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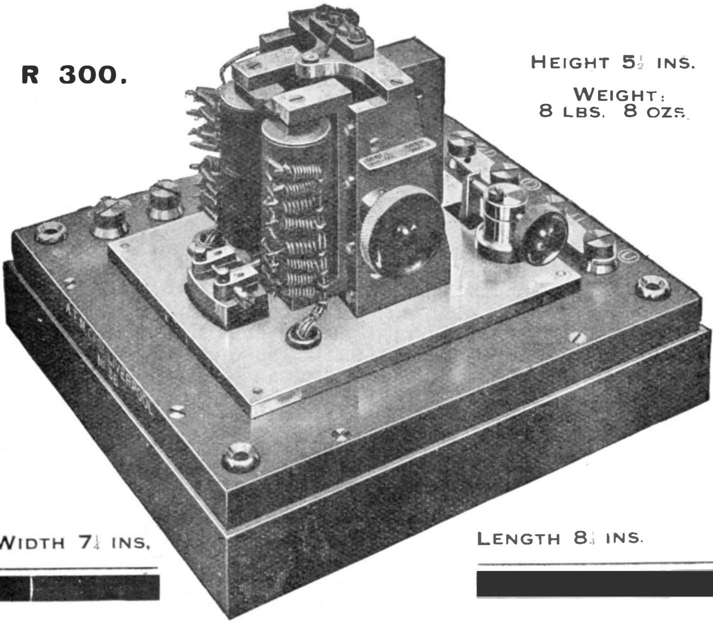

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THE
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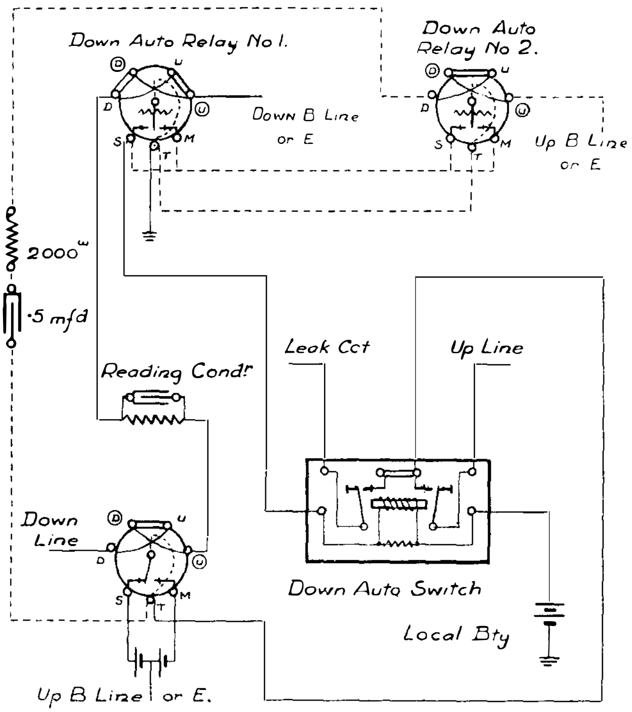
SIMPLEX WORKING ON FAST SPEED REPEATERS.

On long aerial lines difficulty is experienced at times when owing to weather loss, etc., the received currents are too weak to actuate the Auto relay, although the transmitting relay may be



CIRCUIT OF SECOND AUTO. RELAY DOTTED.

functioning perfectly. This applies more especially to the period when reversals are being sent by the distant transmitter. Similar conditions obtain on long underground circuits which are being worked at or near the possible maximum speed.

The Auto relay can never be quite so sensitive as the Line relay owing to the presence of the controlling springs and the necessity for more open contacts, as the tongue must be capable of taking a central position where, when at rest, it touches neither the "marking" nor "spacing" contact.

By the addition of a second Auto relay, joined up as shown by the dotted connections on the diagram, it is possible to utilise the signal sent out by the line relay for the purpose of keeping the automatic switch closed whilst signals are passing.

This arrangement obviates the necessity for reducing the resistance of the reading condenser, as is sometimes done, in order to make the Auto relay function properly and will therefore assist in maintaining the normal speed of working.

E. LACK.

THE LONDON—GLASGOW TRUNK TELEPHONE CABLE AND ITS REPEATER STATIONS.

THE London-Derby No. 2 cable, which was accepted from the Contractors (Standard Telephones & Cables Limited) in December last, completes the London-Glasgow cable, the backbone of the trunk telephone cable network of Great Britain. The Derby-Glasgow section of the cable has already been in partial use for about a year, extension to London being provided by means of spare quads in the London-Derby No. 1 cable.

The object of this article is to describe particularly the London-Derby No. 2 cable, which represents the most modern practice in telephone cable manufacture and installation, and the Repeater Stations between London and Glasgow, all of which were equipped by the Standard Telephones & Cables Limited (formerly the Western Electric Co. Ltd.).

Fig. 1, which is reproduced from our Volume XVIII., page 261, shows the route of the main cable with its spurs and the location of the Repeater Stations.

As an indication of the density of traffic it may be noted that there are three telephone cables in the section London to Fenny Stratford, comprising a total number of 200 quads together with 28 telegraph quads, and between Fenny Stratford and Derby there are two cables, comprising a total of 202 quads including the telegraph quads previously mentioned, while the Derby repeater station is designed for an ultimate equipment of 1500 repeaters.

CABLE.

Of the three cables between London and Fenny Stratford, one is the old London-Birmingham cable which was described in this Journal, Volume VIII., page 206. The second is the London-Manchester cable, which is a medium-medium loaded cable installed immediately after the War and worked exclusively on a 2-wire basis and also furnishes the telegraph quads previously mentioned, and runs from London to Manchester with repeaters at Fenny Stratford and Derby. The third is a new cable furnishing the long circuits going North of Derby on the Glasgow route. A cross-Section of this cable is shown in Fig. 2. This route runs from London to Glasgow with repeaters at London,

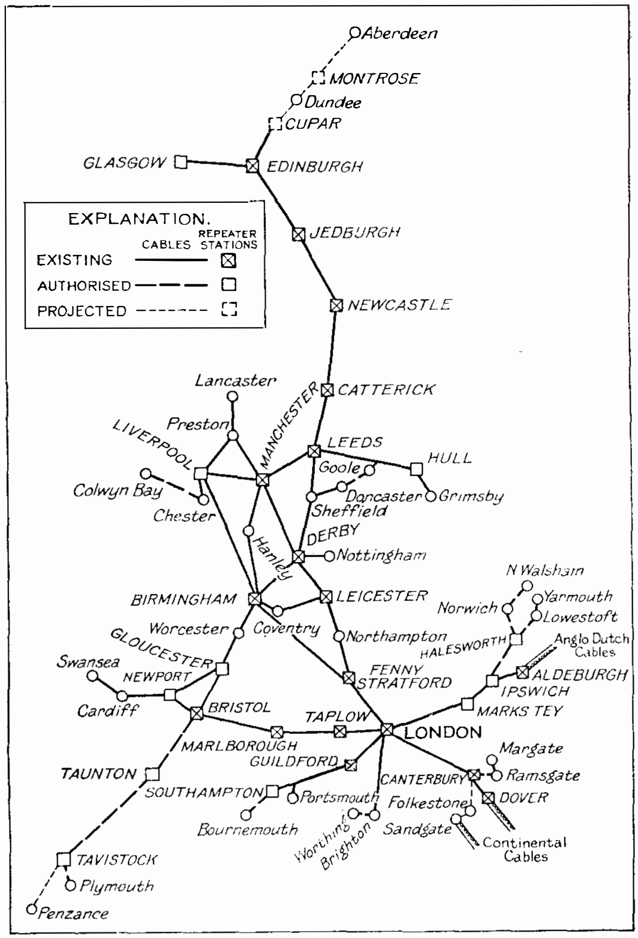


Fig. 1.—Telephone Repeater Stations—Plan of Systems.

Fenny Stratford, Derby, Leeds, Catterick, Newcastle, Jedburgh, Edinburgh and Glasgow. This cable is of particular interest as it shows the segregation of the 4-wire circuits in the Up and Down groups, while the 2-wire circuits form the centre of the cable. The 4-wire circuits are 20 lb. and are medium-heavy, half medium-heavy and extra light loaded in accordance with their allocation to various points on the route, while the 2-wire circuits are 40 lb. medium-heavy loaded throughout.

The order for the London-Derby portion of this long cable together with its loading equipment was placed in November, 1924, and the cable was completed in December, 1925.

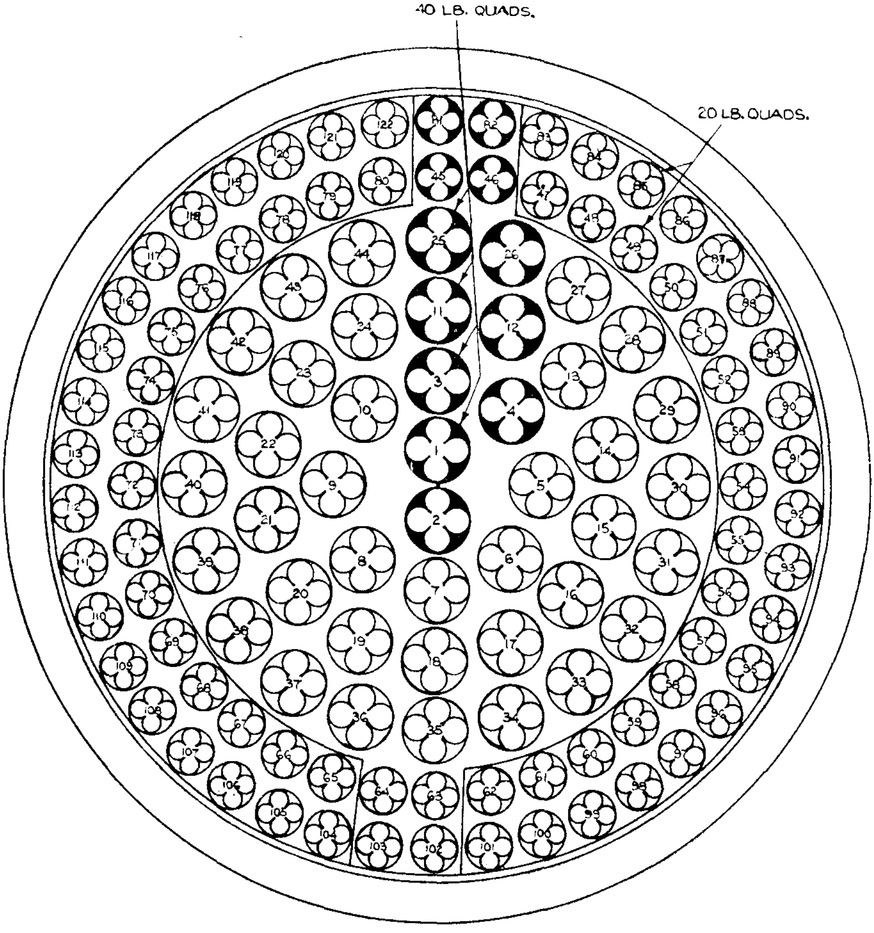


FIG. **2**.—SECTION, LONDON-DERBY CABLE.

During this period nearly 130 miles of cable were pulled in, tested and jointed and over 450 loading coil cases were installed. The cable consists of 44 quads of 40 lbs. conductors and 78 quads of 20 lbs. conductors arranged as shown in Fig. **2**. The loading is H-177-107, H-89-50 and H-44-25 (known as medium-heavy, half medium-heavy and extra light respectively, where H represents the loading coil spacing and equals 6000 ft., the first figure the

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L.S. No.
Type of Test

CAPACITY UNBALANCE DATA SHEET. .... BUFF

Date

LONDON SIDE					SIDE			CALCULATED RESULTANT		CHECK TEST			DERBY. SIDE			
QUAD No.	1 2 3	U V	PH TO S S TO S	JOINTING DIAGRAM	PH TO S S TO S	U V	QUAD No.	PH TO S S TO S	U V	PH TO S S TO S	U V	1 2 3	PH TO S S TO S	U V	1 2 3	QUAD No.
1			−25 −30 −15		+15 +50 +35		26	+10 +20 0					+25 −5 −5			1
2			−30 −20 +15		+30 +15 −10		27	0 −5 +5					+5 −45 +15			2
3			−25 +45 +5		−5 +30 −15		20	−10 +15 0					+50 +40 +5			3
4			−25 −25 +10		−10 −20 −25		32	0 −5 0					−20 −30 +15			4
5			−5 +10 +5		+5 +10 +10		9	0 0 −5					−30 −10 −25			5
6			+25 −30 +15		−15 −15 +15		36	+10 −15 0					−5 −15 −25			6
7			−15 −5 +25		+25 −15 +10		34	−5 +10 0					+5 0 −25			7
8			+10 +10 −10		+15 +10 +10		31	−5 0 0					+15 +30 +15			8
9			−20 +5 +5		+10 +10 +25		29	+5 −5 −5					+5 +10 +10			9
0			+25 −30 −10		−35 −30 −20		33	−10 0 +10					−5 +25 −5			0
11			+30 +25 −25		−20 −30 +15		4	+10 −5 −10					−25 +10 −35			11
12			+20 +10 −10		+15 +5 +15		35	+5 +5 +5					−60 +5 +10			12
13			+10 +5 −30		+15 +10 +25		28	−5 −5 −5					+10 +10 +25			13
14			−20 +25 −30		+35 −15 +30		30	+10 +10 +5					−30 +10 +10			14
15			−20 −20 +10		+5 −45 +15		2	−5 +25 +5					+10 −5 −30			15
16			+25 −25 +5		+5 −10 −20		43	+5 −15 0					−5 −20 −25			16
17			−45 −30 −10		+45 +10 +5		24	0 −20 −5					+20 +15 0			17
18			−40 +10 −5		+50 +10 +5		18	+10 +20 0					+50 +10 +5			18
19			+20 +5 +25		−25 −15 −25		38	−5 −10 0					+5 −10 −50			19
20			−15 −5 −15		+25 +10 +15		40	+10 +5 0					−5 +30 −15			20

TESTER	LOCATION	REMARKS.
JOINTER	TEST POINT	
WEATHER	TO	
SET No.	AND	

FIG. 3.—TYPICAL JOINTING DIAGRAM.

side circuit coil inductance and the second figure the phantom circuit coil inductance). The following circuits are initially provided:—

102	circuits	40 lbs.	H-177-107	for	2-wire.
6	,,	40 ,,	H-44-25	,,	transatlantic work.
60	,,	20 ,,	H-177-107	,,	4-wire.
42	,,	,, ,,	H-89-54	,,	,,
6	,,	,, ,,	H-44-25	,,	,,

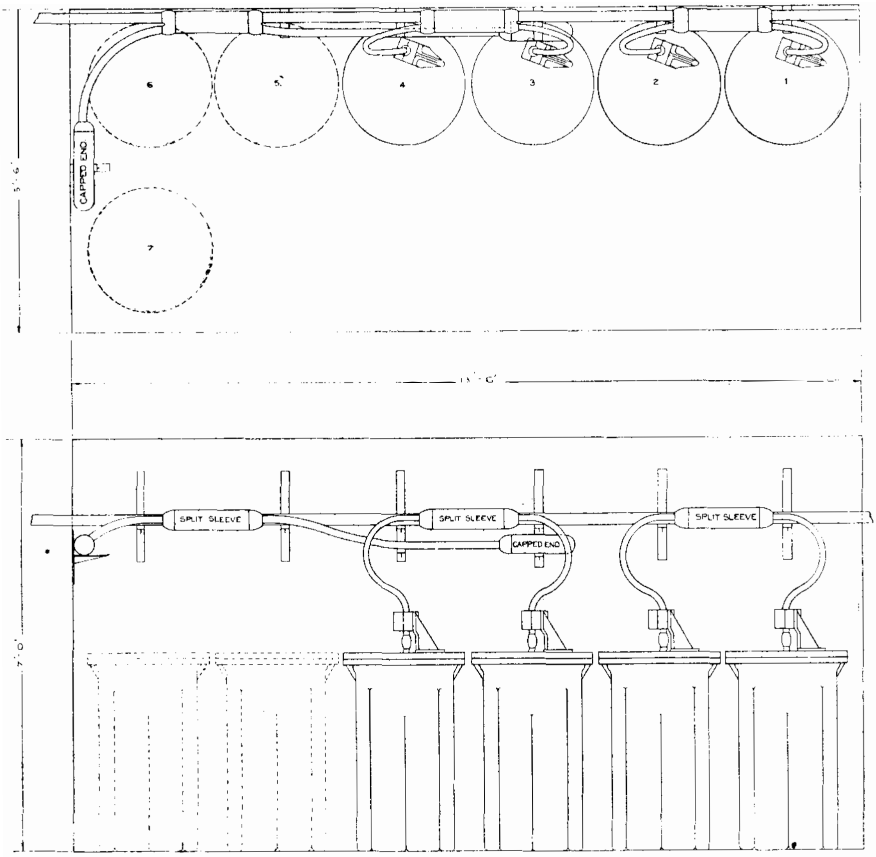


FIG. 4.—LAYOUT OF MANHOLE WITH SINGLE STUB CASES.

A typical jointing diagram for this cable is shown in Fig. **3**, which illustrates the method of jointing a cable by which the capacity unbalance is reduced by cross-splicing. There are usually three or seven such test splices made in each loading section.

Loading.—In connection with the loading of the new cable, of which a cross-section was shown in Fig. **2**, single stub loading coil cases have been used. This method of jointing loading coils into cables has an advantage over the two-stub method generally used on previous cables as it makes the loading coil manhole lay-

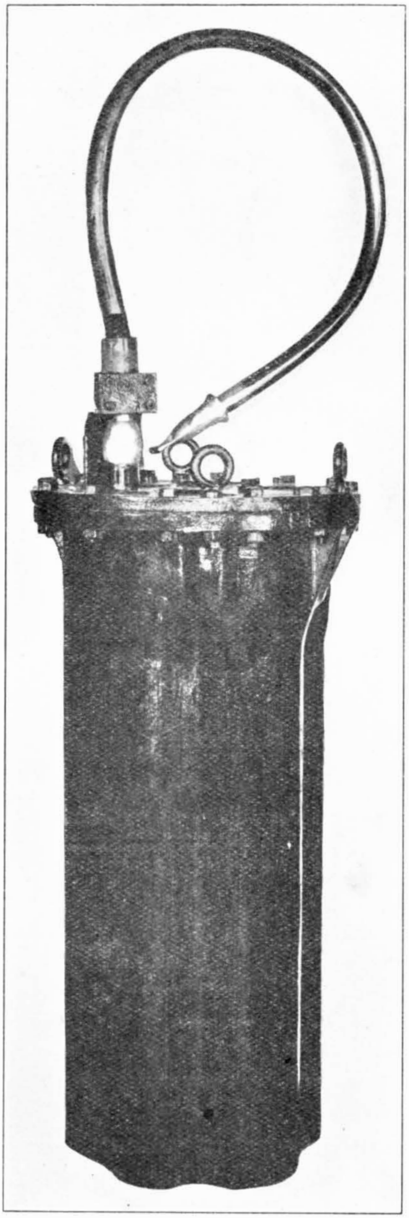


FIG. 5.—LOADING COIL CASE WITH SINGLE STUB.

out very much simpler. Fig. 4 shows the layout of loading coil cases in a manhole on this cable and illustrates the simplicity and advantages of using the single stub construction. A photograph of one of the loading coil cases with a single stub, as used on this cable, is shown in Fig. 5.

Repeater Sections.—From the point of view of obtaining good transmission results from a repeatered system it is necessary that the constants such as impedance, attenuation, etc., of each repeater section shall be as uniform as possible, both as regards the values when plotted against frequency for any individual circuit as well as within each type of group. It is also essential that the cross-talk in the repeater section of cable shall be held within fairly close limits, since it can be proved that the repeater section cross-talk is the most important factor in the overall circuit cross-talk.

As explained above, it is important that the characteristics of the circuits shall remain as constant as possible, and for this purpose the following methods were adopted:—

Capacity Unbalance and Resistance Unbalance.—These unbalances were reduced as much as possible during the manufacture of cable lengths. Further reductions were obtained in the field by means of special test joints. Capacity unbalance was reduced generally at 3 test joints in each loading section, this number being increased to 7 at the ten loading sections adjacent to each repeater station.

Capacity Deviation.—The "regularity" to be maintained on the circuits, which was referred to earlier in this article, is closely connected with the deviations from the average mutual capacity. These capacity deviations are of two kinds, circuit deviations and section deviations. By the former is meant the deviations of the individual circuits of a group in a loading section from the average capacity of all the circuits in that group. By section deviation is meant the deviation of the average mutual capacity per loading section of a group of circuits from the average capacity for that group for all loading sections.

Circuit deviation was reduced both in the factory and in the field. In the latter case one test joint was made in each loading section, but this was confined to the ten loading sections adjacent to each repeater station.

The final tests on this cable were of two kinds, those on repeater sections and those on the repeatered system.

The following tests were made on the two repeater sections:—

(i) Loop Resistance.
(ii) Resistance Unbalance.
(iii) Insulation Resistance.
(iv) Singing Point.
(v) Impedance frequency.
(vi) Attenuation.
(vii) Cross-talk.

Tests Nos. (iv) (v) and (vii) were made from each end of each repeater section, the others being made from one end only. The results of these tests are summarised below:—

(i) *Loop Resistance.* This test was made chiefly as an assurance as to the uniformity of resistance of all similarly loaded circuits of the same gauge.

(ii) *Resistance Unbalance.* This test was made to measure the resistance unbalance between the wires of each pair. In no case was a resistance unbalance of more than 2 ohms found, the average unbalance being about 0.2 ohms.

(iii) *Insulation Resistance.* The insulation resistance was measured on all wires, and no value lower than 50,000 megohms per mile observed.

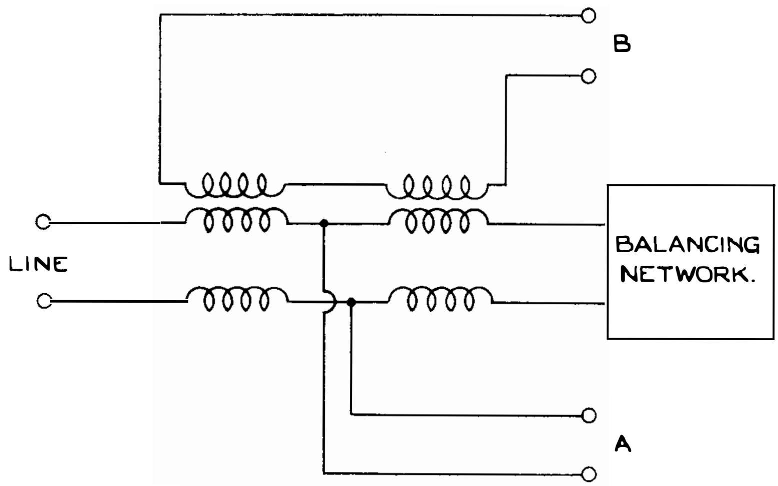


FIG. 6.—CIRCUIT OF UNBALANCE SET.

(iv) *Singing Point.* The singing points of all 2-wire circuits were measured from each end of each repeater section. The results are tabulated later.

Two distinct methods of measurement were adopted, one using a singing point test set and the other an impedance unbalance measuring set.

The singing point test set is virtually a portable 2-wire repeater and the results of the tests made with it are therefore a direct indication of the maximum gain which could be inserted in the line at the point at which the test is taken. As the maximum gain which it is usually desirable to obtain from a 2-wire repeater is of the order of 15 TU it will be seen from the results of the singing point test, that a very ample margin of safety exists on the circuits of the London-Derby cable. This margin, however, has a directly beneficial effect on the quality of speech transmitted.

From the results obtained in this way typical circuits were selected for further analysis.

The other method of measuring singing points is based on the relation between singing point and the impedance unbalance between two circuits or a circuit and its balancing network.

Fig. 6 shows the essential part of the circuit by which singing points are measured when using the Impedance Unbalance Measuring Set. The coil shown in the figure is the so-called "hybrid" coil which is used in 2-wire repeaters to obtain duplex

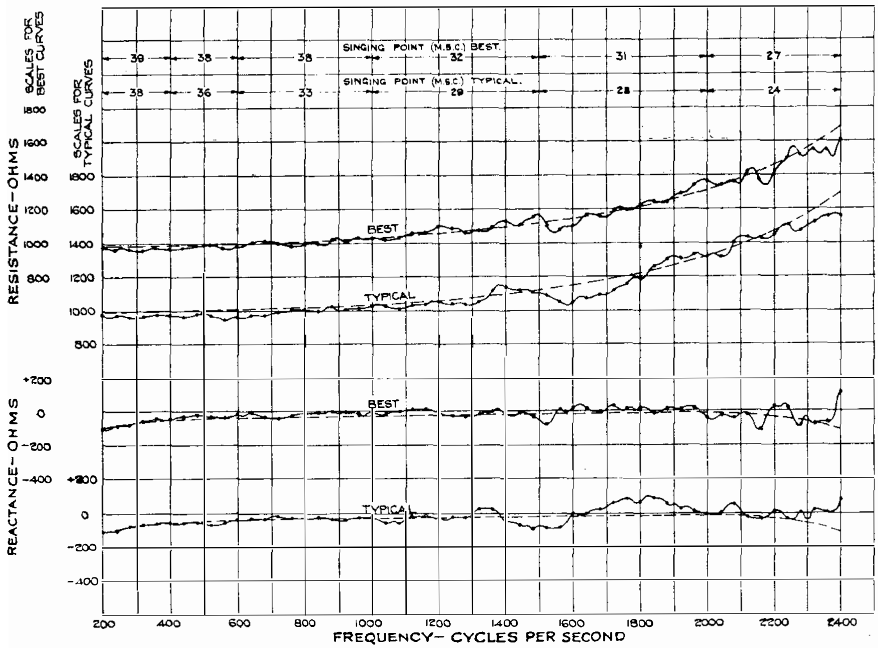


Fig. 7.—Impedance Curves H-177-107. Medium Heavy 40 lbs. Phantom Circuits.

operation. If the balance between line and network were perfect, the transmission loss between A and B would be infinite—*i.e.*, all current entering the circuit at A is divided between the line and network, no current passing across the windings to B. As soon, however, as there is any impedance unbalance between line and network some current does flow from A to B, the amount of this current depending on the magnitude of the impedance irregularity.

The Impedance Unbalance Measuring Set is designed to measure the transmission loss between A and B, and since both this loss and the singing point are dependent on the degree of balance between line and network the set may be calibrated to read the singing point of line and network.

With this apparatus it is possible to measure the singing point of the line at any required frequency, whilst the singing point test set merely selects the frequency, within the efficient range of the repeater, at which the unbalance is greatest and the singing point consequently lowest.

Singing points were measured with this set at frequency intervals of 20 p.p.s. from 200-2400 p.p.s.

This frequency range was then divided up into bands and the lowest value of singing point recorded for each band.

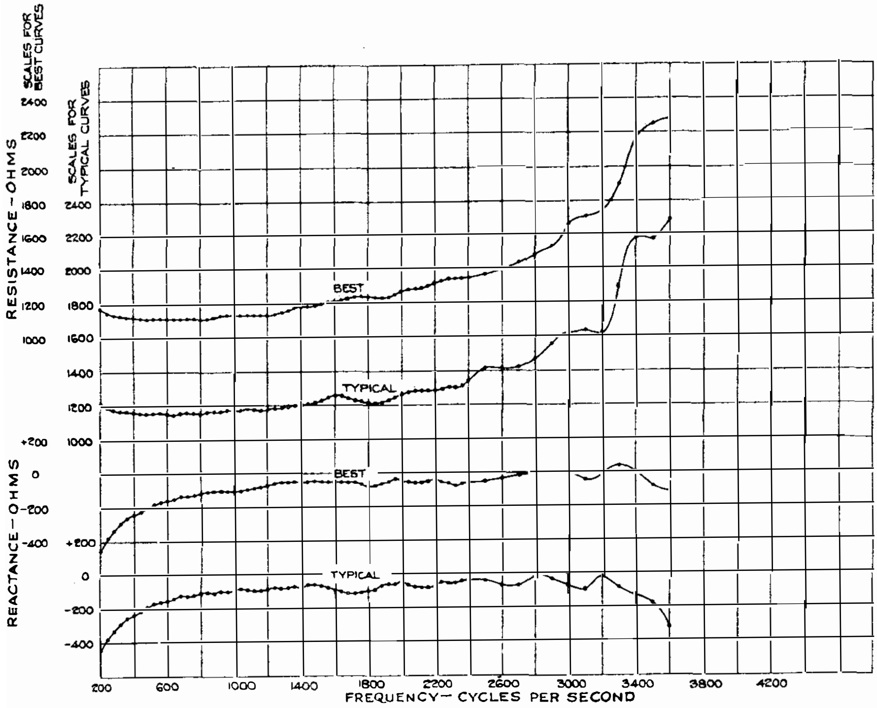


FIG. 8.—IMPEDANCE CURVES H-89-54. 20 LBS. SIDE CIRCUITS.

(v) *Impedance frequency.* Impedance frequency tests were made on about 10% of the loaded circuits in the cable, the 2-wire circuits being the same as those selected for the singing point tests made with the impedance unbalance set.

Typical curves are shown in Figs. **7**, **8** and **9**. Impedance frequency curves afford a ready means of ascertaining the degree of regularity obtained on the circuits. Ideally, of course, the impedance frequency curve for the line would be quite smooth, and in such a case a perfect balance would be possible between a line and its balancing network, which would give an infinite value for the singing point, provided always that the repeater itself were perfectly balanced.

In practice, however, irregularities will always appear in the curve and since it is not practicably possible to construct a balancing network which would follow the irregular shape of the curve there will always be impedance unbalances between line and network at many points in the frequency range.

The singing point of the line will depend on the magnitude of these unbalances.

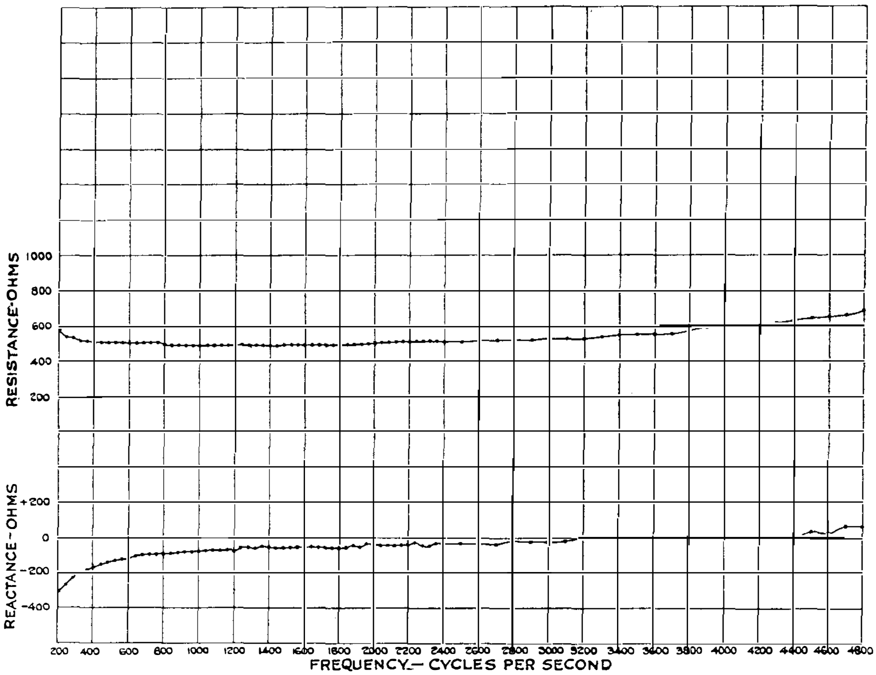


FIG. 9.—IMPEDANCE CURVES H-44-25. 20 LBS. PHANTOM CIRCUIT.

One point is of considerable interest in this connection and is illustrated by Fig. 7, which shows the impedance frequency curve of one of the 2-wire circuits. On the same curve is plotted the impedance frequency curve of the standard network with building out condenser which is employed at the repeater stations. With cables constructed, installed and tested by the method employed on this cable the networks can be designed from the prime constants of the cable and one network will furnish excellent results with all circuits. Details of these networks and a multi-unit condenser which is used as a building-out section will be dealt with under Repeater Equipment.

SINGING POINTS (TU).

Repeater Section.	Tested from	Circuit		Singing Point Measured with Impedance Unbalance Set. Frequency Bands						S.P. Measured with S.P. Test Set.
				200-400	400-600	600-1000	1000-1500	1500-2000	2000-2400	
London	London	Side	Best	37	38	36	35	28	22	32
,,		,,	Worst	37	38	33	26	24	23	24
,,	,,	Phant.	Best	34	33	32	29	28	25	3[illegible]
,,	,,	,,	Worst	36	36	32	26	24	24	22
,,	Fenny Stratford	Side	Best	38	38	35	30	32	24	32
,,		,,	Worst	38	38	30	24	24	26	26
,,	,,	Phant.	Best	37	36	36	30	29	26	32
,,	,,	,,	Worst	38	34	30	29	25	25	26
Derby	Fenny Stratford	Side	Best	37	36	35	34	32	28	32
,,	,,	,,	Worst	37	35	34	34	27	27	29
,,	,,	Phant.	Best	38	34	35	33	24	23	21
,,	,,	,,	Worst	38	31	32	28	24	25	24
,,	Derby	Side	Best	35	38	31	32	29	26	32
,,	,,	,,	Worst	34	35	32	26	28	25	27
,,	,,	Phant.	Best	36	37	37	36	28	21	32
,,	,,	,,	Worst	35	32	32	30	30	22	25

N.B.—The above figures are the lowest values of singing point recorded in the various frequency bands.

(vi) *Attenuation.* Measurements of attenuation were made at various frequencies, all loaded circuits being measured at 800 and at 2000 p.p.s., and a number of circuits, typical of each circuit group, over a frequency range.

The average attenuation, corrected to 50°F., for each type of circuit at 800 and 2000 p.p.s. is given in the following table:—

Attenuation (β per mile at 50° F.).

Type of Circuit.		800 c.p.s.	2000 c.p.s.
40 lb. H-177-107	Side	.0177	.0230
	Phantom	.0145	.0194
20 lb. H-177-107	Side	.0306	.0354
	Phantom	.0249	.0292
20 lb. H-89-54	Side	.0398	.0416
	Phantom	.0320	.0339
40 lb. H-44-25	Side	.0288	.0301
	Phantom	.0238	.0253
20 lb. H-44-25	Side	.0537	.0553
	Phantom	.0451	.0468

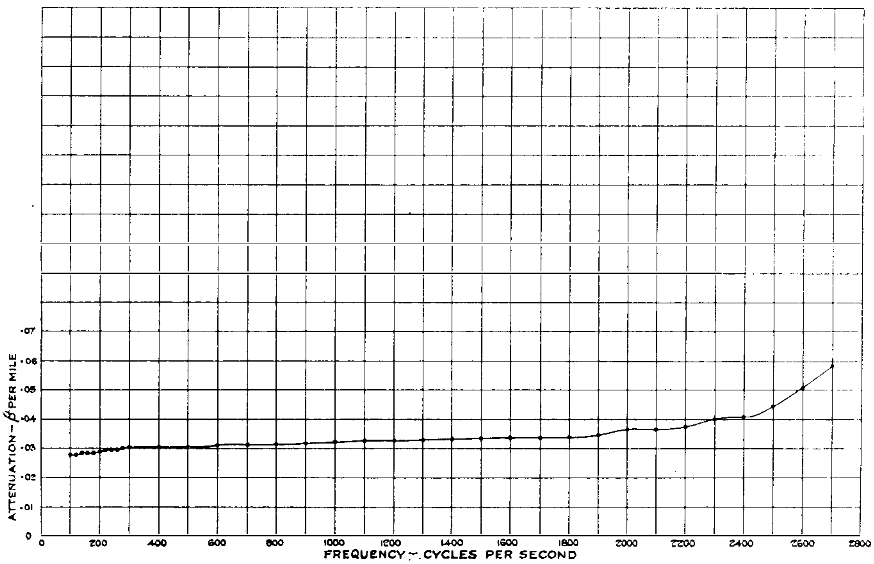


FIG. **10**.—ATTENUATION VS. FREQUENCY CURVE H-177-107. 20 LBS. SIDE CIRCUIT. MEASURING CURRENT 0.5 M.A.

In Fig. **10** is shown a typical attenuation frequency curve.

(vii) *Cross-talk.* Cross-talk measurements were made on all loaded circuits, using as testing current a complex tone which gives results very close to those which would be obtained in a speech test.

Near End cross-talk was measured on all 2-wire circuits. In these tests the measuring apparatus and the source of tone were always at the same end of the circuit.

Far End cross-talk was measured on the 4-wire circuits, tone being placed at one end of the circuit and the measuring apparatus at the far end.

All cross-talk results given in this article have been corrected in the case of phantom to side cross-talk on the basis of the phantom and side circuit impedances, and in the case of Far End cross-talk on the basis of the equivalent of the circuit over which the testing tone is sent.

The results are tabulated below :—

Near End Cross-talk (Cross-talk Units).

	Phantom-side.		Side-side.		Phantom-Phantom.	
	Ave.	Max.	Ave.	Max.	Ave.	Max.
40 lb. H-177-107	185	320	105	160	105	250

Far End Cross-talk (Cross-talk Units).

	Phantom-side.		Side-side.		Phantom-Phantom.	
	Ave.	Max.	Ave.	Max.	Ave.	Max.
London Repeater Section. 46.4 *miles.*						
20 lb. H-177-107	130	295	55	110	45	115
20 lb. H-89-54	90	190	25	60	25	45
20 lb. H-44-25	75	120	15	15	—	—
40 lb. H-44-25	180	250	65	75	—	—
Derby Repeater Section. 81.5 *miles.*						
20 lb. H-177-107	85	115	15	30	10	25
20 lb. H-89-54	60	85	5	5	5	5
20 lb. H-44-25	20	30	5	5	—	—
40 lb. H-44-25	155	175	130	145	—	—

Overall Tests.—The final series of tests made were system tests over repeatered circuits. The cable was completely installed before the repeaters were in operation and temporary repeater equipment was installed in order to enable overall tests to be made.

This temporary equipment was installed at London, Fenny Stratford and Derby in such a way as to allow both 2- and 4-wire repeaters to be inserted in any required cable circuits, which would then be set up from London to Derby and back again to London. Fig. **11** shows the arrangement of the repeaters on these circuits, from which it will be seen that both ends of the circuits were available in London.

The following tests were made on these 250 mile circuits :—

(i) Overall transmission equivalent.

(ii) Cross-talk.

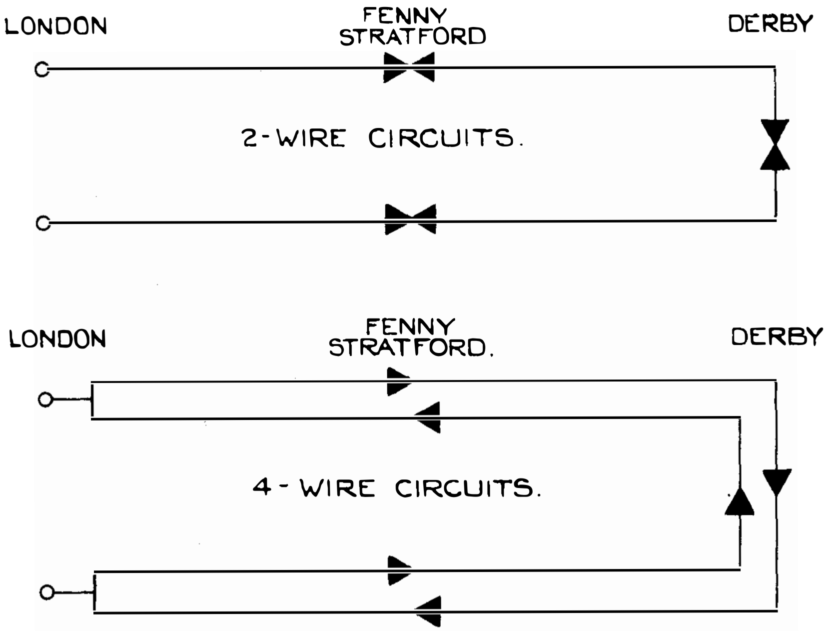


FIG. 11.—OVERALL TESTS : ARRANGEMENTS ON REPEATERS.

(i) Here again, all circuits were measured at 800 and 2000 p.p.s., the results of the tests being given below :—

800 *and* 2000 *c.p.s. tests.*

2-wire. Average overall equivalents in S.M. (1 *S.M.* = βl = 0.109).

	800 p.p.s.	2000 p.p.s.
Side	10.0	21.0
Phantom	9.0	20.0

4-wire. Average overall equivalents in S.M.

H-177-107	800 p.p.s.	2000 p.p.s.
Side	8.0	10.0
Phantom	6.0	7.0

H-80-54	800 p.p.s.	2000 p.p.s.
Side	13.5	15.0
Phantom	9.0	10.0

In the case of the half medium heavy circuit the above figures are somewhat high, due to the conditions of test. Under actual working conditions terminal repeaters will be used at London on the circuits, resulting in lower overall equivalents.

(ii) Cross-talk was measured through all the terminating equipment and the following results obtained:—

Overall Cross-talk (Cross-talk Units).

	Near End Cross-talk. 40 lb. H-177-107.		*Far End Cross-talk.* 20 lb. H-177-107.		20 lb. H-89-54.	
	Ph-S.	S-S.	Ph-S.	S-S.	Ph-S.	S-S.
Avg.	283	163	510	272	300	128
Max.	400	200	836	418	485	165

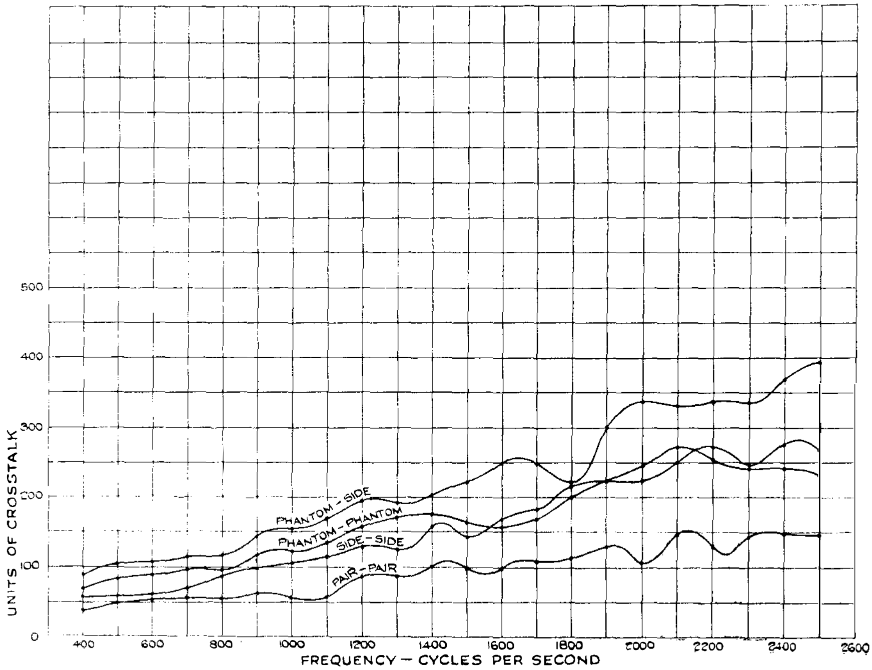


FIG. 12.—AVERAGE CROSS-TALK CURVES.

Particular attention should be paid to the cross-talk frequency curve shown in Fig. **12**, which gives the average figures obtained on the medium-heavy 40-lb. circuits for Phantom-Side, Side-Side, Phantom-Phantom and Pair-Pair, where the pairs are located in different quads.

REPEATER STATION EQUIPMENT.

To give a general picture of the apparatus, power plant, etc., used in the repeater stations on the North-East route, Fig. **13** shows a floor plan of the Derby repeater station. This floor plan does not cover the final station, which will cater for 1500 repeaters, as previously stated, but only with the repeaters installed up to the present time.

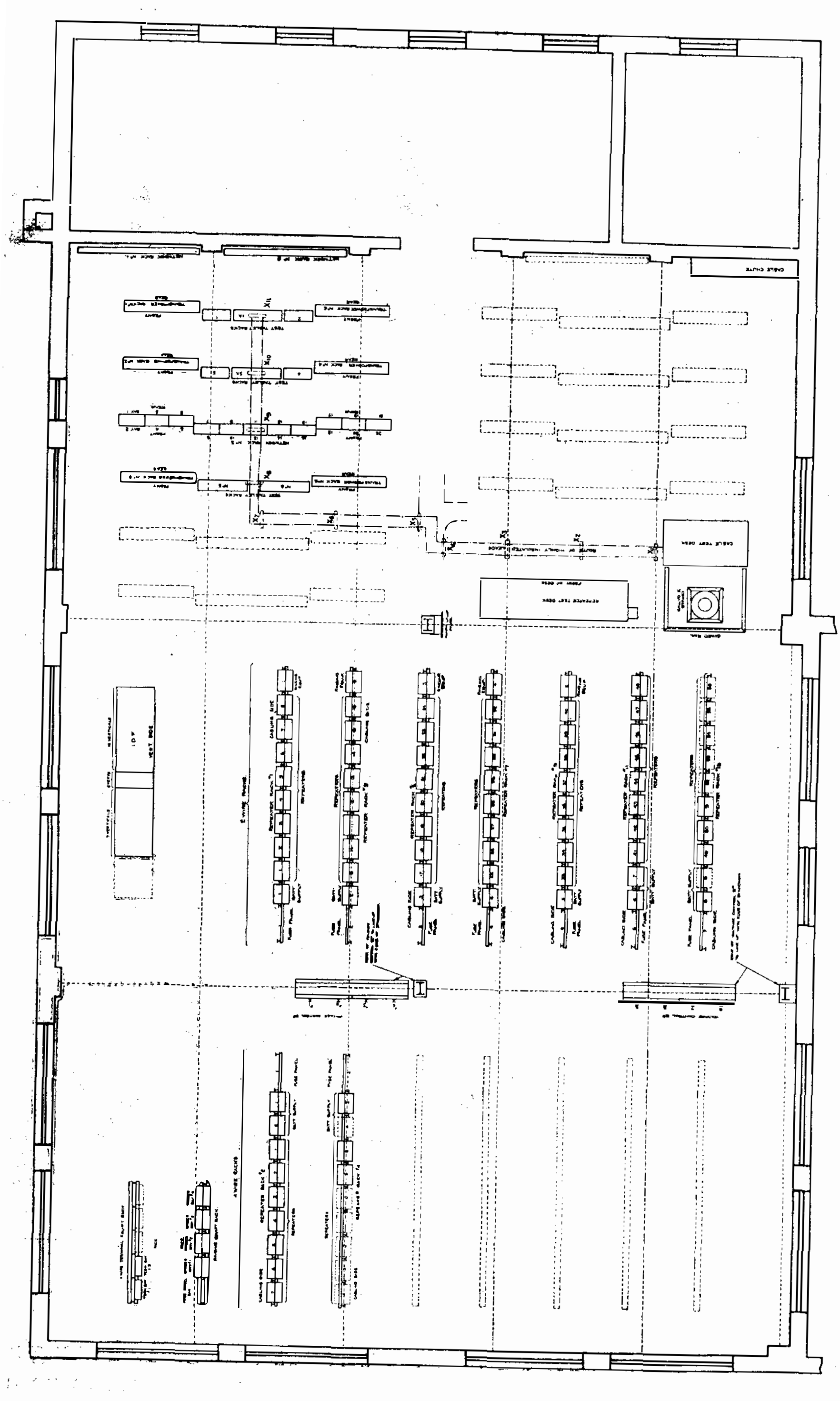
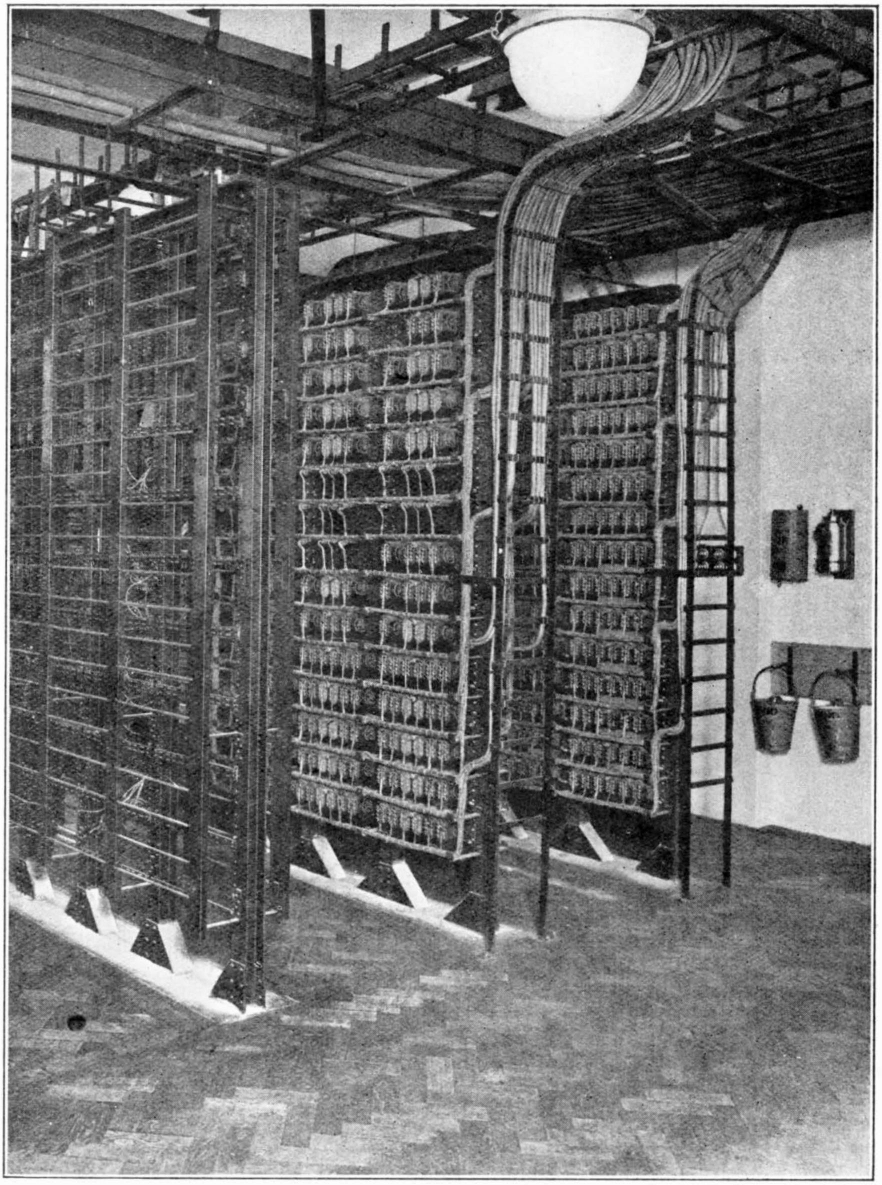


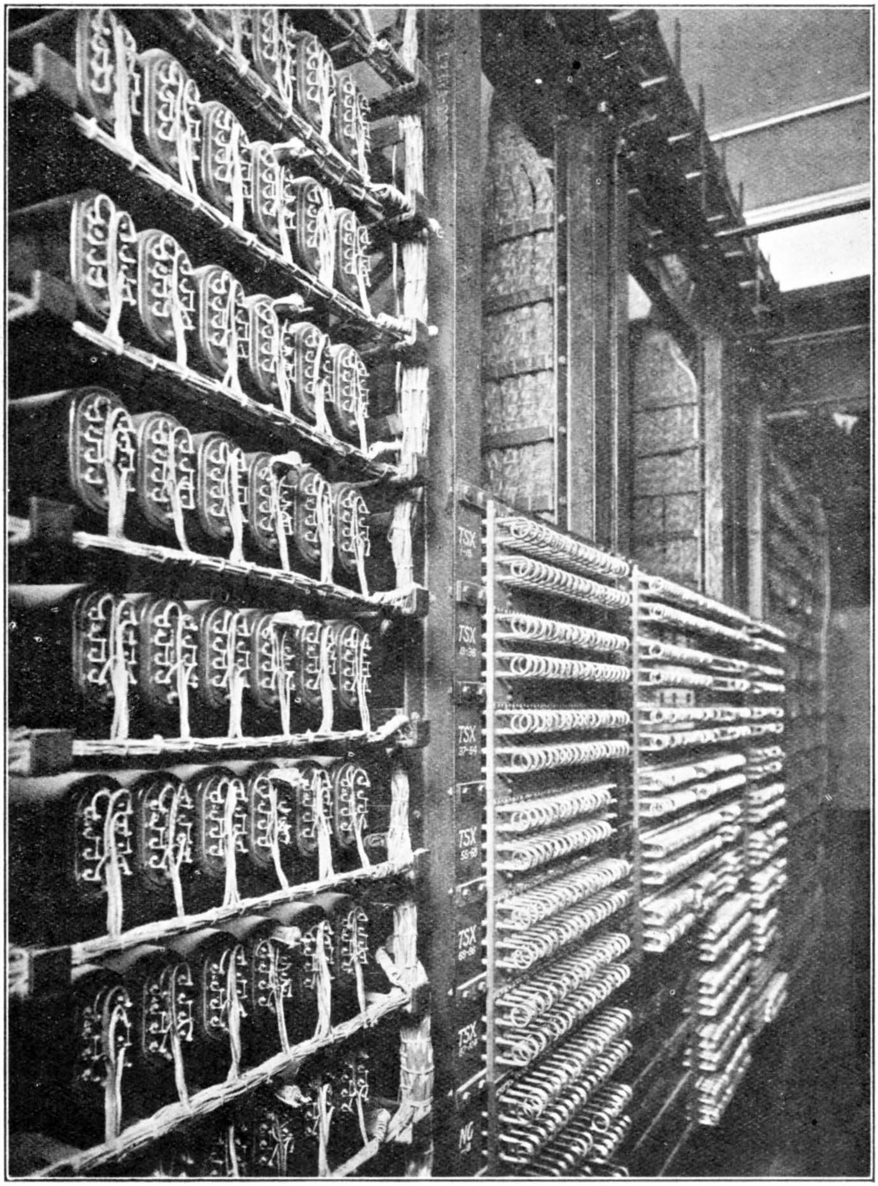
FIG. 13.--FLOOR PLAN, DERBY REPEATER STATION. (S.T. AND C. LTD. DRAWING, L 32669).

A series of photographs is given illustrating the power board, etc., at the Leeds repeater station; repeater bays, coil racks and test units at the Derby repeater station, and individual photo-

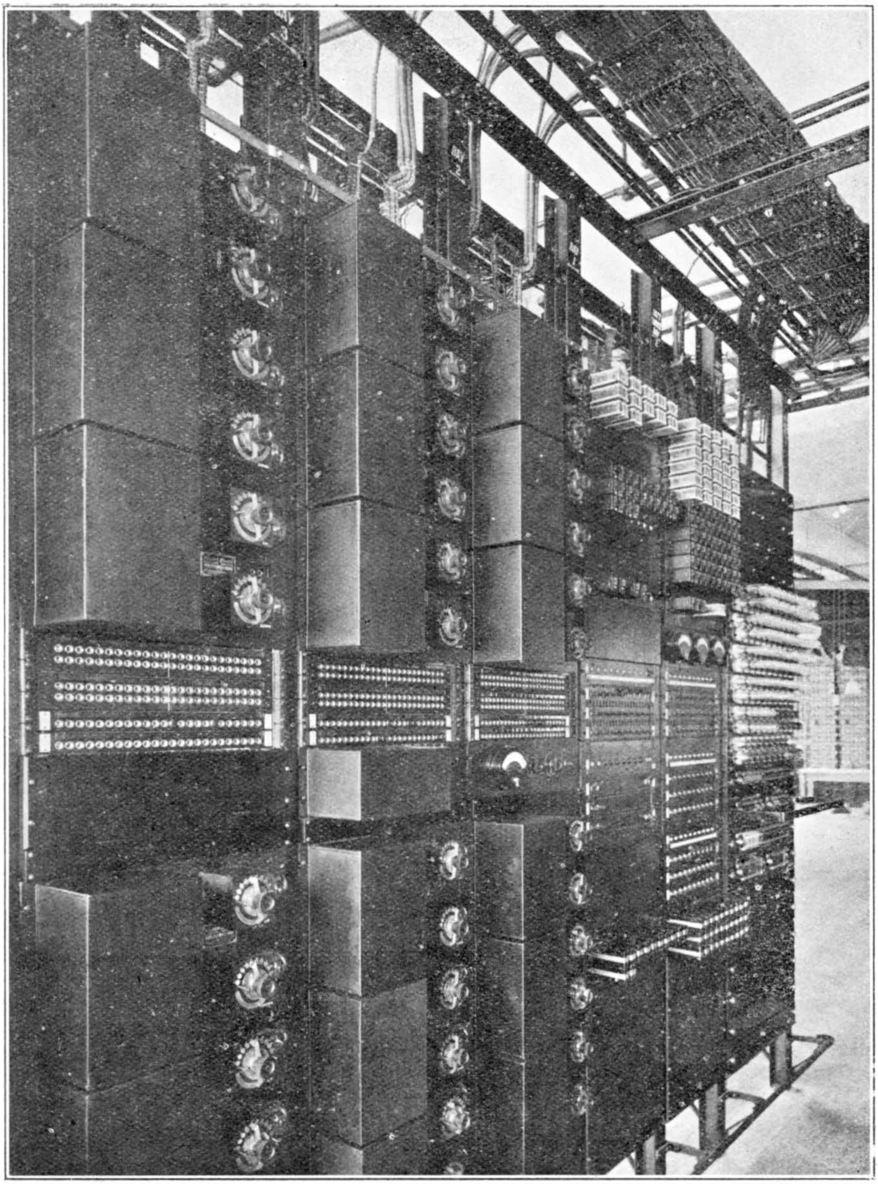


TEST TABLET AND TRANSFORMER RACKS. GENERAL VIEW.

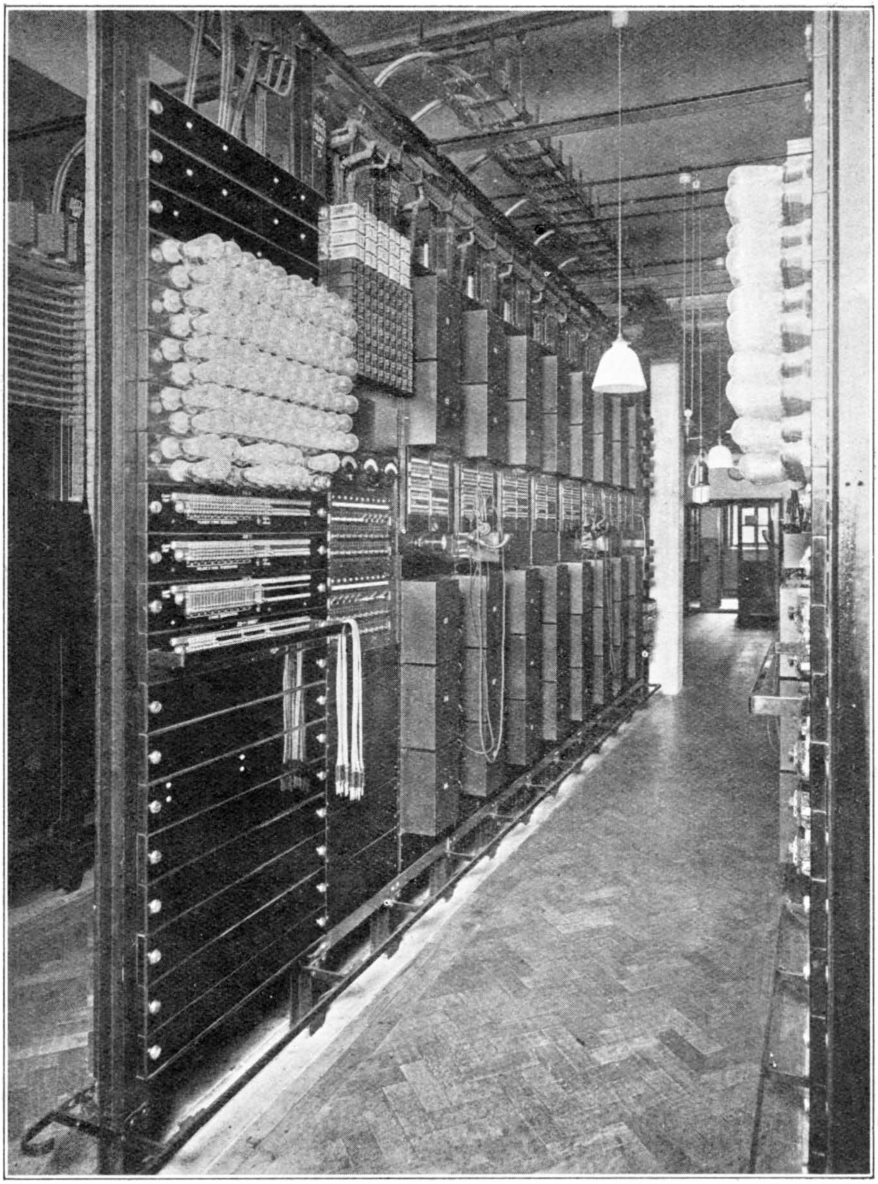
graphs of the repeater units, both 2-wire and 4-wire. It is thought that the photographs are sufficiently self-explanatory not to need any description and that there is more interest in a description of the circuits involved on the whole system than on the equipment.



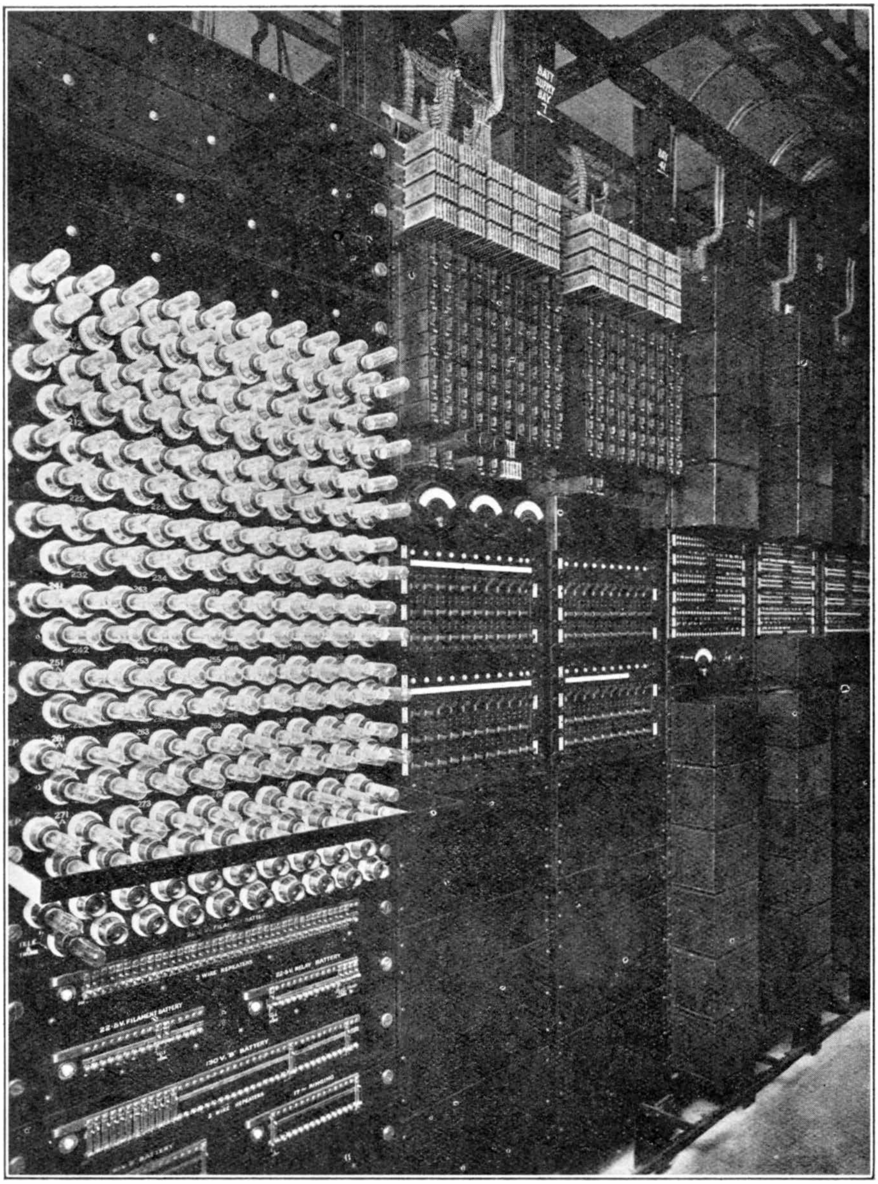
Test Tablets and Transformers.



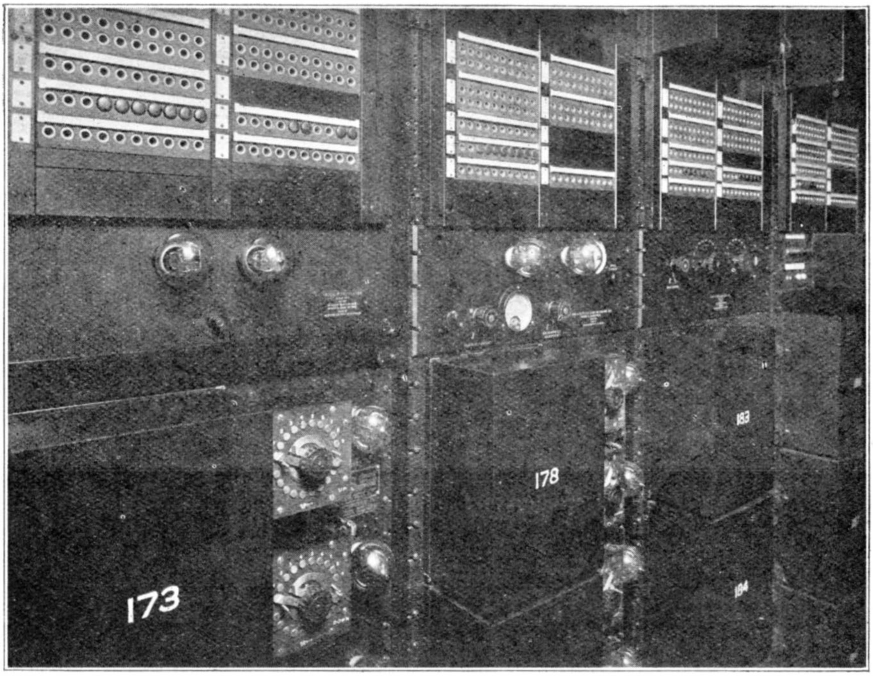
4-Wire Repeater Rack.



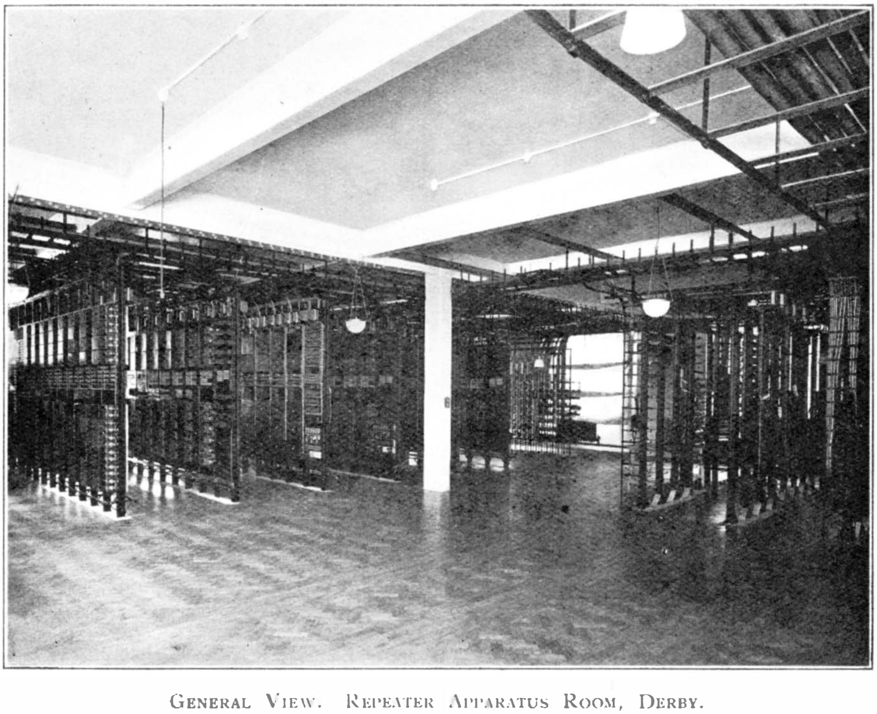
2-Wire Repeater Rack. Repeaters and Low-Frequency Signalling Apparatus.



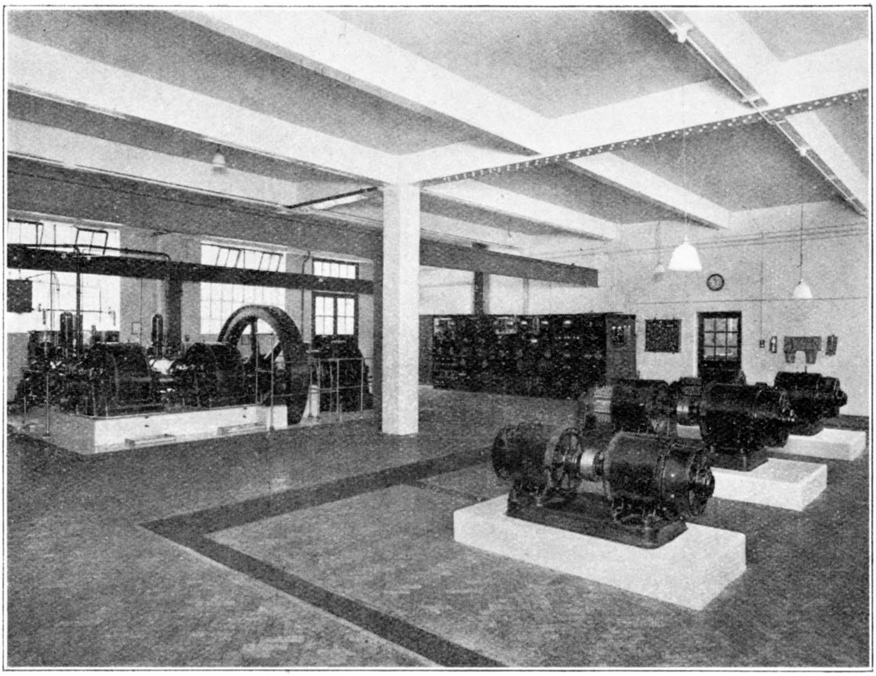
2-Wire Repeaters and Battery Supply Apparatus with Voice Frequency Signalling.



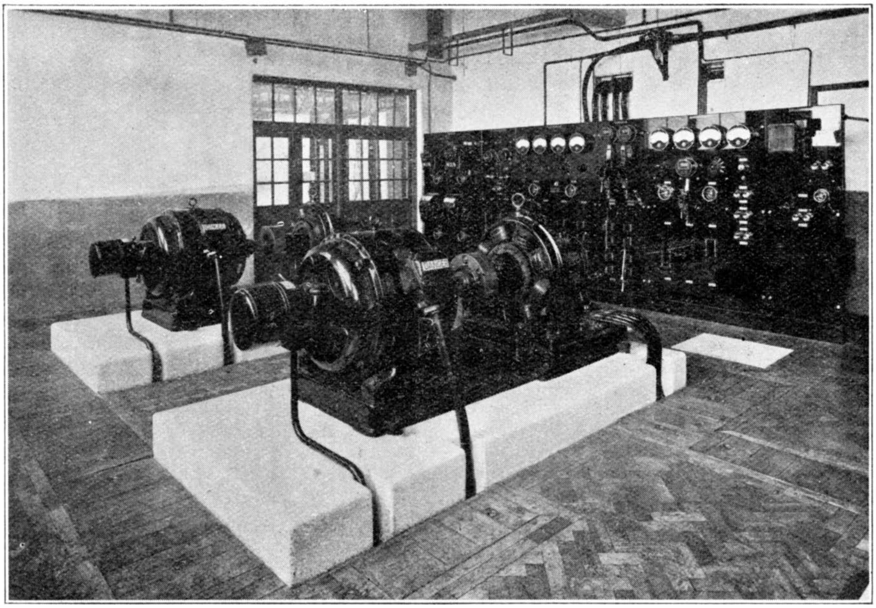
GAIN MEASURING INSTRUMENTS.



GENERAL VIEW. REPEATER APPARATUS ROOM, DERBY.



General View. Power Room, Derby.



Filament Battery Charging Sets and Power Board, Leeds.

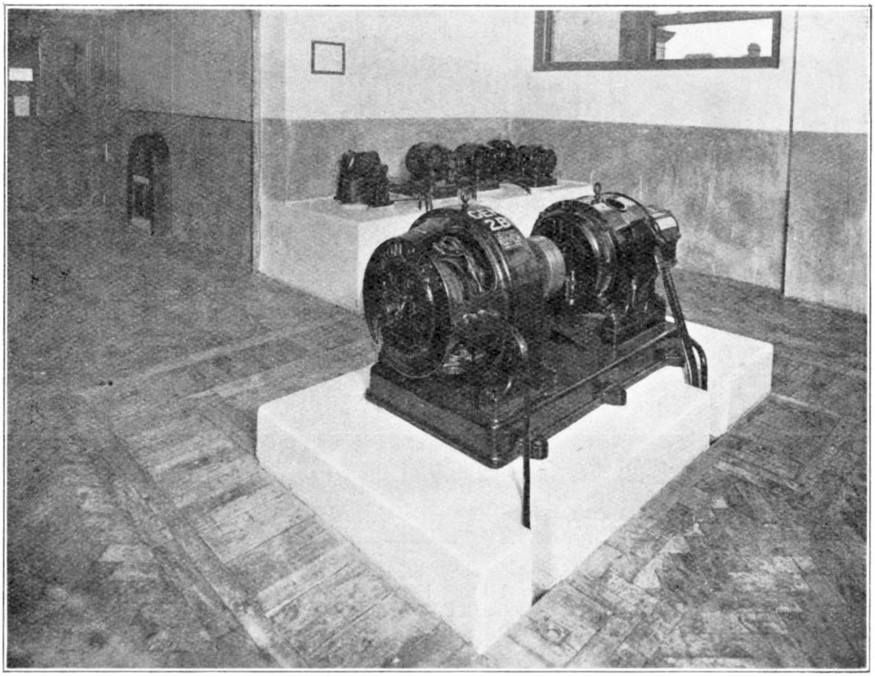
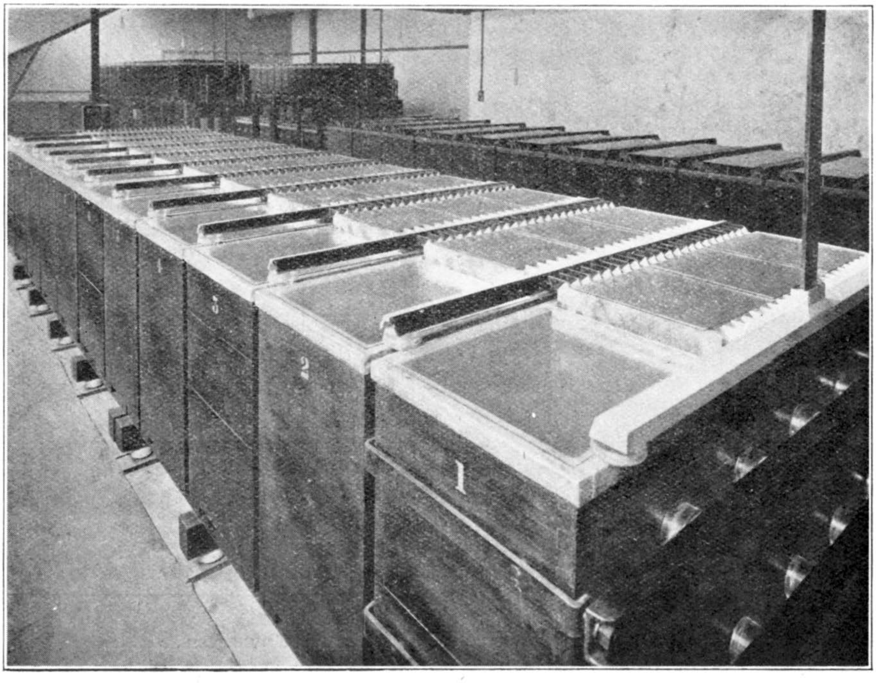
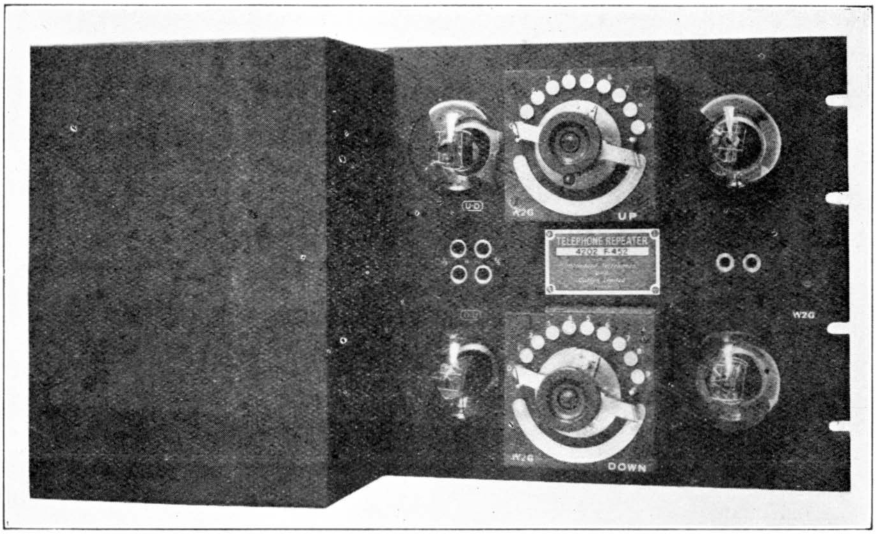


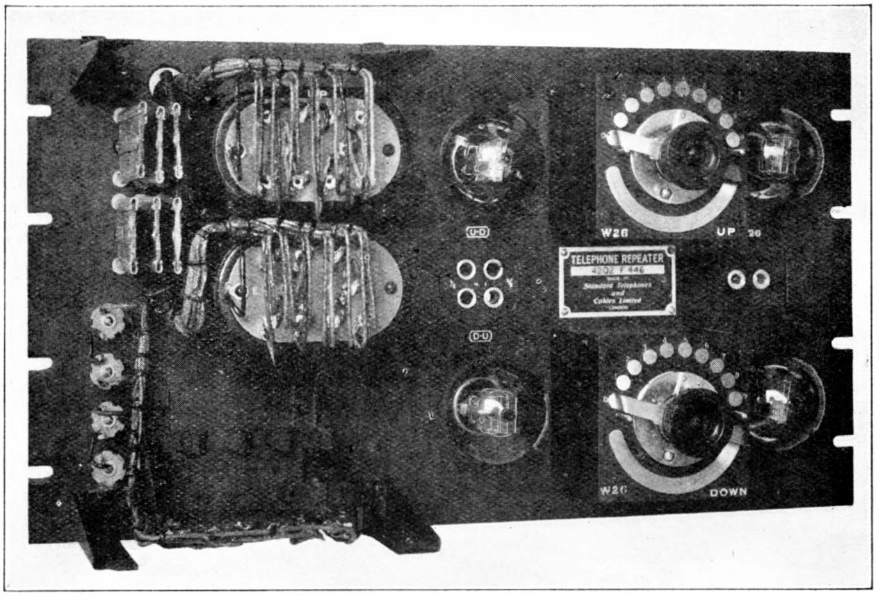
Plate Battery Charging and Ringing Machines, Leeds.



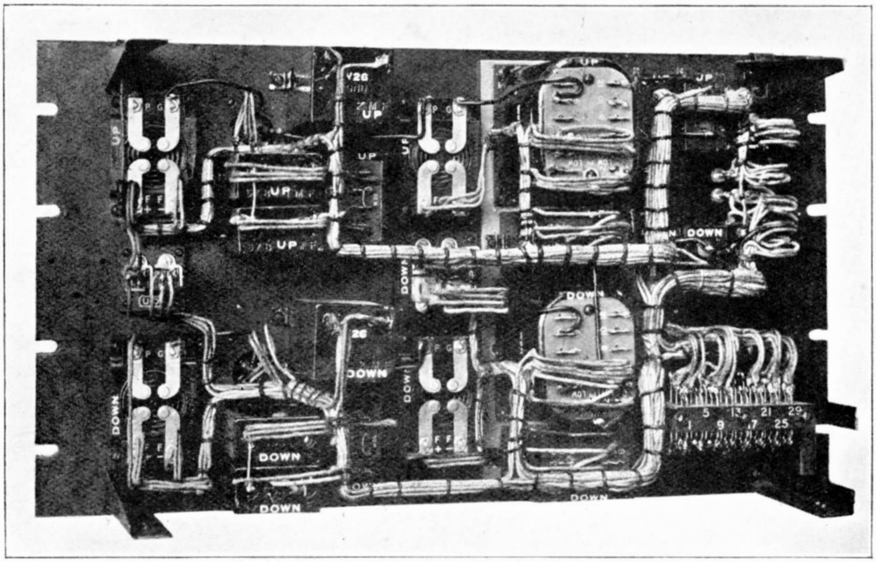
Filaments and Plate Batteries, Leeds.



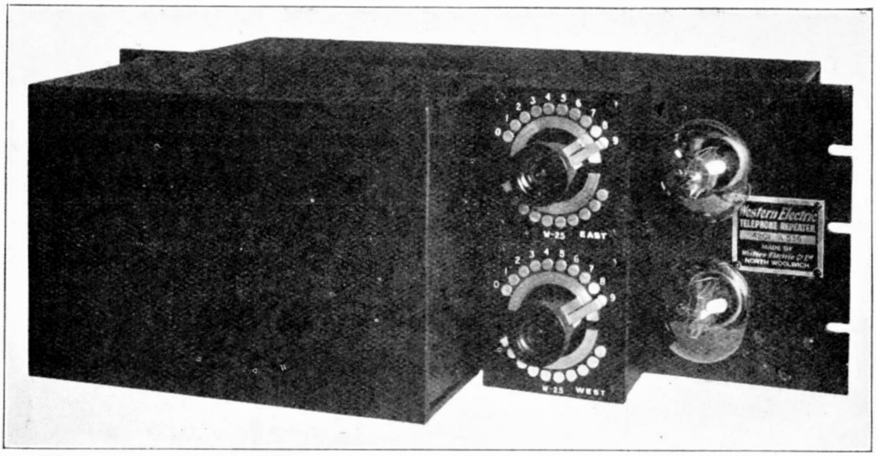
4-Wire Repeater Unit. Front View. Cover on.



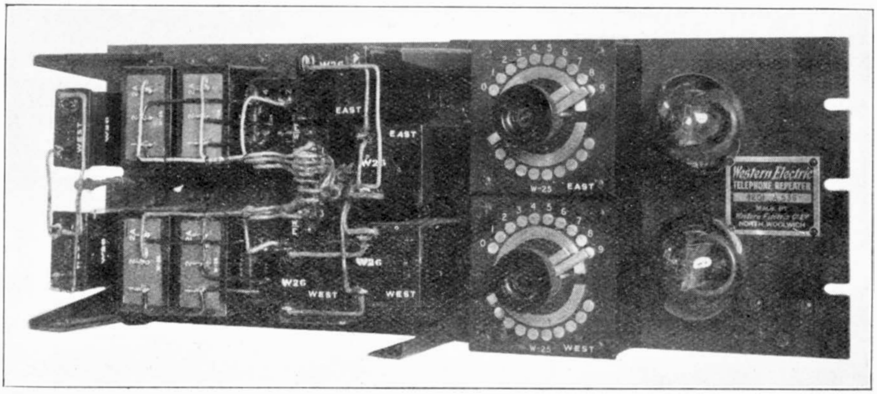
4-Wire Repeater Unit. Front View. Cover off.



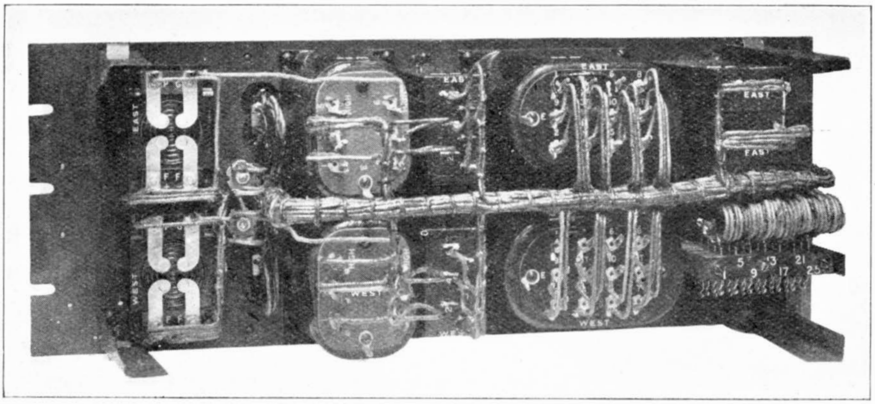
4-Wire Repeater Unit. Rear View. Cover off.



2-Wire Repeater Unit. Front View. Cover on.



2-Wire Repeater Unit. Front View. Cover off.



2-Wire Repeater Unit. Rear View. Cover off.

As a matter of interest the following table gives the initial number of repeaters at the various stations on the route as well as data on various other points:—

	Repeaters 2-wire	Repeaters 4-wire	Vacuum Tubes
London	6	54	228
Fenny-Stratford ...	268	54	752
Derby	308	54	832
Leeds	130	60	500
Catterick	70	50	340
Newcastle	20	50	240
Jedburgh	30	50	260
Edinburgh	50	50	300
Glasgow	—	45	180
Total ...	882	467	3632

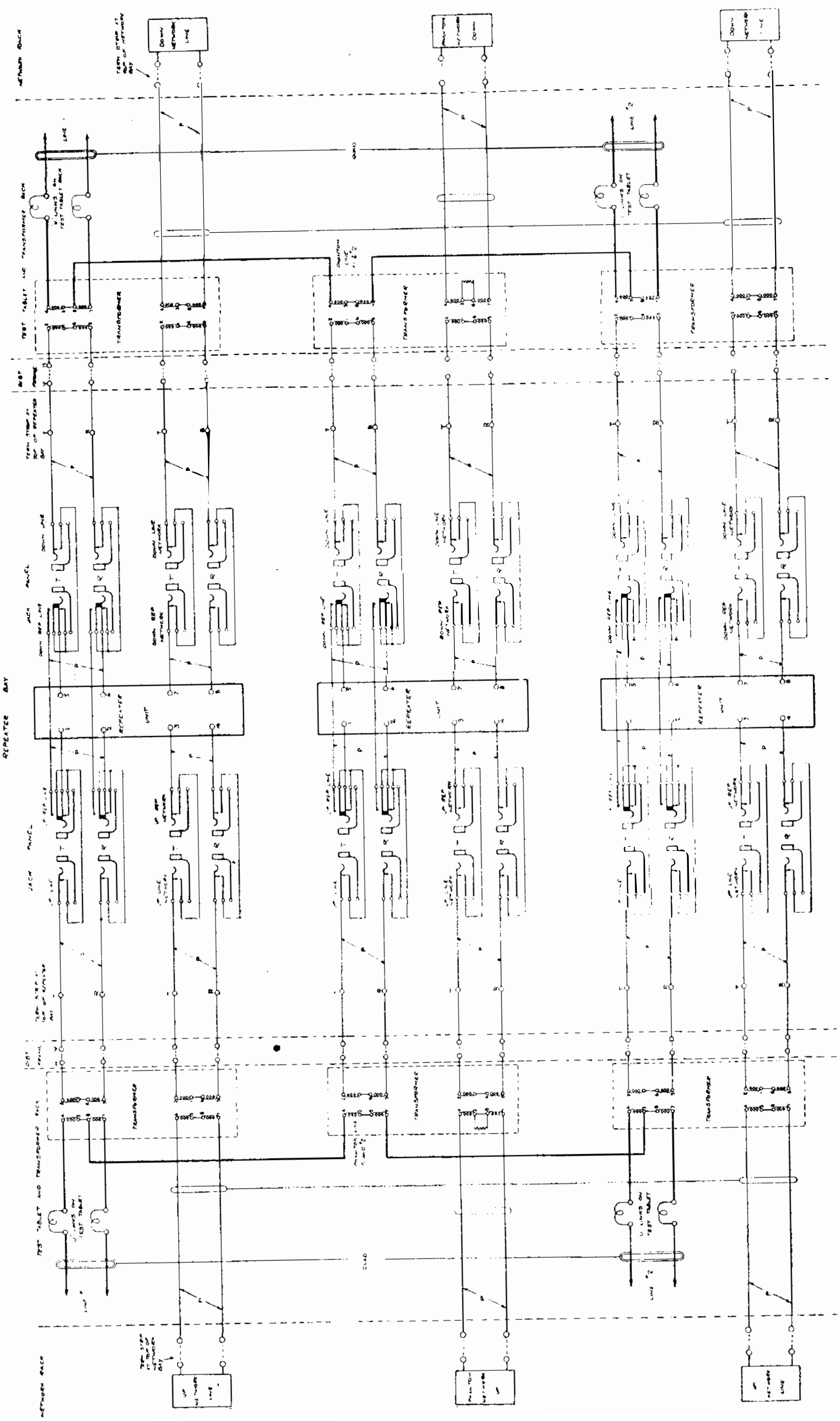


FIG. 14.—SCHEMATIC OF 2-WIRE REPEATERED PHANTOM GROUP, WITH BALANCING NETWORK.

Repeater Circuits.—It will be realised there is of necessity a number of special cases calling for special circuit arrangements in such a network, but it is not felt necessary to emphasise these particular arrangements. Accordingly, only typical arrangements have been dealt with, these, of course, forming the majority of the cases on the North-East route. The following typical circuits are illustrated:—

2-wire repeatered phantom group	Fig, **14.**
2-wire terminal with V.F. signalling	Fig. **15.**
4-wire repeatered phantom group (Through)...	Fig. **16.**
4-wire repeatered terminal with V.F. signalling	Fig. **17.**

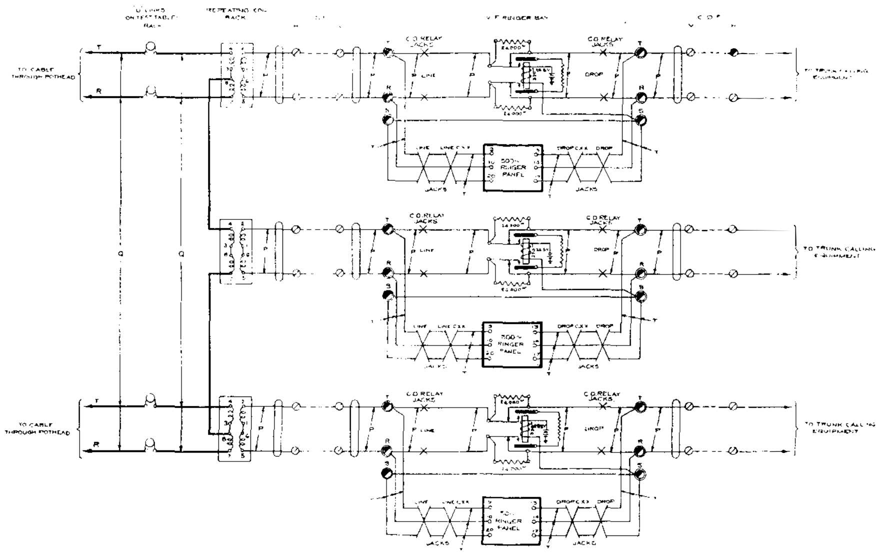


FIG. **15.**—SCHEMATIC OF 2-WIRE TERMINAL WITH V.F. SIGNALLING.

Dealing with the 2-wire through phantom group, the method of connecting the repeaters to the lines and networks is illustrated and shows the U links from which the lines are tested and the jack arrangements by which the repeater units are patched when necessary and are tested with the gain measuring sets. A schematic drawing of a complete 2-wire repeater circuit with its associated battery supply apparatus, operator's telephone and and trunk panel and filament control panels as shown in Fig. **18.** There are several points on this figure which are worth noting. In the first place, the filters are located in the output circuit, which results in a simpler and cheaper design than when they are located in the input circuit. Potentiometers are of the constant impedance type that permits improved impedance of the repeater, and the listening arrangements are such that the

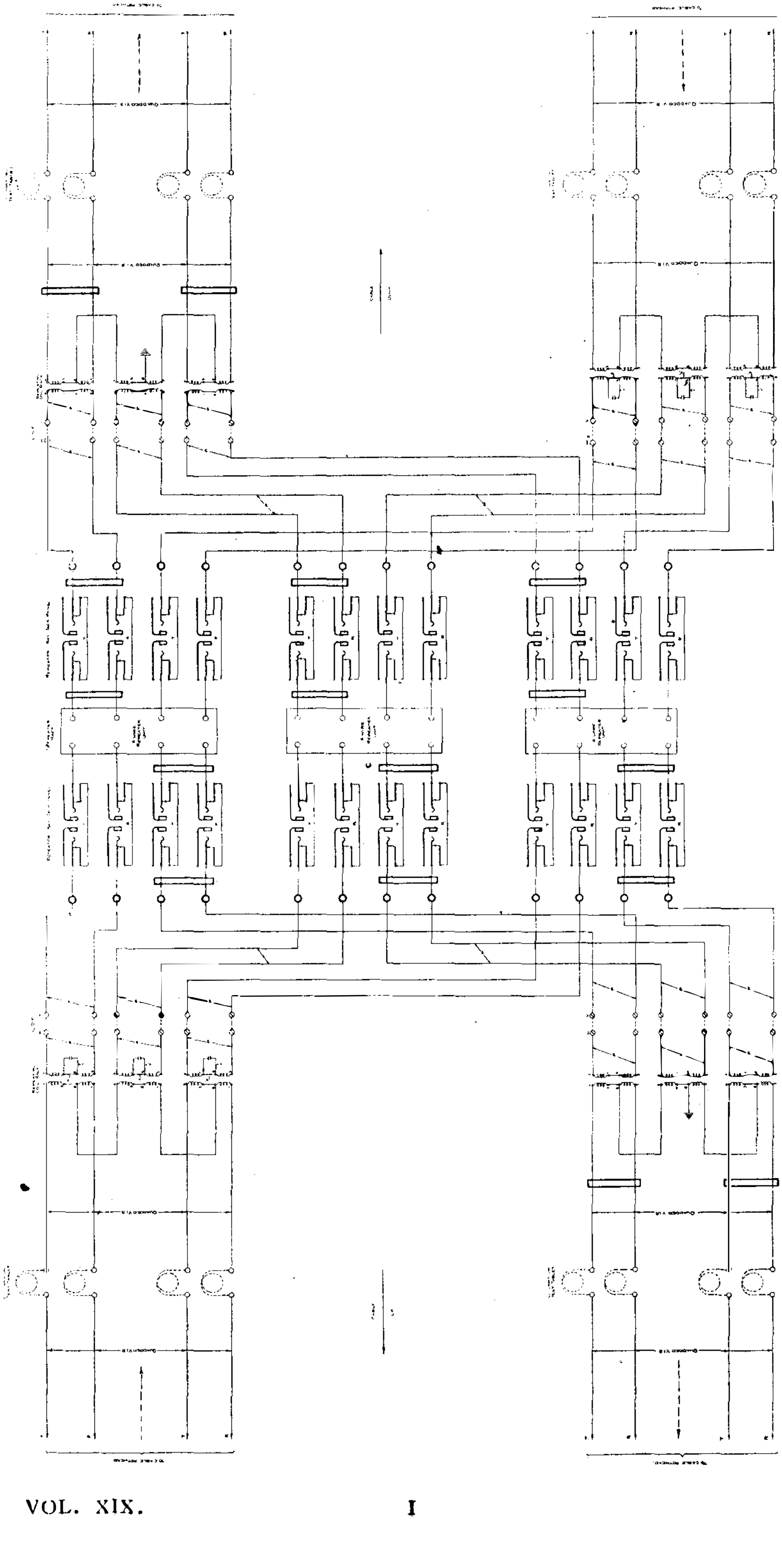


FIG. 16.—SCHEMATIC OF 4-WIRE REPEATERED PHANTOM GROUP.

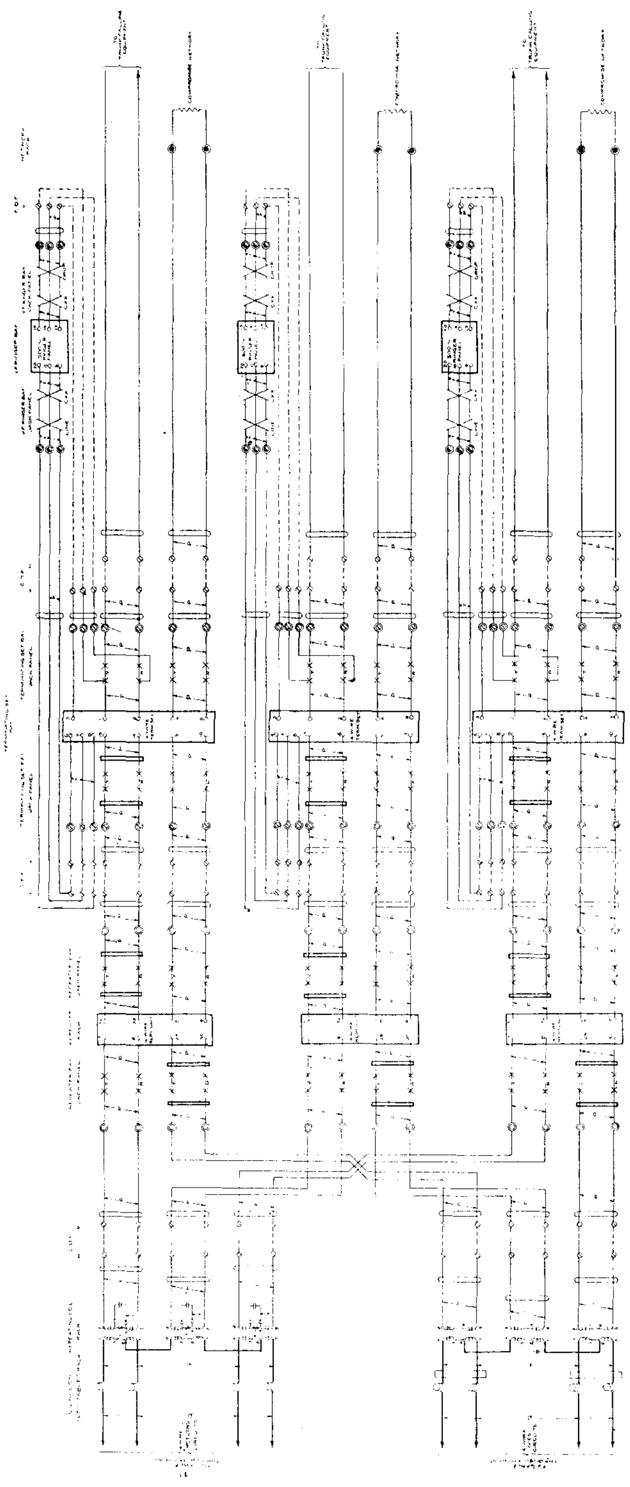


FIG. 17.—SCHEMATIC OF 4-WIRE REPEATERED TERMINAL WITH V.F. SIGNALLING.

repeater attendant can listen and talk in either direction as required or in both simultaneously if necessary. The battery supply arrangements are so designed that the vacuum tubes of two repeater units are worked off one filament circuit, permitting a reduction in the power plant. This arrangement of working necessitates the use of means for reducing the filament cross-talk and the power plant is equipped with a power filter employing electrolytic condensers, thus obviating the necessity for individual filament choke coils.

Since voice frequency signalling is used with these repeater units, there is, of course, no necessity for relaying ringing current at the repeater stations as it is amplified in the same manner as the speech currents, although means are provided for inserting 17-cycle ringers when required.

The basic network used for all 40 lb. medium-heavy loaded circuits is shown in Fig. **19**, and the building-out capacity necessary for each circuit is obtained from a multi-unit condenser containing 10 units, permitting values of capacity to within .001 mf. being obtained up to a maximum value of .1 mf. Since the repeaters are designed to give a better low frequency gain than has been obtained hitherto, it is necessary to employ a network which gives good simulation at low frequencies and this is obtained by means of an excess simulator included in the standard networks, as shown in Fig. **19**.

At the terminal of the 2-wire group as described above, the arrangements shown in Fig. **15** are used. This arrangement consists of the line repeating coils for obtaining a phantom circuit together with the 500 cycle ringer panels and cut-off relays. The ringer panels and cut-off relays are illustrated in more detail in Fig. **20**, which shows the jacks used for testing the ringer panel by means of the ringer test panel shown in Fig. **29**. The ringer panel is equipped with a 500-cycle relay of a new design which permits of the modulating feature used with these frequency ringing circuits for protection against false operation to be obtained from the incoming signalling current. This modulating feature operates the 20-cycle circuit, which immediately follows the voice frequency relay, and the final relays in the train do not operate unless the alternating current operating the voice frequency relay has the correct frequency of modulation.

The test panel associated with these ringers is shown in Fig. **29**, and permits of the time delay feature in the ringer panel being tested and adjusted, as well as checking the complete operation of the panel from the two directions. Facilities are also provided for testing the 20-cycle relays.

The cut-off relay shown in Fig. **20**, when operated, closes the line through a resistance, which is necessary in order to prevent

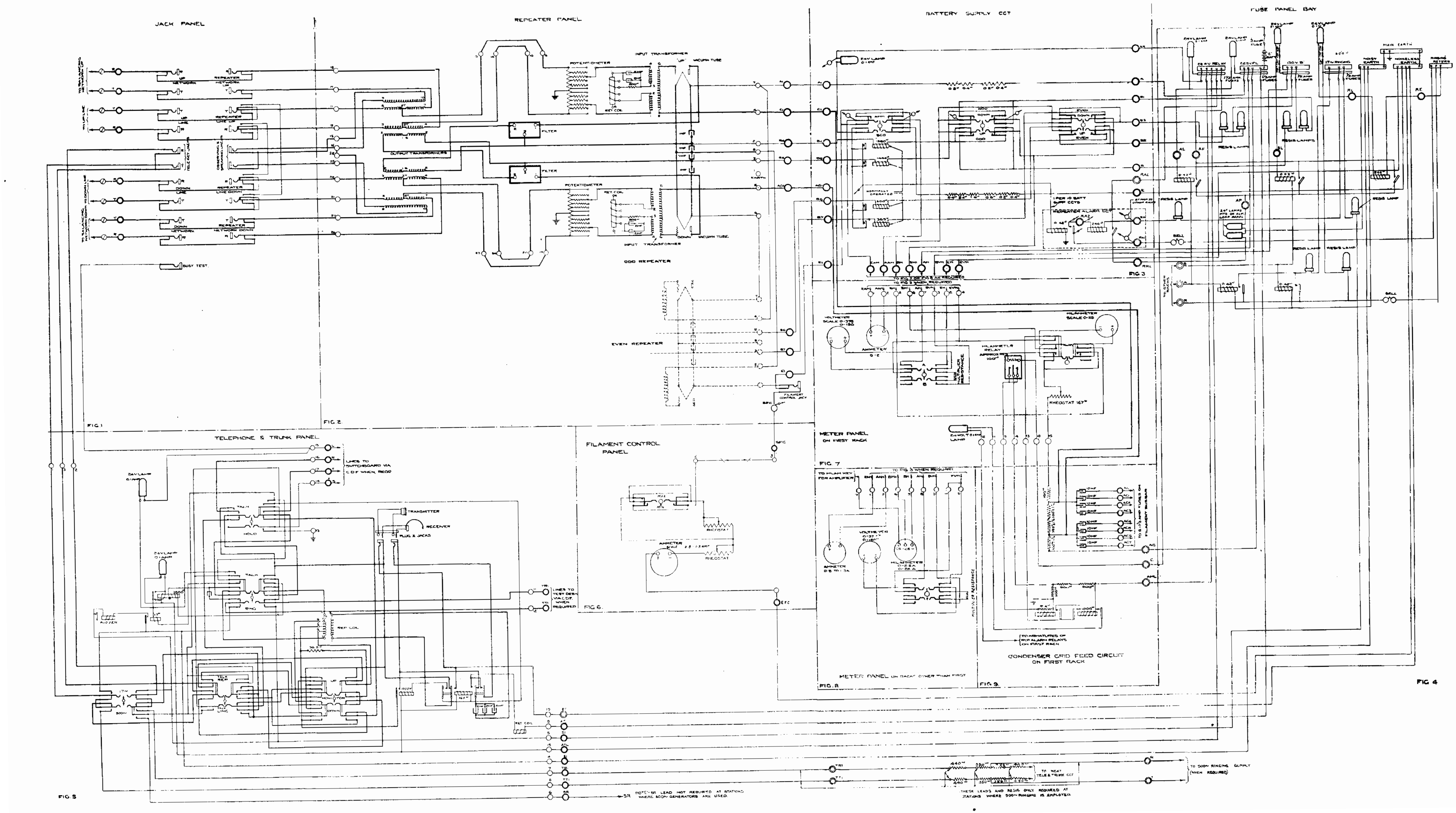


FIG. 18.—DIAGRAM OF 2-WIRE REPEATER CIRCUIT WITH ASSOCIATED APPARATUS. (S.T. AND C. LTD. DRAWING, L 36415).

serious echo currents if the line were open-circuited during the ringing period.

A 4-wire through cable group with repeaters is shown on Fig. **16**, segregation of input and output circuits is shown as well as the jacks used for patching and testing the repeater units. Low frequency corrector condensers are included in the input repeating coils, when necessary, on extra light loaded circuits to equalise the attenuation of a line at the low frequnecies and so prevent excess gain at these frequencies.

The 4-wire repeater unit is shown in Fig. **21**, which shows the unit together with its jacks, telephone and trunk panel, battery supply circuit, meter panels and filament control panel. The listening arrangements are similar to those on the 2-wire repeaters.

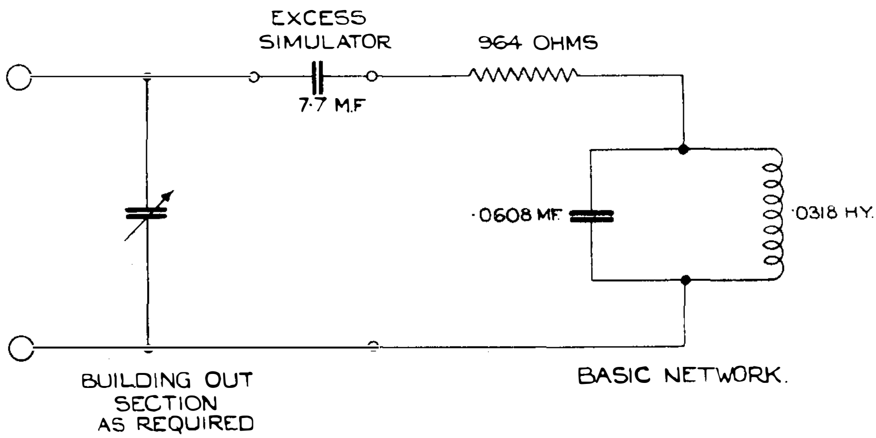


FIG. **19**.—BALANCING NETWORK FOR H-177-107 PHANTOM CIRCUIT.

The gain of the repeater unit is adjusted by means of the tapped input transformer and inter stage transformer, while a fine adjustment is obtained by means of resistances in the output circuit. The repeater unit will cater for medium-heavy loaded lines and extra light loaded lines, the gain frequency curve being adjusted for the former type by means of the retard coil and condenser associated with the first input transformer.

A schematic of the terminating arrangements employed for the 4-wire system is shown in Fig. **17**. This covers the use of terminal 4-wire repeaters, 4-wire terminating sets, and 500 cycle ringer panels. The 4-wire terminating set and the method of connecting the 500-cycle ringer panel to it are illustrated in more detail in Fig. **22**. The operation of the ringer panel is the same as that described for the 2-wire case, except that the cut-off relays are included in the 4-wire terminating set. The 4-wire terminat-

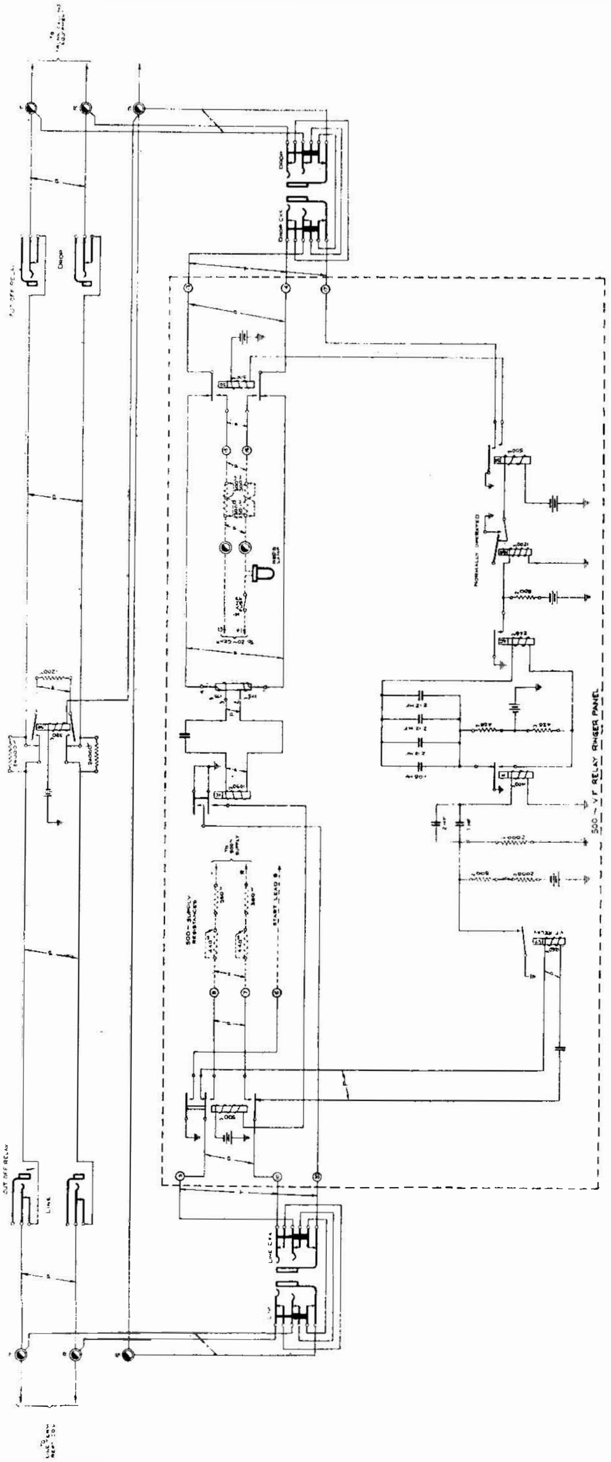


FIG. 20.—SCHEMATIC OF 2-WIRE TERMINAL. 500 CYCLE—20 CYCLE RINGING.

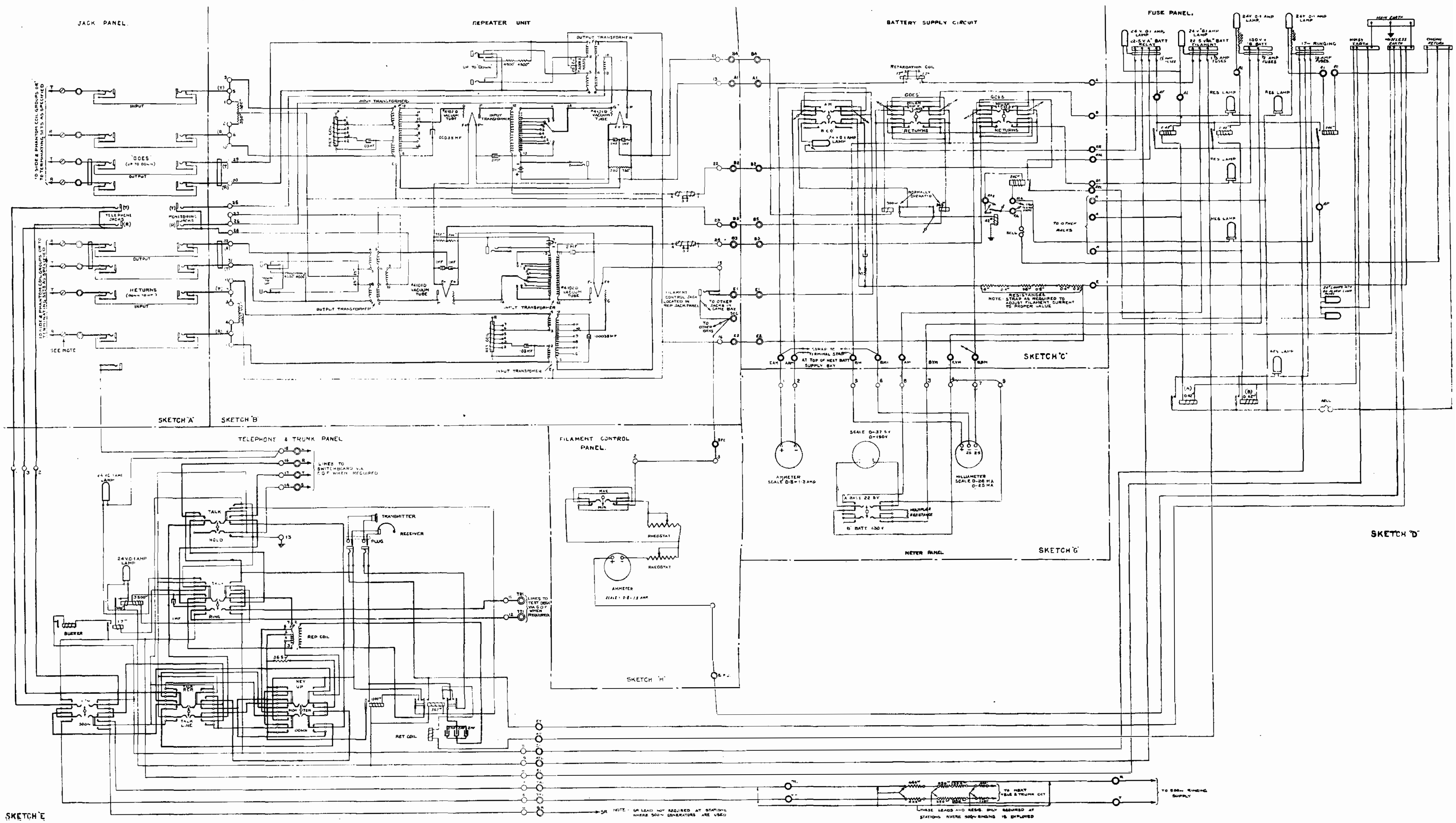


Fig. 21.—Schematic of 4-Wire Repeater Circuit with Associated Apparatus. (S.T. and C. Ltd. Drawing, L 36416).

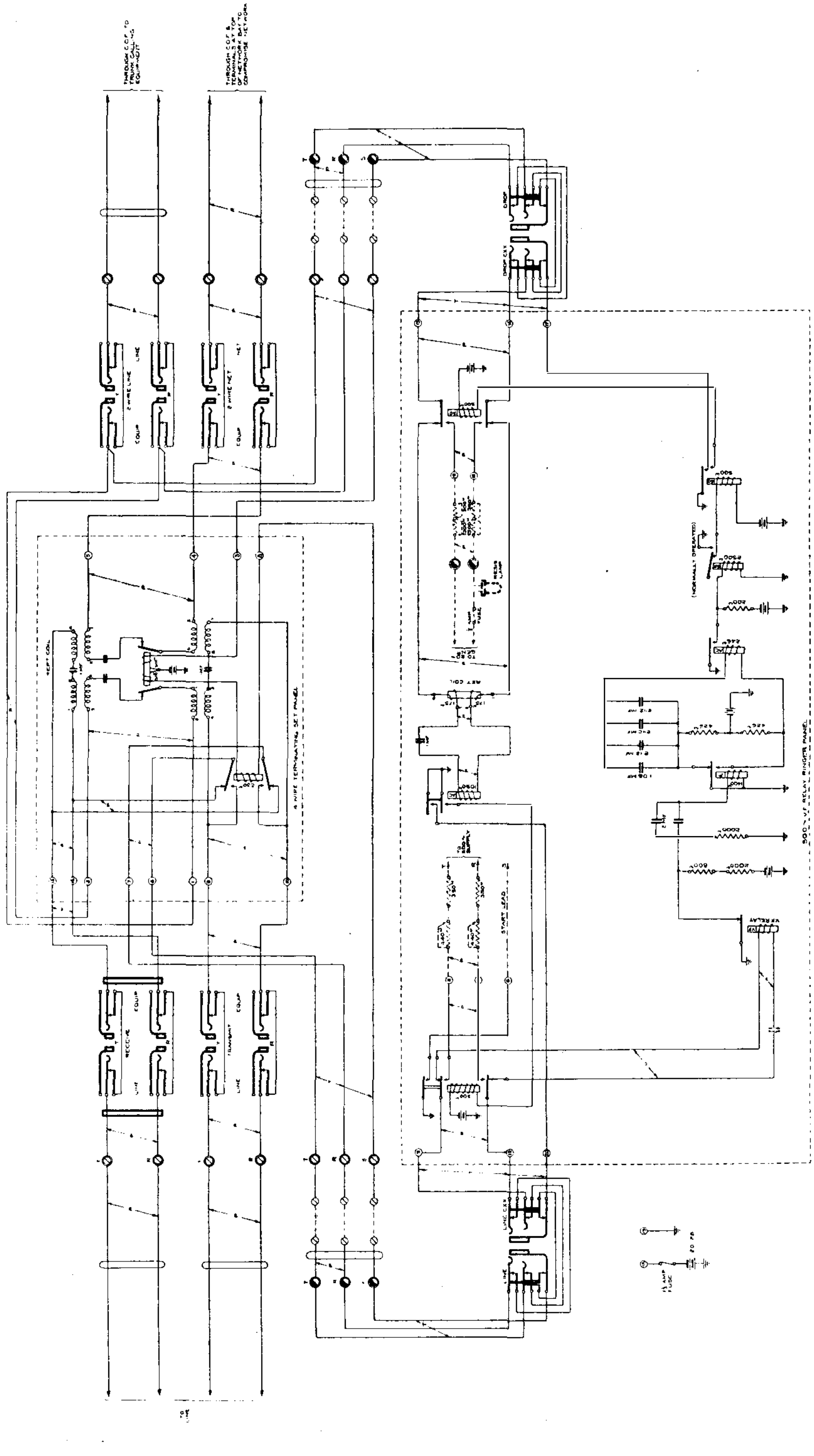


FIG. 22.—SCHEMATIC OF 4-WIRE TERMINATING SET AND METHOD OF CONNECTING.

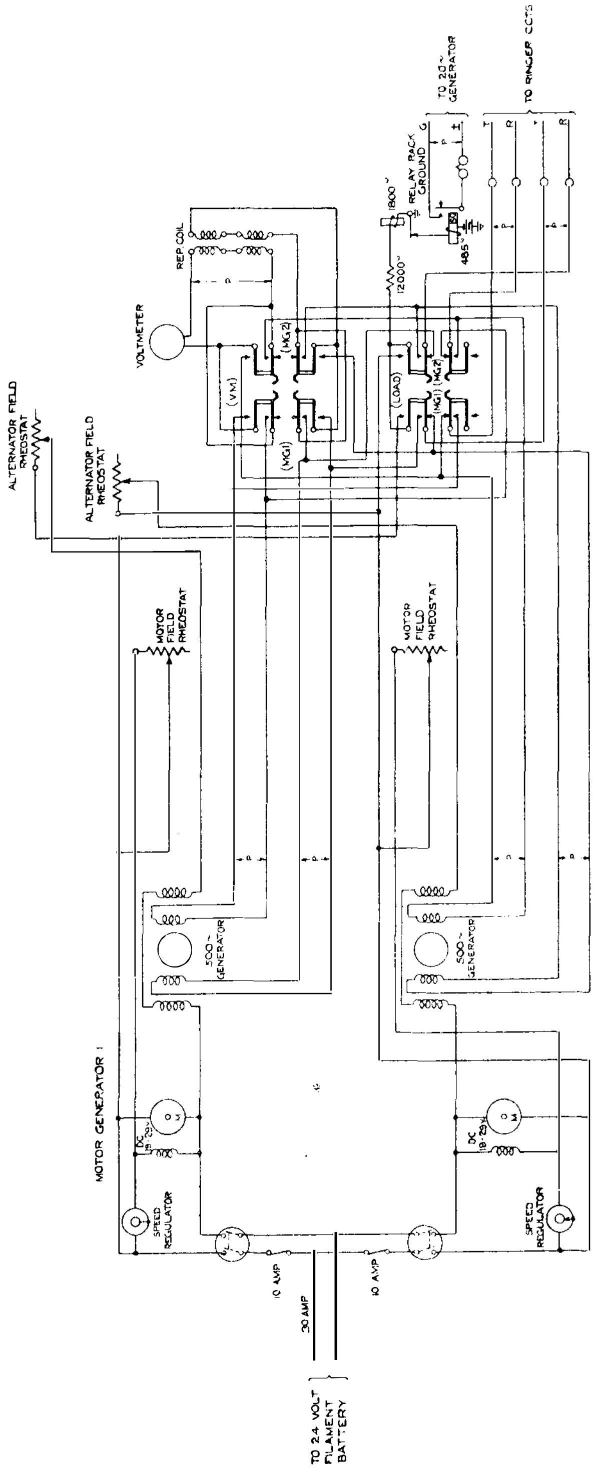


FIG. 23.—VOICE FREQUENCY SIGNALLING MACHINES.

ing set consists of repeating coils and condensers so connected that they serve the double function of a hybrid coil and of a high pass filter.

In connection with the voice frequency signalling arrangements a schematic of the 500-cycle machines and control gear is shown in Fig. **23**. This machine is designed so that its output from the winding is in the form of modulated 500 cycles, thus replacing the old arrangements of commutator output.

Vacuum Tubes.—The vacuum tubes used on the repeaters on the London—Glasgow repeater stations have oxide-coated filaments taking a current of 0.97 amperes. An illustration of one of these tubes indicates the design of the tubes and they are so

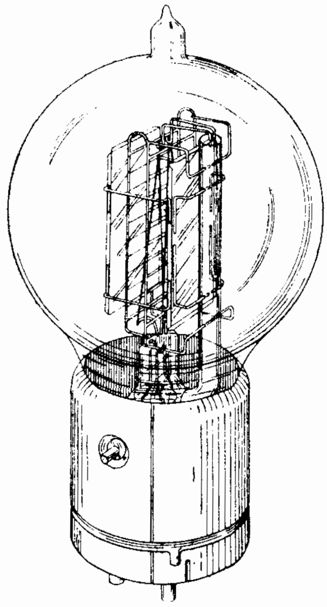


FIG. **24**.—TYPE 4101 D TUBE.

designed that microphonicity is reduced to a minimum. Fig. **27** gives the characteristic of the 4101-D tube under conditions of zero load and when closed through a load impedance of 6000 ohms.

The tube operates normally with a plate voltage of 130 volts and a negative grid voltage of 9 volts. Under these conditions it will be seen from the load curve that the symetric distortion introduced by the tube is negligible.

In order to maintain the overall circuit equivalent under all ordinary conditions of battery fluctuation which occur in practice, vacuum tubes are rejected when the gain of a repeater varies by more than 0.11 βl for a change of filament current from 0.93 amp. to 1.00 amp.

This tube rejection test is made by means of the filament control panel and gain set previously mentioned.

The 4101-D vacuum tube is capable of handling an output power of 0.59 watts, which is a factor to be borne in mind when laying out the transmission level diagrams.

Repeater Apparatus.—Gain frequency curves of the 2-wire repeaters for medium-heavy loaded circuits are shown on Fig. **25** for all potentiometer settings from 1 to 9. These curves show a remarkable uniformity of curve for all settings.

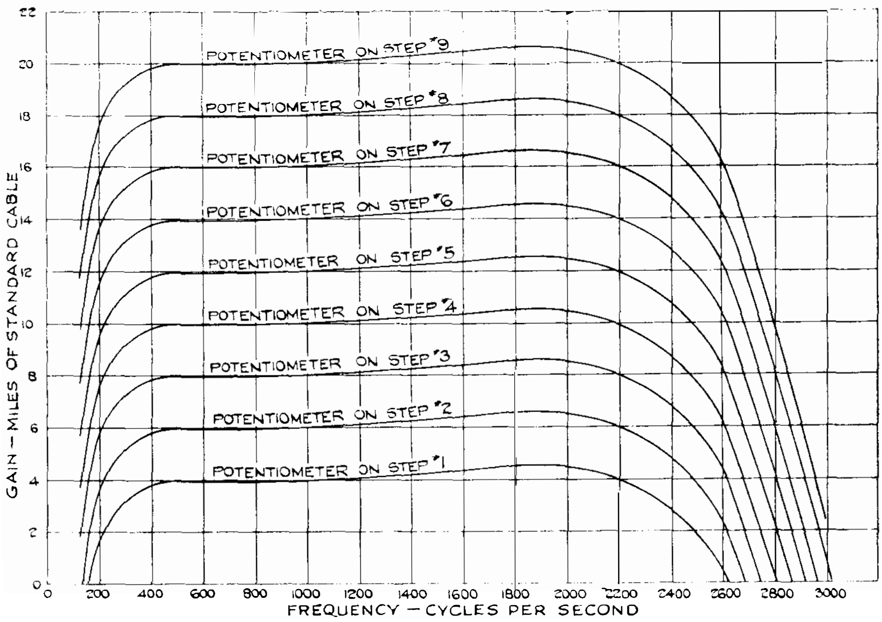


FIG. **25**.—GAIN VS. FREQUENCY. 2-WIRE.

Gain frequency curves of the 4-wire repeater unit are shown in Fig. **26**, the medium-heavy loaded values lying between the two curves shown and various tappings on the retard coil previously mentioned give maximum values at intermediate points. The extra light loaded characteristic is shown below the medium-heavy loaded characteristic.

In setting up a 4-wire medium-heavy circuit the transmitting half of the repeater at the terminal stations is given an extra-light setting having the required 1000-cycle gain obtained from the transmission level diagrams.

All other repeaters, including the receiving halves of the terminal repeaters, are set so that the gain-frequency curve compensates for the attenuation-frequency curve of the previous repeater section. By means of the adjustable tuning circuit mentioned above, it is possible to equalise for any repeater section between the maximum and minimum lengths met with in practice.

Power Plant.—The principal features of repeater station power plants have been previously described in this Journal, and it is proposed in this article only to refer to those features of the power plants for the repeater stations on the North-Eastern cable which differ from the system previously explained. Photos on pages 126/7, and Fig. **28** illustrate the general arrangement of a typical plant and refer to Leeds Repeater Station as representing the system under consideration, which is distinguished from previous systems by the operation of the batteries on a floating routine.

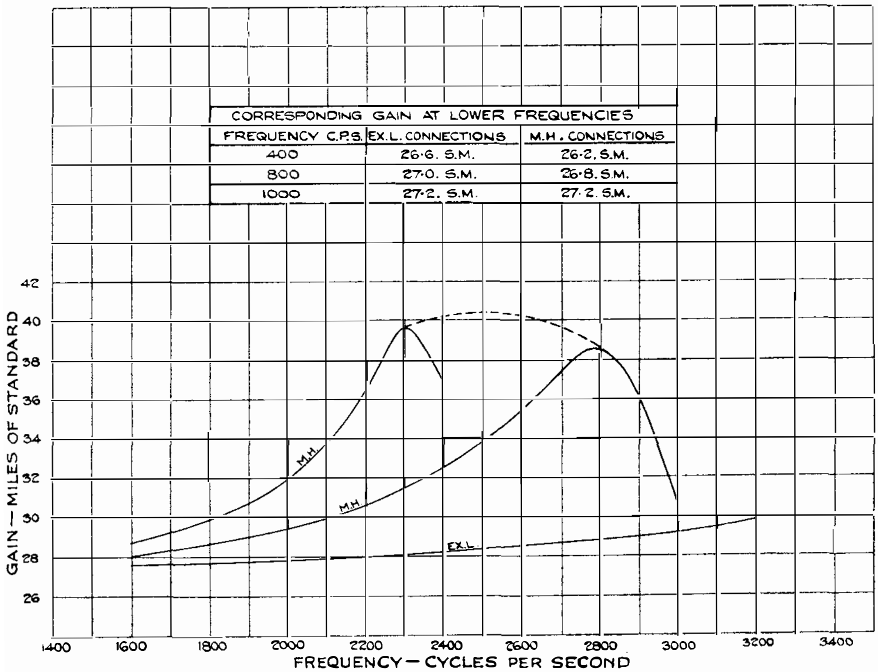


FIG. **26**.—GAIN VS. FREQUENCY. 4-WIRE.

In this instance the power plant supplies both the local telephone exchange and the repeater equipment, and for this reason particular care has been exercised in obtaining a perfectly noiseless supply for the cable circuits. The 22 to 30 volt generators which are used for charging and floating the filament or "A" batteries are of special construction, embodying the usual features of telephone type machines—a large number of commutator segments and armature slots per pole, a long air gap, chamfered pole shoes and skewed armature slots. Such means alone, however, are insufficient to ensure noiseless operation of repeatered circuits, and a special filter is inserted between the generator and the battery when floating. This filter consists of suitable choke coils in the negative lead and a bank of three electrolytic condensers connected across the negative and earth leads. The use of electrolytic condensers enables a high electrostatic capacity to be obtained in a small space. Three condensers, each of 1000 mf., are connected in parallel. In this way all noise arising from the machines and from the relay and miscellaneous exchange circuits is prevented from reaching the repeater circuits.

For repeater working the normal permissible voltage variation at the fuse panel bus-bar is ± 0.5 volt. The floating battery system

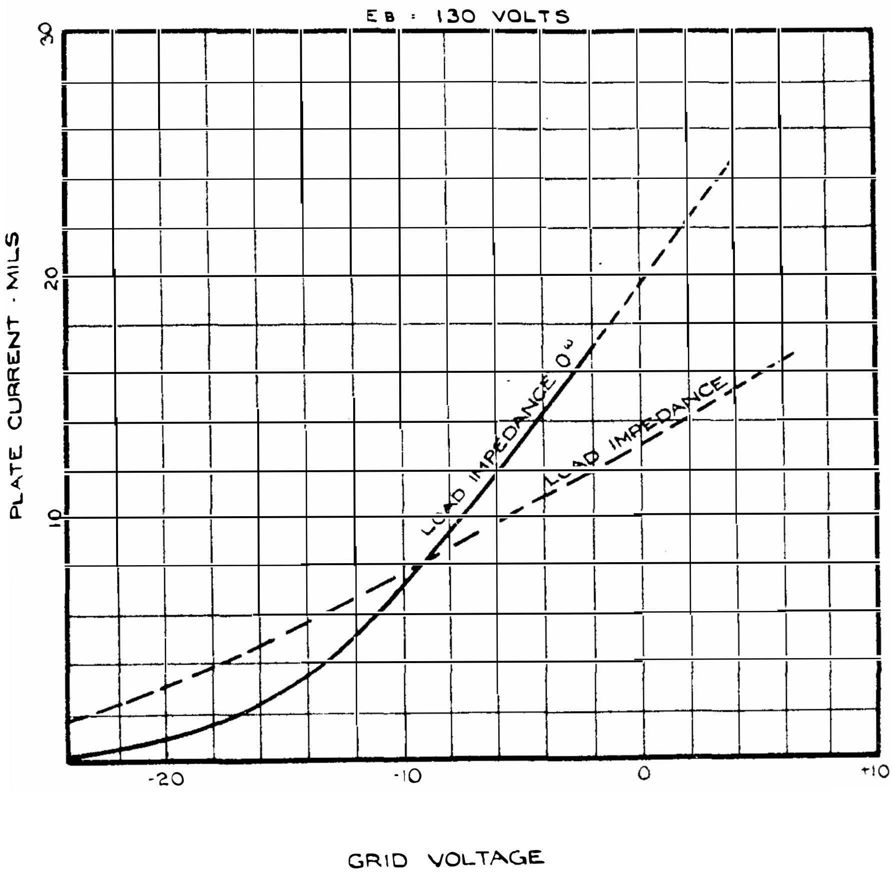


FIG. 27.—CHARACTERISTIC OF TYPE 4101 D TUBE.

provides a ready means of maintaining a steady bus-bar voltage, even over a certain range of load fluctuations, and it is necessary only for the attendant to adjust the generator field regulator when considerable changes of load take place. During periods of failure of the outside power supply the two "A" batteries may be connected in parallel for discharge to the exchange and repeater equipment, in which case a further fall of 0.9 volts is allowable at the fuse panel bus-bars.

The emergency reserve power plant at Leeds consists of an engine coupled to a generator which will produce 60 K.W. at the same voltage and frequency as the normal power supply.

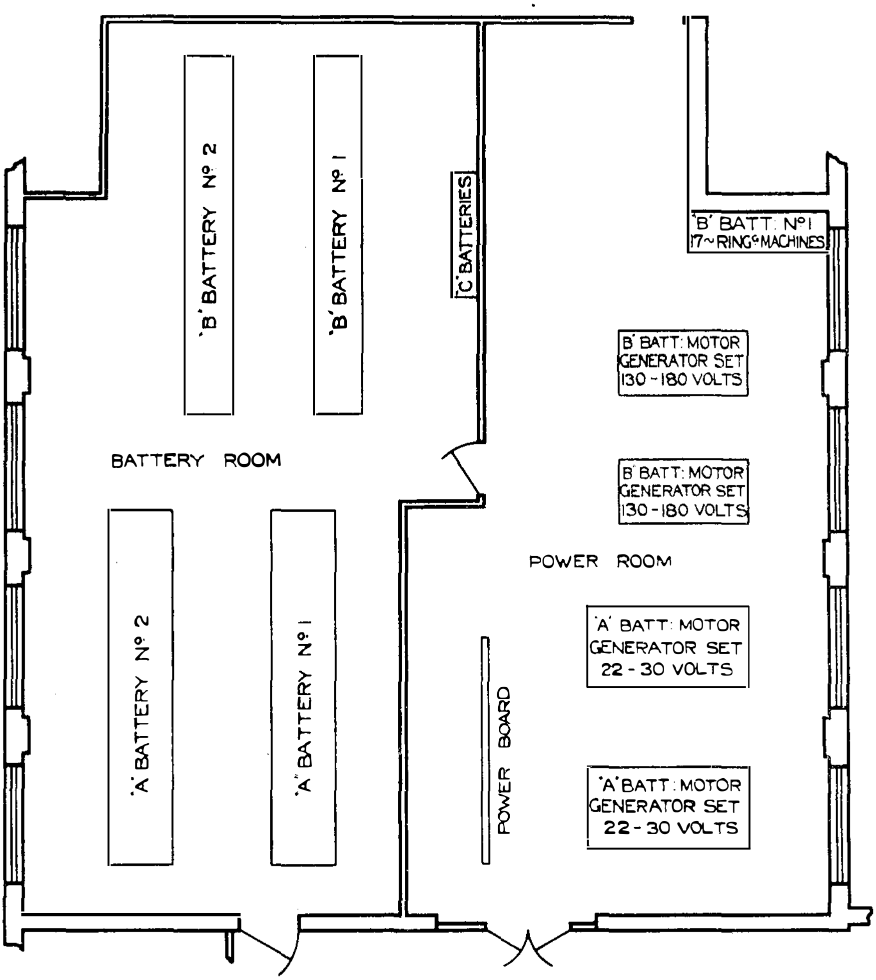


FIG. 28.—LAYOUT OF BATTERY AND POWER ROOM, LEEDS.

The floor plan lay-out of Leeds repeater station battery and power rooms is shown in Fig. **28**, these rooms being located adjacent to the repeater room on the second floor. The equipment is so arranged as to require the shortest possible length of cabling between the batteries, machines and apparatus racks.

The duplicate filament or "A" batteries each consist of 11 wood lead-lined cells with an initial capacity of 5000 ampere hours at the 9 hour rate, suitable for extension to a capacity of 7500 ampere hours at the same discharge rate. The batteries are illustrated on page 127, the space in the cells available for extension being clearly shown.

The duplicate plate, or " B " batteries, each of 65 wood lead-lined cells, are arranged for initial and ultimate capacities of 150 and 300 ampere hours respectively at the 9 hour rate. These batteries, mounted on double tier wooden stands, are seen in the background of the same Fig. The voltage limits for the " B " batteries are 125 to 135 volts measured at the repeater fuse panel, which limits are readily met by charge-discharge operation.

Duplicate grid, or " C " batteries, are supplied, each consisting of 5 glass cells of 20 ampere hours capacity at the 9 hour rate for both the initial and ultimate repeater equipments. The voltage limits for the " C " batteries are 9.5 to 11 volts measured at the repeater fuse panel. The " C " batteries are operated on a charge—discharge routine, charge being effected from the " A " battery bus-bar through a suitable resistance.

The whole of the above batteries are of the Chloride Co.'s manufacture.

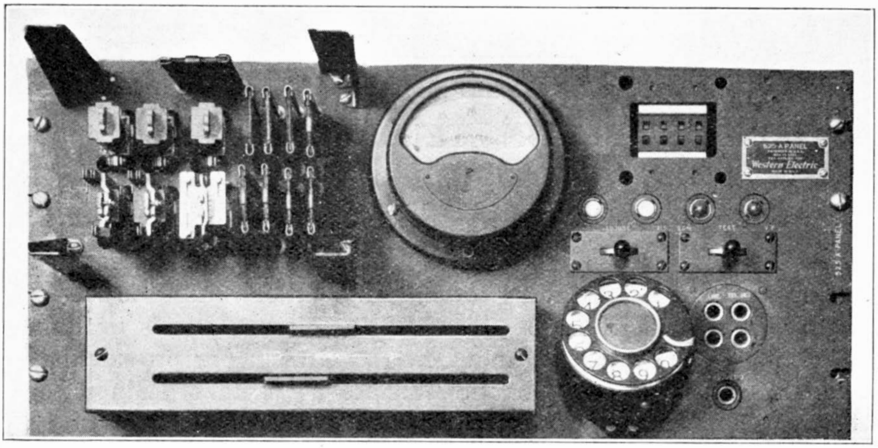


FIG. 29.—RINGING TEST PANEL.

A general view of the " A " battery machines and power board is shown on page 126. Each of these motor generator sets consists of a Crompton Co.'s slip ring induction motor operating on a 200 volt, 2-phase, 4-wire 50 cycle supply and direct coupled to a 22 to 30 volt, 650 ampere telephone type generator, as mentioned above. The motor-starting panel for these machines may be seen on the extreme left of the power board.

Two 130-180 volt, 50 ampere, " B " battery motor generator sets are provided for charging purposes, the generators of which are ordinary commercial type machines manufactured without special restrictions regarding commutator ripple. One of these machines is shown on page 127. The photo also shows the two 17 cycle ringing machines which are provided, one for operation from the outside power supply and the other suitable for running from the "A" batteries. The line driven machine is normally used and the battery driven dynamotor is operated only during periods of power supply failure.

The power board mounts the necessary switchgear, instruments and meters for the machines and batteries described above and calls for no further comment.

We are indebted to the International Standard Electric Corporation for much of the technical detail and the diagrams included in this article; and we desire to take this opportunity of acknowledging the extent to which the present advanced stage of the art of long distance cable telephony has been due to the basic work of the Bell System Laboratories of the American Telephone and Telegraph Company and to the information published in their technical literature.

A.B.H.

LONDON—BERLIN TELEPHONE CIRCUIT.

On the 15th March a night telephone service with Germany was opened. Communication was established with Berlin, Hamburg and Cologne. This limited service is merely a temporary expedient pending the introduction of a full time service later in the year, when the third Anglo-Dutch Cable is brought into use. The Hamburg and Cologne circuits are provided by extending two of the London-Amsterdam Trunks. Since the Berlin Circuit had to be specially dealt with on account of its greater length some details of the arrangements made may be of interest.

In the first instance an attempt was made to establish communication between London and Berlin by extending a London-Amsterdam circuit as in the case of Hamburg and Cologne. It was found, however, that sufficient volume could not be ensured to permit of reasonable extension. The London-Amsterdam circuit used was made up of a two-wire circuit on underground conductors London to Aldeburgh, submarine cable to Domburg, and thence underground Domburg to Amsterdam, with repeaters at Aldeburgh and Middelburg. For the Berlin circuit a repeater was introduced at Amsterdam. From Amsterdam overhead conductors continued the circuit to Münster, between which town and

Berlin a four-wire underground circuit was used with repeaters at Münster, Bassum, Hanover, Magdeburg and Berlin.

As a result of the preliminary trials it was decided to make the London-Amsterdam section of the circuit four-wire. The section Amsterdam-Münster had to remain as a two-wire circuit as spare conductors were not available to make the circuit four-wire throughout.

Fig. 1 indicates the composition, lengths and gauges of conductor and the attenuation lengths of the various sections of line, as finally made up, and also the location of the repeater stations. The total length of the circuit is 877 miles.

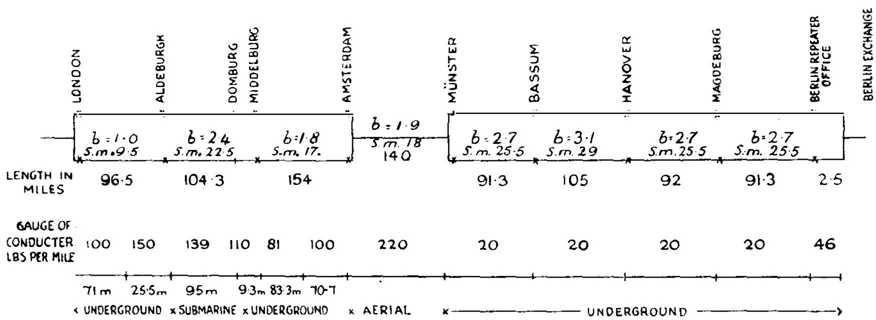


FIG. 1.—MAKE-UP AND PARTICULARS OF CIRCUIT.
b = Attenuation length (βl).

From a study of the attenuation of the various sections of the circuit provisional settings of the repeater gains were arranged. Transmission measurements were then made over a range of frequencies to determine the transmission levels at the various stations and final adjustments were then made to obtain suitable transmission levels and reasonably uniform transmission over the frequency range of commercial speech.

The following table gives the results of tests made when transmitting in the two directions :—

Frequency ω ($= 2\pi f$)	London to Berlin. Transmission level at Amsterdam	London to Berlin. Transmission level at Berlin	Berlin to London. Transmission level at Amsterdam	Berlin to London. Transmission level at Berlin
	Standard miles.		Standard miles.	
4000	+ 11.3	− 8.0	− 1.9	− 7.5
5000	+ 10.9	− 10.3	− 1.0	− 8.0
6000	+ 11.3	− 9.4	− 2.3	− 9.4
8000	+ 10.3	− 13.2	+ 3.8	− 6.3
10000	+ 8.9	− 11.1	+ 7.0	− 5.0

+ = above transmission level at the sending end.
− = below ,, ,, ,, ,, ,,

Taking the efficiencies at $\omega = 5000$ it will be seen that the standard cable equivalent London to Berlin is about 10.3 standard miles, and in the direction Berlin to London 8.0 standard miles. The measurements were made by sending into the circuit at each end in turn the equivalent of 1 milliwatt into an impedance of 600 ohms, and measuring the voltage across the circuit at intermediate and terminal points. The readings were corrected for impedance if the circuit differed from 600 ohms in impedance. The readings given for Amsterdam were taken on the output side of the repeater.

It will be noticed that at the higher frequencies there is a difference in the efficiencies in the two directions. As this did not interfere with satisfactory speech steps were not taken to correct it before bringing the circuit into use.

In a telephone circuit it is not practicable to so arrange the impedance of the terminal apparatus that the whole of the received energy is absorbed in the receiving apparatus. A portion of the energy is therefore reflected back to the sending end. In a short circuit the reflected energy is so quickly transmitted that it becomes merged with the ordinary side-tone in the receiver, and is not noticed. In a long circuit without telephone repeaters the reflected energy returns later, but is so attenuated as to be still unnoticed. In the case of the London-Berlin circuit, however, the time of transmission is much greater than the normal and, owing to the attenuation having been greatly reduced by the introduction of repeaters, the reflected energy is considerable and is relatively much delayed with respect to the transmitted speech. In consequence, unless steps were taken to prevent it, the reflected speech currents would cause the speaker to imagine that the listener was trying to interrupt him, his own speech being heard as an echo.

In order to overcome this difficulty "echo suppressors" have been installed in London and Hanover. This apparatus renders the Berlin-London side of the circuit inoperative when speech is being transmitted from London to Berlin and vice versa.

For a description of the "echo suppressor" as used in London reference should be made to a paper by Messrs. Robinson and Chamney, read before the Institute of Post Office Electrical Engineers, entitled "Recent Research Work on Telephone Repeaters" (Professional Paper No. 99).

It should be mentioned that, in addition to the true "echo" effect, circulating currents due to inevitable out-of-balance conditions at the junction between the four-wire and the two-wire portions of the circuit are also returned to the sending end and operate in the same manner as the true echo. The "echo suppressors" stop these currents also, and it is for this reason

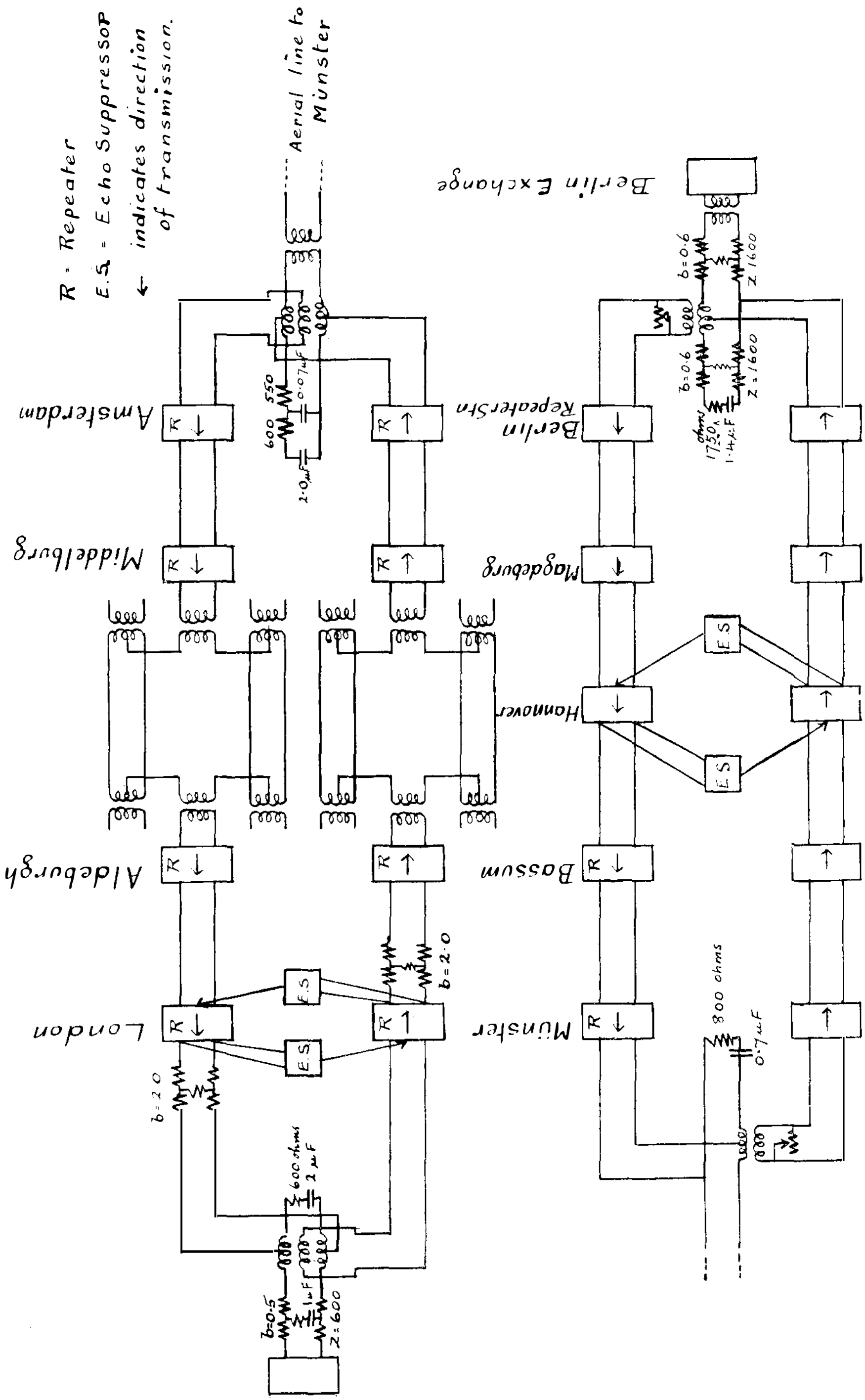


FIG. 2.—CIRCUIT ARRANGEMENTS, SHOWING POSITIONS OF ECHO SUPPRESSORS.

that an " echo " suppressor has been provided for each four-wire section. Fig. **2** shows the circuit arrangements.

At the London end of the circuit a section of artificial cable is connected between the output side of each repeater and the line to enable the maximum amplification of the repeater to be used without unduly increasing the transmission level on the line. This arrangement makes available a greater voltage for operating the " echo suppressors " and the latter thus operate more efficiently with weak speech currents than they would do otherwise.

It will be noticed that phantom circuits are used in the submarine cable.

Signalling is effected by means of 500 cycle alternating current. The energy used is within the scope of the telephone repeater valves and the signalling current is amplified in the same way as ordinary speech currents. Intermediate ringing repeaters with their attendant relay troubles are thus eliminated. Reference to the table of transmission values will show that the efficiency is good at the lower frequencies and this is necessary in order that the ringing currents shall be properly maintained. A test at a frequency of 500 cycles ($\omega = 3140$) showed the efficiency to be practically the same as that at $\omega = 4000$.

Special relays designed to respond to the 500-cycle current are used to receive the signalling current and these relays operate ordinary telephone type relays which send out 16-cycle current to the normal exchange signalling equipment. The operators ring in the usual manner with 16-cycle current and this operates relays which cause 500-cycle current to be passed out on one side of the four-wire portion of the circuit. A diagram of the terminal arrangements for 500-cycle signalling will be found on page 279, Vol. 18, of this Journal.

The echo suppressors were manufactured by the General Electric Coy. (Peel Works, Coventry).

As already explained, the arrangements are only of a temporary character. When the full day service is opened the Berlin circuits will be operated as four-wire underground circuits throughout, except in the submarine cable section which will be worked on a two-wire basis. Repeaters will then be installed at Marks Tey instead of London and the Middelburg station will be replaced by one at Domburg.

[NOTE.—The Anglo-Dutch No. 3 Cable has been laid from Domburg to Aldeburgh and tests prove it to be efficient. We hope to give a description of this cable in our next issue.—ED., *P.O.E.E.J.*]

AUTOMATIC TELEPHONE EXCHANGES IN AMSTERDAM. MAINTENANCE EXPERIENCE.

By Dr. Ir. Ch. E. A. Maitland.

A short description will be given of the installation of the telephone system in Amsterdam.

There are now (1925) four main exchanges and one satellite, viz.:—

2nd level South, Tenier Street. C.B.2 full automatic.
3rd ,, Central, Singel Street. C.B.3 full and semi-automatic.
4th ,, North, Raadhuis Street. C.B.4 semi-automatic.
5th ,, East, Middenweg. C.B.5 full automatic.
6th ,, of which the bulk of the 1st G.S. and 2nd G.S. are placed in the office North, and one satellite is installed on the opposite side of the river at the Wingerdweg C.B.6 (full automatic).

All exchanges are of the Siemens and Halske Strowger system. They work with impulses with earth return. The switches are controlled electro-mechanically by sequence switches. These sequence switches are of a minor switch type with banks and wipers.

The toll traffic is served by means of manual switchboards, except in the satellite of the 6th level, where the toll traffic is distributed automatically.

Table I gives various information about the exchanges. The semi-automatic exchanges are being altered gradually to become full automatic. The figures under 9 and 10 relate to the load during the peak hour 10—11 in the morning for January, 1925. They hold for normal working. On special days higher figures are reached, for example 22500 for C.B.4.

The maintenance of a telephone exchange can be divided into two parts:—

1. Preventive measures.
2. Removal of faults.

The first includes the measures for revealing and removal of faults before they have caused disturbance to traffic. The second refers to the removal of faults which have been revealed by causing disturbance to traffic. The statistics in the first category serve as a judge of the work of the maintenance staff, those in the second category show the quality of the maintenance.

The sharp demarcation of the different types of faults in the maintenance statistics would, however, cause insurmountable trouble. For instance, if a fault is found by the patrol it is by no means sure that a fault of one or another kind has not already arisen in a connection, which, however, has given no cause for a complaint and has not been advised in any other way.

Conversely, the fault may have been noticed owing to supervisory signals, among others, those due to a temporary overload of the switching apparatus, which are therefore not caused by any technical fault. For these reasons it is convenient to divide the various types of faults as follows:—

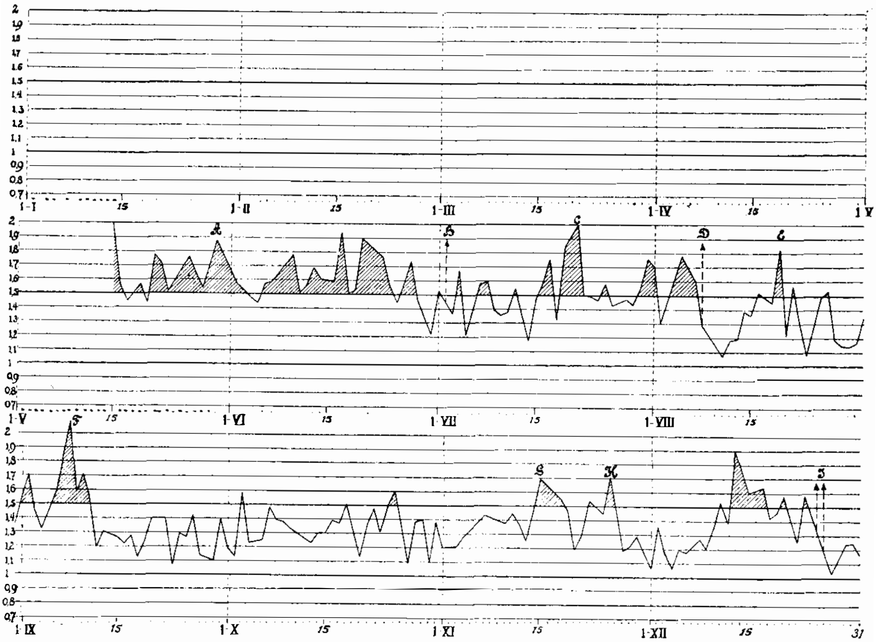


FIG. 1.—NUMBER OF FAULTY CONNECTIONS AS PERCENTAGE OF THE TOTAL NUMBER OF CALLS IN 1924.

(1st) Control faults which have given no cause for a complaint, yet have been found by the staff by means of tests, either by the routine tests or by various supervisory apparatus (C faults).

(2nd) Faults, which are reported by the public to the monitor (S faults).

(3rd) Faults, which are advised by the operators (B faults).

The first category affords an indication of the activity of the staff, while the figures of the second are a measure of the public's appreciation of the service and as such can serve as an indication of the quality of the service.

The third group stands more or less by itself. The faults belonging thereto can belong either to the first or the second group: it is not always clear in which category they should be.

They naturally only appear in the semi-automatic exchanges and are only located in the apparatus which is used in connections completed by the telephonist.

Quantitatively they have not much significance. The sum of the three kinds of faults is a measure of the technical perfection of the whole apparatus. In conjunction with what has just been said, the staff in the exchange may be divided as follows:—

I. *Maintenance staff* (*C faults*).

II. *Fault staff* (*S and B faults*).

The first staff works on its own initiative; the second works when fault reports are handed in.

The maintenance staff includes the following:—

(*a*) Cleaning and tidying.
(*b*) Routine testing of switches.
(*c*) Inspection and revision.
(*d*) Control by means of supervisory signals.
(*e*) Control through fault statistics.

We shall discuss these in more detail.

III. *Cleaning Staff.*

Since the working of an automatic exchange depends so very largely upon many contacts of many sorts it is necessary to keep the rooms very free of dust.

Contact faults arise through burning, *i.e.*, electrolytic oxidation, or owing to the contact being dirty with dust.

In many cases the last stimulates both of the others, especially the second phenomenon. The dust floating in the room collects on the contacts, at first through the breathing of the relay, and, secondly, possibly collects through the electric charge of the contact points. The breathing arises through the heating and cooling of the relay coils, causing air currents to and from the relay casing.

These air currents bring dust with them or what is yet more annoying very fine particles of oily matter, arising from the lubricant, or paint and perspiration from the strongly heated coils.

The greater the number of relays which are enclosed in a relay group the stronger will be the phenomenon of breathing and the greater is the possibility of dust trouble. In a very short time the deposition of dust occurs on the inside of the relay covers. The results of the Amsterdam fault statistics show that a large number of contact faults appeared after 5 or 6 days of dust movement or dust activity. The running and still more the removal of cables, the visits of a great number of people, blowing dust from the I.D.F. and, most troublesome of all, painting with quick dry-ing paint increase the number of faults. This can easily be seen from point L on the curve in Fig. **2**. As a result of the painting of the ceiling and of a wall in the Central Exchange, the faults rose shortly afterwards so much that the percentage of faulty connections reached 2.48%, 1.5% being normal.

Seeing that the phenomenon was well known, and also knowing which contacts were the most likely to suffer, the trouble was quickly removed.

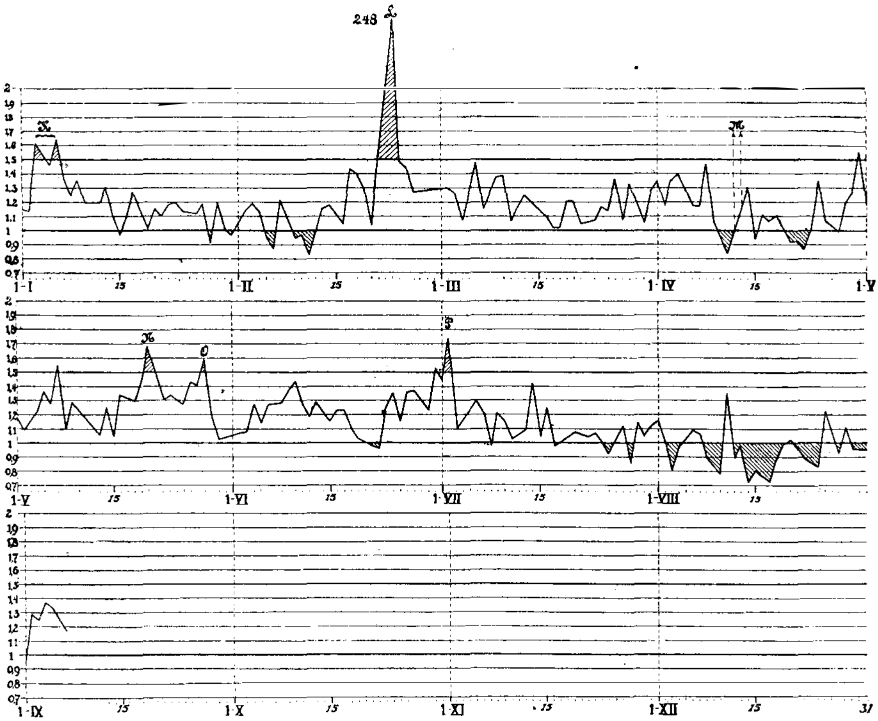


FIG. **2**.—NUMBER OF FAULTY CONNECTIONS AS PERCENTAGE OF THE TOTAL NUMBER OF CALLS IN 1925.

The same thing happened shortly after the exchange " North " was opened, which occurred unfortunately simultaneously with a heavy overload. Here also painting had just previously been done. In this case the contacts chiefly affected were the break contacts of the cut-off relays and largely those which only carried speech currents; (among others, in the manual board selectors).

An improvement can be made here by so designing the trunking scheme that a small direct current is carried over the contact. The case is the same with the impulsing contacts of the motor interrupters. The contacts carrying direct current are not so sensitive to dust, but wear away sooner than the contacts which carry only speech and signal currents (A.C.).

It is necessary to keep the auto room as free of dust as possible. Cleaning of contacts which is necessary to prevent the occurrence of trouble if dust be present must be restricted as far as possible because of the wearing of the contacts, and because much re-adjustment of relays and switches would be necessary afterwards.

It is much better to avoid trouble by preventing dust in any feasible way. Regular cleaning of contacts occurs only now and then and less frequently on the contact banks of the Strowger switches.

The cleaning of the apparatus is restricted to the removal of dust from springs and relay covers (these also on the inner side) while simultaneously the dust displaced is removed by a powerful vacuum cleaner. For this cleaning, two workers are always needed, one controls the dusting brush and one controls the vacuum cleaner. Co-operation between the two is naturally required and needs effective supervision. A powerful vacuum cleaner is installed in the power room in each exchange, to which pipes are connected throughout the whole building. Portable hand blowers are also provided to blow away dust if necessary. These must not be used on switches. They only serve for the cleaning of the M.F. & I.D.F. and are always used in conjunction with the vacuum cleaner. Even with these careful measures it is found that after each time dust is blown away an increase of the number of contacts faults is noticeable. The distributing frames cannot, however, be cleaned in any other way.

To prevent the accumulation of dust, all auto rooms are provided with linoleum on the floors, which is always kept waxed to hold the dust. The rooms are approached through double doors, and the ventilation is done exclusively through ventilators, which draw air through openings covered with flannel filters. The humidity is of much importance. With great dryness, under 30%, there is an increase of dust. This is noticed during periods of hard frost when the heating must be effective, and the air is dry. It is then necessary in one way or another to introduce vapour with high humidity. Above 70%, insulation faults begin to be apparent. For these reasons the humidity is kept between 30% and 70% if possible. Considering that contact faults amount to 20—50% of the total number of faults advised by the public (S faults) it is obvious that the work taken to avoid these is quite justified.

A very great improvement in the number of contact faults has been brought about through the introduction of double silver contacts. The contact spring is split, and each contact consists of two contacts side by side, each with independent contact points.

The improvement brought about by this type of contact in the impulse sender relays in C.B.3 is apparent in the great decrease in the percentage of ineffective connections, after the installation of double silver contacts. (See line D in Fig. 1).

The exchange East, C.B.5 is provided throughout with such contacts, which is evident from the number of contact faults.

The number of contact faults on the break contact of the cut-off relays (*t* contact) amounted to :

C.B.2	20%	of the total S	faults	(with good inspection).
C.B.3	60%	,,	,,	,,
C.B.4	50%	,,	,,	,,
C.B.5	10%	,,	,,	(double silver contacts).

IV. *Routine testing.*

It is necessary to look for eventual faults and defects through the periodical control of the switching apparatus before they have given rise to faults during the working. The more energetically this control functions and the greater the percentage of total faults found in this way, the less will be the hindrance which the public will experience from unavoidable faults. Much routine testing needs a big staff, and a position is reached where increase of staff produces very slight improvement in reduction of C faults.

Too many examinations of the apparatus disturbs the working and reduces the number of switches available for the traffic. Naturally the less busy hours are chosen for routine testing.

The maintenance staff in Amsterdam works from 7 a.m. to 7 p.m.; outside these hours watchmen only are on duty. The testing of switching apparatus takes place mostly between 7 and 9 a.m., 12 to 3 p.m. and 5 to 7 p.m.

There are three kinds of tests :—

First, the functioning of the switches in all levels. For this purpose there are jacks in the connections to the switches.

The faultsman inserts a tester in a jack of the group selector and raises the selector one by one to all rows and lets it rotate.

In the case of the 1st group selectors the signals are observed at the same time. In the case of the final selectors the switch is directed to a control fault number to which the tester has been connected, to prove the working of the signals.

Usually all selectors are tested once a week in this way. Occasionally an extended test takes place, which consists in proving the outgoing trunks of a bank of each. All the contacts of any row are disconnected except one, while the group selectors of the following level are removed. The switch thus comes during rotation to a pre-determined contact, from which the trunks can be controlled. For these tests two men are always necessary and they take a long time. Nevertheless, it is always done when work has been done on the selectors or the preselectors.

Second. Testing switches which are not in the normal position.

This serves to show which switches do not switch out in use. The faultsmen supervise this by investigating with a head telephone the voltage condition of the lines, at the same time all idle switches are tested to see if they are connected to battery.

This test can be done very quickly by efficient men and is done each half hour when possible. It shows up a great many of the C faults.

Third. Making complete test calls. This is done through the traffic office, mainly with other objects, yet it may also be advantageous in the search after faults. The traffic office makes on certain days in the busiest hour a great number of test calls, say from 400 to 600, from numbers in groups with very heavy outgoing traffic, to numbers in groups with very heavy incoming traffic, and investigates in this way the possibility of connections during the most unfavourable hours and under the most unfavourable conditions.

The tests go over all levels and all trunks by varying the test numbers. If faults are then found the switches and lines used are, if possible, held and instantly reported to the relative auto room. The cause of the fault is sought for at once. The tests are made through a routine testing office, with carefully controlled testers, so as to ensure that the defects reported in the exchange will be sought. Owing to the great number of these tests and the variety of the channels used, these tests give an accurate view of what a subscriber should experience when working without error, with good instruments in the most unfavourable conditions.

For the full automatic exchange, the faults found in this way amounted all told to 0.2% ; for the semi-automatic the faults were 3.5%, of which 1.5% were faulty numbers due to telephonists' errors, and 1.5% to the manual board switches.

The preselectors are given no regular tests except when there is a particular reason for it. To do the whole lot regularly would take too much time. The manual board selectors are routine tested about once a fortnight.

V. *Inspection and Supervision.*

An exchange is divided into 6 groups for maintenance: *i.e.*, five of 2000 lines (1st preselectors, 2nd preselectors, 1st group selectors, manual board selectors, 3rd selectors, and finals) and one group taking all second selectors. In the semi-automatic exchanges there is a seventh group comprising the impulse senders with the digit keys. In each group there are two mechanicians and an assistant, who are responsible for the working of the group. They work as far as possible always in the same apparatus group, doing all works, for both tests, and the search for faults. They do the necessary inspection and supervision of the switches. The first consists chiefly in following the working of the selectors in use. They are so practised that to a great extent they work by hearing and recognise any abnormality by sound.

Supervision means the systematic control of the switches and relay groups, for the purpose of adjusting all subsidiary parts, following the adjustment details.

Formerly this supervision occurred periodically. At stated times the apparatus was withdrawn from service and tested for correct adjustment in a mounting on a bench equipped with special testing apparatus. This has usually proved unnecessary. At present the group switches and relay groups are only subjected to supervision when, on account of some kind of fault, they have been taken from their place for repair.

The switches are repaired in the room. The relay groups are repaired in a small work room, placed close to the auto room, where tools and parts are available and also a small test panel whereby the working of the relays and impulse senders can be tested in accordance with rules laid down.

This supervision and the simple repairs are done by the personnel of the group during the time when three men are present, so that two can work in the auto room and one in the workshop. This is normally between 10 a.m. and 4 p.m. See Fig. **4.** It will be seen that in this way the working of selectors comes under supervision, as follows:—

1st selectors, twice per year.
2nd selectors, once per year.
3rd selectors, once per two years.
Final selectors, once per year.

As all selectors are numbered and always stand in the same place, accurate records can be kept.

This gives good control over the quality of the apparatus and of the work of the maintenance men.

VI. *Control via Supervisory Signals.*

These are (*a*) Blown main fuses.
(*b*) Blown distribution switch fuses.
(*c*) Late disconnection of interrupter.
(*d*) Congestion in groups when all available outlets to the following rank are busy. This is only for 1st and 2nd preselectors.
(*e*) Failure of signal interrupter, ringing current, etc.

(*f*) Permanent loops: this is given after 120 seconds.

(*g*) 1st group selectors, where a connection is called for, but does not come to fruition because the connection is broken in the first or following ranks, or through a disconnection in a level. The alarms (*a*) to (*e*) are denoted by various coloured lamps for each section and division of 2000 lines. *a* and *b* are also given audibly.

The signal *f* is a lamp for every row of 10 first group selectors. When it lights, the faultsman looks for the relative selector, connects his test set and finds if a subscriber is talking. These signals are mostly caused by short circuits outside the exchange, which are then discovered by this method.

(*g*) is the most significant alarm; it consists of a small lamp on every 1st group selector. There is, further, a supervisory signal per group, denoting in which thousand a signal *g* has appeared. These lamps are placed near jacks, through which the faultsman can enter the circuit. The signal appears as soon as the connection fails, and lasts as long as the subscriber concerned does not hang up.

The faultsmen in charge of a division during the busy hour remain near the 1st group selectors. As soon as a signal *g* appears, he butts in and seeks for the cause of the fault. The subscriber is sometimes to blame and he can be informed. Sometimes trouble is caused while all lines in the level asked for are busy.

In many cases, however, it is a fault which the faultsman can detect by taking the 1st group selector over from the subscriber, in the position to which it has been raised, and then demanding the same number as the subscriber has done. If this connection cannot be put through the switch can be held and the way in which the call has gone astray can be found and investigated.

A great number of C faults can be found in this way, which requires the continual surveillance of the faultsman. For the sake of completeness it should be mentioned that while the connection the faultsman makes may be successful yet this does not mean that no fault exists. The connection may have been made by another route. However, the faultsman is usually quick and therefore no change has occurred in the position of the succeeding selectors needed to complete the desired connection, and the second connection follows the same route as the first. If the fault be not found, he notes the called number and gives special attention to the fact if more alarms *g* come from the same 1st group selector. Alarms *g* are multipled on a desk in the exchange Inspector's office. The working of the exchange can e judged from the incidence of the glowing of these lamps, and indicates whether his presence is required in the auto room.

VII. *Control by fault statistics.*

Fault statistics afford an indication of the standard of maintenance. In many cases they also serve directly as a means of investigating faults.

In the case of complicated switches, one cannot fully determine that they are fit for service by just testing them at the test table. When a switch fails to function properly five times out of 100 connections, it is not fit for service and yet it is quite possible that it had been found O.K. on test.

The impulse senders give a good example of this. When these are all in the same condition as regards maintenance, and the traffic is distributed well and evenly in the exchange, then for all senders the ratio of the number of ineffective calls to the total effective calls is the same, unless one of the senders has some small fault which brings it into an unfavourable situation as compared with the others.

When it is possible to calculate the proportion aimed at above for the whole of the impulse senders, which in Amsterdam can easily be done, then an average is obtained for any twenty-four hours, from which the individual figures of the switches may deviate but little.

As soon as an impulse sender shows deviations from the calculated average, which lie outside the limits of pure chance, it is switched out and again tested carefully in accordance with instructions. If it is brought back to its place the faults must vanish, which is generally the case.

Fig. **1** and Fig. **2** show clearly the result of working in these ways. The figures show the number of ineffective calls per 24 hours in C.B.3 as a percentage of the total number of calls for the period 15th May, 1924, to 1st September, 1925.

Between points B and D the improvement in impulse senders through the introduction of double silver contacts is apparent, because the figure falls regularly from an average of 1.4% to 1.0%.

The peaks have always some particular cause and as such are interesting.

These are to be imputed either to heavy traffic or to a junction breakdown, or to special circumstances.

The cause of the faults are given below; the letters refer to letters on the figure,

1924. A. Heavy traffic at Ascension Day.
B. Beginning of improvement in impulse senders.
C. Fault in junction cable C.B.2—C.B.3.
D. End of improvement in impulse senders.
E. Fault in junction cable C.B.3—C.B.5.
F. Heavy traffic in C.B.4.
G. Fault in cable C.B.3—C.B.2.
H. Heavy traffic in C.B.4.
J. Christmas.
1925. K. Heavy traffic in C.B.4.
L. Auto room painted. (See above under III.).
M. Heavy traffic before Easter.
N. ,, ,, ,, Ascension Day.
O. ,, ,, ,, Whitsuntide.
P. Two manual board selectors faulty.

It is clear that in these graphs abnormal occurrences are easily separated from the normal and their influence can be predetermined. Space does not allow me to go further into this.

A method similar to that described for the senders was applied to the first group selectors in the full automatic exchange: the proportion of connections which failed due to switch faults to the total number of connections per row of 10 switches for 24 hours were also calculated.

The effect of this system of control is much better than any other testing scheme and the resulting figures may be useful at some time for other purposes.

VIII. *Fault Staff.*

The fault staff has to clear as speedily as possible the faults which have been advised by the complaint office and found faulty by the Testing Operator. They are handled by the faultsmen in the relative group. The great majority of these faults are found in the apparatus particular to the lines, chiefly in the preselectors and in the final selectors.

The same procedure is followed in the case of faults advised by the operating telephonist in the semi-automatic exchange, which usually occur in the manual selectors, impulse senders, or digit keys.

Table II gives % faults in group C, S and B, and of the total T distributed among the various classes of apparatus. The figures for each exchange per month are fairly constant, as can be seen from Fig. 3, though they vary slightly round the average. Also for the various exchanges, they do not vary much from one another unless special reasons exist.

For example for C.B.5 the figures for preselectors are low as

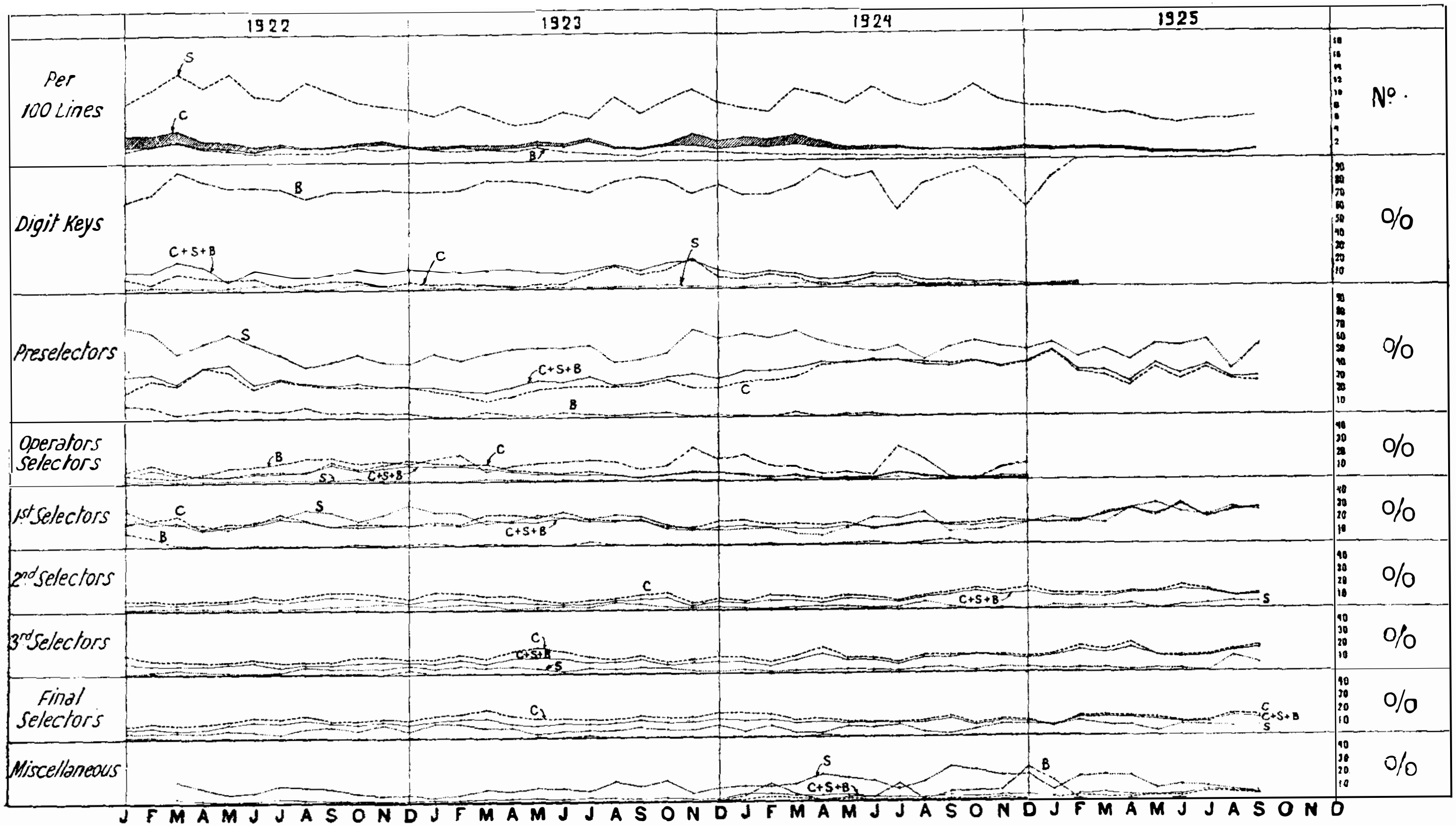


FIG. 3.—FAULT STATISTICS FOR EXCHANGE C.B.2.

a result of the double silver contacts; for the 1st group selectors they are high because there an impulse repeater is concerned which in other cases is wanting. From Table III we see further the distribution of faults among C, S and B: 70—90% were found by the patrol. The high figure for C faults for C.B.5 may be explained through the improved preselector contacts which cause the greatest part of S faults in other exchanges.

It is easy to see that the full automatic exchanges have fewer faults than the semi-automatic. The cause lies in the manual board selectors as appears from Tables II and IV. C.B.3 suffers most; it is the only exchange where the manual board selectors are provided with self interrupters. Fortunately they will disappear after cut-over to the full automatic system.

In conclusion, Table IV shows the proportion of C and S faults in % for each type of switching apparatus, likewise the number of faults per 100 switches per month, calculated from an average over the first 9 months of 1925. The figures for the various exchanges do not vary much from one another and nearly all deviations lie in small differences in the build of the installations. Space does not allow me to go deeper into the question.

IX. *Graphical statistics.*

The best way of watching the maintenance in an automatic exchange is to have appropriate statistics; and the most easily understood are graphs. Each individual exchange can be watched and the results compared with those of all the exchanges. Standards for the various quantities are first obtained. For unfavourable deviations one can find explanations, in order to find how to prevent these occurring.

If the deviations are in the favourable direction one can investigate these to see if the standard can be improved.

In Amsterdam 7 graphs are kept permanently of each of the various types of apparatus in the exchange, *i.e.*, for preselectors, 1st selectors, 2nd selectors, 3rd selectors, final selectors, manual board selectors, digit keys: and for a miscellaneous group not included in the others.

The seven graphs are:—

(1) C faults per 100 switches per month.
(2) S ,, ,, ,, ,, ,,
(3) B ,, ,, ,, ,, ,,
(4) % of the total number of C faults.
(5) ,, ,, ,, S ,,
(6) ,, ,, ,, B ,,
(7) % of the total number of (C + S + B) faults per month.

There were also deduced graphs for

(8) the number of C faults per 100 lines per month.
(9) ,, S ,, ,, ,, ,,
(10) ,, B ,, ,, ,, ,,

The term, number of switches and lines means the working number, not the capacity.

In full automatic exchanges 3, 6, 10 do not appear. Graphs 1, 2, 3; 4, 5, 6, 7; 8, 9, 10, are connected so that the total can conveniently be found. In Fig. **3** the graphs 4, 5, 6, 7, for all types of apparatus are shown for C.B.2, also 8, 9, 10 are indicated for the years 1922-1925. It is seen from the figures how far the quantities are constant, and thus can be considered as standard. Between Feb. 1924 and March 1925, C.B.2 was changed from semi to full-automatic. The effect can be studied on the graphs.

The fall in the number of S faults for 100 lines is noticeable.

The lines 4 show how the control has worked in the previous month and which part of the equipment has been given special attention; so one sees for example from line 4 of the preselectors that in March, 1924, more attention has been given to these. The result is visible in the fall of the line 2 and the rise of 1 (not given in Fig. **3**) relative to the preselectors and similarly through the falling of line 9 without 8 rising appreciably. This is actually the case. After the more intensive control is continued for some time, the lines 1, 2, 8, and 9 all reach a lower level, to which line 4 also approaches, as otherwise the other apparatus would come too far behind. Usually the lines 4 to 7 give results for the equilibrium, that is to say, for a judicious distribution of the maintenance work on the various types of apparatus. The others show more the resultant of the activity. The falling of line 1 with a rise of line 2 and conversely show the transfer of emphasis laid by the maintenance staff on various types, while the same phenomenon appears in lines 4 and 5. If this is not the case, there must be external causes for the discrepancy and these must be sought for. Probably all or at least many of the lines 1 and 2 show the same phenomenon.

Simultaneous rises in lines 1 and 2 have always an external cause, which lies beyond the scope of the maintenance men. Usually any sudden rise in one of the lines is followed by a fall and conversely. With the help of graphs one is always in a position to study the effect of such influences on the other apparatus. The data for these graphs were obtained as follows: Any fault or deviation is written down on a docket by the faultsman who handles the fault.

These dockets are collected on cards and once a month added up and put in graphical form. On the cards the statistics are given in detail, so that it is always possible to analyse further a portion and see the relation to the three categories of faults. This is done as soon as the lines show abnormalities.

The faults are divided into electrical and mechanical faults; these are again subdivided into the groups where they occurred and according to the type of fault observed. These figures are, however, by no means constant.

Sometimes special statistics are taken over selected portions which require investigation. Yet all these activities are secondary, so long as the above mentioned lines are normal. Detailed studies are only undertaken when the graphs give cause for such. It will be noticed from Fig. **3** that the lines are fairly independent of the seasons and also, within definite limits, of the traffic. The last holds also for various exchanges as regards lines 1—7, while the average load per switch in the exchange is the same, which is always the case if the design is good.

The lines 8 to 10 for an exchange with heavy traffic per line naturally lie higher because more switches per line are in use.

In the same exchange, the number of faults is independent of the traffic within certain limits, so long as the normal load on the switches is not exceeded and thus not many calls are lost. When that occurs the faults rise quickly and as soon as the critical point is reached they rise so fast that serious congestion is to be feared. The critical point lies somewhat higher than the capacity of that group of apparatus, which has the smallest capacity as compared with the traffic.

In a well designed exchange the traffic capacities of the various groups of apparatus are about the same. The critical point in C.B.4 lies about 23000 calls per hour. For the impulse senders the conditions are different in some ways. The number of faults in these is proportional to the square of the number of connections; happily the curve of this function is very flat for normal loads.

The difference as compared with the switches is easy to understand. The impulse senders function as long as they are in use and on the average always for the same period which is independent of the traffic. The switches operate, however, only at the beginning and the end of the connection and whenever, as a result of congestion, the average duration of the connection becomes smaller, then the number of times that it is actually in active operation during a definite time begins to increase appreciably.

From that moment the number of faults increases as the square of the traffic, and rises very steeply in the neighbourhood of the critical point.

X. *Staff.*

In the various competitive comparisons between systems, the maintenance staff has always played a significant role. One must here be very careful in judging the figures, because the amount of staff required does not exclusively, nor even principally depend upon the system.

There are other factors which have great influence. These can be described as:—

A. The traffic per line and the size of the telephone system in which the exchange works.
B. The limits set to the quality of maintenance.
C. Service conditions and regulations concerning working hours of staff.
D. The installation and the building of the exchange.
E. The system.

A. The greater the traffic per line so much the greater is the number of switches, and thus the greater the number of faults for an exchange of the same number of lines. In a great network with a lot of junction traffic the second selectors form such a large group that they need special supervision and more maintenance.

Whenever one compares a simple exchange with one of such a system both these factors must be remembered.

B. When a good standard of maintenance has been reached in an exchange, improvement only occurs by increasing the number of C faults and a reduction in the S and B faults. One can be satisfied with 70% in the first category and yet can wish for 90%. The latter necessitates more work and therefore more staff.

Besides this more emphasis can be put on cleanliness in the exchange and the demands for routine testing can be reduced. The influence of this on the number of faults has already been referred to in Fig. 3.

How far must one go with maintenance?

In the first place until a reasonable minimum has been reached for the total number of faults C + S + B. Then one may strive to reduce the percentage of C faults at the cost of the S faults, so long as the result obtained is relatively greater than the increase in cost.

Whenever, for example, it costs 20% more manhours to obtain a reduction of 1/10th in C faults, the limit has been passed.

There is also, however, another limit. Whenever the total of S faults in the exchange has become too small, so that it has no marked influence upon the total number of faults in the network then the improvement in the proportion of C faults to S faults is useless, as it does not pay for itself.

It is no matter that different ideas exist as to the grade of perfection of the maintenance which influence the number of staff considered necessary, and which have nothing to do with the system as such.

As an example one might mention that in Amsterdam none of the exchanges is allowed ever to be unattended, not even at night.

This avoidance of risk may have great influence upon the number of the personnel; above all in connection with what is said below in paragraph C.

C. This factor is one of the most important.

The prescribed hours of labour, rest times, Sunday and night work, the possibility of overtime, the limits within which the work hours must be kept, all these factors influence the formation of staff in the exchange.

If one has several exchanges of dissimilar size in one area then the burdens laid upon the staff in one exchange must not differ much from the burdens in any other, which leads to an overstaffing of the smaller exchanges. Otherwise the frequency of the night and Sunday work would become too great.

One can overcome this disadvantage to some degree by moving the staff from exchange to exchange, but this creates difficulties, above all if the exchanges are not all on the same system.

D. That the nature of the installation and type of exchange has influence upon the staff is obvious.

To have many small rooms for the plant is obviously more disadvantageous than to have large rooms. If the switches of the various groups are scattered irregularly, naturally more staff is required than with a rational layout.

E. The system itself naturally has a bearing on the case. Wear, accessibility of the parts, interchangeability, the necessary number of switches and their form, the tools, overloading, these have all influence on the staff required though not to the extent one might ordinarily assume.

In conclusion, one should consider the type and age of an exchange. For example, consider the exchange with sequence switches (minor switch type) which undoubtedly requires more maintenance than one without the continuous drive, and yet there are very good reasons for keeping this type in use. One thinks among other things of the advantage of similarity.

For the sake of completeness Fig. 4 gives a scheme of the normal staff in a fully equipped automatic exchange of 10,000 subscribers at Amsterdam, from which one sees the distribution of the hours of labour.

There are two groups of mechanicians, each with a foreman, one group of helpers, and one group of cleaners, unskilled workers. During the hours when both groups of mechanicians are present, one is working in the workshop, with the exception of the mechanician who is on evening duty.

In order to even out the service staff the exchange is divided up into six groups, five of 2000 subscribers and one group of 2nd group selectors. For each of these there are two mechanicians and a helper, while two extra helpers are provided for making up the complement of staff in the evening and at night.

The group of cleaners consists of six men, who work wherever they are required in the exchange. The total staff consists of 22 maintenance men and six unskilled workers, as appears from Fig. **4**.

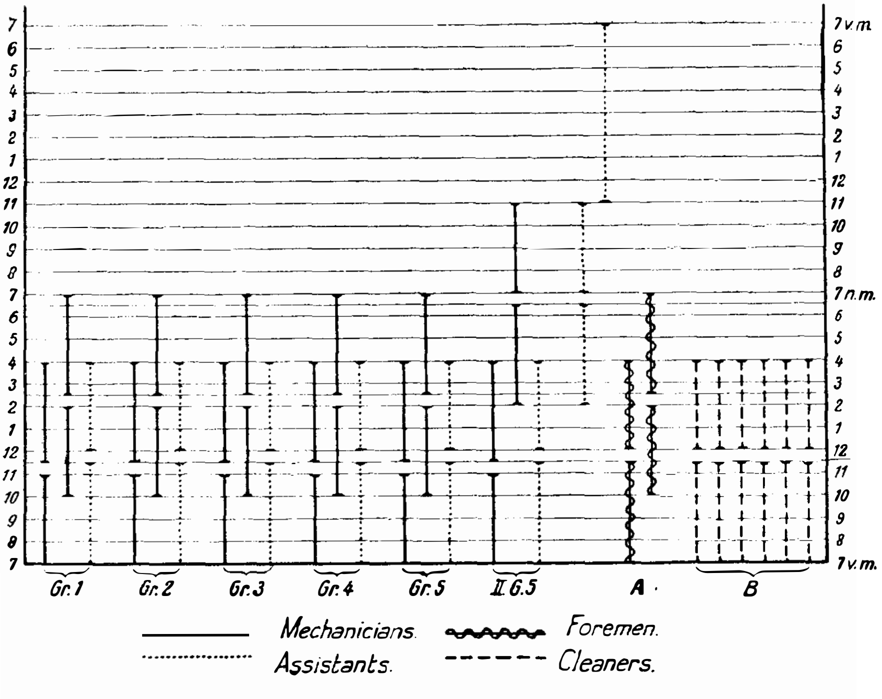


FIG. **4**.—NORMAL STAFF IN 10,000 LINE AUTOMATIC EXCHANGE.

One must look at this scheme in the light of what has gone before, and not consider it as the only one, or as the best for the normal case. It has been evolved for the specific Amsterdam case and requirements. Apart from and alongside of the maintenance staff of the exchange, there is a group of erectors. These are used for the installation of modifications, small extensions, large repairs and if necessary are available for assistance of the exchange staff in the case of long sicknesses and similar absences of several maintenance men. Service in this group is at the present time the practical opening for new staff.

TABLE I.

VARIOUS FIGURES.

Item.	C.B.2.	C.B.3.	C.B.4.	C.B.5.	C.B.6.	Total.
1. Number 1st Pre-selectors ...	10,000	8,000	10,000	4,000	1,000	33,000
2. Number 2nd Pre-selectors ...	1,000	800	1,000	400	100	3,300
3. 1st Group Selectors	600	560	700	240	60	2,160
4. 2nd Group Selectors.						
Trunk ...	340	350	450	120		
Junction ...	360	400	600	240		
Total ...	700	750	1,050	360	100	2,960
5. No. of 3rd Group Selectors ...	700	560	900	280	80	2,520
6. Final Selectors...	1,000	1,120	1,400	410	120	4,050
7. Total Switches...	14,000	11,790	15,050	5,690	1,460	47,990
8. No. of lines, 1 Sept., 1925. Normal ...	v. 8383	h. 3,034 v. 2,130 5,164	h. 7,210	v. 3,121	v. 328	24,206
P.B.X. ...	v. 73	h. 161 v. 93 254	h. 321	v. 54	v. 57	759
Incoming only	v. 26	h. 111 v. 41 152	h. 233	v. 16	v. 18	445
Outgoing only	v. 11	h. 47 v. 18 65	h. 85	v. 12	—	173
Total ...	8493	5,635	7,849	3,205	403	25,583
9. Max. hourly calls Jan., 1925. (Peak load) ...	11,436	h. 9,836 v. 3,480 13,316	19,950	5,593	726 July '25	50,621
10. Average hourly calls, Jan., 1925.	10,749	12,224	17,367	4,917	611 July '25	45,868
11. Year of opening (1) (2)	1911 1919	1922	1923	1924	1925	

h. = halfautom = semi-automatic.
v. = volautom = full automatic.

Table II.

DISTRIBUTION OF THE TOTAL NUMBER OF FAULTS IN THE 3 GROUPS:—CONTROL-MONITOR = S; MANUAL BOARD = B. IN % PER TYPE OF SWITCH.

Type.	C.B.2.				C.B.3.				C.B.4.				C.B.5.			
	C.	S.	B.	T.	C.	S.	B.	T.	C.	S.	B.	T.	C.	S.	B.	T.
Preselector	32.8	53.4	—	36.0	9	40	—	15.8	4.7	53.9	—	15.1	13.4	24.7	—	14.4
1st Selector	23.6	24.2	—	23.2	18	20	—	17.5	23.8	13.2	—	21.5	36.4	38.2	—	36.6
2nd ,, ...	12.5	3.2	—	11.2	15	2	—	12.7	21.1	4.3	—	17.6	16.9	7.0	—	16.4
3rd ,, ...	16.3	3.5	—	14.4	13	4	—	11.3	20.2	4.8	—	17.1	12.6	15.9	—	12.7
Final ,, ...	13.5	8.6	—	12.7	25	12	—	23.5	23.6	8.1	—	20.2	20.2	8.9	—	19.0
Manual Bd. Selector...	—	—	—	—	15	2	30	12.7	3.3	0.5	24	25	—	—	—	—
Digit keys	—	—	—	—	—	—	70	3.8	1.0	—	75	0.7	—	—	—	—
Miscellaneous ...	1.9	7.0	—	2.5	5	20	—	2.7	2.3	15.2	—	5.1	0.5	5.3	—	0.9

TABLE III.

AVERAGE NUMBER OF FAULTS PER 100 LINES PER MONTH IN 1925.

Group	C.B.2.		C.B.3.		C.B.4.		C.B.5.	
		%		%		%		%
Control	6.84	84.2	8.9	71.5	7.96	72	6.9	93.2
Monitor	1.28	15.8	2.94	23.3	2.01	18	0.5	6.8
Manual Board ...	—	—	0.66	5.2	1.11	10	—	—
	8.12	100	12.50	100	11.08	100	7.4	100

TABLE IV.

AVERAGE NUMBER OF FAULTS PER 100 SWITCHES PER MONTH IN 1925.

	C.B.2.					C.B.3.					C.B.4.					C.B.5.				
	C.	%	S.	%	Total	C.	%	S.	%	Total	C.	%	S.	%	Total	C.	%	S.	%	Total
Preselector	1.97	77	0.6	23	2.57	0.66	40	1.04	60	1.7	0.5	33	1.0	67	1.5	0.6	87	0.1	13	0.75
1st Selector	21.7	85	4.0	15	25.7	15.0	71	6.0	29	21.0	21.9	89	2.7	11	24.6	32.0	79	3.0	21	35.0
2nd ,,	10.2	95.3	0.5	4.7	10.7	11.1	96	0.6	4	11.7	14.1	96	0.6	4	14.7	10.	96	0.37	4	10.37
3rd ,,	13.1	95.5	0.5	4.4	13.7	12.1	90	1.4	10	13.5	13.5	96	0.5	4	14.0	9.5	97	0.3	2	9.9
Final ,,	7.7	90	0.9	10	8.6	13.7	85	2.4	15	16.1	10.6	94	0.7	6	11.3	10.5	96	0.4	4	10.9
Manual Bd.*	—	—	—	—	—	17.0	82.5	3.6	17.5	20.6	3	50	3	50	6	—	—	—	—	—

* Faults are advised by the operators.

TIME SAVING TESTERS FOR AUTOMATIC EXCHANGES.

By W. PRICKETT and H. S. SMITH.

Engineer-in-Chief's Office.

THE introduction of devices which effect labour saving to the extent of over 80% is regarded in the commercial world as a considerable gain, but the development by the Department of automatic methods of testing, as compared with manual methods, showed that this figure could be increased to over 90%.

Experience has proved that the former figure was easily reached by using tester " A " (described in the last issue of the Journal) for line switch tests in automatic exchanges. Tester " A," however, although testing automatically each outlet from a lineswitch, required the attention of a testing officer in order to make connection in turn to each of the subscriber's equipments to be tested. Tester No. 56, now to be described, obviates this necessity and makes the transfer automatically to the next line when the tests on the previous one have been satisfactorily completed. This process applies to the whole of the lines available on the multiple on a subscriber's unit, *i.e.*, 100. The testing officer's attention is required only for the commencement of the tests on the first line and for the removal of the tester to the next unit when the last line has been tested. He is thus able to proceed with other duties and need only attend to the tester in the event of its stoppage indicating a fault. The actual time occupied by the tester, in completing the 5000 tests required on a unit equipped with 100 line switches, is 50 minutes.

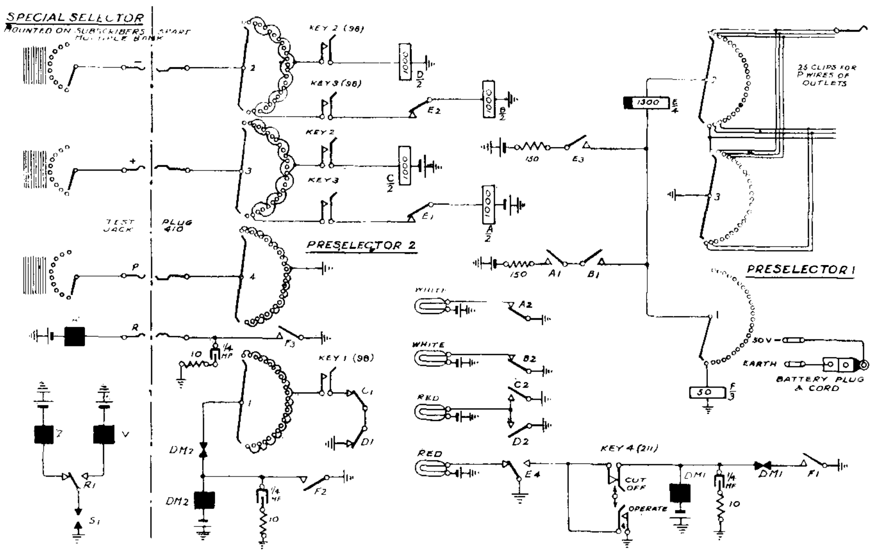
Tester No. 56.—For Testing Line Switches (non-homing) type) and associated Outlets to Selectors.

Tester No. 56 consists of two parts—the testing apparatus itself and a special selector. The latter is mounetd as required on a spare bank on the multiple side of a subscriber's unit and is used to make connection to each subscriber's line in turn. The testing apparatus includes two preselectors, one of which acts in a similar manner to that in Tester " A." The other is used to make the appropriate connections to the line connected by the special selector.

It is required to verify that the wiring and operation of the subscriber's line switches and associated outlets to selectors are in order. The tester, the connections of which are shown in the diagram, is designed to test each outlet twice in order to use each end of the double wipers with which the line switches are equipped.

Before commencing the test it should be verified that all equipped line switches are connected by means of straight jumpers to corresponding numbers on the multiple.

To commence the test, the special selector is mounted on a spare multiple bank and its wipers set to the normal position, which is special to this switch, on contacts 1 of level 1. The selector is connected to the tester by means of a test plug, and battery and earth are supplied *via* the usual contacts on the switch jack. The twenty-five clips provided for the purpose are connected, in order, to the P wires of the outlets on the terminal assembly on the line switch side of the unit.



Connections of Tester No. 56.

Battery and earth for the tester are obtained *via* a cord and plug and the unit power jack.

All line switches and the tester preselectors should now be set to contacts 1.

Keys 2, 3 and 1 are then thrown in this order.

The effect of key 1 is to step on preselector 2 to contact 2. The circuit is from battery *via* DM2, interrupter springs, wiper 1 contact 1 of arc 1, key 1 op., C1 nor and D1 nor to earth.

Key 2 connects relays C and D *via* contacts 2 of arcs 3 and 2 to the + and − lines in order to provide a test for faulty operation or failure of the line switch cut-off relay (BCO). The latter should be operated *via* contacts 1 and 2 and wiper 4 of preselector 2. If the BCO relay has operated correctly, the + and −

lines will now be clear and relays C and D should not operate, thus allowing preselector 2 to step to contacts 3 as before. If, however, either the line relay or earth has not been disconnected by the cut-off relay, relay C or D operates and prevents rotation from contacts 2.

Relays A and B are connected by key 3 to contacts 3 of arcs 3 and 2, and when preselector 2 reaches these contacts are extended by wipers 3 and 2 to the line circuit. The BCO relay is released when wiper 4 reaches contact 3 and allows the line relay and earth to be restored to the line circuit. If there be no reversal in the lines, relays A and B and the line relay now operate. The line relay should cause the line switch to seize the first outlet and extend the line circuit to the selector connected thereon, relays A and B in the latter being operated, causing a guarding earth to be placed on the private wire.

The operation of relays A and B connected battery *via* a 150 ohm resistance at A1 op. and B1 op. to relay E. Relay E operates *via* wiper 2 and contact 1, arc 2 of preselector 1 to the earth on the outlet P wire. As, however, relay E is slow to operate, time is allowed (1) to ensure that the operation of relays A and B is maintained by the selector A relay being connected, without reversal, *via* the outlet and (2) for the line switch line relay to release, ensuring that the earth on the private is that supplied by the selector.

Relay E, operating, provides a holding circuit for itself at E3 op. and disconnects relays A and B at E1 op. and E2 op. to release the selector and cause the holding earth to be removed from the private. It also energises DM1 at E4 op.

Provided that the line switch line relay is not sticking, so maintaining the earth on the P wire, relay E should in due course release and, disconnecting DM1 at E4 nor., causes preselector 1 to step on to contacts 2, in which position wiper 3 busies the P wire of outlet 1 against further use.

The tests are now repeated on the line switch, but as outlet is busy, the wipers should be rotated to outlet 2, which should be seized. As relay E is now connected to the P wire of this outlet *via* contact 2 of arc 2, the sequence of operations should be repeated and if the outlet be O.K., it will in turn be busied and the test transferred to outlet 3.

This process is repeated until each outlet has been tested twice, *i.e.*, with each end of the double wipers.

When the fiftieth test is being made, relay F is connected *via* contact 25 of arc 1 and, on the operation of relay E, receives sufficient current to operate.

Relay F steps-on preselectors 1 and 2 *via* F1 op. and F2 op. and the special selector *via* F3 op.

The latter now makes connection to the second line switch to be tested and the sequence of operations is repeated.

This process continues until the tests have been completed on the tenth line, when the ensuing rotary step of the special selector operates the cam springs S 1, energising the vertical magnet *via* R 1 op. This causes the selector to step up to level 2 and then, on the release of the rotary magnet, springs R 1 return to normal and the release magnet receives an impulse and releases the rotary dog, which allows the wipers to rotate back to contacts 1. Connection is now made to line 21 and the tests proceed as before.

This action is repeated on each level of the subscriber's multiple until the whole of the line switches equipped on the unit have been tested, when the tester comes to rest with the wipers of the special switch above the bank.

The special selector and tester connections are then transferred to the next unit to be tested and so on throughout the exchange.

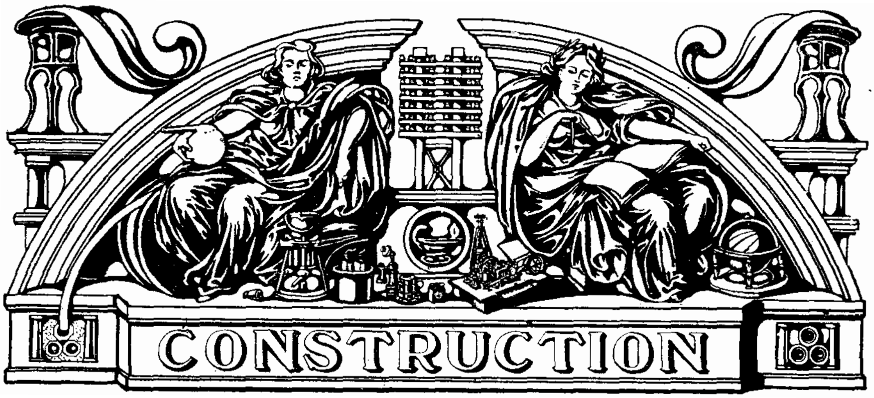
In cases where units are not completely equipped with line switches, the tester will stop when an unequipped line is encountered and the special selector is stepped on by hand to the next equipped line.

Attention is drawn to faulty lines by the tester ceasing to work and an indicating lamp glows to provide a rough indication of the nature of the fault. Thus, faulty operation of the cut-off relay causes a red lamp to glow, while trouble on the + or − lines is indicated by white lamps, and failure on the outlet by another red lamp. The application of these lamp signals is similar to that indicated in the schedule given at the conclusion of the previous article on Tester "A."

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 MARCH 31ST, 1926.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
485,927	582	4,171	54,469	490	London	23,353	55,572	1,658,106	55,883
59,221	1,907	20,916	58,812	1,646	S. East	3,793	24,230	107,717	17,006
63,093	4,463	26,775	47,063	1,914	S. West	13,802	6,553	96,553	28,348
49,381	8,585	31,546	43,483	5,014	Eastern	12,868	27,176	58,837	52,139
81,855	8,448	41,986	52,798	3,455	N. Mid.	20,404	38,681	148,623	110,907
59,919	4,912	26,917	59,166	4,127	S. Mid.	12,384	17,358	114,574	83,432
53,042	5,015	28,405	46,276	2,206	S. Wales	5,274	20,408	86,556	69,492
85,143	8,010	24,555	44,627	5,271	N. Wales	12,318	35,811	171,337	48,929
133,440	1,608	17,031	45,111	3,071	S. Lancs.	12,527	69,011	363,842	37,995
79,963	6,009	30,423	42,660	2,973	N. East	9,391	35,311	178,669	29,479
53,848	3,650	24,235	36,074	2,452	N. West	8,301	30,856	106,953	32,094
40,836	2,367	15,758	24,321	2,134	North	4,167	9,389	73,019	46,907
18,800	4,808	6,214	11,950	262	Ireland N.	140	233	31,241	16
55,579	5,413	23,077	33,808	1,169	Scot. East	2,635	8,055	102,731	37,518
76,337	7,451	23,729	40,247	849	Scot. West	12,264	22,315	190,727	26,831
1,396,384	73,228	345,738	640,865	37,033	Totals.	153,621	400,959	3,489,485	676,976
1,365,643	73,993	341,118	632,959	35,885	Figures on 31st Dec., 1925.	149,290	384,434	3,386,045	615,026



A NEW TYPE OF FUSE MOUNTING FOR THE TERMINATION OF TRUNK, JUNCTION AND TELEGRAPH CIRCUITS.

A. O. GIBBON, M.I.E.E.

A HIGH standard of insulation resistance is required by the British Post Office in connection with all underground cables used for telephone and telegraph purposes, and this is particularly the case where loaded and balanced Trunk cables are concerned. Great difficulty has been experienced in the past in obtaining the same degree of insulation resistance at the terminations of these cables at Main Distribution Frames, and also at testing points.

In the case of loaded and balanced Trunk cables it has been the practice to terminate the cables on an auxiliary testing fitting known as a "Trunk Testing Tablet." This fitting is made of "A" quality ebonite, and is of the "U" Link pattern, accommodating 18 circuits per tablet. The Test Tablet provides for a high standard of insulation, and also affords a ready means for the interception of circuits for testing and cross-connecting purposes. There are, however, certain disadvantages associated with the Test Tablet. It requires a special frame for mounting purposes and the complete installation takes up a fair amount of space; the Test Tablet is also exposed to the air, and loss of insulation follows because of the presence of moisture and also the accumulation of dust on the fitting.

For the termination of Trunk cables which are not loaded and balanced, also in terminating Junction cables, a fitting known as "Fuse Mounting No. 4001" has been used. This fitting has a

Sheet Iron base, and is fixed to the Main Distribution Frame. It suffers from the same disadvantage as the Trunk Test Tablet in that it is exposed to the air, whilst, in addition, the 4001 fitting does not provide facilities for the periodical routine testing of circuits from the Main Frame.

The design of a compact terminating arrangement which will provide for a high standard of insulation resistance has been under investigation for some time and, after a series of experiments with different models, the Standard Telephones and Cables, Ltd., have recently patented a special Fuse Mounting on the

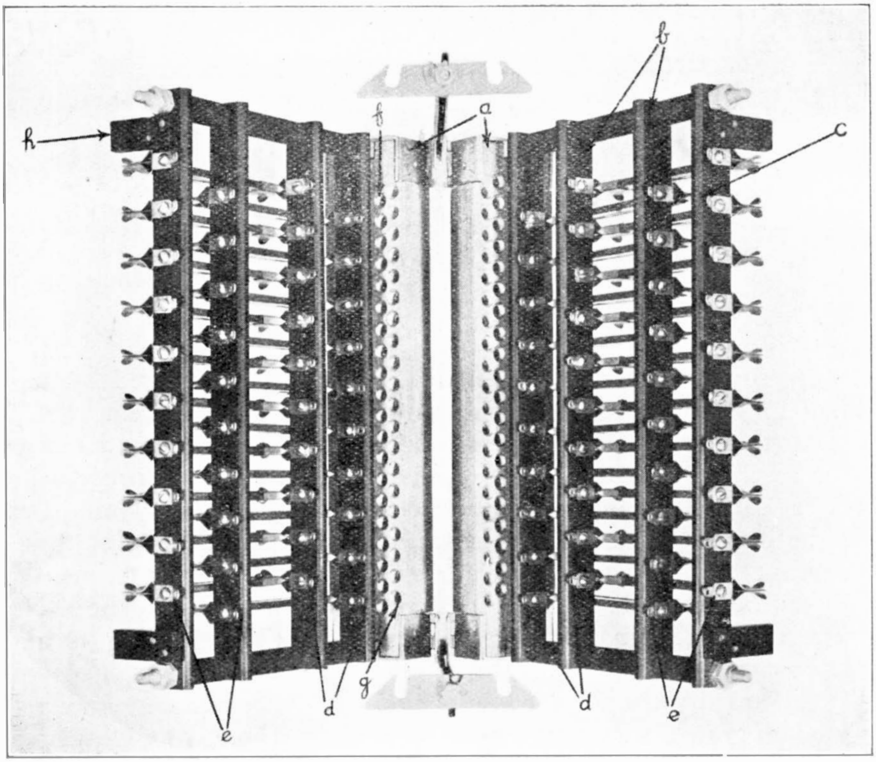


FIG. 1. FUSE MOUNTING NO. 4028.

"Grid-Gate" principle. This mounting has been designed with the following objects in view:—

(1) To provide a high degree of insulation resistance comparable with that of the cable itself.

(2) To provide a ready means of testing and cross-connecting circuits, both on the line and Exchange sides of cable.

(3) To protect the fitting from insulation losses due to moisture and dust, and also to prevent mechanical injury.

The new fitting is known as " Fuse Mounting No. 4028." It is of approximately the same dimensions as Fuse Mounting No. 4001, with which it is interchangeable on Main Distribution

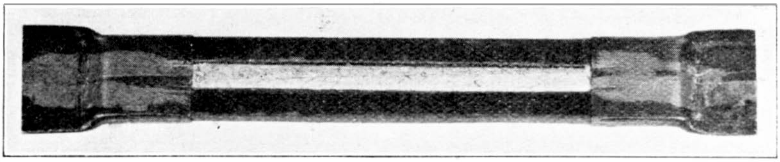


Fig. 2.—Fuse used on Fuse Mounting No. 4028.

Frames. The mounting accommodates 20 pairs of wires on the line and apparatus sides and is a compact fitting. Tests for insulation resistance have yielded results in the region of 30,000 megohms between adjacent tags.

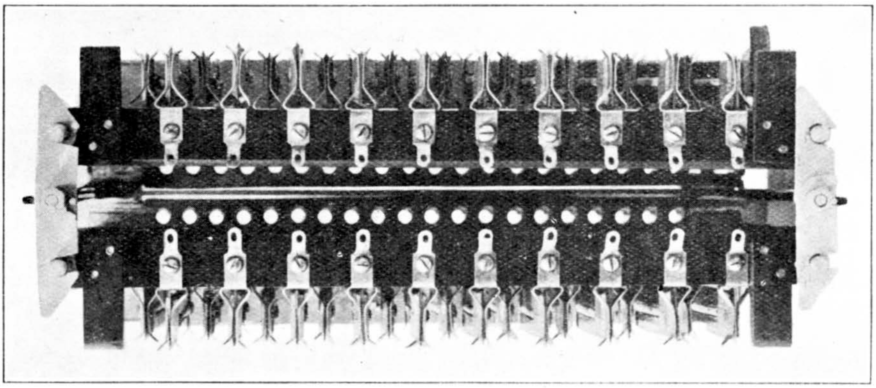


Fig. 3.—Front Closed View of Mounting. Shown Horizontally.

The mounting is made up in the form of a double hinged gate; Fig. 1 shows the fitting in the open position.

Two vertical wooden fanning strips marked " *a* " in Fig. 1 are fixed to the base of the mounting. Between these strips and hinged to them is a metal plate, or lug, which is shaped and bored for fixing to the Main Frame. This is shown clearly in Fig. 5.

A grid or gate consisting of four vertical ebonite strips is attached to each of the fanning strips, as shown in Fig. 1. (Two of these strips are marked "*b*" in Fig. 1). Fuse-holders are clamped to the outside of the ebonite strips, and the soldering tags are continued to the inside of the fitting, where all the wiring is done. The fuse holders and tags are shown at "*c*" in Fig. 1. Knife-blade fuses are fixed to the outside of the fitting.

It will thus be seen from Fig. 1 that all the wiring connections are made inside the fitting, and all testing operations carried out from the outside.

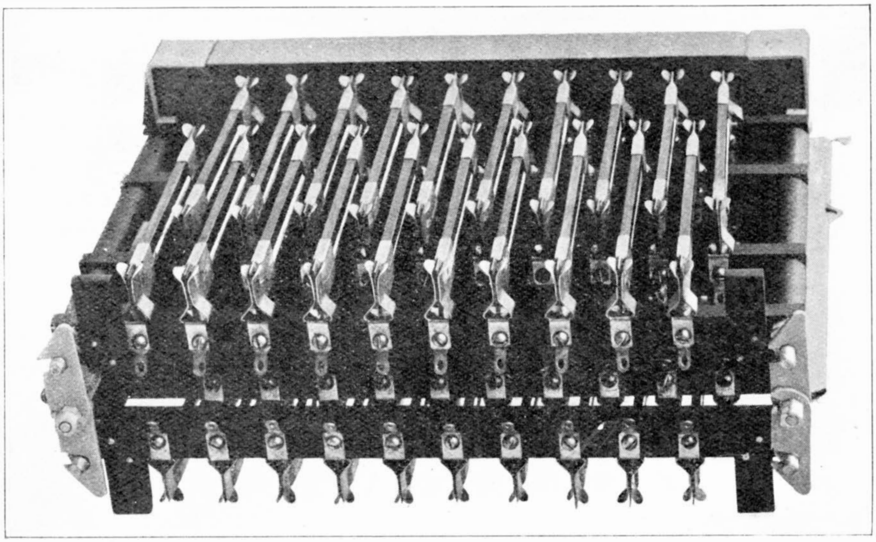


FIG. 4.—SIDE CLOSED VIEW. SHOWN HORIZONTALLY.

Each of the fanning strips is bored with 40 holes, 20 holes for the cable pairs, and 20 for the wiring on the apparatus side. The two vertical strips of tags on each side nearest to the fanning strip are used for terminating the cable conductors (See "*d*," Fig. 1), the outside two vertical strips of tags being used for the wiring on the apparatus side. This is shown at "*e*" in Fig. 1.

The holes adjacent to the vertical ebonite strips on each side are used for the cable conductors, the A and B wires following consecutively from top to bottom. See "*f*," Fig. 1. The two rows of holes nearest the metal plate, between the two fanning strips, are used for the apparatus wiring in the same consecutive order. This is shown at "*g*" in Fig. 1. By this arrangement any crossing of the wires inside the fitting is avoided, and each side of the mounting serves 10 circuits both on the line and apparatus sides.

A special type of knife-blade fuse has been designed for use with the fitting, and these are carried by means of the fuse holders referred to above. The fuses are arranged in alternate positions on the ebonite strips, so that a spacing, centre to centre, of 11/16″ is obtained, whilst at the same time keeping the mounting in a compact space. The fuse consists of an asbestos covered wire, set in a slotted strip of fibre. At each end, the fuse wire is connected

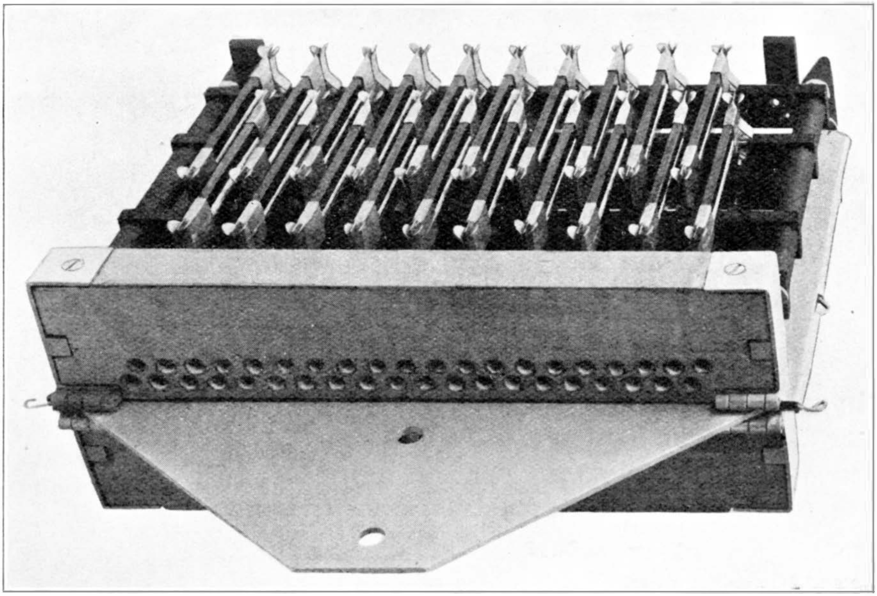


Fig. 5.—Back View showing Mounting Plate.

by a screw to a flat tinned copper sleeve, which is knife-shaped for insertion in the fuse holder. Details of the fuse are shown in Fig. 2.

The spread of the mounting in its open gate position is limited, to avoid any possibility of fouling with adjacent fittings and so making metallic contact through the fuse holders. A further safeguard in this respect is provided by means of four ebonite stops. This is shown at " *h* " in Fig. 1.

Fasteners are provided at the top and bottom of the mounting to maintain the closed position before fixing the dust proof cover.

Fig. **3** shows a front closed view of the mounting; Fig. **4** a side closed view; Fig. **5** a back view, with the plate for connecting to the Main Distribution Frame, whilst the mounting enclosed in its dust proof metal cover is shown in Fig. **6**.

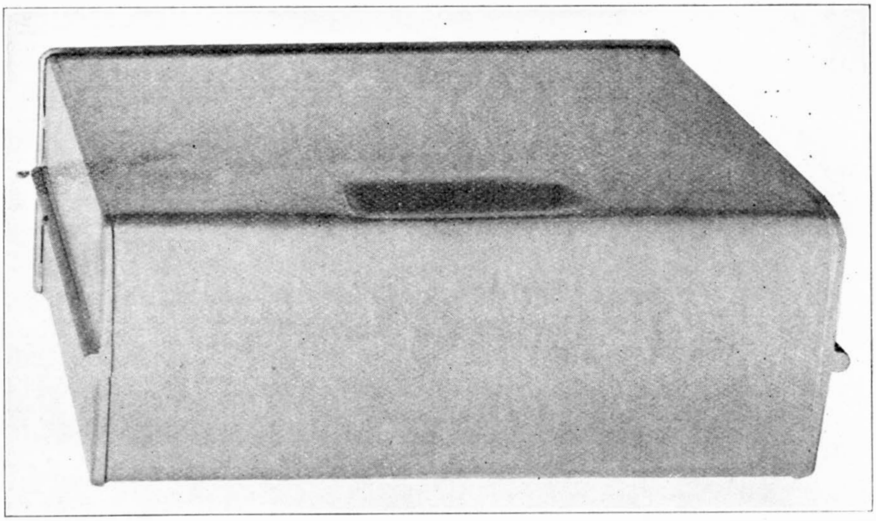


FIG. **6**.—MOUNTING IN DUST PROOF METAL CASE. SHOWN HORIZONTALLY.

The new type of fuse mounting will be fitted in place of the Trunk Test Tablet in all future cases and will effect savings in the cost of terminating loaded and balanced cables; space will also be saved in Exchange Test Rooms.

The new mounting will also be used at Telephone Exchanges where unloaded, non-balanced Trunk cables, Junction cables and Telegraph cables are terminated.

THE PASSING OF BLACKFRIARS POWER STATION.

PROVISION was made in the Act authorising the construction of the Post Office (London) Railway that tenders should be invited for the electric power required for its operation. As the Railway load by itself is not of a very favourable nature it was decided to invite tenders for the whole of the supply required for the P.O. Headquarter buildings—formerly supplied from Blackfriars Power Station—plus the estimated requirements for the Railway, and invitations were accordingly sent to all the authorised Under-

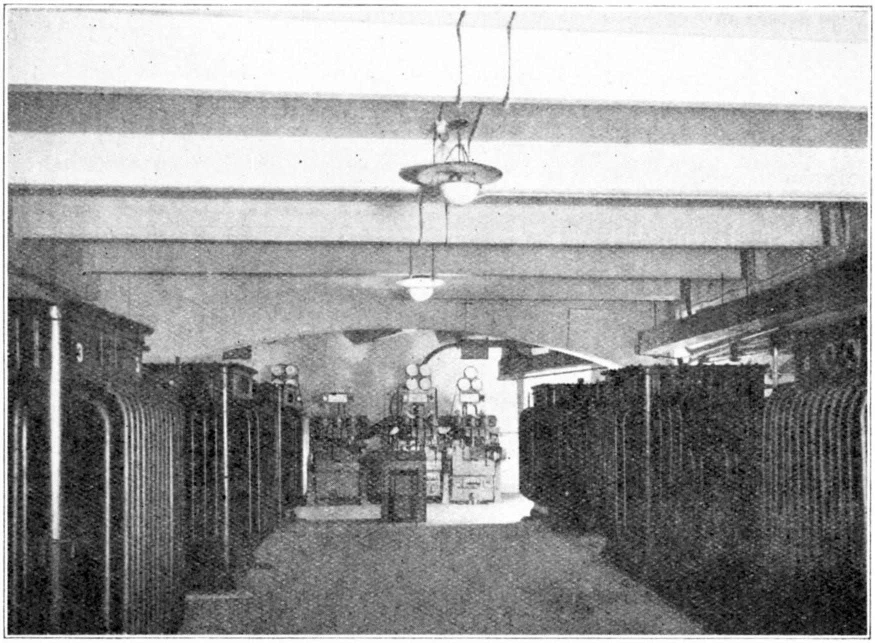


FIG. 1.—SUPPLY COMPANIES' SUB-STATION.

takers in the districts through which the Railway passes. The ultimate requirements were given as 10,600,000 units per annum with a maximum load of 3,900 kilowatts. Keen competition to secure the load ensued and eventually the joint tender of the City of London Electric Lighting Co. and the Charing Cross Electric Supply Co. was accepted and an agreement for a term of 25 years negotiated. The agreement provides for a variation in the price of power depending on the cost of coal or other fuel, and also for extra payments if a fixed maximum demand is exceeded during certain hours in the winter months; the batteries in the P.O. sub-stations will be used to reduce this as far as possible. Payment is made per kilo-volt ampere-hour, thus protecting the supply companies against the Post Office using current at a low power factor.

Under the terms of the agreement the Post Office provided the Companies with a sub-station in King Edward Building Basement, adjoining the existing Post Office sub-station. In this sub-station the Companies installed two banks of transformers with the necessary E.H.T. switchgear, each bank being capable of dealing with 3,750 kilowatts and supplied with independent mains direct from Aldersgate sub-station of the City of London Company and Ludgate sub-station of the Charing Cross Company.

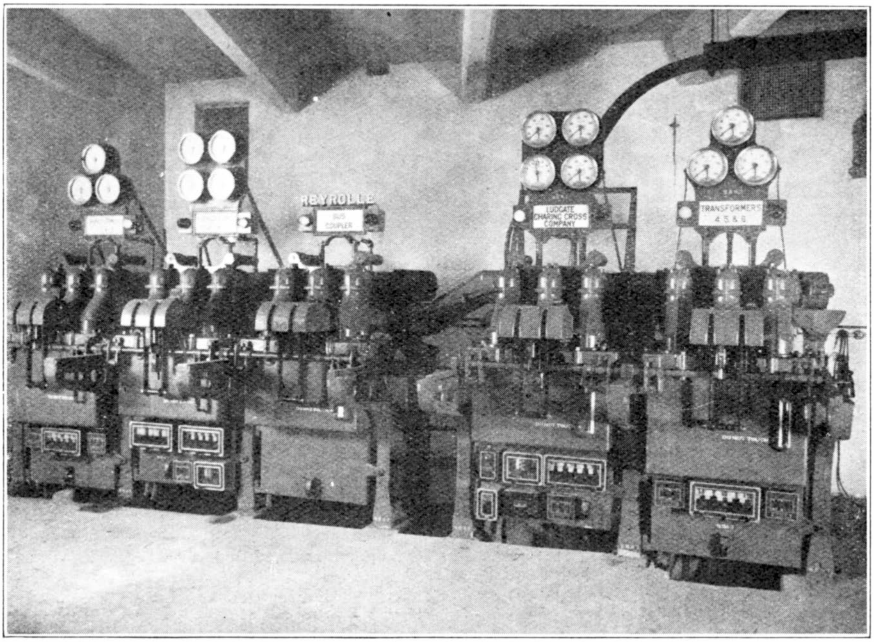


Fig. 2.—Close up View of E.H.T. Switchgear.

The supply is brought in at 10,600 volts 3-phase 50 periods and trasformed down to 6,600 volts, which is the Post Office E.H.T. voltage, and is metered at this latter voltage. A general view of the Companies' sub-station is given in Fig. 1, and a close up view of the E.H.T. switchgear in Fig. 2. Direct telephone communication is provided between the Companies' sub-station and the generating stations at Bankside and Bow, respectively, and also the Post Office sub-stations.

The supply at 6,600 volts is led to the Post Office sub-station, in which additional E.H.T. switchgear has been installed to receive it; this was supplied by Messrs. Ferguson, Pailin & Co.

A view of this switchgear is given in Fig. 3, and of the metering panels in Fig. 4.

The Post Office distribution system consists of sub-stations at G.P.O. (West), Mount Pleasant, King Edward Building and G.P.O. (South); in addition there are two sub-stations on the Railway, at Western Parcel Office and Liverpool Street. G.P.O. (West) and Mount Pleasant supply direct current only and are equipped with rotary converting plant with a large battery of accumulators in each case; King Edward Building and G.P.O. (South) are equipped with static transformers and supply alternating current only. On a failure of supply occurring, the D.C.

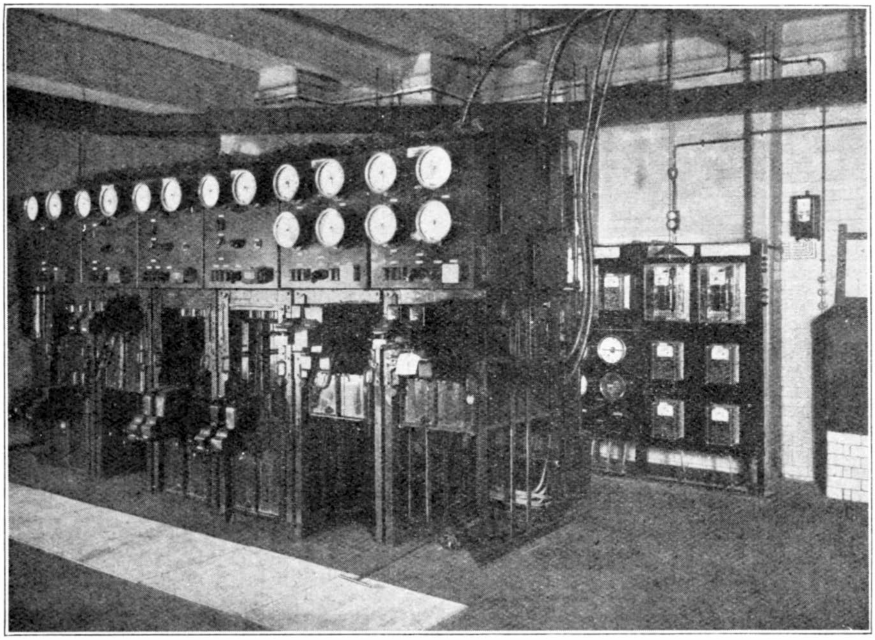


Fig. 3.—Additional E.H.T. Switchgear in P.O. Sub-Station.

supply at G.P.O (West) and Mount Pleasant is maintained from the accumulators, and at the same time the rotary converting plant is reversed, supplying back A.C. to King Edward Building and G.P.O (South), as has been done in the past when Blackfriars was operating. The batteries are capable of maintaining this supply for about 1 hour at full lighting load, the main power load, such as the pneumatic plant and Railway being automatically tripped; in addition emergency steam plant to the extent of 400 kilowatts is installed at Mount Pleasant. The Companies stipulated that under no conditions must their two supplies be joined in parallel; the supply is therefore taken from each Company during alternate months, except in the event of a failure, when the supply is changed over as may be required. The change-over is effected by taking the incoming supply to Mount Pleasant on a spare feeder; it is then synchronised on the E.H.T. side with the rotary plant, which is running reversed off the battery.

The change of supply involved considerable alterations to the existing switchgear and cable system; the first was carried out by the British Thomson-Houston Co. and the latter by Messrs. W. T. Glover & Co., additional switchgear was installed at G.P.O. (South) by Messrs. Reyrolle & Co., and an additional

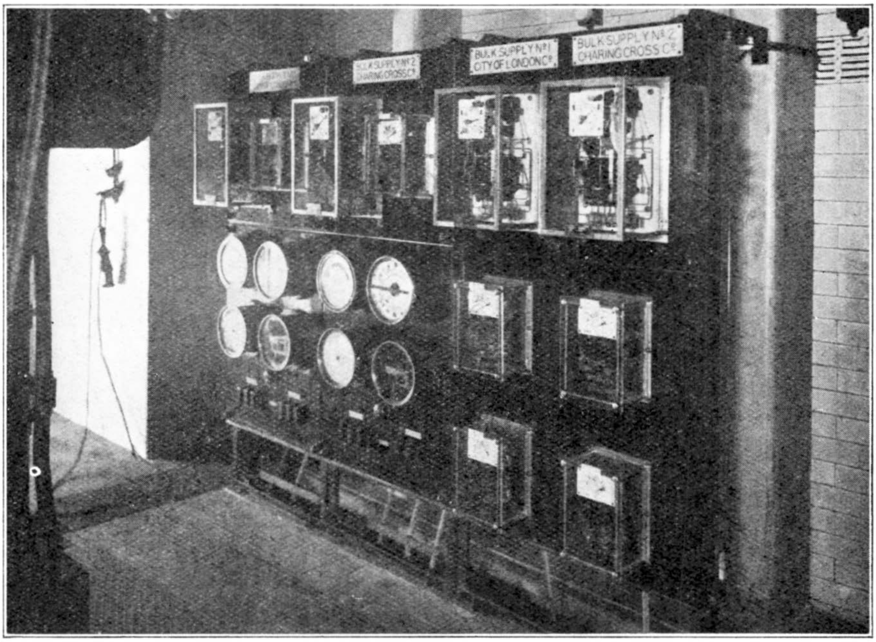


Fig. 4.—Metering Panels.

feeder to Mount Pleasant by the British Insulated & Helsby Co., in each case to the Department's specifications.

The supply was first given by the Companies on February 9th, 1926, Blackfriars Power Station being held in reserve for a fortnight until the new arrangements were proved satisfactory; no hitch occurred in the changeover, and the whole supply has been taken from the Companies since the above date.

It is interesting to recall that Blackfriars Power Station was started up in the autumn of 1910 and has operated uninterruptedly since with only a few minor failures. At the time of the opening of the station it was larger than many public supply stations, and during the whole of its life has compared very favourably with stations of similar size both as regards output and economy of operation. Owing to the enormous growth in modern electric supply stations, Blackfriars became comparatively a very small station and, naturally, was unable to compete in operating costs with stations of 40 or 50 times its capacity equipped with large modern generating units. The station has justified its erection, both from the point of view of economy and security of supply during its life of 15½ years, including the war period and the troublous times that have followed it; without it there is no doubt that the Supply Companies would never have offered such favourable terms as have now been obtained.

It will be seen from the above description that, while Blackfriars Power Station has now been closed down, an extensive and very important distribution system including six substations remains to be operated by the P.O. Engineers.

E.H.W.

THE TRAINING OF OFFICERS OF THE BRITISH POST OFFICE ENGINEERING DEPARTMENT IN PRECISION TESTING OF UNDERGROUND CABLES.

By A. B. Morice, B.Sc. (Eng.), A.M.I.E.E. and
A. Morris, A.R.C.S., A.M.I.E.E.

For a number of years, courses of instruction in precision testing of underground cables have been held, from time to time, in the Research Section of the Engineer-in-Chief's Office. These courses were commenced in 1920 in order to provide special training for suitable Engineering Officers so that the efficient maintenance of the underground telephone cable system of the United Kingdom could be successfully carried out.

The reasons which led up to the decision to use air-space, paper-insulated, lead-covered, underground cables for the long-distance telephone system of the United Kingdom are detailed very fully in a paper read before the Institution of Electrical Engineers*. In Fig. **14** of that paper there is shown the proposed system of underground cables then in course of construction. At first the special maintenance testing of these cables was carried out by Research Officers, but as the scheme progressed it was recognised by the Lines and Telegraph Sections of the Engineer-in-Chief's Office that an adequate staff of trained Officers in the

* Sir William Noble: "The Long-Distance Telephone System of the United Kingdom," Journal, I.E.E., April, 1921, Vol. 59, p. 389.

Districts was necessary in order to undertake the maintenance of the extending network of cables. This need has been met, as occasion demanded, by the special courses of instruction about to be described.

Up to the present about 160 Officers, selected from all the Engineering Districts, have attended courses of training at the Research Section and consequently there exists in each District a number of Officers specially trained to deal with the testing and maintenance of underground cables.

The subjects dealt with in these courses may be broadly described under the following two headings:—

1924-5 CLASS. MR. MORICE IS THE SIXTH FIGURE FROM THE LEFT IN THE FRONT ROW, MR. MORRIS THE SEVENTH.

(A) Maintenance tests and localisation of faults.

(B) Balancing and acceptance tests.

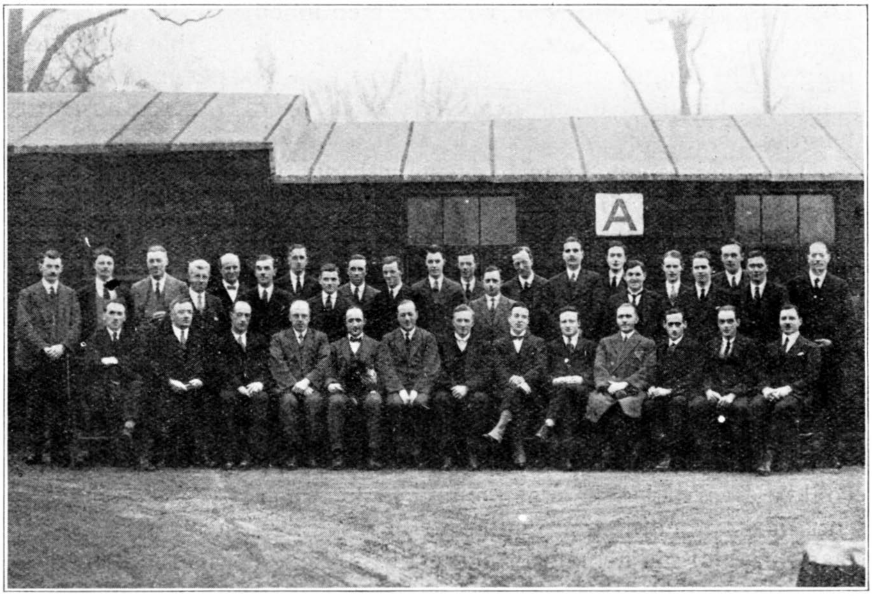
Originally, separate classes were arranged in each of these subjects, but in the last two classes held, viz., those in November, 1924, to February, 1925, and in November, 1925, to February, 1926, both subjects were dealt with during one period of instruction. By means of a series of lectures, practical work in the laboratory, and tests of cables during and after completion, it has been the endeavour to give a complete course of instruction in the latest and most precise methods of testing modern balanced and loaded cables of high insulation resistance.

The two photographs show the members of the classes just referred to, and a detailed description now follows of the courses of instruction given to them.

(A) *Maintenance Tests and Localisation of Faults.*

The most important maintenance tests for a paper-insulated, underground cable are, undoubtedly, insulation resistance tests. If this resistance remains at a satisfactory figure, it can then be concluded that the dielectric is dry throughout the cable length and also that most probably the lead sheath of the cable is in a perfectly sound condition.

The minimum insulation resistance specified for these cables during construction is 10,000 megohms per mile per single wire,



1925-6 CLASS.

when tested against all other wires in the cable earthed. It is very necessary to maintain this figure and it will therefore be appreciated that first-class maintenance testing is required.

It is of great importance that the regular maintenance tests should detect an insulation fault in its early or incipient stage and that suitable localisation tests should be made speedily in order to clear the trouble before it has had time to extend.

Periodical maintenance tests are made with a 500 volt constant pressure, motor-driven megger. The maximum scale reading of this instrument is 1000 megohms, so that the presence of a low insulation fault, even in its early stage, can be detected.

Methods have been developed in the Research Section and were given in this course of instruction by which it is possible to make an accurate localisation of an insulation resistance fault in its early stage of development. The fault resistance is then of the order of several hundred megohms and, consequently, does not interfere with the traffic of the cable. By removing the fault in its incipient stage considerable economy is effected by avoiding the loss of revenue which would be caused by a complete breakdown and also by limiting the extent of the damage caused by the fault and the consequent cost of repair. In some cases the early elimination of a fault in the cable sheath may save a complete cable length from irremediable damage.

In order to illustrate the kind of insulation resistance fault which can be localised and cleared by trained Officers in the Districts an example will now be mentioned. A fault of 500 megohms existed on one wire of an underground cable 100 miles long. The weight of the conductor was 100 lbs. per mile and the fault was localised to the nearest joint between 1/10th mile cable lengths.

This maintenance course dealt with all the different kinds of faults which may be met with in practice and suitable methods of localisation were described. The limitations of the various methods as well as the precautions to be observed to ensure accurate results were fully dealt with. Instruction was also given in the order of making localisation tests so as to obtain precise results in the shortest possible time.

The preliminary work of this course was of a mathematical nature and was arranged to provide sufficient information so that the solution of general bridge networks used in electrical testing could be carried out in a methodical manner. It was necessary for those attending the course to have reached a clearly defined stage in their mathematical studies if full benefit was to be derived from the instruction given. In the case of those members of the class whose mathematical knowledge was insufficient, information was given which enabled them to gain the necessary knowledge by private study outside the class hours.

After the mathematical work had been thoroughly grasped and a number of examples worked out in detail, the electrical testing work was commenced. The following syllabus will give a general idea of the ground covered by the maintenance testing and fault localisation course:—

(1) Theory of determinants and rules for their solution.

(2) Application of determinants to the solution of simultaneous equations.

(3) Kirchoff's Laws and the solution of bridge networks by means of determinants.

(4) Measurement of Insulation Resistance — possible

methods and standard method for maintenance testing.

(5) Description of motor-driven, 500 volt megger, including precautions to be observed in its use particularly on coil-loaded cables and the uses of the guard terminal.

(6) Measurement of Conductor Resistance—loop, single-wire, and differential tests.

(7) Localisation of simple low resistance Earth Fault and of Contact Fault by means of (*a*) Varley, (*b*) Murray loop test.

(8) Description of D.C. precision testing apparatus.

(9) Localisation of Low Insulation (Incipient) Fault in long cable—general case with Varley test, lines of equal or unequal resistance, testing from one or both ends and fault in three stages of development.

(10) Actual connections for Varley test for Low Insulation (Incipient) Fault—precautions in testing, errors to be guarded against, elimination of earthed battery, double-ended test without discharging cable between tests, etc.

(11) Localisation of Low Insulation (Incipient) Fault in short cable—general case with Murray test, lines of equal or unequal resistance, testing from one or both ends and fault in three stages of development.

(12) Actual connections for Murray test for Low Insulation (Incipient) Fault—precautions in testing, errors to be guarded against, effect of resistance of testing leads, etc.

(13) Description of A.C. precision testing apparatus.

(14) Localisation of Disconnection Fault in long cable by D.C. ballistic tests.

(15) Localisation of Disconnection Fault in short cable by A.C. tests.

(16) Localisation of High Resistance (Copper) Fault in long cable by D.C. tests.

(17) Localisation of High Resistance (Copper) Fault in short cable by A.C. tests.

(18) Localisation of Complete Breakdown in cable.

(*a*) Tests from the ends on long cable.

(*b*) Tests on short cable, including A.C. search coil test.

(19) Regular maintenance tests and cable records.

(20) General directions for localisation of faults, including order of making tests, tests on the road, etc.

(21) Practical tests in the laboratory, *e.g.*, localisation of

artificial low insulation faults of 50 to 500 megohms, localisation of artificial disconnection faults, etc.

(22) Localisation of actual cable faults.

Each Engineering District has been provided with at least one set of precision testing apparatus so that the maintenance and fault localisation tests can be carried out by trained Officers. The work of these Officers, in conjunction with each other and with those responsible for the cable construction and repair work, has resulted in a high standard of maintenance of the underground telephone cable system of the United Kingdom.

(B) *Cable Balancing and Acceptance Tests.*

The work of this course was directed to instructing selected members of the Staff of each Engineering District in the field—constructional operations relating to balanced and loaded trunk cables.

In describing the scope of this portion of the work, the operations involved in the field construction of the Department's modern trunk cables will be briefly described, particular reference being given to the testing work performed at each stage, since it was in respect of this testing work that the special instruction was furnished.

The Department's trunk cables are, in the general case, manufactured, drawn into ducts and jointed into loading coil sections by Cable Contractors. Electrical balancing for the purpose of securing interference immunity and longitudinal uniformity of the line constants is effected during the jointing stage of the work, on the completion of which the loading coil sections are submitted by the Contractor for acceptance by the Department.

The balancing methods adopted by British Contractors follow generally the standard practices of the Department.

Descriptions and theoretical explanations of these practices constitute the major and most important portion of the work of this course. Capacity and conductor resistance balancing, for the elimination of cross-talk, and mutual capacity balancing for the promotion of longitudinal uniformity of cable circuits were dealt with. The instruction furnished in this branch was complete and was framed so as to permit, when necessary, of cables being drawn in, jointed and balanced by the Department. Such work has in consequence been successfully performed on more than one subsequent occasion by the trained Staff of the Districts. Furthermore, in those cases where damage to a cable has resulted in replacing lengths of cable being required, the loading coil sections involved have been rebalanced by such local staff. The operations involved in these cases are always more difficult than in the case of new constructional work and are frequently rendered rather involved and complicated by the necessity for keeping circuits working through the cable during the progress of the work. The advantage of having staff available in such cases who possess familiar knowledge of the original construction, and of what will be involved in the work of restoration, has been frequently demonstrated. Such cases of breakdown have been expeditiously handled from the outset, the temporary restoration of service being carried out in such a manner as to facilitate to the greatest possible extent the subsequent permanent repair work.

Up to quite recently the acceptance of loading coil sections from Contractors has been carried out wholly by special testing staff under the control of the Research Section of the Engineer-in-Chief's Office. Trained staff, equipped with the necessary apparatus, is now available in the Districts for the execution of this branch of the work. In addition to insulation and conductor (loop) resistance tests, capacity unbalance, resistance unbalance, cross-talk and mutual capacity measurements are made. Full instruction in these tests was furnished in class, whilst the practical work of the course provided for each officer being attached for a period to a headquarters group actually engaged upon such testing operations.

On acceptance of the loading coil sections the loading coils are inserted, generally by the Department's own workmen, under the supervision of the Superintending Engineers. In the case of side circuit loading only, this work proceeds systematically to completion without the necessity for further special testing other than regular insulation, conductivity and tapping-through tests. On completion, end-to-end or final tests are made prior to bringing the cable into service. These final tests involve special measurements for inductance, cross-talk and noise, and transmission efficiency. The inductance tests are intended to check the freedom of the coils from deterioration due to the inadvertent passage of large currents, reversals of coil windings, the preservation of the Multiple Twin formation of the cable through the coil case—*i.e.*, freedom from split pairs and split cores—and generally the correctness of the loading operations. The transmission or speaking efficiency tests, by comparison of a number of cable loops with an artificial cable, enable the average attenuation and the terminal loss values to be computed. Instruction in such tests does not normally form part of the cable balancing course, but in some cases where time and other circumstances were favourable, lectures were given and opportunities afforded for practical work on completed cables.

In the case of long-distance side- and phantom-loaded cables it is necessary to secure a greater degree of interference immunity than in the case of short, side-loaded cables. This is attained by crossing methods at joints between groups of loading coil sections and coils, the actual mode of connection being determined by the results of cross-talk switching tests. In this case also, detailed class instruction could not always be arranged. The best that could be done in this connection was to provide for brief lectures and a measure of actual work on the road for those officers whose duties in their own districts included the control of staff engaged upon the making of such joints or otherwise handling such cables, *e.g.*, during the carrying out of the above mentioned group tests or during maintenance operations.

The following brief syllabus outlines the work of the Cable Balancing and Acceptance course :—

(1) *Mathematics.* A brief review of elementary mathematical processes with special reference to vectors.

(2) *Elementary Alternating Current Theory.* Simple sine-wave alternating current representation. Impedance and Admittance regarded as vectors. Resistance, Reactance, Conductance and Susceptance. Equivalent direct impedance and admittance networks. Application to direct capacity networks. Solution of impedance and admittance bridges of N members by reduction to 4 member networks and use of Wheatstone principle.

(3) *Cable Balancing.* Capacity balancing for interference freedom, along the lines of T.I. XIX. Conductor resistance balancing. Balancing for limitation of circuit and of length deviations of mutual capacity. Rebalancing methods suitable to different conditions of cable failure.

(4) *Acceptance of loading coil sections of cable.* Descriptions of apparatus and methods of measuring insulation resistance, conductor resistance (loop and unbalance), capacity unbalance, cross-talk and mutual capacity with special descriptions of Post Office Trunk Cable, Conductor Resistance (loop and unbalance), Capacity Unbalance and Cross-Talk Testing Sets and their associated equipment. Mutual Capacity bridge.

In addition to the foregoing some general information relating to these courses will be given.

The members of the courses so far held have been selected by Superintending Engineers. In May, 1923, when a number of officers were required to staff the Headquarters testing groups, suitable men were chosen on the result of a written examination. Of 300 candidates, competing from various parts of the country, 40 were so chosen and subsequently given a suitable course in the work which they were required to perform. They were then allocated as assistants to testing groups and many have since qualified themselves to take charge of a testing unit.

The courses have been given to staff of various ranks from that of Assistant Engineer to Skilled Workman, and they have been adapted as far as possible, from time to time, to meet the special needs of the officers concerned. The methods of explanation and the amount of preliminary work has also been varied to suit the scientific and technical attainments of the members of the several courses which have been given.

In those cases where by reason of the rank of the officers attending a course their normal duties would be largely of a supervisory character, much more general ground relating to the trunk system has been covered and particular attention has been given to the organisation aspect of the work. In other cases the need has been for considerable detail in the testing, recording, selecting and scheduling aspects of cable work.

The writing of lecture and laboratory notes has been provided for. The books have been examined and corrected from time to time and on completion of the courses. Close touch between the lecturers and their assistants and the members of the class has been maintained with very beneficial results.

Present day policy shows some tendency to the placing of cabling contracts involving manufacture, jointing, loading and terminating to completion. By this means it is hoped to relieve the Department of much of the testing work at present carried out. The staff will still, however, require to keep thoroughly up-to-date in this constantly developing aspect of communication work, since they will be closely concerned not only with the inspection of such work in all its constructional stages, but also with the subsequent maintenance and working of the system.

Although no mention has been made of the testing of gutta-percha and balata insulated submarine cables, yet some of the officers who have attended the classes have had to deal with the maintenance testing of such cables in their normal duty. In such cases, some time has been spent in dealing with this important branch of cable work.

In conclusion, it will be noticed that, up to the present time, the classes have been held intermittently and only on such occasions as the need for the immediate services of trained staff arose. It is the opinion of the authors that the future adequate maintenance of the cable system of this country will necessitate the training of suitable officers as a regular feature of the Department's policy.

It will also be observed that the scope of the courses so far given has not included the special line requirements of repeatered cables. In the acceptance of such cables, impedance-frequency tests of the circuits are necessary to prove their satisfactory length-uniformity. Special cross-talk tests to cover the cable and the repeater station line apparatus, as well as overall efficiency tests to cover the behaviour of the line under the energised conditions of the repeaters, are also essential. The maintenance of such circuits will include a similar series of tests, the checking of line balancing networks and of repeater gains. The necessity for trained staff to deal with this aspect of the work is obvious and it is suggested that the need could very well be met by a course along the lines of the Cable Maintenance and Balancing courses described in this article.

ACCIDENTS ON DUTY.*

By R. A. Jones.

One of the most striking phenomena of the industrial history of the last hundred years is the amelioration of the conditions of employment of the worker. The exploitation of child labour, excessively long working hours, and insanitary, unsuitable and inconvenient work places are but a few of the evils which have been removed or remedied by legislation, and in such enactments as the Factory and Workshop Acts regulations have been made for the protection of workers from the dangers of their work, whether accident or occupational disease. In addition to this beneficent action on the part of the State many large employers of labour have supplemented statutory provisions by the introduction of welfare, safety first and other movements for the preservation of the health and lives of their employés during working hours. And further, it is now recognised that mechanical means of promoting industrial efficiency are insufficient unless the human factor in all its variations is taken into account—hence in the scientific management of industry, which has for its object the increase of output, questions of fatigue and unrest have become the study of experts.

In these movements for the protection of the worker physical injury or disability arising out of or in the course of his employment is regarded as a menace to his general well-being, and, as any reduction of his general well-being lowers his standard of effectiveness, industrial accidents must in their results be counted

* A paper read before the North Western Centre, at Preston, on the 30th November, 1925; and before the Northern Ireland Centre on the 9th March, 1926.

as a form of inefficiency inasmuch as they cause labour losses and therefore entail unproductive costs.

To the business man the rate of profit is the measure of efficiency. In the Post Office Engineering Department efficiency is not measured by profit qua profit, for as Mr. John Lee says in his "Economics of Telegraphs and Telephones," "It is worthy of notice, as of national interest, that it is perfectly clear from the preamble of the Telegraph Act of 1868 that there was no intention whatever of making a profit out of the telegraph service, but only an intention of making the service more rapid and more widely extended," our measure of efficiency is the due provision of satisfactory engineering services. Nevertheless, it is required of public servants entrusted with public funds strictly to administer and control expenditure upon the public services which it is their function to supply. In the exercise of this administration and control of expenditure we must have regard, *inter alia,* to the elimination of all unproductive costs, among which, as we have seen, are those entailed by labour losses through accidents.

The elimination of the unproductive costs of accidents can only be effected by the prevention of accidents, and if it were asked what number of accidents may be regarded as the irreducible minimum the answer would be "none." This no doubt is idealistic, but it is not impossible, and it must be the aim if any considerable reduction in the number of accidents is to be secured.

If we would avoid accidents we shall do so most surely by a study of their causation and by the adoption of those means of prevention which are indicated by such a study.

The inevitability of accidents seems to be too readily taken for granted—hence perhaps the reluctance to ascribe contributory negligence, which is admitted in only two per cent. of the cases reported in the North Western District. This may be the outcome of failure to appreciate the precise nature of an accident and a too easy assumption that any and every occurrence by which the person is injured is veritably unavoidable and could not be prevented. An accident according to the New English Dictionary is, "Anything that happens without foresight or expectation; an unusual event which proceeds from some unknown cause or is an unusual effect of a known cause." According to Webster's Dictionary an accident is literally, "A befalling; an event that takes place without one's foresight or expectation; an undesigned, sudden and unexpected event." In the legal sense an accident is, "An event happening without the concurrence of the will of the person by whose agency it was caused; an accident differs from a mistake in that a mistake always supposes the operation of the will of the agent in producing the event, although that will may be caused by erroneous impressions on the mind." Specifically, in equity practice, an accident "is an event which is not the result of personal negligence or misconduct." On the inevitability of of accidents Dr. P. Sargant Florence, an authority on the subject, of the Department of Economics in Cambridge University, in his "Economics of Fatigue and Unrest," writes, "Accidents are often enough accepted as a dispensation of Providence. This may be true of earthquakes, volcanic eruptions, storms and tempests, but in the humanly created conditions of industry accidents must take their place beside turnover, lost time and deficient and defective output as a symptom of human inefficiency," and again, "The word accident, by its very derivation, denotes something which should not happen at all . . . and all industrial accidents arising out of and in the course of employment might be considered as avoidable by the employer." And this is the testimony of the British Health of Munition Workers' Committee in a published memorandum of the results of an inquiry made by them: "Accidents depend in the main on carelessness and lack of attention of the workers, and so the more one can eliminate this lack of attention and increase the concentration of the worker upon his work the more will accidents be reduced." Those who know most of the facts and are therefore best qualified to judge agree that the number of industrial accidents might be greatly reduced. The Chief Inspector of Factories and Workshops says 75% of the accidents that occur could, with reasonable precaution, be avoided. In the face of this well-informed evidence an accident in the course of employment cannot be regarded as inevitable if it might have been prevented by the exercise of foresight and precaution, the application of proper methods, and the skilful use of the most suitable tools and appliances. Failure in any of these respects indicates personal negligence or misconduct, or, as Webster expresses it, the concurrence of the will of the person by whose agency the accident is caused, and these considerations should engage the attention of those whose business it is to decide the question of contributory negligence. It may be that contributory negligence is seldom admitted because of sympathy with the victim and a desire to give him the benefit of the doubt; if this be so, is not the kindness misplaced and would not it be more beneficial to explore the cause of the mishap so as to establish definitely whether it was really unavoidable, and, if not unavoidable, to apply those remedial measures or to take such disciplinary action as would, so far as is humanly possible, have the effect of preventing a similar occurrence? It is somewhat remarkable that while bad and imperfect workmanship, such as faulty plumbing and dry joints, is frequently punished, the unworkmanlike behaviour by which accidents are often caused generally goes unchallenged. As Dr. Sargant Florence says:

"Official investigations often confine their interpretation of cause to the type of machine or object inflicting the injury without inquiry into the action of the object and of the human victim immediately preceding. Variations in accidents as a measure of the injured worker's bodily and mental state and the influence upon him of industrial conditions are being gradually recognised, *e.g.*, an accident due to the glancing or slipping of a tool represents a case in which the injured man's state of mind or body may have considerable influence, but an accident due say to the breaking of a tool is a case where the human factor in the person of the user of the tool could have little or nothing to do with the circumstances." Mr. Henry Ford, of motor car fame, in "My Life and Work," writes of the practice of his own establishment: "Every accident, no matter how trivial, is traced back by a skilled man employed solely for that purpose, and a study is made . . . to make that same accident in the future impossible."

"If a man has worked too hard or through too long hours he gets into a mental state that invites accidents. Part of the work of preventing accidents is to avoid this mental state, part is to prevent carelessness, and part is to make machinery absolutely fool-proof."

According to Mr. Ford, the principal cause of accidents as they are grouped by the experts are:—

(1) Defective structures.
(2) Defective machines.
(3) Insufficient room.
(4) Absence of safeguards.
(5) Unclean conditions.
(6) Bad light.
(7) Bad air.
(8) Unsuitable clothing.
(9) Carelessness.
(10) Ignorance.
(11) Mental condition.
(12) Lack of co-operation.

And he further remarks: "The question of defective structures, defective machinery, insufficient room, unclean conditions, bad light, bad air, the wrong mental condition and the lack of co-operation are easily disposed of. None of the men works too hard. The wages settle nine-tenths of the mental problems, and construction gets rid of the others. We have then to guard against unsuitable clothing, carelessness and ignorance, and to make everything we have fool-proof. . . . Industry needs not exact a human toll."

It has earlier been suggested that any effort to reduce the frequency of accidents is more likely to be successful if it be informed by a study of accident causation. To this end and in the hope that the results will prove to be useful the accident records of the North Western District have been explored and a number of analyses made, of which particulars will now be given.

The number of accidents on duty during a recent year was 186—rather more than one every two working days. The average number of workmen employed was 1,200 and the percentage of accidents was therefore 15.5. The number of days lost was 1,950, or the equivalent of the continuous absence of 6.3 men. The average absence for all accidents was 10½ days, but as 96 of the accidents involved no absence the average absence for the 90 which did involve absence was 21.6 days. The average absence per employé was 1.6 days.

It is difficult to make any useful comparison between the frequency and severity of accidents sustained by the Department's workmen and of accidents sustained by workmen generally as, the Department's work being peculiar to itself, the available statistics of casualties in other industries are not strictly applicable. The case of workers in the dockyards and other establishments of the Admiralty provides perhaps the nearest parallel. There the frequency rate was 30.5, as against this Department's 31.7, and the severity rate .38 as against .68. (The frequency rate is the number of lost-time accidents per million hours worked and the severity rate the number of days lost per thousand hours worked). It will be observed that while the frequency rates are remarkably close, this Department's severity rate, indicating the time lost, is nearly double that of the Admiralty worker.

The frequency of all temporarily disabling accidents in industry generally is given as about 110 per thousand employed. Of these 110 accidents, about 45 accidents a year will probably disable from a day to a week, 48 from a week to a month, and 17 from a month to six months. The general frequency rate of 110 per thousand comes remarkably close to this Department's frequency rate of 109. There is, however, some difference in duration, the Department's figures showing more day to a week absences and less week to a month absences than is the general experience.

The distribution of accidents during the period under review throughout the several Sections of the District was Mid. Lancs. (Internal) Section, 9.1% of the number of workmen employed; Lancaster Section, 16.2%, and Preston and Rochdale Sections, respectively, 18%. The risk of accident on external work is therefore shown to be approximately double the risk on internal work and the dangers of external work to be greater in congested urban areas than in rural districts.

An attempt was made to ascertain whether, and, if so, to what extent, the incidence of accidents is affected from month to month by seasonal differences of temperature or visibility, but, as the following particulars show, no definite conclusion was reached. In November, December, January there were 52 accidents, and in June, July, August 41, an increase of 11 during the winter months, but as against this the number was as high as 19 in May, a good weather month, and as low as 10 in February, a bad weather month. The highest peaks were 24 in March and 19 in May, October and January, respectively, the lowest, 7 in April. This is the general experience, for according to the Annual Report of the Chief Inspector of Factories for 1924 industrial accidents are always heaviest in the months of March and October.

A test was made of the incidence of accidents on the several days of the week, to ascertain whether the freshness of Monday or increasing fatigue as the week advances has any marked effect on the risk. In 200 cases examined, 47 accidents happened on Tuesdays, 42 on Fridays, 41 on Mondays, 27 on Thursdays, 25 on Wednesdays and 18 on Saturdays. The general experience is that most accidents happen on Mondays and Fridays; with us Tuesdays and Fridays are the worst days.

The number of accidents during each hour of the day was investigated to ascertain to what extent liability to accident may be affected by fatigue or hunger. Of 200 cases it is significant that the highest figures were 39 accidents in the fourth hour of the day and 29 in the eighth hour. From this it would appear that fatigue and hunger do increase the risk of accident, and this is confirmed by the fact that fewest accidents happened during the first and sixth working hours, the figures being 11 and 10, respectively.

The ratio of age to risk of accident was examined and it was found that youth is more liable to accident than age, which, on the assumption that youth is generally less cautious and certainly less experienced than age, tends to confirm the suggestion that accidents are largely due to negligence or ignorance. Workmen under 20 years of age, although only 5% of the staff, had 4.5% of the accidents; from 20 to 30 years, 34% of the staff, had 41% of the accidents; 30 to 40 years, 35% of the staff, had 29.5% of the accidents; 40 to 50 years, 19% of the staff, had 17% of the accidents; 50 to 60 years, 10% of the staff, had 8% of the accidents; and over 60 years of age, 7% of the staff, had no accidents. It will be noticed that the highest ratios are those in the groups under 20 years and from 20 to 30 years of age.

It is not surprising to find that the hands suffer the majority of the accidental injuries—85 of 186, or 45%. The head follows, a long way behind, with 19 injuries, and the legs come next with 18. The eyes, with 17 injuries, fare better than might be expected of a member so vulnerable. Of the remaining members the back suffers in 16 cases, the feet in 12, the arms in 10, the knees in 7 and the chest in only 2.

In the year under review there were 9 accidents in connexion with motor vehicles and during a subsequent period of 9 months the number was only 5. This is a gratifying reduction in this type of accident, having regard to the increasing congestion and dangers of the roads, and reflects credit on the drivers.

Some people, by their awkwardness, clumsiness or foolhardiness, or owing to a physical or mental kink—people who do not possess the accident sense—seem to be specially susceptible to accidents. These are they who incur multiple accidents. An examination of the records was made for cases of successive accidents to the same person, to ascertain whether there were any of these susceptibles among the Department's employés. In a period of 18 months, 18 men each sustained two and one man three accidents, and an instance of three accidents within 10 months to the same man came to notice a few days ago. This last case is worthy of recapitulation :—

On the 15th November, 1925, C. scratched the third finger of his left hand with a piece of bronze wire. The wound was not medically treated until the following day. This was the third accident to C. in 10 months. In January he scratched his hand with a wire end and was absent 44½ days, suffering from a septic wound; on that occasion medical attention was not obtained for three days. There was a second accident in April, when C. knocked his hand against a bolt and cut a finger. The most recent injury developed into a septic arm, no doubt rendered septic by the delay in receiving treatment, and the medical officer recommended that C. should in future wear gloves. Whether he will be able to work in gloves or whether, having now protected his hands, some other part of his frame will suffer only time can tell.

On this point the Industrial Fatigue Research Board, in a report on the Incidence of Industrial Accidents, observes that the explanation of this special suspectibility is to be found in the personality of the individual, and that a worker who has had three trivial accidents is a more dangerous person than one who has had a single bad wound.

Safety first methods and devices for the prevention of accidents are now largely employed in all well-conducted industrial establishments, and there is abundant evidence of their success in the reduced rates of frequency and severity. The P.O. Engineering Department is not behind general practice in its appreciation of the importance of the subject. A body of literature and instruction on the matter is to be found in the Department's Regulations, in the brochure "Precautions against Accidents," in Rules for

Workmen, and indirectly, as conducing to workmanlike methods and the skilful use of tools and appliances, in the Department's Technical Instructions and the Pamphlets for Workmen. If the slogan :—

> " *Know* these instructions and apply them even where there is no risk. Report every accident without exception."

prominently printed in red on the covers of " Precautions against Accidents," were generally observed the effect could not fail to be a great reduction in the number of accidents. And it has been written :—

" Industrial accidents are usually neither wholly humanly circumstanced nor yet wholly mechanically, but arise most commonly from the fact that potentially errant human nature is employed on potentially dangerous operations. Anticipation of the likely errors and dangers has substantially reduced the accident rate in several industries and plants, and the adoption of this safety policy indicates the possibility and the economy of minimizing accident."

A few typical accident cases may be of interest, and may serve to point a moral :—

(*a*) A workman removed the nut from an arm bolt and came down the pole for his dinner. Climbing the pole after dinner he grasped the arm for support, forgetting that he had removed the nut ; the arm came away and the man fell to the ground. In this case the man appears to have thought more of his dinner than of his safety and the work he had in hand. His neglect to replace the nut on the arm bolt or to remove the arm before coming down resulted in serious injury to himself (and might have caused injury to others) and loss to the Department. He was incapacitated for seven weeks The Engineer-in-Chief, while agreeing that the failure to make all secure before leaving the work was blameworthy, allowed compensation pay on the ground that it was extremely doubtful whether the man could be held to have been guilty of serious and wilful misconduct within the meaning of the Workmen's Compensation Act, 1923.

(*b*) In this case the workman was assisting to prepare a 40′ pole for erection. The pole jumped the bogey on which it was resting and threw him to the ground, causing a very severe comminuted fracture of the right leg. The pole was lying on the pole cart and as the ground was soft the cart wheels were placed on planks. The pole had been armed while on the cart and was being turned over so that steps could be fixed on the other side when one of the wheels slipped into the soft clay, causing the cart to sink suddenly on one side and the 8-way arms striking the ground levered the pole over the pole cart pins. There is no regulation against using a pole cart to support a pole while it is being fitted, but as the ground was soft the usual trestle support composed of two stout arms crossed would have been a better arrangement, and if it had been used the accident would not have happened. *As so often occurs in accident cases the Foreman was not on the spot.* The victim of this accident was absent for 4½ months and though the functional condition of his leg has been restored there is a permanent defect in the alignment of the limb.

(*c*) A jointer and mate were about to open a joint which was very dirty. Just before they left the job for dinner at noon the joint was washed with petrol. On returning to work and before the manhole was entered an acetylene lamp used for lighting was lowered into the manhole, when an explosion took place. The two men were caught in the flames, the jointer being severely burnt on the face and hands and the mate burnt on the face, and both were incapacitated for seven weeks. The manhole was believed to be free from coal or sewer gas. The roof of the manhole was said to provide a pocket for the fumes and apparently the fire was caused by vapour from the petrol applied to the cable for the purpose of cleaning it becoming ignited by the acetylene lamp. The jointer was ill-advised to use a naked light in such a situation.

(*d*) E.H. was engaged in July, 1924, as a Labourer and on 4th March, 1925, while twisting a pole he slipped and sprained his right knee, which it was only then discovered had previously been weak and limited in movement. He was absent for two months and received compensation pay. This case illustrates the importance of ascertaining before men are engaged whether they are free from physical defect or infirmity.

(*e*) A workman got a splinter of wood in one of his fingers. Surgical aid was not sought till the following day when the finger had swollen and become septic, necessitating 2½ weeks' absence. The man, who is an Ambulance man holding several certificates, washed and attended to the wound after removing the splinter and considered that this was sufficient. The point of this case is that first aid is not intended to preclude the attention of a surgeon. The first rule of ambulance work is "Send for a doctor."

(*f*) A remarkable case is that of E.R. On the 6th May, 1921, this man, 34 years of age, was transferring wires from a ladder to a pole when the ladder broke and caught him on the nose. The injury was described by the Medical Officer as abrasion of the skin of the nose and forehead, and classified as "Slight." The ladder was a borrowed one and was set in an upright position with only two stays, and the Sectional Engineer regarded the foreman as to blame for not arranging for the ladder to be sufficiently stayed before the man ascended it. There was no absence. The man continued to work after the accident and for more than three years afterwards. In December, 1924, he was away for 3 days suffering from syncope-Gastric and from February to August of the following year, 1925, he had successive absences of 19, 11 and 91 days, in all 121 days, suffering from syncope-Gastric, Debility and Epilepsy. His superannuation was then authorized on a retiring medical certificate describing his ailment as Epilepsy associated with marked gastro-intestinal toxœmia. On the 25th September E.R. died in hospital. The doctor who made a post-mortem examination deposed at the inquest that there was no external sign of injury to the skull, but on the inner layer of the skull cap there was a small excavation the size of the end of a lead pencil $\frac{1}{8}''$ deep. On top of the forehead a little to the right of the eye there was a small perforation of the brain about the size of the excavation, and the brain, otherwise healthy, was protruding slightly into the hole. This condition of the skull and brain seemed to be the result of an old injury by violence and not disease; there must have been a fracture four years ago. The cause of death was heart failure following the epileptic state, of which the fracture was possibly the origin. The case was referred to the Chief Medical Officer, who in view of the post-mortem examination considered that it could not be successfully maintained that the accident in 1921 was not the cause of the brain condition responsible for death, and liability under the Workmen's Compensation Act was admitted. This case is cited as a striking illustration of the serious consequences which may follow neglect to use suitable tools and to employ proper methods.

The Department's work cannot be classed as a hazardous occupation. During the last seven years only three fatal accidents have happened in the North Western District, and as will have been gathered from the foregoing particulars the risk of injury necessitating absence is as 3 is to 40. Yet it should not be forgotten that every accidental injury is a potential fatality and that as Dr. Sargant Florence puts it: "Apart from the general condition of the worker . . . . minor accidents such as cuts or scratches do not entail lost time but are yet unquestionably responsible for lowered working capacity."

The appeal of this paper has been largely utilitarian—the need in the interests of efficiency of reducing the number of accidents on duty, but may it not be urged that the prevention of such accidents has an even greater claim on our attention on the higher ground of humanity? The money cost of an accident on duty is £7 or £8, but what it may cost its victim in physical and mental suffering and worry is incalculable.

NOTES & COMMENTS

NOTES AND COMMENTS.

The student of telephony is rather apt to devote too much attention to the purely apparatus and exchange development side of the subject, and to ignore the connecting links and take for granted that the line plant looks after itself. It is true that the intricacies of exchange equipment—especially when one gets down to the principles of machine switching and their application to multi-office areas—are extraordinarily fascinating. The problems have been attacked and are being solved by most ingenious methods; has not someone said that automatic telephony is the high-water mark of human inventive genius? But that is not the whole story of telephone development. The modern long-distance trunk line, balanced and loaded, fitted with repeaters, echo suppressors and accurate line balances, is a product of high engineering skill and is worthy of the closest attention, not only of the student but of those whose duties may not have brought them into intimate contact with external work but yet are zealous enough in their profession to try to master all its phases. It is not possible, we admit, for any one communication engineer to assimilate all the details of all the branches to-day; the time has gone for one man to carry in his head a list of all the screws, tags, terminals and parts of every item of apparatus used by the Departments, as we believe an officer now very high in rank was once capable of doing without apparent effort. To attempt such a thing to-day would be foolish; a glance through the Stores Rate Book will disillusion anyone desirous of attempting it. Nevertheless, the field is not so wide as to debar any engineering officer from acquiring a sufficient knowledge of essentials so that when the time and opportunity come the details can be readily absorbed.

It is for these reasons we welcome the valuable articles on the London—Glasgow Trunk and its repeater stations, by Mr. A. B. Hart, and the description of the precision testing and cable balancing courses by Messrs. Morice and Morris. The cable testing courses form a fitting conclusion to the scheme of education for its staff now carried out by the Department.

A REFERENCE TELEPHONE TRANSMISSION SYSTEM.

The telephone administrations of the world have been concerned for some time on the subject of the adoption of a reference transmission standard, one which would be stable in operation and by which the telephone of commerce could be checked for volume and for articulation and also to bring results obtained by different administrations strictly into line with each other.

Interesting demonstrations were given at the P.O. Research Station at Dollis Hill in the last week in May of apparatus developed by the American Bell System, Siemens and Halske of Berlin, and the British Post Office for use in connection with a standard Reference System. The German and British exhibits, although giving excellent results, had not been developed to the extent of the American system and it was decided, after prolonged discussion, that it would be advisable to adopt *in toto* the American system for the time being. The main points were that here was a completed system which fulfilled the requirements laid down and one on which a great deal of experience had been obtained regarding the stability of the component parts.

It was recommended that the C.C.I. should obtain a complete set of apparatus which would be known as the European Master Transmission Reference System. Administrations could maintain other Reference Systems, which, if approved by the C.C.I. as conforming to certain limits laid down, would be designated Primary Reference Systems. The necessity of a concrete Master System follows from the impossibility, at the present, of obtaining apparatus within sufficiently close limits of difference to ensure that two systems built to the same acoustic-electric-acoustic specification but using different types of apparatus would give performances identical with one another.

Secondary and working standards not involving the elaboration of the Primary Systems could be used and calibrated from them.

Briefly, the Master System comprises six parts:—A transmitter and associated amplifier, a non-reactive line of 600/0 ohms impedance, a receiver with associated amplifier, two electrical networks (one to produce such frequency-characteristic distortion in the transmitter as to give the reference transmitter the same frequency-characteristic as that of the commercial type working standard, and another to do the same for the receiver), and, lastly, the calibration apparatus.

The transmitter used is the now well-known type of condenser transmitter, with a heavily air-damped stretched diaphragm. It is made up in a size comparable with the No. 1 C.B. transmitter and mounted upon a standard type pedestal. The line calls for no comment. The receiver is of the permanent magnet Bell type, but having the diaphragm mechanically damped by a series of thin paper discs placed below the diaphragm. The diaphragm is clamped between faced metal surfaces to ensure uniformity and permanence.

It is claimed that the transmitter and receiver maintain their calibration with great accuracy, but in order to obtain this calibration in absolute units a calibration system is incorporated. This is in reality the essence of the whole system. Calibration of the transmitter is carried out by enclosing the front of the diaphragm with a small chamber in which is held a thermophone consisting of two strips of gold leaf. If a direct polarising current be passed through this and an alternating current be superposed the heating and cooling of the strips heats the air gas in immediate contact. If the chamber in which the strip is located be small in comparison with the wave-length of sound corresponding to the frequency of the alternating current the pressure in the chamber varies in accordance with this current. Since the length of a sound wave in hydrogen is four times its value in air the calibration is carried out in hydrogen. It is claimed that it is possible to calculate the pressure in the chamber when its constants and those of the thermophone are known. The voltage output of the transmitter can thus be obtained in terms of dynes per square cm. on the diaphragm.

The receiver is calibrated by means of the previously calibrated transmitter. The thermophone is removed and the receiver, by means of a metal coupling device, placed airtight in front of the transmitter diaphragm. On passing a known current through the receiver the output in dynes per square cm. is obtained, knowing the calibration of the transmitter.

When required to test an ordinary receiver or transmitter the frequency characteristic in the standard is distorted so as to simulate that of the test instrument. The timbre of the two being then identical it is possible to compare the amplitudes accurately.

Messrs. B. S. Cohen, A. J. Aldridge and W. West, of the Research Section, Engineer-in-Chief's Office, read a paper on "The Frequency Characteristics of Telephone Systems and Audio-Frequency Apparatus, and their Measurement" before the Institution of Electrical Engineers at the May meeting. An interesting discussion followed the reading of the paper, in which a number of P.O. engineers took part.

Mr. Donald Murray sends us the following communication:—

TRANSFER OF AGENCY.

I announced some time ago that I had sold my Multiplex printing telegraph business to Creed & Co., Ltd., of Croydon, on the 30th June, 1925.

I have now arranged for the transfer of my agency for the products of the Morkrum-Kleinschmidt Corporation of Chicago, to the Standard Telephones & Cables, Ltd., of Connaught House, Aldwych, W.C.2, on the 31st March, 1926. After that date all enquiries and orders for Morkrum and Kleinschmidt machines and spare parts should be sent to the Standard Telephones & Cables, Ltd.

The Standard Company (formerly the Western Electric Company) has had very large experience in telegraph and telephone work and I have confidence that in transferring the agency to them the interests of my customers will be amply safeguarded and first class service assured to them.

My permanent address is:—

BM/DMRY,
London, W.C.1.

BM/DMRY is my Monomark and letters so addressed will always be forwarded to me wherever I may happen to be.

DONALD MURRAY.

30th March, 1926.

ROYAL CORPS OF SIGNALS DINNER, 1926, AND FORMATION OF A ROYAL CORPS OF SIGNALS DINNER CLUB.

The above Dinner will be held in London on Monday, July 19th.

Officers (Regular, Territorial and Supplementary Reserve) have already been circularised, but owing to lack of recently authenticated addresses it has not been possible to give information either about the Dinner or the formation of the Dinner Club to more than a very small number of the ex-Officers who served in the Signal Service, Royal Engineers, or who were seconded to the Signal Service during the war.

The Honorary Secretary of the Royal Corps of Signals Dinner Club would be glad if any such ex-Officers would kindly communicate their addresses to him c/o S.D.6, The War Office, S.W.1.

Extract from *The Times*, dated 29th May, 1926 :—

"In face of competition from American, German, French, Swedish and Italian concerns, The New Antwerp Telephone & Electrical Works has secured sole rights for the reorganization and exploitation of the Greek telephone and wireless services. The contract is worth about two and a half millions sterling."

Messrs. W. F. Dennis and Co., 70, Queen Victoria Street, E.C.4, are the sole representatives of the above Company in the British Empire.

Research Laboratories of the
General Electric Company, Ltd.,
Wembley.
28th May, 1926.

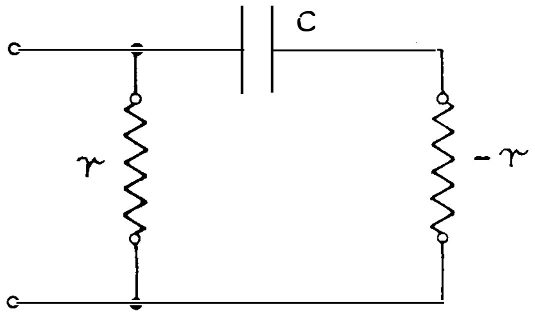
The Managing Editor,
Post Office Electrical Engineers' Journal,
Engineer-in-Chief's Office,
Alder House, E.C.1.

Dear Sir,

In view of the recent discussion in your columns on the Shunted Condenser, the following may be of interest :

An exact solution of the problem of annulling the inductance of a relay coil would be to insert in series with it some circuit or device having an effective negative inductance equal in magnitude to the positive-inductance of the coil.

A circuit having a negative inductance can be constructed by making use of a negative resistance such as the Dynatron or various other thermionic devices.



Assuming that a negative resistance is available consider the simple circuit shown in the Fig., consisting of a resistance r, a capacity C and a negative resistance $-r$.

The impedance of this circuit is

$$\frac{1}{\dfrac{1}{r} + \dfrac{1}{-r + \dfrac{1}{jpC}}} = \frac{1}{\dfrac{1}{r} + \dfrac{jpC}{1 - jpCr}}$$

$$= r - jpCr^2$$

The circuit is thus equivalent to a resistance r in series with negative inductance of value Cr^2.

By inserting such a circuit in series with a relay coil and choosing C and r so that $Cr^2 = L$ the inductance is completely annulled and the growth of current instantaneous.

Further by inter-changing the positive and negative resistances in the Fig. the effective resistance of the circuit becomes negative so that the resistance of the coil can also be annulled and the device in addition becomes an amplifier.

Of course, in practice it would be possible only to approximate to this solution, but since satisfactory negative resistances such as Dynatron have been produced the method should be capable of practical development.

By replacing the capacity by an inductance a negative capacity can be obtained and other more complicated negative impedances can be obtained in a similar way.

Yours faithfully,

A. C. BARTLETT.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

THE following works have been completed :—

Exchange.	Type.	No. of Lines.
Morriston	Auto	320
Ipswich	,,	1560
Swansea Extension ...	,,	440
Barnsley Extension ...	Manual	300
Grangewood Extension ...	,,	1080
Huddersfield Desk ...	,,	—
Hull Toll Extension ...	,,	4 new positions
Ilford Extension	,,	140
Openshaw New	,,	1400
Primrose Hill New ...	,,	4500
Redditch New	,,	340
Speedwell Extension ...	,,	2100
Toll M.F.	,,	130 verticals
Uxbridge Extension ...	,,	220
Auto Strop Razors ...	P.A.B.X.	30
Ashton-u-Lyne Infirmary...	,,	30
Battersea Council ...	,,	70
Birmingham Corporation...	,,	30
Bleachers Association ...	,,	100
Bootle Corporation ...	,,	50
Bradford Infirmary ...	,,	40
Burberry's Ltd.	,,	60
Clark Hunt	,,	40
Collins, Bristol	,,	20
Eastbourne Corporation ...	,,	50
Lambeth Council	,,	50
Lancashire C. Council ...	,,	30
Larkins Ltd.	,,	30
Ledinghams Ltd.	,,	30
Manchester & Salford Co-operative	,,	30
Metal Agencies	,,	70
Middlesex Hospital ...	,,	70
New Hudson	,,	20
North West Road Car ...	,,	30
Owen Owen	,,	60
Pearson Dorman	,,	50
Perfecta Tubes	,,	30
Robinson Bros.	,,	30
Shell Mex (Oxford) ...	,,	30
Spillers & Baker	,,	40
Stelp & Leighton	,,	40
Valor & Co.	,,	30
Wagon Repairs	,,	40
Watney Combe Reid ...	,,	90
Weston-super-Mare Council	,,	30
Yardley & Co.	,,	30

Orders have been placed for the following new Exchanges :—

Exchange.	Type.	No. of Lines.
Chatham Area	Auto	1400
Gillingham	,,	600
Rainham	,,	200
Snodland	,,	200
Strood	,,	400
Foleshill	,,	500
Hanley Area	,,	1080
Burslem	,,	1000
Chesterton	,,	100
Longton	,,	700
Newcastle-under-Lyme ...	,,	500
Stoke-on-Trent	,,	700
Trentham	,,	200
Harrogate	,,	2520
Hereford	,,	800
Macclesfield	,,	1300
Bearsden	Manual	1100
Leek	,,	500
Southend 2nd Relief ...	,,	1100
Armitage & Rigby ...	P.A.B.X.	40
Avonbank Co-operative ...	,,	20
Bootle Corporation ...	,,	50
Barnsley Corporation ...	,,	40
Bristol Times	,,	40
Burberrys	,,	60
Burnley Corporation ...	,,	100
Buxton Lime Firms ...	,,	30
Camberwell Guardians ...	,,	40
Celanese	,,	70
Cullen, W. H. Ltd. ...	,,	30
Dunkelbuhler Ltd. ...	,,	40
Edmonton Guardians ...	,,	100
Fisher & Ludlow	,,	40
Forman & Sons	,,	60
Gaumont Ltd.	,,	50
Glasgow Corporation—		
Town Hall	,,	350
Housing	,,	50
Harrison Ltd.	,,	50
Heywoods Ltd.	,,	60
Kingseat Hospital ...	,,	40
Manifoldia Ltd.	,,	30
Manchester & Salford Corporation	,,	50
Maypole Dairy	,,	80
Mecca Cafe	,,	60
Metal Agencies	,,	70
Middlesex Hospital ...	,,	50
Morris Cars	,,	70
Motherwell Hospital ...	,,	30
Ormrods Ltd.	,,	30
Phillips, J. & A.	,,	30
Pollard & Co.	,,	60
Rudders & Payne... ...	,,	30
Shell Mex (Oxford) ...	,,	30
Shoreditch Council ...	,,	50
Stelp & Leighton	,,	40
Swan & Edgar	,,	100
Transport Workers ...	,,	80
Wm. Walker & Son ...	,,	30
West Bromwich Hospital	,,	30
,, ,, Hallam House	,,	30
West Bromwich & Walsall Corporation ...	,,	40

Orders have been placed for extensions to existing equipments as follows :—

Exchange.	Type.	No. of Lines
Broughty Ferry	Auto	200
Dundee	,,	1000
Sketty	,,	170
Birmingham East ...	Manual	380
Blackpool	,,	1600
Bournemouth	,,	1680
Brixton	,,	1480
Clerkenwell	,,	560
Grangewood	,,	1080
Harrow	,,	1530
Ilford	,,	140
Kingston	,,	1680
Leamington	,,	380
Leith	,,	260
Nelson	,,	260
North	,,	1300

RETIREMENT OF ANDREW FRASER.

Mr. Andrew Fraser, having reached the age of sixty, has retired from the service. A native of Aberdeen, where the stories of meanness come from, he was a characteristic Scot and, acting on the Prime Minister's advice, he remained one to the end. He passed through the stages of Relay Clerk, Second Class Engineer and Assistant Engineer, and for the past two years he was Executive Engineer in the Telegraph Section. For many years he acted for the Department as the examiner of telegraphists for the Overseer's Certificate, and gained for himself a high reputation for absolute fairness. In the early days of the Journal Mr. Fraser contributed a very interesting series of articles on electrical pioneers, and several times since then his writings have graced our pages. He retires with the best wishes of all his engineering colleagues, and we are sure also with the kindliest regard of the staffs of every important telegraph office in the kingdom.

LONDON DISTRICT NOTES.

During the quarter ended March 26th, 1926, the number of exchange lines, internal extensions and external extensions provided and recovered, were as follows :—

	Exchange lines.	Internal Extensions.	External Extensions.
Provided ...	11,029	6,982	1,398
Recovered ...	3,162	3,213	636
Net ...	7,867	3,769	762

LONDON DISTRICT NOTES.

External Construction.

Mileage Statistics.

During the three months ended 31st March, 1926, the following changes have occurred:—

Telegraphs.—Nett decrease in open wire of 37 miles and a nett increase in underground of 410 miles.

Telephones (Exchange).—Nett decrease in open wire (including aerial cable) of 416 miles and a nett increase in underground of 38,369 miles.

Telephones (Trunk).—Nett decrease in open wire of 10 miles and a nett increase in underground of 1,090 miles.

Pole Line.—Nett increase of 90 miles, bringing the total to date to 5,362 miles.

Pipe Line.—Nett increase of 160 miles, the total to date being 6,545 miles.

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

Telegraphs	24,766
Telephones (Exchanges)	1,713,362
Telephones (Trunks)	60,998
Spares	56,372

Internal Construction.

New Exchanges.—A new C.B. 10A Exchange was opened at Waterloo on April 19th. The equipment was installed by the Department's staff in a building adjoining the Hop Exchange, which will be afforded much needed relief.

A new C.B.1 Exchange was opened at Primrose Hill on May 13th. The equipment was installed by Messrs. Ericsson's Manufacturing Company, and will accommodate 4,500 lines.

A C.B.10 Exchange, known as "Kelvin," was brought into use on May 19th. The Exchange, which was installed by the Department's staff, is located in the building erected for the accommodation of the Western Automatic Exchange.

Two new C.B.1 Exchanges are in course of construction by the General Electric Company at Rodney (Walworth), and Battersea. The Exchanges will accommodate 3,700 and 5,490 subscribers respectively.

The *S.M.T. Trial Equipment* at City Exchange has been completed by the A.T.M. Company, and is in course of being tested out.

Progress is being made with the construction of the Holborn Mechanical Tandem, Holborn Automatic, and Bishopsgate Automatic Exchanges.

Closing of Bank Exchange.—The Bank Exchange was closed on June 5th, the subscribers being transferred to the Exchanges serving the areas in which the subscribers' premises are located.

TELEGRAPHS.

The Jersey circuit has been fitted with modern Creed apparatus and similar apparatus has been installed in connection with the Norwegian circuits which are now to be worked from the Central Telegraph Office instead of by a Cable Company.

There are now four types of Creed in use: (1) Pneumatic, with air pressure in common; (2) Pneumatic self-pumping; (3) Wholly electric, and (4) Electric modified.

Apparatus of the Wheatstone and Creed types has been installed in appreciable quantity in connection with the Wireless Beam Stations, and the accommodation for Wireless work is being taken up rapidly.

Teletypes are still increasing and two patterns—typewheel and typebar—are now in use. These instruments are being used for Private Wires as well as Public Telegraphs.

MR. JAMES HAY THOW.

The death of Mr. J. H. Thow, Assistant Superintending Engineer, London District, has to be recorded with great regret. His numerous friends in the Engineering Department were shocked to receive, on the morning of April 22nd, the news that he had passed away suddenly and unexpectedly after a short illness. Mr. Thow, who was in his 59th year, was on duty, apparently in the best of health, up to Easter, when he met with a slight accident, but this was not thought to be serious. He was seen by some of his colleagues very shortly before his death, and then seemed to be in good spirits and making rapid steps towards recovery.

Mr. Thow entered the Department's service as a Telegraphist at Glasgow in October, 1884, and was transferred in March, 1892, to the Engineering Branch, in which Department he passed through the grades of Junior Clerk, Second Class Clerk and First Class Clerk prior to 1898, when he became a Second Class Engineer. In 1902 he came to London as a First Class Engineer in the (then) South Metropolitan District, and took charge of the Ealing Exchange Area when the Ealing Exchange was opened in 1904. After some years in charge of the Western Exchange Section he was engaged for a short time in the Technical Section of the Superintending Engineer's Office, and was then transferred to the C.T.O. Section. In this Section he took a very active interest in the Dudley pneumatic tube (continuous suction low vacuum) system. He made many attempts to solve some of the difficulties inherent in the street tube system in London, but his experiments came to a close on his promotion to Assistant Superintending Engineer in the South Midland District, with headquarters at Reading.

During the War, Mr. Thow took special charge of the installation and maintenance of works in connection with Air Defence in the South Midland District. After the War, extensive underground works, including the South Midland District portion of the London-Bristol, London-Southampton, and a number of the London Toll cables, were mainly under his control.

In 1922 he was transferred to the London Engineering District where he dealt more particularly with telegraph matters, buildings and the technical training of the minor staff.

His interests and hobbies were many. At Ealing he was well known in local circles and for many years was a member of the choir of the Parish Church. On his return to London from Reading he lived at Tulse Hill and became a member of the Church Choir there. In all, his services as a chorister extended to fifty years.

Mr. Thow was a very capable amateur mechanic and was skilled in the use of tools. He was also expert in cabinet making and wood working, and his work would be creditable to a professional craftsman.

Our late colleague possessed an exceptionally bright and cheerful personality, and was popular with all grades of the staff. He was a devoted husband and father, and those who knew him intimately mourn the loss of a sincere friend. An indication of the love and respect of those with whom he came in contact is contained in the fact that upwards of two hundred letters of condolence were received by his family.

R.A.W.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

ELECTION OF COUNCIL FOR THE YEAR 1926-27.

The constitution of the new Council will be as follows:—

Chairman—Mr. A. L. DeLattre.

Honorary Treasurer—Mr. B. O. Anson.

Representing Staff of the Engineer-in-Chief's Office—

Mr. C. J. Mercer, and Mr. E. J. Wilby.

,, Executive Engineers—

London: Mr. A. Wright.

Provinces: Mr. W. J. Rolfe.

Representing Assistant and Second Class Engineers—
London: Mr. J. H. Bell.
Provinces: Mr. C. E. Morgan.

,, Chief Inspectors—
London: Mr. W. A. B. Romain.
Provinces: Mr. A. S. Carr.

,, Clerical Staff—
London: Mr. E. T. Larner.
Provinces: Mr. A. W. Lines, and Mr. H. Longley.

,, Inspectors—
London: Mr. C. W. Messenger.
Provinces: Mr. R. P. Collins.

,, Draughtsmen—
London and Provinces: Mr. J. Millet.

Secretary—Mr. R. V. Hansford.

LOCAL CENTRE NOTES.

LONDON CENTRE.

SESSION 1925-26.

It is satisfactory to record that increasing interest in the activities of the Institution has been shown. Six Ordinary Meetings, the Annual General Meeting, and five Informal Meetings were held.

The programme for the Ordinary and Annual General Meetings was as follows:—

13th October, 1925, a Lecture by Major A. G. Lee, M.C., B.Sc., M.I.E.E., on "The work of the Wireless Experimental Section."

24th November, 1925, a paper by Harvey Smith on "The Problem of Flexibility in Subscribers' Cable Distribution."

8th December, 1925, a paper by Capt. H. Hill, B.Sc., M.I.E.E., on "The Engineering Aspect of Telephone Exchange Accommodation."

12th January, 1926, a paper by W. Layton on "Precision Testing in the London Engineering District."

9th February, 1926, two papers by Capt. N. F. Cave-Brown-Cave, B.Sc., M.I.E.E., on (*a*) "Testing of Secondary Cells," and (*b*) "Torch Blowing Lamps."

9th March, 1926, a paper by Messrs. E. S. Ritter, D.F.H., A.M.I.E.E., and G. P. Milton on the "Testing of Telephone Circuits and Apparatus with Alternating Currents."

1st June, 1926 (Annual General Meeting), a paper by Messrs.

G. F. O'dell, B.Sc., A.K.C., M.I.E.E., and W. W. Gibson on "Automatic Trunking in Theory and Practice."

Most of the papers have been recommended for printing, but some time must elapse before the printed copies are available. For the convenience of members a typewritten copy of each paper has been deposited with the Librarian.

The subjects for the Informal Meetings were as follows:—

October 27th, 1925. Notes on "American Telephone Industry—an Outline of its Development, Organisation and Control," prepared by Mr. W. Day, M.I.E.E. [These notes have been printed in the May, 1926, issue of the *Telegraph and Telephone Journal*.]

December 15th, 1925. Notes on "Pipe Laying by Magnall Irving Thrust Boring Apparatus in London," prepared by Mr. Arthur Miller.

January 19th, 1926, was reserved for the continued discussion on Mr. Harvey Smith's paper on "The Problem of Flexibility in Subscribers' Cable Distribution."

January 26th, 1926. Notes on "Transmission Values of Circuits in the London Area," prepared by Mr. J. S. Elston.

February 23rd, 1926. Notes on "Minor Staff—Recruitment, Training and Advancement," prepared by Mr. W. A. Williams. [A copy of these notes has been deposited with the Librarian.]

Visits: Arrangements were made for a visit to the Sterling Telephone and Electric Co., Ltd., Works at Dagenham, Essex, and to the Standard Telephones and Cables, Limited, Works at New Southgate. The development of Automatic Telephones and Wireless Broadcasting made these visits particularly interesting and it was unfortunate that so many of the members who had notified their intention of visiting either or both of these works were prevented by the exigences of their official work. The Committee would like to take the opportunity of thanking the Managing Directors and their staffs for the excellent programmes arranged for the visitors.

The members of Committee for the 1926-27 Session are as follows:—

Chairman—Major A. G. Lee, M.C., B.Sc., M.I.E.E.
Vice-Chairman—Mr. J. W. Atkinson, M.I.E.E.
Representing Staff Engineers at Headquarters—
Mr. P. T. Wood.
,, Executive Engineers—
Mr. F. Blick, A.M.I.E.E., and Mr. J. Cowie, M.I.E.E.
,, Assistant Engineers—
Mr. W. W. B. Crompton, A.M.I.E.E., and Mr. W. Dolton, M.I.E.E.

Representing Chief Inspectors—
Mr. J. Hargreaves, (vacancy).
,, Inspectors—
Mr. D. C. Maddocks, and Mr. A. Miller.
,, Draughtsmen—
Mr. H. Taylor.
,, Clerical Staff, London Engineering District—
Mr. E. T. Larner, A.I.E.E.
,, Engineering Staff, South Eastern District—
Mr. W. J. Jenkins.
,, Clerical Staff, South Eastern District—
Mr. P. J. Dodgson.
Local Secretary—Mr. F. W. Friday.

On the 11th May, Messrs. G. F. O'dell and W. W. Gibson read a paper on "Automatic Trunking in Theory and Practice." The following is a synopsis of the paper :—Introduction. Divergence between theory and practice. Difference between manual and automatic exchange traffic. Use of the theory of probabilities—its value and the conditions necessary for making best use of it. Traffic carried by each switch in a simple group calculated and measured. Method of estimating theoretically the traffic carried by a grading, comparison of this method with results of practical tests. Method of taking records in automatic exchanges.

(1) Measurement of congestion or last contact traffic.
(2) ,, of lost calls or overflows.
(3) ,, of total calls.
(4) ,, of traffic carried by a group of switches.
(5) Recording instruments.

A most interesting discussion followed.

R.T.R.

SCOTLAND WEST CENTRE.

For our March fixture the lecturer for the day was Captain Hill, B.Sc., M.I.E.E., of the Engineer-in-Chief's Staff, the subject being "The Engineering Aspect of Telephone Exchange Accommodation." The attendance was unusually large, being augmented by visitors from the staffs of the District Managers and from the Postmaster's staff. It is understood that the paper is being read before other Centres, and consequently it is unnecessary here to go into any details of the subject, beyond stating that the paper proved of great interest to the audience—an interest much enhanced by the style of delivery. The demand for copies of the paper could not be met.

The last item on the programme for Session 1925-26 was reached on 19th April, when three films were shown—

(1) Aiding the Art of English Conversation.
(2) Creating the Instruments of Speech.
(3) The Audion.

The first two films illustrated operations in the manufacture, handling and laying of cables; also various stages in the production of telephone equipment and Wireless Apparatus. The third film, "The Audion," illustrated in detail the action taking place inside the Thermionic Valve. There was a large turn-out of members, and of visitors representing kindred institutions. The films were very much appreciated, and the thanks of the local centre are due to the lenders of the films, namely, Standard Telephone and Cables, Limited (formerly Western Eelectric Company, Ltd.).

Many members of the Engineering Department who were at one time associated with the Glasgow Telegraph Instrument Room or who have in the past been attached to the Scotland West District will regret to learn of the passing of their old acquaintance, John Paxton, whose death took place on the 8th of April. Mr. Paxton had been in failing health for some considerable time, but the end, when it came, was very unexpected.

Mr. Paxton joined the Engineering Department towards the end of 1902 and was appointed to Higher Clerical rank in 1920. His death has caused keen regret among his colleagues of all ranks in the District with which he was connected for a period of over 24 years.

NORTH WALES CENTRE.

The fourth meeting of the Session was held at the Shrewsbury Technical School on the 13th January, 1926, when Mr. A. E. Stollard read a paper on "The Relay System of Automatic Switching—Private Branch Exchanges." Mr. Stollard traced the progress of telephonic communication from the original invention by Dr. Graham Bell and exhibited a series of slides showing early types of switchboards and proceeded from this to a description of the components of the relay automatic system and of the design and characteristics of the relay. The paper concluded with a description of the Fleetwood Relay Automatic Exchange.

At the fifth meeting which was held on the 1st February, 1926, Captain H. Hill, of the Engineer-in-Chief's Office, read his paper on "The Engineering aspect of Telephone Exchange Accommodation." The paper has already been referred to in these columns and it was followed by a very full discussion and a hearty vote of thanks to Captain Hill.

The sixth and final meeting of the Session was held on

Wednesday, the 10th of March, when Messrs. R. S. Dacombe and J. T. B. Donnellan read a paper entitled "Plant Records, Their Preparation and Use." The paper was illustrated by slides and diagrams and contained a very full and interesting description of the plant records of various kinds which are maintained under the official instructions. Slides illustrating the official route maps, vandyked plans, cable records, mileage plans, pole diagrams, etc., etc., were exhibited and their usefulness explained. In the discussion which followed many complimentary references were made to the manner in which the drawing office work at Birmingham is carried out and to the assistance which the very complete plant records afford the officers engaged on development and rearrangement schemes.

The Session which has just ended has been a very successful one as regards attendance and interest in the papers. The former has varied from between 70 to 80 and the discussions have not infrequently had to be hastily concluded to allow members to catch their trains homeward.

ROBERT GARDNER MASAROON.

Robert Gardner Masaroon, who is well known throughout the Post Office Engineering Department, retired from the position of Assistant Superintending Engineer of the North Wales District on the 26th January last after 44 years' service to the State in various capacities.

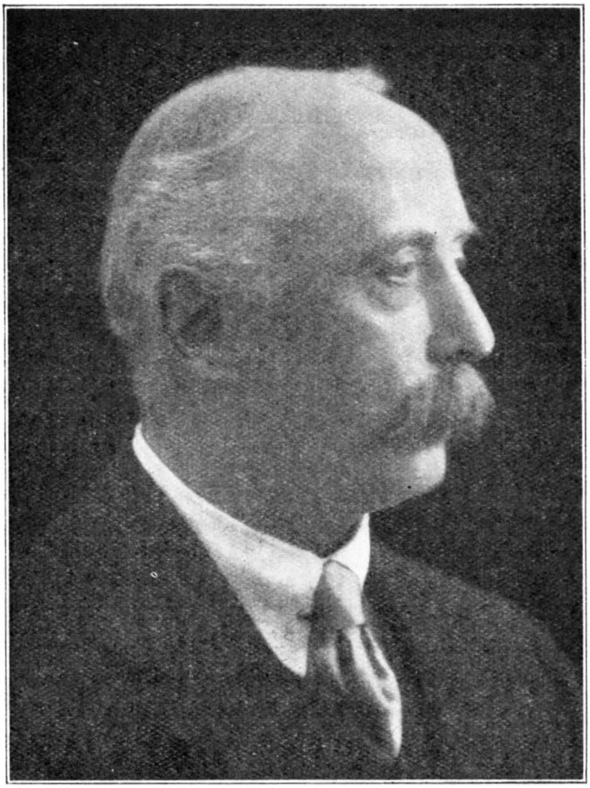
After serving for two years at sea, during which he made the famous trip round Cape Horn to California and back in an old wind-jammer, he entered the Post Office service as a telegraphist at Londonderry in 1882. A year later he joined the Telegraph Battalion of the Royal Engineers, subsequently serving in the Egyptian campaign of 1885. He was invalided home to England and continued his military service in the old Southern Engineering District.

Mr. Masaroon's reputation as an efficient administrator was such that during the South African war, when all the Royal Engineer officers were withdrawn for active service, he was placed in charge of the South-West portion of the Southern District as Acting Superintending Engineer. The manner in which he carried out this duty elicited the special thanks of the Engineer-in-Chief.

In 1904, on the completion of his military service, Mr. Masaroon was appointed 1st Class Engineer in the Post Office Engineering Department, in which capacity he served at Bristol until 1909, when he was promoted, after a competitive examination, to the position of Assistant Superintending Engineer. After a short period of service in Ireland he came to the North Wales

District, where he remained until his retirement in January last. This, very briefly, is the record of Mr. Masaroon's meritorious career.

It is no mere platitude to say that Mr. Masaroon's retirement leaves a distinct gap in the North Wales District; and it is also regarded as a personal loss not only by his engineering colleagues, but also by his many friends in other Departments with whom he came into official contact. His long and varied experience had filled his mind with precedents, which enabled him to suggest



R. G. Masaroon

ways and means of removing difficulties and getting things done, and his chief characteristic in his official duties was his readiness to place his experience at the service of his subordinates of all ranks.

Those of his more intimate colleagues have a very warm regard for him for his personal qualities, and they cherish the hope that there may be many opportunities of meeting him at Weston-super-Mare, his chosen place of retreat, where he will have more leisure to devote to his well-stocked library, which he has gathered together through a long course of years.

It has been said that any man who has led an active life has at least one good book in his head if he would only write it, and the saying should certainly be true of Mr. Masaroon, but instead of writing a book he prefers to tell his experiences to his friends orally, and it is his delightful table-talk which has always made him the best of good company. Both officially and personally he leaves many pleasant memories behind him.

At a recent Staff gathering a presentation of a barometer and 3-valve wireless set was made to him, and representatives of all grades of the staff expressed their hearty good wishes to him and Mrs. Masaroon for a happy retirement.

We deeply regret to record the death of Mr. A. E. Giffen, Executive Engineer, Hanley, which took place on the 3rd of February. Mr. Giffen, who had been ill for some months previously, was 55 years old. He entered the service as a Sorting Clerk and Telegraphist at Glasgow in 1886 and was, later, transferred to the Engineering Department as a junior clerk. He became, successively, Sub-Engineer, Engineer 2nd Class, Engineer 1st Class, and Executive Engineer, his various Districts being North Wales, Ireland, Midland, Metropolitan Central, South Midland, and finally again, North Wales, where he was Sectional Engineer at Stafford and Hanley for over 17 years. In him the Department had a very efficient and zealous officer who combined very highly developed powers of organization and control with unfailing courtesy and consideration towards his subordinates. His personal qualities were appreciated not only by his colleagues but by his fellow citizens in the Potteries area, where he took a full part in the local Engineering associations and in the local and national organizations connected with the church to which he belonged. G.R.

NORTHERN CENTRE.

On the 17th March Capt. H. Hill, B.Sc., M.I.E.E., of the Engineer-in-Chief's Office, delivered a very instructive and informative lecture on "The Engineering Aspect of Telephone Exchange Accommodation," before a well attended meeting. The paper was very well received and the discussion, which had to be curtailed owing to time considerations, was replied to in a very able manner. A vote of thanks to Capt. Hill was carried with hearty acclamation.

The members of the Centre were invited by The Junior Institution of Engineers to a show of films on the 19th March, illustrating the manufacture of Morris Cars and Dunlop Tyres.

Mr. J. H. Bell, A.M.I.E.E., of the London Engineering District, made a welcome return visit to Newcastle on the 7th April, when he gave a blackboard Automatic lecture, his subject being the "Final Selector for P.B.X. Groups." Mr. Bell is an experienced lecturer and employs a unique method of illustrating his subject by building up diagrams step by step in a simple and absorbing manner on the blackboard.

The meeting was very enjoyable and instructive, and the members voiced their thanks to the lecturer adequately.

The Committee for next Session has been selected as follows:—

Chairman—J. R. M. Elliott.
Vice-Chairman—F. G. C. Baldwin.
Representing Executive Engineers—G. A. Peck.
,, Clerical Staff—J. A. Motyer.
,, Assistant Engineers—C. P. Kay.
,, Chief Inspectors—W. Weightman.
,, Draughtsmen—S. J. Millett.
,, Inspectors—A. H. Wade.
Local Librarian—J. Stark.
,, Secretary—A. C. Smith.

NORTH WESTERN CENTRE.

The closing meeting of the 1925-26 Session was held in the Lecture Hall of the Preston Scientific Society, Fishergate, Preston, on the 29th March, 1926, when a paper entitled "Amateur Wireless Stations" was read by Mr. H. Horrocks. J. M. Shackleton, Esq., M.I.E.E., the newly appointed Superintending Engineer of the North Western District, presided and was accorded an ovation upon taking the Chair. Mr. Horrocks, in the course of an interesting paper dealt chiefly with the conditions which would likely be found by an officer called upon to make an inspection of an Amateur Wireless Station and touched upon the following points:—Permits, Aerials, Wavemeters (Buzzer and Heterodyne), Transmitting Circuits, Receiving Circuits, etc., and related some actual experiences which he had had in his capacity as inspecting officer. The paper was illustrated by an excellent set of lantern slides.

The 1925-26 Session has been most successful. Six meetings have been held, and a visit has also been paid to the new super power station of the Preston Corporation. There has been a nett increase of 11 in the membership during the year, there have been no resignations and the total of membership of the Centre now stands at 101. There has been a marked increase in the average attendance at the meetings and a point worthy of mention is the helpful discussions which have taken place.

Local Organization, Session 1926-27 :—

Chairman—J. M. Shackleton, Esq.

Vice-Chairman—J. Sinclair Terras, Esq.

Committee—Messrs. W. J. Rolfe, W. Beattie, C. Coward, R. B. Austin, E. Hopper, and H. S. Turner.

Local Librarian—Mr. H. Howarth.

,, Secretary—Mr. D. Barratt.

SOUTH LANCS. CENTRE.

It is with extreme regret that we have to record the death of Mr. J. Cardoc Jones, Assistant Engineer, Manchester, in his 57th year.

All who knew him during his varied career will regret the passing of a highly respected colleague and a well informed and zealous servant of the Department.

SOUTH WALES CENTRE.

Annual Report.

As no District Notes have appeared in the Journal for a long time, I shall be obliged if you will have the following published :—

The local committee for the 1926-7 Session has been elected as follows :—

Executive Engineers—Mr. W. Scott.

Assistant Engineers—Mr. W. H. Lane.

Chief Inspectors—Mr. H. W. Gifford.

Inspectors—Mr. S. H. Pendleton.

Clerical—Mr. A. G. Packer.

Draughtsmen—Mr. E. W. Thomas.

Local Secretary—Mr. F. J. B. Clarke.

The position of Local Secretary, very ably filled by Mr. E. C. J. Badger, has been relinquished by him owing to his retirement from the Department's service next August.

Six meetings were held during the Session 1925-6 and the following papers were read :—

"Notes on Cable Balancing." Mr. J. F. Stewart, Haverfordwest.

"The Engineering Aspect of Telephone Exchange." Capt H. Hill, E.-in-C.'s Office.

"The Training of an Engineering Inspector." Mr. H. W. Gifford, Cardiff.

"Some points on Trunking in Automatic Exchanges." Mr. G. F. O'dell, E.-in-C.'s Office.

"Inspection of Amateur Wireless Stations." Mr. H. B. Somerville, E.-in-C.'s Office.

"Newport Repeater Station." Mr. S. H. Pendleton, Newport.

After the reading of the last paper a visit was made to the Repeater Station, which was greatly appreciated by the members.

A. HOARE.

SOUTH MIDLAND CENTRE.

The 57th meeting on 31st March, 1926, was the first of the Centre held in the College after its elevation to the dignity of a University. The attendance numbered 63.

The proposal of Mr. Halton that the Vice-Chancellor be congratulated in the name of the Centre on the grant of a charter conferring University status was endorsed by all the members present and the Secretary was instructed accordingly.

Mr. H. C. McCormack then commenced his paper :—

"Organisation of a Superintending Engineer's Office."

This was arranged under seven headings—historical note, accommodation, arrangement of work, staff provision, training, annual leave and inspections. The ideals which should be sought when providing or selecting accommodation for a District Headquarters were set out and the fittings required for use in the various rooms were described.

Under "arrangement of work" the standard division of the functions between the groups was examined, minor differences existing in the South Midland District explained and a method was outlined which would reduce the time occupied in dealing with registered papers.

Mr. McCormack identified himself with the benevolent policy of the encouraging angels when criticism of imperfect work was justified.

Substantial economies which have followed the clerical reorganisation of 1922 were described and the opinion advanced that an Accountant or Principal Clerk should be appointed in each District and a second Assistant Superintending Engineer in the larger Districts.

In discussing the training of the clerical force, generalisation as opposed to specialisation was favoured and plans for the vocational education of the District Headquarters' staff were disclosed.

The paper concluded with details of the inspecting duties handed down in recent years to lower ranks by Superintending Engineers and their assistants.

The discussion which followed did not lack animation and although the unprecedented number of nine spoke, several sheaves of notes were being waved at the Chairman when, as the usual hour of closing the meeting had passed, he asked Mr. McCormack to reply. The nine successful in the competition to catch the

Chairman's eye were Messrs. Harry, Halton, J. S. Brown, Lines, Roach, Beetlestone, Dwyer, King and Roberts and the lecturer succinctly disposed of the many questions asked and views expressed.

Mr. McCormack was thanked for his contribution by enthusiastic applause.

Seventy-four were present at the 58th meeting, the last of the 1925-6 Session which took place on the 28th April.

The members and visitors stood in silence as a mark of respect to the memory of the late Mr. J. H. Thow, onetime Vice-Chairman, and of Mrs. Robb, wife of a former Chairman of this Centre. Mr. Thow and Mrs. Robb died during April.

The certificates gained in the 1925-6 Essay Competition were presented to:—Mr. C. A. Maggs, Mr. A. E. W. Maslin, Mr. F. W. Dye, and Mr. C. L. Wicks, the first two of whom had each received a cheque at an earlier date. The Chairman, in handing over the certificates congratulated the staff of the South Midland District on its splendid record in gaining 7 out of a total of 20 awards made in connection with the three competitions held to date.

The paper read at the meeting was entitled:—" The Duties of an Inspector," by Mr. F. D. Traviss.

The lecturer first dealt with the general responsibilities of Inspectors and passed on to give his views about the training of workmen. The U.C.C. and U.M.C. systems came under notice, two posers within the construction costing system were enunciated and in connection with maintenance the question of faults was discussed.

The preparation of estimates was described under the headings of overhead and internal and the engineering work required before a new rural exchange was ready for opening was explained. Mr. Traviss dealt with the organisation necessary in arranging for the supply of stores for works and detailed the records set up.

Advice Note work and pole spottings were touched upon and the system adopted for the filing of W.O's, A.N's and Maps was described. The routine of recording, with special reference to A.N's route cards and surplus stores, was outlined.

The paper ended with the lecturer's views on the question of the grade whom he considered should be employed in the negotiation of wayleaves.

The last minutes of the Session were profitably occupied in answering the questions put by Major Harris, Messrs. Stevenson, Peck, Dwyer, W. L. Taylor, Capt. Horton, Messrs. Lewis, Atkins, Wakefield, Halton, Campbell and Dickinson.

The Chairman, in thanking Mr. Traviss, stated that the record number of questions had demonstrated the great interest which the audience had in the subject of the lecture.

The past Session has been a successful one, the average attendance at the seven meetings has been 64. The number of the offers received of papers to be read during the next Session is most encouraging. A.W.L.

BOOK REVIEWS.

"Elementary Electrical Engineering." By O. R. Randall London: Sir Isaac Pitman & Sons, Ltd. Pps. 233. 5s. nett.

This book should prove useful to those taking a laboratory course in Electrical Engineering. It deals with the subject essentially from a practical standpoint, but contains enough theory to make it interesting and intelligible without at the same time being too mathematical.

Useful chapters appear on instruments, D.C. motors and generators and simple A.C. circuits. The subject of secondary cells, however, which nowadays is of special interest to all P.O. Engineers concerned with the installation and maintenance of small power plants receives scant treatment, as do also the chapters on electric lamps and arcs.

H.C.J.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Pennington, W. ...	Executive Engineer, London District.	Asst. Suptg. Engr., London District.	18-5-26
Finlayson, W. J. ...	Assistant Engineer, N.West District.	Executive Engineer, N.West District.	25-3-26
Sharpley, A. J. ...	Assistant Engineer, E.-in-O. Office.	Executive Engineer, E. District.	1-4-26
McMullin, J. F. ...	Assistant Engineer, S.Wa. District.	Executive Engineer, S.Mid. District.	6-4-26
Gibbon, A. O. ...	Assistant Engineer, E.-in-O. Office.	Executive Engineer, E.-in-C. Office.	3-4-26
Fleetwood, H. O. ...	Assistant Engineer, Met. Power District.	Executive Engineer, Met. Power District.	To be fixed later.
Croker, J. R.	Assistant Engineer, E. District.	Executive Engineer, S.E. District.	do.
Escott, H.	Assistant Engineer, S.Lancs. District.	Executive Engineer, S.Lancs. District.	do.
Bedford, J. G. ...	Prob. Assistant Engr., E.-in-C. Office.	Assistant Engineer, E.-in-C. Office.	1-4-26
Missen, E.	Prob. Assistant Engr., E.-in-C. Office.	Assistant Engineer, E.-in-C. Office.	1-4-26
Chinn, W. E.	Prob. Assistant Engr., E.-in-C. Office.	Assistant Engineer, E.-in-C. Office.	1-4-26

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date.
Romain, W. A. B. ...	Chief Inspector, London District.	Assistant Engineer, London District.	27-3-26
Keir, A. D.	Chief Inspector, Scot.E. District.	Assistant Engineer, Scot.W. District.	To be fixed later.
Parker, T.	Chief Inspector, N.E. District.	Assistant Engineer, S.E. District.	do.
Green, H. W. ...	Chief Inspector, N.Wa. District.	Assistant Engineer, N.Wa. District.	do.
Richards, T.	S.W.1, N. District.	Inspector, N. District.	16-11-25
Luxton, W. G. ...	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Turner, H. M. ...	Prob. Inspector, S.Lancs. District.	Inspector, S.Lancs. District.	12-1-26
Swift, R. E.	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Knowers, A. D. V. ...	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Brett, S. I.	Prob. Inspector, London District.	Inspector, London District.	12-1-26
Potts, E.	,,	,,	12-1-26
Chew, W. G. N. ...	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Franklin, R. H. ...	,,	,,	12-1-26
Berkeley, G. S. ...	,,	,,	12-1-26
Hibberd, W. A. ...	,,	,,	12-1-26
Harvey, E. D. ...	Prob. Inspector, London District.	Inspector, London District.	12-1-26
Phillips, R. S. ...	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Ackerman, H. M. W....	Prob. Inspector, London District.	Inspector, London District.	12-1-26
Penn, H. A.	Prob. Inspector, London District.	Inspector, London District.	12-1-26
Tester, H. F.	S.W.1, London District.	Inspector, London District.	28-2-26
Murphy, J. C. ...	S.W.1, Scot.W. District.	Inspector, Scot.W. District.	18-4-26
Blackman, R. W. ...	S.W.1, E.-in-C. Office.	Inspector, E.-in-C. Office.	1-3-26
Thorpe, L.	S.W.1, S.E. District.	Inspector, S.E. District.	17-2-26
Allen, J. L.	,,	,,	22-6-25
Lock, G. R.	,,	,,	8-3-26
Stead, A. D.	,,	,,	14-12-25
Sandford, W. H. ...	,,	,,	17-5-26
Wallis, H. W. ...	,,	,,	24-5-25
Eaves, A.	,,	,,	14-5-26
Seach, G. E.	S.W.1, E. District.	Inspector, E. District.	1-2-26
Gilbert, F. W.... ...	,,	,,	26-1-26
King, R. R.	,,	,,	20-3-26
Partington, B. G. ...	S.W.1, S.Lancs. District.	Inspector, S.Lancs. District.	19-10-25

APPOINTMENTS.

Name.	Grade.	Date.
Richards, E. M. ...	Probationary Assistant Engineer, Testing Branch.	22-3-26
Stratton, J.	,,	1-4-26

STAFF CHANGES.

Transfers.

Name.	From	To.	Date.
McCormack, W. ...	Executive Engineer, S.Lancs. District.	Executive Engineer, S.E. District.	To be fixed later.
Jackson, J. M. ...	Assistant Engineer, E.-in-C. Office.	Assistant Engineer, N.W. District.	14-3-26
Snell, W. S.	Assistant Engineer, E.-in-C. Office.	Assistant Engineer, S.W. District.	16-5-26

Retirements.

Name	Grade.	District.	Date.
Whitehead, J.	Executive Engineer,	Eastern District.	31-3-26
Brown, J. S.	Executive Engineer,	S.Mid. District.	31-3-26
Fraser, A.	Executive Engineer,	E.-in-C. Office.	2-4-26
Barradell, D.	Chief Inspector,	S.E. District.	29-4-26
Sargeant, A. J. ...	Chief Inspector,	London District.	28-5-26

Deaths.

Name.	Grade.	District.	Date.
Thow, J. H.	Asst. Suptg. Engr.,	London District.	22-4-26
Jones, J. C.	Assistant Engineer,	S. Lancs. District.	27-3-26
Antliff, A. E.	Inspector,	S.W. District.	30-4-26
Barker, W. L. ...	Inspector,	London District.	28-2-26

CLERICAL ESTABLISHMENT.

Appointments as Clerical Officer.

Name.	District.	Date.
Griffiths, W. J.	South Western.	23-2-26
Wheater, J.	North Midland.	21-3-26
O'Carrigan, J. T. ...	London.	7-3-26
Laird, D. S.	Met. Power.	21-3-26

Promotions.

Name.	Grade.	Promoted to	Date
Tennant, T. M. ..	Executive Officer, E.-in-C. Office.	Staff Officer, E.-in-C. Office.	1-5-26
Impett, C. W. ...	Clerical Officer, E.-in-C. Office.	Executive Officer, E.-in-C. Office.	1-5-26

Retirements, etc.

Name	Grade.	District	Date.	Remarks
Fisher, H. G.	Staff Officer.	E.-in-C.O.	30-4-26	Retired.
Jackson, R.	Clerical Officer.	London.	13-5-26	,,
Bell, A.	,,	Scot.W.	25-3-26	,,
Paxton, J.	Higher Clerical Officer.	Scot.W.	8-4-26	Deceased.
Bowkett, C.	Clerical Officer.	N.Wales.	5-5-26	,,

COMMUNICATIONS.

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

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ESSAY COMPETITION, 1925-26.

The Judges have reported to the Council that the Prize Winners in the recent Essay Competition, arranged in order of merit, are as follows:—

1. S. H. Johnson, External Section, Birmingham.
   "The Technical Certificates—Why, and how to acquire them."
2. C. A. Maggs, Repeater Station, Marlborough.
   "The Vacuum Tube Amplifier and its application to Telephone Repeater Circuits."
3. A. W. T. Baldwin, City External Section, London.
   "Secondary Batteries."
4. A. E. W. Maslin, Oxford Section.
   "Telephone Development in Rural Districts."
5. J. E. Wright, Research Section, E.-in-C.O.
   "Insulating Materials."

The number of entries this year was 71, a great increase over the corresponding number of last year. The Judges report that the average quality is higher than last year, and, on their recommendation, the Council has decided to award Certificates of Merit to the following five competitors who were next in order of merit:—

6. H. Satterthwaite, Fordrough Lane Depôt, Birmingham.
   "Testing new Stationary Secondary Cells."
7. A. J. Allison, South East External Section, London.
   "Coder Call Indicator."
8. F. W. Dye, Guildford Section.
   "The Testing of Lines and Apparatus at Telephone Speech Frequencies."
9. R. D. Sutter, Greenock, Scot. W. District.
   "Section Stock."
10. C. L. Wicks, Repeater Station, Marlborough.
    "Telephone Repeater Station Power Plant."

R. V. Hansford,
Secretary.

April, 1926.

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