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ADVERTISEMENT INDEX

see page xii.

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THE NEW TELEGRAPH REPEATER STATION AT LOWESTOFT (LWV).

E. G. Furneaux.

A DESCRIPTION of the old station was given in this Journal, Vol. XVI., Part 4, p. 295.—The space available for the apparatus in that building was not sufficient to enable the best possible working conditions to be obtained, and as the lease was about due for renewal arrangements were made to obtain a better position and with better working conditions. The one disadvantage is that the Anglo-German cables and one Dutch cable have had to be increased in length by the addition of 784 yards of paper-insulated lead-

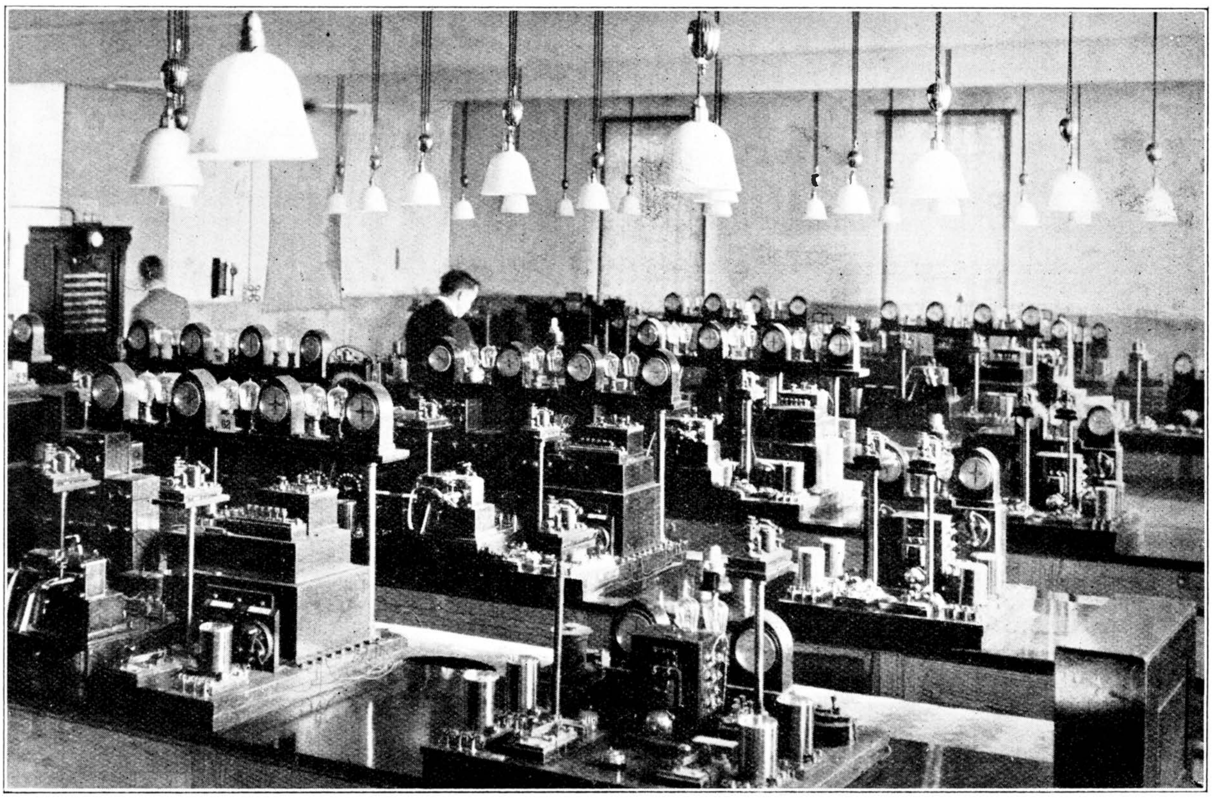


Fig. 2.—Portion of interior of Repeater Station.

covered cable, but the two Dutch cables *via* Benacre have been decreased in length by a similar amount.

Fig. 1 gives a view of the new building which is situated on Battery Green and overlooking a portion of the harbour. It has a very pleasing appearance with its walls of Atlas white cement, purple brick dressings and wide low-pitched roof of small slates.

Fig. 2 shows a portion of the Repeater Room, which occupies most of the first floor and has windows on three sides; the fourth side separates this room from the retiring room and the staircase.

A plan of the first floor is given in Fig. 3 and shows the chief dimensions, positions of the tables and the Repeaters for the various circuits. Repeaters 41 to 48 are used on the

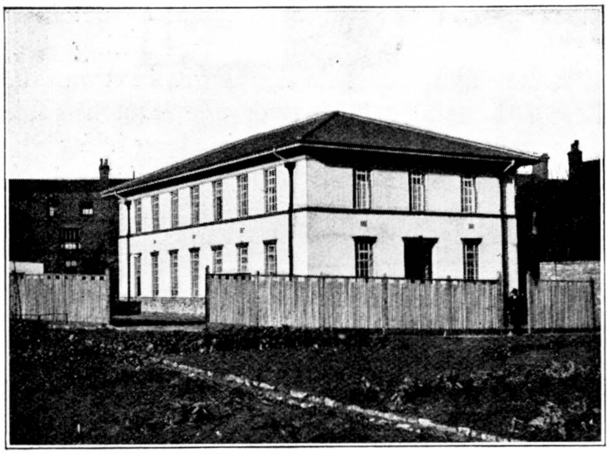


FIG. 1.—LOWESTOFT TELEGRAPH REPEATER STATION.

German cables, and 33 to 62 on the Dutch lines.

There are five repeaters on each table, four being for use on the four wires of a cable and one in reserve.

The systems in use are Baudot Triple and Double Duplex, and Hughes Simplex or Duplex for the public lines, while Wheatstone Duplex and Western Union Double Duplex are used on the two private wire circuits.

The spare repeaters are for Simplex Hughes working in order to avoid changes in the adjustment of relays and duplex balances when the double-current duplex systems are closed down for night and Sunday working and are replaced by single-current Hughes simplex sets. The time required to cross from one Repeater to another is very much less than the time required to re-arrange the adjustments on the double-current duplex boards.

On the submarine cable side the working is by single wire with "Earth," but on the London side the circuits are metallic loops without "Earth," requiring separate batteries for each circuit.

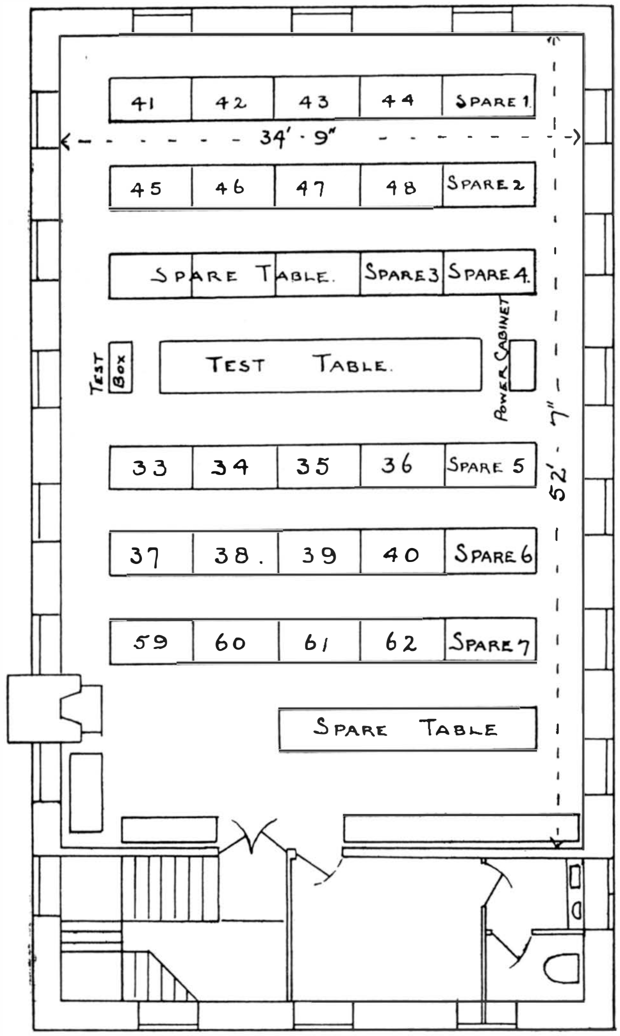


FIG. 3.—PLAN OF REPEATER ROOM, SHOWING ARRANGEMENT OF INSTRUMENT TABLES.

The extensions of the submarine cables are made by conductors of approximately the same size as those of the submarine conductors.

The change from open aerial wires to underground cable has added materially to the stability of the services, both in regard to the lessened liability to interruption and to the preservation of the duplex balances.

The Ground Floor, Fig. 4, provides an office for the Engineering Inspector, a room for the linemen and stores, a heating chamber, a dynamo room, and space for the batteries.

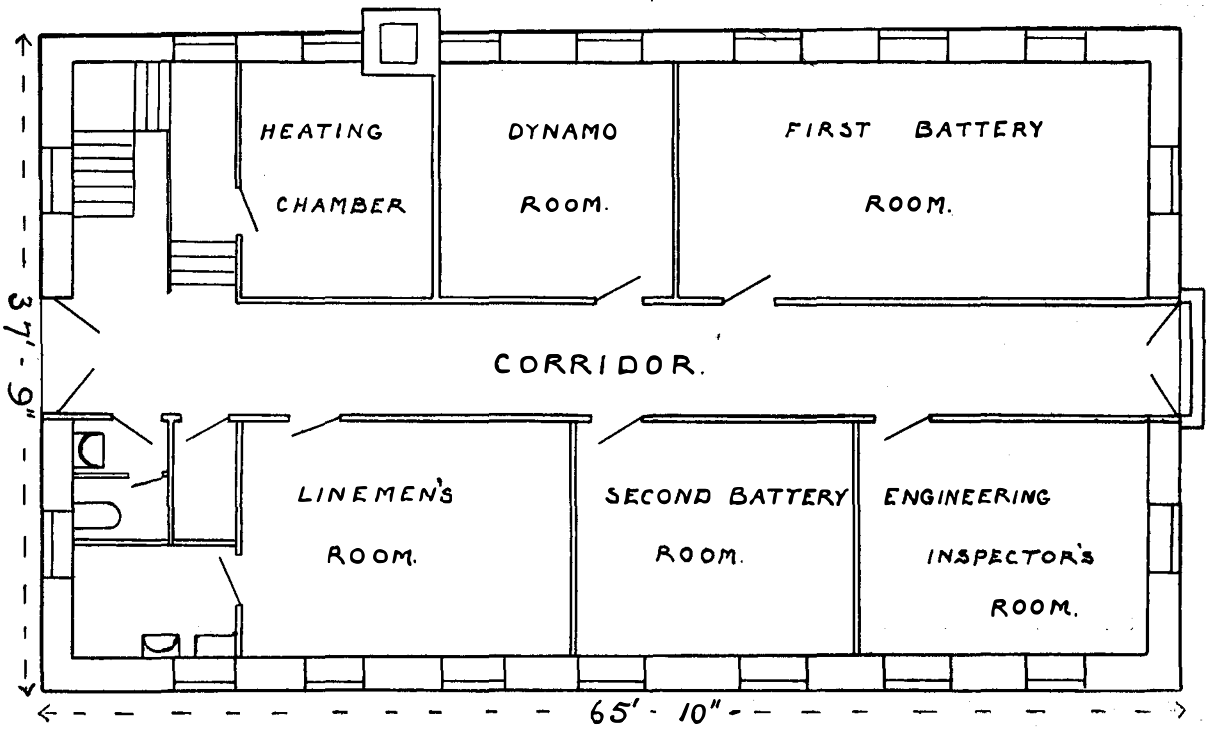


FIG. 4.—PLAN OF GROUND FLOOR.

DETECTOR No. 4.

CAPTAIN H. YORKE STARKEY.

THIS instrument has been evolved with a view to meeting the more stringent conditions due to the changes in the nature of telephone plant to be maintained and, at the same time, to provide a robust detector suitable for general maintenance purposes. The apparatus has been designated "Detector No. 4," and takes the form of a combined voltmeter and ammeter of the moving coil type. It may be regarded as a refinement of the familiar Detector No. 2.

In addition to the instrument itself, shunts and resistance coils or multipliers are provided for external connection by means of which the current and voltage ranges may be considerably increased. A contact spike is also provided which, when not in use, is housed in a slot at the back. When required the spike is screwed into a socket at the base of the instrument. The spike facilitates the use of the detector in point-to-point testing such as D.P.'s across bolted connections and voltage of individual cells.

The illustration, Fig. 1, gives a general view of the detector together with the accessory resistances, shunts and spike.

The introduction of the compound switch permits of the necessary external connections being made by provision of only 4 terminals. The switch is of a novel character and is in the form of a commutator and, contrary to the usual practice in switches of this nature, is so arranged that the "clicks" are between the "on" positions. The switch connections are thereby made by rubbing contacts which ensure good connection. A margin of operation is also allowed on either side of the switch point. The switch and terminals are shown in Fig. 2.

No. 2 terminal is common to all tests and is marked "common positive." Separate terminals are used for current and voltage readings, while the fourth gives connection direct to the moving coil circuit through a fuse.

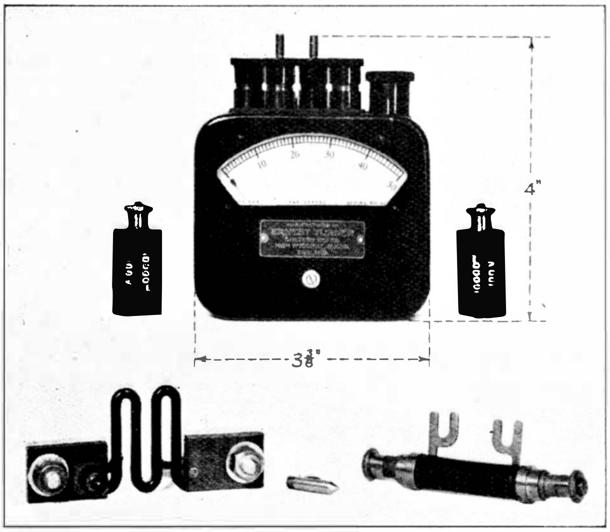


FIG. 1.—GENERAL VIEW OF DETECTOR NO. 4 AND PARTS.

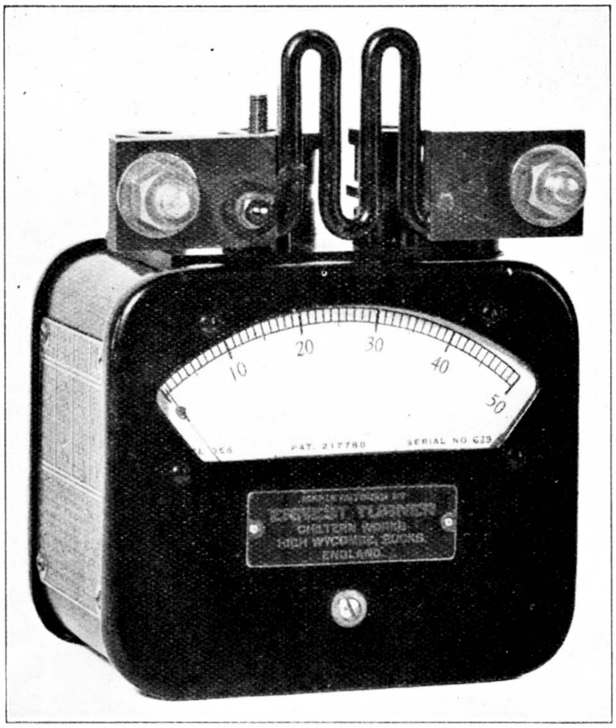


FIG. 3.—DETECTOR WITH 25-AMP SHUNT FITTED.

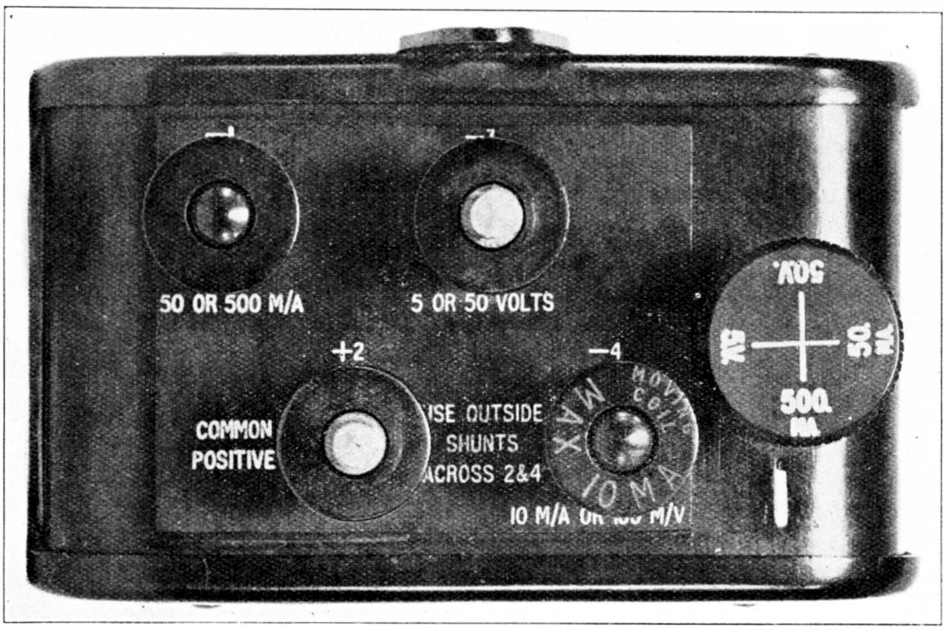


FIG. 2.—PLAN OF TOP, SHOWING TERMINALS.

An interesting feature which conduces to the sensitiveness of the instrument is the low resistance of the moving coil circuit, *i.e.*, 10 ohms, which is made up as follows:—

Moving coil (copper wire) ...	3.00	ohms.
Two hair springs (phosphor bronze)	1.30	,,
Fuse (Eureka)	0.70	,,
Series resistance (manganin)	5.00	,,
	10.00	,,

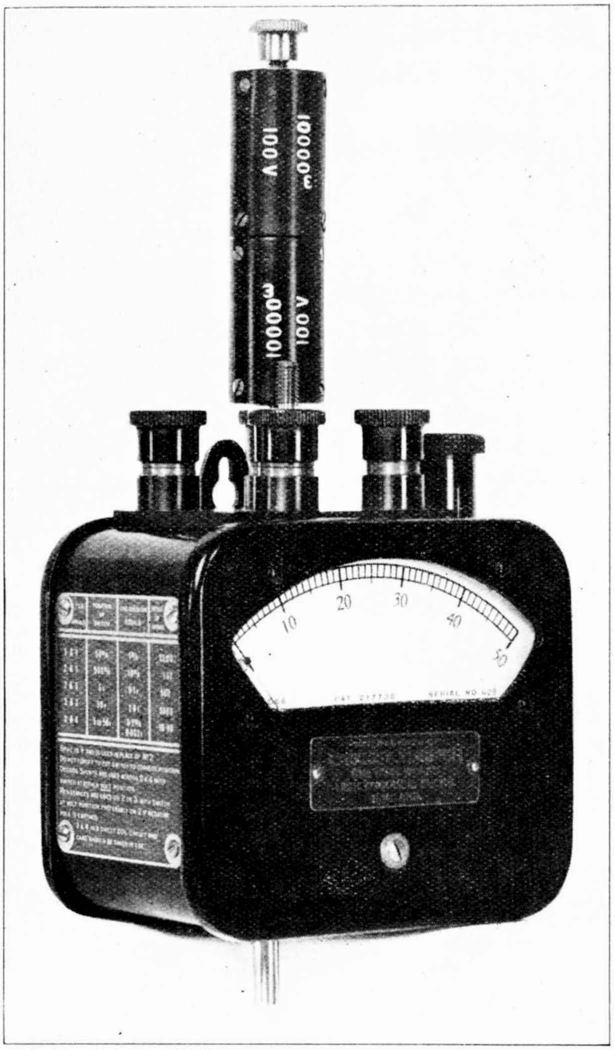


FIG. 4.—DETECTOR WITH BOTH MULTIPLIERS FITTED ON TERMINAL 3.

The make-up of the circuit results in a low overall temperature coefficient; the error due to temperature variation as an ammeter or voltmeter is 0.13% per degree Centigrade as against 0.427% were the circuit made up of copper wire. When used as a voltmeter the temperature variation is, of course, negligible.

The equipment of shunts and resistances consists of one 5A and one 25A shunt and two 10,000-ohm multipliers.

The shunts are so designed that they may conveniently be fitted across the moving coil terminals Nos. 2 and 4. Fig. **3** illustrates the 25A shunt fitted.

The multipliers may be screwed together in series and the threads of terminals Nos. 2 and 3 are elongated to accommodate one or both, depending on the range required. Fig. **4** shows both multipliers fitted to terminal No. 3. Terminal No. 2 should preferably be used for this purpose if the negative pole be earthed and terminal No. 3 if the positive pole be earthed, the reason being, of course, that it is desirable when working with the higher voltages that the internal connections of the instrument should approximate to earth potential.

A full scale deflection is given with 10 mA and the ranges of the instrument are given in the following table:—

Range.	Terminals.	Value per division.	Resistance in ohms.	Shunts and resistances in use.
Current.				
0—10 mA	2 & 4	0.2 mA	10.00	Direct on moving coil.
0—50 mA	2 & 1	1.0 mA	12.00	Internal shunt.
0—500 mA	2 & 1	10.0 mA	1.47	Internal shunt.
0—5 A	2 & 4	100.0 mA	0.0199	External shunt.
0—25 A	2 & 4	500.0 mA	0.004006	External shunt.
Volts.				
0—0.1 v.	2 & 4	.002 v.	10.00	Direct on moving coil.
0—5 v.	2 & 3	.100 v.	500.00	Internal resistance.
0—50 v.	2 & 3	1.000 v.	5000.00	Internal resistance.
0—150 v.	2 & 3	3.000 v.	15000.00	External resistance.
0—250 v.	2 & 4	5.000 v.	25000.00	External resistance.

The compound switch has four positions, which are 50 mA, 500 mA, 5 V and 50 V respectively. When multipliers are used the switch should be in the 50 V position. When external shunts are used the switch should be in

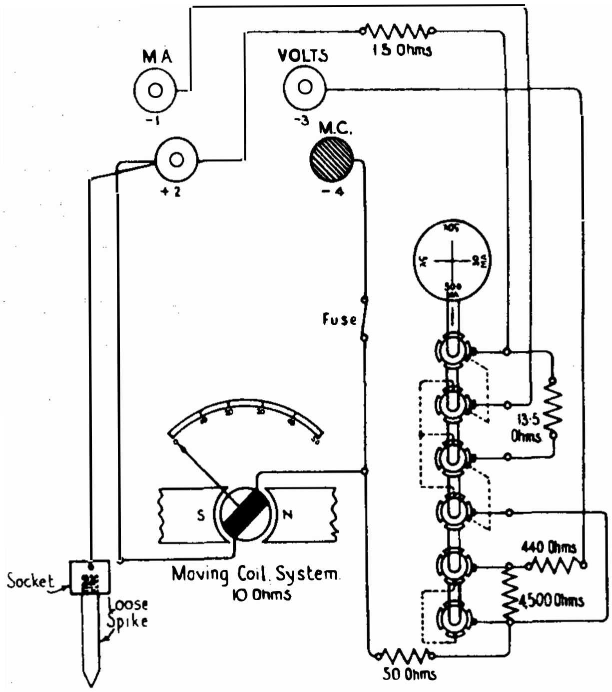


FIG. 5.—INTERNAL CONNECTIONS OF DETECTOR.

either volt position. It will be seen that the range of the instrument lies between 0.2 mA and 25 A and between 2 millivolts and 250 V, a comprehensive range which renders it capable of performing a variety of tests.

When used as a voltmeter the resistance is 100 ohms per volt. In exceptional cases where readings of over 250 volts may be required the range may, of course, be increased by 100 volts or upwards by the addition of the requisite 10,000 ohm multipliers. The voltage readings are to the Grade 1 standard, which is considered essential in view of the importance of the tests required to be carried out.

The internal connections are given in Fig. **5** and the theoretical connections in Fig. **6**, which are self-explanatory.

The zero may be adjusted by means of the screw provided. An instruction plate, giving particulars of scale readings and terminals to be used, etc., is mounted on the instrument. The case is of brass, black japanned, and the overall dimensions are 4″ × 3⅜″ × 2″ deep. The detector is accommodated in a leather case, which is slotted to permit of readings being taken without the instrument being removed, and is fitted with a shoulder strap. An additional leather case is provided for the external shunts and multipliers.

The moving system operates on dead hard steel pivots, which are coned with rounded

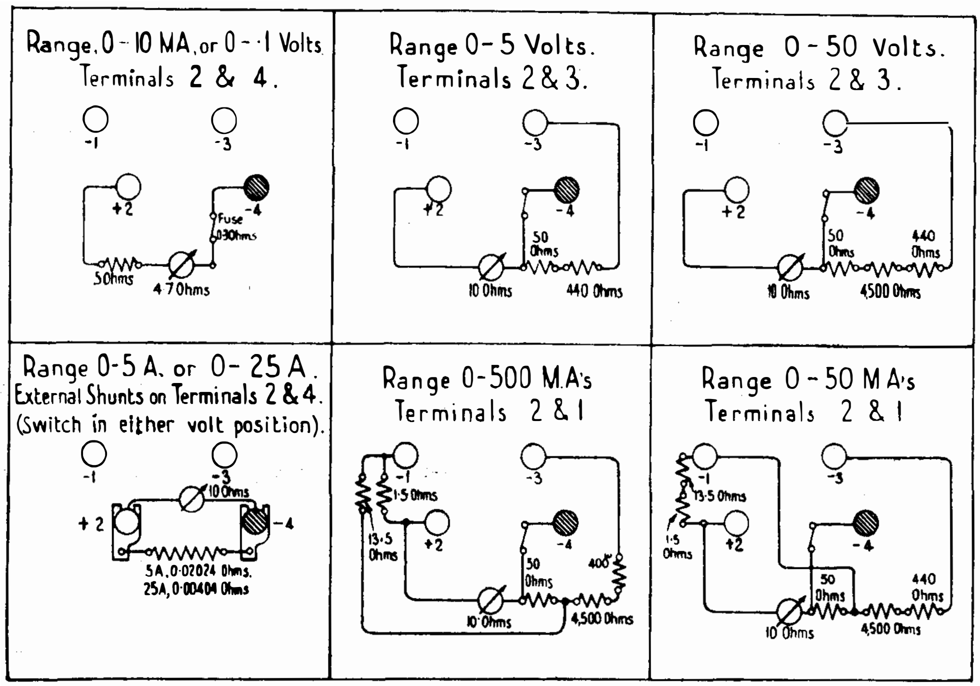


FIG. 6.—CONNECTIONS BETWEEN TERMINALS IN VARIOUS POSITIONS OF SWITCH.

ends polished under a microscope. The pivot holes are fitted with sapphire jewels. The hair springs are made of phosphor bronze. The frame former is of insulated silver and is wound with copper wire of 5 mils diameter, insulated with single silk and baked in bakelite. The fuse wire is of 2 mils Eureka, which will fuse at 0.5 amperes, the fusing point of the moving coil being approximately 3 amperes. The external shunts are made of manganin wire and are carefully calibrated and interchangeable. The magnet is well aged and the scale accurately divided. The instrument is sufficiently robust to withstand all the ordinary use and most of the occasional abuse which portable instruments are more or less bound to receive. In this connection it is of interest to note the very light weight of the moving system, including the two hair springs, which is 0.7 gram or 10.801 grains as compared with the weight of the instrument which is 1 lb. 10 ozs. Altogether by its sensitiveness, wide range and adaptability it provides an efficient testing instrument eminently suitable to meet the many and varied requirements in the maintenance of telephone and telegraph apparatus, among which the following may be enumerated:—

- Low P.D. tests of power board and secondary cell bolted connections; fuse and switch connections. Tests of main earth connections.
- Cable sheath current tests.
- Tests of high voltage batteries used in conjunction with Repeater and Wireless Stations and Precision testing.
- Secondary Cell discharge readings.
- Resistance of power leads.
- Internal resistance of Primary Cells.
- Automatic exchange maintenance.
- Maintenance of Baudot and other machine Telegraphs.
- Checking calibration of power board instruments.

It is also suitable for panel mounting on power boards.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST MARCH, 1927.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileage.				Engineering District.	Underground Wire Mileage.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
534,407	541	4,130	52,189	243	London	23,309	60,933	1,936,599	114,257
65,951	1,876	21,656	62,112	1,589	S. East	3,869	40,352	151,433	15,370
69,932	4,465	29,497	49,603	2,413	S. West	16,300	8,964	124,403	55,943
54,938	6,836	33,685	47,772	4,315	Eastern	19,214	33,448	79,927	79,095
87,773	8,678	43,683	55,275	3,496	N. Mid.	22,960	44,982	202,055	124,476
67,323	4,784	28,598	65,048	4,005	S. Mid.	12,957	21,013	133,562	88,875
54,046	4,790	29,099	49,322	2,575	S. Wales	5,787	24,916	97,206	69,757
92,741	8,219	25,338	47,230	4,957	N. Wales	12,826	39,413	214,944	59,633
144,021	1,602	17,013	42,484	2,804	S. Lancs.	12,717	75,696	428,377	46,299
85,327	6,061	29,809	44,479	3,504	N. East	10,612	40,401	194,868	71,419
57,916	3,622	24,224	36,034	1,708	N. West	8,402	31,707	139,978	38,049
43,625	2,531	15,691	23,378	2,653	Northern	4,595	11,511	87,843	53,424
19,649	4,769	6,884	12,933	335	Ireland N.	128	1,977	36,491	718
59,928	5,296	24,310	35,648	1,223	Scot. East	2,863	10,074	138,092	49,955
81,199	7,365	24,098	41,161	838	Scot. West	12,172	24,287	207,897	35,512
1,518,776	71,435	357,715	664,668	36,658	Totals.	168,711	469,674	4,713,675	902,782
1,479,800	72,723	355,078	657,124	36,146	Figures at 31st Dec., 1926.	166,401	448,109	4,013,916	867,514

SHEFFIELD'S AUTOMATIC EXCHANGES.

H. W. Dipple, A.M.I.E.E.

AT midnight on March 5th, 1927, the the whole of the Sheffield Telephone area was simultaneously converted from Manual to Automatic working. A total of 11 Manual Exchanges were closed down and 9 Automatic Exchanges brought in service. A new Trunk Exchange and Manual Board in connection with the Automatic system was also cut into service.

The exchanges concerned in the transfer, to-

Fig. 1.—Trunk Exchange, Sheffield. A and J.E. positions on left. Enquiry in centre.

gether with their initial and ultimate equipment, are as follows:—

Exchange.	Initial Equipment.	Ultimate Capacity.	Remarks.
Central ...	6300 lines	9000 lines	
Broomhill ...	2800 ,,	3500 ,,	
Sharrow ...	1800 ,,	2600 ,,	
Beauchief ...	1200 ,,	1900 ,,	
Attercliffe ...	1000 ,,	1500 ,,	Satellite on Central.
Owlerton ...	800 ,,	1200 ,,	,, ,, ,,
Ecclesfield ...	200 ,,	300 ,,	,, ,, ,,
Woodhouse ...	200 ,,	300 ,,	,, ,, ,,
Oughtibridge ...	100 ,,	100 ,,	,, ,, ,,
West (Relief to Broomhill) ...	—	—	Closed; and lines transferred to Broomhill.
South (Relief to Sharrow) ...	—	—	Closed; and lines transferred to Sharrow.

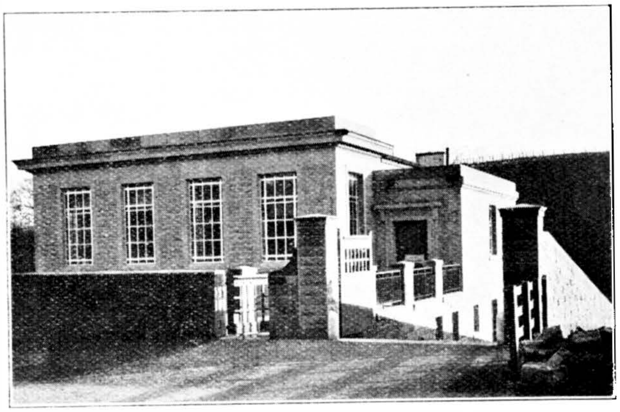


FIG. 2.—BEAUCHIEF EXCHANGE EXTERIOR.

The ultimate numbering scheme for the area is as follows:—

Central	...	...	20000—28999
Ecclesfield	...	...	40000—40299
Woodhouse	...	...	40400—40699
Oughtibridge		...	40800—40899
Attercliffe	..	...	41000—42499
Owlerton	...	...	43000—44199
Sharrow	...	...	50000—52599
Broomhill	...	...	60000—63499
Beauchief	...	...	70000—71899

The conversation of the Sheffield area represents the third of what might be termed the "large scale transfers" undertaken by the Post Office within the past two years. The transfers at Leeds and Edinburgh were described in the April, 1926, and January, 1927, issues of this Journal, the Edinburgh transfer being then

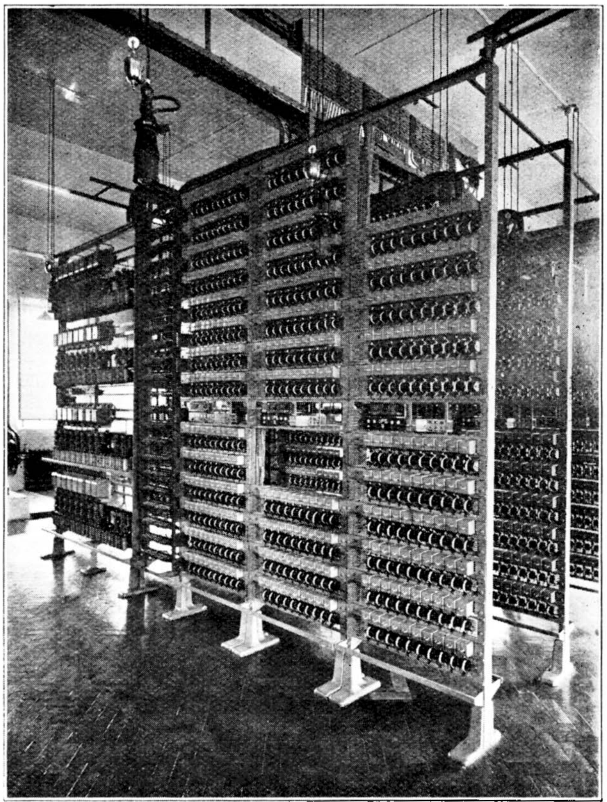


FIG. 3.—BEAUCHIEF EXCHANGE. FIRST PRESELECTOR RACKS AND FINAL SELECTOR RACK WITH SECTIONAL I.D.F.

FIG. 4.—SHARROW EXCHANGE. FIRST SELECTOR RACK AND MOTOR-DRIVEN INTERRUPTERS.

referred to as the largest ever undertaken by the British Post Office. At Sheffield, however, while the total number of Exchange lines dealt with was less than at Edinburgh, the larger number of Exchanges to be dealt with simultaneously and the complexity of the transfer arrangements make the transfer the largest and most difficult yet undertaken by the Post Office Engineering Department and probably constitutes a world's record. The transfer of nine exchanges simultaneously is a difficult task in itself, but the rearrangements of Exchange boundaries which were carried out at the same time increased the difficulties considerably, and the Sheffield Engineering force is to be congratulated on the successful termination of a long and difficult task.

The transfer scheme included the following change of lines from one area to another :—

Central	to	Broomhill ...	... 234	lines.
,,	,,	Attercliffe	... 181	,,
,,	,,	Sharrow ...	... 112	,,
,,	,,	Owlerton	... 29	,,
,,	,,	Woodhouse	... 6	,,
,,	,,	Beauchief	... 5	,,
,,	,,	Oughtibridge	... 4	,,
Sharrow	to	Beauchief	... 2	,,
Attercliffe	to	Woodhouse	... 1	,,

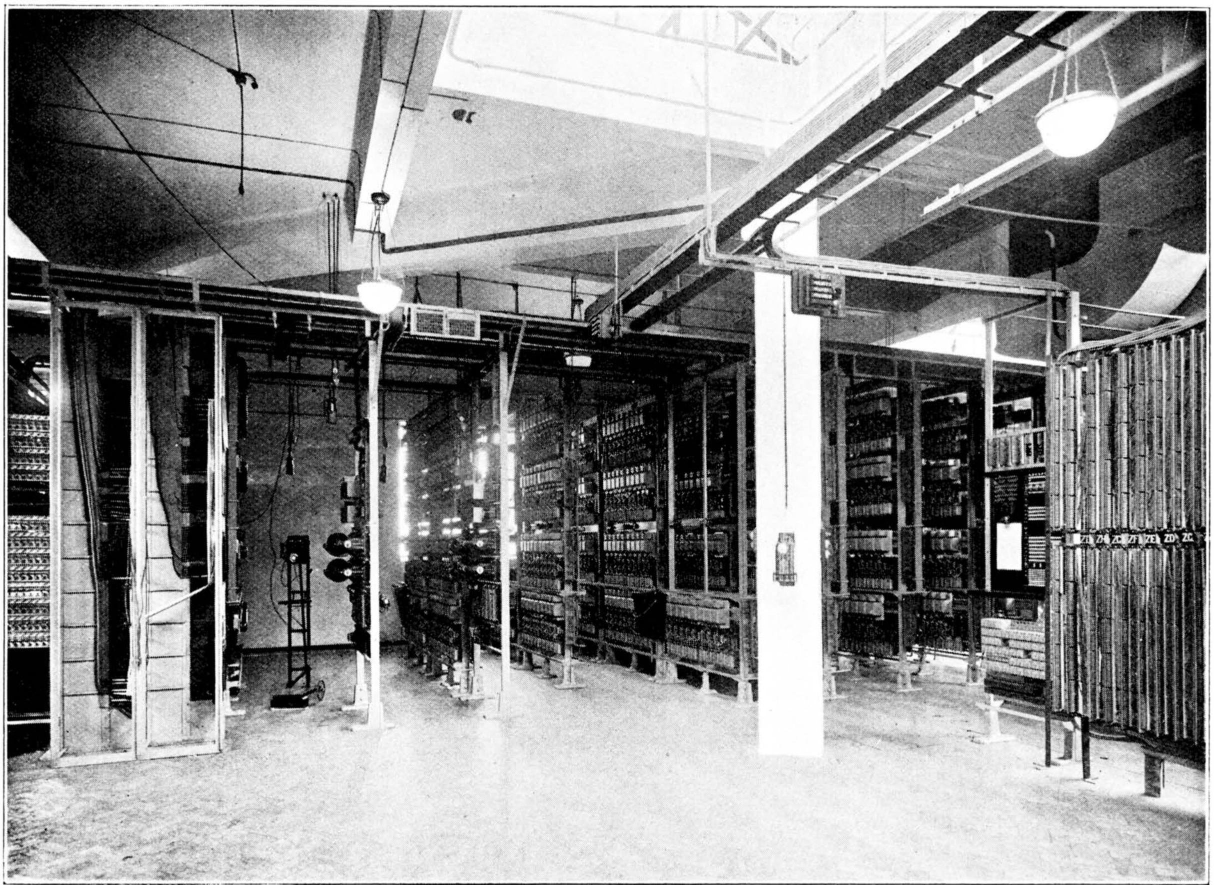


FIG. 5.—CENTRAL EXCHANGE, SHEFFIELD. FIRST SELECTOR RACKS.

In addition to these circuits, a total of approximately 1200 lines were transferred from South and West to Sharrow and Broomhill Exchanges. The total number of Exchange lines dealt with was 9928, and after the rearrangements the distribution of circuits was as follows :—

Central	4646
Broomhill	1847
Sharrow	1141

Beauchief	763
Attercliffe	661
Owlerton	575
Woodhouse	123
Ecclesfield	115
Oughtibridge	44
	9915
Rural party lines on Manual Board	13
Total	9928

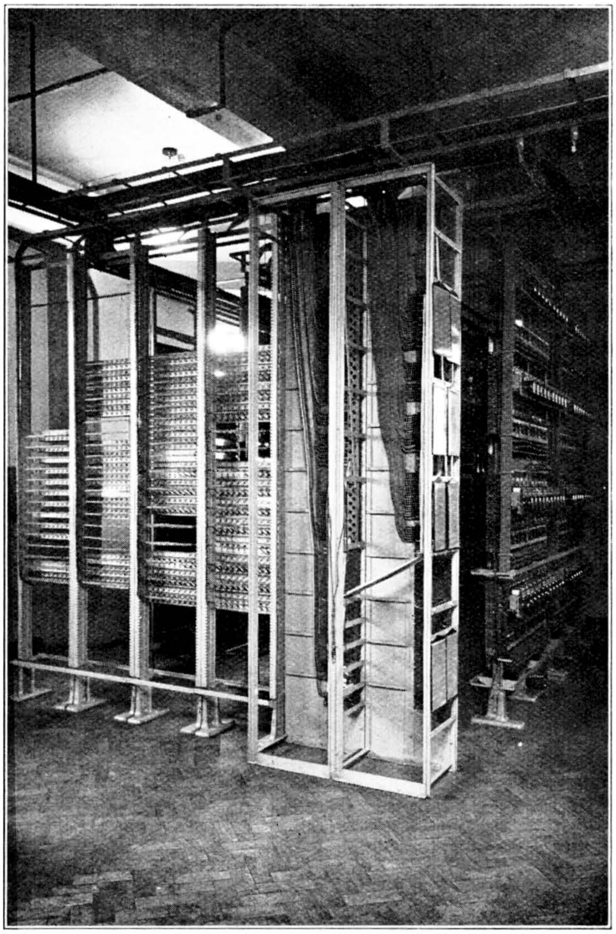


FIG. 6.—CENTRAL EXCHANGE, SHEFFIELD. REAR VIEW OF TRAFFIC METER RACKS AND CROSS-CONNECTION FRAME.

The automatic switching plant was manufactured and installed by Messrs. Siemens Bros. & Co., and is of the well known No. 16 type. Attercliffe and Owlerton satellites are equipped with Discriminating Selectors which allow of local calls being completed within the Exchange. Ecclesfield, Oughtibridge and Woodhouse Exchanges are equipped as ordinary satellites without the Discriminator scheme, all local calls being completed *via* Central over an Incoming Junction. The plants at Central, Sharrow, Beauchief, Owlerton, Woodhouse and Oughtibridge are housed in new buildings provided by the Office of Works, and at Attercliffe,

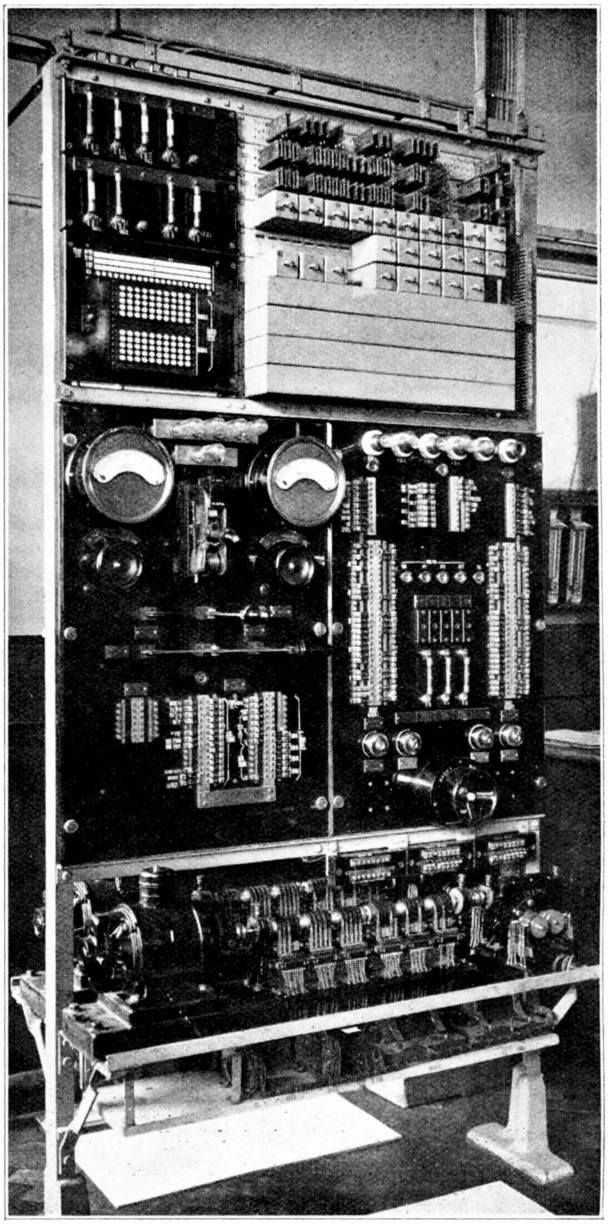


FIG. 8.—POWER PANEL. OWLERTON EXCHANGE.

Broomhill and Ecclesfield in existing buildings adapted to automatic requirements. The Trunk Exchange and Manual Board equipment is accommodated at the Head Post Office and includes the following:—

22 Long distance positions.
3 Order wire positions with Key Sender Impulse equipment.
3 Jack-ended junction positions.
21 A positions for Toll calls and calls from Coin Box lines.
1 Service P.B.X. position.
16 Enquiry positions.

Portions of the equipment and buildings are illustrated as follows:—

Fig. **1** shows the Trunk Exchange, the A. and J.E. positions being on the left, and the Enquiry positions in the Centre.

Fig. **2**. The Exterior of Beauchief Exchange.

Fig. **3**. 1st Preselectors, Final Selectors and Sectional I.D.F., Beauchief Exchange.

Fig. **4**. 1st Selector Rack and Motor-driven Interrupter machines, Sharrow Exchange.

Fig. **5**. 1st Selector Racks, Central Exchange.

Fig. **6**. Rear view of Traffic Meter Rack and cross-connection frame, Central Exchange.

Fig. **7**. 8 Position Test Desk, Central Exchange.

Fig. 7.—Central Exchange, Sheffield. Test Desk, 8-position.

Fig. **8**. Power and Fuse Panel and Interrupter Machines, Owlerton Exchange.

Fig. **9**. General view of 1st Preselectors and Repeater Rack, Woodhouse Exchange.

Fig. **10**. Power Panel and Mercury Arc Rectifier Unit. Woodhouse Exchange.

A few hours prior to the main transfer, a large number of junctions and Trunks were transferred to the new Trunk Exchange, the remainder going over at midnight. Promptly at midnight the signal was given to commence cutting out at the old Exchanges and in about 10 minutes the transfer was complete. Immediately after the transfer, a total of 293 "permanent loops" on the 9 Exchanges was observed, this being 2.9% of the working lines. As it was subsequently ascertained that a considerable number of these P.L.'s were due to subscribers' errors at P.B.X. switchboards, or at the old telephone, it is clear that the transfer can be regarded as extremely satisfactory, and quite up to that high standard of efficiency at which all Post Office Engineers aim in carrying out such schemes.

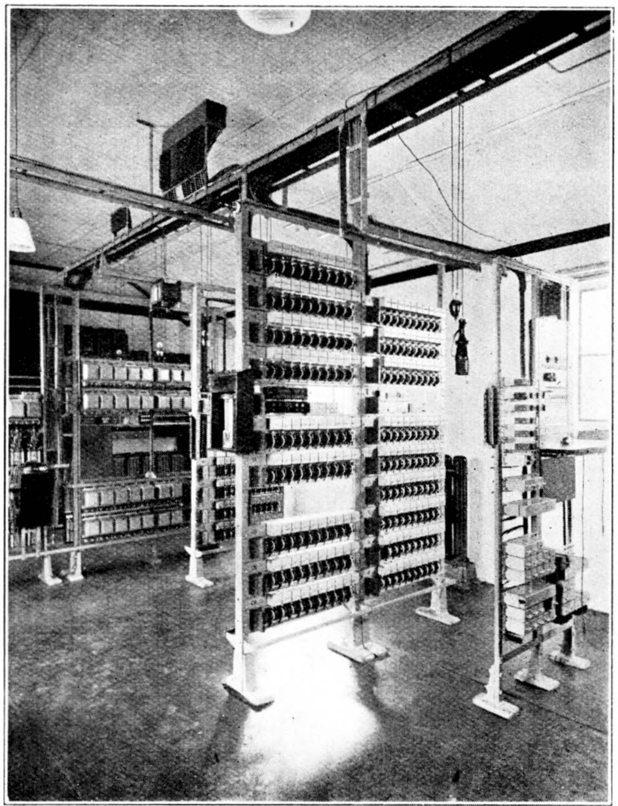


Fig. 9.—Woodhouse Exchange. First Preselector and Repeater Rack.

On the Monday and Tuesday following the transfer, considerable traffic congestions were experienced, the greater part of which was due to slowness and misoperation of the new telephone on the part of the subscribers. This gradually righted itself, and by Wednesday the traffic was flowing satisfactorily.

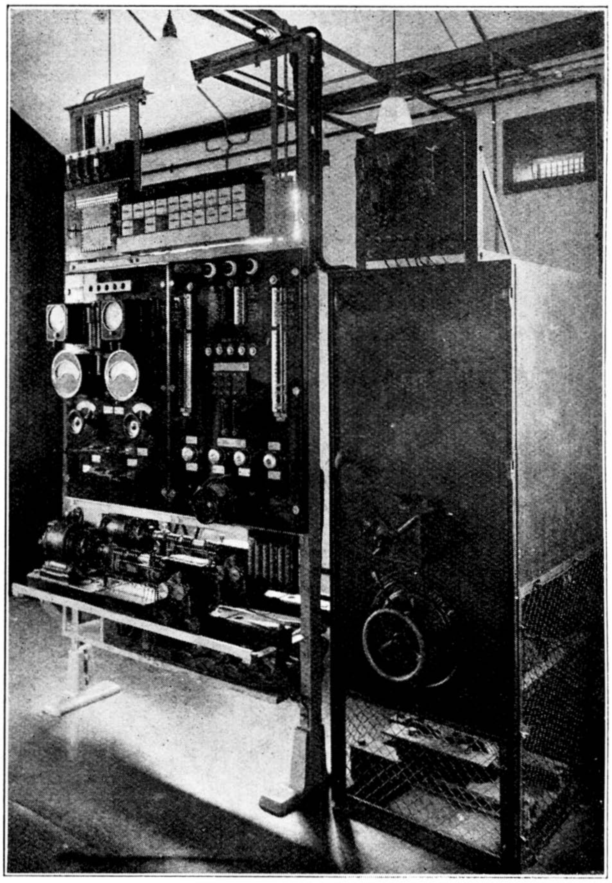


Fig. 10.—Woodhouse Exchange. Power Panel and Mercury Arc Rectifier Unit.

Thanks are due to Messrs. Siemens Bros. & Co. for the photographs with which this article is illustrated.

MESSRS. SIEMENS' AUTOMATIC IMPULSE SENDER.

[*From a lecture by* J. INNES, B.Sc., *before the Scotland East Local Centre.*]

INTRODUCTORY.—The general practice in the Department for handling traffic to Automatic Exchange areas from outlying Manual Exchanges having direct Junctions, is to provide dials on each operator's position, so that with very little additional cost at the outgoing end each operator may obtain the called subscriber without the intervention of a second operator. It is possible, therefore, to reduce the size of the Manual Board in an Automatic Area to a relatively great extent. There are, however, limits to the length of circuit over which dialling can be considered reliable, and other arrangements must be made in cases where dialling would not be satisfactory. Such cases may be divided into two classes:—

(1) Small groups which can be operated economically on a manual basis, and
(2) Large groups where order wire working with some form of machine dialling is essential.

The Key Sender associated with an Order Wire position has been designed to meet the requirement of the latter case, and is the subject of this paper.

"B" Position Equipment.—In the Edinburgh Area this position is of the Cordless type, provision being made for an ultimate capacity of 40 Order Wire Junctions, the equipment installed being for 25 circuits.

Each Junction is led through a break jack on the position, so that any Junction may be brought into use as an Order Wire in the event of the normal circuit becoming faulty. A pair of plugs and cords is provided for this purpose. The Junctions are continued from the break jacks to the Automatic Exchange, where each is terminated on a Switch equivalent to a First Selector.

Cord Circuit.—The transmission bridge and supervisory facilities which are normally located in the cord circuit are provided for each Junction as part of its equipment and are located on the Special Apparatus Rack. The "B" operator has no control over the Junction when the call is through, and the usual supervisory signals are transmitted direct to the "A" operator who has complete control of the call.

Assignment Key and Supervisory Lamp.—An Assignment Key and Supervisory Lamp are provided for each Junction and mounted on the keyshelf. The "B" operator presses the appropriate Assignment Key when she names the Junction to be used by the "A" operator and the glowing of the Supervisory Lamp gives her the necessary information regarding Engaged Junctions. Certain other supervisory facilities are referred to later.

Digit Keys.—Five strips of ten digit keys, engraved 1 to 0, are fitted to replace the dial, one strip for each of the Ten Thousands (N), Thousands (M), Hundreds (H), Tens (T) and Units (U) digits used in the five figure system.

Each strip of digit keys is wired to the bank contacts of three preselectors (one in each of the three senders); but the connections are made in inverse order, thus No. 1 Key is connected to No. 10 contact, No. 2 Key to No. 9 contact, No. 3 to No. 8 contact and so on. The effect of pressing a key is to mark the particular contact to which the associated wipers will step and come to rest. When sending commences, the preselectors return to their normal contacts and the number of steps taken represents the number set up by the operator.

Sender Supervisory Facilities.—The operator is provided with the following facilities for the Three Senders which form the complete Impulse Sender:—

(1) *Sender Engaged Lamp.*—To indicate the sender in use. It also indicates if there is any holding up of a Sender due. for example, to the "A" operator not having taken up the Junction. In such a case the Sender Lamp flashes.
(2) *Sender Disconnect Key.*—One per sender is fitted, and the Key is used to cut out any faulty sender.
(3) *Sender Release Key.*—One per sender is fitted. It is used for disconnecting a sender from a Junction with which

it has been engaged for an abnormal time. The indication of this is the flashing of the Sender Engaged lamp and the operator can release the Sender by depressing this Key.

(4) *Cancel Key.*—Should an operator depress a wrong digit Key and immediately realise the fact, she may return the sender to normal and again set up the number. If operated before the sender has completed sending out impulses *and before another assignment key is depressed,* all automatic switches brought into use will be returned to normal, the sender remaining linked with the Junction.

(5) *Reassignment Key.*—If the operator presses the wrong assignment key and realises it before completing the set-up of the call, she will release the Junction from the sender by operating the Reassignment Key. The correct Assignment Key can then be operated and the call set up. If the error is not observed until the call has been set up, the operation of this Key, *if done before another Assignment Key is operated,* will release the switches brought into use, at the same time releasing the sender from the Junction.

Holding up of Calls.—Provision is made in the Sender to hold up the last digit until the " A " operator takes up the Junction, so that the call will not mature before the calling operator is ready to take it. False calls to subscribers are clearly impossible. The lamp flash indications to the " B " operator have already been referred to.

Impulse Sender Equipment.—The Impulse Sender consists of (1) an Assigner, (2) Sender Junction Seeker, (3) Sender Controller and (4) Sender.

(1) *The Assigner.*—Two are provided with switching facilities to bring either into use. A standard preselector is used for each, the " A " and " C " banks being used, and two controlling relays AP and AQ. The purpose of the Assigner is to bring the three Senders into use in sequence and it stands on the first free Sender in the machine.

(2) *Sender Junction Seeker.*—These are standard preselectors, the number used depending on the number of Junctions terminated on the position. With 40 Junctions, 4 preselectors are used, the " C " bank contacts being wired up to the Assignment Keys associated with each Junction so that the depression of an Assignment Key marks the corresponding bank contact and the Junction Seeker drives until the marked contact is reached. The Junction is thus linked up with a Sender.

(3) *Sender Controller.*—The function of the Controller is to ensure that the impulse trains are sent out in the correct order and to regulate the pause period between each train, to give selectors time to hunt for free outlets to the next rank of switch. Standard preselectors are used in this case also.

(4) *Sender.*—Each of the three Senders consist of 5 preselectors corresponding to the five digits N, M, H, T and U, used in the Edinburgh system. The " A " banks are wired to the digit keys on the " B " position as already described. The function of the other banks is described in the details of operation.

There are two speeds used in the drive circuits in the Impulse Sender, viz., 40 and 10 Impulses per second. The two speeds are used as follows :—

40 *Impulses per second.*

Junction Seekers searching for Assigned Junction and returning to normal.

10 *Impulses per second.*

Sender Controller.

Sender Switches returning to normal (*i.e.,* sending out impulses).

A special Motor Interrupter Machine is provided with the Impulse Sender to give the high and low speed drives. All leads are brought out to knife edge contacts so that the spare machine can be brought into use quickly.

Marking Condensers.—Although the Senders drive at 40 Impulses per second, it is possible that an operator would have released a digit key before the wipers had reached the corresponding contact, and failure would result. To guard against this and to avoid operators having to hold down the digit keys, each contact has a marking condenser associated with it, and which is charged when the key is depressed. The condensers are momentarily short-circuited before a number is set up to guard against wrong numbers being set up due to a partially charged condenser.

Night Start Facilities.—Provision is made for starting up the machine at night should the traffic warrant the bringing into use of the "B" position.

Alarms.—A motor stopped alarm is given if the motor stops or fails to start. The usual Fuse Alarm is of course provided.

An additional safety precaution is provided to cut off battery from the interrupter bus-bar immediately the motor is stopped. This protects the spring sets and magnet windings from continuous current.

Operating Procedure. — On receipt of a request for a number from a distant "A" operator, the "B" operator assigns a Junction for the call and at the same time depresses the corresponding Assignment Key. With the operation of this key the bank contact in the Sender Junction Seeker is marked and as the Assigner stands on the first free Sender, the Seeker will drive until the Junction has been picked up. A Sender has thus been linked up with the assigned Junction and the corresponding Sender Engaged Lamp will glow.

The "B" operator will now set up the "called number" by depressing the appropriate digit keys and with the depression of the last key the sender will commence to send out the impulse trains to the Automatic Switches. (The digit keys may be depressed in any order or simultaneously).

By this time the "A" operator should have taken the assigned Junction and the Supervisory Lamp will glow steadily if she has done so, and the whole of the digits will pass out of the Sender which will again become free to take other calls.

Until the "A" operator has taken up the assigned Junction a slow flash (standard interrupted earth) will be given on the Supervisory Lamp. The last digit of the train of impulses is held up by the Sender until the "A" operator has taken up the assigned Junction, and the Sender Engaged Lamp will flash to show the position to the "B" operator.

If the "A" operator picks up the wrong Junction, a fast flash or flicker (10 per second) is given on the Supervisory Lamp of the Junction actually taken, while slow flash as described above will be given on the assigned Junction. If the "B" operator has not assigned another Junction before observing this, she may rectify it by depressing the Re-assignment Key, pressing the key associated with the Junction actually taken and again setting up the number.

With the passing out of the impulses from the Sender, the Sender is released and the "B" operator drops out entirely, the control of the Junction remaining with the "A" operator, who releases the Junction and automatic switches with the withdrawal of the plug at the distant Exchange.

Circuit Operations.—The diagram referred to throughout the description of the circuit operations is on the detached contact principle and refers to one Sender. It may be taken that there are identical Preselectors, Relays and Contacts for each of the other two Senders.

For simplicity, the diagram has been prepared without reference to the actual location of the apparatus. Relays are named by letter and are followed by a number representing the number of Contacts. All Relay Contacts are shown in their normal (unoperated positions) and all Preselectors are shown on their normal Contacts.

The Assigner.—The two Assigner mechanisms consisting of the "A" and "C" banks of the duplicate preselectors have been shown. The driving magnets are lettered D. The two relays controlling the Assigner operations are AP 2000^{ω} and AQ, three windings, each 3000^{ω}.

The three Contacts (Nos. 2, 5 and 8) on the "A" banks are multipled together and wired through Q Contacts (referred to later) to the normal contacts of the D banks of the Sender Junction Seeker.

The corresponding contacts on the "C" banks are each wired (in parallel with one winding of the AQ Relay) through their Sender Disconnect Key to the back of a contact S_1 in each Sender Controller. If a Sender is free, this contact is connected to earth through the moving spring and is "dis" while a Sender is engaged.

Taking the "Free Sender" case first and remembering that the Assigner stands on the first free sender, the AP and AQ relays will both be operated as they have a path to earth *via* the S_1 contact. Contacts AP_1 and AP_2 will therefore be in the operated position and the drive circuit of the Assigner will be disconnected.

If now the operator depresses an Assignment Key, a Q Relay will be operated and the closing of the $Q^1{}_1$, $Q^2{}_1$, $Q^3{}_1$ or $Q^4{}_1$ contact will complete the drive circuit of the Junction Seeker, as the operation of the AP contacts prepared this condition by providing the necessary earth. (This point is referred to in detail in the Junction Seeker operations).

The AQ Contacts open and thus disconnect the earth from the normal Contact of the "C" bank, and this condition will be maintained as long as there is one free Sender.

Immediately all the digits have been passed into the Sender, its S_1 contact will be operated and Relay AP will release (Relay AQ will also release if both other Senders are engaged). With the release of AP, the AP contacts restore to normal and the drive circuit is completed from Battery through the Interrupter Spring Set, driving Magnet D to earth *via* AP_1 or AP_2. The wipers will be stepped round the banks until they reach a contact on which there is an earth, when Relay AP will be operated and the drive is cut. Such an earth will only be found on a "free" Sender *via* its S_1 contact, or if all Senders are engaged at the normal contact on the "C" bank.

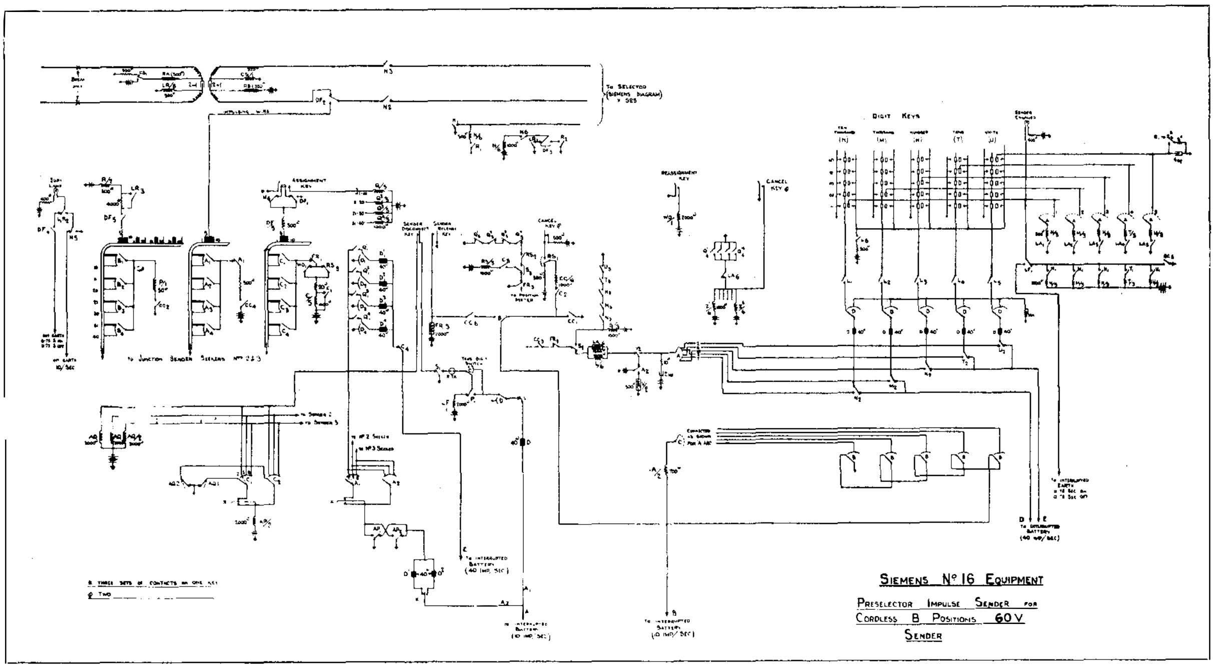


Fig. 1.

In the latter case, immediately a Sender becomes "free" the AQ Relay will be operated, thus releasing AP and again bringing in the drive to take the wipers to the "free" Sender.

It will be clear that the Senders are taken in strict rotation. Unless there is any unnecessary holding up of a Sender due to the "A" operator not taking up the Junction, there is little likelihood of all three Senders being engaged. In the case of the digits 27999 being set up, the approximate times may be taken as follows:—

	Milli-seconds.
Operator assigns Junction and sets up number	3000
Sender steps to marked Contacts ...	500
Sender sends out 36 Impulses at 10 per second	3600
4 Pause periods between digits at 850 milli-secs.	3400
Total	10500

Say, 10.5 seconds.

This number represents practically the maximum number of impulses on the present numbering scheme and the time shown could be taken as the maximum period for which a Sender is engaged under normal conditions. The 3 seconds for assigning the Junction and setting up the number is probably on the low side, as it represents calls set up at the rate of 20 per minute or 1200 per hour, a speed never likely to be maintained. Even at this rate, however, the operator will take 9 seconds to set up three calls, and making allowance of 1.5 second to cover the slight interval between two calls, the first Sender will be free ready for the fourth call.

Sender Junction Seeker Operation.—The diagram shows four Relays (Q^1 to Q^4) associated with the Assignment Keys, one Relay being provided for each group of ten Junctions. The circuit of Junction No. 5 is shown on the diagram and the depression of the Assignment Key No. 5 causes Q^1 to operate from battery *via* the back contact of Key, contacts DF_1 and N_4 and front contact of Key to earth. The depression of the Key also applies an earth to the No. 5 bank contact of the C Arc.

(1) *With the operation of Q^1.*

Contacts Q^1_1, Q^1_2, Q^1_3 in the drive circuits of the three Seekers are closed. Assuming No. 1 Sender has been assigned the closure of Q^1_1 will complete the drive circuit from interrupted battery, C_4, Drive Magnet D^1_1, Wiper D, Q^1_1, A arc and wiper of the Assigner and contact AP_1 or AP_2 to earth.

Q^1_4 operates Relays " Z " and the " Z " contacts short-circuit the marking condensers to ensure that there is no partial charge.

Q^1_5 opens to release the RS relay in the Sender already in use. When No. 5 contact is reached, Relays C and DF will operate in series.

(2) *When DF operates,* contact DF_1 gives a holding earth for both relays DF and C against the release of the Assignment Key.

DF_2 connects the impulse wire from the Sender to the B wire of the Junction.

DF_3 prepares the circuit of Relay N in Junction.

DF_4 connects interrupted earth to the Supervisory Lamp circuit.

DF_5 prepares a circuit for Relay R in Junction and P in Seeker.

(3) *When Relay C operates*

C_4 cuts the drive circuit.

C_1 short-circuits the 1000^{ω} coil of C marking No. 5 engaged to the two other Senders.

C_2 completes a circuit to operate Relay CC *via* the normal Contact and " B " wiper of the Sender Controller to earth at the " B " wiper of the N digit switch in the Sender.

C_3 completes a circuit for Relay RS in the Sender Controller, Battery, Relay RS, C_3, S_3, FR_3 to earth.

C_5 provides an earth for the Night Start Relay operative when the Sender is not continually in use. This is shown on the diagram of the Motor Interrupter.

(4) *When Relay CC operates.*

CC_1 completes a locking earth for CC.

CC_2 completes the circuit for the operation of Relay R in the Junction circuit from Battery through Relay R, 4000^{ω} Spool, DF_5, B arc and wiper of Seeker Relay P and CC_2 to earth. (Note Relay P does not operate until 4000^{ω} spool is short-circuited by " A " operator taking up the Junction).

CC_3 completes a circuit for operating Relays L and LA in parallel (Battery A_2, V_2, Relays L and LA, S_2, FR_2, CC_3 to earth).

CC_4 connects Battery through 500^{ω} Spool and Contact A, to Impulsing wire and thus through " B " wire of Junction to the Selector.

CC_5 prepares the circuit for the holding coils of Relays N, M, H, T, and U, and lights the Sender Engaged Lamp *via* Contact LF.

CC_6 prepares a circuit for Relay FR to release the Sender when the sending out of the digits has been completed.

(5) *With the operation of RS:*

RS_1 changes over; but CC does not release.

RS_2 prepares a holding circuit for RS after S operates *via* the Q_5 Contacts.

RS_3 opens, leaving Relays C and DF dependent on the circuit *via* WO_1.

(6) *Relays L and LA in operating prepare the following circuits:*—

LA_1 to LA_5 prepare the circuits of the Digit Switches N, M, H, T and U on the " A " arcs in the Sender.

LA_6 opens the "Z" Relay circuit to remove the short-circuit from the marking condensers applied when Q^1 was operated.

L_1 to L_5 prepare the drive circuits of the Digit Switches *via* the normal contact on the " D " arcs.

L_6 connects battery to the right hand springs of the Digit Keys.

(7) *Junction Circuit Operation.*

With the operation of Relay R, Contact R_1 completes the circuit of Relay N on the C wire of the Junction to the Selector and N operates, while R_2 prepares a holding circuit for N.

N_1 applies an earth to the C wire to hold the T Relay in the Intermediate Selector used in this case as a 1st Selector.

N_2 and N_3 extend the A and B wires to the Selector and as the changing over of DF_2 (see (1)) has connected battery from the Seeker to the B wire, the A Relay in the Selector will be operated and the switch prepared to receive impulses.

N_4 opens the Assignment Key circuit, leaving DF dependent on its holding earth *via* DF_1.

N_5 prepares a circuit for the Supervisory Lamp.

N_6 completes the holding circuit of the 1000^ω coil of N already prepared at DF_3—See (1) —and R_2.

When the " A " operator takes up the assigned Junction, Battery is fed over the B wire and LR operates, and

LR_1 provides an alternative holding circuit for N when DF releases with the dropping out of the Sender.

LR_2 completes the circuit of the Supervisory Lamp which will glow.

LR_3 short-circuits the 4000^ω spool to allow Relay P to operate in the Sender.

It should be noted that until the operator picks up the Junction, Interrupted earth is connected to the lamp circuit *via* DF_4 and LR_2 and slow flash will be given on the Supervisory Lamp. Later, when the sending out of the call has been completed, the CS Relay will be operated over the called subscriber's loop and CS_1 applies Battery to the A wire, thus giving standard supervisory signals to the " A " operator. If the called subscriber be engaged, busy flash will be transmitted to her by intermittent operation of Relay CS.

If the " A " operator takes up the wrong Junction, the LR Relay in the Junction actually taken will be operated and LR_2 changes over, and the Supervisory Lamp on the Junction taken will flicker due to the connection of Earth 10 times per second.

(8) *Sender Controller and Sender Operations.*

Although these operations take some time to describe, they take place practically instantaneously and the operator may now set up the required number on the Digit Keys.

Interrupted Battery is fed through Cams A and B contacts N_2, M_2, H_2, T_2 and U_2 to the Driving Magnets of the Sender, the completion of the drive being effected by the operation of appropriate N, M, H, T and U Keys by the earth on the left-hand spring. Five keys on each strip are shown with the number 12345 set up.

When the operator depresses the Digit Keys, Battery is applied through the right-hand outer spring (which makes first) to the corresponding bank contact in the A arc of the Sender, the marking condensers being charged at the same time. Earth is applied at the left-hand outer spring of the keys to give the first step to the Sender Switches. The drive circuit of the N digit switch, for example, is from Interrupted Battery through N_2 Contact, Driving Magnet D, wiper normal contact L_1, contact N digit key to earth. After the first step the drive is completed to earth *via* the D arc and the MA Relay. The drive circuits for the other switches are similar.

The wipers will continue to drive until the marked contacts are reached when the marking condensers will discharge through the N, M, H, T and U Relays, the circuits of these Relays having been prepared by the closing of Contacts LA_1 to LA_5.

(9) As each of the Relays N, M, H, T and U operates, a holding circuit for each is completed by N_1, M_1, H_1, T_1 and U_1 *via* CC_5 to earth, while N_2, M_2, H_2, T_2 and U_2 break the drive circuit and connect up the Driving Magnets with contacts on the A arc of the Sender Controller ready to send out the impulses in proper order.

It should be noted that the B wipers being off-normal, earth is only connected at this stage to the B arc of the N digit switch, and the M digit switch B wiper will only be earthed when the N wiper has reached normal. This arrangement ensures that the digits are sent out in proper sequence. Contacts N_3, M_3, H_3, T_3 and U_3 will all be closed when the complete number has been set up; Relay S will then be operated and the Sender can now commence to send out the digits.

(10) *When S operates.*

S_1 disconnects the Sender in use from the Assigner which will step to the next free Sender. That is, the Assigner will not connect another Sender to the Operator until she has sent in all the digits to the Sender already taken. S_1 also completes the drive circuit of the Sender Controller.

S_2 releases Relays L and LA and provides a holding circuit for S *via* FR_2 and CC_3. The release of L and LA frees the keys for use on another Sender.

S_3 changes over but does not release the RS Relay which is now maintained *via* RS_2 and the Q_5 contacts. This Relay, which is associated with the cancel-out function, will, however, release immediately a Q Relay is operated, as it indicates that the operator has finished with the particular call on which it was operated.

With the release of Relays L and LA the Digit Keys will not affect the Sender in use and the keys can now be used on another call on one of the other Senders.

(11) When S_1 changed over, the Drive circuit of the Controller was completed from Interrupted Battery, Driving Magnet, V_1 D arm, C arc and wiper of Tens Digit Switch (which is off normal) Routine Test Key and S_1 to earth.

The Controller is stepped at 10 Impulses per second until the 7th contact is reached. This contact on the C arc is connected to the B arc of the N digit switch, which is earthed through its wiper. The circuit of the Relay A, which is connected to the C wiper, will therefore be completed when this contact is reached.

The interrupted battery feeding to Relay A lags behind the interrupter driving the Controller so that the C wiper will reach the 7th contact before battery is applied to A and a cut impulse is avoided. Relay A operates, and

A_1 opens the impulse circuit to the Selectors.

A_2 changes over and operates Relay V, which is a slow release Relay and holds during impulsing.

V_1 breaks the Controller Drive circuit.

V_2 prepares the circuit of the N digit switch magnet *via* the 7th contact on the A arc.

Interrupted Battery is supplied through Relay A, the C wiper and the 7th contact on the C arc to earth at the B arc in the Sender, and the A relay will therefore impulse.

Contact A_1 impulsing will cause the Selector Switches to rise while A_2 applies battery during each break period through V_2 and the A wiper and arc, N_2 and Driving Magnet of the Sender to earth *via* the MA Relay. The Sender N Switch will step in unison with the A_2 contact and this will continue until the normal contact is reached, when the circuit of Relay A will remain broken at the B wiper in the Sender. Relay V will release and its contacts return to normal. (The number of steps taken by the Switch in returning to normal corresponds with the number set up by the operator).

With the closing of V_1 the Controller drive is again completed and the Controller rotates until the C wiper reaches Contact No. 3, where earth is connected *via* the B arc and wiper of the M digit switch, normal contact and B wiper of the N digit switch. Relay A will again be operated and the thousands (M) digits will be sent out in the same way as the ten thousands (N) digits.

The contacts in the Controller associated with the five digit switches are:—

N—7: M—3: H—10: T—6: U—2, so that the Controller takes 7 steps between each digit, making a pause period of approximately 700 milli-seconds, plus the period of release of the V relay to allow switches to hunt for disengaged outlets. In the earlier part of the paper I have taken the release period of the V Relay as 150 milli-seconds, giving a total pause period of 850 milli-seconds between each set of digits. The Rotary Drive on ordinary Selectors is at 35 Impulses per second and 10/35th of a second or 286 milli-seconds is required to test over all outlets.

(12) The same procedure follows for the Hundreds and Tens digits; but if the A operator has failed to pick up the assigned Junction by the time that the Tens digits have been transmitted, the Controller drive circuit will be broken at the C arm of the Tens digit switch, which will be at normal.

As already described in (7) the A operator energises the Relay LR in the Junction and LR_1 short-circuits the 4000$^{\omega}$ spool in the B wire circuit of the Junction Seeker. Until this occurs, Relay P will not be operated, and with the return of the Tens Digit C arm to normal the circuit of Relay LF is completed and LF_1 changes over and gives slow lamp flash on the Sender Engaged Lamp.

Immediately the A operator takes up the Junction, Relay P will be operated and P_1 will change over, causing LF to release and the Sender Lamp to glow steadily. At the same time, the Controller drive circuit is completed *via* P_1 and normal contact of C arc to earth at S_1 and the Units Digits are transmitted in the same manner as described for the other digits.

If the A operator fails to pick up the Junction within a stated time, the B operator releases the Sender and Switches by pressing the "Sender Release Key."

(13) When the Units impulses have been transmitted, all the digit switches will be at normal and the Controller will be standing on Contact 2. The V Relay will release with the release of A, and V_1 completes the drive circuit *via* the D arc of the Controller. When the 10th contact is reached a circuit will be completed for Relay FR *via* CC_6 B arc and wiper to earth *via* the B wipers of the Sender in series and relay FR operates.

FR_1 releases Relays C and DF.

FR_2 opens the alternative earth provided for holding S.

FR_3 opens to prevent RS again operating with the release of S.

(14) *With the release of DF,*

DF_1 opens the holding earth.

DF_2 disconnects the Impulse wire from the Junction and establishes loop conditions towards the called subscriber.

DF_3 changes over but still holds N *via* LR_1.

DF_4 disconnects the Interrupted earth from the Supervisory Lamp circuit.

DF_5 opens and releases the R and P Relays.

When Relay R releases R_1 and R_2 return to normal, but Relay N holds as long as the A operator keeps a plug in the outgoing Junction Jack. The Junction is therefore now clear of the Sender and is under the control of the A operator entirely.

The release of P restores normal conditions for holding up the last digit on the next call passed into that Sender.

(15) Relay C was released by the operation of Relay FR. In turn, Relay C releases Relay CC and the closing of C_4 completes the drive circuit of the Junction Seeker which returns to normal and stands on its normal Contact. With the opening of CC_5, Relays N, M, H, T and U will be released. These Relays in releasing open the circuit of Relay S and with the restoration of the S Contacts normal conditions are restored to the Sender.

(16) Special arrangements can be made to send four, three and two digit calls by suppressing one, two or three digits by strapping out the particular N, NM, or NMH contacts in the S relay circuit, in which case the digit keys must be depressed in a specific order if five digit calls are also to be made.

Suppression of the last four digits can also be arranged for by making special wiring arrangements to complete the S Relay circuit through the bank Contacts on the C arcs of the digit switches.

(17) Reference has already been made to the functions of the Sender Disconnect Key; Sender Release Key; Cancel Key and Reassignment Key. The details of the operations are as follows:—

The Sender Disconnect Key opens the circuit of the AP and AQ Relays in the Assigner which will step to the next free Sender.

The Sender Release Key operates the FR Relay, thus bringing into operation the ordinary release functions.

These Keys are associated always with a particular Sender.

The Cancel Key, after the operation of Relay RS, is in the circuit of Relay CC and if operated; CC will release and CC_5 will release the N, M, H, T and U Relays, thus restoring normal lay R in the Junction Circuit, thus releasing the selectors.

The Reassignment Key operates the WO Relay and since RS is operated the opening of Contact WO_1 opens the circuit of the C Relay and the Sender is released.

These Keys are common to all the Senders; but are definitely linked with the Sender in use.

(18) *Motor Interrupter.*—For continuous run-

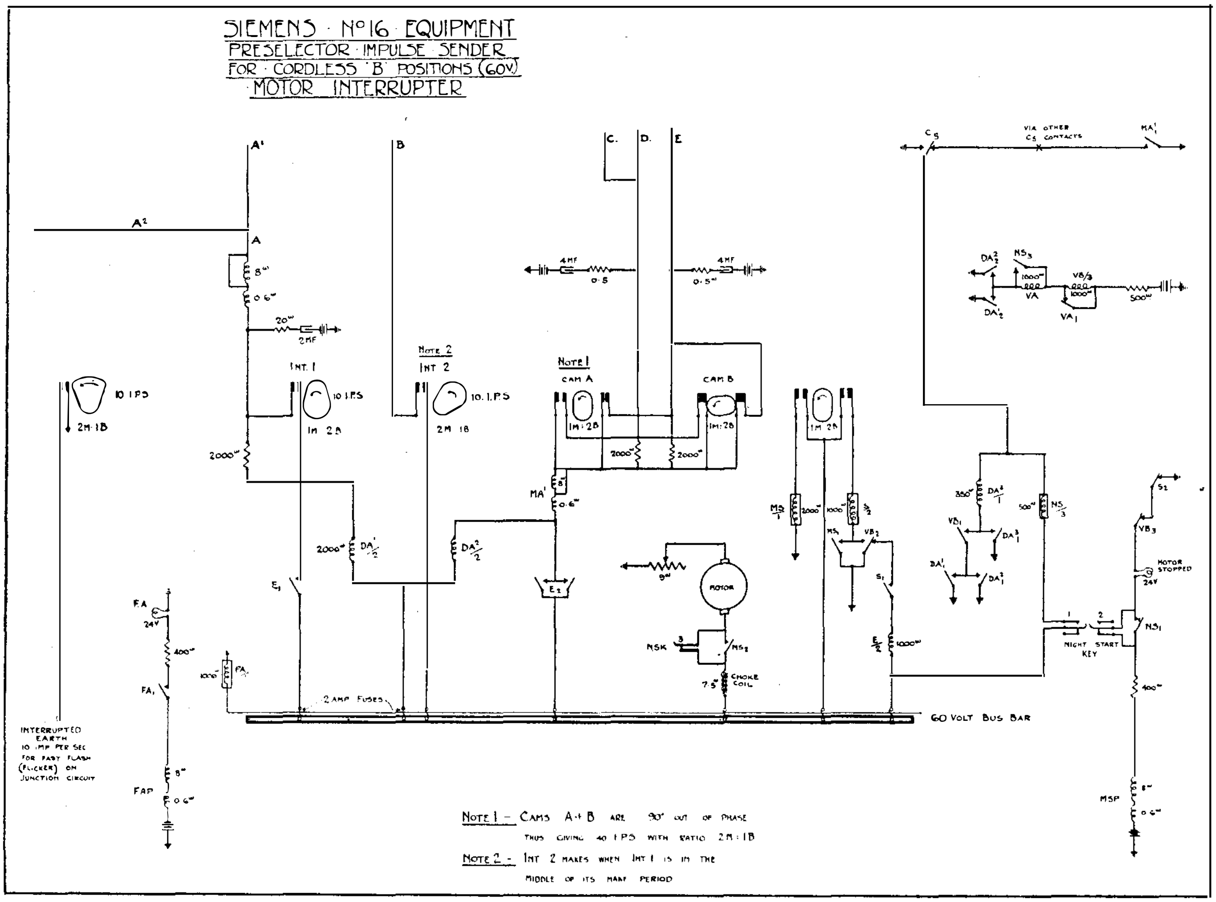


FIG. 2.

conditions on the Digit Switches and the Sender with the consequent release of Relay S. A second Contact of this Key operates the Z Relays to discharge the condensers, thus clearing the contacts of the digit switches; but the Junction remains linked with the Sender, as Relay C is still operated.

Contact CC_2 opens the circuit of Re-

ning the Night Start Key is normal and the circuit of the Motor is completed *via* Contact No. 3.

With the first throw of the cams Relay MS is operated and MS_1 closes, thus preparing the circuit of Relay S. When the cam operates the right hand spring set Relay S will operate, and as both are slow release they will hold all the time the Motor is running.

S_1 operates Relay E while S_2 opens the Motor Stopped Alarm Circuit. If the Motor stops, Relay S will release and the Motor Stop Pilot Relay (MSP) will be operated and the Motor Stopped Lamp will glow.

With the operation of Relay E, Contacts E_1 and E_2 close to complete the battery feed to the Interrupter Spring Sets. Motor failure will release E, thus disconnecting the battery feed and avoiding the possible burning out of Spring Sets and Driving Magnets.

Night Starting.—In this case the Key is thrown and the Motor Circuit and Motor Stopped Alarm are dependent on the operation of Relay NS.

The closing of the Q_1 Contact in the Drive circuit of the Seeker completes a circuit for Relay DA^2.

With the operation of DA^2

DA^2_1 prepares a circuit for DA^3 in series with NS.

DA^2_2 operates VA (Battery 500ω VA' Relay VA DA^2_2 to earth).

With the operation of VA

VA_1 opens the short circuit across VB, allowing the latter to operate when VB operates VB_1 completes the circuit of Relays NS and DA^3.

VB_2 disconnects E against the operation of S before the Motor has reached its normal speed.

VB_3 breaks the Motor Stopped Alarm circuit.

The operation of DA^3_1 closes a locking earth for NS and DA^3 in series independent of VB_1.

When Relay NS operates,

NS_1 prepares the MSP circuit which will be held open until VB releases.

NS_2 starts the Motor.

NS_3 short circuits VA which releases slowly. With the release of VA Contact VA_1 will short circuit Relay VB which will also release slowly.

The normal operations now come into play, MS being operated and in turn operating S, which in turn operates E. If the Motor stops during the application of current or if it fails to start, Relay S will not be operated after the operations of VA and VB, and the Motor Stopped Lamp will glow and the MSP Relay will bring in the Main Audible Alarm.

When the Junction Sender Seeker finds the Junction assigned, Relay C in the Seeker will be operated and C_5 changes over and holds NS; but short-circuits DA^3, which will release. When the impulses have been sent out, Relay C is released and C_4 completed the Seeker drive circuit, thus operating the MA^1 Relay. MA^1_1 will therefore be operated and with the return of C_5 to normal, Relay NS will be held until the drive of the Sender Seeker has been completed, *i.e.*, when the Preselectors reach normal. Relay MA^1 will then be released and Relay NS will also release.

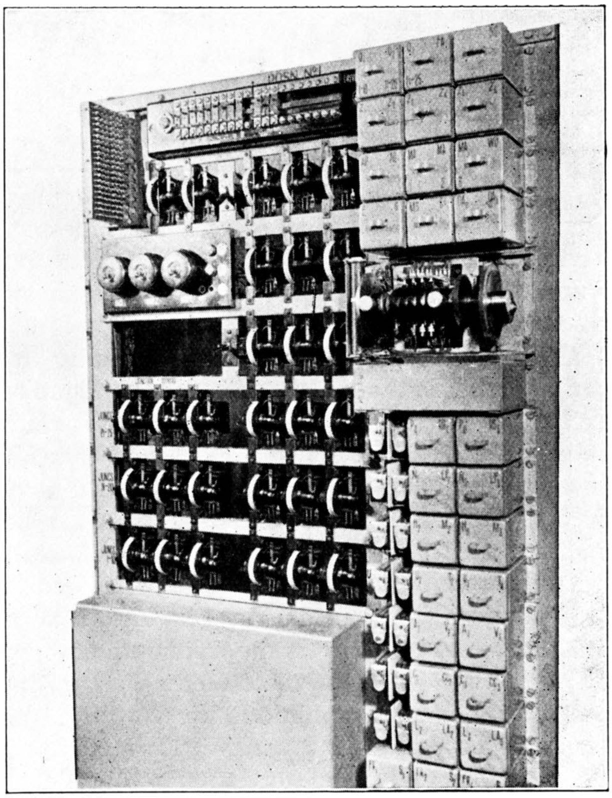


FIG. 3.—GENERAL VIEW OF IMPULSE SENDER AND RELAY ASSEMBLY.

In this case the Motor Stopped Alarm will not be given, as it is stopped purposely.

Magnet Alarm.—On each operation of a Magnet a Relay MA will be operated. If this operation be prolonged, an alarm is given.

The diagram of the SA and ZA Relays and slow acting Cam used for bringing this Alarm into operation is not shown, as the arrangement applies generally to the Siemens No. 16 System and is not particular to the Impulse Sender.

The duration of the slow alarm is ⅝ to $1\frac{1}{4}$ minutes.

Fuse Alarm.—This is the standard alarm circuit and need not be described in detail.

Routine Testing.—Provision is made for a Maintenance Officer observing the action of the Preselectors in sending out digits. The Routine Test Key is provided in the Drive Circuit of the Controller so that no digits can be sent out if the Key is operated. The Maintenance Officer may release the digits as soon as he is ready to observe the operation of the Preselectors.

AUTOMATIC EXCHANGE DEVELOPMENT.

DISCRIMINATING SELECTORS FOR SATELLITE EXCHANGES IN NON-DIRECTOR AREAS.

By J. Hedley, M.I.E.E.

Up to the present each telephone contractor has developed and installed Switching Selector Repeater equipment, or repeaters having access to discriminating selectors, at Satellite exchanges for working to the main or parent exchange provided by them.

The most economical method of affording the various conditions which are required at Satellite exchanges have been the subject of close study and investigation by Post Office Engineers for some considerable time, and a scheme has now been evolved, which it is proposed shall be manufactured, and installed by every contractor.

The underlying principle followed has been to incorporate features of existing circuits in such a manner that not only is the minimum amount of plant provided at the Satellite exchange, but well known circuit conditions are employed as far as is economically possible, thus enabling the equipment at Satellite exchanges to be as simple as possible, which will be advantageous from a staff training standpoint.

The method adopted in the standard group selector is employed by means of the 5 relays, A, B, C, G and H for impulsing, engaging and testing, and the usual mechanical functions of a step by step switch by means of the vertical rotary and release magnets.

Except for one or two contacts inserted owing to the need for discrimination the action of the discriminating selector switch is identical with that of a standard group selector.

The selector is provided with a 4th bank, and a 4th wiper. The additional contacts on the 10 levels of the extra bank are utilised to operate discriminating relays to enable the following facilities to be provided:—

(*a*) The first local digit to be absorbed, by restoring the switch to normal.

(*b*) The first and second local digits to be absorbed by restoring the switch to normal.

(*c*) Direct routing to an adjacent Automatic Exchange.

(*d*) Direct routing to the Manual board on "0" level calls.

(*e*) The junction to the main Exchange to be disconnected for conditions (*a*) (*b*) (*c*) and (*d*).

(*f*) The magnet circuits of the discriminating selector to be disconnected for all junction calls *via* the main Exchange.

The circuit arrangements are shown in (1).

The operation is as follows:—

(1) A operates over subscribers' loop.

(2) B is energised *via* A to place earth on private to engage the selector to other calling subscribers.

(3) Junction finder now rotates, and when an idle junction to parent exchange is found, K operates, joining the Selector through to the parent Exchange, from which point the calling Subscriber receives the dialling tone. The earth from contact B is also extended *via* K contacts to the private of the selected junction, to engage it against other calling subscribers.

(4) MD is energised *via* contacts of B, and is retained *via* its own contacts. The relay provides an alternative earth on the private for "0" level calls *via* the manual board so pro-

viding the required operator hold facility on such calls; it also keeps the metering circuit open until the called subscriber replies.

Local Calls Completed Direct from Satellite.

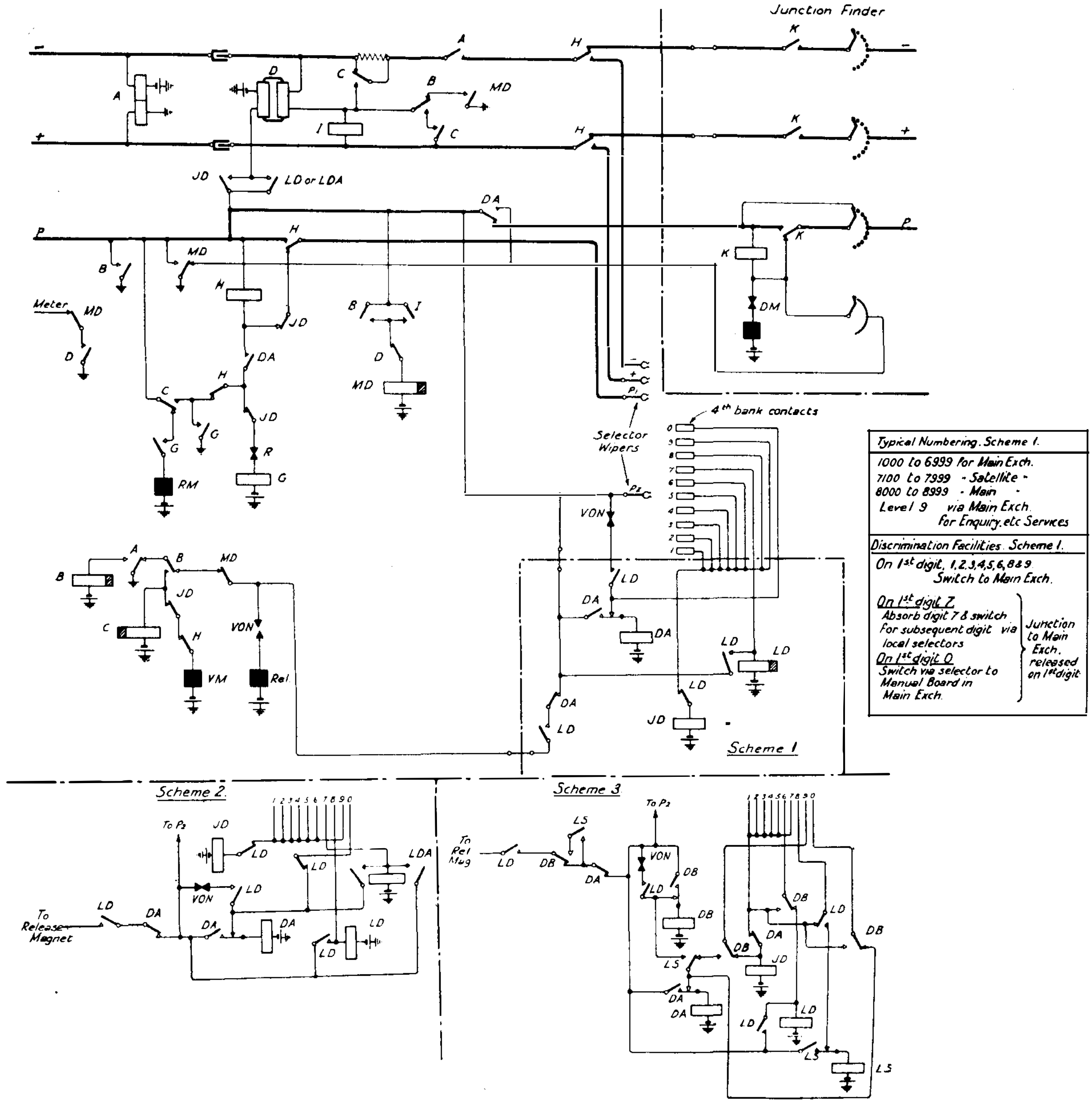
(5) For discriminating Scheme 1.

Subscriber dials the first local digit 8; the vertical magnet VM and C are energised in parallel. The Switch at the parent Exchange is also operated *via* contacts of A, C and B.

(6) G operates *via* C and B, and when C releases at the cessation of dialling, RM makes one rotary step, disconnecting G, and connecting wiper P2 with the discriminating bank of the selector on level 8.

(7) LD operates *via* wiper P2 and contacts of B and locks, *via* its own contacts. The release magnet is energised *via* contacts of VON, LD and B, causing the switch to restore to normal.

(8) DA now operates *via* LD and B and



Satellite Exchange. Non-Director Areas. Discriminating Selector.

locks *via* its own contacts, disconnecting K, releasing junction to the parent Exchanges and restoring the junction finder to normal.

(9) Subscriber dials second local digit, say, "82." VM and C again operate in parallel to step the switch to the required level and as wiper P2 is now disconnected, relays G and H function in the normal manner to test and connect with the trunk outgoing to the Final Selector.

(10) The remaining 2 digits operate the Final Selector in the usual manner, and when the called subscriber replies D is energised to release MD and meter the call over the 4th bank of the rotary line switch in a manner similar to that adopted in director areas.

"0" Level Calls via the Manual Board for Trunk and Toll Traffic.

(11) After operations 1 to 6 are completed, in this case to level "0" instead of level 8, DA operates *via* wiper P2 and contacts of B and locks *via* its contacts, disconnecting K, releasing the junction to the parent Exchange and restoring the junction finder to normal.

(12) The circuit of G and H is also completed *via* DA and these relays function in the normal manner to test for and connect with an idle junction direct from the bank contacts of level "0" to the manual board associated with the parent Exchange.

(13) Battery is connected to the line relay at the manual Exchange *via* the loop of I and D; the line relay operates and signals the operator; when the latter answers, the cut-off relay is energised to disconnect the line relay.

(14) Battery is now received direct from the Manual Exchange Cord Circuit on the positive line to energise I, but not D; the operator is able to hold the connection after the calling subscriber has restored his receiver *via* I, contacts B and MD.

Non Fee Junction Calls via the Parent Exchange.

(15) For discriminating scheme 1 after operations 1 to 6 are completed, in this case for any level except "8" and "0," JD operates *via* wiper P2 and contacts of B and remains energised until the calling subscriber restores his receiver.

The operation of JD disconnects the vertical and rotary magnet, relays G and H and the selector now functions as a repeater for transmission and metering purposes only.

Non Fee Junction Calls Direct from the Satellite Exchange.

(16) Discriminating scheme 1 does not provide for this service but for discriminating scheme 2. After operations 1 to 6 are completed, in this case *via* level 7 instead of 8, the call proceeds direct to the distant automatic exchange selector, the discriminating selector functioning as described under operations 11 and 12.

(17) For discriminating scheme 3, after operations 1 to 6 are completed, in this case *via* level 6 instead of 8, LD operates and the switch functions as for operation 7.

(18) DB now operates *via* LD and B and locks *via* its own contacts to prepare circuit for DA.

(19) Subscriber now dials 9 and DA is energised *via* wiper P2 and contacts of B and locks *via* its own contact and the switch functions as for operations 11 and 12 to connect with an idle junction *via* level 9 to the distant Automatic Exchange.

From the foregoing description of the circuit operations of Discriminating Scheme 1 and operations 15 to 18 for Schemes 2 and 3, the general principles for the remaining services available under Schemes 2 and 3 will no doubt be apparent. It will also be evident that the actual wiring of the discriminating relays to the 4th bank of the selector switch and the number of relays required will vary according to the numbering scheme adopted for the area and whether or not direct trunking to an adjacent automatic exchange from the Satellite Exchange is required.

The outstanding advantages of the Discriminating Selector, as now developed, are:—

1. Improved delayed metering conditions over 4th wire, enabling booster metering battery to be dispensed with.
2. Direct routing to adjacent automatic exchanges when required, instead of trunking all non-fee junction calls *via* the parent exchange, thus enabling economy on line plant to be effected.
3. Auxiliary relay equipment at the Satellite Exchange for calls to the manual board *via* level

"0" is dispensed with—thus improving transmission conditions on originating toll or trunk traffic.

4. Simpler circuit arrangements: the functions of the relays A, B, C, G and H and the vertical and rotary magnet correspond to those for impulsing and testing on group selectors, relays D, I, and MD to those on the 1st Code Selectors, for registration, manual supervisory and holding conditions. leaving only the group of discriminating relays 3, 4, or 5 to be wired for the particular numbering scheme and routing conditions of the Exchange concerned.

5. Scope for competitive tenders widened, as the P.O. Discriminating Selector can be manufactured by any Contractor and is suitable for operation with any Contractor's system existing at the main or parent exchange.

AN OUTLINE OF THE TRUNKING ASPECT OF AUTOMATIC TELEPHONY.

[*Abstracted from a Paper read by* Mr. G. F. O'Dell, B.Sc., *before the Institution of Electrical Engineers and published with the permission of the Institution.*]

As defined in the Post Office, the "grade of service" is the proportion of calls which fail to mature on account of shortage of switching plant. The grade of service has been defined in other ways by various investigators, but in the author's opinion the definition just given is simplest in conception and easiest to measure.

The settlement of a standard grade of service must clearly be based on a compromise between the desire to give subscribers as good a service as possible and the equally important desire to render that service as cheaply as possible. In the Post Office the standard has been fixed at 1 lost call in 500 at each switching stage, with the proviso that if the traffic increases temporarily by 10 per cent. the service shall not deteriorate below 1 in 100. The latter proviso is to allow for the well known fact that a large group of switches cannot stand an overload so easily as a small group, and it is desired that, in the event of a sudden increase of traffic of a temporary nature, the service shall not unduly deteriorate. In the special case of small groups of external junctions, which are often very expensive to provide, a rather lower grade of service than the standard is allowed.

The development of trunking may conveniently be considered under two aspects—the quantitative, which is concerned with the amount of switching plant required to handle a given amount of traffic, and the qualitative, which relates to the methods adopted for arranging switching plant to the best advantage. In recent years a considerable literature on the former has grown up, and it can only here be stated that the theory associated with the name of Erlang is considered most nearly to represent conditions obtaining in the Post Office. On the qualitative side there has been considerable development, and the central link frame of Messrs. Siemens Bros. (described in "Siemens

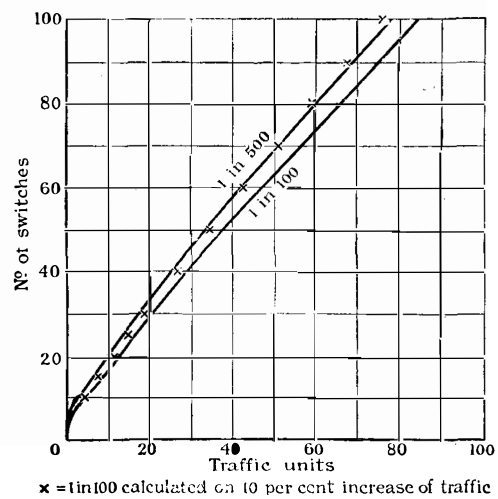


Fig. 1.—Traffic Capacity of Switch Groups.

No. 16 Automatic Equipment," by C. W. Brown, Institution of Post Office Electrical Engineers, Professional Paper No. 100) and the link frame terminal assembly of the Automatic Telephone Manufacturing Co. (now being introduced into Post Office exchanges) represent the latest phase.

Erlang's curves have been published many times, but it may be of interest to consider the effect of the two-fold grade of service adopted by the Post Office.

TABLE I.

TRAFFIC CAPACITY OF SWITCHES (ERLANG'S THEORY).

(Grades of service of 1 in 500, 1 in 100, and also 1 in 100 calculated on 10 per cent. increase of traffic.)

Number of switches.	Traffic capacity for grade of service of		
	1 in 500.	1 in 100	1 in 100 on 1.1 traffic.
1	0.002	0.01	0.009
2	0.065	0.153	0.139
3	0.25	0.455	0.414
4	0.53	0.870	0.791
5	0.90	1.36	1.24
10	3.43	4.46	4.05
15	6.58	8.11	7.37
20	10.07	12.03	10.9
24	13.01	15.3	13.8
25	13.76	16.1	14.6
30	17.7	20.4	18.5
40	25.7	29.0	26.4
50	33.9	37.9	34.5
60	42.4	46.9	42.6
70	51.0	56.1	51.0
80	59.7	65.3	59.4
90	68.5	74.7	67.8
100	77.4	84.1	76.4

Table I. gives in cols. 2 and 3 the amount of traffic carried by groups of the sizes given in col. 1 for grades of service of 1 in 500 and 1 in 100 respectively. In the last column the values of traffic are 10/11 of those in col. 3, *i.e.*, the traffic in col. 4 is the traffic which, if increased by 10 per cent., will give a grade of service of 1 in 100 with the size of group given in col. 1. To conform with both parts of the standard grade of service, then, the traffic chosen for any size of group must be the smaller of the two values given in cols. 2 and 4. These values are the same for a group of 70 switches. For smaller groups the grade of service of 1 in 500 is more severe than the grade of service 1 in 100 reckoned on 10 per cent. increase of traffic; for larger groups than 70 the reverse holds. These results, which of course apply only to the "full availability" case, are illustrated in Fig. **1**; the curves are for grades of 1 in 500 and 1 in 100 respectively, while the figures in col. 4 of Table I. are shown, for clearness, as crosses.

Those familiar with the design and construction of automatic switching plant will realise that the "full availability" conditions do not occupy a very large place in practice. Taking the exchanges now being installed in London as an example, each subscriber's pre-selector has a bank of 24 contacts and therefore has access to a maximum of 24 1st selectors; in other words, the "availability" of 1st selectors is limited to 24 on account of the design of the pre-selectors. In any exchange where the number of 1st selectors exceeds 24, therefore, full availability conditions do not obtain, and the "availability" is said to be "limited." Similarly group selectors having 10 contacts per bank level limit the availability of succeeding switches to 10, and the more recent group selectors having 20 contacts in the bank level similarly limit the availability to 20.

When the availability is limited, the question arises of how best to join the banks of the switches of one rank to the wipers of the next. In most of the earlier exchanges, both in this

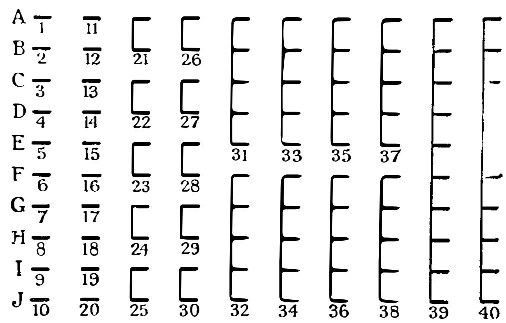


FIG. 2.—DIAGRAM ILLUSTRATING PRINCIPLE OF GRADING.

country and in America, the switches of one rank were divided into groups each containing a number equal to or at any rate not greater than the number of contacts in the banks of the preceding switches.

This arrangement—besides being uneconomical—is very inflexible. An examination into other methods of trunking is too long to be reproduced here. Suffice it to say that the method of grading has now been adopted by the Post Office. The principle of grading is illustrated in Fig. **2**. A detailed study of the traffic capacity of gradings leads to the information shown in Fig. **3**, which shows the traffic capacity of 10-contact gradings with various numbers of groups.

From a study of these curves it will be deduced that 2-group gradings are satisfactory if the number of outlets required does not exceed 15, 4-group gradings are satisfactory if the number of outlets required does not exceed 25, and 10-group gradings if the number does not exceed 50. It will be noticed that the latter number is just one-half the maximum possible number of outlets from the grading, namely, 100. Speaking generally it may be said that no grading should be used, if it can be avoided, in which the actual number of circuits required to the next rank of switches exceeds half the maximum possible number. An 18-group grading, for example, should not be used when more than 90 circuits are required. This rule may be departed from in the following cases where the number of groups is small; thus 2-group gradings may be used for a maximum of 15 outlets, 4-group gradings for a maximum

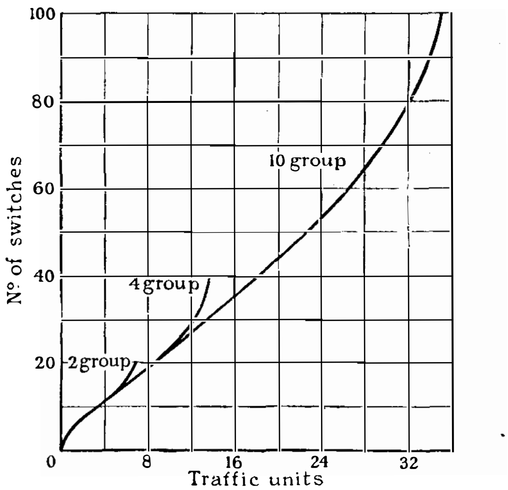


FIG. 3.—TRAFFIC CAPACITY OF GRADINGS.

of 25, and 6-group gradings for a maximum of 32 outlets. If the rule be departed from in other cases, a loss in traffic capacity will occur and the tables and curves given later will not apply. These specific data are, of course, with reference only to the gradings of 10-contact switches.

A study of Fig. **3** will show that the curves are very approximately straight from 10 switches until the point of maximum traffic capacity is reached, and that they lie very approximately on the same line. Similarly, in Fig. **4**, it will be seen that the value of the average traffic capacity per switch is tending towards a constant value, so that there is no great advantage in very large gradings.

Summarising, the best effect from a grading of the type described is only obtained if, first, the grading is "smooth," and, second, the number of groups is so chosen that the number of outlets does not exceed half the maximum possible number. In practice, the number of groups to be adopted for any given case will depend on other factors; it should always, if possible, be at least equal to the value found as above.

Another factor which has to be taken into account is the "distribution" of traffic.

In all the foregoing it is assumed that we are dealing with pure chance traffic. Where this is not the case other considerations must enter. But first it will be asked—"What is pure chance traffic?" A first reply, which will be investigated in slightly more detail, is that pure chance traffic is traffic occurring when a call is as likely to originate at any one instant as at any other during the period under consideration. Such a condition can only apply to a

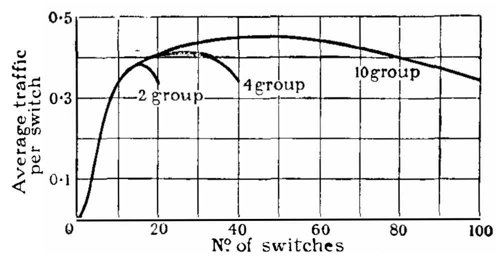


FIG. 4.—AVERAGE TRAFFIC PER SWITCH FOR VARIOUS GRADINGS.

small portion of the day—usually considered to be the busy hour—and even then is liable to be upset by various incidental circumstances. If, for instance, a subscriber makes two calls in the busy hour, these calls cannot be in progress simultaneously. In other words, the time at which the second call originates is governed to some extent by the first. Again, a fire or breakdown of power supply will cause many calls which would not otherwise have been made, and the tendency is for such calls to be simultaneous. But the effect of the conditions mentioned is comparatively small, and tests have shown, very approximately, that the calls originated by subscribers during the busy hour are as likely to originate at any moment of that hour as at any other—in other words, the traffic is pure chance.

But what happens to traffic within the exchange? Before a call can be connected to the required subscriber, whether in the same exchange or any other, it passes many switching points, and at each of those switching points the traffic undergoes some alteration.

Considered as a whole, of course, the traffic undergoes no change in distribution as it passes through the exchange. Except for the comparatively few calls which fail at some stage due to shortage of switching plant, to faults or to abandonment, all calls follow in the same sequence and at the same intervals. The sum total of calls on all 2nd selectors in a single junctionless exchange, for example, is the same as that on all 1st selectors, and the proportion of simultaneous calls of various numbers is the same at both stages if we consider the whole traffic. When outgoing and incoming junctions are taken into account, the actual calls at any one stage are not identical with those of other stages, but, broadly speaking, the distribution of traffic is not altered.

But when the various groupings of 1st selectors or of 2nd selectors are considered, then this equality of distribution need hold no longer. Assuming, for instance, that we have a volume of pure chance traffic and wish to distribute it among various groups of switches, we can imagine the distribution effected either by a chance method or by a definite selection. As an illustration, suppose that 1000 calls occurring within an hour and with an average duration of 3.6 minutes need to be divided among 10 groups; we can either in imagination draw counters for each call in order to determine which group shall take any given call or we can use our judgment and not leave the matter to chance. We might, for instance, say that calls shall take the various groups in definite relative order. In the latter case the number of calls in each group would be exactly 100; in the former it would average 100 but would vary from group to group. But, more important still, the proportion of time during which any given number of calls existed simultaneously would be very different in the two cases. The average traffic per group will be the same in each case, namely, $100 \times 3.6 \div 60 = 6$ traffic units. The difference in distribution can be illustrated by curves such as those in Fig. 5, which show the proportion of time during which exactly 0, 1, 2, etc., calls are in progress simultaneously for pure chance distribution in curve A, and for "selected" distribution in curve B.

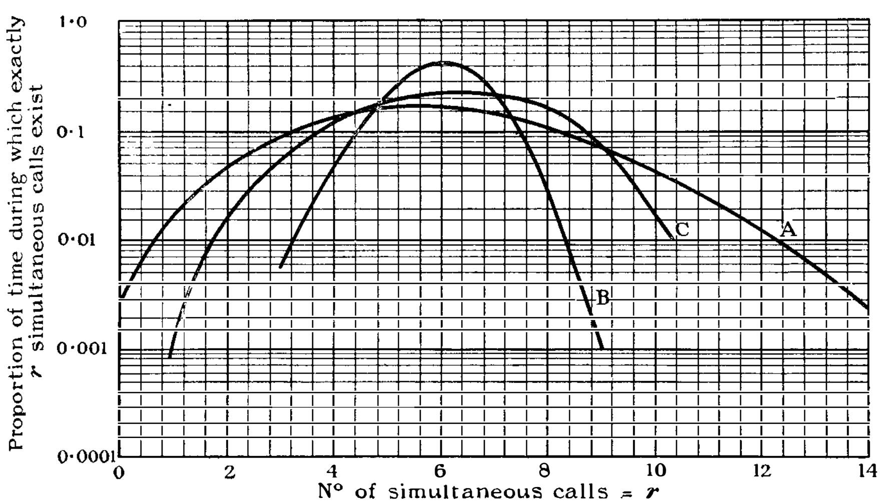


Fig. 5.—Traffic Distribution Curves.

In the latter case the distribution is much smoother, and it is therefore to be expected that fewer switches would be required to carry it at subsequent stages than would be required for pure chance traffic. But, though we can imagine calls being distributed in this selective way, it is not possible actually to accomplish such selection in practice.

We can, however, exercise some discrimination by means of such a scheme as the well known 1st and 2nd pre-selector scheme used by Siemens Bros. and others. When the calls are scattered over 100 1st selectors in this way it is to be expected that the distribution of calls over any shelf is smoother than would be the case for pure chance traffic of the same volume. The effect is increased by the group control arrangement, which prevents calls from coming into any row of 20 2nd pre-selectors when all the outlets from this row to 1st selectors are engaged. As is well known, the arrangement is almost equivalent, so far as traffic capacity is concerned, to "full availability" over 100 1st selectors, because any call may reach any one of those 100 selectors. The distribution of 6 traffic units on one shelf of selectors in this case is shown in curve C of Fig. **5**.

Allowing for this effect between 1st and 2nd selectors, 6 principal design curves are now used by the Post Office. They are illustrated in Fig. **6**.

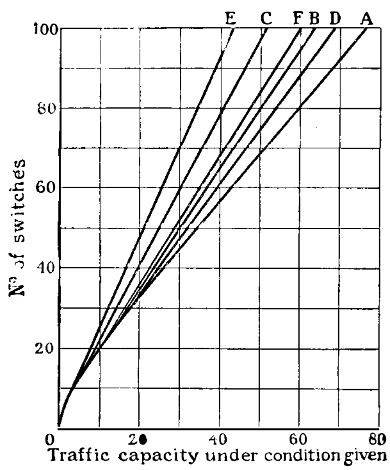


FIG. **6**.—TRAFFIC CAPACITY OF SWITCHES UNDER VARIOUS CONDITIONS. STANDARD GRADE OF SERVICE.

Traffic records are required for three purposes:—(1) In order to measure the grade of service given over various routes, (2) in order to measure the traffic passing over various routes and (3) for general statistical purposes.

It will be realized from what has gone before that for any grouping of switches the amount of traffic lost for any given volume and distribution of total traffic is exactly determinate. The same is true of the traffic carried by each individual switch in the grouping. Hence the traffic carried by any one of these switches may be used as a measure of the traffic carried by the whole, and also of the lost traffic. The relation between these three quantities is very involved and difficult to find, but, once determined, is available for all time. When the arrangement of a grading is considered, the most convenient switch for the measurement of traffic is seen to be the one connected to the last contact of the grading, because this is to some extent affected by the traffic on all the groups in the grading. As a measure of the total traffic carried by the grading, the number of traffic units (rather than the number of calls) carried by this last contact is required. This traffic is, however, very small and therefore one or two calls of abnormal duration might easily lead to wrong conclusions. The circuit is therefore designed to measure in addition the number of calls carried by the switch; the ratio of the two quantities is the average holding time of calls carried by this switch. Fig. **7** shows the actual circuit arrangement. The private wire of the last contact of the grading is connected to a meter, A, and battery; the meter is therefore operated once

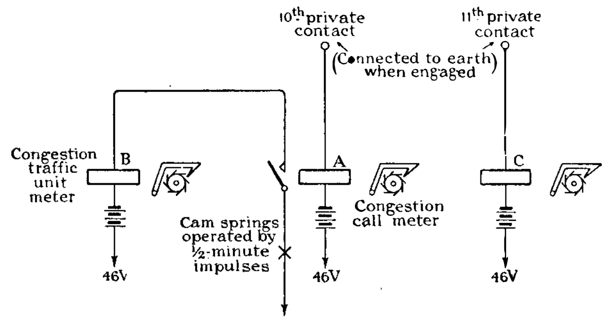


FIG. **7**.—CONGESTION AND OVERFLOW METERING CIRCUITS.

(by means of the earth which is then connected to the private contact) for each call carried by the switch connected to this last contact. In the local circuit of meter A is a second meter, B, the circuit of which includes contacts closed for a few seconds every half-minute. Such contacts are included in practically all automatic exchanges as they are required in connection with the exchange alarm scheme. Meter B therefore records the average number of times the switch concerned is engaged at half-minute intervals, that is, the reading of meter B divided by 120 is the traffic carried by the switch in traffic units. The ratio of the reading of meter B to that of meter A is the average duration in half-minutes of calls carried by the switch. One disadvantage of using the last-contact switch for traffic measurement is that it carries a very small amount of traffic; the readings of the meters therefore vary considerably and must be continued for a long period before they give a reliable indication of the traffic on the whole grading.

Calls which fail to find a disengaged outlet are recorded on an overflow meter (meter C in Fig. 7). Each shelf of selectors has an eleventh contact in the private bank on all levels, and this contact is multipled over the same shelves as the tenth. The overflow meter is connected to this contact and therefore records calls which fail to find an outlet in that particular grading.

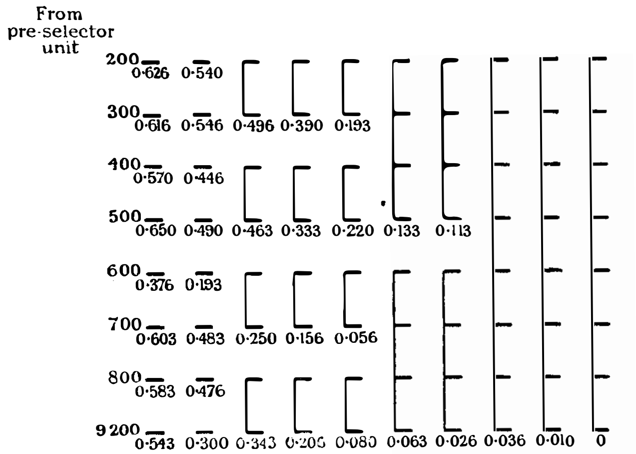


FIG. 8.—TRAFFIC DISTRIBUTION CHART.
The figures against each Circuit show the average traffic carried by that Circuit. Total Circuits working = 35.

This meter remains operated as long as the calling subscriber remains on the line. Should a second call fail to find an outlet in the same grading, it will not be recorded. As is well known, the calling subscriber in both these cases will receive the busy signal. The error due to this "overlapping" of busy calls will be negligible as long as a good service is given.

Measurements of the traffic passing over various routes are based on the fact mentioned several times, that the traffic carried by any group of switches is equal to the average number of switches simultaneously engaged. This number can be determined quite easily in many cases by actual observation, the number of engaged switches being recorded at convenient intervals (usually ½ minute to 3 minutes) and the average found. This method has the advantage that the traffic carried by each switch can be determined if desired, and the distribution of traffic over the grading is then known. Though a large number of records have been taken by this means it is tedious, and an automatic method of counting the switches has been devised.

As an example of the results obtained by the manual method of measuring traffic, Fig. **8**, showing the traffic carried by each outlet in a grading from one level of 1st selectors at Official Exchange, may be of interest. As will be expected, the individual outlets carry most traffic. It will be seen that the total traffic carried by the group of circuits is 11.6 traffic units, as against 14.6 which the group may be expected to carry with the normal grade of service. Noticing further that the last contact carried no traffic during the period of observation, and remembering that the total number of calls in this period (10 hours) was approximately 4,000, it will be seen that the grade of service is exceedingly good. The record was taken shortly after a rearrangement, in which some allowance was made for growth of traffic; hence the exceptionally good grade of service.

Records taken by these means on all the groups in an exchange may conveniently be summarized on a traffic diagram such as that shown in Fig. **9**. This diagram bears the results of a traffic record taken at Ipswich during August and September, 1926. Each group was observed for a period of 2 busy hours per day for 5 days and the records for the busier hour for each of the 5 days were averaged. In order to economise staff the records were not taken all at one time, but were spread over a period of 4 weeks. On the diagram the traffic carried on each route is shown against the route. It will be found possible by this diagram to obtain a check between the traffic passing into a group of switches and the total traffic passing out over the various levels of these switches.

If desired, the theoretical traffic carried by each group may also be added to the diagram, to facilitate the detection of cases in which groups are either over-loaded or under-loaded. The conclusions deduced by these means should be compared with those reached from a study of the congestion and overflow meters.

There is a possibility of apparent contradiction between these conclusions on account of the distribution of traffic over the groups of a grading being uneven. This can be checked by means of diagrams such as Fig. **8**.

Successive diagrams of the kind shown in Fig. **9** render possible a watch on the growth of traffic.

Since the paper was read, a very interesting description by Dr. Maitland of the traffic recording scheme in use at Amsterdam has appeared in the *Post Office Electrical Engineers' Journal,* 1927, Vol. 20, No. 1, p. 22.

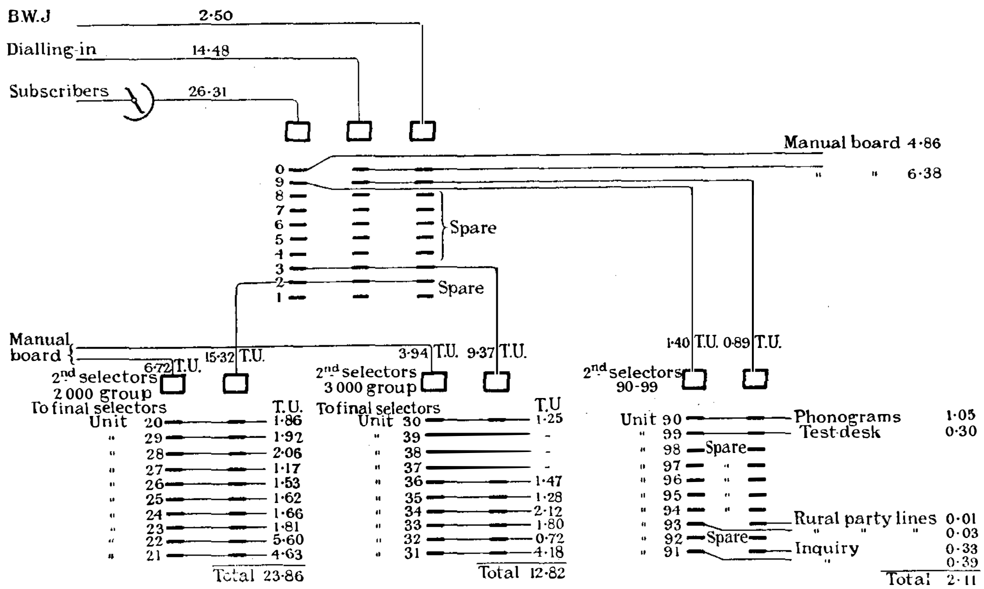


FIG. **9**.—TRAFFIC DIAGRAM, IPSWICH.

SOME TESTS ON SOUND ABSORBING MATERIALS.

W. WEST, B.A., A.M.I.E.E.

1. INTRODUCTORY.

THE present article is a review of a brief investigation carried out at the Post Office Engineering Research Section Laboratories on a few materials of good absorbing power, and the conclusions arrived at, where general, are applicable to porous materials such as curtains, studio drapings, etc., wherein the pores are small and very numerous.

While in general the effect of a sound wave meeting an obstacle is divisible into Transmission through, Reflection from and Absorption by the obstacle, the actions involved may differ according to the nature of the obstacle. Thus the transmission of sound through a wall of paper is mainly due to diaphragm action, that is motion of the paper in response to the alternating air pressure, while if the wall is of muslin the transmission is mainly accounted for by penetration of the sound through the interstices of the fabric. This latter is the nature of the transmission through materials of the kind dealt with in this article.

2. APPARATUS.

The apparatus used for testing the materials comprised essentially a brass resonating tube, about 6 cms in diameter and 80 cms in length, into the centre of which was suspended a Rayleigh disc. A window was provided in the side of the tube to admit a beam of light reflected from the disc to a graduated scale on which readings were taken. The general arrangement is illustrated in Fig. **1**.

The tube was fitted with adjustable end pieces, one of which (A) communicated with a telephone receiver which supplied the sound energy required to maintain resonance. Tests were made by introducing samples of material at the other end (B).

The Rayleigh disc was about 0.8 cm in diameter, suspended normally at about 45° to the axis of the tube. Readings of the deflection of the spot of light on the graduated scale indicate the angular deflections of the disc which are proportional to the square of the air particle velocity at the cross section of the tube through the disc.

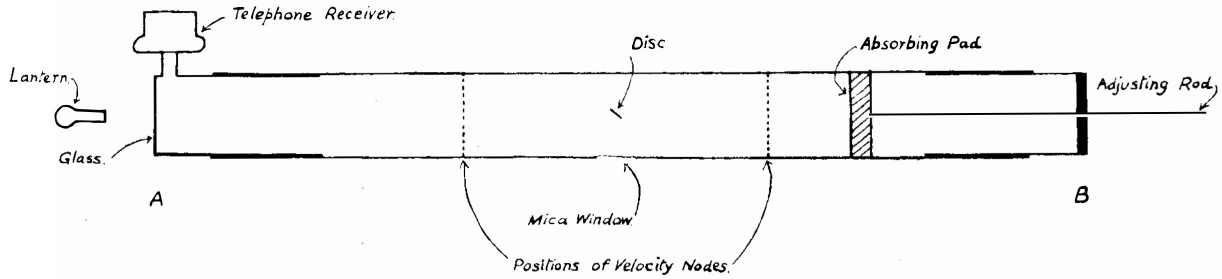


FIG. 1.

When a closed tube is in resonance at a frequency whose wave-length is λ, its length is a multiple of $\lambda/2$ and nodes of velocity exist at the ends and at sections of the tube distant $\lambda/2$ apart, while loops of velocity exist midway between the nodes.

3. Preliminary Test.

For this test the apparatus was arranged as shown in Fig. **1**. The ends were 84 cms apart, the disc being midway between them. A frequency of 600 cycles per second was used (λ = 56 cms) and nodes of velocity existed in the positions shown in the figure. End B was closed except for a small aperture through which could be pushed a wire, used to vary the position of a pad of material (cotton waste, 1 inch thick) within the resonating tube. Readings were taken of the disc deflections for different positions of the pad, and these are plotted in Fig. **2**, Curve 1.

The curve shows that the strength of resonance was greatest when the pad was at a velocity node and least when at a loop, and that the variation was considerable. As a similar effect might be produced by reflection from the face of the pad, a further test was made. The closed end B was removed and replaced by a deep packing of loose cotton wool, so that, instead of resonance, the conditions approximate to those of a plane wave travelling along the tube and, for the most part, being absorbed at the end. Readings taken of disc deflection and position of the pad (Curve 2) show that the effect is small as compared with that in the previous test.

The inference is that the absorbing power of a layer of a material (thin as compared with a wave length) when introduced into a sound field of standing waves varies with the position of the material, being greatest at a velocity loop and least at a velocity node. This result is confirmed by a later test, described in the following section.

In cases where walls are covered by a thin

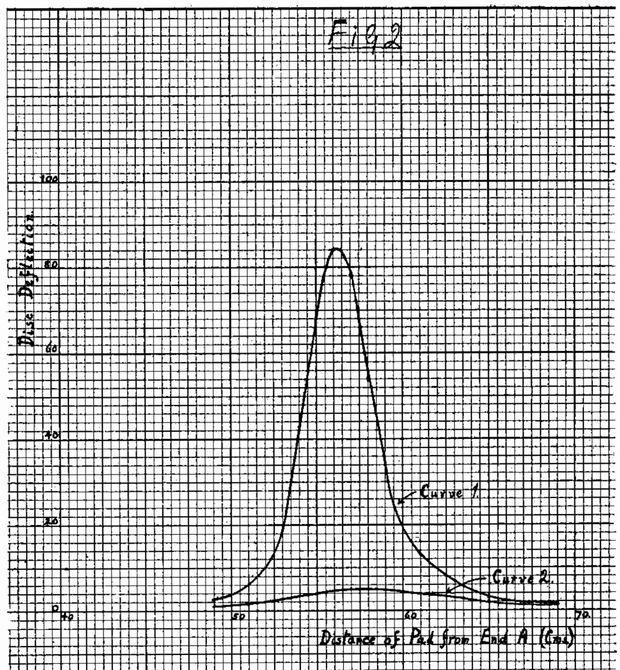


FIG. 2.

layer of draping at their surfaces, for sounds of high frequencies the nearest velocity loop may lie within or near the draping, while for lower frequencies it will be situated farther off. This is one reason why, in a room of this type, a larger proportion of sound is reflected at low frequencies than at high frequencies.

4. Decrement Tests.

For this method of test the author is indebted to Professor E. Mallett of the City and Guilds College. Essentially the method consists in determining the decrement Δ_0 of a resonating column of air, then introducing a sample of material and finding the decrement Δ_1 with the added resistance due to the material. Since the decrement of a simple resonating system is proportional to the resistance (the other constants being unchanged) it follows that Δ ($= \Delta_1 - \Delta_0$) is proportional to the frictional resistance due to the presence of the sample under test, and is therefore a measure of the absorbing power.

In order to determine the decrement, the electrical input to the receiver was maintained at a constant value while a number of readings were taken of the deflection of the disc for small changes in the length of the resonating tube near the correct length for resonance. A curve plotted in terms of tube length against disc deflection has the nature of a simple damped resonance curve, and the decrement may be obtained by means of Professor Mallett's graphical method.*

As shown by the previous test, it is important that each sample of material tested should occupy the same space and position in the tube for the results to be comparable. For these tests, the results of which are given in Table I., the sliding end at B was closed and filled with material, packed as far as possible to a uniform density, to a depth of 2 inches.

Table I.

f = 600 CYCLES PER SEC., λ = 56 CMS., Δ_0 = 0.4.

Sample number.	Material.	Mass Gms.	Δ $(=\Delta_1-\Delta_0)$
1	Cotton Waste	10.5	0.9
2	Cotton Wool	2.5	1.5
3	Packing Felt	3.0	0.45
4	Towelling	8.8	2.0
5	Gamgee Tissue (4 layers to 2 ins.)	3.6	2.2
6	Gamgee Tissue (7 layers to 2 ins.)	6.3	2.8
7	Gamgee Tissue (9 layers to 2 ins.)	8.1	2.75

* *Journal I.E.E., Vol.* 62, *p.* 517, *June,* 1924.

Samples 1-3 were taken from loose material, the remainder were cut, from sheets, into discs which were laid together to a depth of 2 inches. The cotton waste was not brushed and only partially purified. The gamgee tissue was a good quality surgical cotton wool laid in sheets between muslin.

An individual test was made with sample number 5 placed, instead of against the closed end B, at a distance of about $\lambda/4$ therefrom. This gave Δ = 5.3, a result which confirms that of the preceding section.

A test was also made with sample No. 5, replaced at B, at a higher frequency, namely, 1000 cycles per second, at which Δ was found to be 3.3.

5. Ratio Tests.

Another method of test* was used for determining the absorption of an unlimited thickness of the material. (This method can be applied to find the percentages of sound reflected from and absorbed by any obstruction provided that the percentage transmitted is negligible. Thus it can be applied in the case of a thin layer of absorbent material backed by a rigid surface provided that the relative positions of the material and the wall are kept the same for the test, and that it is understood that the test applies to the material and the wall, in combination, in the particular relative positions under which the test is made.)

For these tests the sliding tube at B was replaced by one about a foot long, open at both ends and filled with the material under test. The test was carried out by sliding this tube in the main resonating tube and observing the disc deflection—which has alternate maximum and minimum values for positions $\lambda/4$ apart of the sliding tube. The ratio of the maximum to the minimum values was observed. In order to verify that sufficient material was being used to give the equivalence of unlimited depth, the far end of the filled tube was closed and opened, and it was observed that the disc deflections were unchanged.

Since in the test the conditions are those of a plane wave meeting the material, the reflected wave also being plane, the results, when referred

* *Similar to that of H. O. Taylor, Physical Review, October,* 1913.

to obstacles in the open, therefore apply only to surfaces with dimensions large as compared with λ.

If d_1 be the maximum deflection observed and d_2 be the minimum, then, of the velocity of a single plane wave incident on the material, the fraction k which is reflected is given by

$$k = \frac{\sqrt{D} - 1}{\sqrt{D} + 1}, \text{ where } D^2 = \frac{d_1}{d_2}.$$

(A method for obtaining this equation is given in an appendix). The fraction k also applies to the ratios of pressure and of amplitude of the incident and reflected waves; the energy ratio is given by k^2. Since the percentage transmitted is zero, it follows that the fraction of the incident wave that is absorbed is given by $1 - k^2$ in terms of energy.

The results of tests are shown in Table II. for a frequency of 600 cycles per second, and in Table III. for observations, at a few different frequencies, on sample number 13.

TABLE II.

f = 600 CYCLES PER SECOND, λ = 56 CMS.

Sample Number.	Material.	Deflection Ratio (D^2)	Reflection factor (Amplitude) (k)	Absorption factor (Energy) ($1-k^2$)
8	Cotton Waste	7	·23	·945
9	Cotton Wool	5	·2	·96
10	Loose Packing Felt	5	·2	·96
11	Towelling	12	·3	·91
12	Gamgee Tissue (Moderately Compressed) ...	8.5	·25	·93
13	,, ,, (,, Loose)	6	·22	·95
14	,, ,, (Loose)	4	·17	·97

TABLE III.

TESTS ON SAMPLE NUMBER 13.

Frequency f	Wave-Length λ	Deflection Ratio (D^2)	Reflection factor (Amplitude) (k)	Absorption factor (Energy ($1-k^2$)
600	56.0	6	·22	·95
995	54·2	4	·17	·97
1377	24·7	3	·14	·98

6. Comparison of the Methods.

The results so far obtained by these two methods are not comparable, since in the decrement test the material was limited to a thickness of two inches, placed against a rigid surface, while in the ratio test the thickness of the material was, for practical purposes, unlimited. Even were this not the case, although both methods of test would give the same relative indication of the absorption qualities of different samples of materials, the numerical results would not be directly comparable. It is therefore of interest to notice the relationship between the decrement figures of different samples (tested under the same conditions) and the absorption or reflection factors of similar samples.

When the tube is adjusted to resonance, the maximum velocity, as measured by the Rayleigh Disc, is inversely proportional to the frictional resistance, that is, to the decrement. This velocity is also proportional to $\left(\frac{1 + k}{1 - k}\right)$ (see Appendix), whence $\frac{\Delta(1 + k)}{(1 - k)}$ is a constant for different materials or arrangements of material.

The ratio test was applied to a few of the samples whose decrement figures had previously been determined (Table I.), and the results are given below in Table IV. It will be seen that the values of $\frac{\Delta (1 + k)}{(1 - k)}$ given in the last column are the same—within limits allowable for experimental error.

TABLE IV.

f = 600 CYCLES PER SEC., λ = 56 CMS.

Sample Number. (See Table I.)	Deflection Ratio (D^2)	Reflection factor (k)	Decrement Δ (Table I.).	$\frac{\Delta (1+k)}{(1-k)}$
2	240	.60	1.5	6.0
4	90	.51	2.0	6.2
5	60	.47	2.2	6.1
6	27.5	.39	2.8	6.4

7. GENERAL COMMENT.

Considerations affecting the sound absorption properties of materials are dealt with in § 351, Vol. II. of Lord Rayleigh's "Theory of Sound," wherein the case of a continuous wall perforated by a number of similar narrow channels is considered in detail. The nature of absorption by these means is similar to that by the materials which have been tested, but the conditions are not exactly identical; for example, in the theoretical case no reflection takes place within the wall, but the present tests indicate, from the position of the material within the resonating tube, that reflection occurs within the material as well as at its extremities. Reference to these theoretical considerations, when taken in conjunction with the results of the tests and other available data, may be of assistance in dealing with particular problems of sound absorption, or in estimating the absorption qualities of a material by examination of its composition.

It would seem that the nature of the fibres constituting the absorbent material is, within reasonable limits, of minor importance, and that it is their disposition to give a large number of similarly sized meshes, for the penetration of the sound, that gives absorbing value to the material.

The chief point to consider is the influence of the size of the meshes, or pores of a material on its absorbing properties, *i.e.*, the effects due to varying the density of packing of the material. Obviously, if an unlimited thickness of material be available, the percentage of reflection will decrease, or the percentage of absorption will increase, continuously as the pores are made wider, *i.e.*, as the density of packing is reduced. If, however, the thickness of material be limited to a specified value, two opposing influences have to be considered; one of these is the tendency of the material to admit more sound for absorption as the pores are widened, and the other is the corresponding increase in the amount of sound which passes through the material. (If there be a rigid surface at the further side of the material, sound will be reflected from this surface back through the material). Hence for a given thickness of material (and a given frequency of sound) there will be an optimum density of packing to give a maximum of absorption.

It has been shown in Section 3 that the absorption by a thin layer of absorbent material, placed in a field of standing waves, varies with the position of the material, being a maximum at a velocity loop. Under such conditions it would seem probable that the optimum density of packing will also vary with the position of the material, being least when the material is at a velocity loop. No experiments have, however, been made to confirm this conclusion.

The effect of varying the frequency of the sound is of importance, and the few tests that were made show that in all cases an increase in frequency gave increased absorption. Generally, as the frequency is increased, the sound will be more completely absorbed, and at the same time a smaller depth of material will be required. With absorbent materials, such as are used in practice, it seems certain that a limit will be imposed on the increase of absorption with increasing frequency, but, in general, no serious falling off in absorption beyond this limit need be anticipated.

When the thickness of material is limited, since the optimum density of packing, for a maximum of absorption, requires a compromise between reflection from and transmission through the material, it would seem, in general, that the lower the frequency the more should the material be compressed for maximum absorption at that frequency. This does not necessarily mean that absorption at higher frequencies will be less than at the frequency at which the density of packing is best, but that it is less than could be obtained with the specified thickness of material.

These considerations affecting absorption are by no means complete, but are sufficient to form a working basis for most practical purposes. They demonstrate that variations in the degree of absorption are liable in consequence of changes in any of the conditions of position (relative to a velocity node), density and thickness of material and frequency of sound.

The information required from the tests was merely qualitative and the numerical results obtained can only be taken to represent a first approximation. When quantitatively accurate results are required it may be necessary to purify the acoustic output from the source of sound, and to ensure that its intensity is independent of the acoustic load. If this load be varied, the intensity of the source may be maintained, for example, by means of observations on a sound pressure recording device communicating with the cavity behind the telephone receiver diaphragm. In any case the nature of the samples tested was such that differences, such as variations in the density of packing, are liable between a small sample and a large surface of material.

APPENDIX.

The Ratio method of Section 5 of the text is similar to a method described in a recent issue of the "Scientific Papers of the Bureau of Standards."*

The sound velocity measured by the Rayleigh Disc is the sum of the velocities, at the disc, of the plane wave travelling along the tube from the source and of all the ensuing reflected waves. This sum must take into account the phase as well as the direction of each of these components. Suppose that the disc is so situated that the rigid end A (see Fig. 1) of the tube is at a distance which is an odd multiple of $\lambda/4$—where λ is the wavelength of sound. It will first be assumed that waves are reflected without loss at A and without change of phase at either surface. Let V be the velocity of the initial plane wave travelling from A to B, and let kV be that of the first reflected wave (k is then the reflecting factor for the surface in terms of velocity, amplitude or pressure, all of which are proportional in a plane wave). The difference between the phases of the velocities of any of the waves is, at the disc, a multiple of π, and an infinite convergent series can be built up to represent the velocity at the disc due to the combined effect of all the waves present in the tube.

Obviously the condition referred to is that giving a maximum velocity at the disc, and, since the deflection of the disc is proportional to the square of the velocity, the maximum deflection, d_1, is related to k thus:—

$$\sqrt{d_1} \propto 1 + 2k + 2k^2 + 2k^3 + \ldots \text{ to inf.} \quad \ldots\ldots(1).$$

$$\propto \frac{(1 - k)}{(1 + k)} \text{ (by summation of the series)} \ldots(2).$$

Now if the end B be moved until its distance from the disc is an *even* multiple of $\lambda/4$, the end A remaining fixed, the conditions are those obtaining when the minimum deflection d_2 is observed, and hence

$$\sqrt{d_2} \propto 1 - 2k + 2k^2 - 2k^3 + \ldots \text{ to inf.} \quad \ldots\ldots(3).$$

$$\propto \frac{(1 + k)}{(1 - k)} \quad \ldots\ldots(4).$$

From equations (2) and (4)

$$\sqrt{\frac{d_1}{d_2}} = D = \left(\frac{1 + k}{1 - k}\right)^2 \quad \ldots\ldots(5).$$

$$\text{whence } k = \frac{\sqrt{D} - 1}{\sqrt{D} + 1} \quad \ldots\ldots(6).$$

where the symbol $D = \sqrt{\frac{d_1}{d_2}}$ is used for abbreviation.

It has hitherto been assumed that reflection occurs without change of phase at B; this condition is not always realised in practice. The fact that the phase relationship between the incident and reflected waves is unknown is, however immaterial to the test, since the positions for maxima and minima deflections of the disc are determined by observation, and the theory outlined above holds good whatever this phase relationship may be. This may be proved as follows:—

Suppose that, at a cross section X of the tube,

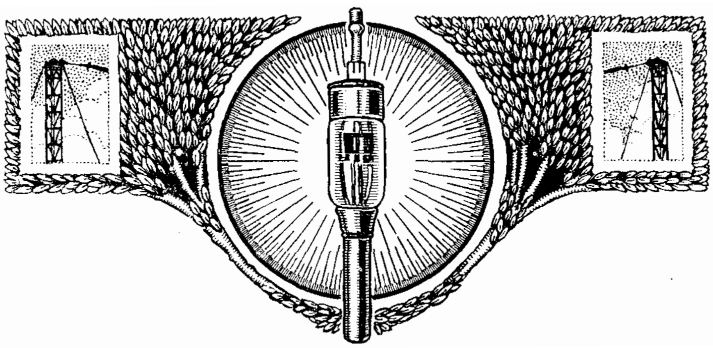
* *Vol. 21, p. 53, Paper No. 526. By E. A. Eckhart and V. L. Chrisler. The method makes use of a sound pressure measuring device —instead of a Rayleigh Disc—with some advantages which are important for the measurement of materials of low absorption.*

near to end B, the phase difference between an incident wave and its reflected wave is ϕ, and that the distance of X from the disc is x (the position of X being considered fixed relatively to the end B). Let V Sin ωt be the instantaneous velocity of the initial wave at the disc, then $V \text{ Sin } \left(\omega t + \frac{2\pi x}{\lambda}\right)$ is the velocity of the initial wave at X, and $kV \text{ Sin } \left(\omega t + \frac{2\pi x}{\lambda} + \phi\right)$ is the velocity of the reflected wave at X, and $kV \text{ Sin } \left(\omega t + \frac{4\pi x}{\lambda} + \phi\right)$ is the velocity of the reflected wave at the disc.

The instantaneous value of the velocity at the disc due to the initial and first reflected waves is therefore

$$V \text{ Sin } \omega t - kV \text{ Sin } \left(\omega t + \frac{4\pi x}{\lambda} + \phi\right)$$

Now if x be such that $\frac{4\pi x}{\lambda} + \phi$ is an odd multiple of π, the phase relationships at the disc are identical with those from which equation 1 was derived. Similarly if $\frac{4\pi x}{\lambda} + \phi$ is an even multiple of π, equation 3 holds good, and it is obvious that these conditions give respectively maximum and minimum values of the velocity at the disc.



CONSTRUCTION

THE ANGLO-FRENCH (1926) CABLE.

LEAD-SHEATHED, PAPER CORE, CONTINUOUSLY LOADED.

ANOTHER important link in the network of cables joining this country with the Continent was completed on the morning of the 17th March, when the cable ship "Silvergray" landed the English shore end of the Anglo-French (1926) continuously loaded telephone cable on the beach at Seabrook between Sandgate and Hythe. She had delivered the French end near Audrecelles, a village some

FIG. 1.—THE "DRUDGE" GOING IN WITH SHORE END.

nine and a half miles north of Boulogne, at eleven o'clock the preceding morning and had laid the cable in a continuous length, arriving off Sandgate about 5 p.m.

The laying of the main portion went without a hitch, except a momentary over-running of the cable on the drum just after the start. The delivery of the French end was accomplished by the use of a shallow-draught tug, appro-

FIG. 2.—THE "DRUDGE" AND CABLE AT LOW TIDE.

priately termed the "Drudge," which was loaded with the necessary length of cable to extend from the cable ship to the cable hut some way up the beach. The coiled cable was turned over, the lashings were cast off and the "Drudge" steamed slowly ashore at high water, paying out as she went. She sailed right in until she sat down comfortably on the bottom, fully one hundred yards above low

Fig. 3.—Swinging Cable clear.

water mark. The cable was then swung round on the beach to let her float clear on the next tide, which she did successfully without damage. Fig. **1** shows the "Drudge" steaming ashore and almost aground; Fig. **2** the tug high and dry; Fig. **3** swinging the cable round to clear the propeller; Fig. **4** the cable hut in the bents below Audrecelles.

Fig. 4.—Cable Hut at Audrecelles.

At the English side a tug was employed to tow the barge which carried the shore end. The weather had been very fine for the season, but as the cone was hoisted indicating the approach of a gale from down channel it was decided to load up the barge and push the landing through the night. About three quarters of a mile of cable was therefore paid into the barge and turned over ready for paying out when the tug cast off from the ship. At 11.30 p.m. Mr. Elwin, of Siemens Bros., and the writer jumped on board the barge to join the cable party and at 3.30 a.m. we came ashore on the beach at Seabrook. A cinema operator had been waiting to take a film of the proceedings, but he had left when darkness fell—rather luckily for us as our landing was perhaps not so dignified as we should have wished. Four hours hanging on

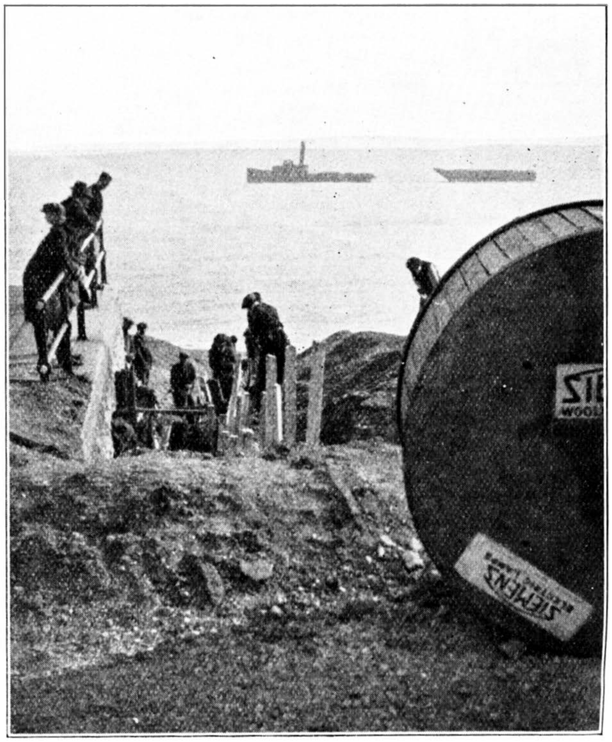


Fig. 5.—Digging Trench at Seabrook.

to the bare deck of a barge on a windy dark night in the Channel does not produce the equanimity and pose required to face a "close-up" for the movies, but it killed a bad cold which had been worrying the writer for a fortnight. Fig. **5** shows the digging party with the tug and barge in the offing; Fig. **6** the barge at 8 a.m.; Fig. **7** the testing huts over the manhole and the Research test van near the fence.

Description of Cable.—The cable is of the same type and capacity as the Anglo-Belgian (1926) cable, described in the January issue of this Journal by Mr. W. T. Palmer. The block, showing the cross section of the cable and used to illustrate that description is reproduced here in Fig. 8, the only difference between the two cables being a distinguishing black line on the white wire of the AB pair in each quad. The submarine portion, 23.9 nautical miles in length,

FIG. 6.—THE BARGE AT DAYLIGHT.

is extended by a through joint to a land cable laid from Seabrook to Canterbury, and on the French side from the cable hut to Boulogne. These two land cables are continuously loaded and have practically the same electrical constants as the sea cable, but they are not

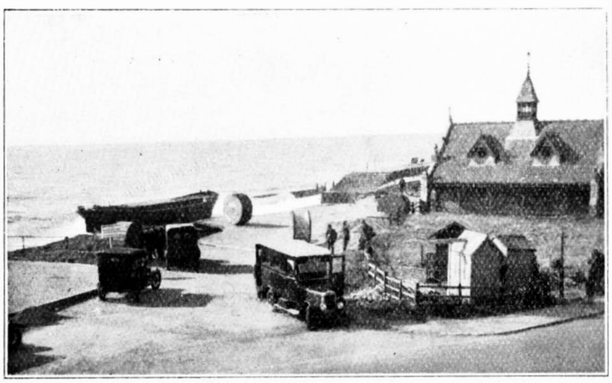


FIG. 7.—TESTING HUTS INSIDE FENCE ABOVE MANHOLE.

armoured and have only one lead sheath. Their make-up is as follows:—

Land Cables.—28 wires continuously loaded, paper core, lead-covered, made up in seven 4-wire units of quad formation. Weight of each conductor approximately 102 lbs. per statute mile. Weight of loading material 29.5 lbs. per statute mile (in the form of two iron wires wound side by side in one layer), 8 mils. diameter. Each conductor is insulated with three spiral lappings of paper, the outer paper of distinguishing colour. Four such insulated conductors are quadded upon a substantial paper centring, and the whole wrapped with an open spiral of paper of distinguishing colour. The colour scheme of conductors and of quads is as follows: R, W with black line, AB pair of quad; B, W, CD pair of quad. Spacing cores of paper are provided between the quads; the arrangement of the quads is one in the centre and six surrounding quads. Two spacing cores separating R_1, B_1 and W_1 are orange coloured; the others are white. The whole cable is fully lapped with paper and enclosed in a lead sheath having a uniform thickness of 0.107 inches, with an overall diameter of 1.42 inches.

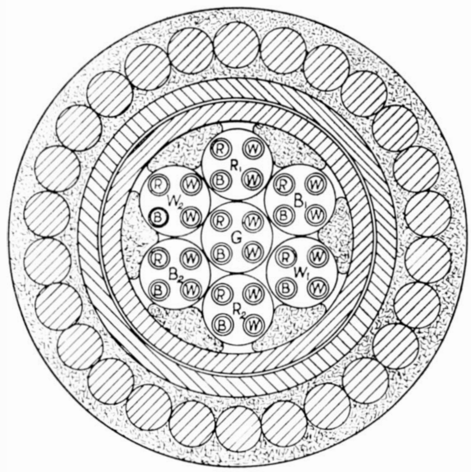


FIG. 8.—CROSS SECTION OF SEA CABLE.

Balancing Arrangements.—After the quads were stranded into the cable, a large number of quads of appropriate length were taken and measured for inductance and alternating current resistance unbalance. From these results quads of the same colour were selected to make up quads equal in length to that of the finished drum length. In selecting the quads, crosses were allowed to be introduced between the wires of individual cores (but no crosses between the cores—since single quads only were dealt with at this stage). In jointing, the copper wire of each conductor is scarfed, the iron loading wire is replaced by copper wire of the same diameter for an inch or two and the whole is then silver soldered. The seven quads of each drum length balanced for inductance and effective resistance were then stranded into a cable in the usual manner. The drum lengths were jointed on the site into approximately $4\frac{1}{2}$ mile lengths, selections being made initially for capacity unbalance and later for impedance unbalance of the cores. The uniform distribution of the line constants with length was arranged for by grading on site.

Tests.—(1) Factory or drum lengths. (*a*) For degree of uniformity (*i.e.*, deviations from a mean value) and average magnitude of primary constants and of Z_o and β at 5000 radians per second. Comparison with results obtained on constants. (*c*) Effective resistance and inductance unbalance of circuits. (*d*) Cross-talk between circuits.

(3) End-to-end Tests. (*a*) D.C. insulation resistance and conductor resistance (loop and unbalance). (*b*) Z_o and β from Z_f Z_c tests of all circuits at 5000 and at 12,500 radians per second. (*c*) β and • from Z_f Z_c tests on representative circuits at five frequencies over range 3000 to 12,000 r.p.s. (*d*) Z_o/f for representative side and phantom circuits over range 3000/125,000

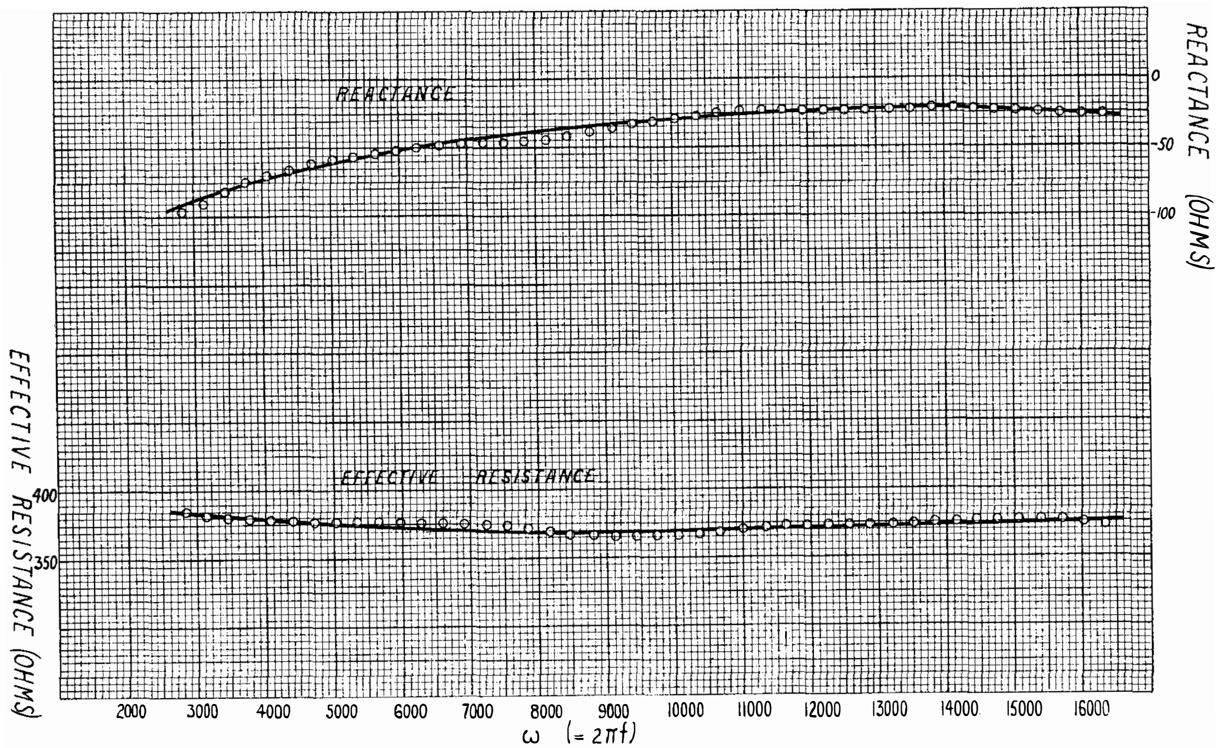


Fig. 9.—Impedance/Frequency Characteristics of Side Circuits. Tested from Canterbury on land length Canterbury-Seabrook.

submarine portion. (*b*) For magnitude of Z_o and β at 12,500 radians per second. (*c*) For magnitude of primary constants at five frequencies, viz., 3000, 5000, 7000, 10,000 and 12,000 radians per second. (*d*) For alteration of inductance after passage of 100 *m*A, D.C. (*e*) Cross-talk between circuits.

(2) Nominal $4\frac{1}{2}$ mile Sections. (*a*) Primary and secondary constants at 5000 radians per second on representative circuits. (*b*) Z_o/f characteristics for uniformity of distribution of r.p.s. from each end. (*e*) Cross-talk between circuits.

Particulars of Land Cable Lengths.

Locality— Canterbury to Seabrook.	Audrecelles to Boulogne.
Total length— $35{,}022\frac{1}{2}$ yds. or 19.9 miles.	16,800 yds. or 9.55 miles.
No. of lengths— 103 of approximately 340 yds. each. 55 tested.	47 of approx. 357.5 yds. All tested plus 1 spare length.
No. of Sections— 4 of mean length 4.95 miles.	2 of mean length 4.77 miles.

Results of Tests on English Side Lengths.

Factory Lengths.

		Side Circuits.	Phantoms.
Average mean values per 2029 yds. at 5000 r.p.s.	R	20.5 ohms	10.1 ohms
	L	12.7 *m*H.	5.99 *m*H.
	C	0.0906 μ.F.	0.2548 μ.F.
	Z_0	385 ohms	158 ohms
	β	0.0278	0.03355
ditto 12,500 r.p.s.	Z_0	374.7 ohms	153 ohms
	β	0.0334	0.0392
Terminated Cross-talk Reed Hummer	S/S	Mean 53, Max. 100.	
	S/+	,, 230, ,, 616.	
	+/+	Less than 10.	
After applying 100 *m*A, D.C.		δL + 0.2%	

Nominal 4½ mile Sections.

		Side Circuits.	Phantoms.
D.C. Res. unbalance. % per Section		Mean 0.05, Max. 0.14.	
Values for certain cores per 2029 yds. at 5000 r.p.s.	R	19.68 ohms	9.64 ohms
	L	12.37 *m*H.	5.73 *m*H.
	C	0.0900 μ.F.	0.2513 μ.F.
	G	1.2 m.mhos.	1.5 m.mhos.
	Z_0	379.7 \8° 45′	154.9 \9° 16′
	β	0.02643	0.03204
Terminated Cross-talk Reed Hummer	S/S	Mean 60, Max. 130.	
	S/+	,, 230, ,, 400.	
	+/+	Between quads 20/70.	

End to end Canterbury to Seabrook.

D.C. Res. Loop 330.9 ohms. Max., 330.3 ohms mean.
,, Unbalance 0.09% Max., 0.027% mean.
,, In. Res. 21,000 megohms per mile.

		Side Circuits.	Phantoms.
5000 r.p.s.	Z_0	382.5 \8° 50′ (CU)	156 \9° 19′ (CU)
	,,	383.0 \8° 32′ (Seabrook)	156.8 \9° 0′ (Seabrook)
,,	β/Naut.	0.0268 (CU)	0.0324 (CU)
	,,	0.0269 (Seabrook)	0.0325 (Seabrook)
Cross-talk. Terminated. *Speech.*	S/S	37/100 (CU)	50/80 (Seabrook)
	S/+	220/350 (CU)	220/350 (Seabrook)
	+/S	307/400 (CU)	299/500 (Seabrook)
	+/+	Nil (CU)	Nil (Seabrook)

The values obtained on the French Land Lengths, Audrecelles to Boulogne, were to all intents and purposes similar to the foregoing results.

Overall Tests—Canterbury to Boulogne.

The following are the results of the principal overall tests made on the cable, including both

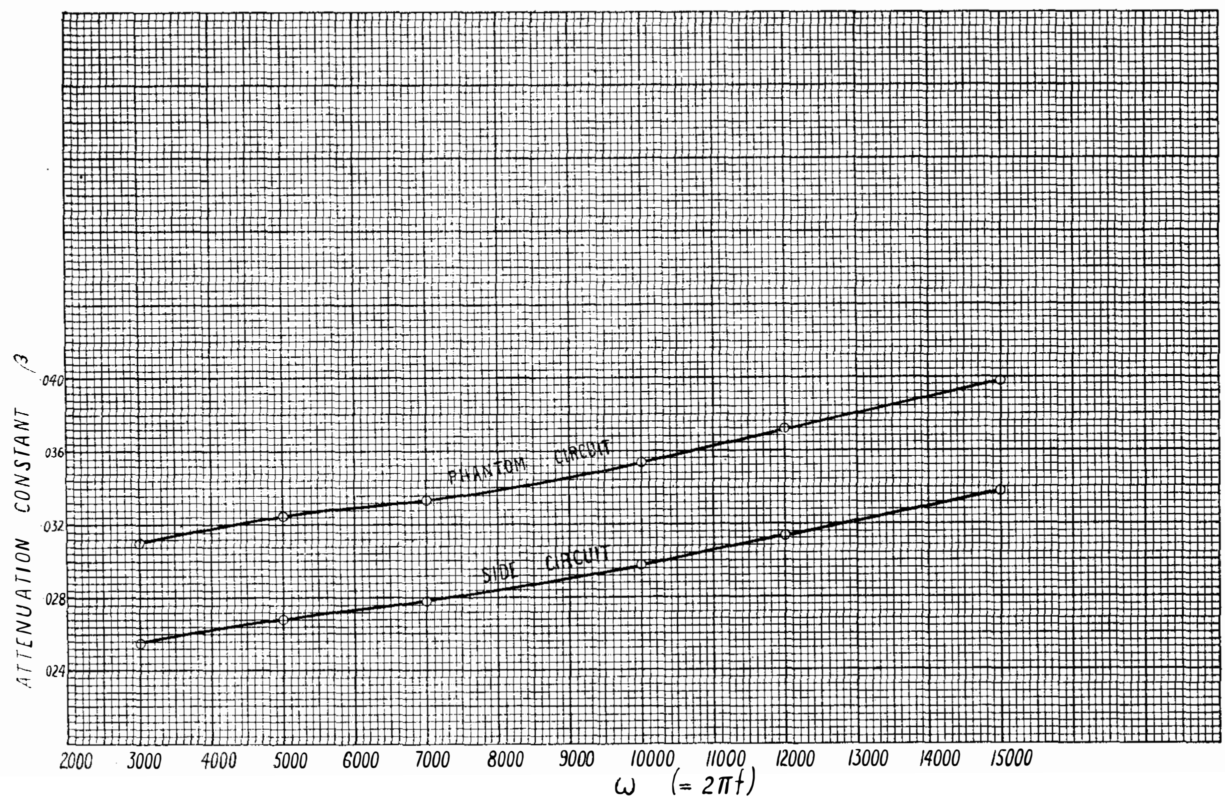


Fig. 10.—Attenuation/Frequency. Tested from Canterbury on land length Canterbury-Seabrook.

land cables and the sea portion, from the two Repeater Stations:—

D.C. Tests.

(1) Mean Insulation Resistance of each core to all the other cores earthed = 40,000 megohms per naut. after 1 minute's electrification.

(2) Mean Conductor Resistance = 9.76 ohms per naut.

(3) D.C. Capacity. Average side circuit capacity = 0.0902 μ.F. per naut. loop.

Average phantom circuit capacity = 0.2720 μ.F. per naut. loop.

A.C. Tests.

(1) Transmission Efficiency and Distortion. Each circuit was measured for its characteristic impedance and attenuation constant from both ends with a testing current of 1 mA at a frequency corresponding to an angular velocity of 5000 radians per second. The mean results are shown in Table I.

TABLE I.

ATTENUATION CONSTANT AND CHARACTERISTIC IMPEDANCE AT $\omega = 5000$ RADIANS PER SEC. FOR LENGTHS OF CABLE = 49.45 NAUTS.

Circuit.	Attenuation Constant per Naut. Loop $\equiv \beta$		Characteristic Impedance in Vector Ohms $\equiv Z_0 \mid\phi_0$.	
	From Canterbury.	From Boulogne.	From Canterbury.	From Boulogne.
Average of the 14 Side Circuits ...	$.0273_3$	$.0273_5$	386.8 $\backslash 8^\circ\ 42'$	375.3 $\backslash 10^\circ\ 0'$
Average of the 7 Phantom Circuits	$.0329_5$	$.0328_7$	157.5 $\backslash 9^\circ\ 34'$	151.7 $\backslash 10^\circ\ 23'$

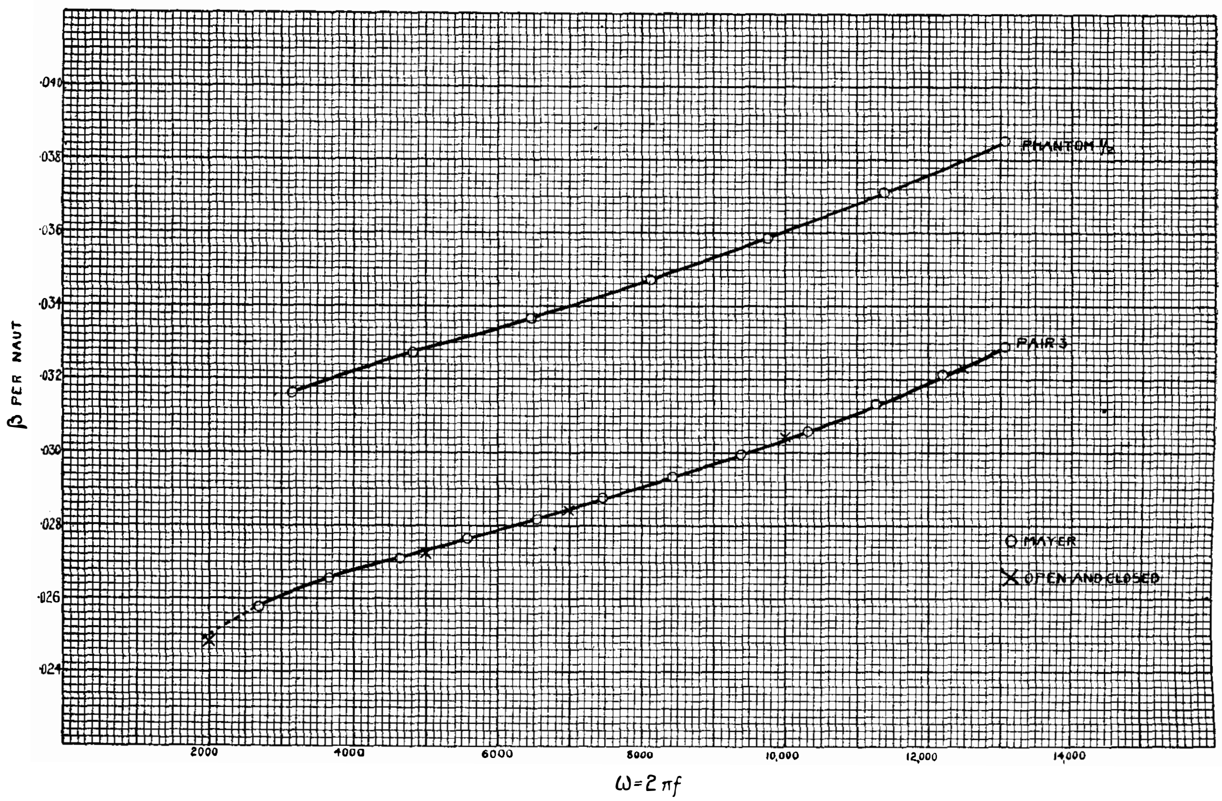


FIG. 11.—VARIATION OF ATTENUATION WITH FREQUENCY. TESTED FROM CANTERBURY BY "MAYER" AND "OPEN AND CLOSED" METHODS, CANTERBURY-BOULOGNE.

FIG. 12.—IMPEDANCE/FREQUENCY CHARACTERISTICS OF PAIR 3. TERMINATED WITH Z_0 OHMS.

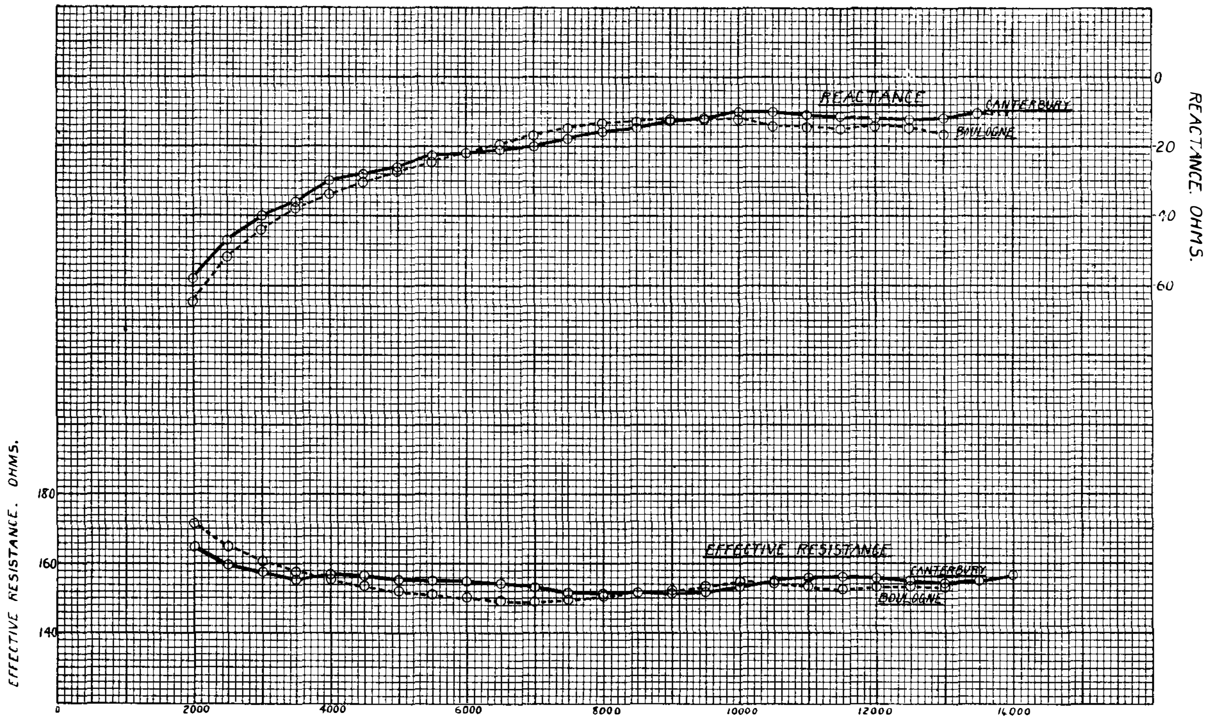


FIG. 13.—IMPEDANCE/FREQUENCY CHARACTERISTICS OF PHANTOM 3/4. TERMINATED WITH Z_0 OHMS.

From Table I. the side circuits of the cable are found to be approximately equivalent to 12.7 M.S.C. and the phantom circuits to 15.4 M.S.C.

The variation of the attenuation constant with frequency for a selected pair and phantom is shown by Table II. and Fig. **11**. This curve was obtained by the Mayer method of measuring attenuation and check tests by the " open and closed impedance " method agreed exactly with these results. From the curves in this figure it can be shown that the mean distortion for the side and phantom circuits between $\omega = 2000$ and $\omega = 12{,}500$ radians per second is equivalent to a βl of approximately .35 or an equivalent distortion of nearly 3.3 M.S.C. in either case.

(2) Uniformity of Electrical Constants. All the circuits were tested for characteristic impedance over a range of $\omega = 2000$ rads. per sec. to $\omega = 13{,}000$ rads. per sec. from Boulogne. The circuits in three quads were similarly tested from Canterbury. Figs. **12** and **13** show typical examples of the variation in Z_0 obtained from each end of the cable on one selected side and one phantom circuit. These curves are drawn to a large scale and the maximum deviation of each from a smooth mean curve is less than $\pm$ 2%, whilst in no case did the variation exceed $\pm$ 5%, the figure guaranteed by the Makers.

(3) Interference Between Circuits. Cross-Talk tests were made with the P.O. apparatus using a Western Electric Cross-Talk Meter which expresses the induced current in millionths of the inducing current.

Table II. shows the cross-talk readings obtained for circuits within each of the seven quads, while Table III. gives the results obtained for cross-talk between quads.

TABLE II.

CROSS-TALK READING FOR CIRCUITS WITHIN QUADS.

Taken with the meter in parallel and the distant end of the cable terminated by its characteristic impedance.

SOURCE OF DISTURBANCE—SPEECH.

Tests from Canterbury.					Tests from Boulogne.				
Speaking on :		Listening on :			Speaking on :		Listening on :		
Quad	Cct.	AB	CD	+	Quad	Cct.	AB	CD	+
1—2	AB	—	130	500	Green	AB	—	100	900
	CD	130	—	500		CD	100	—	800
	+	800	600	—		+	1000	1200	—
3—4	AB	—	70	300	Red$_1$	AB	—	70	400
	CD	70	—	300		CD	70	—	400
	+	400	400	—		+	700	600	—
5—6	AB	—	70	700	Blue$_1$	AB	—	100	600
	CD	70	—	400		CD	100	—	700
	+	800	600	—		+	800	900	—
7—8	AB	—	130	400	White$_1$	AB	—	70	500
	CD	130	—	250		CD	70	—	400
	+	500	400	—		+	800	600	—
9—10	AB	—	100	700	Red$_2$	AB	—	200	500
	CD	100	—	500		CD	200	—	400
	+	900	700	—		+	700	600	—
11—12	AB	—	40	300	Blue$_2$	AB	—	130	500
	CD	40	—	500		CD	130	—	1000
	+	400	700	—		+	800	1100	—
13—14	AB	—	70	350	White$_2$	AB	—	130	300
	CD	70	—	300		CD	130	—	500
	+	500	450	—		+	500	600	—

Table III.

CROSS-TALK BETWEEN QUADS.
END CONDITION AS IN TABLE II.
SOURCE OF DISTURBANCE—REED HUMMER.

Circuits under Test.	Maximum Reading obtained on Cross-talk Meter.	
	From Canterbury.	From Boulogne.
Side to Side ...	100	100
Side to Phantom or *vice versa* ...	40	160
Phantom to Phantom ...	<20	40

The Specified Maximum Values of Cross-Talk for the Submarine Portion were as follows :—

	Divisions on Cross-talk Meter.
Side cct. to Side cct.	400
Side cct. to Phantom cct. ...	2000
Phantom cct. to Phantom cct....	400

The complete cable from Canterbury to Boulogne, which will form the main trunk route to Paris and southwards, was manufactured and laid by Messrs. Siemens Bros., Woolwich, who also carried out all the tests on the French land side. Mr. A. Morris of the Research Section was present during the final runs at the request of the French Administration. To him and to Mr. W. T. Palmer the author is indebted for much of the information contained in the foregoing; the photos of the French side were taken by Mr. J. McA. Owen, who also assisted in the final tests with Messrs. Morris and Palmer.

W.C.

NOTES & COMMENTS

THE change in size of the Journal, which was introduced with last issue, has been received with almost general favour and we have to thank our many friends, personal and professional, for the expressions of approval and goodwill that have been extended to us in our new venture. It is to be regretted that several press notices, while congratulating the Board of Editors on the improved format, omitted to mention the very important point that at the same time our subscription had been reduced from six to five shillings per annum.

Members of the old brigade of P.O. engineers will have heard with very sincere regret of the death, on the 3rd of May, of Mr. H. Hartnell at the good old age of eighty-one years. He was one of the original members of the Board of Editors of this Journal and on his retirement in 1911 he was created a honorary member of the I.P.O.E.E. for his services in connection with the Institution. Always a worker, Mr. Hartnell continued to test materials for the Colonial services right up almost to the end and it was perhaps this life interest that enabled him to enjoy his pension for so long. The following extracts are taken from the notice on his retirement which appeared in our April, 1911, issue:—"The Engineer-in-Chief's Office loses one of its ablest officers, and his colleagues one of their best personal friends. . . . Of Mr. Hartnell's services during the twenty-seven years he worked in the Engineer-in-Chief's Office it is perhaps unnecessary to say much, as they are well known and highly appreciated. There was scarcely any class of work in which he was not more or less closely in touch, and the benefit of his ripe experience was constantly sought. At the head of the 'Examinations' Section he had a large staff to control and very responsible duties to perform. Not only did these duties relate to the examination of physical bodies, but also to the examinations of members of the Commercial Staff for double increments and for promotion. Mr. Hartnell was particularly qualified for the task in view of his sound knowledge and tactful character. His knowledge of all matters in connection with cable (both submarine and underground) construction was extensive and thorough, and the mileage which passed under his personal observation reached an astonishing figure; indeed, his knowledge in this respect resulted in his being appointed a member of the Standard Committee."

We have received from Mr. E. H. Bennett, Manager and Engineer, a copy of the Balance Sheet, Revenue Statement and Statistics, of the Guernsey States Telephone Department for the year ended 31st December, 1926. The department appears to be in a very healthy condition. The number of subscribers' lines shows a regular yearly increase from 217 in 1898 to 3302 at the end of last year; the overhead metallic mileage in the same period rose from 146½ to 2434¼, while the underground metallic mileage rose from 2½ to 4486. The number of employees in the service of the department, starting with a total of 24 in 1898, has increased to 86. The Revenue Account for the year shows the same satisfactory result. After meeting working expenses, overheads, depreciation and sinking fund charges the account shows a balance of nett profit for the year of £762. The capital is made up of States 3% Loan (1905) £32,000, of which some £8,253 has been redeemed; States 5% Loan (1920), amount subscribed £27,150, of which £2,500 has been repaid; and States 4½% Loan (1925), amount subscribed £15,000, of which £200 has been repaid. The liabilities are fully covered by the certified plant, buildings, etc., in situ, by cash and by £9,000 5% War Loan.

Television is following rapidly on the heels of wireless. On the 7th April a public exhibition was given by engineers of the Bell Telephone Laboratories in Bethune Street, New York City, with remarkable success. The receiving apparatus was switched on to a trunk line, and an address was delivered by Secretary Herbert Hoover, in Washington over 200 miles away, which was heard well on a loud speaker, while every line and movement of Mr. Hoover's face was seen on a screen synchronising perfectly with the words. Further demonstrations were carried out between the laboratories and the experimental station at Whippany, New Jersey. While these experiments were demonstrated over line wires, there is nothing really to prevent their repetition by radio means, and the time is rapidly nearing when a wireless receiving set at home can be equipped with a screen on which the face and movements of the speaker will be seen as clearly as the sounds are heard now. Mr. J. L. Baird in this country has also been successful in his efforts in the same direction.

Mr. Frank G. Baum, a consulting engineer for the Westinghouse Electric and Mfg. Coy., has patented an arrangement whereby he claims to have solved the problem of transmitting economically large amounts of electric power over distances of several hundred miles. The invention " covers the connection of a plurality of automatically regulated synchronous condensers at suitable intermediate points directly to a high-voltage transmission line." These so-called synchronous condensers are really special motor-alternators operated from the line which automatically regulate the electrical characteristics of the line itself and change the capacity of the system in accordance with requirements to maintain constant voltage with varying power demands. With the development of the Shannon scheme in Ireland, the Lochaber hydro-electric development in Scotland and the start about to be made by the Electricity Commissioners in the Central Scotland area, the necessity for maintaining the voltage of the grid constant with widely-varying loads is at once apparent, if the advantages of standardisation are to be fully secured in this country. Mr. Baum speaks confidently of the coming of a power line which will be fed from the water power of the Rockies and will serve economically the electrical requirements of the Mississippi Valley.

We regret to announce the death of Mr. W. H. Winny, O.B.E., Assistant Staff Engineer, Test Section, who was just entering his sixtieth year. He has been suffering from ill-health for some time and passed away in a nursing home on the 31st of May. He was an enthusiastic officer of the St. John's Ambulance Association, and did very good work during the trying period of the air raids. We hope to give a fuller sketch of his career in our next issue.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

Following works have been completed:—

Exchange.	Type.	No. of Lines.
Harrogate	New Auto.	2600
Chesterfield	,,	925
Staveley	,,	50
Halifex	,,	3100
Attercliffe	,,	1000
Ecclesfield	,,	200
Oughtibridge	,,	100
Woodhouse	,,	200
Brighton	,,	3360
Hove	,,	2940
Rottingdean	,,	130
Preston	,,	740
Portslade	,,	214
Morningside	,,	2340
Murrayfield	,,	1600
Newington	,,	1980
Sloane M.F.	,,	
Portsmouth	Auto. Extn.	4 Posns.
Wallington	Manual New.	2900
Newcastle Relief	,,	2140
Dartford	,,	530
Sheffield	,,	50 Posns.
Wellington (Salop)	,,	480
Mill Hill	Manual Extn.	760
Nelson	,,	260
Jesmond	,,	520
Carlisle	,,	400
Birmingham, North	,,	960
North (London)	,,	1300
Darlaston	,,	40
Blackpool	,,	1600
Enfield	,,	760
Birmingham, South	,,	1360
Barnet	,,	760
Weston-Super-Mare	,,	460
Birmingham, East	,,	380
Palmers Green	,,	1630
British Xylonite	P.A.B.X.	10
Greatrix, Junior	,,	30
Blackley Co-op.	,,	30
Calico Printers	,,	40
Maypole Dairy	,,	80
Britannia Assn.	,,	40
Leyland Rubber	,,	30
Bury Co-op.	,,	50
Illustrated News	,,	70
Connolly's	,,	30
Vickers	,,	160
Carpet Manufacturers ...	,,	40
Player & Sons	,,	80
Kaye & Sons	,,	60
Royal Arsenal Co-op.	,,	60
Macclesfield Co-op.	,,	30
Reading Bd. of Guardians ...	,,	30
Sheffield Corporation	,,	130
Hove Council	,,	50
Castener Kellner	,,	70
Beswick Co-op.	,,	40
Monks Hall & Co.	,,	30
Bristowe Tarvia	,,	60
Beattie's	,,	30
Dorset Council	,,	60
Taylor & Co.	,,	30

Orders have been placed for the following new Exchanges:—

Exchange.	Type.	No. of Lines.
Metropolitan	New Auto.	9500
Lofthouse Gate	,,	100
Cosham	Auto. Extn.	200
Roundhay	,,	850
Ecclesfield	,,	90
Headingley	,,	500
Shrewsbury	,,	300
Chapletown	,,	810
Hurley	,,	30
East Grinstead	Manual New.	460
Bishops Stortford	,,	460
Rainham	,,	740
Horsham	,,	720
Garston	,,	1400
Goole	,,	500
Sutton	,,	4880
Harpenden	,,	700
Cobham	,,	600
East (London)	Manual Extn.	1410
Lee Green	,,	2240
Doncaster	,,	340
Walton (Liverpool)	,,	420
Wilmslow	,,	340
Maryland	,,	1340
Monks Hall & Co.	P.A.B.X.	30
Burris & Sons	,,	30
Vickers Sons & Co.	,,	30
Berkshire Hospital	,,	50
Bristowe Tarvia	,,	60
Butlers	,,	30
Beattie's	,,	30
Synthetic Ammonia	,,	200
Trades Union	,,	100
Lipton's Ltd.	,,	100
Taylor, W. T.	,,	30
Shell Mex (N. on T.)	,,	20
Carlisle Co-op.	,,	30
Asquith, Wm.	,,	30
Harrods Stores	,,	670
,, Estates	,,	50
Cumberland Council	,,	40
Hall, J. & E.	,,	100
Union Cold Storage	,,	40
Liverpool Warehousing Co. ...	,,	60
Heinmann	,,	30
Salter, G.	,,	40
Lunn's Tours	,,	20
Shell Mex (Stroud)	,,	40
Accles & Pollock	,,	50
Goodyear & Sons	,,	30

THE THIRD CONFERENCE OF THE INTERNATIONAL ADVISORY COMMITTEE ON LONG DISTANCE TELEPHONE COMMUNICATION.

THE annual conference of this Committee (referred to elsewhere as the "C.C.I.")* was held in Paris from the 26th November to the 6th December, 1926.

M. Milon, the re-elected president, emphasised the increased importance of the Committee, resulting from its recognition by the International Telegraph Union, whereby the C.C.I. membership will embrace delegates from other than European countries. In view of the objects of the Committee in organising the extending international telephone communication, the admission of delegates from other Continents for participation in its work is the natural result of the increasing range of commercial telephone communication.

The work of the conference was undertaken in sections as hitherto, and a summary of the recommendations of the Committee is given hereafter.

General Organisation.

It was agreed by the Commission on General Organisation that the C.C.I. shall comprise the General Assembly, a General Secretary elected by the assembly, and a series of commissions of reporters (" rapporteurs "); that the plenary assembly shall meet annually and that all delegations shall have the same voting power.

The full assembly will determine the work of the commission of reporters, nominate the administrations participating, and undertake the duty of accepting, rejecting or modifying all reports presented by those commissions. Further, it will appoint the General Secretary and three Auditors. The commissions are authorised to invite experts in the telephone industry to participate in their deliberations.

In addition to the regular secretarial duties, the General Secretary is authorised to take part, when desirable, in the meetings of the commission, and is also charged with the duty of collating their reports; and circulating them to all administrations adhering to the C.C.I., at least one month before each annual meeting of the full assembly.

* *Comite Consultatif International des Communications telephoniques a grande distance.*

Telephone Engineering Sub-Commission.

This sub-commission, under the presidency of the Engineer-in-Chief of the British Post Office, issued recommendations of importance in connection with matters of standardisation and maintenance. The decision to establish a European master reference standard of telephone transmission in Paris for the calibration of the working standards of the various administrations is evidence of the standardisation which is resulting from the committee's labours. The equipment, which is a replica of the apparatus constituting the Bell system standard is being constructed in America and should be installed in the Autumn of this year.. In connection with a standard unit for expressing measurements of transmission, it was not possible to arrive at unanimous agreement upon the adoption of either the natural or the decimal logarithmic telephone transmission unit. Each Administration is therefore left free to use either of these units in its internal and international relations, and no Administration has the right to demand the exclusive use of the unit it has adopted. In due course, the British standard mile will be replaced by one of these units. It was agreed that in technical literature, and in the documents of the C.C.I. in particular, transmission equivalents, losses, or gains shall be expressed in both units.

The committee has now rigorously defined most of the expressions used in telephone transmission problems, and its recommendations now embrace every aspect of international line construction, maintenance and supervision. Unanimous agreement was reached upon most of the questions referred for study by the previous assembly. These recommendations included the method of expressing frequency, the limits of overall attenuation on international circuits at 800 p.p.s. under all conditions of service, and the total permissible losses in the connection of a subscriber to his international exchange. The recommendation has particular regard also to the quality of speech, in that the transmission frequency characteristics must be made to conform to prescribed limits by the use of attenuation equalisers and by the use of specified types of loading. The use of echo suppressors was recommended for circuits exceeding specified lengths which had been determined experimentally.

The administrations were invited to study the "transient" problems that arise in connection with circuits of greater length than 800 km. In this connection the suggestion of the German Administration to consider the limitation of the transmitted frequency range, with a view to "transient" elimination, is of interest.

Particular attention was directed to the homogeneity of international circuits and particularly to the preservation of uniform line characteristics between adjacent repeater stations. Limits were agreed upon for the terminal impedance of international circuits.

It was recommended that all subscribers' telephones used for international calls shall be tested once each year and investigations are in progress with a view to obtaining uniformity in the testing methods employed.

The recommendations in connection with the maintenance and supervision of international circuits do not present any feature not already embodied in the existing instructions upon the maintenance of Post Office aerial and repeater trunk circuits, except that noise and cross-talk limits are imposed. The tests to be employed are clearly prescribed and scheduled and particular attention is directed to the restoration of service by the replacement of defective sections of circuits by other lines with suitable transmission characteristics.

The possibility of use of international circuits for relaying radio transmission was considered and the necessary transmission characteristics of lines for both music and speech transmission are announced.

The study of simultaneous telegraphy and telephony in cables and particularly the development of international voice frequency telegraph systems is proceeding.

The existing publications of the C.C.I. on engineering matters were revised and have since been reissued in a volume known as the "Livre blanc." This volume, with its annexes and bibliography, forms a most valuable treatise on modern telephone engineering practice. An English translation of the Engineering Section will be issued shortly.

The Sub-Commission on Traffic and Exploitation.

Under the presidency of Mr. Van Embden (Holland) the traffic sub-committee reviewed all previous recommendations and the rules governing transit traffic were passed without material modification. A number of practical administrative and traffic questions were also discussed outside the formal committee meetings.

Protection of telephone lines from extraneous interference.

Dr. Breisig (Germany) presided over the meetings of the sub-commission dealing with protection against power circuits. The questions arising out of inductive interference and allied matters involved consideration of so many reports that the discussion of reports referring to the protection of lead covered cable against the effects of electrolytic and chemical action had to be postponed for consideration at the next conference.

The question of inductive interference involved the consideration of acoustic shock, induced charges from insulated power networks, electro-magnetic effects produced by short circuits on power systems, the characteristics of harmonics produced by machines of continuous current traction systems, inductive noise limits in overhead telephone cables, the effects of earthing the neutral points of 3-phase power systems and the importance of arranging for the reliable conductivity of the rails on electric traction systems using single and polyphase currents.

Exhibition of Telephone Equipment.

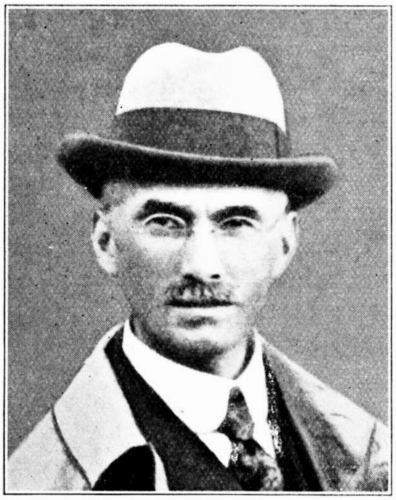
An exhibition was held with a view to presenting the latest technical developments in the equipment employed in long distance telephony. The British Post Office exhibit included many of the devices which have been referred to and described in the reports of the C.C.I.

The relations between the delegates were most cordial and the progress achieved has been very rapid and is a happy augury of the future of long distance telephony.

The Commission's recommendations and details of the various limits imposed will form the subject of short articles in future issues of the Journal.

RETIREMENT OF MR. M. RAMSAY.

To those engineers who have grown up, as it were, with the Post Office Telephone Service, the retirement of "M.R." came as a shock would come to a building which had been suddenly bereft of one of its main members. No engineer had been so intimately and so long associated with the development of the apparatus side of the telephone service as Mr. Ramsay. Since the days when Sir John Gavey came back from America with the C.B. system in his pocket the initials "M.R." can be traced on the official diagrams, right through the series of P.C., C.B.S., C.B. and Auto. It is perhaps in connection with the C.B. circuits and exchanges that Mr. Ramsay was best known to the outside



MR. M. RAMSAY.

engineer, although he had mastered the intricacies of the latest automatic practice as thoroughly as he had assimilated the C.B., and in his capacity as Staff Engineer in charge of the Equipment Section he was responsible for the equipment and installation of all exchanges, manual and automatic, erected by contractors for the last twelve years.

When the P.O. started the telephoning of London, his old digs in Colebrook Row was open house to all interested in telephone matters and he freely communicated the information which he himself appeared to acquire so easily. His open-handedness in this respect was continued right up to the end, for after his return from America he gave a series of lectures to his staff and distributed complete sets of diagrams of the Panel system developed in the States and which at one time loomed large on our own horizon. He never spared himself, either on behalf of the Department or of the staff, and it is not going too far to say that had he been less of a stickler for duty he would have been stronger in health to-day. That was, however, always Magnus's way. His job was his first thought—get on with the work and play afterwards. He was always ready to take on a difficult piece of work which others had attempted and many laborious nights he spent in producing "clean" and reliable circuits and methods out of chaos.

Mr. Ramsay entered the P.O. service as a telegraph messenger at Aberdeen in 1885 and in 1890 he was appointed telegraphist in the same office. He was not content to remain in that capacity and devoted most of his spare time to studying technical subjects. He kept fit by walking and running long distances with the local P.O. harriers. He just missed winning the Long Distance Championship of the North of Scotland by inches in a stirring race in the spring of '95. He began his career in the Engineering Department as a Junior Clerk in Scotland West in 1896 and three years later he was transferred to a 3rd Class Clerkship in the E.-in-C.'s Office. In 1901 he was promoted to the rank of Second Class Engineer, and in 1904 he took first place in a keenly contested examination for the post of Second Class Technical Officer. In the same year those officers received a new stock description and became Staff Engineers Second Class, while later, in the re-organisation of 1911, the same men were re-christened Assistant Staff Engineers. During this period Mr. Ramsay was attached to the Telephone Section, but when the Company was acquired the Designs Section took charge of exchange equipment, specification and installation work, and Mr. Ramsay was placed in control of the group. The work grew to such an extent that a separate section—now one of the largest at headquarters—was formed in 1915 with Mr. Ramsay as Staff Engineer in charge. The decision of the Department to introduce automatic working in the provinces, and later in London, involved a tremendous amount of work and the Equipment Section grew in response—although the growth of the staff was, we are afraid, always lagging in phase behind the work. Heavy responsibility was thrown on the head of the section, but it was never shirked.

Strenuous work on committee in connection with the development of the London schemes and a trip to the United States to study and report on the Panel and other systems were features of the last few years. The trip to America did him little good from the health point of view, as he was suffering from a severe cold at the time and the climatic conditions of the States were not then at their best. Shortly after his return Mr. Ramsay tried a spell in the King Edward Sanatorium at Midhurst, but the improvement was only temporary. His health gradually grew worse, and after struggling gamely, as was his wont, for months he had to give up and retired from the service on the 22nd March, at the age of 56. While at Glasgow Mr. Ramsay was C. and G. Medallist in Honours Telephony and in 1900 he repeated his success and won the Silver Medal in Honours Telegraphy. For the past few years prior to his retirement he was examiner for the City and Guilds Telephony examinations.

By his staff he was admired and loved. Strangers may have considered him reserved, and even taciturn at times, but this trait is only a shell that shelters a most kindly, straight and strong personality. The writer of this all too brief notice has been a privileged friend since the salad days and he can say with assurance that in all these years he never knew Magnus to perform a single action which was not clean and without guile. Mr. Ramsay was quietly proud of his profession and it is doubtful whether there is a telephone engineer in the world with a wider knowledge and a stronger grip of the problems involved in the provision of modern exchange equipments.

His staff was anxious to give him some token of the regard in which he was held and as he has many friends scattered all over the service they were invited to participate. As a result Mr. Ramsay was presented privately, on the 6th May, with a gold English lever watch, suitably inscribed, and a gold bracelet watch for Mrs. Ramsay. His son, who is an Honours B.Sc. of London University, was second in the last open competition for Probationary Assistant Engineers, and his daughter, also an Honours graduate in Arts of London, is completing a course at Cambridge.

Since he was relieved of the strain at the Office Mr. Ramsay has taken things quietly, and he has certainly not gone backwards. After a life of service, hard enough in the early days, we know, and always faced with a cheery equanimity even when the work was heaviest and the physical frame on the verge of breaking down, it is surely not too much to hope that his indomitable spirit will yet have its reward in many years of ease and tranquility.

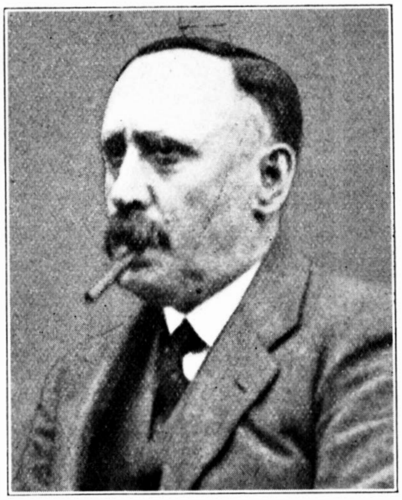
W.C.

MR. H. A. McINNES.

HAD he lived another twelve months Mr. McInnes would have entered his sixtieth year and been looking forward to a whole time devotion to his favourite hobby, the improvement of gramophone sound boxes. This was not to be, however, and to the sincere regret of his many friends he passed away on the 11th January.

Shortly after he joined the Designs Section in 1924 it became evident he was not in a good state of health and that it was only his indomitable courage which enabled him to remain on duty. In 1925 he underwent a serious operation and from this he really never recovered. The untimely deaths of his colleagues and near neighbours, Messrs. J. H. Thow and W. Pennington, came as a severe shock and tended to depress his naturally cheery disposition. It is also probable that the change from the active life of a country section to a sedentary job at headquarters had its effect.

Mr. McInnes began his official career in Hull, that nursery of British P.O. engineers, and from a learner in 1883 he graduated as telegraphist in 1885. He entered the Engineering Department as a Junior Clerk in the N.E.



THE LATE MR. H. A. McINNES.

District in 1891 and seven years later he succeeded Sir William Noble (then of course Mr. W. Noble) as Second Class Engineer at Aberdeen. He was promoted to First Class Engineer at Oxford in 1905 and Executive Engineer on the revision in 1911. He was therefore in the City of Colleges for nearly twenty years and took full advantage of the educational facilities and higher social life which a University town affords. His son, N. A. McInnes, B.Sc., was a well-known figure in the University for years and represented his 'Varsity in many athletic contests, his special forte being the 3 miles foot race, at which distance he was for several years unequalled. He is now in the service of the Morris Car firm and making good there as he did on the running track. A daughter remains with Mrs. McInnes to mourn the loss of one of nature's gentlemen.

J.J.M.

LONDON DISTRICT NOTES.

DURING the quarter ended 31st March, 1927, the nett increase in the number of Exchange lines and extensions were respectively 8234 and 6132.

MILEAGE STATISTICS.

The following changes have occurred during the March quarter :—

Telegraphs.—A nett decrease in open wire of 24 miles and a nett increase in the underground of 29 miles.

Telephones (Exchange).—A nett decrease in open wire (including Aerial Cable) of 1,471 miles and a nett increase in underground of 84,157 miles.

Telephones (Trunk).—A nett decrease in open wire of 41 miles and a nett increase in underground of 2,212 miles.

Pole Line.—A nett increase of 31 miles, the total to date being 5,665 miles.

Pipe Line.—A nett increase of 650 miles, the total to date being 8,554 miles.

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

Telegraphs	24,609
Telephones (Exchanges)	1,989,575
Telephones (Trunks) ...	66,307
Spares	114,500

INTERNAL CONSTRUCTION.

A new Exchange was opened at *Wallington* on the 16th March last with the transfer of 1200 lines. The work was completed in advance of the original scheduled date and was carried out without a single fault being recorded.

An extension of the *Enfield* Exchange, which was commenced on the 11th January last, was completed and brought into use on the 13th April.

An extension of 600 lines is being carried out by the Standard Telephones and Cable Company at *Reigate* Exchange. The work was commenced on the 13th April last and completion is anticipated early in August.

The Contractors' work at *Holborn Tandem* Exchange is completed and the equipment is now under test. The first 79 positions have been allocated for experimental traffic to 33 Manual Exchanges where the C.C.I. apparatus has been completed.

Progress is being made with the 5 Automatic Exchanges under construction in the District

—*Holborn, Bishopsgate, Sloane, Western* and *Monument.* It is anticipated that the three first-named Exchanges will be brought into public service during the year. The changing of subscribers' apparatus in connection with these three exchanges is well in hand.

TELEGRAPHS.

Pneumatic Tubes in New Grand Stand at Epsom Racecourse.—A system of pneumatic tubes has been installed in the new Grand Stand at Epsom Racecourse. A 3″ gravity tube linking up the Press Gallery on the 3rd Floor with the Telegraph Office on the 2nd Floor has been fitted, and a 1½″ tube, capable of working in both directions, has been installed between the Members' Counter on the Ground Floor and the Instrument Room. It is anticipated that the system will be extended at a later stage, when an electrically-worked blower will supersede the hand-operated pump.

Kiosks.—During the past two months 40 Kiosks No. 2 have been erected in the London Engineering District. The brilliant colour of the Kiosk is a welcome one and is a stage towards the realisation of the "Brighter London" ideal.

R.A.W.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

The Annual General Meeting of the Institution was held at the Institution of Electrical Engineers, London, on Tuesday, May 10th, 1927.

The Chair was taken by the President, Col. T. F. Purves, M.I.E.E.

The business included the following items:—

1. Presentation of Annual Report of Council.
2. Presentation of Statement of Accounts for Year 1926-27.
3. The Annual Report and Statement of Accounts were accepted.
4. Vote of thanks to retiring Members of Council passed.
5. Presentation by President of Medals for Session 1925-26, and Booth-Baudot Award.

MEDALS FOR SESSION 1925-26.

In view of the fact that three medals only were awarded for Session 1924-25 the Council decided to make five awards for the Session 1925-26 as follows:—

Senior Silver Medals to Messrs. E. S. Ritter and G. P. Milton, for Paper No. 110 on "Testing of Telephone Circuits and Apparatus with Alternating Currents."

Senior Bronze Medal to Mr. F. O. Barralet, for Paper No. 108 on "Some Applications of Optical Methods to the Examination of Engineering Materials."

Junior Silver Medals to Capt. H. Hill, for Paper No. 105 on "The Engineering Aspect of Telephone Exchange Accommodation," and to Messrs. G. F. O'dell and W. W. Gibson, for Paper No. 107, "Automatic Trunking—in Theory and Practice."

Junior Bronze Medal to Mr. F. Johnston, for Paper No. 102, on "The Law of Contract in relation to P.O. Engineering Contracts."

BOOTH-BAUDOT AWARD 1926-27.

Mr. A. T. Sadler's suggestion for a new design of platen holder for Morkrum Teletype No. 2A has been adopted by the Department, and for this device he was presented with the award for the year.

PRINTED PAPERS.

The following is a list of the printed papers issued to the Membership during the year:—

No. 102. "Law of Contract in relation to P.O. Engineering Contracts," F. Johnson, A.C.I.S.

No. 103. "Automatic Switching Methods in Multi-Exchange Systems," H. H. Harrison, M.I.E.E.

No. 104. "Cable Testing," E. S. Ritter, D.F.H., A.M.I.E.E.

No. 105. "The Engineering Aspect of Telephone Exchange Accommodation," Capt. H. H. Hill, B.Sc., M.I.E.E.

No. 106. "Notes on Cabling Work and Labour Saving Tools," R. C. Balcombe, A.M.I.E.E.

No. 107. "Automatic Trunking—in Theory and Practice," G. F. O'dell, B.Sc., A.K.C., M.I.E.E., and W. W. Gibson.

The following papers are in the press and will be issued shortly:—

No. 108. "Some Applications of Optical Methods to the Examination of Engineering Material," F. O. Barralet, M.Inst. Metals, A.M.I.E.E.

No. 109. "The Problem of Flexibility in Subscribers' Cable Distribution," Harvey Smith.

The Annual Meeting was followed by a meeting of the London Centre at which a paper was read by Mr. C. W. Brown, A.M.I.E.E.

The paper read by Mr. Brown was on "Some Notes on Automatic Working," of which the following is a brief summary:—

P.B.X. arrangements in Automatic Exchanges.

Large groups, Medium groups, Small groups — Standard schemes.

Use of divided multiple on small groups.

Small groups, Large groups — Siemens No. 16 system.

Night service arrangements.

The facilities explained were demonstrated on a working equipment very successfully by Mr. Brown.

COUNCIL FOR THE YEAR 1927-28.

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. J. Cowie.
Provinces: Mr. S. Upton.

,, Asst. & Second Class Engineers—
London: Mr. P. G. Hay.
Provinces: Mr. A. E. White.

,, Chief Inspectors—
London: Mr. J. D. Boulton.
Provinces: Mr. A. S. Carr.

,, Clerical Staff—
London: Mr. E. T. Larner.
Provinces: Mr. H. Longley and Mr. H. Willcock.

,, Inspectors—
London: Mr. C. W. Messenger.
Provinces: Mr. Thos. Davidson.

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

Secretary—Dr. R. V. Hansford.

LOCAL CENTRE NOTES.

SOUTH LANCS. CENTRE.

Since the last notes were forwarded from this Centre the proceedings for the 1926-27 session have been completed. The further papers read are as follows:—

1926.

Dec. 6th. "Economics of Line Plant Provision." H. Kitchen, M.I.E.E.

1927.

Jan. 17th. "Motor Transport." T. Kenyon.

Feb. 7th. "Problems in large Underground Works." J. Cleaver, A.M.I.E.E.

Mar. 7th. "Voice Frequency Telegraphs." W. Cruickshank, M.I.E.E.

The high standard attained by authors of papers read before this Centre during recent years was fully maintained and the lectures by experts from the Engineer-in-Chief's office were specially appreciated. The paper by Mr. W. Cruickshank on "Voice Frequency Telegraphs" proved to be of outstanding interest, both to the local membership and to the considerable number of visitors from the Surveyors Staff and Engineering firms who honoured us by their presence. Mr. Cleaver's paper dealing with difficulties encountered and surmounted in connection with Manchester Main Automatic Duct Scheme was also particularly interesting and instructive.

The programme included a further paper on "Telephone Repeaters, Operation and Maintenance," by Mr. J. E. Statters, but it is regretted that owing to the illness of the author he was unable to complete it in time for this session. It is hoped, however, that he will visit Manchester to read it early next session.

On March 16th the members visited the extensive works of the British Insulated Cable Co., at Prescot. Approximately 90 participated in the visit and as access to the works is not very convenient by rail the parties were conveyed by motor char-a-bancs and buses from Manchester and Liverpool respectively.

The proceedings of the session were on the whole very successful, but a gloom was cast over the later meetings by the knowledge of the very serious illness of the Chairman, Mr. W. J. Medlyn, who was stricken with pneumonia on January 19th. (Mr. Medlyn has now happily recovered). The last I.P.O.E.E. Meeting at which he presided this session was that of January 17th, when Mr. T. Kenyon read his paper on "Motor Transport." At the subsequent meetings the Chair was ably filled by the Vice-Chairman, Mr. T. E. Herbert, who on each occasion expressed the very genuine regret of everyone at the circumstances which precluded the Chairman from officiating as usual. This was endorsed by a unanimous vote of sympathy coupled with the wish for his speedy recovery, which is recorded in the minutes of the meeting on February 7th.

The Local Committee for the session 1927-28 will be constituted as follows:—

Chairman: W. J. Medlyn.
Vice-Chairman: T. E. Herbert.
Executive Engineers' Representative: C. Brocklesby.
Assistant Engineers' Representative: R. C. Balcombe.
Chief Inspectors' Representative: A. Kemp.
Inspectors' Representative: R. J. Vernon.
Draughtsmen's Representative: J. C. Beaumont.
Clerical Representative: J. Mawson.
Librarian: W. N. Whittaker.
Local Secretary: C. E. Morgan.

NORTHERN CENTRE.

The last meeting of the Session was held at West Hartlepool on the 8th March, when Messrs. W. A. Nicholson and R. Parker read a paper on the "West Hartlepool Exchange Transfer." Prior to the meeting the members, to the number of 83, were marshalled into conveniently sized groups and shown over the new Automatic Exchange (Siemens No. 16). Experts, stationed at suitable points, explained the operation of the apparatus and the visit was thereby made as interesting and instructive as possible.

A description of the transfer from Magneto to Automatic switching at West Hartlepool was given in the January issue of this Journal. The joint paper of Messrs. Nicholson and Parker, who contributed the External and Internal portion respectively, dealt in a detailed manner not only with the actual transfer operations but with the organisation which was evolved to ensure that all preliminary steps received prompt and adequate attention. Particulars were given of the various means adopted for maintaining steady progress and for ensuring satisfactory results. The paper was illustrated with lantern slides and should be invaluable to members for reference purposes.

After the meeting a pleasant social gathering took place at Birks's Cafe, where the members partook of light refreshments.

SCOTLAND EAST CENTRE.

Session 1926-1927.

The Session was opened on 30th November by Mr. J. Innes, B.Sc., with a descriptive paper on "Messrs. Siemens' Automatic Impulse Sender." The paper provides a useful addition to the literature on Automatic Telephony and is reproduced in this Journal. The Local Committee were particularly indebted to Mr. Innes for filling a vacant date at only a week's notice. Mr. Innes's paper appears elsewhere in this issue.

Much valuable and helpful information was given in a paper on "Reports," read by Mr. J. D. Taylor, M.I.E.E., on 21st December. The paper was illustrated by lantern slides. These showed certain fundamentals applicable in all cases of report writing. Specimen cases also were illustrated and it was perfectly clear that, by proceeding along the lines indicated, much of the difficulty in preparing satisfactory reports would be overcome, and the number of papers referred back for additional information minimised. The paper was illumined by humorous and expressive quotations from various reports. A spirited and instructive discussion followed.

On the 18th Januray, Mr. W. B. Crompton, of the Engineer-in-Chief's Office, read a paper on " Local Line Plant Economics " by Mr. H. Kitchen, M.I.E.E. The paper, which has been described elsewhere in the Journal, was thoroughly appreciated and the many points raised in an interesting discussion were ably replied to by the lecturer.

The fourth meeting was held on 22nd February, when a paper on " Scientific Organisation and the Post Office Engineering Department " was presented by Capt. F. G. C. Baldwin, Assistant Superintending Engineer, Newcastle-on-Tyne. A copy of the paper had been supplied to each member and was taken as read. A general survey of the ground covered by the paper, with explanations of an excellent series of lantern slides, were given by Capt. Baldwin, and a full discussion followed. A brief description of the paper has already appeared in the Journal. The arrangement of inviting a lecturer from a neighbouring Centre proved an admirable one and will, it is hoped, be repeated.

Mr. J. M. Couch, A.M.I.E.E., contributed a paper on " Secondary Cell Installations " at a meeting on 15th March, 1927. Mr. Couch is always a popular lecturer and his highly interesting and instructive paper was closely followed and gave rise to a good discussion.

A hearty vote of thanks was accorded all the lecturers.

SCOTLAND WEST CENTRE.

The fifth and last meeting for Session 1926-27 was held in the Royal Technical College, Glasgow, on Monday, 7th March. Before taking the routine business the Chairman referred to the loss sustained by the Local Centre in the death of Mr. D. W. Watson, Executive Engineer, who died as a result of injuries received in a motoring accident.

The lecturer for the day was Mr. T. Hetherington, A.M.I.E.E., who took for his subject " Growth of the Trunk System." The lecture was a review of the steps by which the trunk system had advanced from the earliest stage, when overhead construction was compulsory, to the present time with the longest circuits wholly underground.

Beginning with tables of the growth year by year in the number of trunk calls from 1896 onwards, and the corresponding yearly increase in the number of trunk circuits required to meet the public demand, the lecturer showed, chiefly by data relating to Scotland West District, how routes rapidly became congested owing to the necessity of overhead construction being adhered to, and the need which arose for some method of relief being forthcoming. This relief came when loading extended the distance over which speech was possible on underground circuits. The development of tandem schemes linking up the larger towns in an area was then touched on, and the Scotland West schemes were shown in detail. Finally, the lecturer referred to the advance which the thermionic valve made possible and gave details of the London-Glasgow cable to illustrate the progress made.

There was a very good attendance of members and a good discussion followed.

H.C.M.

BOOK REVIEWS.

" Electric Switch and Controlling Gear." Charles C. Garrard, Ph.D., M.I.E.E., A.M.I.E.E. Third Edition. Ernest Benn, Ltd. 63/- net.

In view of the rapid development and increasing variety of modern switch and control gear Engineers will welcome the third and up-to-date edition of this work; it is impossible for others than specialists to keep in touch with all the latest designs and applications of electric switch and control gears and this work should therefore prove of special value as a standard book of reference to electric power engineers.

The first chapter naturally deals with materials and manufacturing methods; in the 2nd chapter 100 pages are devoted to what is the most important piece of apparatus on a switchboard, namely, that required for making and breaking electric circuits, starting from the ordinary knife switch up to the latest type of oil circuit breaker. The next two chapters are perhaps the most valuable and deal exhaustively with the prevention of dangerous currents and with apparatus for regulating the amount of current. The selection of suitable protective apparatus for use on a Power system is perhaps one of the most difficult problems to be faced by the Engineer, and the information given should be of considerable value for this purpose.

Starting and controlling apparatus are dealt with in the next chapter and then come the complete switchboards; here, in view of the preeminence of British manufacturers in the ironclad type of switchgear, we should have expected more information on this subject. The question of supervisory control or automatic control of substations is dismissed in a few paragraphs, although this subject has now reached an important stage of development and is being extensively adopted.

The question of apparatus protecting electrical machinery against abnormal electrical conditions is adequately dealt with in the final chapter.

Ten Appendices follow, but as these only contain information which is usually to be found in Books of Reference, it is suggested that the space might have been more usefully occupied by further information on the development of Ironclad Switchgear and Automatic Substation control.

E.H.W.

"The Engineers Year Book, 1927," compiled and edited by H. R. Kempe, M.Inst.C.E., M.I.Mech.E., M.I.E.E., and W. Hanneford Smith, F.R.S.E., Assoc.Inst.C.E., M.Inst.Met. Crosby Lockwood & Son. 3101 pp. 30/- net.

The first edition of the Engineers' Year Book issued in 1894 was compiled as a standard Book of Reference for the Engineer in the practical work of his calling and included Civil, Mechanical, Marine, Electrical and Mine Engineering. Revisions and additions to succeeding editions have increased the size from 570 pages to 2900 pages of subject matter, the principal new and re-written sections in the 1927 edition being those relating to Automobiles, Aero Engines, Refrigeration and Lighting.

The necessarily voluminous nature of this work, covering as it does almost every subject connected with Engineering, avoids the difficulties which might otherwise be met with in the facilities for ready reference by its excellent subdivision into appropriate sections and the complete index of more than 70 pages.

Somewhat unexpectedly, having regard to the special knowledge and experience of the Editor-in-Chief, the subject of Communication Engineering has had less expansion in the space devoted to it than other branches of Engineering. The data and subject matter of this section might well be amplified to cover the ground of recent developments in Telegraphy, Telephony and Radio Engineering.

The production, printing and general arrangement of the volume is maintained at its usual high standard and it fully maintains its usefulness as a work of reference for the Engineer who has occasion for authoritative information outside his usual range of subjects.

A.S.A.

"Questions and Solutions in Telegraphy and Telephony, Grade I. Examinations." H. P. Few. 350 pp. Price 6/6.

This book supplies answers to the City & Guilds examinations in Grade I. from 1904 till 1919 inclusive and for 1925, also some questions and answers in the written and oral examinations for Overseers and an index. The answers have been fully and carefully dealt with, as one would expect from our late colleague who was himself a Silver Medallist and First-class Honoursman in Telephony and a certificated Teacher of the City & Guilds of London Institute. He is also the author of a book on "Elementary Determinants for Electrical Engineers." Our old friend died in September of last year, but this book will serve to keep him in mind for many a year. It should be invaluable for all students preparing for the Grade I. examination, not only for the information supplied but also as a model for the way in which questions should be answered, showing the examiner that the question is thoroughly understood and that the answer has not been unduly prolonged with details not required.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to.	Date.
Bailey, W. J.	Assistant Staff Engineer, E.-in-C.O.	Staff Engineer, E.-in-C.O.	23-3-27
Thompson, H. S.	Executive Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	23-3-27
Markwick, J. J.	Executive Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	19-3-27
Cowling, G.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	28-2-27
O'dell, G. F.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	23-2-27
Balcombe, R. C....	Assistant Engineer, S. Lancs. Dist.	Executive Engineer, N. West District.	19-4-27
McClarence, F.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	7-4-27
Phillips, A. C.	Assistant Engineer, S. West District.	Executive Engineer, S.E. District.	To be fixed later.
Lane, W. H.	Assistant Engineer, S. Wales District.	Executive Engineer, N. West District.	,,
Eason, A. B.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	7-6-27
Beach, W. R.	Probationary Assistant Engineer.	Assistant Engineer, E.-in-C.O	1-4-27
Straw, J. G.	,,	Assistant Engineer, E.-in-C.O	,,
Tyson, W. R.	,,	Assistant Engineer, E.-in-C.O	,,
Jones, H. C.	,,	Assistant Engineer, E.-in-C.O	,,
Williams, H.	,,	Assistant Engineer, E.-in-C.O	,,
Tufnail, M. E.	,,	Assistant Engineer, E.-in-C.O	,,
Baines, J.	,,	Assistant Engineer, E.-in-C.O	,,
Hollinghurst, F.	,,	Assistant Engineer, E.-in-C.O.	,,
Edwards, J. J.	,,	Assistant Engineer, N.E. District.	,,
Cox, H. E.	,,	Assistant Engineer, E.-in-C.O	,,
Morrill, A. E.	,,	Assistant Engineer, London District.	,,
Wright, F. V.	,,	Assistant Engineer, S.W. District.	6-4-27
Cooper, M. C.	,,	Assistant Engineer, E.-in-C.O	1-4-27
Reading, J.	,,	Assistant Engineer, E.-in-C.O	,,
Palmer, R. W.	,,	Assistant Engineer, E.-in-C.O	,,
Perkins, B. H.	Inspector, S. Mid. District.	Chief Inspector, S. Mid. District.	14-4-27
Young, W.	Inspector, S. East District.	Chief Inspector, S. East District.	25-12-26
Myers, W. H.	Inspector, S. Lancs. District.	Chief Inspector, S. Lancs. District.	2-1-27
Mealing, W. B.	Inspector, N.E. District.	Chief Inspector, N.E. District.	10-4-27
Kilgour, A.	Inspector, Scot. West District.	Chief Inspector, Scot. West District.	To be fixed later.
Edwards, J. R.	Inspector, N. West District.	Chief Inspector, Northern District.	15-5-27
Green, W.	Inspector, Eastern District.	Chief Inspector, S. East District.	To be fixed later.
Haseley, S. H.	S.W. Class I., S.E. District.	Inspector, S. East District.	1-10-26
Halls, A. N.	S.W. Class I., S.E. District.	Inspector, S. East District.	9-8-26
Jolliffe, A. P.	S.W. Class I., S.E. District.	Inspector, S. East District.	25-4-26
Veneer, A. G.	S.W. Class I., S.E. District.	Inspector, S. East District.	4-10-26
Miles, A.	S.W. Class I., S.E. District.	Inspector, S. East District.	22-1-27
Fox, L. A....	S.W. Class I., Testing Branch.	Inspector, Testing Branch.	24-11-26
Wells, H. G.	S.W. Class II., London District.	Inspector, London District.	1-10-26
Bazley, W.	S.W. Class I., London District.	Inspector, London District.	1-3-26
Pollard. A. C.	S.W. Class I., London District.	Inspector, London District.	12-1-27
Burnell. C. I.	S.W. Class I., London District.	Inspector, London District.	1-3-26
Weinel, C. F. G.	S.W. Class I., London District.	Inspector, London District.	8-1-27
Town, A.	S.W. Class I., London District.	Inspector, London District.	1-3-26
Hopgood, C. L.	S. W. Class II., London District.	Inspector, London District.	16-3-27
Chasmar, W. P....	S. W. Class II., London District.	Inspector, London District.	1-1-27
Roberts H. T.	S. W. Class II., London District.	Inspector, London District.	30-1-27
Brinkley. E.	S. W. Class I., Eastern District.	Inspector, Eastern District.	1-3-26
Harben, A. E.	S. W. Class I., Eastern District.	Inspector, Eastern District.	26-1-27
Ware, F.	S. W. Class I., Eastern District.	Inspector, Eastern District.	20-1-27
Taylor, W.	S. W. Class I., Eastern District.	Inspector, Eastern District.	1-3-26
Short, C. C.	S. W. Class I., Eastern District.	Inspector, Eastern District.	1-1-27
Waugh, J....	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	26-3-27
Henderson, R. M.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	6-1-26
Kelt, W.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	16-8-26
Hall, H.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	4-8-25
Sherriffs, J.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	11-4-27
Goodfellow, R.	S.W. Class I., Scot. East District.	Inspector, Scot. East District.	11-4-27
Wilkinson, H. T.	S.W. Class I., N. East District.	Inspector N.E. District.	25-7-26
Marshall. F. E.	S.W. Class I., N. East District.	Inspector N.E. District.	27-5-27
Fender, J. D.	S.W. Class I., Northern District.	Inspector, Northern District.	5-2-27
Blackie, J.	S.W. Class I., Northern District.	Inspector, Northern District.	13-2-27
Watt, A.	S.W. Class I., N. Ireland.	Inspector, N. Ireland.	1-4-27
Blaney, H. J.	S.W. Class I., N. Ireland.	Inspector, N. Ireland.	1-4-27

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date.
Morrow, J. G. M.	S.W. Class I., N. Ireland.	Inspector, N. Ireland.	1-4-27
Steedman, C. A.	S.W. Class I., S. Mid. District.	Inspector, S. Mid. District	7-6-26
Curling, T.	S.W. Class II., London District.	Inspector, London District.	27-2-27
Skeoch, W.	S.W. Class I., Scot. West District.	Inspector, Scot. West District.	25-10-26
Godfrey, A. E.	S.W. Class I., London District.	Inspector, London District.	27-3-27
Masters, F. R.	S.W. Class I., London District.	Inspector, London District.	9-4-27
Faulkner, F. G.	S.W. Class I., London District.	Inspector, London District.	9-3-27
Collerson, W. J. Y.	S.W. Class I., London District.	Inspector, London District.	19-4-27
Walker, A. G.	S.W. Class I., Eastern District.	Inspector, Eastern District.	15-2-27
Pettet, V. D.	S.W. Class I., Eastern District.	Inspector, Eastern District.	12-3-27
Francis, A. R.	S.W. Class I., Met. Power District.	Inspector, Met. Power District.	19-4-27
Lyddall, A. G.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	25-8-26
King, W. D.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	4-9-26
Roche, J. J.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	23-8-26
Abbott, G. A. O.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Sawyer, R. W.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	28-8-26
Waters, S. A.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Hull, S. D.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	23-8-26
Magnusson, L. E.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Mills, A. D.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Winch, B.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	26-8-26
Rudham, J.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	28-8-26
Young, J. S.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	19-10-26
Lague, J. H.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	25-8-26
Goman, L. V.	S.W. Class II., E.-in-C.O.	Inspector, E.-in-C.O.	21-8-26
Jenkinson, H.	S.C. & T.	Repeater Officer Class II., N. Wa. District.	16-9-26
Florance, F. V.	S.C. & T.	Repeater Officer Class II., S. Wa. District.	16-9-26
Anderson, A. G.	S.C. & T.	Repeater Officer Class II., N. Wa. District.	16-9-26
Halliday, W. G.	S.C. & T.	Repeater Officer Class II., Eastern District.	14-10-26

APPOINTMENTS.

Name.	Grade.	District.	Date.
Beard, A. T. J.	Probationary Assistant Engineer.	London.	18-3-27
Fisher, H. C.	Fourth Engineer.	H.M.T.S. Monarch.	25-2-27
Stacey, P. A.	Probationary Inspector.	E.-in-C.O	6-3-27
Reed, T. F.	,,	S.W.	27-4-27
Waters, H. S.	,,	S.E.	27-4-27
Howarth, H.	,,	S. Lancs.	—
Chandler, R. W.	,,	E.-in-C.O	16-5-27
Bavin, A. E.	,,	Testing Branch.	3-3-27
Buck, G. L. N.	,,	,,	29-4-27
Styles, G. E.	,,	,,	19-4-27

DEATH.

Name.	District.	Grade.	Date.
Winny, W. H.	E.-in-C.O.	Assistant Staff Engineer.	31-5-27

TRANSFERS.

Name.	Grade.	Transferred. From.	Transferred. To.	Date.
Lockhart, J.	Executive Engineer.	N.W. District.	Scot. W. District.	To be fixed later.
Cheetham, W. B.	Assistant Engineer.	N.W. District.	Eastern District.	
Stratton, J.	Proby. Asst. Engineer.	London District.	E.-in-C.O.	23-5-27

RETIREMENTS.

Name.	District.	Grade.	Date.
Wicker, G. J. M.	N. Wales.	Chief Inspector (unestablished)	7-4-27
Martin, W.	Met. Power.	Chief Inspector	30-4-27
Naylor, F. D.	S. Lancs.	Inspector (Unestablished).	3-5-27
Colyer, E. J.	London.	Inspector.	31-5-27
Hart, H.	,,	,,	31-5-27

CLERICAL ESTABLISHMENT.

TRANSFERS.

Name.	Grade.	From.	To.	Date.
Corney, P. A.	H.C.O.	S.W. District.	S.M. District.	24-4-27
McMullin, T.	,,	N. Ireland.	S.W. District.	3-5-27

DEATH.

Name.	Grade.	Cause.	Date.
Payne, C. W. H....	H.C.O.	Death.	9-3-27

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List II.

No.	*Title.*	*Author.*
836	Glossary of terms used in Electrical Engineering	B.E. Standards Association.
837	La Telephonie Automatique ...	H. Millon.
838	Prize Essays. Competition 1926-7.	
839	Treatise on Probability	J. M. Keynes.
840	Mathematics for Engineers ...	R. W. Dull.
841	Textbook of Wireless Telegraphy and Telephony	W. Greenwood.
842	Electric Switch and Controlling Gear	C. C. Garrard.
843	Essai sur L'Electricité des Corps.	