meter reading} = \text{overflow meter reading}\left[\frac{x}{A} - 1\right]$$

$$\text{or } A = \frac{\text{overflow meter reading} \times x}{(\text{congestion meter + overflow meter) readings}} \quad \text{.......(16)}$$

In the case of graded groups within the limits given on a previous page this will become

$$\text{Congestion call meter reading} = \text{overflow meter reading}\left[\frac{N}{A'} - 1\right] \quad \text{.......(17)}$$

Expressions (15)-(17) have been derived by utilising the assumption that the average holding time of a last choice call would be equal to the average holding time of an overflow call if it had been effective.

If, therefore, we record readings on both congestion and overflow meters for a reasonable length of time, we can determine approximately what traffic is being carried by a group of switches.

As an example—the following figures have been extracted from an early traffic record and the value of A deduced and compared with the actual value.

Average congestion meter reading = 1.2
,, overflow ,, ,, = 0.6
x = 8

$$\text{Hence } A = \frac{\text{overflow meter reading} \times x}{\text{congestion} + \text{overflow meter readings}}$$
$$= 2.66 \text{ traffic units.}$$

The actual value was 2.44 traffic units.

As an illustration of the results obtained when applied to a grading we have,

Average congestion meter reading = 4.9
,, overflow ,, ,, = 8.9
N = 15

$$\text{Hence } A' = \frac{\text{overflow meter reading} \times N}{\text{congestion} + \text{overflow meter readings}}$$
$$= 9.6 \text{ traffic units.}$$

The actual value was 9.24 traffic units.

Comparing this with a full availability group, it is seen that

$$4.9 = 8.9 \left(\frac{x}{A} - 1 \right) \text{ where } x = 10$$

or equivalent full availability traffic A = 6.4 traffic units.

Fig. **2** shows that the lost traffic will be 0.385 traffic unit. When the value of lost traffic is 0.385, the curve in Fig. **5** shows that the total traffic for the graded group will be 9.25 traffic units.

(*b*) The present method of recording the traffic carried by a group of switches is to determine, either manually or automatically, the total number of simultaneous engagements of switches within the group at stated intervals and to divide the total by a factor dependent upon the frequency of the readings and duration of the record.

This method, except in specified cases, only gives the traffic carried by each shelf of switches and has no regard to the distribution of traffic over the grading, actual grade of service or to the type of traffic passing the group.

If we can measure accurately the traffic carried by the last choice in any group of switches, it is quite easy to determine from curves the total traffic being carried and the grade of service. Since, however, the last contact traffic is generally quite small, the effect of small inaccuracies will be great in the final result and it is therefore more desirable to record the traffic carried by an earlier choice. Dependent upon the grading the first " common " or two " partial commons " should be selected and the traffic recorded on these. In the latter case any unevenness in distribution will be shown. In these cases the traffic carried will be greater and small inaccuracies will not affect the result to any great extent. The values of total traffic and grade of service could then be determined from curves. Figs. **2** and **4** show the relation between traffic offered to 11th contact and total traffic, and traffic carried by 10th contact and total traffic, which are examples of the type of curves used for graded groups of 10 contact switches.

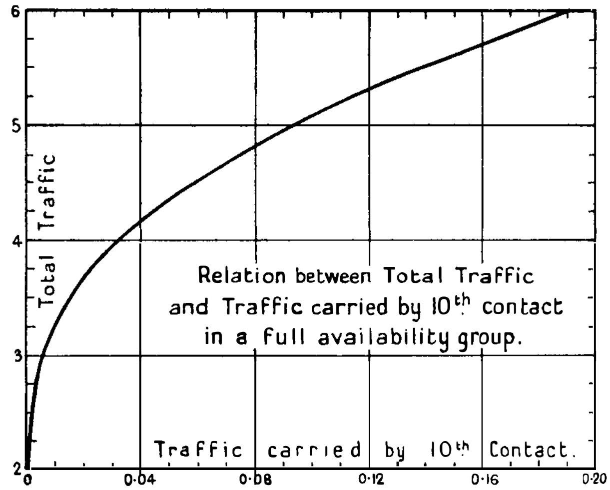


Fig. **4**.

The following are illustrations of the method both for full availability and graded groups.

The third choice in a full availability group of three outlets carried 0.14 traffic unit when the total traffic carried was 1.03 traffic unit. Curves, which are not illustrated, showed that if 1.00 traffic unit was offered to three circuits the third would carry 0.14 traffic unit.

As examples of the application of the principles to grading, results have been extracted from various traffic records available and the steps made are given in tabular form in Table 3.

TABLE 3.

No. of circuits.	Actual Traffic Carried.	Last Contact Traffic.	Values obtained from curves.		
			Traffic A.	Lost Traffic.	Theoretical Traffic A.
15	6.05	0.05	4.44	0.037	6.4
31	10.83	0.04	4.16	0.025	12.0
71	30.1	0.06	4.6	0.055	30.0

In preparing this table use has been made of Fig. **5**, which shows the relation between lost traffic and total traffic for various sizes of groups of 10 contact switches, where the traffic may be assumed to be pure chance.

The close agreement between actual and theoretical values depends entirely upon an even distribution of traffic, an event which at the present time is realised on most of the groups in exchanges due to an efficient maintenance of the required service conditions.

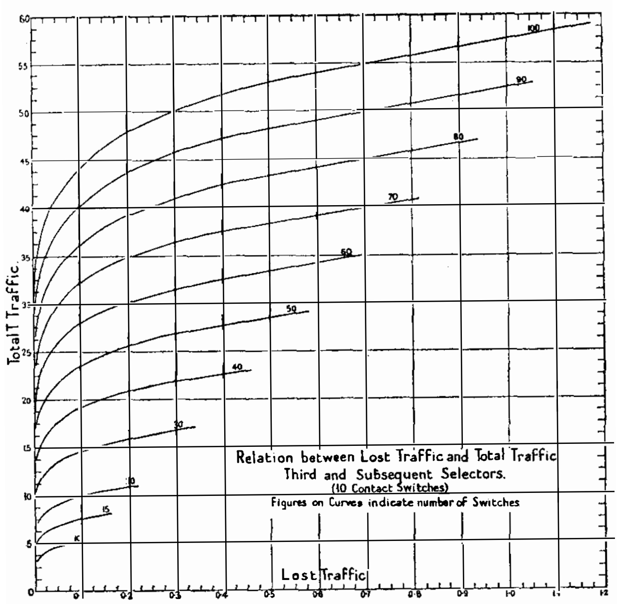


FIG. 5.

(*c*) The third suggested use is mainly applicable to artificial traffic tests and other cases where the grade of service given when a certain quantity of traffic is being passed through a group is required approximately. For example, we may be passing four traffic units through a group of nine circuits fully available. It is known that 3.96 (approximately four) traffic units offered to a group of 10 circuits gives a grade of service of 1 in 200.

Expression (11) repeated gives,

$$\text{traffic offered to } x\text{th switch} = \frac{P_x \times X}{1 - P_x}$$

Substituting $x = 10$ and $P_x = 0.005$

$$\text{traffic offered to 10th switch} = \frac{10}{199}$$

Hence, grade of service of group of nine circuits with a traffic of 3.96 traffic units =

$$\frac{199 \times 3.96}{10} = \frac{1}{79}$$

The grade of service with a traffic of four traffic units would be approximately 1 in 75.

Carrying the case a little further by applying similar principles to a graded group of availability 9. Such odd availabilities are likely to be encountered in the trunking scheme for the Controller and Translator Bypath Systems. The author has selected the case of 14 traffic units offered to a group of 29 circuits with this availability. Design tables show that when this amount of traffic is offered to 30 circuits with an availability of 10 the grade of service is 1 in 200. With the same loss, namely, $\frac{14}{200} = 0.07$ traffic unit, curves show that the equivalent full availability traffic will be 4.78 traffic units. Using the previous nomenclature

$$BA = 0.07$$

$$\text{or } B = \frac{4.78}{0.07}$$

But expression (11) states that traffic offered to

$$\text{10th contact} = \frac{Bx}{1 - B} = \frac{\frac{0.07}{4.78} \times 10}{1 - \frac{.07}{4.78}} = \frac{0.7}{4.71}$$

This is the traffic lost from the 9th choice in the graded group and therefore grade of service

$$= \frac{0.7}{14 \times 4.71} = \frac{1}{94}$$

Conclusion.

The whole of the matter in this article has been based on pure chance traffic and therefore only applies to those cases where this type of traffic occurs in practice. The question of " smoothing effect " has hardly been broached, but it is felt that it would be difficult to derive methods based on theoretical principles which could be used in a similar manner to those given on earlier pages.

It is surprising, however, to what extent difficulties succumb to careful investigation and the author has no doubt that some reliable methods can be devised to cover the cases where smoothing effect is evident.

The comparison of the theoretical values with those obtained in practice, combined with the easy mathematical treatment, indicates that there is every possibility of determining, within a reasonable degree of accuracy, traffic values from comparatively little data.

In conclusion the most important expressions which have been derived and used are here recapitulated in which

x = the availability of a full availability or graded group.
A = traffic offered to a full availability group, or is the equivalent full availability traffic for a graded group.
N = number of switches in a graded group.
A′ = traffic offered to graded group.
P_x or B = grade of service for a full availability group.
B′ = grade of service for a graded group.

For a full availability group,

$$\text{last contact traffic} = P_x \left[\frac{x}{(1 - P_x)} - A \right] \ldots\ldots(7)$$

$$\text{last contact traffic} = P_x \, [x - A] \ldots\ldots\ldots\ldots\ldots(10)$$

$$\text{traffic offered to last contact} = \frac{P_x x}{1 - P_x} \ldots\ldots\ldots(11)$$

For a graded group,

$$\text{last contact traffic} = \text{loss} \left[\frac{x}{(A - \text{loss})} - 1 \right] \ldots(13)$$

$$\text{last contact traffic} = \text{loss} \left[\frac{N}{(A' - \text{loss})} - 1 \right] \ldots(14)$$

with certain limitations as indicated in the text.

Application of traffic meter readings,

$$\text{Congestion call meter reading} = \text{overflow meter reading} \left[\frac{x}{(A - \text{loss})} - 1 \right] \ldots\ldots(15)$$

$$A = \frac{\text{overflow meter reading} \times x}{(\text{congestion meter} + \text{overflow meter})\ \text{readings}} \ldots\ldots\ldots(16)$$

$$\text{Congestion call meter reading} = \text{overflow meter reading} \left[\frac{N}{A'} - 1 \right] \ldots\ldots\ldots(17)$$

with certain limitations as indicated in the text.

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 30TH SEPT., 1930.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileage.				Engineering District.	Underground Wire Mileage.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
691,262	527	3,945	54,060	132	London	25,066	93,233	2,630,931	76,189
92,459	2,228	21,549	71,255	2,212	S. Eastern.	4,094	64,679	279,638	36,043
95,433	4,523	32,648	67,466	3,875	S. Western.	22,198	18,777	207,548	66,445
77,341	6,325	39,550	71,105	7,037	Eastern.	24,932	49,716	166.315	61,165
109,226	9,589	45,532	67,387	4,687	N. Mid.	33,664	70,521	282,326	97,086
95,701	4,841	31,611	82,307	4,095	S. Mid.	13,927	33,446	234,524	78,6[illegible]
63,487	4,417	30,061	60,647	3,843	S. Wales.	6,871	31,660	142,771	67,410
119,843	7,929	27,174	57,029	4,416	N. Wales.	13,628	43,822	326,1[illegible]8	57,229
172,826	1,443	16,036	45,285	3,085	S. Lancs.	14,919	88,705	550,222	67,845
102,838	6,065	30,907	51,039	3,183	N. Eastern	14,727	52,421	283,006	70,212
70,025	3,888	24,089	41,680	2,743	N. Western.	7,968	37,880	180,983	42,375
53,010	2,481	15,916	27,896	3,260	Northern.	8,169	22,483	147,262	37,055
24,221	4,434	9,071	15,173	618	Ireland N.	135	3,161	52,198	2,406
73,877	4,733	27,714	42,982	1,324	Scotland E.	7,561	18,071	160,96[illegible]	38,713
96,320	7,241	24,955	46,632	1,247	Scotland W.	11,776	30,191	246,301	34,083
1,937,869	70,664	380,758	801,943	45,757	Total	209,635	658,766	5,900,174	832,924
1,918,248	70,998	378,481	789,730	44,811	Figures as at 30th June, 1930.	205,363	639,313	5,798,285	841,130

POWER DISTRIBUTION IN AUTOMATIC TELEPHONE EXCHANGES.

S. A. Wickerson,
Engineering Department,
Automatic Telephone Manufacturing Co., Ltd.

IN Strowger Automatic Telephone Exchanges where the familiar Line Switch Units and Selector Trunk Boards are installed, the method of power distribution employed is mainly by means of main bus bars or feeder cables from the Power Board to a number of Feeder Bus Boards located in centralised positions in the automatic equipment rooms. From these points numerous pairs of V.I.R. distribution cables are provided, generally on the basis of one set of feeders per ten Line Switch Units or three Selector Trunk Boards. Fig. **1** shows the rear of a Feeder Fuse Board with its associated power cabling.

This system of power distribution was the best which could be evolved when a method of mounting automatic equipment involving many different types of racks of varying sizes both in height and floor area was used.

It necessitated the supply of various sizes of power cables, cable runway, feeder fuse boards, spare fuse cabinets; also installation work was a rather slow process, involving many soldered joints at terminating lugs.

With the adoption of open type racks as standard for British Post Office exchanges, a new system of power distribution evolved by the A.T.M. Coy. will be installed for the first time in this country at Bristol Central Exchange. Comparison with other schemes, where feeder fuse boards are used, will then be possible.

Bus bar work has been previously used in the power and battery rooms of telephone exchanges, also up to the feeder fuse boards in the automatic equipment rooms, and it is an extension of the principle of using bus bars for power distribution instead of V.I.R. power cables with which this article is concerned.

Fig. **2** illustrates a method of linking the end cells of a battery together using bus bars, all joints being treated with vaseline and then clamped.

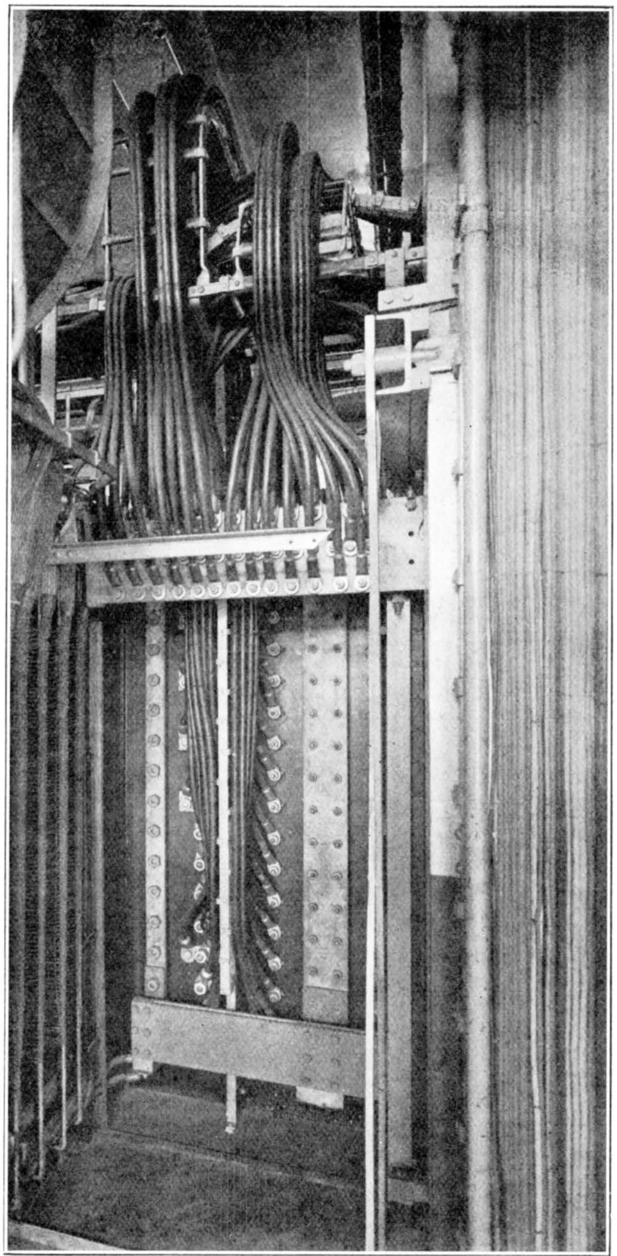


Fig. 1.

Figs. **3** and **4** are front and rear views of a telephone power board showing the laminated bus bar work to the feeder fuse boards, etc. The bus bars shown in Figs. **3** and **4** will now

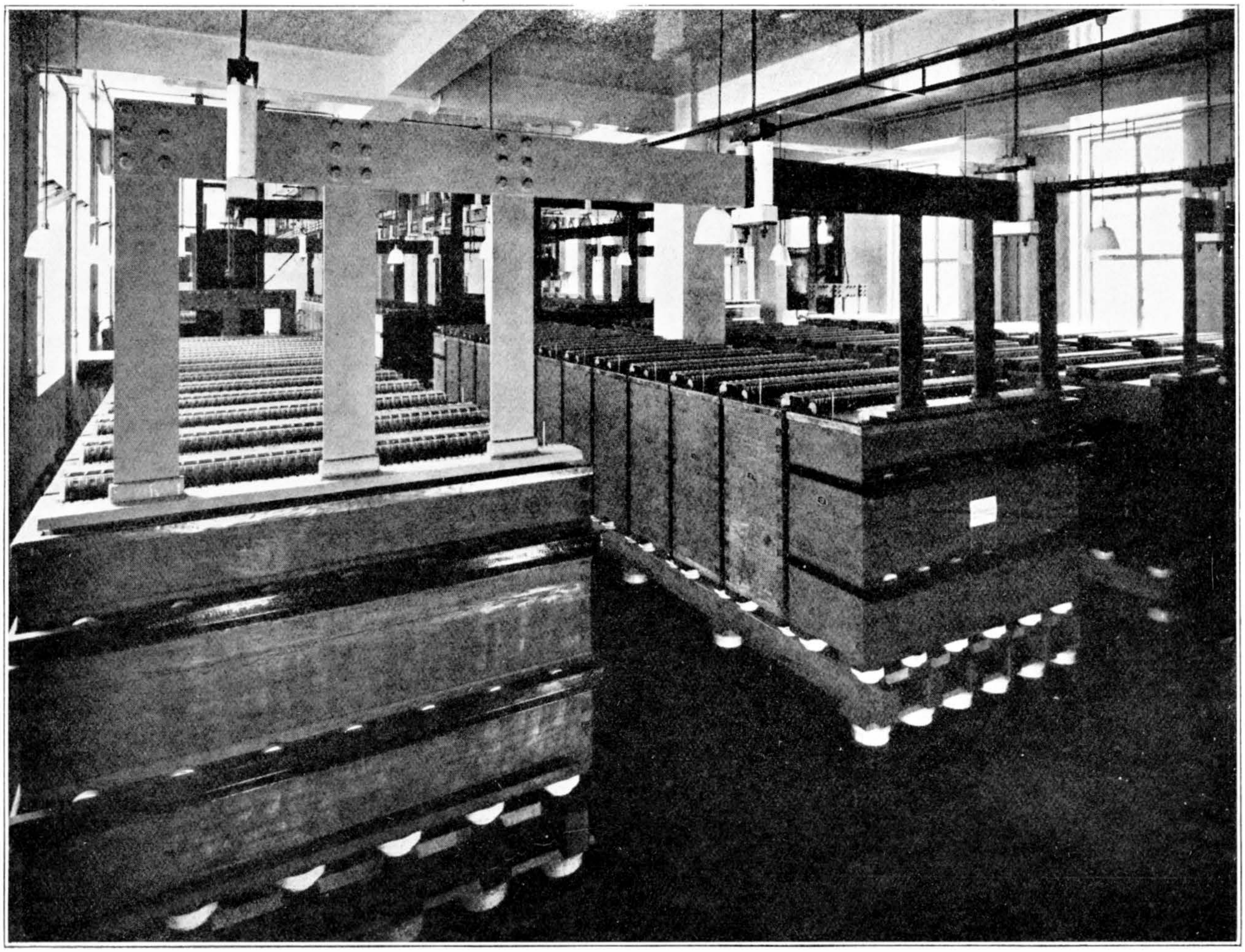


FIG. 2.

terminate on the main bus bars feeding the suites of racks as illustrated in Fig. 5.

This photograph shows suites of automatic equipment racks of standard height and width, with the main feeder bus bars running transversely along the top of the end racks.

Inter-rack bus bars, illustrated in Fig. 6, are connected to the mains as shown in Fig. 10, which in turn are clamped to the individual automatic equipment rack bus bars running vertically at the left hand side of each rack, see Fig. 7.

The route of the main bus bars feeding the suites of racks is shown in Fig. 8, which is a plan of the apparatus room at Bristol Central Exchange. Telephone exchanges at Buenos Aires and Victoria, B.C., have already been equipped in this manner.

Three main sets of feeder bus bars are indicated by the thick chain dotted line, each set of mains feeding the suites of associated equipment.

From Figs. 9 and 10 it will be seen that the main bus bars, which may be of 1-2 or 3 laminations as required, are supported by robust bobbin type porcelain insulators carried on steel posts screwed in to the rack uprights. All joints in the bus bars are treated with vaseline and then clamped, and it is found that the resistance of a well-made joint of this type is less than that of a continuous bar of the same cross-sectional area. The surfaces of the bus bars to be jointed are cleaned with emery cloth under a coating of vaseline, removing any oxide and preventing further oxidisation before clamping the joint.

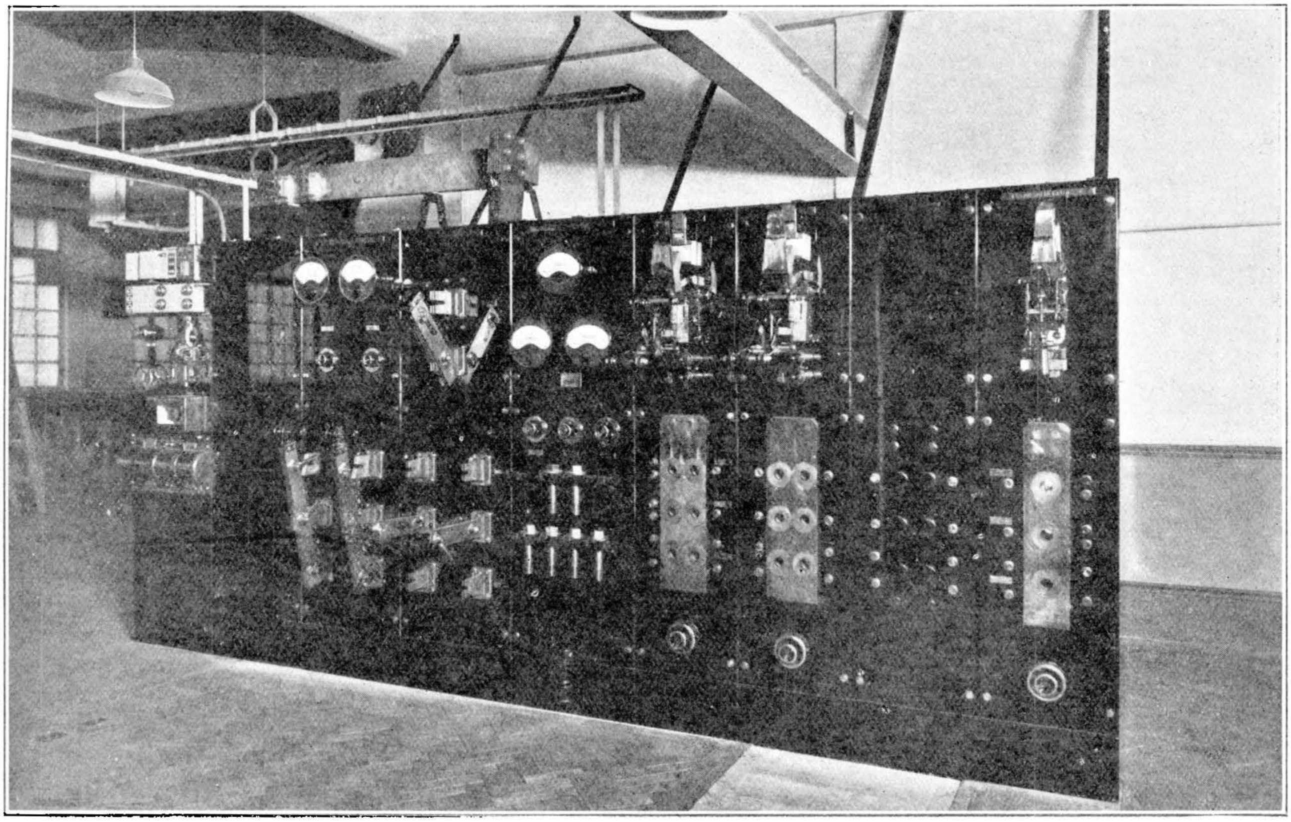


FIG. 3.

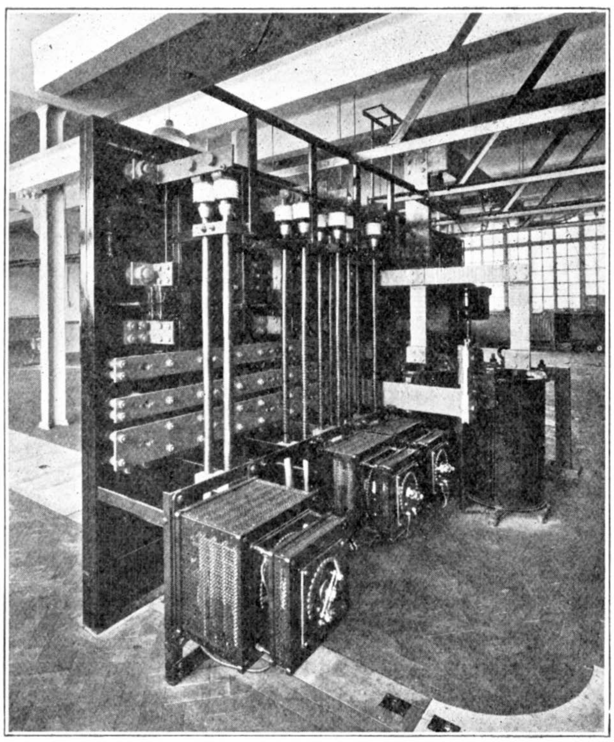


FIG. 4.

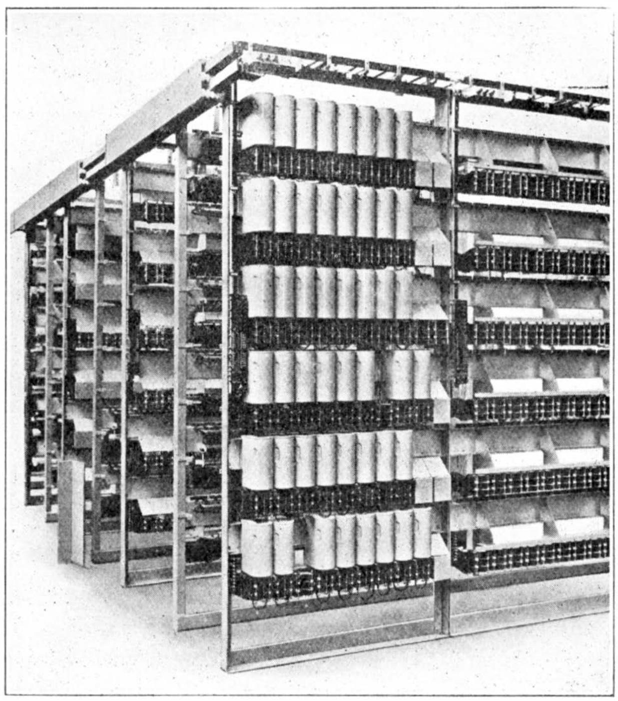


FIG. 5.

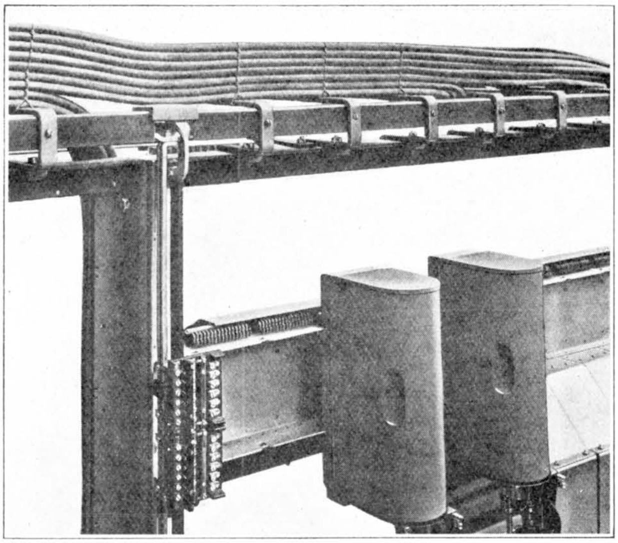


FIG. 6.

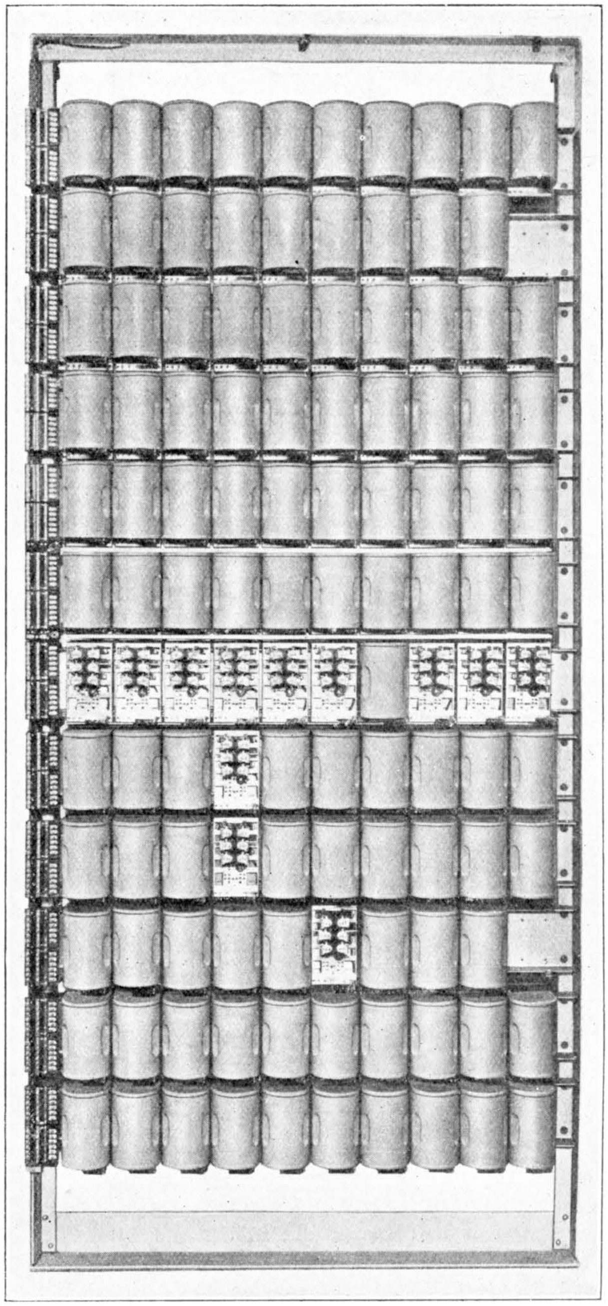


FIG. 7.

The bus bars are stock material, undrilled and can be graded along the suites of racks as required by the current drain.

When an exchange is only partially equipped, sufficient material is furnished in the main conductors to provide for the initial requirements, further laminations being added as the exchange grows.

The bus bar cross-sections are calculated in accordance with the formulæ evolved by Mr. A. Prado, A.M.I.E.E., of the Automatic Telephone Manufacturing Company, Ltd., and which were published in "Telephony," dated 14th, 21st and 28th December, 1929, under the heading—"Laws of Potential Drop in Conductors." The purpose of the article describing the formulæ was to outline methods whereby power distribution schemes could be designed with a minimum mass of metal. In order to avoid unnecessary repetition of the various formulæ, reference should be made to the issue of December 28th of the foregoing publication in which will be found the general method of calculation.

The main bus bars are protected from accidental damage with simple pressed steel rear and front covers.

Figs. **9** and **10** show in detail the main and inter-rack bus bars, method of clamping joints, porcelain insulators, covers, etc., the upper bars being negative and the lower positive potential. The brackets supporting the inter-rack bus bars also carry the switchboard cables feeding the suite of racks.

For protection and isolation purposes a small circuit breaker of the overload type rated at 75 amps. is provided for each suite of equipment, with facilities for extending an alarm into the main alarm system of the exchange in the event of a circuit breaker tripping for any reason such

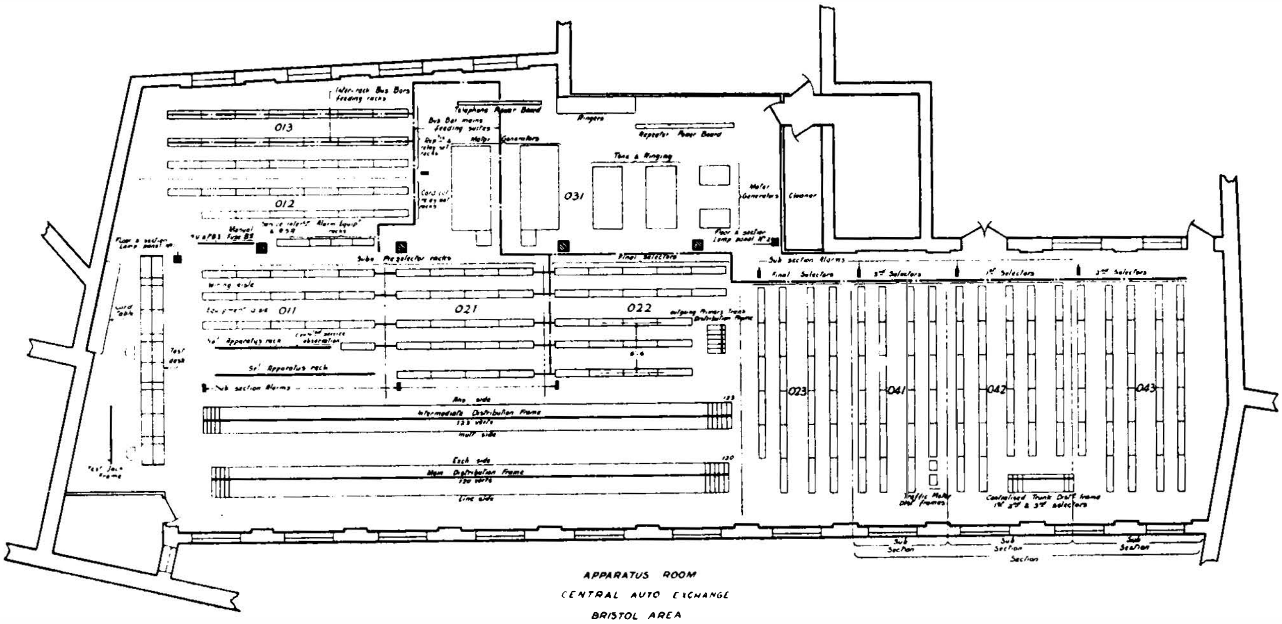


FIG. 8.

as an accidental short-circuit or temporary overload. The circuit breakers are also equipped with a delay device, causing the breaker to delay operation in a similar manner to the fusing characteristics of a power fuse.

The position of the exchange alarm lamps is indicated in Fig. **8** and it will be seen that upon a circuit breaker tripping through any cause, sub-section, section and floor lamps will glow; the usual audible indications will also be given. Upon the Maintenance Officer proceeding to the sub-section affected, the position of the circuit-breaker handle will indicate which circuit-breaker has tripped.

The maximum allowable voltage drop between the battery and the automatic equipment is one volt; therefore, as the internal resistance of the circuit-breaker is measured at .0012 ohm a saving in the size of the conductor necessary will be possible when it is realised that the internal resistance of a feeder fuse used in the old system ranged between .1 ohm and .2 ohm.

The inter-rack bus bars are standardised at $\frac{3}{4}'' \times \frac{1}{4}''$ and are supported inside the cable slats which are in turn clamped to the top angle of the equipment racks. Fig. **10** shows the bus bars between racks connected to the mains, the negative feed passing *via* the circuit-breaker. The negative and positive bus bars are cleated

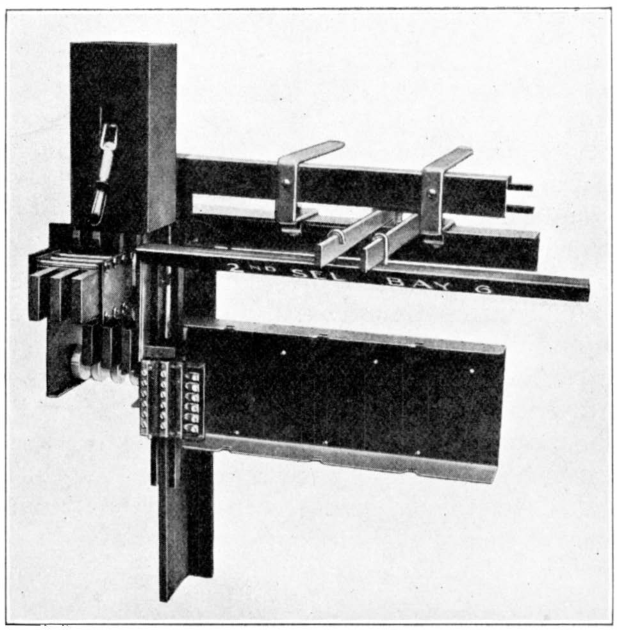


FIG. 9.

to the cable slats and protected with sheet steel covers.

In exchanges having a battery capacity of 1000 a.h. and under, suite circuit-breakers are not provided, the main circuit-breaker giving the necessary protection.

It will be noticed in Fig. **6** that the rack

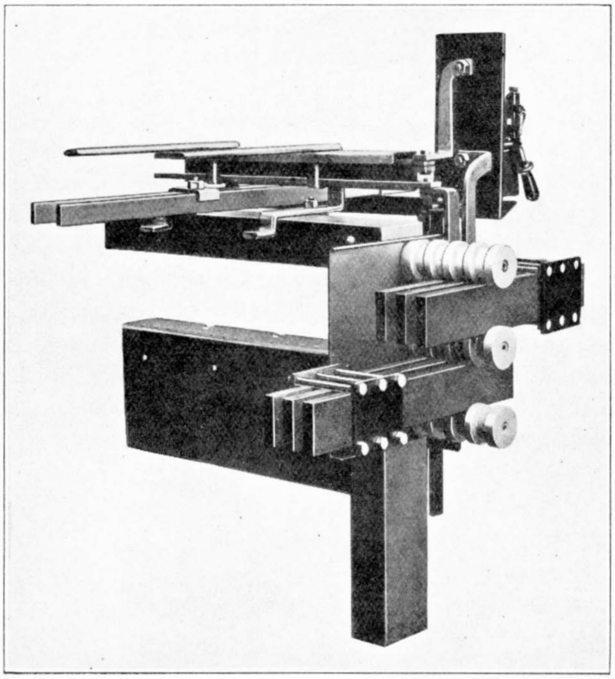


FIG. 10.

positive bar is clamped directly on to the positive inter-rack bar, whilst it is necessary to provide an insulated link between the negative rack and inter-rack bus bars. Joints in bus bars have been eliminated as far as possible and where they do occur lock nuts are provided.

At the junction of adjacent racks a porcelain insulator is furnished as shown in Fig. **6**.

The bus bar arrangement on the equipment racks is shown in Fig. **7** and consists of two sets of duplicate $\frac{1}{4}'' \times \frac{1}{4}''$ bars, spaced $\frac{1}{4}''$ apart. This scheme allows the utmost flexibility with regard to the positioning of the unit type fuse panels, also obviating the drilling of the vertical bus bars. The rack bus bars are supported from the rack uprights and the fuse panels clamped to the bars where required. The requisite amount of strength is thus obtained for the supporting of the fuse panels, also the cross-section of the bus bar material provides for the maximum current drain of any automatic equipment rack.

A cross-section of the inter-rack bus bars is illustrated in Fig. **11**, exposed portions of the negative rack or inter-rack bus bars being protected with split bakelite tube, which is sprung over the bus bar as shown. This occurs between rack fuse panels, etc.

Adequate protection is thus provided, it being practically impossible to effect an accidental short-circuit.

The material used as a conductor in this all bus bar system of power distribution is aluminium, the reasons for employing this instead of copper are mainly engineering.

Aluminium as a conductor is approximately half the weight of a copper bar of equal resistance, and as the weight of the conductors in the power distribution system of a large telephone exchange is considerable, this is a definite advantage. The cross-sectional area will be greater than that of a copper bar carrying an equivalent current value to the extent of 61%, but this is no serious disadvantage.

Installers will find it easier to handle than copper; bending, drilling and filing operations, etc., being much easier.

With the standardised automatic equipment racks now provided in telephone exchanges, allowing a uniform lay-out as shown typically in Fig. **8** an all bus bar system of power distribution as described in this article is possible.

Distribution circuit-breakers can be replaced immediately in the event of temporary overloads occurring, instances of this being actually recorded during periods of abnormal traffic.

Feeder fuse boards, V.I.R. distribution cables and cable runway, etc., are eliminated and the process of installation considerably simplified.

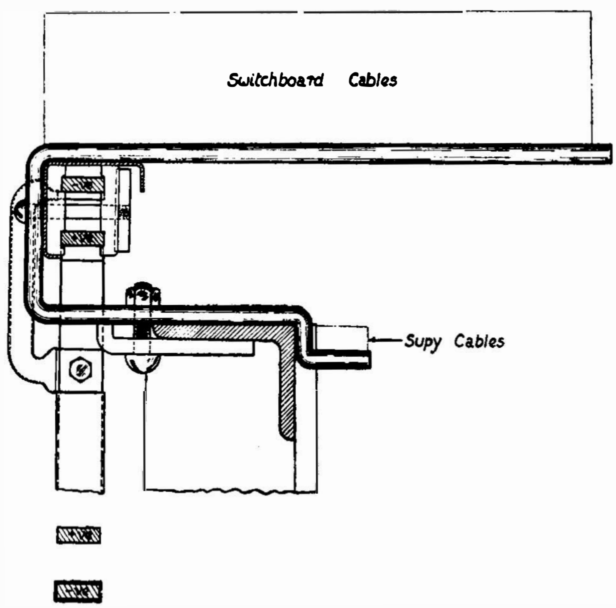


FIG. 11.

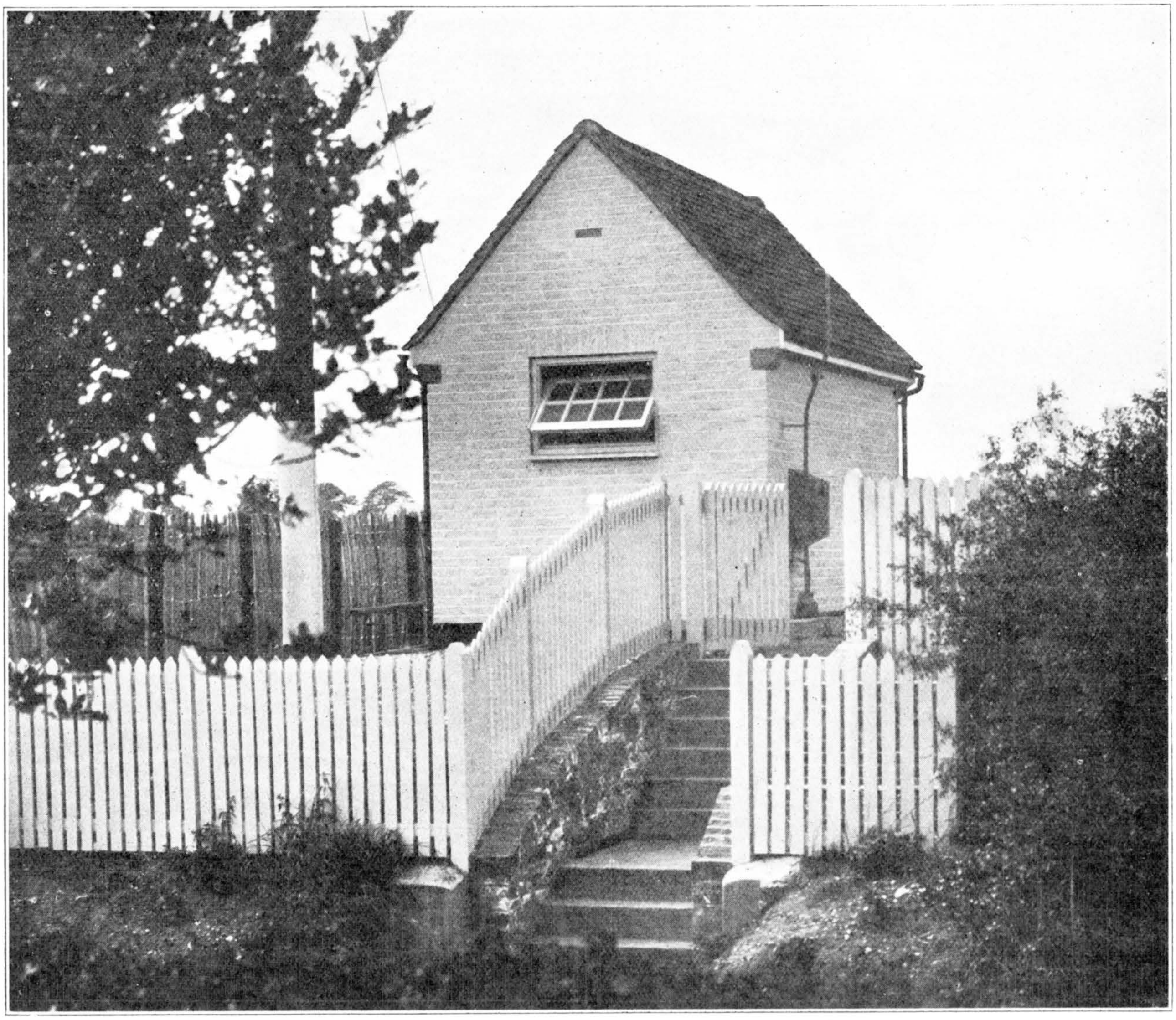
FROM ST. MABYN TO DRUMLITHIE.

J. C. Dallow.

THE infant of the telephone service grows to adolescence. Barely two years of age, it has, in its truly remarkable and unparalleled progress, journeyed over the whole country, from tiny hamlets in the Devon valleys to the barren moors of Inverness.

The infant referred to is the Rural Automatic Exchange. As its name implies, this type of equipment caters for sparsely populated districts in which only a small number of subscribers scattered over a wide area can be obtained.

A detailed technical description of the system was given in the July, 1929, issue of this Journal, and therefore it will be unnecessary to do more than refer to the salient features of the scheme in this account of its progress.



Photograph by Dallow.

Fig. 1.—A typical brick R.A.X.

Installation Procedure.

Exchanges are opened when a minimum of eight applications for service have been signed. In order that the prospective subscribers shall be given service with the least delay, every stage of the work from the acquisition of the land to the opening of the exchange is carried through as expeditiously as possible.

Upon authorisation of an exchange, instructions are issued to the engineering section concerned to obtain an offer of a suitable site on which to erect the building. Local officers have become adept in negotiating for the small plots of land required for this purpose. When the site has been chosen, a detailed report with plans is furnished to Headquarters and, if approved, the land is bought by the Post Office. The legal negotiations usually occupy a few weeks, and during this period tenders for the standard type of building are invited from local builders and held until legal possession of the site is granted. Immediately possession is obtained, the building contract is placed and the erection of the building proceeds under the supervision of the Sectional engineer.

The building may be either of brick or of stone, but the general construction and dimensions (14′ × 7′ 7″ × 9′ high internally) are standard for all exchanges. Typical brick and stone buildings are shown in Figs. **1** and **2** respectively.

While the building is in course of construction, the external line work is put in hand and the internal equipment is obtained. The latter consists of one or more automatic units and the power plant. Each automatic unit contains switching equipment for 25 lines, together with a ringing vibrator, tone generator and other

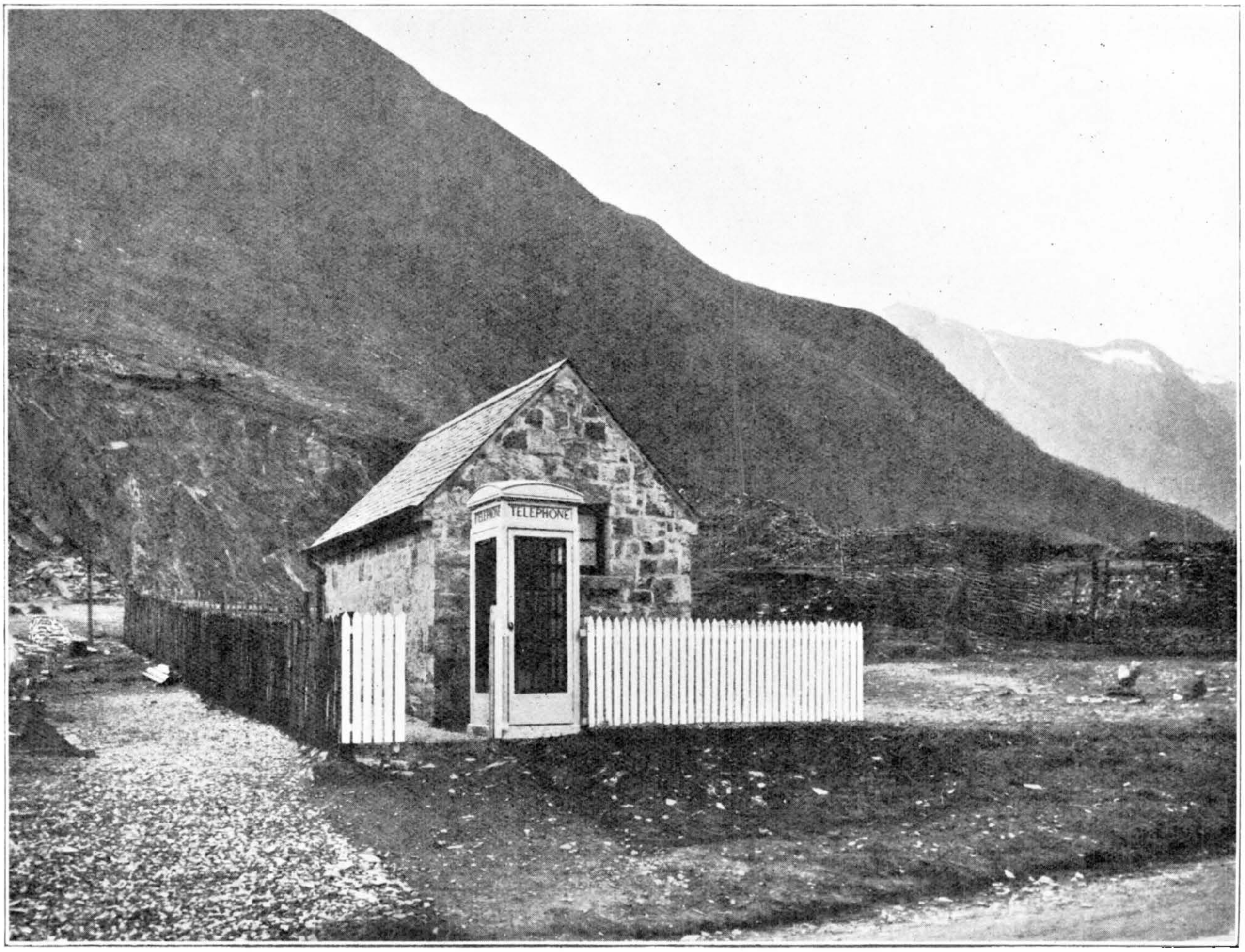


FIG. **2**.—A STONE R.A.X. THE SNOW-LINED HILLS ON THE RIGHT GUARD THE ENTRANCE TO GLENCOE.

common apparatus. A unique feature of the unit is that all the equipment is enclosed in a steel double walled air-spaced cabinet in order to make the interior as damp-proof and dust-proof as possible. Not more than four units can be fitted, so that the maximum capacity of an exchange in a standard building is 100 lines. In most cases the power plant comprises a 1 H.P. petrol engine coupled to a small generator; two sets of 50 volt 40 amp. hour secondary cells and a small charging control panel are also provided.

After completion, the building is allowed to dry out for a week or two, and installation of the equipment proceeds. The batteries and power plant are fitted first, followed by the automatic units.

Installation of the subscribers' telephones and the apparatus at the distant ends of the junctions is undertaken while the exchange is being fitted. When all is completed, a test of the whole equipment is carried out and the exchange is brought into service.

Establishment Period.

It will be readily understood that the establishment of an exchange, including all phases of the development from the selection of a wayside plot of virgin soil to the testing out of the equipment, demands foresight and co-ordination at every step in order to attain the minimum overall period. The average period for providing an R.A.X. from the commencement of site search to the opening date is just over seven months. This average takes into account a number of cases in which the legal negotiations for the land have been protracted, and others which have been delayed by the erection of buildings specially finished to harmonise with the amenities of the surroundings. The record time stands at 4½ months, this being attained in several instances.

Progress of Scheme.

The first few R.A.X's were opened in the spring of 1929. Since then, the development has proved that there has been a large number of potential subscribers in country districts waiting for the introduction of a telephone system capable of solving the difficulties associated with rural manual systems. Indifferent operating, absence of night service, non-secrecy and many other obstacles are swept aside by the R.A.X., the result being that 300 exchanges have been brought into service in less than two years. Approximately 75% are entirely new additions to the telephone system.

Such a phenomenal demand for these exchanges necessitates systematic working of all concerned and every stage of the work is therefore scrutinised with the object of bringing to light avoidable causes of delay. Legal work in connection with the site has been reduced to a minimum; a new standard building has been designed to obviate prolonged drying out; and modifications to the internal equipment are being introduced to lessen the installation work.

The attention given has been reflected in the results obtained. Early in 1929 exchanges were being opened at about three per month. This rate was steadily improved to 15 per month in the spring of 1930 and has been further increased until, for November, 1930, these exchanges have been brought into service at the rate of one per

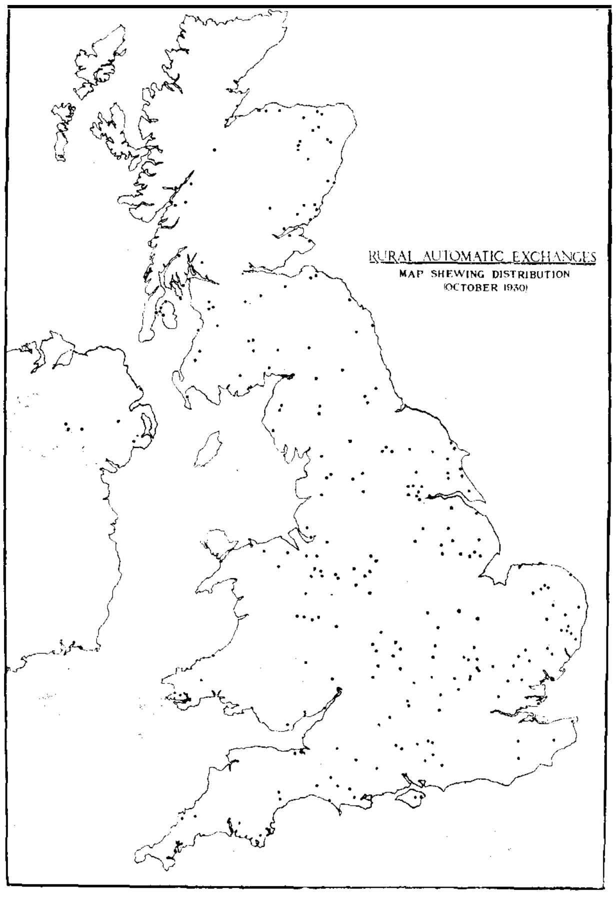


Fig. 3.—Positions of R.A.X's.

day. The opening of an R.A.X. has therefore become a daily habit in the Department.

A very encouraging feature is that in 35 of the exchanges already opened, the capacity of the initial equipment has been exhausted owing to increases in the number of subscribers, and additional automatic units have been fitted. This is concrete evidence of public satisfaction and confidence in the new system, even to personal recommendation of it.

Fig. **3** shows an outline map of the United Kingdom and indicates each exchange by a dot; flavour conjures up in one's mind picturesque villages nestling far from the roar of civilisation. It is not generally known that there is a Maze in Northern Ireland; Scotland has a Mouswald and an Eden. Hebron is in South Wales, while Essex can boast a Good Easter.

Visits to several of the exchanges have confirmed also that they are placed in beautiful surroundings. One forgives Llanfairtalhaiarn its name on seeing its grey stone cottages clustered on the hillside and the River Elwy threading its way through the meadows below.

Photograph by Dallow.

FIG. **4**.—THE KIOSK ATTACHED TO A RURAL AUTO. EXCHANGE IN THE LONDON DISTRICT.

a complete list of the exchanges opened to the end of November, 1930, is given in the Appendix to this article.

Statistics are usually of interest only to those immediately concerned. Schedules of names do not as a rule set the imagination wandering and are generally devoid of romantic interest. This list is an exception. The quaint names included are fascinating in themselves and their old-world

Walkern takes on a new interest when one has lunched in the village tavern, complete with old oaken beams, cavernous fireplace, pewter and brasses.

Fig. **4** shows the attractive locality in which the kiosk connected with Stapleford, the only R.A.X. in the London District, is situated. Indeed, the list can be taken as a wholesale introduction to those unspoiled parts of rural Britain for which the tourist searches; a very pleasant holiday could be spent by taking extracts from the list and visiting the villages concerned.

Extension to 200 Lines.

The success of this type of exchange has prompted the development of an R.A.X. with a capacity of 200 lines. The possibility of future extension was visualised at the commencement of the original scheme, and all the sites obtained are large enough to allow for an increase in the length of the building to accommodate apparatus for 200 lines.

The first few exchanges employing the larger capacity equipment will be brought into service very shortly.

RURAL AUTOMATIC EXCHANGES.

(Installed up till the end of November, 1930, throughout the country)

No.	Exchange.	Parent Exchange.	Engineering Section.	District.	No. of Working Lines initially.	No. of Units fitted.	Date opened.
1	*Ramsay	Peterborough	Peterborough	N. Mid.	60	—	24-10-21
2	*Hurley	Maidenhead	Reading	S. Mid.	47	—	20-12-21
3	†Blockley	Moreton-in-Marsh	Gloucester	S. Wa.	23	—	25-3-24
4	‡Haseley Knob	Warwick	Coventry	N. Mid.	11	—	19-3-25
5	Haynes	Bedford	St. Albans	E.	12	1	4-2-29
6	Harbury	Leamington	Coventry	N. Mid.	13	1	26-2-29
7	North Stainley	Ripon	York	N.E.	12	1	11-3-29
8	Elsham	Brigg	Lincoln	N.E.	12	1	26-3-29
9	Hampton	Malpas	Shrewsbury	N. Wa.	14	1	8-4-29
10	Rendham	Framlingham	Colchester	E.	9	1	22-4-29
11	Collier St.	Paddock Wood	Tunbridge Wells	S.E.	9	1	23-4-29
12	Sinderby	Thirsk	York	N.E.	9	1	30-4-29
13	Weston	Letchworth	St. Albans	E.	15	1	1-5-29
14	Church Stoke	Welshpool	Shrewsbury	N. Wa.	9	1	6-5-29
15	Marbury	Whitchurch	Shrewsbury	N. Wa.	13	1	7-5-29
16	Walkern	Stevenage	St. Albans	E.	12	1	14-5-29
17	Longhoughton	Alnwick	Newcastle N.	N.	8	1	15-5-29
18	West Cranmore	Shepton Mallet	Exeter	S.W.	10	1	21-5-29
19	Clifton	Shefford	St. Albans	E.	30	2	22-5-29
20	Broughton	Kettering	Coventry	N. Mid.	9	1	28-5-29
21	Quainton	Aylesbury	Oxford	S. Mid.	11	1	30-5-29
22	Ellastone	Ashbourne	Leicester	N. Mid.	12	1	10-6-29
23	Offton	Ipswich	Colchester	E.	11	1	10-6-29
24	Aughnacloy	Armagh	Belfast	N. Ire.	12	1	11-6-29
25	Barrhill	Girvan	Glasgow S.	Scot. W.	9	1	20-6-29
26	Pipegate	Hanley	Stoke	N. Wa.	19	2	25-6-29
27	Ampleforth	Easingwold	York	N.E.	13	1	25-6-29
28	Crucorney	Abergavenny	Hereford	S. Wa.	13	1	25-6-29
29	Dunsop Bridge	Clitheroe	Blackburn	N.W.	12	1	25-6-29
30	Ardwell	Stranraer	Glasgow S.	Scot. W.	11	1	2-7-29
31	Islandmagee	Whitehead	Belfast	Ire. N.	12	1	5-7-29
32	Bridge of Cally	Blairgowrie	Dundee	Scot. E.	9	1	16-7-29
33	Pirnmill	Brodick	Glasgow N.	Scot. W.	8	1	16-7-29
34	Closeburn	Thornhill	Glasgow S.	Scot. W.	9	1	19-7-29
35	Welford-on-Avon	Stratford-on-Avon	Coventry	N. Mid.	12	1	23-7-29
36	Lumsden	Huntly	Aberdeen	Scot. E.	7	1	24-7-29
37	Newbrough	Hexham	Newcastle S.	N.	8	1	24-7-29
38	Mouswald	Dumfries	Glasgow S.	Scot. W.	9	1	26-7-29
39	Gamlingay	Sandy	St. Albans	E.	23	2	29-7-29
40	Cerne Abbas	Dorchester	Bournemouth	S.W.	8	1	30-7-29
41	Hampden Row	Gt. Missenden	Oxford	S. Mid.	10	1	30-7-29
42	Reepham	Lincoln	Lincoln	N.E.	9	1	6-8-29
43	Onich	Fort William	Glasgow N.	Scot. W.	10	1	6-8-29
44	Rhynie	Huntly	Aberdeen	Scot. E.	10	1	7-8-29
45	Slaidburn	Clitheroe	Blackburn	N.W.	16	1	13-8-29
46	Broadwindsor	Beaminster	Bournemouth	S.W.	9	1	13-8-29
47	Old Meldrum	Inverurie	Aberdeen	Scot. E.	29	2	14-8-29
48	Cayton Bay	Scarborough	York	N.E.	12	1	20-8-29
49	Catterline	Stonehaven	Aberdeen	Scot. E.	10	1	21-8-29

* Siemens Village Exchange. † A.T.M. Co. R.A.X. ‡ Relay Company's Equipment.

All others standard. (Auto Units No. 5.)

No.	Exchange.	Parent Exchange.	Engineering Section.	District.	No. of Working Lines initially.	No. of Units fitted.	Date opened.
50	Corpach	Fort William	Glasgow N.	Scot. W.	8	1	27-8-29
51	Chilbolton	Andover	Bournemouth	S.W.	9	1	3-9-29
52	Beattock	Moffat	Glasgow S.	Scot. W.	9	1	3-9-29
53	Abbotts Ann	Andover	Bournemouth	S.W.	11	1	5-9-29
54	Lorton	Cockermouth	Lancaster	N.W.	10	1	10-9-29
55	Llanfairtalhaiarn	Abergele	Bangor	N. Wa.	13	1	17-9-29
56	Abbotsbury	Weymouth	Bournemouth	S.W.	12	1	17-9-29
57	Coningsby	Horncastle	Lincoln	N.E.	20	1	17-9-29
58	Whitwell	Welwyn	St. Albans	E.	24	2	23-9-29
59	Brent Pelham	Bishop Stortford	Cambridge	E.	9	1	23-9-29
60	Long Sutton	Langport	Taunton	S.W.	10	1	1-10-29
61	Kilmaurs	Kilmarnock	Glasgow S.	Scot. W.	26	2	8-10-29
62	Terling	Witham	Colchester	E.	10	1	14-10-29
63	Badingham	Framlingham	Colchester	E.	9	1	14-10-29
64	Crossford	Carluke	Glasgow S.	Scot. W.	12	1	15-10-29
65	Tunstall	Kirkby Lonsdale	Lancaster	N.W.	8	1	22-10-29
66	Comberbach	Northwich	Stoke-on-Trent	N. Wa.	18	1	22-10-29
67	Brancaster	Hunstanton	Cambridge	E.	15	1	28-10-29
68	Hunmanby	Filey	York	N.E.	18	1	29-10-29
69	Lockeridge	Marlborough	Reading	S. Mid.	11	1	31-10-29
70	Toward	Dunoon	Glasgow N.	Sot. W.	8	1	1-11-29
71	Fenny Compton	Banbury	Oxford	S. Mid.	9	1	4-11-29
72	Auchengray	West Calder	Glasgow S.	Scot. W.	10	1	5-11-29
73	Banknock	Bonnybridge	Glasgow N.	Scot. W.	23	2	12-11-29
74	Laxton	Howden	York	N.E.	10	1	19-11-29
75	Lothersdale	Crosshills	West Yorks.	N.E.	9	1	19-11-29
76	Fundenhall	Wymondham	Norwich	E.	8	1	19-11-29
77	Kinnersley	Wellington	Shrewsbury	N. Wa.	9	1	19-11-29
78	Tysoe	Banbury	Oxford	S. Mid.	10	1	25-11-29
79	Kinlochleven	Fort William	Glasgow N.	Scot. W.	25	2	26-11-29
80	Longville	Church Stretton	Shrewsbury	N. Wa.	11	1	26-11-29
81	Bainbridge	Leyburn	Middlesborough	N.	8	1	27-11-29
82	Huxley	Torporley	Shrewsbury	N. Wa.	13	1	3-12-29
83	Machrie	Brodick	Glasgow N.	Scot. W.	11	1	3-12-29
84	Gorthleck	Inverness	Inverness	Scot. E.	8	1	5-12-29
85	Parwich	Ashbourne	Leicester	N. Mid.	10	1	10-12-29
86	Elton	Peterborough	Peterborough	N. Mid.	9	1	11-12-29
87	Gt. Tew (Oxon)	Chipping Norton	Oxford	S. Mid.	14	1	12-12-29
88	Great Alne	Alcester	Birmingham	N. Wa.	10	1	17-12-29
89	Carradale	Campbletown	Glasgow N.	Scot. W.	8	1	17-12-29
90	Ancroft	Berwick	Newcastle N.	N.	11	1	18-12-29
91	Bassingham	Lincoln	Lincoln	N.E.	10	1	20-12-29
92	Airth	Falkirk	Glasgow N.	Sc . W.	12	1	20-12-29
93	Wiseton	Retford	Lincoln	N.E.	12	1	20-12-29
94	East Allington	Kingsbridge	Plymouth	S.W.	10	1	23-12-29
95	Hollington	Uttoxeter	Stoke	N. Wa.	10	1	1-1-30
96	Kimpton	Welwyn	St. Albans	E.	23	2	6-1-30
97	Marrburn	Thornhill	Glasgow N.	Scot. W.	9	1	7-1-30
98	Aldbourne	Marlborough	Reading	S. Mid.	10	1	8-1-30
99	Worlington	Framingham	Colchester	E.	10	1	13-1-30
100	St. Osyth	Clacton	Colchester	E.	24	2	13-1-30
101	Fenwick	Kilmarnock	Glasgow S.	Scot. W.	23	2	14-1-30
102	Bassenthwaite	Cockermouth	Lancaster	N.W.	9	1	14-1-30
103	Inverkeilor	Arbroath	Aberdeen	Scot. E.	24	2	15-1-30
104	Kincaldrum	Forfar	Aberdeen	Scot. E.	9	1	20-1-30
105	Kilchattan Bay	Rothesay	Glasgow N.	Scot. W.	11	1	21-1-30
106	Long Sutton	Basingstoke	Guildford	S. Mid.	8	1	11-2-30
107	Bolton Abbey	Skipton	W. Yorks	N.E.	11	1	11-2-30
108	Hardwick	Worksop	Sheffield	N. Mid.	11	1	13-2-30
109	Denholme	Bradford	W. Yorks	N.E.	23	2	17-2-30
110	Riccall	Selby	W. Yorks	N.E.	11	1	18-2-30
111	Hanmer	Whitchurch	Shrewsbury	N. Wa.	10	1	18-2-30
112	Ashwell	Letchworth	St. Albans	E.	28	2	18-2-30
113	Benburb	Armagh	Belfast	N. Ire.	12	1	25-2-30
114	Normanby-by-Spital	Lincoln	Lincoln	N.E.	10	1	25-2-30
115	Morham	Haddington	Edinburgh (O)	Scot. E.	12	1	3-3-30
116	Rockbourne	Fordingbridge	Bournemouth	S.W.	8	1	4-3-30
117	Luss	Helensburgh	Glasgow N.	Scot. W.	9	1	4-3-30
118	Hartington	Buxton	Manchester	S. Lancs.	25	2	4-3-30
119	Knowsley	Huyton	Liverpool	S. Lancs.	26	2	4-3-30
120	Bawdeswell	Dereham	Norwich	E.	13	1	4-3-30

No.	Exchange.	Parent Exchange.	Engineering Section.	District.	No. of Working Lines initially.	No. of Units fitted.	Date opened.
121	Manston	Ramsgate	Canterbury (E)	S.E.	17	1	4-3-30
122	Yardley Gobion	Stony Stratford	St. Albans	E.	22	2	11-3-30
123	Whiterashes	Dyce	Aberdeen	Scot. E.	10	1	11-3-30
124	Strachur	Dunoon	Glasgow N.	Scot. W	10	1	14-3-30
125	Homersfield	Bungay	Norwich	E.	8	1	17-3-30
126	Twinstead	Sudbury	Colchester	E.	12	1	18-3-30
127	Upton Grey	Basingstoke	Guildford	S. Mid.	21	1	18-3-30
128	Marshbrook	Church Stretton	Shrewsbury	N. Wa.	10	1	18-3-30
129	Dunlop	Kilmarnock	Glasgow S.	Scot W	16	1	18-3-30
130	Rillington	Malton	York	N.E.	17	1	25-3-30
131	Ash	Whitchurch	Shrewsbury	N. Wa.	9	1	25-3-30
132	Luthrie	Cupar	Dundee	Scot. E.	14	1	26-3-30
133	Boarhills	St. Andrews	Dundee	Scot. E.	10	1	26-3-30
134	Maze	Lisburn	Belfast	N. Ire.	13	1	31-3-30
135	Aldeby	Beccles	Norwich	E	8	1	31-3-30
136	Topcliffe	Thirsk	York	N E.	13	1	1-4-30
137	Rumford	Padstow	Plymouth	S.W.	9	1	7-4-30
138	Ballachulish	Oban	Glasgow N.	Scot. W.	18	1	8-4-30
139	Martin	Metheringham	Lincoln	N.E.	15	1	8-4-30
140	Ridgewell	Haverhill	Cambridge	E.	11	1	14-4-30
141	Privett	Petersfield	Guildford	S. Mid.	10	1	15-4-30
142	Clifford	Hay	Hereford	S. Wa.	10	1	15-4-30
143	Steele Road	Liddesdale	Edinburgh (Outer)	Scot. E.	10	1	16-4-30
144	Little Gaddesden	Boxmoor	St. Albans	E.	8	1	15-4-30
145	Glemsford	Sudbury	Colchester	E.	25	2	28-4-30
146	Wenvoe	Cardiff	Cardiff	S. Wa.	9	1	29-4-30
147	Dunure	Ayr	Glasgow S.	Scot. W.	12	1	29-4-30
148	Tow-Law	Bishop Auckland	Middlesbrough	N.	23	2	1-5-30
149	Charlton-on-Otmoor	Oxford	Oxford	S. Mid.	7	1	5-5-30
150	Good Easter	Chelmsford	Southend	E.	13	1	12-5-30
151	North Waltham	Basingstoke	Guildford	S. Mid.	24	2	13-5-30
152	Hale	Garston	Liverpool	S. Lancs.	27	2	13-5-30
153	Linley	Bishops Castle	Shrewsbury	N. Wa.	12	1	20-5-30
154	Watton	Driffield	York	N.E.	13	1	20-5-30
155	Aberlemno	Forfar	Aberdeen	Scot. E.	10	1	21-5-30
156	Morland	Penrith	Lancaster	N.W.	13	1	27-5-30
157	Kinlet	Kidderminster	Hereford	S. Wa.	8	1	27-5-30
158	East Langton	Market Harboro	Leicester	N. Mid.	10	1	29-5-30
159	Salmondsmuir	Carnoustie	Dundee	Scot. E.	10	1	29-5-30
160	Walcot	N. Walsham	Norwich	E.	10	1	2-6-30
161	Lochranza	Brodick	Glasgow N.	Scot. W.	9	1	3-6-30
162	Lea	Ross	Hereford	S. Wales	13	1	3-6-30
163	Callaly	Alnwick	Newcastle N.	N.	12	1	3-6-30
164	Bubwith	Selby	York	N.E.	20	1	3-6-30
165	Wendling	Dereham	Norwich	E.	9	1	3-6-30
166	Mareham-le-Fen	Horncastle	Lincoln	N.E.	13	1	4-6-30
167	Stickney	Boston	Peterborough	N. Mid.	11	1	4-6-30
168	Gt. Wakering	Southend	Southend	E.	38	2	4-6-30
169	Broadclyst	Exeter	Exeter	S.W.	22	2	10-6-30
170	Farnell	Montrose	Aberdeen	Scot. E.	9	1	11-6-30
171	Llanbryde	Elgin	Inverness	Scot. E.	8	1	16-6-30
172	Yetminster	Yeovil	Taunton	S.W.	12	1	17-6-30
173	Lower Guiting	Cheltenham	Gloucester	S. Wa.	16	1	17-6-30
174	Milbourne St. Andrews	Blandford	Bournemouth	S.W.	17	1	17-6-30
175	Bressingham	Diss	Norwich	E.	9	1	18-6-30
176	Gt. Bardfield	Halstead	Colchester	E.	20	2	23-6-30
177	Sacriston	Durham	Newcastle S.	N.	24	2	30-6-30
178	Inchture	Dundee	Dundee	Scot. E.	23	2	30-6-30
179	Hebron	Carmarthen	Swansea	S. Wa.	10	1	1-7-30
180	Clawdd Newydd	Ruthin	Bangor	N. Wa.	10	1	3-7-30
181	Stoke Fleming	Dartmouth	Exeter	S.W.	12	1	14-7-30
182	Drumlithie	Stonehaven	Aberdeen	Scot. E.	10	1	14-7-30
183	Alves	Elgin	Inverness	Scot. E.	18	2	15-7-30
184	Barr	Girvan	Glasgow S.	Scot. W.	11	1	15-7-30
185	Camblesforth	Selby	York	N.E.	11	1	15-7-30
186	Crossmichael	Castle Douglas	Glasgow S.	Scot. W.	11	1	8-7-30
187	Eccleston	Chester	Shrewsbury	N. Wa.	10	1	8-7-30
188	Kildrummy	Alford	Aberdeen	Scot. E.	8	1	10-7-30
189	Broadhaven	Milford Haven	Swansea	S. Wa.	13	1	22-7-30
190	Bovington Camp	Wareham	Bournemouth	S.W.	27	2	22-7-30

No.	Exchange.	Parent Exchange.	Engineering Section.	District.	No. of Working Lines. initially.	No. of Units fitted.	Date opened.
191	East Knoyle	Shaftesbury	Bournemouth	S.W.	12	1	28-7-30
192	Ochiltree	Cumnock	Glasgow S.	Scot. W.	13	1	29-7-30
193	Burn	Selby	York	N.E.	15	1	30-7-30
194	Hackleton	Northampton	Coventry	N. Mid.	11	1	30-7-30
195	Knock	Huntly	Aberdeen	Scot. E.	8	1	1-8-30
196	Stenton	East Linton	Edin. Outer	Scot. E.	11	1	5-8-30
197	Woodbury Salterton	Exeter	Exeter	S.W.	10	1	5-8-30
198	Doddington	Lincoln	Lincoln	N.E.	8	1	6-8-30
199	Johnston	Milford Haven	Swansea	S. Wa.	11	1	7-8-30
200	Gosforth	Whitehaven	Lancaster	N.W.	9	1	12-8-30
201	Moccas	Hereford	Hereford	S. Wa.	12	1	12-8-30
202	Eden	Banff	Aberdeen	Scot. E.	9	1	14-8-30
203	Etchingham	Hawkehurst	Tunbridge Wells	S.E.	25	2	18-8-30
204	Stapleford	Theydon Bois	London	London	15	1	18-8-30
205	Boreland	Locherbie	Glasgow S.	Scot. W.	10	1	19-8-30
206	Leconfield	Driffield	York	N.E.	14	1	19-8-30
207	Brading	Ryde	Southampton	S. Mid.	28	2	26-8-30
208	Auchterless	Turriff	Aberdeen	Scot. E.	8	1	26-8-30
209	Skipsea	Hornsea	York	N.E.	11	1	26-8-30
210	Hendre	Mold	Shrewsbury	N. Wa.	28	2	26-8-30
211	Lumphanan	Torphins	Aberdeen	Scot. E.	8	1	27-8-30
212	Ingrams Green	Midhurst	Guildford	S.Mid.	10	1	1-9-30
213	Copdock	Ipswich	Colchester	E.	37	2	1-9-30
214	King Edward	Turiff	Aberdeen	Scot. E.	8	1	2-9-30
215	Ash Bank	Hanley	Stoke-on-Trent	N. Wa.	10	1	2-9-30
216	Nether Stowey	Bridgwater	Taunton	S.W.	34	1	2-9-30
217	Ballygawley	Armagh	Belfast	N. Ire.	7	1	3-9-30
218	Elmsted	Ashford	Canterbury E.	S.E.	18	1	8-9-30
219	Ubbeston	Halesworth	Norwich	E.	9	1	8-9-30
220	Witton-le-Wear	Crook	Middlesboro'	N.	17	1	9-9-30
221	Whipsnade	Luton	St. Albans	E.	14	1	9-9-30
222	Spean Bridge	Fort William	Glasgow N.	Scot. W.	12	1	9-9-30
223	Cawood	Selby	York	N.E.	20	1	9-9-30
224	Swanton Morley	Dereham	Norwich	E.	9	1	12-9-30
225	Rawcliffe	Goole	Lincoln	N.E.	15	1	16-9-30
226	Drayton	Abingdon	Oxford	S.Mid.	9	1	16-9-30
227	Ashley	Market Drayton	Stoke-on-Trent	N. Wa.	11	1	23-9-30
228	Hallbankgate	Carlisle	Lancaster	N.W.	11	1	23-9-30
229	Dunnington	York	York	N.E.	14	1	23-9-30
230	Sandon	Stafford	Stoke-on-Trent	N. Wa.	13	2	24-9-30
231	Harwell	Abingdon	Oxford	S.M.	13	1	29-9-30
232	Sigglesthorne	Hornsea	York	N.E.	12	1	30-9-30
233	Roslin	Loanhead	Edin. Inner	Scot. E.	33	1	30-9-30
234	Ythanwells	Huntly	Aberdeen	Scot. E.	10	3	2-10-30
235	Snape	Saxmundham	Colchester	E.	11	1	6-10-30
236	Llangranog	New Quay	Swansea	S. Wa.	9	1	7-10-30
237	Hamstall Ridware	Rugeley	Stoke-on-Trent	N. Wa.	11	1	7-10-30
238	Hemingboro	Selby	York	N.E.	12	1	7-10-30
239	Nesscliffe	Shrewsbury	Shrewsbury	N. Wa.	13	1	7-10-30
240	Humberstone	Grimsby	Lincoln	N.E.	45	3	8-10-30
241	Samlesbury	Preston	Preston	N.W.	9	1	14-10-30
242	Durisdeer	Thornhill	Glasgow N.	Scot. W.	9	1	14-10-30
243	Shaugh Prior	Plymouth	Plymouth	S.W.	16	1	16-10-30
244	Arreton	Newport	Southampton	S.Mid.	23	2	21-10-30
245	Langtoft	Duffield	York	N.E.	11	1	21-10-30
246	Culgaith	Penrith	Lancaster	N.W.	12	1	21-10-30
247	Gt. Witchingham	Norwich	Norwich	E.	17	1	27-10-30
248	St. Mabyn	Bodmin	Plymouth	S.W.	9	1	28-10-30
249	Burton Pidsea	Holl Toll	York	N.E.	9	1	28-10-30
250	Tetford	Horncastle	Lincoln	N.E.	7	1	28-10-30
251	Selbourne	Alton	Guildford	S.Mid.	16	1	28-10-30
252	Seaforde	Downpatrick	Belfast	N. Ire.	9	1	
253	Hemswell	Gainsborough	Lincoln	N.E	13	1	29-10-30
254	Tarland	Aboyne	Aberdeen	Sc. E.	21	2	30-10-30
255	Sutton Courtenay	Abingdon	Oxford	S. Mid.	19	2	30-10-30
256	Earl Soham	Framlingham	Colchester	E.	22	2	3-11-30
257	Uplawmoor	Glasgow Central	Glasgow City	Sc. W.	36	2	4-11-30
258	Gobowen	Oswestry	Shrewsbury	N. Wa.	14	1	4-11-30
259	Stoke Ferry	Downham Market	Cambridge	E.	18	1	4-11-30
260	Frampton Mansell	Stroud	Gloucester	S. Wa.	16	2	4-11-30

No.	Exchange.	Parent Exchange.	Engineering Section.	District.	No. of Working sought initially.	No. of Units filled.	Date opened.
261	Crantock	Newquay	Plymouth	S.W.	9	2	4-11-30
262	Culloden Moor	Inverness	Inverness	Scot. E.	10	1	5-11-30
263	Walsham-le-Willows	Bury St. Edmunds	Cambridge	E.	10	1	5-11-30
264	Tredunnock	Caerleon	Newport	S. Wa.	9	1	6-11-30
265	Upper Largo	Leven	Dundee	Sc. E.	29	2	6-11-30
266	Kirkgunzeon	Dumfries	Glasgow S.	Sc. W.	11	1	7-11-30
267	Kirton	Ipswich	Colchester	E.	10	1	10-11-30
268	Adderley	Market Drayton	Stoke-on-Trent	N. Wa.	10	1	11-11-30
269	Bishops Teignton	Teignmouth	Exeter	S.W.	23	2	12-11-30
270	Blythburgh	Southwold	Norwich	E	9	1	17-11-30
271	Bishop Wilton	Pocklington	York	N.E.	12	1	18-11-30
272	Bow	Crediton	Exeter	S.W.	13	1	18-11-30
273	Holme Hale	Swaffham	Norwich	E.	11	1	18-11-30
274	Bradley	Stafford	Stoke	N. Wa.	10	1	18-11-30
275	Llanferres	Mold	Shrewsbury	N. Wa.	13	1	18-11-30
276	Wootton	Immingham	Lincoln	N.E.	11	1	19-11-30
277	Keresley	Coventry	Coventry	N.Mid.	24	2	20-11-30
278	Old Rayne	Insch	Aberdeen	Sc. E.	8	1	25-11-30
279	Loppington	Wem	Shrewsbury	N. Wa.	9	1	25-11-30
280	Drybridge	Irvine	Glasgow N.	Scot. W.	11	1	25-11-30
281	Dervock	Ballymoney	Belfast	N. Ire.	12	1	26-11-30
				Total	3865	324	

CHILDHOOD OF AUTOMATIC TELEPHONY.

FERDINAND M. STEGMANN,
Ministerial Counsellor of the Bavarian P.O. Administration, chief pioneer of Automatic Telephony in Europe.

OUR attention has been directed to an article in a supplement to a recent issue of the "Münchner Neuesten Nachrichten," by Ministerialrat Stegmann. Mr. Stegmann is very well known in European telephone circles as a brilliant engineer, possessing to an unusual degree the courage of his opinions, and as one of the pioneers of Automatic Telephony, the development of which in Europe owes a very great deal to his energy and courage. His description of the early days of automatic telephony, written in a delightfully humorous and interesting manner, cannot fail to be of interest to those of our readers who have followed developments in this particular branch of telephony.

Mr. Stegmann recalls that at the beginning of November, 1898, he was instructed by his Administration to proceed to London, in order to study the automatic switches which were being exhibited there. He says that, at this particular time, the Bavarian Administration was extremely interested in this matter. (The *fons et origo* of this interest are not difficult to guess!) This Administration is admitted to have been at that time one of the most progressive in Europe. As far back as 5th October, 1895, a switchboard had been installed at the Head Post Office in Munich for 6,000 subscribers, equipped with self-restoring indicators. This equipment, according to Mr. Stegmann, together with that installed at Zürich about the same time, but afterwards destroyed by fire, was the first of its kind in

Europe. On 29-30 July, 1899, a second Exchange was opened in Munich, equipped for 10,800 subscribers, with lamp signalling—the first time such an equipment was installed in Europe. Thanks to the excellence of this technical equipment and to a specially chosen and splendidly-trained staff, the telephone service in Munich was regarded at the end of the century, wihout exaggeration, " as a pattern to the whole world." " In spite of this," says Mr. Stegmann, " people cropped up who said that the whole complicated system of telephone traffic could be carried out solely by means of machines! This idea, at that time, was just as fantastic as is to-day the proposal to travel to the moon by means of a rocket."

After recounting the circumstances of his arrival in London on 17th November, 1898, during a thick yellow fog, Mr. Stegmann goes on to describe very amusingly his adventures in trying to find his way about the Metropolis in the dark. On the following morning, the German deputation succeeded in reaching Winchester House, 66 Old Broad Street. In a room at this address, they saw, with wonder, for the first time, the uncanny machines. The party was received by representatives of the Direct Telephone Exchange Syndicate, Messrs. Benno Seimert, Charles Hof, Consul-General Leubold and a young American Engineer called Dickinson, who demonstrated the apparatus. The principles of the so-called Strowger system were explained. Installations for 100, 200, 400, 1,000 and 10,000 subscribers were shown. Connections were established with extraordinary speed and precision. "In spite of the many defects which the system naturally possessed at that stage, it created a great impression in the minds of the visitors. Mr. Stegmann felt instinctively that this was the system of the future. After a few days of intensive study, they met three gentlemen belonging to the Automatic Telephone Exchange Company of Washington, who owned the Strowger patents. The trio appeared daily for a few hours, smoking their pipes, never uttering a word, and taking not the slightest notice of the visitors. Shortly before Mr. Stegmann and his companions left, they asked Dickinson whether they might take a switch with them to Munich. Dickinson answered that he could only agree to this with the permission of the Attorney (one of the three). The Attorney at first refused. It appeared that, shortly before, another gentleman (Dr. Feyerabend, now Secretary of State for the German Post Office) had taken away a switch to Germany, and the Attorney apparently was afraid that, if he did not take care, the whole equipment might gradually be transferred to the Fatherland! " Where do you come from? " asked the lawyer. " From Bavaria," replied Mr. Stegmann. " Bavaria; where is that? " Apparently he had never heard of Bavaria, and, in order to allay his fears, Mr. Stegmann, through Dickinson, told a little fib (only a little one!); he said that Bavaria belonged to Switzerland. The Attorney was then quite satisfied, and said " All right; you can take the switch " (which is carefully preserved in Munich as a memento of the occasion).

On his return to Munich, Mr. Stegmann reported fully on the results of his visit to London, and gave a lecture on 22nd March, 1899, to the Electrotechnischer Verein of Munich on " Automatic Telephone Exchanges." Even at that time he expressed his conviction that automatic exchanges, equipped for subscribers up to 1,000 could work satisfactorily and possessed great economic advantages over manual exchanges as regards both installation and operation. Shortly after this lecture, a young student called Friederich Merk came to see Mr. Stegmann at his house. The idea of telephone traffic carried out by automatic means had made such a deep impression on Merk that he decided forthwith to devote himself to this new aspect of engineering. He stated that during a sleepless night, he had worked out a plan whereby any subscriber in Berlin could be connected automatically with any subscriber in Paris, Rome, Petersburg, etc. Mr. Stegmann replied, " Steady! my dear Merk; we have a long way to go before reaching that stage." (Friederich Merk afterwards took a leading part as inventor and constructor in the development of automatic telephony in Europe, and was associated with all the leading firms, such as Loewe, Siemens & Halske, Mix & Genest, finally founding a company of his own).

Up to the year 1900, about 40 automatic telephone exchanges were in operation in the United States of America. The largest of these was in Augusta, Georgia, and was equipped for

600 subscribers. All these exchanges were in the hands of independent companies, *i.e.*, they had nothing to do with the huge and influential American Telephone & Telegraph Company, which decisively refused to have anything to do with the automatic system. Mr. Stegmann quotes an opinion given by one of the principal engineers of the latter company, dated October, 1898. This engineer stated—" The apparatus is generally regarded as interesting and ingenious, but entirely impracticable under working conditions." It appears that the development and dissemination of the system was considerably retarded owing to questionable financial deals by these independent companies. In Europe, the development of the automatic system, since its first demonstration in London, was followed by various Administrations with interest. The German Post Office in Berlin installed an experimental equipment for 400 subscribers in 1900, and, two years later, another for 1,500 subscribers. In Vienna, an experimental plant for 200 subscribers was put into service in the year 1904, but up to that time no automatic exchange existed for public service.

In America, at the beginning of the twentieth century, a fresh impetus was given to automatic telephony. The Strowger Company in Chicago had bought the Strowger patents and the manufacture of the apparatus was entrusted to the Automatic Electric Company of Chicago. Contradictory reports as to the success of the system reached Europe. Some of these stated that large automatic exchanges existed in Chicago, Los Angeles, Baltimore, Philadelphia and other towns. The opponents of the system contended that this was all " American humbug." For example, the most fantastic rumours were being promulgated with respect to the Chicago installation. According to these, there was a large automatic exchange for 100,000 subscribers and a widely-developed underground cable system was being constructed. In order to ascertain the real situation, Mr. Stegmann obtained leave to visit America, and went there in September, 1904. On the night of 17-18 October, on reaching Chicago from St. Louis by the " St. Louis Limited," a compatriot met him at the station and smilingly asked him whether he had not been robbed. It appeared that the same train, a few nights before, had been stopped in the open country and " total ausgeplündert." It was, of course, particularly interesting to Mr. Stegmann to make the personal acquaintance of the Chiefs of the Automatic Electric Company, which was then the chief agency for the development of the invention. He met the Engineer-in-Chief, Alexander Keith, and the two brothers Charles and John Erickson, one of whom, apparently, was regarded as a mechanical and the other as an electrical genius. Both brothers were originally farmers and had never seen a telephone exchange when they undertook their work in connection with the automatic machines. The alleged large automatic exchange in Chicago was found to be in actual existence and was working with an efficiency beyond all expectation. About 8,000 subscribers' lines were in operation. The cables for connecting the subscribers with the exchange were laid in tunnels about three metres broad and 2.3 metres high. These had been constructed with extraordinary speed by the Illinois Telephone Construction Company. They had not, however, been made for this particular purpose, but for the underground transport of goods from railway stations to business houses. In order to obtain a reliable opinion of the quality of the automatic service, Mr. Stegmann went into restaurants, shops, etc., and selected and spoke to various subscribers. The connections were made and severed with astonishing rapidity and reliability. He heard nothing but praise for the new system in every quarter. One day, when he asked a subscriber, " Have you really no difficulties? " he was informed—" Oh! yes, we have had difficulties, but only when the user had such a thick finger that he could not insert it in the holes of the dial! "

On his return home, Mr. Stegmann had a long conversation with the Chief Engineer of the New York Telephone Company—Mr. John Carty (now General Carty) who afterwards, as the Engineer-in-Chief and technical leader of the American Telephone & Telegraph Company, became so famous. In reply to the statements made by Mr. Stegmann, in which the latter indicated the tremendous impression which the automatic telephone had made upon him and stated his firm conviction that the general introduction of this system was only a question of time, Mr. Carty adopted a very non-committal attitude. Indeed, on the occasion of the second international meeting of Telegraph Engineers of State Administrations in Paris in the year 1910, Mr. Carty still refused to bless the full automatic system.

In his report to the Bavarian Minister of Communications, Mr. Stegmann stated—"To sum up, I should like to express my conviction that the substitution of the Strowger system or possibly another equally efficient system in place of manual exchanges is only a question of time. In this connection, I am still of the opinion, expressed in 1898, according to which an automatic system is the most suitable for very large installations."

This report merely caused head-shaking on the part of the authorities of the Administration. In spite of this scepticism, the report was the basis of a decision some years later to instal automatic working in Munich.

After the first demonstration of the Strowger system in London, Messrs. Ludwig Loewe & Co., of Berlin, obtained the patents for all European countries, except England and France, and entrusted the manufacture of the machines to the German Arms and Munition Factory in Carlsruhe. The telephone industry, however, for the time being, was antagonistic. Even far-seeing men, such as the Director of the Wernerwerke of Siemens & Halske, the unforgettable Professor Dr. Raps, expressed their scepticism in no uncertain manner. As often as he met Dr. Raps, whether in Berlin, Munich or Vienna, Mr. Stegmann never lost an opportunity of endeavouring to persuade him to undertake the introduction of automatic telephony. It was not until the year 1907, however, that a "Company for Automatic Telephony" was formed under the auspices of Siemens & Halske. This company took over the patents and manufacturing rights from the Loewe Company. The new company was afterwards incorporated in Siemens & Halske, which firm is now energetically perfecting the automatic system and adapting it to German conditions.

The first full automatic exchange for the public service in Germany was opened at Hildesheim on 10th July, 1908, and was equipped for 900 subscribers. The effective development of automatics in Germany, as in other countries on the Continent of Europe, began only when the Bavarian Ministry of Communications, under the direction of Herr von Frauendorfer, at the beginning of 1908, decided to convert to automatic working the whole of the local telephone system of Munich, with the installation of exchanges for 100,000 subscribers. "It must be confessed," says Mr. Stegmann, "that this decision was not taken without difficulty, and required a very high degree of courage in accepting responsibility." When the head of the technical department concerned, the jovial Ministerial-Director von Bredauer, affixed his signature, with a heavy heart, to the contract with Siemens & Halske, he laid his pen down with the words "That's that: either it goes, in which case all's well, or it does not go, and then I go!"

The first provincial exchange with preselectors, junction lines to other exchanges and central battery working, having a capacity of 5,000 lines, was opened on 4th November, 1909, in the Schwabing area. At first it was not satisfactory. A storm of indignation raged for months in the daily press. Indeed, this movement of antagonism went so far that a committee of dissatisfied subscribers, who had been accustomed to the excellent manual working, and composed also of some deputies of the Bavarian Landtag, insisted on the abolition of the automatic equipment. It was only slowly and gradually that the storm subsided. The members of the public, who originally were themselves responsible for difficulties, owing to false manipulation, and had of course to become accustomed to the new system of telephony, soon found the advantages of the automatic system and became enthusiastic supporters. The extension of automatic working was energetically pursued until the outbreak of war. During the second year of the war, *i.e.*, on 1st April, 1915, a further exchange at Neuhausen was installed, but, after this, a long interval occurred before further extensions took place. Mr. Stegmann gives details of the opening of exchanges in 1922 and 1923, in which latter year the whole of the Munich-Pasing local system was converted to automatic working. In this system, which extends to the suburbs, there are now working eight full automatic exchanges and 13 semi-automatic exchanges, with about 43,500 lines and 77,000 subscribers' stations.

Mr. Stegmann claims that Munich must be

famed for all time for being the first large city on the European Continent to be equipped with full automatic telephone exchanges. It was in Munich that the first proof was given that large automatic telephone exchanges are superior to manual exchanges from operating, technical and economic points of view.

In America, up to May, 1907, the Automatic Electric Company had built 73 automatic exchanges of various sizes, all for the so-called "independent companies." In the home of automatic telephony, progress was hindered because of the fact that the mighty Bell concern, strangely enough, firmly maintained its antagonistic attitude. It was only after the war, *i.e.*, from the year 1921, that the American Telephone & Telegraph Company began to instal the automatic (dial) system in the large towns. The Strowger (step-by-step) system is employed in places with only one exchange and in towns of medium size, where there are several exchanges.

At the beginning of 1930, there were in operation 194 such Exchanges, with 1.6 million lines. For the larger cities, such as New York, Chicago, San Francisco, etc., a system of the Western Electric Company called the "Panel System" has been developed. At the beginning of 1930, 128 Exchanges, also with 1.6 million lines, equipped according to this very complicated system, were in service.

Mr. Stegmann visited America (Chicago) again in the autumn of 1926 and found that in the meantime, the Automatic Electric Company had expanded enormously. (This Company supplies at the present time the Strowger apparatus for the Bell Companies). Strowger, Dickinson and Keith were all dead. Only the two Ericksons remained. They were found to be still employed with the Automatic Electric Company, but occupied very subordinate positions—"inventors' fate!"

Mr. Stegmann concludes his very interesting article as follows:—

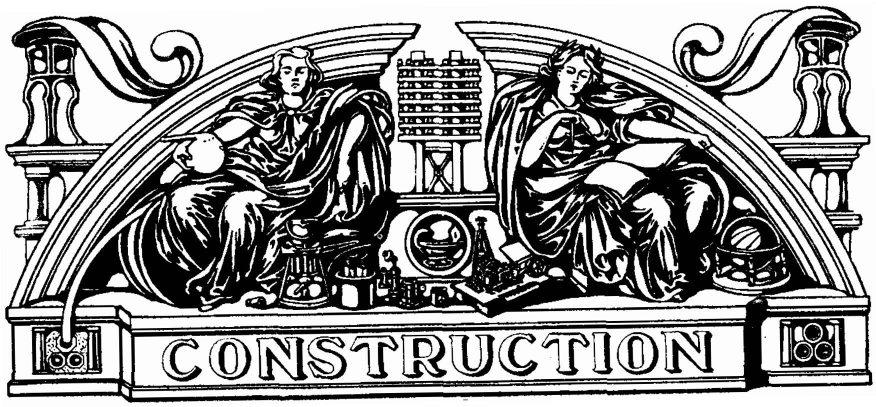
"In large cities, manual exchanges are things of the past. Wherever, in such communities, manual exchanges have to be replaced or additional exchanges installed, the automatic system will hold the field. This system, however, is being more and more developed in smaller towns and villages and, in the not distant future, whole countries will be converted to automatic working.

"Even in the extension of automatic telephones to country places, Bavaria has been a pioneer." (Mr. Stegmann gives details of the development since 1922 in this respect, and states that, already in Bavaria, serious consideration is being given to the inauguration and development of long-distance automatic traffic).

"No one finds it astonishing to-day that he is able, by his own efforts, to establish and sever telephone connections with other subscribers. Neither, however, do people consider what a tremendous effort of intelligence, pertinacity and courage in accepting responsibility was necessary in order to perfect this engineering marvel. It is perhaps not out of place to remind the younger generation that there were other times in which the transmission of human speech was by no means so perfect as it is to-day.

"The development of telephony during the last 30 years borders on the fabulous. The fact that all the 30 million telephone stations throughout the world can, by means of the transatlantic services, establish satisfactory communication with one another at any time, and that from any telephone station it is now possible to communicate with large passenger steamers on the ocean or with aircraft flying over foreign continents, might give reason for the belief that there is nothing more to be done or to be invented. It will probably be found, however, if the signs of the times are not misleading, that the development during the next 30 years as regards the number of telephone stations and the ease and speed with which these can be connected together, will be such that the achievements of the past will be completely eclipsed. Everything is becoming faster and faster. Whether, however, people will be happier by reason of this than they were in the good old times of mail coaches is another question."

B.J.S.



THE ANGLO-BELGIAN (1930) SUB-MARINE TELEPHONE CABLE.

M. E. TUFNAIL and J. F. DOUST.

SYNOPSIS.—This article describes the construction and briefly the laying operations of the Anglo-Belgian (1930) Submarine Telephone Cable. The Transmission characteristics of the pair, phantom and super-phantom circuits of the completed cable from Canterbury to La Panne are given.

Another telephone link between England and the Continent was completed when the last joint in the Anglo-Belgian (1930) Cable was made at Dumpton Gap on 7th September, 1930. This cable is the sixth paper-core submarine telephone cable and provides twenty-four channels of communications for Anglo - European international telephony. The total number of speech channels now available in such cables is 120, a large increase since the first paper-core cable was laid, viz., the Anglo-Dutch (1924), which provided 12 circuits.

The Anglo-Belgian (1930) Cable was manufactured by Messrs. Siemens Bros. & Co., Ltd., Woolwich, London, who were responsible for the laying of the cable between Canterbury Repeater Station (England) and La Panne Repeater Station (Belgium).

The cable consists of approximately 16 nautical miles of land cable between Canterbury and Dumpton Gap and 50½ nautical miles of submarine cable from Dumpton Gap to La Panne. The land and submarine cables are identical in electrical characteristics, but the land cable is not armoured and has only one lead alloy sheath. The cable contains 28 conductors of solid copper, .08 inch in diameter; each conductor is closely wound with one layer of iron wire, .008 inch in diameter, which increases the inductance of the pair circuits to approximately 12½ milli-henries per nautical mile.

Each conductor is insulated with four helical wrappings of paper, the outer paper being coloured for identification purposes. The insulated conductors are arranged in seven quads, formed by stranding four insulated conductors on a paper centre in the colour order: Red, Blue, White with a black line, and White. The diagonally opposite wires, *i.e.*, Red and White-black, Blue and White form the pair circuits. Each quad is lapped with a coloured paper tape which provides identification. The cable is formed by stranding seven quads, the colour order being: centre, Green; outer layer Red_1, $Blue_1$, $White_1$, Red_2, $Blue_2$, and $White_2$. The interstices are filled with packed paper wormings to provide a compact cable, two worming papers being coloured orange to distinguish the Red_1 quad.

The protection of the cable consists of two continuous, seamless sheaths of a Lead-Antimony-Cadmium Alloy (Pb 99.25%, Cd .25%, Sb. .5%) which are served with jute to form a bedding for twenty-five No. 4 S.W.G. and three No. 12 S.W.G. stranded armouring wires. The finished cable weighs $26\frac{1}{4}$ tons per nautical mile and is 2.58 inches in diameter. A cross-section of the cable is shown in Fig. 1.

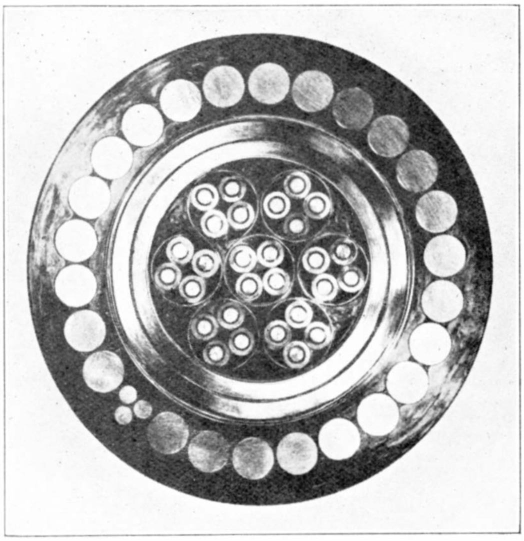


FIG. 1.—CROSS-SECTION, ANGLO-BELGIAN CABLE (1930). OVERALL APPROX. 2.6″.

It will be seen that, mechanically, the cable only differs from the 1926 cable in respect of the alloy sheathing, the latter providing greater mechanical protection than pure lead. A different method of jointing the land cable has, however, been employed to ensure that the quads retain their relative positions throughout as in the sea cable. This restricted method of jointing the quads was necessary for the satisfactory working of circuits which are superimposed on the phantom circuits of the six outer quads, See Fig. 2. One such circuit is formed on two diagonally opposite quads, such as Red_1 or Red_2 (called the " A " circuit); a second is formed on the two remaining pairs of quads, one pair of adjacent quads forming each element of the circuit (called the " B " circuit; the third super-phantom (called the " C " circuit) is superimposed on these two circuits. It will be seen that the " C " circuit is not symmetrical in regard to its two elements and this prevents the further super-position of an earth super-phantom circuit.

There are three ways of choosing the " A " super-phantom circuit (*i.e.*, using the Red, Blue or White quads), and the choice of this circuit necessarily decides the formation of the " B " and " C " circuits. Any " B " or " C " circuit will be described herein by the colour of the quads forming the associated " A " circuit. Thus, White " C " will be the circuit formed with quads $White_1$ and $White_2$ as the corresponding " A " circuit.

It is possible to super-impose circuits on the phantoms in other ways, but these will not permit the working of more than two circuits owing to capacity unbalance considerations.

With regard to the side circuits of the cable, in addition to the usual requirements of cross-talk and attenuation limitations, details of which are given later, the circuits were required to have the same characteristic impedance, at frequencies from 300 to 2000 p.p.s., as the circuits in the 1926 cable. This feature provides for the easy interchange of terminal apparatus and also reduces the stock of spare cable held in readiness for repair purposes. The limit guaranteed by the manufacturers for this impedance agreement

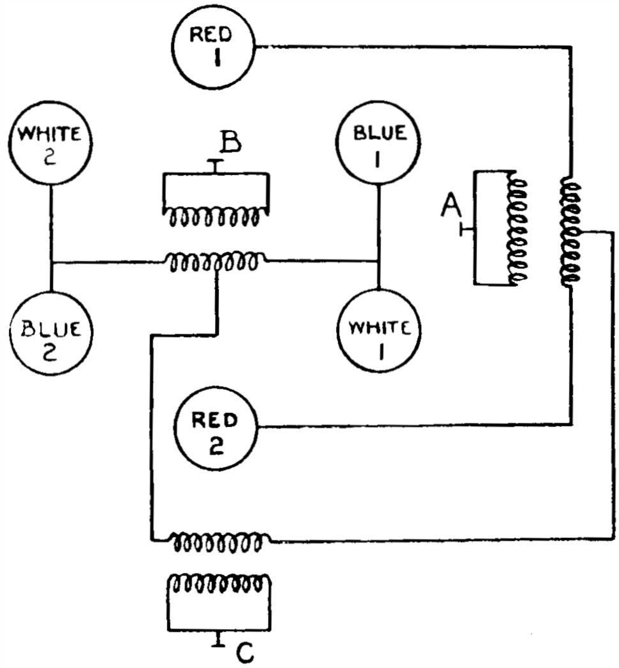


FIG. 2.—METHOD OF FORMING A, B AND C SUPER-PHANTOM CIRCUITS.

was $\pm 7\frac{1}{2}\%$ between the mean of the characteristics of all side circuits in each cable and this guarantee has been met.

The laying of the land cable followed the usual lines, the balanced sections, approximately four nautical miles in length, were joined with selected joints to form the total of 16 nautical miles of cable from Canterbury to the coast. Tests on this 16 nautical miles showed that it complied with the requirements for the completed cable.

The submarine cable was laid in two portions, one of 16 nautical miles from La Panne on August 26th and one of 34 nautical miles from Dumpton Gap on September 2nd. Fig. 3

FIG. 3.—" KATHERINE " READY TO LAND SHORE END AT DUMPTON GAP.

shows the drifter " Katherine " laying the shore end at Dumpton Gap. A sea joint between the two lengths was then made on board the cable ship " Faraday." This joint was selected for reduction of near and distant end cross-talk by switching tests.

After the completion of the preliminary tests on the submarine cable, which showed the laying to have been satisfactorily completed without damage to the cable, the final joint was made at Dumpton Gap and, in this case also, near and distant end cross-talk tests were made to determine the method of connecting the wires of each quad. The length of the cable after completion was 66.52 nautical miles.

A description of the measured electrical characteristics of the circuits of the cable follows. Section I. deals with the pair and phantom circuits and Section II. with the super-phantom circuits.

SECTION I.

Direct Current Tests.

Conductor Resistance: Mean of 28 wires = 9.98 ohms per naut. Insulation Resistance, measured with 130 volts, between each quad and all other quads earthed, after one minute electrification. Maximum reading 31,000 megohms per naut. Minimum reading 26,500 megohms per naut.

Alternating Current Tests.

1. *Cross-talk.*—Table No. 1 gives the speech cross-talk between the side circuits and the phantom circuit of each quad. The figures represent the power transference ratio between the disturbed and the disturbing circuits, expressed in decibels. The maximum values guaranteed by the contractor are also given in the table.

2. *Transmission Efficiency.*—The attenuation frequency characteristics of the side and phantom circuits are given in Fig. 4, from $f = 300$ to $f = 7000$ p.p.s. These characteristics were determined by calculation from the open and closed impedances of the circuits of a ten naut.

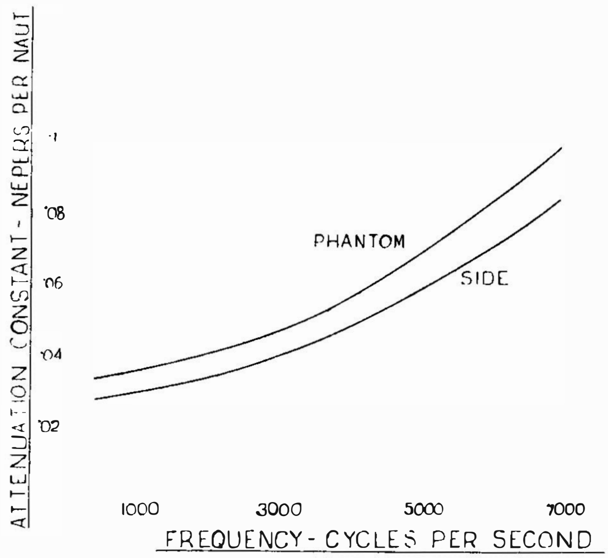


FIG. 4.—ATTENUATION FREQUENCY CHARACTERISTICS OF SIDE AND PHANTOM CIRCUITS FROM 400 TO 7,000 CYCLES PER SECOND.

length of cable. The tests at frequencies above 4000 p.p.s. were made with an A.C. Bridge by heterodyning the receiver current with a second oscillator and balancing out the beat note so produced by adjustment of the variable bridge arm. The values measured on the completed cable over the frequency range from $f = 300$ to

$f = 3000$ p.p.s. are in close agreement with those given in Fig. **4** and are shown in Fig. **5**, which also gives the specified maximum values for the side circuits.

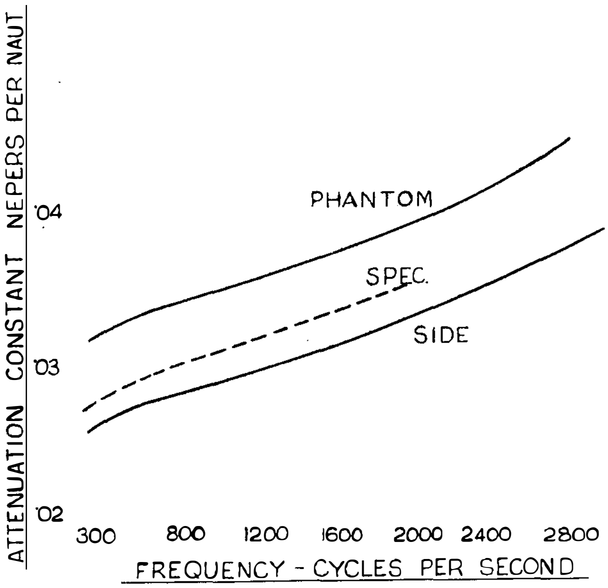


FIG. **5**.—ATTENUATION FREQUENCY CHARACTERISTICS OVER AUDIO RANGE.

The amplitude distortion of the cable from $f = 300$ to $f = 3000$ p.p.s. is .86 and .93 nepers for the side and phantom circuits respectively. The wave-length constants of the side and phantom circuits were found to be directly proportional to the frequency and correspond to

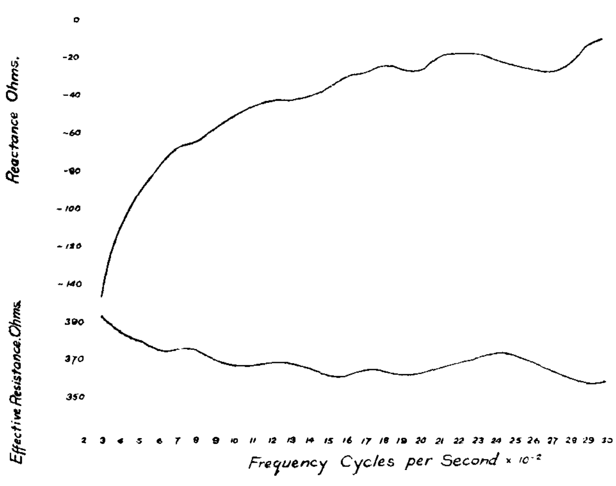


FIG. **6**.—IMPEDANCE FREQUENCY CHARACTERISTICS OF SIDE CIRCUITS FROM 300 TO 3,000.

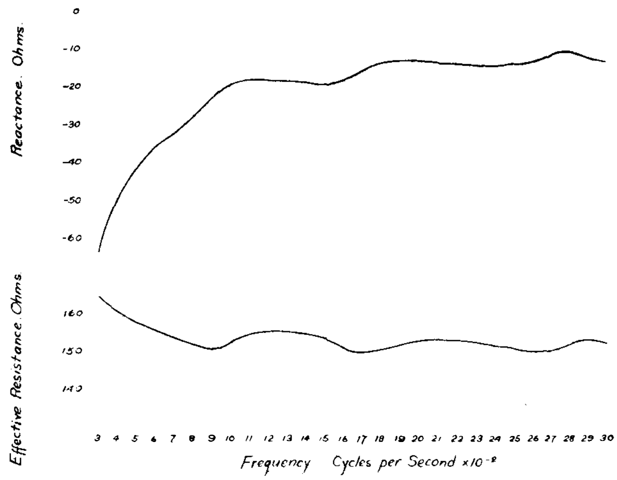


FIG. **7**.—IMPEDANCE FREQUENCY CHARACTERISTICS OF PHONTOM. TESTED AT LA PANNE.

constant velocities of 30,000 and 25,000 nauts per second respectively.

Table No. 2 shows the mean primary constants of the circuits per nautical mile measured at 800 p.p.s. in the Contractors' works.

3. *Characteristic Impedance and Uniformity of Electrical Constants.*—Fig. **6** shows the variation of characteristic impedance with frequency in the case of a side circuit tested at Canterbury over the usual audio-frequency range. The curve is similar in shape to the curves of other pairs tested at Canterbury and also at La Panne. The maximum deviation of the impedance from the mean curve was found to be $3\frac{1}{2}\%$, in the case of some circuits when tested at La Panne. This deviation is due to the difference of impedance between the two portions of the sea cable laid from the Belgian

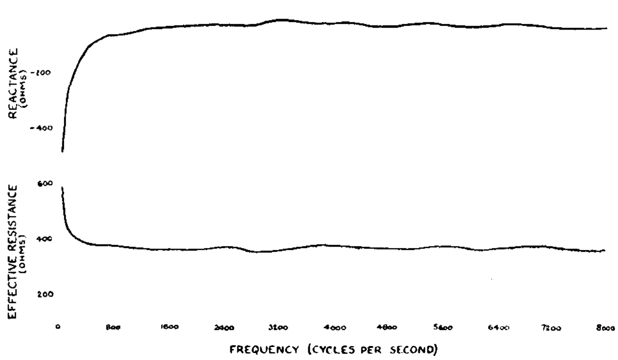


FIG. **8**.—IMPEDANCE FREQUENCY CHARACTERISTICS OF SIDE CIRCUIT FROM 60 TO 8,000.

and English coasts. The figure is, however, within the guaranteed maximum of 5%.

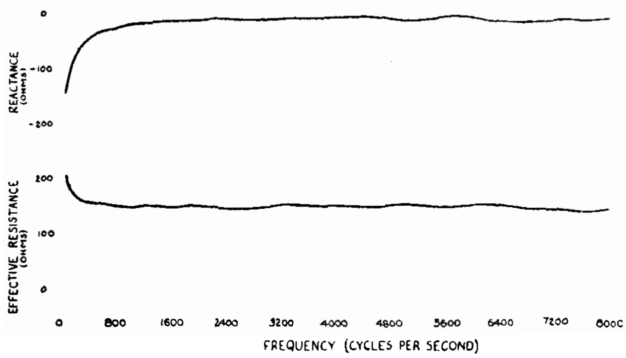


FIG. **9**.—IMPEDANCE FREQUENCY CHARACTERISTICS OF PHANTOM FROM 100 TO 8,000.

Fig. **7** shows the same characteristic for a phantom circuit tested at La Panne.

The characteristic impedance variations of side and phantom circuits over a larger frequency range (from $f = 60$ p.p.s. to $f = 8000$ p.p.s.) are shown in Figs. **8** and **9** respectively. These curves indicate that from the point of view of impedance deviation little difficulty would be experienced in the operation of repeaters between these limits of frequency, and that the cable may therefore be considered satisfactory in this respect for the transmission of music.

SECTION II.

Super-phantom Circuits.—The super-phantom circuits were not included in the specification of the cable and primary consideration was therefore given during the construction of the cable to the side and phantom circuits. Tests carried out at Messrs. Siemens Bros. Works were made with the object of determining whether satisfactory super-phantom circuits could be provided without degrading the specified circuits in any respect. The tests were carried out on the completed ten-naut. armoured lengths, in order to avoid delay to the completion of the cable.

At four joints the arrangement of the quads was determined by switching tests made on the

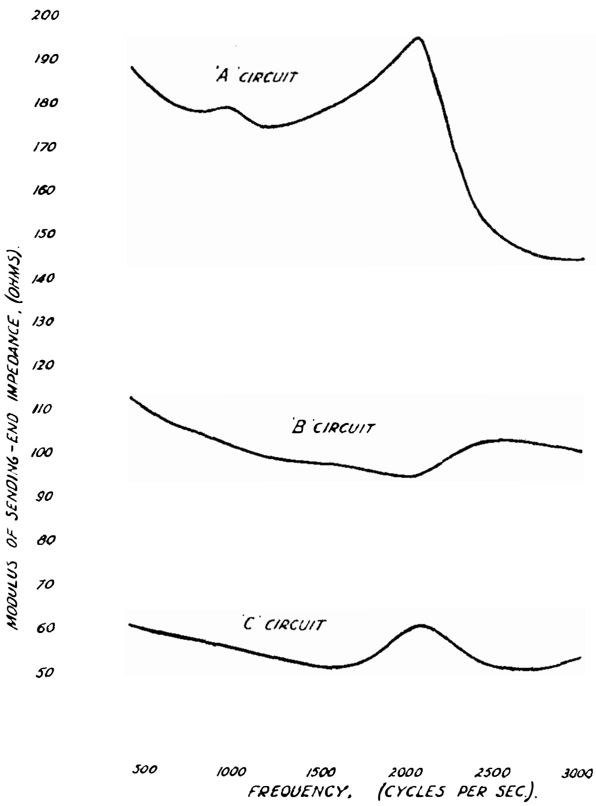


FIG. **10**.—IMPEDANCE AND FREQUENCY CHARACTERISTICS OF SUPER-PHANTOMS. 10 NAUT. LENGTH.

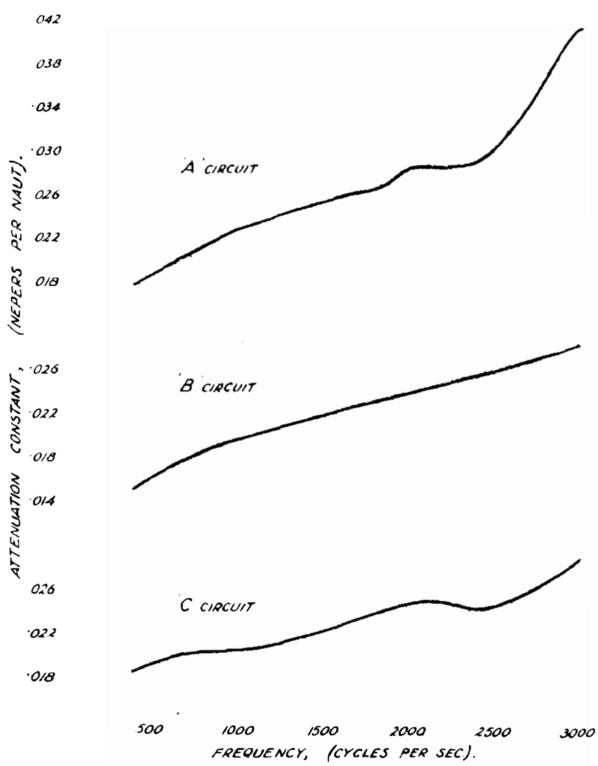


FIG. **11**.—ATTENUATION CONSTANT AND FREQUENCY CHARACTERISTICS OF SUPER-PHANTOMS. 10 NAUT. LENGTHS.

super-phantoms, the two joints nearest the ends being switched for reduction of near-end cross-talk and the two joints nearer the centre being switched for reduction of distant-end cross-talk. Those joints switched for near-end cross-talk were dealt with first and the super-phantoms which would be used, if possible, were chosen at the English and Belgian ends of the cable. The joints switched for distant-end cross-talk were tested simultaneously, the middle portion (14 nauts. in length) of the cable being, in effect, rotated between the end portions (one of 20 nauts. and one of 16 nauts.) until the six possible arrangements of quads at the joints had been tested for distant-end cross-talk. Of the latter two joints, only one was made in the contractors works, the other was the joint made at sea on September 2nd. In this case the arrangement of quads giving the best super-phantom circuits was scheduled from the results of the tests in works described above, but the method of jointing the wires of the quads was determined by switching tests during the jointing operations.

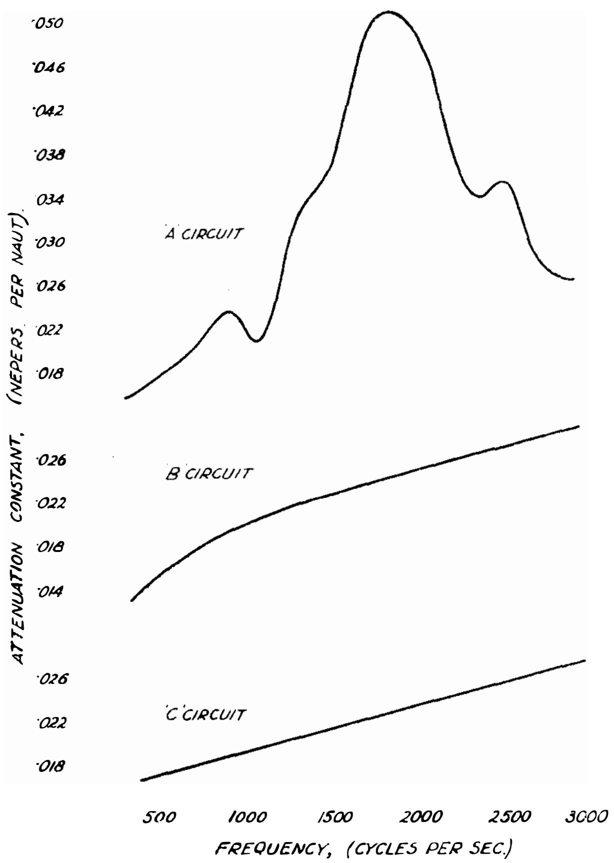


FIG. 12.—IMPEDANCE FREQUENCY CHARACTERISTICS OF SUPER-PHANTOMS. COMPLETED CABLE.

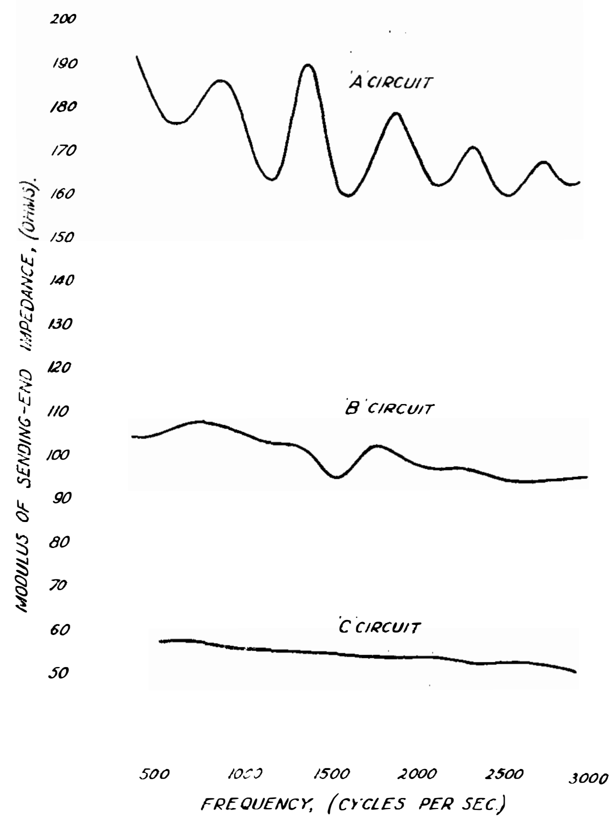


FIG. 13.—ATTENUATION FREQUENCY CHARACTERISTICS OF SUPER-PHANTOMS. COMPLETED CABLE. Measured with Speech.

The tests made on the super-phantom circuits were utilised to determine only the arrangements of the *quads* at the joints, the method of jointing the *wires* of the quads being decided by switching tests for reduction of cross-talk between side circuits and between side and phantom circuits. Had the cross-talk between circuits within the quads proved unsatisfactory, then, although the efficiency of the super-phantom circuits in regard to cross-talk would have been impaired, the arrangement of the quads would have been changed.

Considerable improvement of the super-phantom circuits was effected by means of the above tests, and there is little doubt that a further reduction in cross-talk could have been obtained had it been possible to make similar tests earlier in the process of manufacture of the cable.

Figs. **10** and **11** show the variation of characteristic impedance and attenuation with frequency for the super-phantom circuits of a ten-naut-armoured length for frequencies below $f = 3000$ p.p.s. A marked irregularity occurs in the impedance curve of the A circuit. This is probably due to transference of energy (cross-talk) to other super-phantom circuits not directly in use.

Figs. **12** and **13** are similar characteristics for the completed cable over the same frequency range, calculated from open and closed impedance measurements. The impedance curve of the A circuit shows a comparatively regular variation and the amplitude distortion for the same circuit (2.56 nepers between $f = 300$ and $f = 1900$ p.p.s.) as indicated by the attenuation curve is considerable.

The difficulty of constructing an efficient balance for a two-wire repeater would render the A circuit rather unsatisfactory for normal traffic purposes, but it could be used as a service line between repeater stations. The impedance and attenuation characteristics of the B and C circuits are more regular and they could be used for commercial purposes when required.

The cross-talk results for the super-phantom circuits are given in Table No. 3. The table shows that it is possible to provide super-phantom circuits in a seven quad submarine cable.

TABLE 1.

NEAR END AND DISTANT END CROSSTALK BETWEEN SIDE CIRCUITS AND BETWEEN SIDE AND PHANTOM CIRCUITS.

Measured with Speed.

All values in decibels.

QUAD	AB/Phantom			CD/Phantom			AB/CD		
	Tested at Canterbury	Tested at La Panne		Tested at Canterbury	Tested at La Panne		Tested at Canterbury	Tested at La Panne	
	N.E.	N.E.	D.E.	N.E.	N.E.	D.E.	N.E.	N.E.	D.E.
GREEN	76	72	70	71	72	78	85	86	100
RED_1	72	68	66	74	67	70	90	86	98
$BLUE_1$	72	67	74	71	70	66	85	82	94
$WHITE_1$	74	70	68	73	70	62	84	82	90
RED_2	75	70	68	67	67	64	89	82	104
$BLUE_2$	71	67	74	72	70	66	87	82	106
$WHITE_2$	72	71	72	72	70	64	90	82	90
SPEC^n	61			61			70		

TABLE 2.

MEAN PRIMARY CONSTANTS PER NAUTICAL MILE OF SIDE AND PHANTOM CIRCUITS AT $f = 800$ *p.p.s.*

Circuit.	R Ohms.	L Milli-henries	C Micro-farads.
Side	10.90	12.78	0.092
Phantom	5.34	6.04	0.268

TABLE 3.

NEAR-END AND DISTANT-END CROSSTALK BETWEEN SUPERPHANTOM CIRCUITS AND BETWEEN SUPERPHANTOM AND PHANTOM CIRCUITS.

Measured with Reed Hummer Supply.
All values in decibels.

Disturb.	Listen.	Cross-talk (*db*). At Canterbury. Near End	At La Panne. End. Near	At La Panne. Distant End
C	A	63	55	61
C	B	62	59	68
A	B	63	60	72
A	Red$_1$ (+)	60	57	64
	Red$_2$ (+)	66	66	64
B	Blue$_1$ (+)	65	60	70
	White$_1$ (+)	67	65	65
	Blue$_2$ (+)	61	70	70
	White$_2$ (+)	68	63	64

[A description of the Anglo-French (1930) cable laid about the same time as the Anglo-Belgian cable will appear in the April issue.—Eds. P.O.E.E.J.]

OUTLINE NOTES ON TELEPHONE TRANSMISSION THEORY.

W. T. PALMER, B.Sc. (Eng.), Wh. Ex., A.M.I.E.E.

SECTIONS 2, 3 AND 4.

SECTION 2.

Simple Classical Theory of Electric Wave Propagation along two Parallel Conductors.

The theoretical case of two parallel conductors is the nearest approach to the practical case of an ordinary transmission line. It is important to bear in mind that many assumptions are made in the derivation of the following transmission equations, although, generally speaking, mathematical analysis with these assumptions gives results which enable the efficiency of telephonic circuits to be predicted and improved in practice. The principal assumptions made are as follows:—

(*a*) Each conductor is geometrically the same and uniform.

(*b*) Each conductor is electrically the same and uniform.

(*c*) The voltage and current at the sending end of the line are sine functions of time and continue as sine functions at all points along the line.

N.B.—A complex speech wave may be resolved into a number of sine functions by Fourier's series, or some other method, and hence the propagation of a speech wave can be studied by first treating the case of the propagation of the constituent sine waves.

(*d*) The electrical primary constants do not change with frequency and current change.

(*e*) The electrical energy is transmitted by the surrounding medium and the conductors act as guides for the wave.

(*f*) The rate of propagation of the flux in the magnetic flux plane is negligible.

(*g*) The rate of propagation of the electrostatic strain is negligible.

(*h*) The transient effects produced by connecting and disconnecting apparatus are negligible and the steady-state phenomena only considered.

(*i*) The line is supposed to be divisible into elements each containing a series-impedance branch and a shunt-admittance branch. See Fig. **4** (*a*) and (*b*).

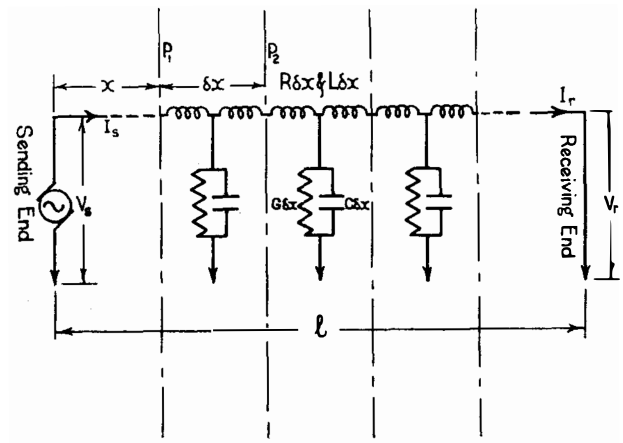


FIG. **4** (*a*).—SINGLE WIRE VALUES OF PRIMARY CONSTANTS. R, L, G AND C PER UNIT LENGTH.

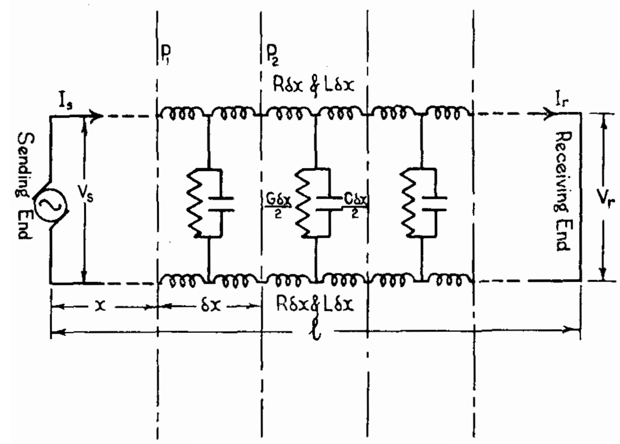


FIG. **4** (*b*).—LOOP VALUES OF PRIMARY CONSTANTS. 2R, 2L, $\frac{G}{2}$ AND $\frac{C}{2}$ PER UNIT LENGTH.

Recent developments in picture-telegraphy, voice-frequency and sub-audio telegraphy—employing conductors hitherto exclusively used for speech transmission—indicate that the assumption (*h*) cannot be neglected with impunity.

I.—*To express the Voltage and Current existing at any Point, Distant (x) from the Sending End, in Terms of the Sending End Voltage and Current respectively.*

Consider Fig. 4 and the following symbols:—

Let x denote the axis of propagation

Single Wire Values of Primary Electrical Constants.

- R = resistance of unit length of circuit in ohms
- G = leakance of unit length of circuit in mhos
- C = capacity of unit length of circuit in farads
- L = inductance of unit length of circuit in henries

I = maximum value of current at distance x from the sending end,

V = maximum value of voltage at distance x from the sending end,

v = instantaneous value of voltage and $v = \mathrm{V} \sin \omega t$

and i = instantaneous value of current and $i = \mathrm{I} \sin (\omega t \pm \theta)$

where ω = pulsatance of supply = $2\pi \times$ frequency

and θ = time phase angle between voltage and current at distance x from the sending end.

Hence considering the element δx and using instantaneous values of v and i:—

Let v be the voltage at the point P_1,
and $v + \delta v$ be the voltage at the point P_2,
Let i be the current in the line at P_1,
and $i + \delta i$ be the current in the line at P_2.

Then $$-\delta v = \mathrm{R}.\delta x.i + \mathrm{L}.\delta x.\frac{di}{dt}$$

and $$-\delta i = \mathrm{G}.\delta x.v + \mathrm{C}.\delta x.\frac{dv}{dt}$$

$$\therefore \quad -\frac{dv}{dx} = \mathrm{R}.i + \mathrm{L}.\frac{di}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

and $$-\frac{di}{dx} = \mathrm{G}.v + \mathrm{C}\frac{dv}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Now using maximum values for voltage and current equations (1) and (2) become—

$$-\frac{d\mathrm{V}}{dx} = \mathrm{RI} + j\omega\mathrm{LI} = (\mathrm{R} + j\omega\mathrm{L})\mathrm{I} = z\mathrm{I} \quad \ldots\ldots(3)$$

and $$-\frac{d\mathrm{I}}{dx} = \mathrm{GV} + j\omega\mathrm{CV} = (\mathrm{G} + j\omega\mathrm{C})\mathrm{V} = y\mathrm{V} \quad \ldots\ldots(4)$$

where $z = \mathrm{R} + j\omega\mathrm{L}$ and $y = \mathrm{G} + j\omega\mathrm{C}$

Differentiating with respect to x, equations (3) and (4) may be written:—

$$-\frac{d^2\mathrm{V}}{dx^2} = z\frac{d\mathrm{I}}{dx} \text{ and } -\frac{d^2\mathrm{I}}{dx^2} = y\frac{d\mathrm{V}}{dx}$$

respectively.

$$\therefore \frac{d^2\mathrm{V}}{dx^2} = zy\mathrm{V} = \gamma^2\mathrm{V} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

and $$\frac{d^2\mathrm{I}}{dx^2} = \gamma^2\mathrm{I} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

where γ is a constant $= \sqrt{zy} = \sqrt{(\mathrm{R} + j\omega\mathrm{L})(\mathrm{G} + j\omega\mathrm{C})}$, is dependent for its value on the primary constants of the circuit, and is known as the *propagation constant* of the circuit. [Since γ is a complex quantity it is of the form $\beta + j\alpha$ and the real part, β, is called the attenuation constant of the circuit and the imaginary part, α, is called the wave-length constant. The reasons for these terms will be evident from the remaining considerations and from Section 3.]

Taking the differential equation (5), viz.,

$$\frac{d^2\mathrm{V}}{dx^2} = \gamma^2\mathrm{V}$$

the solution is

$$\mathrm{V} = \mathrm{A}e^{\gamma x} + \mathrm{B}e^{-\gamma x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

where A and B are constants which can be calculated from boundary conditions. This solution can easily be verified by differentiating equation (7) twice, which will give $\gamma^2\mathrm{V}$, *i.e.*, equation (5).

Now differentiating (7) with respect to x and substituting in it from equation (3) we have

$$\mathrm{I} = \frac{\gamma(\mathrm{A}e^{\gamma x} - \mathrm{B}e^{-\gamma x})}{-(\mathrm{R} + j\omega\mathrm{L})}$$

and since $\gamma = \sqrt{(\mathrm{R} + j\omega\mathrm{L})(\mathrm{G} + j\omega\mathrm{C})}$, if we write

$$\mathrm{Z}_0 = \sqrt{\frac{\mathrm{R} + j\omega\mathrm{L}}{\mathrm{G} + j\omega\mathrm{C}}}$$

we get

$$\mathrm{I} = -\left(\frac{\mathrm{A}e^{\gamma x} - \mathrm{B}e^{-\gamma x}}{\mathrm{Z}_0}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

and Z_0, a vector quantity, dependent on the primary constants of the circuit, is called the *characteristic impedance* of the line and, as will be clearly seen from Section 3, is the sending-end impedance which would be offered by the circuit if it were extended to an infinite length.

[*Loop Values per Unit Length.*

It will be noticed that equations (7) and (8) hold for the case where loop values for the primary constants are used, because in this case :

$$\gamma = \sqrt{\left(2R + 2j\omega L\right)\left(\frac{G}{2} + \frac{j\omega C}{2}\right)}$$
$$= \sqrt{(R + j\omega L)(G + j\omega C)}$$

which is the same as for the case of single wire constants. Hence the general transmission equations derived later can be used for calculation using either single wire or loop values per unit length.]

To find Values for A and B, of equations (7) and (8), in terms of V_s, the voltage at the sending end and I_s, the current in the line at the sending end:—

Put $x = 0$ in (7) so that $V_s = A + B$

and $x = 0$ in (8) so that $I_s Z_0 = -A + B$

$$\therefore \quad A = \frac{V_s - I_s Z_0}{2}, \text{ and } B = \frac{V_s + I_s Z_0}{2}$$

Now (7) and (8) can be written—

$$V = \left(\frac{V_s + I_s Z_0}{2}\right)e^{-\gamma x} + \left(\frac{V_s - I_s Z_0}{2}\right)e^{\gamma x} \text{..(9)}$$

$$\text{and} \quad I = \left(\frac{\frac{V_s}{Z_0} + I_s}{2}\right)e^{-\gamma x} - \left(\frac{\frac{V_s}{Z_0} - I_s}{2}\right)e^{\gamma x} \text{......(10)}$$

and these equations can be thrown into a more useful form (See Section 1, pp. (*d*)) and written :

$$V = V_s \cosh \gamma x - I_s Z_0 \sinh \gamma x \text{ ....(11)}$$

$$I = I_s \cosh \gamma x - \frac{V_s}{Z_0} \sinh \gamma x \text{ ....(12)}$$

Note 1.—These equations (11) and (12) are most important fundamental transmission equations and, though they represent maximum values of potential (V) and current (I) at a distance x from the sending end, it must be borne in mind that these quantities are *vector quantities*.

Note 2.—It will be seen from these equations that the characteristics of the circuit appear only through two parameters, viz., the propagation constant γ, and the characteristic impedance Z_0. These two quantities are in practice usually readily measurable for any given circuit and the methods of measurements, with the necessary precautions, etc., will be dealt with in a later Section.

Note 3.—The student must memorize equations (11) and (12) because numerous important relations are deduced from them. The method of derivation of these equations should be followed closely and a little study will enable the results to be obtained in a much shorter space than that just occupied.

II.—*The General Transmission Equations in Terms of the Receiving End Voltage and Current respectively.*

Let V_r = receiving-end voltage
I_r = receiving-end current
l = total length of circuit, so that
$(l - x)$ = distance of point considered from the receiving-end.

Then it can be shown, after the manner already adopted, that equations (11) and (12) become :—

$$V = V_r \cosh \gamma(l-x) + I_r Z_0 \sinh \gamma(l-x) \text{ ....(13)}$$

$$I = I_r \cosh \gamma(l-x) + \frac{V_r}{Z_0} \sinh \gamma(l-x) \text{..........(14)}$$

III.—*To express the Attenuation Constant (β), and Wave-length Constant (α), in Terms of the Primary Electrical Constants, R, L, G and C.*

The propagation constant, γ, is a vector quantity and may be written :—

$\beta + j\alpha = \sqrt{(R + j\omega L)(G + j\omega C)}$...(See eqn. 6)

Squaring both sides we get

$$\beta^2 + 2j\beta\alpha - \alpha^2 = GR - \omega^2 LC + j(\omega LG + \omega CR)$$

Equating real and imaginary parts this gives:

$$\beta^2 - \alpha^2 = GR - \omega^2 LC \text{ ....(15)}$$

$$2\alpha\beta = \omega(LG + CR) \text{ ....(16)}$$

But since $(\beta^2 - \alpha^2)^2 = (\beta^2 + \alpha^2)^2 - (2\alpha\beta)^2$

$$\therefore \quad \beta^2 + \alpha^2 = \sqrt{(G^2 + \omega^2C^2)(R^2 + \omega^2L^2)} \text{ .....(17)}$$

Adding equations (15) and (17) we get

$$\left.\begin{array}{l}\text{The Attenuation}\\ \text{Constant}\end{array}\right\}\beta =$$

$$\sqrt{\tfrac{1}{2}\left\{\sqrt{(R^2 + \omega^2L^2)(G^2 + \omega^2C^2)} + (GR - \omega^2 LC)\right\}} \text{ (18)}$$

Subtracting equations (15) and (17) we get

$$\text{The Wave-length Constant } \alpha = \sqrt{\tfrac{1}{2}\left\{\sqrt{(R^2+\omega^2L^2)(G^2+\omega^2C^2)} - (GR - \omega^2LC)\right\}} \quad (19)$$

Note.—Equations (18) and (19) are identical in form except for the sign of the last expression. They are very important equations as from them many useful simple approximations are made for dealing with problems, *e.g.*, if a circuit has negligible resistance and leakance ($R = 0$, $G = 0$) then β becomes zero and the wave-length constant becomes :—

$$\alpha = \omega\sqrt{CL}$$

In other words, when there are no resistance or dielectric losses then the wave-length constant is proportional to the frequency of supply and there is no attenuation of either voltage or current.

IV.—*Secondary Cable Constants.*

Sometimes the constants Z_0, β, α and γ are called the *secondary* cable constants. They all vary with frequency as shown in the foregoing equations, as well as being derived from the *primary* constants R, L, G and C, the latter being generally assumed to be constant with change of frequency.

Section 3.

The Imaginary Case of an Infinitely Long Circuit.

It will be shown later that what is termed "*infinite* length" conditions can be produced in an actual *finite* line and that, further, it is frequently desirable to produce "infinite length" conditions for reasons of efficiency. Hence a brief study of an imaginary infinitely long circuit is necessary.

Consider Fig. **5** below :—

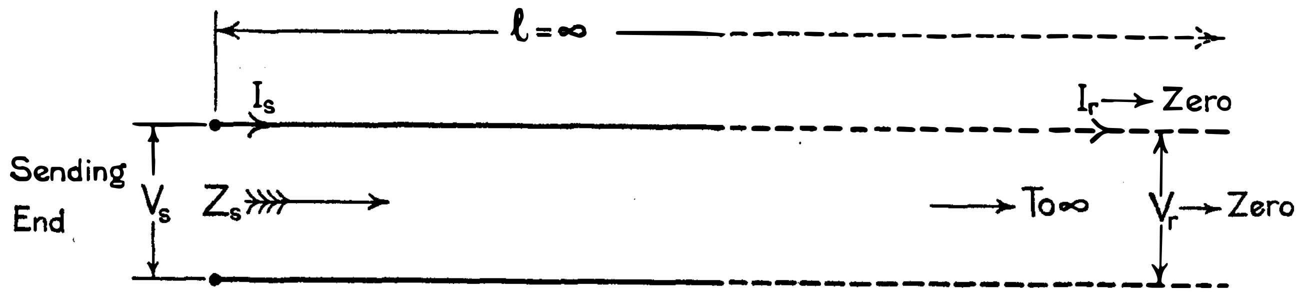


Fig. 5.—Infinitely Long Circuit.

I.—*Sending-End Impedance (Z_s).*

$\dfrac{V_s}{I_s} = Z_s =$ impedance measured from the sending end and looking in the direction of the feathered arrow. Since the line is infinitely long the current at the distant end (I_r) will be zero whether the end is open or closed and the voltage (V_r) will be zero also.

Equations (11) and (12) of Section 2 can therefore be each equated to zero. Using equation (11) we get :—

$$\therefore\quad V_s \cosh \gamma l - I_s Z_0 \sinh \gamma l = 0$$

$$\text{i.e.,}\qquad V_s = I_s Z_0 \tanh \gamma l$$

But since $l = \infty$ then $\tanh \gamma l = 1$ (See Fig. **1**) and

$$\therefore\quad V_s = I_s Z_0$$

$$\text{or } \frac{V_s}{I_s} = Z_0 \quad \text{.......................................(1)}$$

Since Z_0 is a vector, let its angle be ϕ_0 (*i.e.*, write $Z_0 e^{j\phi_0}$) and then write equation (1) as

$$I_s = \frac{V_s}{Z_0} \cdot e^{-j\phi_0} \quad \text{.....................................(2)}$$

The important physical significance of equations (1) *and* (2) *lies in the fact that the impedance* $\dfrac{V_s}{I_s}$ *offered at its sending end, by an infinitely long line, would be equal to the characteristic impedance* (Z_0).

The same result, viz., $Z_s = Z_0$ for an infinite line, is obtained by equating equation (12) of Section 2, to zero.

II.—*Expressions for the Voltage (V) and Current (I) existing at any point distant (x) from the Sending End of an* **Infinitely Long Circuit.**

By equation (11) of Section 2 we have

$$V = V_s \cosh \gamma x - I_s Z_0 \sinh \gamma x \quad \text{...........(3)}$$

But in the case of an infinitely long line we have by the foregoing equation (1), $V_s = I_s Z_0$.

Equation (3) becomes

$$\therefore \quad V = V_s (\cosh \gamma x - \sinh \gamma x) = V_s e^{-\gamma x}$$

$$\therefore \quad V = V_s e^{-\gamma x} \quad \text{..............................(4)}$$

Similarly from equation (12) of Section 2 it can be shown that

$$I = I_s e^{-\gamma x} \quad \text{.......................................(5)}$$

Substituting $\gamma = \beta + j\alpha$, then the equations (4) and (5) become, (Cf. Section 1, pp. *(c)*):—

$$V = V_s e^{-(\beta x + j\alpha x)} = V_s e^{-\beta x} (\cos \alpha x - j \sin \alpha x) \ldots(6)$$

$$\text{and } I = I_s e^{-(\beta x + j\alpha x)} = I_s e^{-\beta x} (\cos \alpha x - j \sin \alpha x) \ldots(7)$$

Equations (6) and (7) are of the same form exactly and can be represented as in Fig. **6**, which shows maximum values at different points along the line.

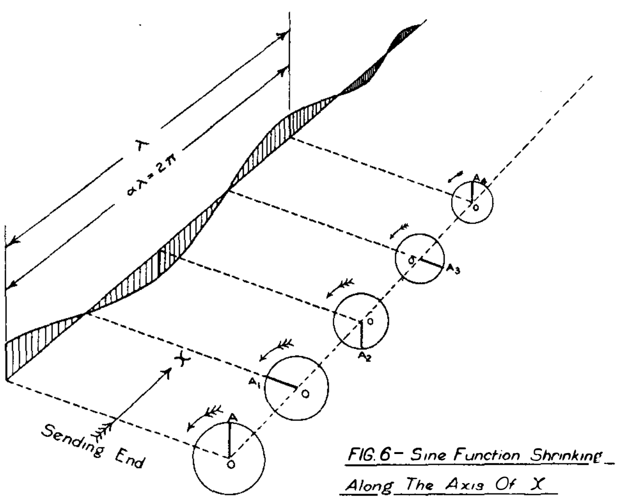


FIG. 6 – Sine Function Shrinking Along The Axis Of X

Equations (6) and (7) show that both voltage and current decrease exponentially along the line (in the infinite line condition) whilst both voltage and current lag in phase behind their respective sending-end values by an angle αl radians, or α radians per unit length. In Fig. **6** the vector OA is a shrinking sine function, *i.e.*, as it proceeds along the axis of x its magnitude decreases according to the law $e^{-\beta x}$ whilst it revolves uniformly with such a velocity as to pass through a phase angle of α radians per unit length traversed. Hence α is sometimes called the "*phase constant*" and since a complete wave or cycle is passed through by OA in 2π radians then the length of line traversed is $\frac{2\pi}{\alpha} = \lambda$ units of length, say. Hence α is often called the "*wave-length constant,*" and λ is the "*wavelength.*"

(The student should compare equations (6) and (7) with that obtained for the oscillatory discharge of a condenser which can be represented by a shrinking sine function and can be projected from a logarithmic spiral).

III.—*Velocity of Wave Propagation (v).*

If the rate of propagation of OA (Fig. **6**) along the line is α radians per mile, *i.e.*, $\frac{1}{\alpha}$ miles per radian, and if the pulsatance ($2\pi \times$ frequency) of supply is ω radians per second, *i.e.*, 1 radian per $\frac{1}{\omega}$ seconds we can write $\frac{1}{\alpha}$ miles traversed per radian as:—

$\frac{1}{\alpha}$ miles traversed in $\frac{1}{\omega}$ seconds.

i.e., $\frac{\omega}{\alpha}$ miles per second.

In other words the velocity of propagation, v miles/second, is given by:—

$$v = \frac{\omega}{\alpha} = \frac{2\pi f}{\alpha}$$

SECTION 4.

The Case of D.C. Transmission—Steady State.

All the foregoing equations in Section 3 apply to D.C. transmission if the frequency, f, or pulsatance, ω, put equal to zero.

Thus for D.C. transmission over a line:—

$$Z_0 = \sqrt{\frac{R}{G}},$$

$$\gamma = \beta = \sqrt{RG}, \text{ etc.}$$

The fundamental equations (11) and (12) as well as the results derived from them also apply of course to D.C. work if ω is put equal to zero.

Examples *taken from recent Examination Papers and Solutions contained in whole or in part in Sections 1 to 4 of the Notes.*

(Some of the numerical questions will be solved in full in a later Section).

Example 1.—Explain what is meant by the propagation constant of a telephone line. If a line that may be taken as infinitely long has a propagation constant per mile of $0.04 + j\,0.08$, and the current at the sending end is $1.0 \cos 5{,}000\,t$, find an expression for the current at a point 80 miles along the line. [London Univ., B.Sc., 1927.]

Note.—Use equation (5) of Section 3.

Example 2.—Discuss the part played by complex quantities in the solution of transmission problems. [City and Guilds, 1929.]

Example 3.—A line 90 miles long has the following loop-mile constants: $R = 6.3$ ohms; $h = 0.06$ henry; $G = 0.15$ micromhs; $C = 0.054$ microfarad. Find the attenuation constant and wave-length constant. [City and Guilds, 1930.]

Note 1.—Use equation (18) for β and equation (19) for α. Take $\omega = 5000$ radians per second (mean speech value) since the value of ω was not given in the examination question.

Note 2.—Remember C must be in *farads* for calculation and G in mhos. Therefore for the equations (18 and 19), put $C = 0.054 \times 10^{-6}$ and $G = 0.15 \times 10^{-6}$.

Useful Text-books and References for Sections 2 to 4.

"The Propagation of Electric Currents in Telephone and Telegraph Conductors," by J. A. Fleming. Published by Constable, London.

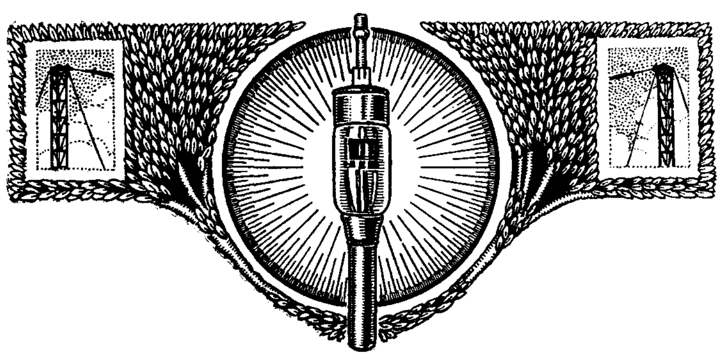
"Smithsonian Mathematical Tables—Hyperbolic Functions." Published by Smithsonian Institute, City of Washington (London Agents—W. Wesley & Son, 28, Essex Street, Strand).

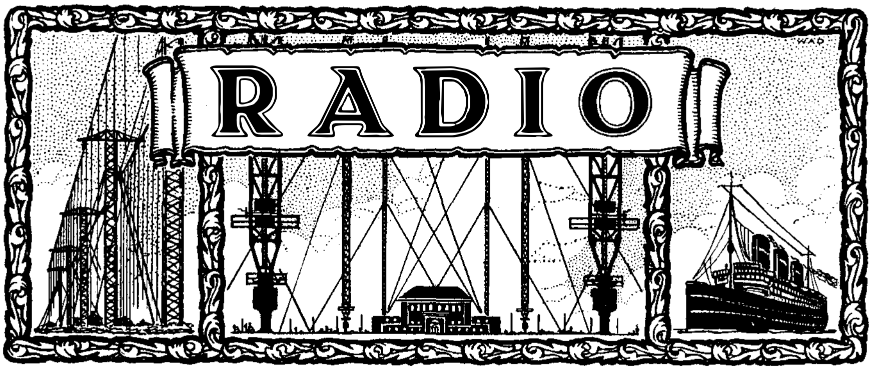
"Tables of Complex Hyperbolic and Circular Functions," by A. E. Kennelly. Published by Howard University Press.

"The Application of Hyperbolic Functions to Electrical Engineering Problems," by A. E. Kennelly. Published by Univ. of London Press.

"The Elements of Telephone Transmission," by H. H. Harrison. Published by Longmans Green & Co., Ltd.

"Telephonic Transmission," by J. G. Hill. Published by Longmans Green & Co., Ltd.





UNDERGROUND CIRCUITS FOR THE TRANSMISSION OF BROADCAST PROGRAMMES.

A. C. TIMMIS, B.Sc., A.M.I.E.E., and C. A. BEER, Wh.Sch., A.C.G.I., D.I.C.

AN essential part of the Regional Broadcasting System now being constructed in this country is the network of land lines or repeater circuits (Fig. 1) which link up the studios in London and elsewhere with the radio transmitters, so that a programme from any studio may be radiated from all or any of the transmitters. So far, aerial lines, which do not involve any Post Office repeaters, have been used almost exclusively and have proved quite satisfactory as regards transmission of the wide range of audible frequencies required for music. But, unfortunately, aerial lines are liable to breakdown and their attenuation depends to some extent on the weather. Further, noise and cross-talk may be troublesome, especially if conversation on a trunk or private line happens to be made audible by this means on thousands of loud speakers.

These are the main reasons why underground cable circuits for programme transmission are being adopted here, on the Continent of Europe and in America. It is of course well known that for all telephonic transmission in this country the overhead aerial circuits are being fairly rapidly displaced by underground cables.

From the technical standpoint the faithful transmission of music under commercial conditions will involve three main considerations :—

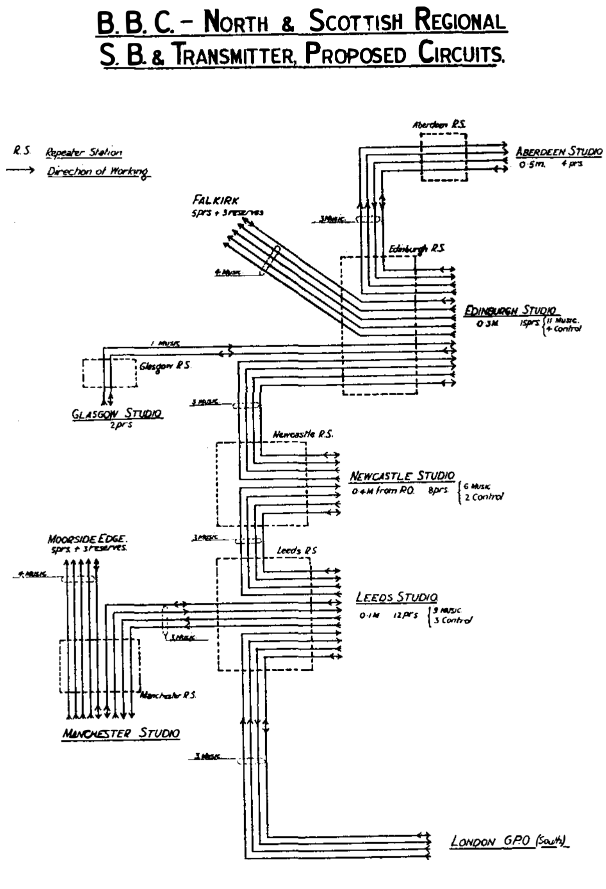


FIG. 1.

Firstly, the attenuation must be fairly constant over a wide range of frequencies and there should be no deterioration in this respect when the volume is varied over a fairly wide range. Secondly, distortion involving the production of harmonics should be negligible, and transient phenomena should similarly be indiscernible. Thirdly, cross-talk both to and from the music circuit should be negligible under all working conditions.

Frequency Range.—The B.B.C., in common with many other broadcasting concerns, has provisionally adopted a frequency range from 30 to 10,000 p.p.s. as a basis of design and there is no doubt that this range is sufficient to give complete satisfaction to listeners on the best present day loud speakers and receiving apparatus. Some administrations have shown by the use of filters introduced in the circuit that it is very rare for any musical critic to observe any difference when all frequencies above 10,000 p.p.s. are definitely cut out, while in the case of the great majority of observers the limitation of the maximum frequency to a much lower value produces no perceptible effect. It is said, however, that frequencies up to 30 kilocycles are sometimes audible, but it might be noticed that, in general, for very low and very high frequencies considerable volume must be delivered before they become audible.

As regards much narrower bands of operation, tests made on certain underground circuits, before the transmitting stations at Brookman's Park were opened, were made with the co-operation of the B.B.C. in which frequencies from 100 to 5,000 p.p.s. only were transmitted. Only 3% of the observers were able to record perceptible deterioration under normal conditions of reception, but the receiving apparatus was possibly not quite as good as the best available to-day.

More recently a test was similarly made in which a frequency range from 35 cycles to 6,500 cycles was transmitted and no difference could be detected on the best moving-coil loud speaker, except for the presence of a phenomenon probably due to transient effects when notes such as the lower range of a piano were involved. This was only detectable, however, with a quick change over.

In connection with the frequencies to be considered, it may be observed that the *fundamental* frequencies occurring in orchestral music usually have extreme minimum and maximum values of approximately 26 and 4,000 respectively, while in the case of the human voice the corresponding values are of the order of 80 and 1,000 respectively.

In view of all the considerations involved and the results obtained by independent investigators, the frequency range to be aimed at in broadcasting appears to be 35 to 8,000 p.p.s. As a contrast to this, it is interesting to note that very satisfactory commercial telephone circuits are designed on the basis of 300 to 2,400 p.p.s.

Volume Range and Measurement.—To transmit a volume range corresponding to a power ratio of one million to one, or 60 dbs, is found to be possible and the ear is generally able to appreciate the extremes. The question must, however, be also viewed from the standpoint of the residual noise unavoidable in the best systems and it is found that a volume range of 40 dbs will give great satisfaction to the listener, and can be achieved without undue expense.

Again, the volume of audio frequency signal is of importance not only when modulation of the carrier frequency at the radio transmitter is considered but also as regards the overloading of repeaters, distortion and cross-talk.

The measurement of volume therefore, which of necessity does not usually arise in telephone circuits excepting where voice-operated devices are employed, has to be given special consideration.

If the current due to speech or music is measured by means of a highly damped instrument, such as a thermo-milliammeter, the reading will indicate the R.M.S. value over a period in which the peak value of the current may change enormously. For a pure sine wave the ratio of peak to R.M.S. value is $\sqrt{2}$. In broadcast programmes this ratio may vary between 3 and 10 for speech, and even more for some kinds of music.

It is well known that valves may be overloaded by the peak value exceeding a certain amount, but the wonderfully accommodating human ear will disregard even a considerable overload if it be only momentary, of the nature of an isolated peak. If the peaks are repeated within, say, $\frac{1}{4}$ second, distortion of a very unpleasant kind is noticed, and the amount of this distortion probably depends on the time-integral of the peaks over a small fraction of a second.

Obviously a damped R.M.S. instrument will give very little idea of peak values, and an instrument which indicates the time-integral just mentioned is necessary. The Western Electric "volume indicator," used by the Post Office and the B.B.C., meets this requirement fairly well. It consists essentially of a rectifying valve operating a moving coil instrument whose construction is such that it may be regarded almost as a ballistic galvanometer, giving deflections proportional to the time-integral of the current over, say, 1/5 second. In use, the input to the valve is adjusted by means of a tapped transformer until the needle swings up to a certain mark which is taken as "reference volume." If average speech from a good C.B. telephone is applied, across 600 ohms, to the volume indicator the instrument should indicate reference volume.

Now, if this speech is amplified by an ordinary repeater valve whose maximum distortionless output is 57 milliwatts, then the maximum amplification which can be tolerated without sensible distortion is 10 db. That is to say, the output of the valve is 10 db above reference volume. We can therefore use the volume indicator (which is in effect a high impedance valve voltmeter) to determine the volume at any part of a circuit as a criterion of overloading, or rather, of avoidance of overloading.

If on the other hand we transmit through the same valve high quality speech from a broadcasting microphone, or music, and listen to the result on a good modern loud speaker, the distortion will be appreciable when the volume indicator shows 10 db above reference volume at the output of the valve. This is mainly because the ear cannot tolerate so much distortion (measured by the time-integral mentioned above) as in the case of commercial telephone speech, where no very high or very low frequencies are produced. Once calibrated by the judgment of a trained ear, however, the volume indicator will serve reasonably well to indicate the safe volume level at various points in a broadcasting system. At the output of a valve such as that mentioned above volumes of 4 db above reference volume for medium quality broadcast and about 5 db below, for high quality broadcasting, have been agreed upon in co-operation with engineers and musicians of the B.B.C.

It is interesting to note that the American Telephone and Telegraph Co., when considering the design of music lines and amplifiers, arrived at practically the same result.

Other methods of indicating volume may be used, such as a condenser-charging peak voltmeter, or a Moullin (valve) voltmeter, but the former seems to be too much affected by the peaks, and the latter too little.

As a great deal of confusion has arisen from attempts to compare reference volume with the milliwatt at 800 p.p.s. (.78 volt on a 600 ohm line) generally used for testing trunk circuits, a slight digression with the object of discouraging any such comparison may perhaps be allowed.

The volume indicator is used to adjust amplifiers while speech (or music) is passing through a circuit. The milliwatt of steady tone is used to adjust the various amplifiers (repeaters) so that each deals with its proper share of the line attenuation. Repeater output levels are determined more by cross-talk considerations than by risk of overloading, and the milliwatt happens to be a convenient amount of testing power. Since the distortionless output of an ordinary repeater is 57 milliwatts the transmission level would have to exceed 18 dbs (above a milliwatt) before overloading would occur during test.

It is often convenient to use steady tone to test the working of voice-operated devices such as echo-suppressors or certain types of volume indicator, but it is essential that the R.M.S. value of steady tone, which produces the same effect on the device under test as reference volume speech, should first be determined.

For instance, it was found that a milliwatt through 10 db produced the same result on a certain echo suppressor as reference volume speech—not counting or droning, which may, of course, amount practically to a steady tone.

Although the type of distortion usually known as valve overloading which results in the production of grid current is generally the most important, such factors as non-linearity in valve characteristics and in transformers are partly responsible for fixing the maximum safe volume which an amplifier can transmit.

Underground Cables.—The size of conductor and loading will obviously be dependent firstly on the minimum value of the cut-off frequency and, secondly, on the maximum permissible repeater section attenuation. At the present time there is in this country a considerable length of circuit involving 40 lb. conductors, 22 or 16 *m*H loading coils and 2,000 yards spacing; although it must not be overlooked that certain unloaded conductors are giving great satisfaction on some routes. The above loadings involve cut-off frequencies of 7,700 and 9,000 p.p.s. respectively, thereby catering satisfactorily for transmission of frequencies up to 6,000 and 6,800 p.p.s. It has been decided that as soon as practicable transmission circuits with a coil spacing of only 1,000 yards shall be set up, so as to obtain a cut-off frequency of 11,000 p.p.s. and transmission up to 8,000 p.p.s.

In the case of the existing 16 *m*H loaded circuits, screened pairs are employed, metalised paper strip being used for this purpose. By this means cross-talk attenuation between adjacent pairs is greater than 100 dbs for frequencies up to 7,000 p.p.s. or more. For the ordinary multiple twin cables the pair-to-pair cross-talk attenuation with 22 *m*H loading had an average value of 90 dbs and worst values of 84 dbs. The shields can, however, be rendered unnecessary by such means as segregation of the music pairs, closer spacing of coils and a restriction on the repeater section attenuation lengths. In certain new cables in Europe shielded pairs are in use, while in America segregation and closer coil spacing are preferred.

The loading coils have cores of a powdered alloy of high permeability, giving eddy current and hysterisis factors of a very small order. The latter is especially advantageous in reducing to a negligible quantity the effect of current magnitude on the circuit loss. The phantom circuits are not used in any circumstances and in this country side circuit transformers are also cut out.

Typical attenuation frequency and impedance frequency curves for the 40 lb., 16 *m*H loaded circuits with 2,000 yards spacing are shown in Figs. **2** and **3**.

In regard to attenuation it will be seen that below, say, 2,000 p.p.s. the curve falls, the shape approaching that for unloaded conductors and it will be found that the useful effect of loading is

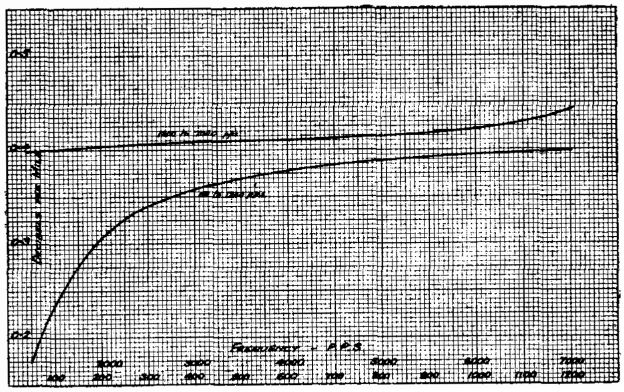


FIG. **2**.—ATTENUATION FREQUENCY (CALCULATED) 40 LB. CONDUCTORS LOADED 16 *m*H AT 2000 YARDS.

completely lost for frequencies below about 100 p.p.s. Here, of course, ωL is negligible compared with R. Above 2,000 p.p.s., the usual type of lumped loading curve becomes manifest, although the increase of attenuation on a 50 mile length of circuit up to, say, 70% of the cut-off is only 1 db.

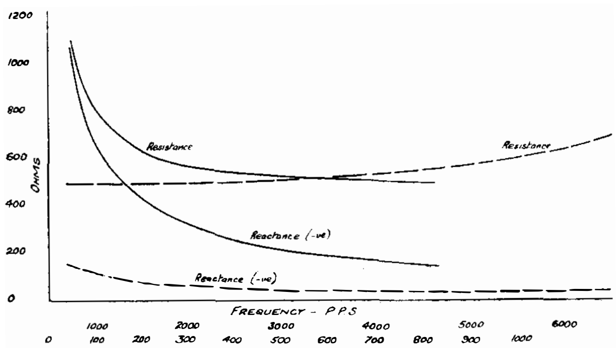


FIG. **3**.—IMPEDANCE OF 40 LB. CIRCUITS, LOADED 16 *m*H AT 2000 YARDS. FULL LINES 50-800 P.P.S. BROKEN LINES 800-6500 P.P.S.

Broadcast Repeaters.—The principal factors involved in the design of a suitable type of repeater are:—

(*a*) A uniform gain over the frequency range, say, 35 p.p.s. to 8,000 p.p.s. and means for gain frequency equalisation to cope with the line attenuation frequency characteristic.

(*b*) For volumes extending from the loudest passage down to those which are about 20 db weaker the gain should be constant.

(*c*) Depending upon the cross-talk conditions prevailing in the broadcast system, the repeater output should be fixed at a certain volume, in relation to, say, reference volume.

(*d*) Distortion, additional frequencies, transients, etc., should obviously be negligible.

Dealing now with these in more detail we have :—

(*a*) By the use of the high permeability alloys such as permalloy, mumetal and radiometal for the transformer cores it is relatively easy to obtain sufficiently high inductance for the faithful transmission of the low frequencies, while experiencing no deleterious effects from capacity at the higher frequencies. The design adopted (Fig. **4**) shows input and output transformers with resistance-capacity coupling at the interstage, two stages being employed with the nominal maximum gain of 38 dbs.

The equalisation scheme shown consists of the series resistance-condenser combinations (x) for the low frequency correction, a well known form of resonant circuit (y) and condenser arrangement (z) for the high frequencies. By these means flat gain characteristics or gain equalisations with a tolerance of $\pm$ 0.2 db are generally possible. Gain adjustment is effected by the potentiometer and taps on input transformer and interstage resistances. The minimum gain obtainable is 6.5 dbs and the adjustment is in steps of 1.5 dbs.

(*b*) Gain variation for different current strengths will not only complicate the question of setting up circuits but involve the production of harmonics due to the non-linear amplification. This phenomenon is usually associated with the low frequency end, where in transformers the product ωL is relatively small, not only due to ω but also for feeble currents the permeability falls and L is reduced. For higher frequencies the value of ω masks the possible variations in L. In existing telephone repeaters this feature is evident below about 150 cycles, such that at 50 cycles the gain may be reduced by 12 dbs when the input current falls by 20 dbs. This variation has to be avoided in the broadcast repeater, usually by increasing L to a value higher than might be necessary if currents were always large. Therefore copper losses in the output transformer and the effect of magnetic leakage are increased.

In the design shown which has been developed by the Department, some of these difficulties are removed by the push-pull feature, while for 30 dbs variation in current strength the change of gain is less than 0.5 db throughout the frequency range of 50 to 8,000 p.p.s.

In general, however, the effect of the current in the loading coils may predominate over that in the repeater. From the following table it will be observed that in a circuit consisting of 90 miles of 40 lb. cable, loaded with 22 *m*H at 2,000 yards and with three repeaters of the design shown in Fig. **4**, the overall effect was quite negligble :—

Frequency P.P.s.	Overall Transmission Gain, dbs. in circuit for input current of level (dbs.)			
	0	− 10	− 20	− 30
35	10.5	10.6	10.9	10.8
100	11.6	11.8	11.9	11.9
2000	11.3	11.5	11.5	11.5
6000	11.2	11.8	12.0	12.2

(*c*) Tests were made on unshielded circuits with light loading and on the unloaded pairs in two typical cables and it was found that at the cable termination the volume of cross-talk from other adjacent circuits which might be expected is of the order of 80 dbs below reference volume. Furthermore, it was considered that in quiet surroundings the minimum signal to noise ratio should be not less than 60 dbs. The latter figure has of course to take account of a 40 db change in broadcast signal strength, in conjunction with a satisfactory maximum value of cross-talk or noise background.

Under these conditions and since the worst relative disturbances are speech, cross-talk or ringing, and assuming the relevant circuits are transmitting in the same direction, it follows that the volume of the loud broadcast signal should never fall below − 20 dbs in relation to reference volume. Whence it is seen that with an assumed value of as much as 30 db attenuation between repeater stations the repeater output volume should have a normal maximum value of + 10 dbs in relation to reference volume. It is considered that these conditions will, from the standpoint of cross-talk, ensure satisfactory broadcast transmission without interfering with the ordinary telephone circuits. The conclusions are confirmed by experience with temporary underground music circuits where the attenuation length between certain repeater stations is at present too high for the volume the repeaters will handle.

In these circumstances therefore a broadcast repeater to handle 10 dbs above reference volume, with existing plate voltage supplies of 130 or 150 volts and using ordinary valves, must be of the push-pull type.

of permalloy core input and output transformers and resistance-capacity interstage coupling. It was found that the magnitude of harmonics when the former was delivering sensibly sinusoidal power of 170 milliwatts was slightly better than when the latter was delivering only 1.7 milliwatts, which is 20 dbs less. The value of the total harmonic content was in each case about 38 to 40 dbs below the level of the fundamental.

In a comparison of these two types it should generally follow that the push-pull type has the advantage, not only in partially or wholly eliminating the even harmonics of the valve

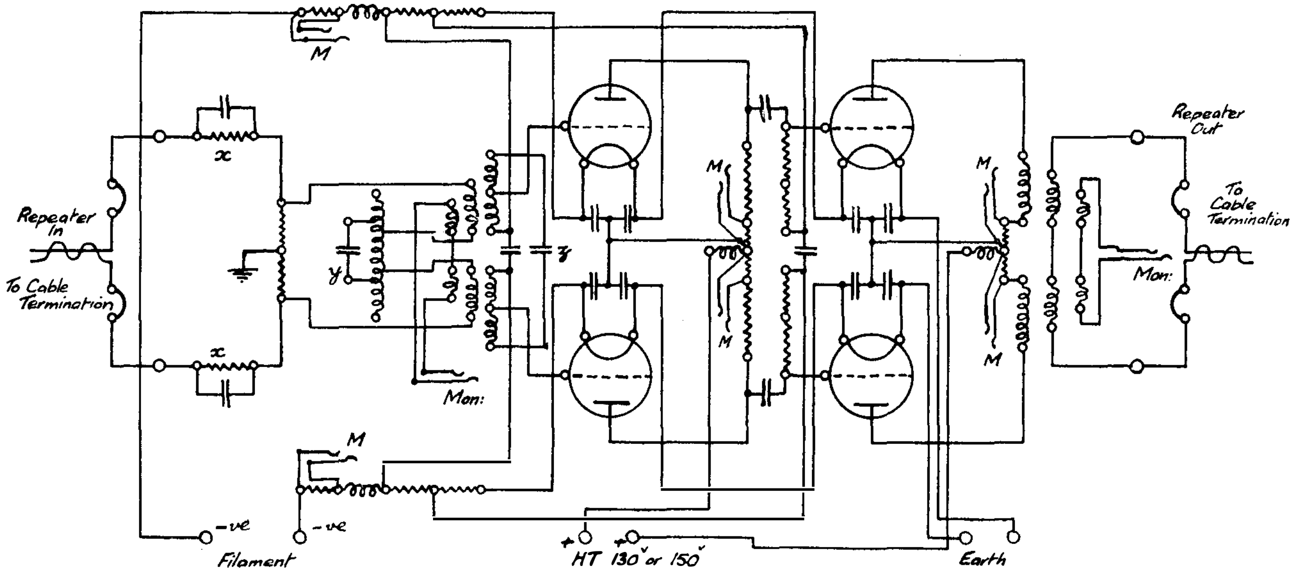


FIG. 4.—REPEATER FOR BROADCAST TRANSMISSION CIRCUITS. M—MEASURING JACKS. MON—MONITORING JACKS.

(*d*) Both the types of distortion dealt with under headings (*a*) and (*b*) are easily prevented. Under (*c*) it is interesting to note that the B.B.C. generally use amplifiers of the non push-pull type, but with plate voltages of 300 volts, where the power to be handled is smaller than in the case of the line repeaters. With small grid priming voltages the even harmonics due to curvature of the valve characteristics are thereby rendered negligible in value.

A test to determine the magnitude of harmonics generated in the repeater with different output powers was made, especially in regard to a comparison between the push-pull and the non-push-pull types. The former was of the design shown in Fig. 4, while the latter consisted

curve, but also in the case of the output transformer where the direct current flux can be made practically negligible. It appears that the output transformer is the main culprit in the generation of harmonics, for valves which were not well balanced with each other could be introduced without causing any perceptible change. An interesting test on these lines was made by the B.B.C. where it was found that with amplifiers of their own design the quality of music reproduction was best in the case of a push-pull type of repeater in which the output stage arrangement involved no transformers. In order of merit the other types were as follows: second, non-push-pull without transformers; third, push-pull with transformer; and last, non-push-pull with transformers. In all these cases the plate voltage was 300 volts.

Apart from the steady state forms of distortion, that is to say, imperfection of frequency response and non-linear distortion, transient effects in lines and transformers are certainly present, both at very high and very low frequencies, but, fortunately, with the distances and numbers of repeaters involved in this country the transient effects can probably be safely neglected. The subject is being investigated, however.

In conclusion, the authors wish to emphasise that the type of repeater which has been evolved is capable of giving a much higher output than the ordinary telephone repeater. There are two main reasons for this:—First, the existing main cable system had to be adapted to the rapidly expanding broadcasting service and this sometimes meant higher attenuation between repeaters than would be aimed at when starting *de novo*. Second, where new cables provide opportunity for laying out the music circuits to the best advantage it is well to have a margin of power in the repeaters to meet a possible demand for still higher quality of transmission. The line amplifiers used by the B.B.C. can deal with power output far above that which they normally transmit at present.

DEVELOPMENTS IN BROADCAST RADIO RECEIVING APPARATUS.

PART II.

A. J. GILL, B.Sc., M.I.E.E., M.I.R.E., and A. G. McDONALD, A.C.G.I., B.Sc., A.M.I.C.E.

THE outstanding event of the last few weeks in broadcasting circles has been the annual Radio Exhibition at Olympia. Speaking generally, it can be stated that while nothing of unexpected novelty appeared among the exhibits there was a general improvement in design and manufacture, both in component parts and in complete equipments.

A pleasing feature is the tendency of manufacturers nowadays to publish actual figures for the performance of their apparatus. The manufacturers of the better-class components are beginning to see the advantages of having their products tested by a reputable laboratory, such as the National Physical Laboratory, and publishing the results of the tests. This is all to the good and cannot fail to have a stimulating effect in improving the quality of apparatus. Some of the radio periodicals, notably the "Wireless World," have made a practice of testing components such as gramophone pick-ups, chokes, etc., and giving the results of these tests for the guidance of their readers. This practice also serves as a useful check against makers overstating their claims for the performance of their goods.

In previous years of the Exhibition, components formed a large proportion of the exhibits. This market has now been served to a great extent by the supply of kit sets in which the whole of the components are supplied with wiring diagram and cabinet at an inclusive price. The valve manufacturers have been responsible for much of this development and several of the larger firms market kits suitable for the use of their valves. In this way the purchaser is able to acquire what is practically a factory-built set without royalty payments.

There were, however, a large number of stalls exhibiting components. One of the chief developments in this line was the number of well-designed ganged condensers available. Four or five single condensers ganged to permit single knob control were common. In practically all cases, individual adjustment of capacity (or trimming) was possible without recourse to separate trimming condensers.

Exhibits of complete receivers predominated at this year's event. The housing of the receivers was for the most part well made and reasonably decorative without approaching the rather ornate style peculiar to American receivers.

A large amount of space was devoted to Radio-Gramophone equipment and a commendable feature was the increasing use of A.C. induction motors for driving the turntable. The universal type of motor has the advantage of being suitable for both A.C. and D.C. supplies and hence is suitable for districts at present using D.C., but which will shortly be changed to A.C. under the grid reorganisation scheme. Owing to the presence of a commutator, however, such motors are a potential source of noise and their use on A.C. systems is not to be recommended.

Gramophone pick-ups, with the exception of Celestion, Edison Bell and Brown models, appeared to follow ordinary practice. The Celestion pick-up is noteworthy in that, contrary to most other makers' practice, no attempt is made to correct for the bass cut-off in ordinary gramophone recording. The Edison Bell pick-up has an ingenious system of volume control by sliding the permanent magnet towards or away from its pole pieces. This would appear to be of use only for pre-setting to avoid overloading, as it cannot be adjusted during playing. Correcting networks to increase the bass response on gramophone reproduction were exhibited by Messrs. Gambrell, Celestion and Igranic. These devices to be effective should be designed for specific input impedances. Messrs. Gambrell have now produced a model suitable for high impedance pick-ups such as the Marconiphone.

Detectors.—Grid lead detection has always been considered to give inferior results to anode bend detection. Few receivers were fitted with the latter system of detection, as the correct biasing of the detector was considered to be a process demanding more skill than the average user possessed.

A variation of the usual values of grid leak and condenser has led to a new system of grid detection called power grid detection. The new values are 0.0001 mfd. for the condenser and 0.2 to .25 megohms for the grid leak. A high radio frequency amplification is used prior to detection and the grid swing applied to the detector valve amounts to tens of volts. A high anode potential of the order of 150 to 200 volts is used on the detector and the output can, if desired, be applied directly to the loud speaker. This system, if properly adjusted, provides an output of high quality surpassing most other methods.

There seems to be no reason why power grid detection should not be adopted even in battery-operated sets, as the resulting increase in anode current is not prohibitive. The clearer quality and better reproduction of transients due to the lowering of the time constant of the grid circuit is at once evident when the new system is fitted in a set.

Selectivity.—In the majority of cases, several tuned circuits were used to secure the necessary selectivity. In the case of sets consisting of two H.F. stages detector and L.F. stages, three tuned circuits were, with few exceptions, considered sufficient. Band-pass tuning has not as yet been widely adopted. With one or two notable exceptions, wave traps have practically disappeared. The rather haphazard effect of these traps on the tuning of most receivers is probably the reason. In the case of most wave traps marketed in previous years, the tuning coil had too great a high frequency resistance for the trap to be really effective.

The Ferranti " Regional " two-valve receiver was interesting in that two circuits tuned to the Regional and National wave-length were used. The switching arrangements were such that, when one of the tuned circuits was switched in, a wave trap tuned to the unwanted frequency was also brought into circuit.

In order to secure ganging of controls the effect of the loading due to the attachment of an aerial has been minimised by the use of a weak aperiodic coupling. This has materially assisted in securing a higher selectivity, although a reduction in input has followed. The selectivity of receivers is a subject on which makers could be a little less bashful, particularly in the case of receivers fitted with single knob control. Where multi-controls are provided, it is of course impossible to quote figures for selectivity, as the same adjustment is never obtained twice on any one wave-length. A suitable method of defining the selectivity is to state the width of the resonance curve at points 3, 10, 20, 40 and 60 decibels down from the value at the tuned frequency. The resonance curve published by one manufacturer for his sets shows that these values are approximately 10, 20, 60 and 120 kilocycles respectively. This means that two stations of equal field strength would have to be about 60 kilocycles different in frequency for one to be received without interference from the other. Interference 60 decibels below the wanted signal is practically inaudible and would not be noticed. Interference 40 decibels below the wanted signal is apparent in the silent periods of the wanted station's transmission, but otherwise does not cause inconvenience.

Screening.—In order to stabilise radio frequency amplifiers, screening is extensively employed. Originally, a simple metal partition was employed between stages, but of late the tendency has been to screen the individual components. Individual stage screening together with separate condenser screening is used in the Osram Music Magnet Four, three cans being used for the two H.F. and detector stage. The use of ganged condenser control has no doubt led to the use of separate screening for the coils, valves, valve leads, etc. Most of the sets exhibited seemed to consist of screens, cans, etc., mounted on a metal chassis. These components are often mounted very close together, so that if faults develop, tracing the source will be rather difficult. It would seem that even for the simplest of faults, such as burnt-out decoupling resistances, a return of the set to the makers would be necessary. In all receivers now, wave changing is carried out by switching rather than by changing coils and this necessitates a symmetrical lay-out of the inductances. Placing the valves within separate tubular screens enables a symmetrical valve lay-out to be used and also has the additional advantage that the valve electrodes are removed from the field of the tuning coils. Complete screening demands that the whole of the receiver components be mounted on a metal chassis. This leads to rather more expensive mountings. In the majority of components shown, such as volume controls, switches, variable condensers, etc., direct mounting on a metal panel was not possible. There is a definite demand for the insulated type of component which is not fully met at the present time.

Mains Components and Sets.—For reasons of economy and also because of its high stage gain, the use of a pentode as the output valve appears to have been widely adopted. With the new range of tapped output transformers made by Messrs. Ferranti and Messrs. Varley a reasonable matching of the loud speaker impedance to valve impedance is possible. The fact that the high tension is derived from the mains and is often several hundred volts makes it essential that the output terminals of the set should be connected to the anode circuit of the power valve by means of a choke filter or transformer. If the choke is tapped, a position in which the high note accentuation of the pentode is counteracted by a low frequency resonance can usually be found and reasonable quality secured.

The pentode is characterised in that within the working range the anode current is determined solely by the grid potential and is not affected by anode potential. As a result, the power delivered to the anode circuit is proportional to the load impedance. Many types of loud speaker, notably the moving iron type, have an impedance which increases rapidly with frequency. With such loud speakers in the output circuit of a pentode, heavy accentuation of the high notes occurs and some kind of correcting network is necessary. One suitable form is a resistance and condenser in series shunting the loud speaker terminals. This combination gives an increasing loss with frequency and can produce a marked improvement.

With regard to grid bias, in practically all main-driven sets, this was derived from the mains. The use of a small metal rectifier was favoured in some cases, but a straight-forward potential divider was mostly in use. A good example of this system is that used in the Pye Twintriple A.C. receiver. The use of free grid bias (that is, by the insertion of resistance in the H.T. negative return) does not seem to be so popular; possibly owing to the difficulty in avoiding unwanted couplings between stages with this system.

In the bulk of the radio gramophone sets and most of the four valve sets, a substantial power or pentode output was used and it seemed evident that H.T. voltage of between 300 and 400 are now in common use. Whilst the metal rectifier was used for many sets having low H.T. voltages, in practically all cases where higher values were used valve rectification was adopted. A notable feature was the extensive choice available of combined high tension eliminators and trickle chargers. For the possessor of a battery-operated set this represents the most economical form of electrification. A commendable feature was that the bulk of these sets had a variable output tapping for screen grid potential, so that the voltage best suited to the H.T. voltage in use could be readily obtained.

Loud Speakers.—The outstanding feature of the exhibits of loud speakers was the large number of permanent magnet moving-coil models shown. In many cases the working flux density of the air-gap was stated, and flux meters with search coils were exhibited on several stands, enabling the qualities of the magnets to be demonstrated on the spot. The question at once arises as to the permanence of these magnets. The answer is reassuring—in many cases the makers guarantee the permanence with very little loss for a number of years. Where the magnets are of cobalt steel, containing 35% of cobalt, very little is to be feared on this score. Quite satisfactory magnets are produced, however, having considerably less a proportion of cobalt, which of course tends to cheapness. The inductor type of moving-iron loud speaker, in which the armature system moves parallel to the pole faces and hence has an unrestricted movement, was shown by Messrs. G.E. Co. and Messrs. Lamplugh. The balance of tone from this loud speaker was pleasing and the reproduction of transients was agreeably crisp.

Moving-coil loud speakers in which the field current is supplied from a self-contained Westinghouse metal rectifier were surprisingly popular.

In conclusion, it may be said that the whole industry appears to be in a state of healthy development on sound lines and the progress that has been made during the last twelve months in the improvement of methods and products is a happy augury for the future.

NOTES & COMMENTS

REDUCTION IN PRICE OF JOURNAL.

THE Board of Editors has decided to reduce the price of the Journal to One Shilling per copy, beginning with the April 1931 issue, which is the first number of a new volume. In returning thus to the original pre-war figure, the Board has been encouraged to its action by the splendid response to the appeals for further support among the rank and file of the staff which the Board has been issuing from time to time during the past few years. As most of our readers are aware, the Journal is self-supporting, and while the proposal receives the hearty support and sympathy of the Council of the Institution, the Board has to bear the onus of responsibility for the success or non-success of the undertaking. We feel confident of success. We shall continue to maintain the high quality of the contents and endeavour to make the magazine still more useful to the industry than it has been in the past. If the twenty per cent. reduction in price is followed by a twenty per cent. increase in circulation we are safe, but we are not fixing such a limit to the latter. Engineers and Inspectors in the districts can help to push the sale in their sections especially among the younger members of the staff. To them, the study of the Journal contents—viewed from a mere mercenary standpoint—is surely of much better value than a large packet of cigarettes.

KEMP MEMORIAL FUND.

Many of our readers will have noticed in the Electrical Press recently the reference to Mr. H. R. and Mrs. Kempe's celebration of their golden wedding at their house at Lavethan, Brockham, Surrey, and to the announcement that the parishioners of Brockham Green, where Mr. and Mrs. Kempe have resided for over 45 years, are taking steps to recognise the many services which Mr. Kempe has rendered to the Parish by establishing a permanent memorial at Christ Church, at which he is Churchwarden and lay reader. The memorial is to take the form of a set of oak choir stalls and fittings in the Church, together with a tablet bearing a dedicatory inscription. The cost of the memorial is estimated at £175 and in response to a request by the Memorial Committee to make the proposal known among any old Post Office friends who might wish to be associated with this tribute, a circular letter was issued by Colonel Sir Thomas Purves on 31st July last. Up to the present, an amount of £36 17s. od. from approximately 75 subscribers has been received. In acknowledging in October this contribution the Hon. Treasurer of the Fund stated that including this amount the Fund stood at £100 and that he was hopeful that orders for the work could be placed without further delay.

Colonel Purves will be pleased to receive and pass on to the Fund Committee any further contributions to the Memorial.

COMPLIMENTARY DINNER TO MR. G. BALCHIN.

There was a great foregathering of members of the Post Office Engineering staff on Wednes-

IMPORTANT NOTICE.

Reduction in Price.

As from the 1st of April next, the price of the Post Office Electrical Engineers' Journal will be reduced to

ONE SHILLING PER COPY

POST FREE: 1/3

The Annual Subscription will be reduced to

FOUR SHILLINGS PER ANNUM

POST FREE: 5/-

Post Office Subscribers should send their orders to the Local Agent in the nearest Superintending Engineer's District Office.

Other Subscribers, including those in the Dominions, Colonies, and Foreign Countries should order from

"THE ELECTRICAL REVIEW," 4, LUDGATE HILL, LONDON, E.C. 4.

MR. GEORGE BALCHIN.

day, 15th October, at the Florence Restaurant, Piccadilly Circus, when the many friends of Mr. George Balchin gave a complimentary dinner to him to celebrate his promotion to the rank of Executive Engineer, and also to present him with a handsome radio-gramophone set, as a mark of the high regard and esteem in which he is held in all quarters of the Engineering Department of the General Post Office. The gathering was held under the auspices of the Post Office Engineering Federation, with Mr. Charles H. Smith (Chairman of the Federation and General Secretary of the P.O.E.U.) in the chair.

Among those present in addition to the guest of the evening, were Mr. E. H. Shaughnessy, O.B.E. (Assistant Engineer-in-Chief), Lt.-Col. A. G. Lee, O.B.E., M.C. (Assistant Engineer-in-Chief), Major H. Brown, O.B.E. (Assistant Engineer-in-Chief), Mr. A. G. Tydeman (Vice-Controller, P.O. Stores Department), Lt.-Col. A. S. Angwin, D.S.O., M.C., T.D. (Staff Engineer), Messrs. J. W. Bowen, M.P., George Middleton, J.P., M.P., W. Ewart Llewellyn, O.B.E. (Chairman, National Whitley Council, Staff Side), George Chase and A. C. Winyard (Joint Secretaries, National Whitley Council, Staff Side).

A telegram expressing regret for absence owing to a heavy cold was read from Mr. E. Raven, C.B. (Second Secretary to the Post Office and Deputy Chairman of the Post Office Engineering Departmental Council). The Chairman said that Mr. Raven had looked forward to coming to the dinner and would have proposed the toast of Departmental Whitleyism. A letter of apology for inability to attend was also received from the Engineer-in-Chief, Colonel Sir Thomas F. Purves, M.I.E.E., O.B.E., who regretted absence owing to unavoidable circumstances.

The toast list included " Our Guest," proposed by the Chairman, who also made the presentation. The toast was drunk with musical honours and was received with great enthusiasm. Mr. Balchin made a characteristic reply.

Mr. E. H. Shaughnessy submitted the toast " Departmental Whitleyism," which was replied to by Major H. Brown. " National Whitleyism " was proposed by Mr. W. E. Llewellyn and Mr. J. W. Brown responded.

The speeches have already been reported in full in the various service organs.

The " Wellington Journal and Shrewsbury News," of the 27th September, has an account of the funeral of our late colleague, Mr. E. A. Lakey, Executive Engineer, Telegraph Section, E.-in-C.O., who was buried in the churchyard, Oakengates, on the 14th September. The service was fully choral and there was a large congregation, the Engineering Department being represented by three colleagues of Mr. Lakey. Among the many wreaths were one from the Engineer-in-Chief and staff, and one from Col. A. C. Booth and the staff of the Telegraph Section.

The Editor, *P.O.E.E. Journal.*

Sir,

Oct. 5th, 1929—Dr. R. V. Hansford.
Oct. 5th, 1930—R101.

The fifth of October, 1930, will be remembered sadly in this country for many years to come, and to us in the Post Office it is impossible not to associate the disaster to R101 with our own more personal loss exactly one year previously.

Is the connection between these events one of date only? I think not. If we suppress all our personal feelings of loss by the untimely death of Dr. Hansford, we still feel the loss of an officer who could serve as an ideal for all who knew him. He embodied in a high degree all those qualities of enthusiasm, initiative, leadership, energy, courage and determination which distinguish the pioneer from those who are content to do merely the work which comes before them.

Can we not also respect the same pioneering qualities in those who have been responsible for airship development in this country? Can we not, without presuming to pass judgment on the technical aspect of the case nor on the findings of the Court of Enquiry, whatever they may be—can we not still pay tribute not only to those who were lost with R101, but to all those still left who have played any part in the development of lighter-than-air-craft? If R101 had succeeded in her flight to India, we should all have felt pride in a great national achievement. Though she failed in this test, can we believe that the margin between success and failure was other than a narrow one? Most of us in a humble way have been responsible for some measure of investigation work, and are used to the experience of half-a-dozen failures to one success. If we take our disappointment at any one of those failures and multiply it by a hundred thousand we have some idea of the disappointment which must be felt by all those connected with the R101.

There is always a danger at times like these that policy may be influenced by the panic tendencies of the press. Surely it is up to all those engaged in scientific development in any direction to support a saner and more balanced attitude. To say that the R101 experiment should never have been made is to say that the dead have died in vain.

C. F. O'Dell.
19 Oct, 1930.

HEADQUARTER'S NOTES.

EXCHANGE EQUIPMENT.

The following works have been completed:—

Exchange.	Type.	No. of Lines
Cradley Heath	New Auto.	540
Southend	,,	3050
Stoneygate M.F.	,,	Main Frame
Basford	Auto Extn.	570
Hove	,,	900
Ipswich	,,	300
Temple Bar	,,	100
Boscombe	New Manual	2300
Crawley	,,	620
Merrylee	,,	1600
Silverthorne	,,	1660
Altrincham	Manual Extn.	960
Allenby & Layfield	P.A.B.X.	30
Birmingham Mental Homes ...	,,	20
Black Motley	,,	30
Bradbury Agnew	,,	Re-arrangements
Bristol Police	,,	30
M.G. Cars	,,	30
King Edward Hospital (Windsor)	,,	30
Price Taylor, Ltd.	,,	20
Widnes Corporation	,,	30
Illustrated London News ...	P.A.B.X. Extensions.	50
Vickers, Ltd.	,,	Re-arrangements

Orders have been placed for the following works:—

Exchange.	Type.	No. of Lines
Calthorpe	New Auto.	1520
Denton	,,	500
Great Barr	,,	300
Hampton	,,	920
Heaton Moor	,,	1900
Hither Green	,,	3240
Kings Norton	,,	960
London Engineering District Inter Com.	,,	300
Longford	,,	880
Merton Abbey	,,	4200
Prestbury	,,	240
Sale	,,	2900
Shirley	,,	900
Smethwick	,,	1220
Sheldon	,,	300
Solihull	,,	1500
Stockport	,,	2680
Stoneygate	,,	1860
Tile Hill	,,	200
Westcotes	,,	400
Woodley	,,	520
Woolston	,,	430
Beckenham	Auto Extns.	Excess Fee Metering
Brierley Hill	,,	,, ,,
Cradley Heath	,,	,, ,,
Dudley	,,	,, ,,

Exchange.	Type.	No. of Lines.
Hillside	,,	,, ,,
Ilford	,,	,, ,,
Leicester	,,	80 Lines & re-arrangements
Macclesfield	,,	Re-arrangements
Mitcham	,,	Excess Fee Metering
Oxford	,,	340 Lines
Preston (B'ton)	,,	970 ,,
Rainham	,,	200 ,,
Rollingdean	,,	70 ,,
Stoke	,,	Re-arrangements
Southampton	,,	Re-arrangements
Stourbridge	,,	Excess Fee Metering
Tandem	,,	Re-arrangements
Wallsall	,,	Re-arrangements
Staines	New Manual	1460 Lines
Winton	,,	2420 ,,
Bexhill	Manual Extn.	Observation Equipt.
Boscombe	,,	Observation Equipt.
Mansfield	,,	Observation Equipt.
Palmers Green	,,	800 Lines
Park Western	,,	Order Wire Equipt.
Truro	,,	240 Lines
Black Notley	P.A.B.X.	30
Bristol Motors	,,	20
Bristol Police	,,	30
King Edward Hospital ...	,	30
Lesme, Ltd	,,	30
Shell Mex (Belfast)	,,	20
Taylor & Sons	,,	20
Taunton Corporation	,,	20
Willesden Council	,,	20
Illustrated News	P.A.B.X. Extn.	50
Vickers, Ltd.	,,	Re-arrangements
West Riding C.C.	,,	40

Mr. J. H. Simmance, M.I.E.E.

With the retirement of Mr. J. H. Simmance on the 13th November last another of the remaining links connecting the Engineering Department with the Telegraph Service is severed. Mr. Simmance entered the C.T.O. on the 2nd May, 1885, where he spent fifteen years. In March, 1900, he passed into the Engineering Department as a Junior Clerk, where his capacity for thoroughness and mastery over detail quickly attracted attention, with the result that he was advanced directly to the rank of Second Class Engineer. In 1911 he was graded Assistant Engineer and, as such, rendered conspicuous service in connection with the valuation of the late National Telephone Company's plant, for which he received the personal commendation of the Postmaster-General. In March, 1919, he became Executive Engineer in the Telephone Section and took charge of the very anxious and important work of reconstruction—the aftermath of the great war. Notwithstanding his preoccupations at this epoch, his leisure hours were given to the Chess Club where he was accounted a valuable asset and was in great request for the various Inter-Departmental events.

On the decease of the late Mr. W. Humphris-Winny, O.B.E., on the 31st May, 1927, Mr. Simmance was promoted to fill his place as Asst. Staff Engineer in the Test Section.

The 17th November last saw a gathering of about 70 colleagues and friends assembled in the Deputation Room, G.P.O. North, to say official farewell to the subject of these few notes. Testimony was given by those whose privilege it had been to come into contact with him of the esteem and regard in which he was held. Several members of the late N.T. Coy's staff spoke of the helpful way in which J.H.S. initiated them into the mysteries of State Service.

Col. Sir Thomas F. Purves, in his usual urbane manner, then presented our friend with a Ferranti All Electric Wireless Set on behalf of friends and colleagues. A gramophone pick-up also accompanied the gift.

Mr. Simmance, in a characteristic speech, spoke of the good spirit that pervades the whole of the Engineering Department and asserted his firm conviction that it was without equal among the various government departments as regards efficiency. He admitted that he was only a recent convert to the rôle of wireless listener, but he had felt hitherto that radio did not give an adequate interpretation of music and particularly of opera. Recent scientific developments, however, had caused him to modify his views hence the selection of his first wireless set. The staffs of the London and Birmingham Testing Branches had presented him with a Ferranti Moving-Coil type loud speaker and he would be able in retirement to hear his favourite operas at their best and so the apparatus would be a constant reminder of the kindness of his friends in the Post Office.

We wish " Simmy " many years of health

and happiness and if he should take that tour around the world of which he has whispered to some confidants then we hope that it will prove to be a very pleasurable one.

G.F.T.

MR. S. A. POLLOCK, O.B.E.

An interesting little ceremony took place in the Lecture Theatre, Dollis Hill, on the 14th November, when Mr. E. Gomersall presented Mr. Pollock with an album bearing the signatures of many of his friends in the service. Complimentary speeches were also delivered by Mr. Shaughnessy, Mr. J. E. Taylor, Mr. C. Robinson, Mr. Bartholomew, Major Reid, Mr. W. D. Robinson, Mr. A. E. Harrison and Mr. E. D. Hebden. On behalf of the Research Staff, Mr. W. Cruickshank presented Mr. Pollock with a pair of loving cups. The recipient made a characteristic reply. Col. Purves sent a letter intimating his regret at not being able to be present.

LONDON DISTRICT NOTES.

Telephone Growth.—Although the telephone service has not escaped the effect of the trade depression, there is still steady growth to record. During the quarter ended September 30th the nett growth of direct exchange lines and stations was 4,532 and 6,505 respectively.

The provision of plant to meet prospective development is proceeding and the total single wire mileage of local line plant has increased to 2,685,763 miles.

Equipment is being installed in six new automatic exchanges and in addition 22 new buildings are in course of erection.

Special Arrangements.—In connection with the Indian Conference being held at St. James' Palace a special telephone installation has been provided, consisting of a suite of sections to which are connected 10 exchange lines, 26 extensions, 15 call office circuits and seven private wires. A suite of 27 telephone cabinets has also been provided. The general arrangements are similar to those provided for the Naval Conference as previously described in these notes.

At the request of one of the large West End Stores an Order Department Equipment has been installed, consisting of four tables, each equipped for ten operators and with ten incoming circuits multipled thereon. Full supervision over all operators' positions and circuits is provided by means of a Supervisor's position, and the arrangement permits of team working. It is expected that other large stores will require similar installations. Those that are first in the field will no doubt reap the greatest advances.

Voice Frequency Key Sending.—Arrangements are being made for the installation of this equipment at most of those Manual Exchanges in the London Automatic Area which are not being converted to automatic working in the near future.

Kiosks.—The work of redecorating the whole of the kiosks of the No. 1 type in the London Engineering District was commenced in the spring, and already 500 of the kiosks have been reconditioned to the familiar Post Office red and stippled stone colour. The work has been carried out systematically and with due regard to the public convenience. Since the October issue of the Journal nearly 80 kiosks of the No. 2 type, 90 No. 3, and one No. 4 have been erected and brought into service in the London area. There have also been 40 telephone cabinets in suites of 2 to 12 made up in the District workshops with the now familiar polished teak or oak fronts and folding doors and are erected at Post Offices and Railway Stations, and in two cases provided for Provincial Head Post Offices. In addition, 96 single cabinets have been reconditioned and repainted. The increase in the number of call office kiosks for the six months ended Sepember 30th was 15%. The total is now over 2,000.

Retirement. — Mr. R. Wilson, Assistant Superintendent Engineer, has retired after completing over 40 years' service, a large proportion of which was spent in the London Engineering District. Mr. Wilson was of a retiring nature and shunned all publicity, but those who worked with him learnt to appreciate his sincerity, kindness and patience. There are few who have retired of whom it can be said more truly:—" He left only friends behind." Those friends regretted that, owing to the very serious illness of his wife, Mr. Wilson could not face a company to say " Farewell." They determined nevertheless that he should take away a token of remembrance and therefore quietly presented him with a handsome wireless set. (Mr. Wilson's late colleagues will be grieved to hear that his wife passed away within a week of his retirement).

Promotions.—Mr. T. H. Edgerton has been promoted to fill the vacancy caused by the retirement of Mr. Wilson and Mr. H. G. Peck has been promoted to Executive Engineer in charge of the Centre Internal Section. Mr. Peck was in the District some years ago and is welcomed back again.

I.P.O.E.E. Informal Meetings.—The informal meetings which are held in the Dining Room at Denman Street are amongst the most useful activities of the Institution. They are really informal and really informative. Regard is not paid to the official rank of the speaker and smoking is permitted. Members who do not attend are missing a golden opportunity for obtaining inside knowledge of a type which in many cases it would be premature to print. A typical case was the very fine paper recently contributed by Mr. H. S. Pate. In these days of specialised knowledge it is very important to find out what the other fellow is doing, unless you are going to be a one-job man all your life.

Swimming Successes.—It is not usual to report social or sports events in these notes, but in view of the extraordinary success of the London Engineering District Swimming Club it is thought that a reference is justified. The following are the principal successes during the season just ended:—

Premier Division Team League Championship.—Ellison-McCartney Cup.

Civil Service Team Championship.—Clark Cup.

Post Office Team Championship.—Gresham Shield.

Aggregate Points Competition.—Taxes Cup.

One of the members won the $\frac{1}{4}$ mile championship of the Civil Service and in this competition the L.E.D. took seven out of the first ten places. There were numerous other successes.

Greetings.—The members of the London District sends hearty greetings for the New Year to previous members now in the Provinces and throughout the world.

Silverthorn Exchange.

A No. 1 Common Battery Manual Exchange was opened for service on Thursday, November 6th, 1930. This exchange replaced the Chingford (Magneto) Exchange and at the transfer 780 exchange lines were cut over to the new exchange. In these days when transfers running into thousands of lines excite but little comment—or are only of purely local interest—unless, of course, adverse circumstances arise, this reference to Silverthorn may seem superfluous.

What then are the reasons which call for any comment? In this transfer there were exceptional conditions which will probably seldom arise again in the case of a manual opening. Particulars of the transfer may, therefore, be considered worth placing on record.

The London Automatic area is contained within a circle of ten miles radius with Oxford Circus as the centre. Chingford Exchange was situated just outside this circle on its N.E. periphery and, in accordance with the existing junction routing arrangements, calls from the majority of the London Exchanges were before the transfer routed *via* Toll " A " Exchange on a group of Toll-Chingford junctions.

The new exchange (Silverthorn) is situated just within the ten mile circle in the same locality and thus becomes part of the London Automatic network. In consequence, arrangements for routing calls from all London exchanges either direct or *via* Tandem had to be made, and a group of 25 junctions from Tandem Exchange was, therefore, provided. These junctions carry the traffic both from Manual and Automatic exchanges. Calls from Manual Exchanges pass *via* the Cordless B positions at Tandem to the C.C.I. position at the new exchange, and from Automatic *via* the Automatic Repeaters at Tandem.

The first three letters of the old exchange, viz., *Chi*ngford, are the same as those already in use in another part of the London area, viz., Chiswick. It became necessary therefore to alter the name of Chingford, and Silverthorn was selected.

We then arrive at this situation—that whereas before the transfer the calls for Silverthorn (SIL) were routed *via* Toll " A," at the transfer the calls must route to the new Silverthorn exchange *via* Tandem, and that the change must be effected without interruption. This was accomplished in the case of calls from Automatic Exchanges by an alteration of the translation on the Directors from TOL to TAN and the exceptional nature of the transfer now becomes apparent.

At the time of the opening of Silverthorn there were 22 Director Automatic Exchanges in the London Area, at which translation changes were required on no less than 410 Directors serving the 7th level, viz., the Exchanges whose initial letter is P, R, and S.

The transfer took place at 1.45 p.m. and it therefore became necessary at this hour to arrange for an alteration of the translation on the Directors to take place simultaneously throughout the London area. The arrangements were as follows:—

In each Automatic exchange, 50% of the Directors in the group in question were busied one by one, commencing one hour before the transfer, and the alteration in the translation carried out, the directors remaining busied until the time of transfer. Simultaneously with the opening of the new exchange these directors were thrown into service and the remaining 50% busied *en bloc* and treated in a similar manner, but with the exception that they were put back to service as each director translation was changed.

The directors were routined before being restored to service and a few test calls put through from each Automatic Exchange to the new Silverthorn Exchange. Only 11 men were engaged in the work of actual transfer at Silverthorn Exchange, but approximately 50 men were occupied with the transfer in the rest of the London area.

Calls from Manual Exchanges were directed to the new Silverthorn exchange by operators who were previously instructed, as from 1.45 p.m. on the day of transfer, to pass calls over the Tandem Order Wire instead of *via* Toll Exchange, the SIL translation on the Tandem 7-digit senders having been brought out previously.

Close co-operation was essential throughout the whole of the operations and, incidentally, it was necessary for all officers concerned to " synchronise " their watches with the Engineer in charge of operations at Chingford Exchange.

A.W.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

COLONIAL CORRESPONDING MEMBERSHIP.

The following grades of officials of Colonial Government Administrations are eligible for Colonial Corresponding Membership of the Institution:—

Australia.

Cadet Engineers.
Engineers, Class E, D, C, B.
Sectional Engineers.
Deputy State Engineers.
State Engineers.
District Engineers.
Supervising Engineers.

New Zealand.

District Telegraph Engineers.
Telegraph Engineers.
Technical Clerks.
Engineering Cadets.

India.

Chief Engineer, Telegraphs.
Deputy Chief Engineer, Telegraphs.
Deputy Chief Engineer, Telephones.
Directors, Telegraph Engineering.
Divisional Engineers, Telegraphs.
Electrical Engineer-in-Chief.
Asst. Divisional Engineers, Telegraphs.
Asst. Engineers, General.

India—(continued).

Asst. Engineers, Telephone.
Asst. Electricians.
Deputy Asst. Engineers, General.
Deputy Asst. Engineers, Telephone.
Deputy Asst. Electricians.
Director of Wireless.
Divisional Engineers, Wireless.
Asst. Divisional Engineers, Wireless.
Asst. Engineers, Wireless.
Deputy Engineers, Wireless.

South Africa.

Engineers (Headquarters).
Asst. Engineers (Headquarters).
Divisional Engineers-in-charge of Provinces.
Asst. Engineers.
Engineering Assistants.

Southern Rhodesia.

Engineers.
Sub-Engineers and Technical Clerks.
Officers in Charge of Automatic Exchanges.
Engineering Assistants, Grade A.

Ceylon.

Chief Engineers.
Asst. Engineers.
Divisional Engineers.
Engineers.

BOOTH-BAUDOT AWARD.

Applications are invited for the "Booth-Baudot Award" of £10 which is offered annually for the best improvement in Telegraph, Telephone or Radio Apparatus or Systems. The award is governed by the following conditions:—

1. The Award will be restricted to employees of the British Post Office.
2. Applications for the Award should be made between 1st January and 31st March, 1931, and such applications should refer to improvements made, or suggested, during the twelve months ending 31st December, 1930.
3. The Award may be withheld at the discretion of the Council of the Institution of Post Office Electrical Engineers if, after full consideration of the applications received, the adjudicators appointed by the Council are of the opinion that no award is warranted.
4. Applications for the Award, accompanied by full details of the improvement, should be addressed to the Secretary, The Institution of Post Office Electrical Engineers, G.P.O. (Alder House), London, E.C.1.

P. G. Hay,
Secretary.

December, 1930.

CENTRE AND DISTRICT NOTES.

LONDON CENTRE.

The opening meeting of the Session was held on October 21st when a record attendance, presided over by the President, Col. Sir T. F. Purves, O.B.E., M.I.E.E., saw and heard Departmental and Western Electric Co.'s films.

The films exhibited had been selected to demonstrate the educational possibilities of silent and talking films and were:—

Western Electric Co.'s films—
- Finding His Voice.
- Behind the Lines.
- Business in Great Waters.
- Characteristics of Sound.

Departmental films—
- Assembling and adjusting an Automatic Dial.
- Jointing a Lead Covered Cable.
- Pole hole excavation.

The second meeting, presided over by Mr. E. Gomersall, O.B.E., M.I.E.E., was held on November 11th, when Mr. L. L. Tolley, B.Sc. (Hons.), A.M.I.E.E., read a paper entitled "Testing of Paper for use in Telegraph System." The paper was illustrated by a series of fine slides, many of which were coloured to show more clearly the fibres of different papers.

A good discussion followed to which Mr. Tolly ably replied.

At the beginning of the meeting, the Chairman urged upon the members the desirability of increasing the membership of the London Centre. He pointed out the value of the Institution to those who wished to keep in touch with modern development.

Informal Meetings.

The first Inormal Meeting, presided over by Mr. P. T. Wood, A.M.I.E.E., was held on Tuesday, October 28th, when Mr. H. S. Pate opened a discussion entitled " Manual v. Automatic; Some comparisons of Costs."

Mr. P. G. Hay opened the subsequent discussion and many other speakers contributed to a very interesting and instructive evening.

The second Informal Meeting, presided over by Mr. P. T. Wood, A.M.I.E.E., was held on Tuesday, November 25th, when Mr. A. F. E. Evans, Grad.I.E.E., opened a discussion before a record attendance entitled " The Development of Key Sending from " A " Positions "; the talk being illustrated by lantern slides.

The subsequent discussion was opened by Mr. W. S. Proctor, and other speakers made valuable contributions which brought out the far reaching effects of key sending.

SOUTH LANCASHIRE CENTRE.

The first meeting of the Session was held on October 13th, 1930, when the Chairman, Mr. T. E. Herbert, gave an address in which the various activities of the Engineering Department during the past year were outlined. In the course of his remarks special emphasis was laid on the necessity for an all-round decrease in Maintenance and Construction Costs.

After the meeting a number of members visited Telephone House, to inspect the Auto-Manual Equipment recently brought into use and the Blackfriars Automatic Exchange in course of construction.

The second meeting of the Session was held on November 10th, when a paper was read by Mr. A. J. Pratt, entitled " The Development of the Telephone System." This was a specially revised and adapted form of a paper under the same title read previously by Mr. Pratt before the Liverpool and North Wales Centre of the Institution of Electrical Engineers, of which he is Chairman this Session.

The paper gave an excellent review of past progress and, in addition, showed the direction in which important modifications of the telephone system might be expected.

The reading of the paper was followed by the display of a cinematograph film loaned by the Standard Telephones and Cables, Ltd., giving a comparison between their Step-by-Step Automatic System and manual systems of operation.

SCOTLAND WEST CENTRE.

The first meeting of the Session, also the first under our new Chairman, Mr. Whillis, was held on Monday, 6th October, in the Royal Technical College. The lecturer for the day was Mr. R. MacWhirter, B.Sc., and the subject " A.C. Rectification for Power Purposes." After some introductory remarks, adjournment to the Electrical Engineering laboratory was made for the purpose of demonstrating a Mercury Arc rectifier in operation. The lecture proper was delivered in the Electrical Engineering lecture room. The general problem of converting A.C. to D.C. was reviewed and possible methods of solution were discussed. Practical types of rectifiers were considered and their action explained, the Tungar rectifier being more particularly dealt with. Dry plate and electrolytic rectifiers, their theory and characteristics, were also touched upon. Efficiencies and other characteristics of the various types of rectifiers were compared with special reference to Departmental requirements.

Voltage and current relationships between A.C. and D.C. sides of a rectifier, effect of chokes and condensers, smoothing circuits, and battery loads were also treated and a visual demonstration by oscillograph of current and voltage waves was given.

The lecture concluded with a review of progress towards the ideal rectifier and an expression of thanks to the College Authorities and Professor Parker Smith for placing the lecture room and apparatus at the disposal of the Institution, and to Dr. M. G. Say and others who kindly assisted in preparing and giving the demonstration.

H.C.M.

NORTHERN DISTRICT.

Annual Dinner and Presentation to Mr. J. R. M. Elliott, M.I.E.E.

A memorable gathering representative of all ranks in the Northern Engineering District met on Saturday, the 11th October, at the County Hotel, Newcastle-on-Tyne, to attend the first Annual Dinner of the District and to take official leave of Mr. J. R. M. Elliott, M.I.E.E., the retiring Superintending Engineer. The function was not only unique in the history of the Northern District on account of its size and representative nature, but the occasion marked the first visit of the Engineer-in-Chief, Sir T. F. Purves, to a local social gathering.

In addition to Sir Thomas Purves and Mr. Elliott, the guests of the evening included Mr. F. Ferguson, Postmaster-Surveyor, Newcastle-on-Tyne; Mr. J. D. Taylor, Superintending Engineer, Edinburgh; Mr. J. M. Shackleton, Superintending Engineer, Preston; Mr. J. W. Atkinson, Superintending Engineer, Leeds; Mr. C. Whillis, Superintending Engineer, Glasgow; Mr. J. D. W. Stewart, District Manager, Newcastle; Mr. Tattersall, Assistant Superintending Engineer, Edinburgh; Mr. J. K. A. Nicholson, B.B.C., Newcastle; Mr. J. B. Purves, G.E.C., Newcastle, and Mr. E. C. Brooks, Standard Telephones & Cables, Ltd.

After dinner, Sir Thos. Purves proposed the health of Mr. Elliott, and in a felicitous speech, backed by an apparently inexhaustible repertoire of stories, the Engineer-in-Chief endeared himself to the assembly with his homely geniality and the sincerity of his tribute to Mr. Elliott. He said that Mr. Elliott's retirement had deprived him of a wise counsellor, an open-minded advisor, and a zealous officer, who would be difficult to replace. At this point Sir Thomas could not resist the temptation to glance at Messrs. Elliott and Baldwin and hazard the opinion that Mr. Elliott's full suit of armour might prove difficult to fill. Mr. Elliott, continued Sir Thomas, had fully maintained the status, dignity, and reputation of the Department in a great industrial area. He had been a loyal, zealous and efficient officer and he retired with the love, esteem and regard of his staff. Sir Thomas wished him many years of happiness and good health in the rest which he had so well earned.

In supporting Sir Thomas, Mr. A. Cook said that Mr. Elliott had endeared himself to every member of the staff from Pot Boy to Engineer. He was glad to take this opportunity of acknowledging the indebtedness of the staff for the many kindnesses they had received from Mr. Elliott, who had followed with credit and distinction a succession of able men.

Mr. Jas. A. Motyer considered Mr. Elliott's parting as a great loss. Mr. Elliott was retiring under the happiest auspices. He enjoyed good health, his children were well placed, he had many interests to absorb his activities and he was surrounded by a circle of staunch friends. Mr. Elliott had a long and distinguished record of which any man might be proud, but surely the greatest achievement was to retire after 47 years' service with the assured respect and warm affection of every member of his staff.

Mr. J. B. Croney also supported the toast.

Before calling upon Sir Thomas to present Mr. Elliott with a solid silver tea and coffee service and a handbag for Mrs. Elliott, the Chairman, Mr. F. G. C. Baldwin, M.I.E.E., took the opportunity of saying that in his relationship with Mr. Elliott they had never been at cross purposes, their acquaintance had been both intimate and cordial; this was probably due to Mr. Elliott's equable temperament. The handbag was being presented to Mrs. Elliott to mark the gratitude of the staff for the many kindnesses and uniform consideration which she had always shown to the staff.

In acknowledging the gifts of the staff, Mr. Elliott, who was received with musical honours, said that no words could express adequately his gratitude for the tokens of kindness as represented by the presents. The Engineer-in-Chief's action in travelling a distance of 300 miles after a strenuous week's work was characteristic of his nature. Mr. Elliott said that the welfare of the staff had always been one of his chief concerns. The success of the District had been due to the spirit of "camaradie" which permeated the staff. If the country were searched no force more competent and more loyal could be met with. The Clerical staff he had always held in the highest regard and examining officers from the Headquarters staffs had repeatedly complimented him upon the clerical work. For the Engineering Officers he had nothing but the highest praise. Mr. Baldwin had been a tower of strength. He had always been a pleasant assistant, a very hard worker, and all his work had been thoroughly and efficiently done. The Engineer-in-Chief might rest assured that the future control of the District was quite safe in the hands of Mr. Baldwin and Mr. Bramwell. The Local Centre of the I.P.O.E.E. had been particularly successful and had enjoyed the distinction of 100% membership for several years, due largely to the enthusiasm and untiring energy of the local secretary, Mr. A. C. Smith.

The workmen of the District were second to none in the country. According to the costing figures issued periodically, the Northern District holds an unassailable position. Since 1924, the District had consistently held the premier position and this performance was a matter of pride. This position was achieved by close and constant supervision and by encouragement and tuition of the staff on one hand and on the other by conscientious workmen backed by a spirit of loyalty towards their supervisors. It was a great pleasure to know that he had so many good friends in the service and particularly in the Northern District. He expressed the hope that each one might enjoy the best of health and that the future might bring the best of luck.

Before moving a vote of thanks to Sir Thomas Purves, the Chairman thanked the members of the Committee with Mr. F. Johnston as secretary for the admirable arrangements made in connection with the function.

Sir Thomas replied to the vote of thanks in a characteristic manner to the delight and merriment of the company.

The musical items were extremely well rendered by local professional talent, with Mr. F. J. Shadforth as hon. accompanist.

SOUTH WALES DISTRICT.

John Henry Haynes.

Mr. J. H. Haynes, Assistant Superintending Engineer in the South Wales District, retired from the service at the end of August. Entering the service as a telegraphist at Gloucester forty-five years ago, he went over to the Engineering Department at Cardiff in 1892. Mr. Haynes was made Engineer 2nd Class in 1899 and Engineer 1st Class in 1907, filling positions successively in the North Eastern, Scotland East, South Eastern and South Midland Districts. In 1924, he returned to Cardiff as Assistant Superintending Engineer, thus completing his Post Office career in the same District in which he commenced it. During his long period of service Mr. Haynes has seen all the modern developments in the work of the Engineering Department and he has been associated at different times with many important works. His long spell of service in charge of the Guildford Section included the period of the Great War, during which the normal responsibilities of the position were seriously added to by frequent urgent demands for special work which had to be carried out by a much-depleted staff and by the fact that Aldershot lay within the Section. However, Mr. Haynes was equal to the occasion and came through this trying period with conspicuous success. The years immediately following Mr. Haynes's return to South Wales in 1924 were full of activity, conversions of the telephones to automatic working taking place at Swansea, Gloucester and Cheltenham, while the former automatic system in Hereford was replaced by standard step-by-step equipment.

By his courteous and amiable disposition, Mr. Haynes had made himself a universal favourite with all ranks of the staff and his departure was sincerely regretted. He was a loyal and conscientious colleague with a high conception of duty, who never spared himself in the matter of hard work. His counsel based on wide experience was valuable and was freely at the service of all who sought for it.

At a meeting in the District Office at Cardiff on 16th October, Mr. Terras on behalf of the staff in the District presented Mr. Haynes with a cheque as an expression of their esteem and good wishes. Mr. Haynes intends to spend this partly in purchasing some books of reference to assist him in the pursuit of the literary studies in which he has always been deeply interested and partly in going towards the cost of a gold watch.

Walter Scott.

Mr. Walter Scott, Executive Engineer in charge of the Technical Section at Cardiff, who retired on 31st July, had the unusual distinction of having spent 43 out of his 47 years of service in the South Wales District. Entering the Post Office service at Pontnewydd in Monmouthshire in 1883, he went to Cardiff three years later and in 1898 transferred to the Engineering Department in that city. After short periods of service in Newmarket and Salisbury, Mr. Scott returned to South Wales in 1902 to take charge of the Carmarthen Section. After two years spent in Carmarthen, he came back to Cardiff, where the remainder of his official life was spent. Mr. Scott reached the rank of Assistant Engineer in 1911 and of Executive Engineer two years later, the latter promotion carrying with it the charge of the Technical Section in the District Office, a position which Mr. Scott filled with distinction for a period of seventeen years.

Mr. Scott's official activities ranged over every class of work and when an awkward technical problem arose he was generally able to give valuable advice from the store of his own experience. Among his outstanding qualities may be mentioned his clear perception of the fundamental importance of economic considerations in plant design. Mr. Scott's genial nature made him a favourite with his colleagues, and the absence of his familiar figure from the District which has known him for so many years has created a very definite gap.

The Staff of the District have marked the occasion of Mr. Scott's retirement by presenting him with a settee and two armchairs to express their good wishes and the esteem in which they held him.

NORTH WALES CENTRE.

The 1930-31 Session was opened by a meeting held at Shrewsbury on 8th October, 1930, at which the Chairman, Mr. R. A. Weaver, presided over an attendance of about 70. The paper for the day was by Mr. W. E. Radford, on "Electrolysis," and covered the many kinds of fault arising from this source, the method of location, and the various expedients which have been adopted to prevent the trouble. The paper was a very practical one, written by an officer who has been dealing regularly with electrolysis cases for some years, and epitomized his accumulation of experiences. It brought up about a dozen speakers and a very interesting discussion.

The second meeting was held on 19th November, 1930, when Mr. B. Lynn, of the Equipment Section, Engineer-in-Chief's Office, read a paper entitled "Straightforward Trunking," which had originally been read at an informal meeting in London, and which had been rewritten and brought up to date to cover the introduction of A.C. (Voice frequency) signalling. As the latter device has not yet been introduced into the North Wales District, the paper was in the nature of an introduction to new developments in trunking, which the members were hearing about for the first time. The ensuing discussion consequently took the form of a series of enquiries for more information rather than a criticism of any of the systems described. Eventually a hope was expressed, and a promise given, that an opportunity would be found for a further informal discussion on the subject at a later date, and the members departed with something very new in the way of automatic trunking devices to think about.

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South Rhodesia.

LONG LINE TELEPHONE AND TELEGRAPH SYSTEM OF AUSTRALIA.

NORMAN W. V. HAYES and ROY JAMES ATTKINS.

Mr. Attkins has sent us a copy of the September, 1930, issue of the Journal of the Institution of Engineers, Australia, which contains a verbatim report of the above paper—No. 326, originated in the Melbourne Division of the Institution.

The following extracts will be of interest:—

HISTORY.

In 1851 the telegraph was first used in Australia, while in 1854 it was first used commercially between Melbourne and Williamstown. Telegraphic communication was established between Sydney, Melbourne and Adelaide in 1858. The first link with the outer world was established in 1872 when the line from Adelaide to Darwin was built to connect with a submarine telegraph cable extension from Java.

The telephone was introduced almost immediately after its invention and the first long distance conversation was one in 1878 between Melbourne and Ballarat. Since 1887, the telephone system has been associated with the Post Office under Government control. In 1907 a direct telephone trunk service was established between Melbourne and Sydney and, finally, in 1930, the long line telephone trunk system was connected with England and a number of European countries by the establishment of the Anglo-Australian radio-telephone service.

DEVELOPMENT OF LINE PLANT.

In comparing trunk line practice in Great Britain, U.S.A. and Australia, the authors say:

Great Britain, with short heavy routes, a thickly populated country, and severe climatic conditions, finds the solution in underground cable.

The United States, with long heavy routes, a much less densely populated country, and severe climatic conditions, finds it in aerial cable or open wires carried on mechanically strong supports.

In Australia, with long but relatively lightly loaded routes passing mostly through sparsely populated country, and much less severe climatic conditions, open wire lines with fewer poles per mile have met the case.

On many main routes in Australia, beginning in 1925, the introduction of carrier systems enabled a considerable increase in available circuits to be installed at comparatively small expenditure, but at the present time the Department has to give serious attention to the majority of its main routes. The authors then proceed to discuss the methods by which these routes can be enlarged. In general, the possible alternatives are to:—

(*a*) Reconstruct and rearrange the existing aerial routes;

(*b*) Build duplicate routes;

(*c*) Strengthen the existing routes, and run aerial cable, or

(*d*) Provide underground cable. In this connection, in a number of cases at present trunk entrance cables leading into the capital cities have been laid and loaded and they will form the beginnings of the longer loaded trunk cables which will eventually extend outwards from those cities.

Carrier Systems and their application to both telegraph and telephone services are discussed at some length, and the details are explained in a manner eminently suited for a gathering which evidently was not composed wholly of communication engineers.

Telegraph Services.

It is interesting to find that the present trend is definitely towards the replacement of the skilled Morse telegraphist in cases such as—

(*a*) very short distances and heavy loads where pneumatic tubes are being installed;

(*b*) short distances and light loads, where the telephone is being used in place of the Morse code telegraph line; and

(*c*) longer lines with heavy loads, where printing telegraph systems of various forms are being used.

There is still a place for the telegraph service from which it is unlikely to be ousted by the telephone service, but the Morse telegraphist is gradually being replaced by the skilled mechanic as the mechanisation of the telegraph art advances. Economic considerations demand that expensive long lines shall carry the maximum number of messages and this has been met by introducing machine systems.

Machine Printing Systems.—The two forms of machine printing telegraph which are most extensively used on the Department's long telegraph lines are—

(1) The teletype system; and
(2) The Murray multiplex system.

Carrier telegraph systems are installed between Sydney and Melbourne, and also between Melbourne and Adelaide. A further system is now being installed between Adelaide and Perth, and another system is to be installed between Sydney and Brisbane.

The particular advantage of this system is that the current values transmitted per channel are comparable with telephone currents, and this makes it practicable to have the telegraph and telephone systems working on the same pole line without the one interfering with the other.

Trunk Services.

The first really long trunk telephone line erected in the Commonwealth was that from Sydney to Melbourne, which was completed in 1907, and, with a telephone repeater added, is still in use. It was run on the pole line which follows the railway line *via* Albury and is approximately 600 miles long. When this line was engineered, it was necessary to use conductors of such dimensions that with the normal speech level from a subscriber's telephone at the one end, sufficient power would still be available at the further end to operate the receiver of the called subscriber.

Ten years ago it was not practicable satisfactorily to telephone in Australia over a longer distance than that between Sydney and Melbourne, some 600 miles; whereas to-day it is practicable to speak over land lines from Cloncurry to Adelaide—a distance by line of over 3,000 miles. In the not-far-distant future this will be extended to 5,000 miles when the Adelaide-Perth line is completed and a Cloncurry to Geraldton conversation becomes possible. In 1922 the Department had some 33,000 miles of trunk channels, while at 31st December, 1929, there were 186,806 miles—an increase of 566 per cent.

Telephone Stations.

In 1915 there were 157,317 telephone instruments in Australia; in 1930 (June 30th) there were 520,169.

BOOK REVIEWS.

" The Romance of the Civil Service." By Samuel McKechnie. London, Sampson, Low, Marston & Co., Ltd. Price 6/-.

Mr. McKechnie is engaged in the Telephone Section of the Engineer-in-Chief's Office.

His first book, " The Romance of the Civil Service," presents a fine, broad, general view of the Civil Service and its history and development. The book contains much of interest to the general public and goes far to correct many erroneous impressions with regard to the work of the Civil Service. The average Civil Servant, who knows little of the problems and duties of his colleagues engaged in other Departments, will find a great deal of interesting information in the book.

The circumstances and needs which governed the setting up of the various Departments are explained and dovetailed into historical perspective with a fine understanding, and the fortunes of the various Departments are clearly traced.

Much information is given about the official lives of famous Civil Servants of the past, including Charles Lamb, Geoffrey Chaucer, Adam Smith, William Shakespeare, Addison, Steele, McAdam, Trollope, Robert Burns, and even Ralph Allen, immortalised as Squire Allworthy in Fielding's " Tom Jones." As is the case today, however, most of the great men of the Civil Service had to leave the service in order to accomplish their best work. It may be that they had merely to sacrifice the less for the greater, like the parson and his golf, or it may be there is something in the atmosphere of state service that stirs certain men to have done with routine writing work, a sort of call of the wild, as it were, something akin to the impulses that makes the young city clerk linger and watch the ships loading up in London Pool.

The book contains many fine illustrations of Service buildings in Whitehall and a chapter is devoted to the Civil Service Sports movement and the progress of the Arts movements.

The Rt. Hon. Philip Snowden, M.P., writes an interesting foreword to the book in which he expresses the sincere hope that the volume will serve not merely as a historical account of the Civil Service but will create among the general public a new interest in and a greater appreciation of a Service to which every citizen is deeply indebted.

Readers of the *Post Office Electrical Engineers' Journal* will find the chapter on the work of the Post Office Engineering Department inadequate.

" Principles of Electric Power Transmission by Alternating Currents." By H. Waddicor. London, Chapman & Hall, Ltd. Pp. 419. Price 21/-.

The increasing use of long distance lines for the transmission of alternating current power has demanded a more precise knowledge on the part of electrical power engineers of the behaviour of such lines and of the effects which they introduce when interposed between a generator or source of power and the load.

The behaviour of transmission lines when carrying currents of speech frequencies became of practical importance and engaged the attention of telephone engineers at an earlier date, and at the present time there is an ample selection available of literature dealing with the subject.

The subject of power lines is perhaps not so well served, and it is thus pleasing to note the publication of a second edition of a very useful work dealing with this branch of electrical engineering. The second edition is not very different from the earlier edition with the exception of an additional chapter on the power limits of transmission systems.

The book deals not only with the characteristics and performance of the lines themselves, but also with the economies of power transmission and the protection of lines and systems against dangerous currents and pressure rises. As regards the performance of lines, this is dealt with by two methods, firstly by localised capacitance methods of solution and, secondly, vigorously by the use of hyperbolic functions.

A pleasing feature of the book is the number of carefully worked out examples, some occupying several pages. The reader is thus assured of being able to apply the information given to obtain practical numerical results.

The book is not only a very suitable text-book for students, it is also a work of great practical usefulness to engineers.

A.J.G.

"Handbook of Technical Instruction for Wireless Telegraphists." By H. M. Dowsett. London, Iliffe & Sons, Ltd. Pp. 487. 25/- net.

The aim of this book is to provide simple instructions for sea-going operators and others, in the general principles and practice of Wireless Telegraphy and is intended to provide a complete theoretical course for the P.M.G's certificate.

The present issue marks the fourth edition of this work, the first edition being due to Mr. J. C. Hawkhead. The present edition is completely revised and the scope of the book has been widened to meet the more exacting requirements of the sea-going operators' duties of today. The book, which in the earlier edition described only Marconi apparatus, now covers practically the whole range of apparatus likely to be encountered on British ships and includes very complete descriptions of apparatus manufactured by Messrs. Siemens Bros. and by the Radio Communication Company. In addition to dealing with the normal types of transmitting and receiving apparatus, chapters are devoted to auto-alarm apparatus and direction-finding gear.

The work is of a most comprehensive character and completely fulfils the object for which it is written. It can be recommended to all seeking information on marine wireless equipment.

A.J.G.

"The Elementary Principles of Wireless Telegraphy and Telephony." By R. D. Bangay, third edition revised by O. F. Brown, M.A., B.Sc. London, Iliffe & Sons, Ltd. Pp. 268. 10/6 net.

Very few persons engaged on wireless in pre-war days will be unacquainted with Bangay's work. The writing of a successful book on elementary principles is always a difficult matter as the author rarely manages to come down to the level of the reader. Bangay was particularly successful in this way and was able to retain the interest of the reader and to cover by easy stages a fairly complete outline of the subject.

In this revised edition the first 149 pages contains the original text with a few minor additions; the remainder is due to Mr. O. F. Brown. The result has been very successful and the present book constitutes a very useful elementary text-book. Among the subjects dealt with in the added section is the more detailed explanation of the principles of thermonic valves and their associated circuits, the subject of valve transmitters, radio telephony transmitters, broadcasting receivers and direction-finding. The book is a welcome addition to the elementary literature on the subject of radio telegraphy and telephony.

A.J.G.

"Easy Lessons in Television." By R. W. Hutchinson. London, W. B. Clive—University Tutorial Press, Ltd. Pp. 175. 1/9 net.

This little book gives an elementary description of the principles and apparatus used in television by the Baird system.

The book contains descriptions of much apparatus which, strictly speaking, has nothing to do with television, such as electric motors, wireless components, spark radio telegraphy and wireless receivers, and as a result the reader is liable to acquire rather a confused idea of the subject. This result is also assisted by the disjointed method of dealing with the subject.

On the other hand the book is low in price and contains a fair amount of information which will doubtless be of interest to those desiring an elementary idea of the subject.

A.J.G.

" The Theory and Design of Illuminating Engineering Equipment." By L. B. W. Jolley, M.A. (Cantab.), M.I.E.E., J. M. Waldram, B.Sc. (Eng.), G. H. Wilson, B.Sc. (Eng.), A.M.I.E.E. 709 pp. Published by Messrs. Chapman & Hall. Price 45/- net.

This book covers a very large field which is only limited in that electrical sources of light alone are dealt with. It deals comprehensively with the design of the equipment necessary to obtain good illumination and to this end physiological considerations are taken into account as far as they affect design and methods of calculation.

That the book is comprehensive will be seen from the following brief summary of the contents. After a preliminary discussion as to the nature of light, vision, and visual reactions, a section is provided dealing with methods of calculation; the distribution of light flux and intensity of illumination; and the effects of reflecting and transmitting media. The physics of light production are then considered and the various types of lamps dealt with seriatim. We thus get a full discussion of the ordinary types of incandescent lamps, vacuum and gas filled, tungsten arc lamps, carbon arc lamps and gaseous conduction lamps such as those of the neon and mercury vapour types.

The authors then deal with the types and uses of equipment for interior lighting, street lighting, flood lighting, display lighting, etc. The materials used and the details of design are fully considered with the use of reflectors, refractors and diffusers. Optical projecting systems dealt with include car headlights, searchlights, signal lights for street and railway use, and cinema projectors.

Special equipments such as are required for stage lighting, illuminated signs, studio lighting, air port lighting and many other uses are also considered, together with such auxiliary apparatus that is specially applicable to illuminating engineering and is not described in detail elsewhere.

The book is completed by a series of appendices giving useful data, lamp characteristics, tables and diagrams for use in calculations, etc.

It will thus be seen that the authors have written a book which is comprehensive in its scope, and being well illustrated and arranged it forms an excellent reference book on all aspects of electrical illuminating engineering.

J. McG.

" Telegrafia Sottomarina (Cablografia)." By Ing. Italo de Giuli. Published by Ubrico Hoepli, Milan. Price 30 lire.

This practical manual of submarine cable telegraphy is somewhat unique in that it covers the entire field of elementary theory, laying, operating, maintaining and testing submarine cables and submarine telegraph apparatus. The first section is devoted to descriptions of methods of manufacture and the laying of cables and of transmitting and receiving apparatus. Alphabets, signals and elecrical characteristics are also dealt with in a simple fashion. The second section deals with the equipment of cable stations. In the third section the principal tests used in submarine cable telegraphy are described and explained. Section four deals with multiplex working and section five is devoted to the construction, characteristics and testing of loaded cables. The book is well illustrated and will be useful not only to those actively employed in maintaining and operating submarine cables, but also to students and others who wish to obtain a general knowledge of the whole of this interesting subject.

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