THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

VOL. 20 PART 4

JAN: 1928

Price 1/6 net.

ADVERTISEMENT INDEX
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THE
Post Office Electrical Engineers' Journal

LONDON AUTOMATIC SYSTEM.

INSTALLATION OF C.C.I. EQUIPMENT.

J. RADFORD, A.M.I.E.E.

PREVIOUS articles in this Journal have dealt with Coder Call Indicator working principally from the points of view of engineering and traffic facilities and with circuit operations.

It is thought, however, that both as a matter of historical interest and also to mark the completion of an engineering undertaking, considerable in magnitude and novel in character, some notes on the installation aspects of the work should be placed on record.

In order to meet the restrictions on space in this issue of the Journal the subject matter must be necessarily condensed, and no attempt will be made to describe in detail circuit operations, particulars of which are otherwise available.

It is well understood, of course, that the introduction of automatic working in London could not be effected by a simultaneous transfer from Manual to Automatic conditions of all the London exchanges. It was necessary, therefore, to provide means whereby, during a transition period extending over several years, traffic from the earlier automatic exchanges could be completed, as far as the automatic subscribers were concerned, on a full automatic basis, *i.e.*, that there should be no differentiation between the method employed by an automatic subscriber in making a call either to another automatic exchange or to a manual exchange.

For instance, Holborn was the first public automatic exchange to be opened in London and a Holborn subscriber is able to obtain a subscriber on any manual exchange in the London area in the same manner as would be employed to obtain an automatic subscriber on the Holborn or any other automatic exchange, *i.e.*, by dialling first the three letter code of the exchange required, followed by the four digits representing the wanted subscriber's number.

The completion of auto to auto calls needs no further comment, but it will be apparent that special arrangements are required at manual exchanges to receive calls automatically and to complete them manually.

The method adopted to meet this need was the provision of automatic equipment at every manual exchange, this equipment, in brief, receiving the calls from automatic exchanges, directing them to specially equipped positions, and displaying thereon, by means of lamps (see Fig. 1, Display Panel) the 4 digit number required, the operators at these special positions then completing the calls manually by the insertion of the plug of a specially equipped cord circuit, after making the usual busy test, into the multiple jack designated by the displayed number.

The junction arrangements adopted in London also provide for the routing of calls between

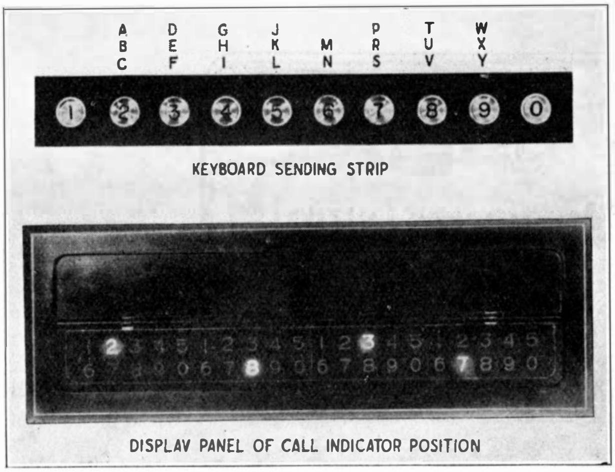


Fig. 1.—Keyboard Sending Strip and Display Panel.

manual exchanges in a similar manner, *i.e.*, the " A " operators order up the calls to " B " operators located on the cordless " B " Key-sending positions at the Tandem exchange in the Holborn building. These " B " operators assign a junction; the " A " operators connect their calling subscribers to the allotted junction and the " B " operators then set up the required number, exchange code and 4 digit number as in the case of auto to auto calls, by means of a Key set consisting of a strip of 10 keys, each key being numbered in the sequence **1-0** (see Fig. **1**, Keyboard Sending Strip). The call is then received and displayed at the required manual exchange precisely as in the case of an Auto to Manual call.

Numerous facilities are afforded by pilot and supervisory lamps, cancel, busy, release and special service keys, etc., but space does not permit more than passing mention of these.

Call Indicator Equipment.

Each incoming junction at Manual exchanges from Tandem or from automatic exchanges terminates on an Incoming Rotary Line Switch. When a junction is taken up, these switches hunt over a bank of 25 contacts in search of a disengaged outlet to a C.C.I. position. Various subsidiary portions of the equipment are also operated, more or less concurrently, such as Markers, Position Load Distributors, Decoding and Storage Relays and Position Trunk Relay Groups; all of these, with the exception of the latter, being freed and made available for further calls as soon as the display disappears, which happens immediately the operator at the C.C.I. position has inserted a plug into the required multiple jack.

Each C.C.I. position is equipped with 36 Cord Circuits, and associated with each Cord Circuit is a Rotary Line Switch.

The insertion of any one of the 36 plugs causes the associated R.L.S. to hunt in search of the Position Trunk Relay Group on which the call is standing and, this operation being complete, the through connection is established.

The main items of equipment installed at each manual exchange and the basis of provision are:—

Incoming Rotary Line Switch—
Number provided in accordance with traffic requirements, not exceeding 50 per position.

Position Trunk Relay Groups—
40 per position, Capacity 50.

Cord circuit R.L.S. and Relay Groups—
36 per position.

Markers—
5 per position.

Decoder Control Switch and Relay Group—
1 per position.

Storing and Display Relay Group—
1 per position.

Position Load Distributor—
1 per 5 positions.

These items are mounted on specially designed racks, two racks being required normally

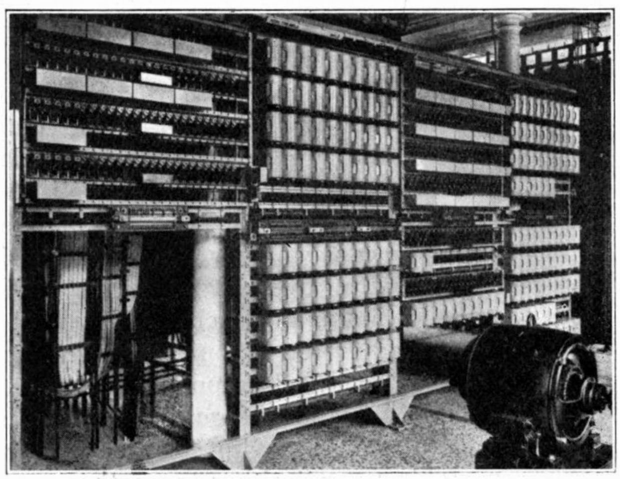


Fig. 2.—Four Racks at a 2-position Exchange.

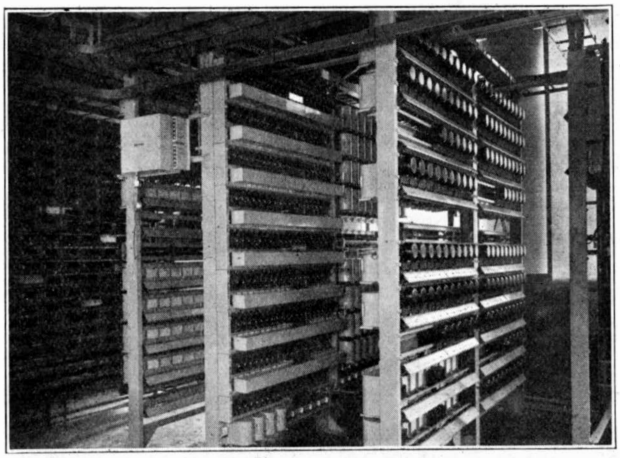


Fig. 3.—An Exchange with more than one Line of Racks.

to accommodate the equipment for each position, the weight of each equipped rack being approximately half a ton. The height of the racks is 9′ 0″ and the gangway space between racks is 2′ 4″ between centres (wiring sides) and 4′ 0″ (apparatus sides).

Fig. **2** shows 4 racks in a single line fitted at a 2 position exchange. Fig. **3** shows the arrangement where more than one line of racks is installed, and Fig. **4** is a front view of a rack accommodating Cord Circuit R.L. Switches, and miscellaneous equipment.

In addition to the C.C.I. apparatus racks provision has to be made in the lay-out for the Distribution Fuse Panel (one per exchange) and for the I.D.F. The latter item is supplied and installed by the Department and comprises *n* Frames M.D.F. 0/240, the number of frames depending on the number of positions to be equipped, the usual basis being one frame per position.

Works procedure.

Active preparations for the installation of the work commenced in October, 1923, with a programme of 74 exchanges, the number of positions varying between 1 and 14, the total number of positions being 289, the exchanges being located in 7 Internal Sections of the London Engineering District and in 7 cases two exchanges are situated in the same building.

In addition to the contract work, a very considerable amount of rearrangement and new work was undertaken by the Department.

A separate specification was prepared for each exchange, but in view of the novel character of the work, the miscellaneous subsidiary requirements, and the need for allocating the respective portions of the work between the Department and the Contractors, and also in order to ensure co-ordination of the work and uniformity of practice, a set of instructions (Circular, Telephones C.C.I. No 1. Notes on Works Procedure) was compiled and issued for the guidance of all engaged in carrying out the work.

Following are the principal matters dealt with in this Circular, some of which will be dealt with more fully elsewhere in this article:—

Accommodation and Lay-out, Exchange Sketches, Surrender of positions, Type of position to be converted, Cord circuits, Position

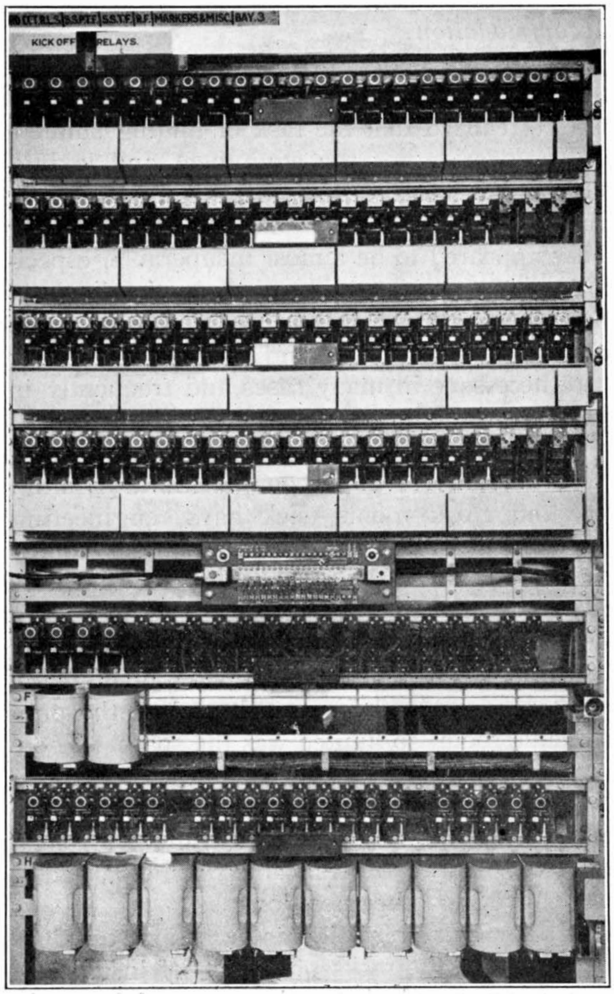


Fig. 4.—Rack fitted with Cord Circuit Rotary Line Switches and Miscellaneous Equipment.

Equipment, Terminating points, Power Data, Position Battery Feeds, Interrupted Earth, Busy tone and Ringing supplies, Meters, Emergency arrangements, Special Service Circuits, Operators Routine Test Jacks, Routine Tester, Congestion and Night Alarm circuits, Coupling Keys, Auxiliary I.D.F., Cross Connections, Keyboard and Panel equipment, Display and Marker lamps, together with a complete list of all the exchanges with particulars of Position numbers and whether pure C.C.I. or combined CBOW/CCI.

Incorporated with this Circular were also drawings showing the change-over arrangements to be adopted in the case of combined positions, the Keyshelf and panel equipment, the cabling scheme, the position wiring scheme and the coupling key arrangements.

Accommodation.

To anyone acquainted with the congestion existing in many of the London exchanges it will be realised that the task of finding suitable accommodation for the equipment and laying-out the same to the best advantage was a task which presented many difficulties; these at times appeared to be almost insuperable, especially as, in quite a number of cases, the displacement of staff was the only practicable solution.

Structural alterations and floor strengthening were necessary in many cases and frequently in order not to delay the work measurements had to be taken and lay-outs planned in advance of the availability of the accommodation. Dining, rest and cloak rooms, sick bays, engineering and clerical offices were all laid under contribution, and although it would be an exaggeration to say that the paint had to be scraped from the walls in order to obtain the necessary space, it is true that in one case a narrow mantelpiece had to be removed from each end of the only available room, so limited was the space. There were also many cases where obstructions, such as electric light fittings, conduits, pipes, fire appliances, and also exchange equipment, such as power plant, batteries, cable runs, etc., had to be removed to other positions.

In a few cases also, it was necessary to reduce the height of the racks on acount of insufficient head room or of obstructions caused by main cable runs.

The usual procedure in planning the lay-out was for the exchange to be visited in company with the Contractor's representative and with the local engineering officer. The details obtained on these visits were embodied in exchange sketches, one of which was prepared for each exchange, and these sketches formed the basis of the Contractor's floor and cable runway plans. In practically every case the exchange sketches were submitted to the Office of Works for their decision on the question of floor strength.

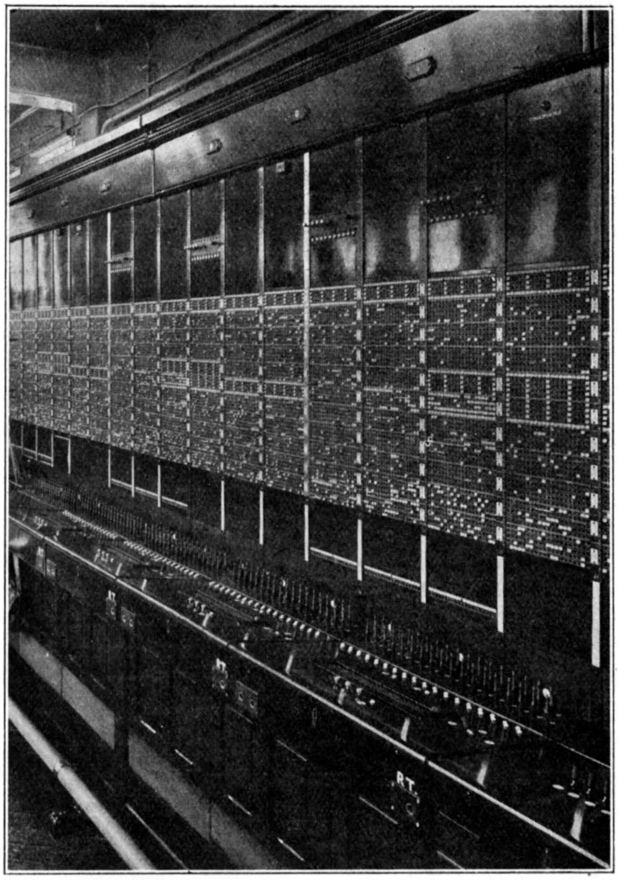


FIG. 5.—PHOTOGRAPH SHOWING POSITION EQUIPMENT.

Position equipment.

The equipment provided on each position is illustrated in Fig. 5, and comprises the following items, viz.:—

Keyboards and plugshelves.—Display panel, increase of cord circuits and supervisory lamps to 36 per position, decoder release, busy, coupling and special service keys, pilot, emergency and special service trunks busy lamps. In the majority of cases the equipment was accommodated on the existing keyboards.

Panel equipment.—Marker keys and lamps and Special Service overflow multiple.

Rear of Sections.—Operators' telephone circuit equipment.

Miscellaneous. — Manual emergency keys, Position Load Distributor change-over keys for bringing duplicate equipment into use on odd and even days, spare decoder keys in single position exchanges, congestion pilot lamps, operators' routine test jacks, etc.

Combined CBOW/CCI positions.

Where spare positions were available they were equipped at the outset as pure C.C.I. positions. In the majority of cases, approximately 200 positions, however, the existing C.B. order wire positions had to be converted for C.C.I. working whilst remaining in use as C.B.O.W. positions up to the time of transfer, and this necessitated the provision of change-over strips and extensive cabling re-arrangements. The strips were fitted in the most suitable positions having regard to the local conditions, the general location being either at the rear of the section, inside the rear of sections or in the cable-turning section.

Cable Scheme.

As a general rule the C.C.I. equipment is located in the apparatus room, and this involves a cable run between the apparatus room and the manual switchboard. In order to avoid the Contractors running cables over existing runs, and to facilitate the work generally, it was decided that the Department would provide the main cabling between the C.C.I. equipment and the manual board, the terminating points of these cables being on the C.C.I. I.D.F., fitted as near the apparatus as possible, and connection strips fitted in the cable-turning sections. Approximately 100 wires per position were provided between these two points, 40 of these being required for the display lamp circuits.

The I.D.F. in addition to serving as a handing over point for the Contractor's and the Department's cabling also provides cross connection facilities for the outlets from the I/C R.L.S. shelves to the P.T.R. groups, and for various miscellaneous services such as Special Service and Position Load Distribution circuits.

In some cases, owing to insufficiency of floor space, it was necessary to provide vertical extensions of the I.D.F's. and in others, to provide separate locations for portions of the frame.

Drawings.

In addition to many miscellaneous sketches produced by the Department, the Contractors furnished circuit and other drawings to the number of approximately 120 for each exchange. Changes during the progress of the work, circuit modifications, etc., necessitated many changes of drawings (the issue number of one drawing being 30), so that approximately 25,000 drawings were furnished by the Contractors and distributed *via* the District Office to the various Engineering Sections and thence to the individual exchanges.

City Trial Installation.

As was more fully described under " Trial Equipment " in Mr. Hedley's article on Mechanical Tandem Exchange " (*I.P.O.E.E. Journal,* Oct., 1927), an experimental installation was provided at City Exchange in December, 1925, and remained in use until the early part of 1927.

The installation comprised one position on the City " B " suite, fully equipped as a C.C.I. position, and two cordless " B " Key-sending positions fitted temporarily in the City Manual Switchroom.

Various types of regular and artificial traffic were handled at these positions and as a result of the experience gained numerous circuit modifications were decided upon, these modifications being subsequently carried into the regular C.C.I. equipments at all the London Exchanges.

Additional Work.

The modifications referred to involved both additional circuit arrangements and re-arrangements of existing ones and portions were carried out by the Department and the Contractors respectively.

The engineering of these modifications during the progress of the main works was a problem which necessitated close attention to detail and co-ordination, especially as in some cases the work in connection with as many as six modifications was in progress in the same exchange at the same time, and running concurrently with the main installation work.

Distribution of Traffic.

It will perhaps be convenient at this stage to set out the traffic and engineering facilities and requirements which, in combination, were specified in order to afford the most efficient means for the regular distribution of incoming junction traffic worked on a Call Indicator basis.

The principal desiderata were as follows:—

(1) The distribution of calls over all the positions, in cyclic order, irrespective of the exchange of origin or of the number of Call Indicator Positions.

(2) The distribution of calls, as in (1), over any number of positions in an exchange, irrespective of the number of positions which may be open.

(3) The distribution of calls, as in (1), without pre-determination of the particular position or positions which are to remain open for normal concentration or other purposes.

(4) The elimination of the possibilities of traffic congestion unless and until all the positions are fully loaded at one and the same time.

(5) The ability to equip additional positions for C.C.I. working, to meet development requirements, without reference to the direction of growth of the suite of positions.

(6) The ready adjustment of the operating staff to meet the traffic requirements at any time.

(7) The relative simplification of the cross connecting arrangements.

(8) The reduction of complicated circuit arrangements, to a minimum.

(9) The avoidance both of the segregation of Tandem traffic and of its consequent distribution to certain pre-determined positions.

(10) The ability to place any C.C.I. position out of commission, either for engineering or traffic reasons, without effecting the general distribution of traffic over the other positions.

(11) The provision of sufficient outlets from each I/C R.L.S. shelf, this being done if necessary by the provision of means whereby the number of outlets, which are subject to physical limitations, may be augmented.

(12) The provision of means to indicate to the traffic staff when the opening of additional positions is necessary.

(13) The provision of some ready means whereby additional positions may be opened by the traffic staff as and when the need arises.

(14) The maintenance of approximately the same standard of service at all C.C.I. exchanges, irrespective of the number of C.C.I. positions or of the size of the junction groups.

The majority of the foregoing facilities were specified at the outset, but the need for others was demonstrated during the progress of the work, and also as a result of observations on the City experimental installation.

It became necessary therefore to make a complete investigation into the question of traffic distribution as effected by the operation of I/C R.L.S. and Position Load Distributor Switches.

The results of this investigation are incorporated in another special circular (Circular, Telephones C.C.I. No. 2), which deals with the cross-connection arrangements to be adopted to produce the conditions previously set out.

Having arrived at conclusions respecting the methods to be adopted for cross-connecting the incoming junctions to the I/C R.L. Switches, and the outlets from the I/C R.L.S. Shelves to the P.T.R. Groups, schedules were prepared and issued to the District showing the actual cross-connections to be carried out at each exchange. This was done in order to preserve uniformity of practice at each exchange and also to ensure co-ordination with the officers dealing with the trunking and grading arrangements of the juctions incoming at the C.C.I. Exchanges from M.T. Exchange.

Testing out.

The ordinary physical and electrical tests were carried out during installation as far as possible. On completion of installation, however, it became necessary to test the equipment as a whole and as nearly as possible under working conditions.

The equipment at M.T. exchange was not available for this purpose, so it was decided to reproduce the M.T. conditions by specially designed circuit arrangements.

Testing equipment, assembled and wired in a unit form, was made up in the C.T.O. workshop and was designated Tester "X."

This Tester is designed:—

(1) To typify the conditions which will obtain at M.T. exchange in respect of calls to C.C.I. exchanges, including coding and sending functions, and

(2) To set up these calls in the C.C.I. equipment and to test the operation of the latter including all facilities under regular traffic conditions.

Concurrently with the production of this Tester complete testing out instructions were compiled and embodied in a special circular (Circular, Telephones C.C.I. No. 5, Testing Out Instructions).

The circular contains full instructions regarding the tests to be applied and the method of applying the tests, but following is a brief summary of the more important tests.

Call through tests.

These are the final tests of the equipment and are carried out when the installation is entirely completed with all cross connections run. They are designed to prove that the equipment as a whole functions correctly under working conditions for all classes of calls and through every traffic channel in accordance with the specified engineering and traffic requirements.

The tests on a single call basis comprise verification of the following conditions, viz., Ringing Tone, Ringing Trip, Supervision, Metering, Wrong disconnect, Regular Pilot and Recall, Special Service Key and Multiple, Manual Emergency, Markers, Position Load Distribution, Busy tone and flash, Decoder release, and Decoder Control Switch.

After completion of the single call through tests, a load test is applied, the object of which is to prove that the equipment as a whole functions correctly under continuous load conditions, irrespective of the number of positions, the volume of traffic, and of the exchange of origin of the traffic.

The load test is not primarily concerned with the display of correct numbers and in the initial stages of the test one setting of the digit keys suffices, resulting in the same number being repeatedly displayed. As the tests proceed, however, the setting of the digit keys is altered, resulting in numbers being displayed corresponding to the particular setting of these keys.

The utility of the Tester having been demonstrated in practice, several more were constructed in order that testing out might proceed simultaneously at different exchanges. The circuit arrangements as originally designed remained substantially unaltered and the Tester proved to be an invaluable aid to the satisfactory completion of the work.

Opening of the C.C.I. service.

As the engineering work at each exchange was completed, the equipment was handed over to the Traffic officers. Artificial traffic trials were then carried out and on the satisfactory completion of these the C.C.I. equipment was at once used for regular traffic between Manual Exchanges *via* Tandem.

The first 20 exchanges were opened simultaneously on the 18th August, 1927, the remaining exchanges, in number varying from one to four at a time, being opened on various dates until the 3rd November, 1927, when the last two exchanges in the first London programme were cut into service, the whole of the 74 exchanges thus being ready for the opening of Holborn Automatic exchange (an essential condition) which took place on the 12th November, 1927.

This is not the occasion on which to record judgment on the performance of the equipment, as this will no doubt be done on a future occasion when more experience under actual working conditions is available.

It will no doubt be conceded that the engineering of a work of this character and magnitude, over a period of four years, has been a task which has made a heavy demand on the initiative and energy of all officers concerned and it is gratifying to record its successful accomplishment.

The whole of the C.C.I. equipment provided under contract was manufactured and installed by the Automatic Telephone Manufacturing Co., Ltd., Liverpool.

HOLBORN.

HOLBORN Automatic Exchange, the first in Europe provided with Director equipment, was successfully brought into service at midnight on the 12th November. The installation was carried out by the Automatic Telephone Manufacturing Co., of Liverpool.

The opening of this Exchange is a further step forward in the standardisation of the Department's automatic system and is a milestone in the history of telephony in this Country. The problems of equipment and design in connection with the London system were so numerous that an Equipment Committee was set up at Headquarters under the late Mr. M. Ramsay, and later under Mr. W. J. Bailey, to control conditions so as to work towards an ultimate standardisation; special and significant interest consequently attaches to the operation of the Holborn equipment. Telephone Administrations all over the world are interested in the conversion of the London area to automatic working, chiefly because of the special conditions that prevail, and telephone officials from many different countries have consequently visited the Exchange during the installation.

The Holborn equipment was installed concurrently with that of the Tandem Exchange and with the installation of Call Indicator equipment at 74 Manual Exchanges in the area, the completion of which was necessary before the Exchange could be brought into service. The Tandem exchange is described in an article in this Journal for October by Mr. J. Hedley, and the Call Indicator scheme in this issue by Mr. J. Radford.

The Exchange is located in the same building as the Tandem Exchange at 270, High Holborn. The automatic apparatus occupies the first floor, the manual equipment being situated on the top floor, as shown in Fig. **3** of Mr. Hedley's article in the October Journal. The Exchange has a capacity for 10,000 lines and the following schedule of the equipment installed and brought into use at the transfer will convey some idea of the magnitude of the work.

Line Switches...	9,400
"A" digit Selectors	188
Directors	232
1st Code Selectors (Auto)	1,173
Do. (from Manual Positions)	50
2nd Code Selectors	1,065
3rd Code Selectors	347
1st Numerical Selectors	1,633
Do. (from Manual Positions)	27
2nd Numerical Selectors	1,932
PBX Final Selectors (2/10 lines)	1,680
Do. (11/20 lines)	180
Do. (over 20 lines)	26
Outgoing Junctions	1,400
Incoming Junctions	1,900
Incoming Trunk Junctions	80
Senders (Keysending "B" Positions)	50
Coders (Call Indicator Traffic)	80
No. of Lines working at transfer	4,739

Owing to the large number of P.B.X. subscribers in the Holborn area, regular Final Selectors are not installed; subscribers with single lines are accommodated on P.B.X. (2/10 lines) Final Selectors.

The Holborn power plant is described in an article by Mr. P. B. Frost in the April issue of this Journal.

The testing out of the equipment prior to acceptance was a prodigious task, involving the use of special testers, designed at Headquarters, descriptions of several of which have already been published in this Journal by Messrs. W. Prickett and H. S. Smith, with the object of reducing the number of manual operations to a minimum and thus speed up the work. The number of testing operations performed during testing out was of the order of 2,500,000, the work being carried out by the Holborn staff under the direction of Headquarters officers.

The transfer was accomplished by the simultaneous withdrawal of heat coils from the protectors in the manual exchange and the removal of wooden strips from the protectors in the Automatic Exchange. Prior to the transfer subscribers were given practical demonstration in the use of the dial and the significance of tones by the use of special demonstration sets constructed in the Training School, located in the Automatic Exchange, to which the lines were extended. In addition, subscribers have been provided with a specially prepared pamphlet explaining the features and operating procedure of the system.

Some technical details of the system will be given in a subsequent issue.

C.W.B.

BRIGHTON AREA.

TRANSFER TO AUTOMATIC WORKING.

J. RADFORD, A.M.I.E.E.

AUTOMATIC working was inaugurated in the Brighton Area by the simultaneous closing of 7 manual exchanges and the opening of 5 automatic exchanges at midnight on the 12th November, 1927.

The traffic "all clear" signal was given at 11.57½ p.m., the old exchanges were cut out by 11.59½ p.m. and the new exchanges were cut into service by 12.5 a.m., the whole transfer operations thus occupying a period of 7½ minutes. In view of the complex exchange system in this area and the large number of lines involved, approximately 8,000, this is regarded as very satisfactory, especially as all concerned in the transfer had been instructed that accuracy, and not speed, was of primary importance.

The old exchanges closed were Central (Ship Street), Post-Brighton (Ex Corporation) and Kemp Town, together with the old exchanges replaced by new exchanges, particulars of which are shown in the subjoined table:—

	D.E.L.	Stations.	Multiple Initial Equipment.	Multiple Capacity.
Central ...	3337	4952	4700	6900
Hove ...	2916	3966	4200	6200
Preston ...	727	888	1000	1400
Portslade ...	274	324	400	600
Rottingdean	98	119	200	400
Southwick...	*	*	200	400
	7352	10249	10700	15900

Immediately after transfer the number of P.G's. observed was 54, giving a percentage of 0.7 on the 7352 direct exchange lines transferred. The faults giving rise to these P.G's. were quickly localised outside the exchanges and were dealt with in due course under ordinary fault procedure.

The usual engineering tests (condenser tests) were carried out from the Main Frames forthwith and these were completed by 5 a.m. on the 13th November.

* *See separate paragraph re Southwick.*

FIG. 1.—CENTRAL AUTO. EXCHANGE, BRIGHTON.

The exchange equipment (Siemens No. 16) has been installed in new buildings in each case, a requirement in connection with most of the buildings being that they should conform as far as possible with the residential character of the districts in which they have been erected.

Fig. 1 shows the Brighton Central Exchange building, which also provides sorting office and bag-cleaning accommodation, and Fig. 2 shows

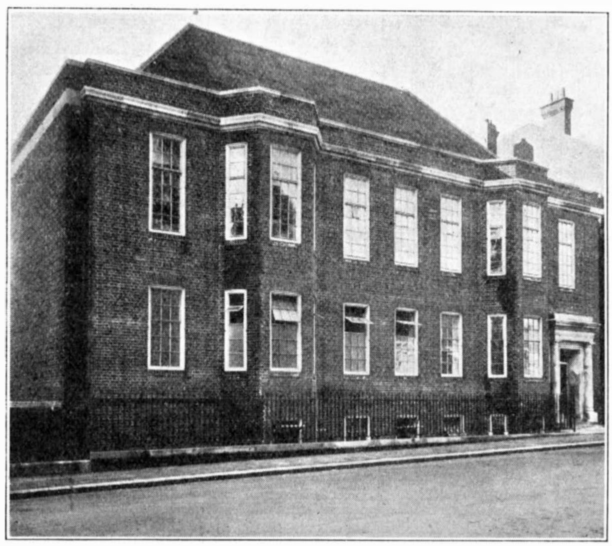


FIG. 2.—HOVE AUTO. EXCHANGE.

the Hove building. The latter photograph illustrates the extent to which the requirements regarding conformity with the residential type of building have been met.

Correction of area transfers were carried out at the same time as the main transfer, the following circuits, which were formerly connected to out-of-area exchanges, being dealt with, viz.:—

Brighton to Hove	77
,, to Preston	37
Post-Brighton to Hove	269
,, ,, ,, Preston ...	112
Hove to Brighton	6
,, ,, Portslade	2
,, ,, Preston	8
Preston to Brighton	1
Total	512

The number of trunks and junctions dealt with was 654, made up as follows:—

Manual I/C	69
O/G	73
B/W	68
Automatic	444
Total	654

The multi-exchange area comprises two main exchanges, Brighton and Hove, and 4 satellite exchanges, two of which, Preston and Rottingdean, are satellites on Brighton, the remaining two, Portslade and Southwick, being satellites on Hove. The trunking scheme for the area is shown in Fig. 3.

Each of the satellites is equipped with discriminating selectors and repeaters. Local calls are thus completed within the exchange, but all other originating traffic is dealt with by the

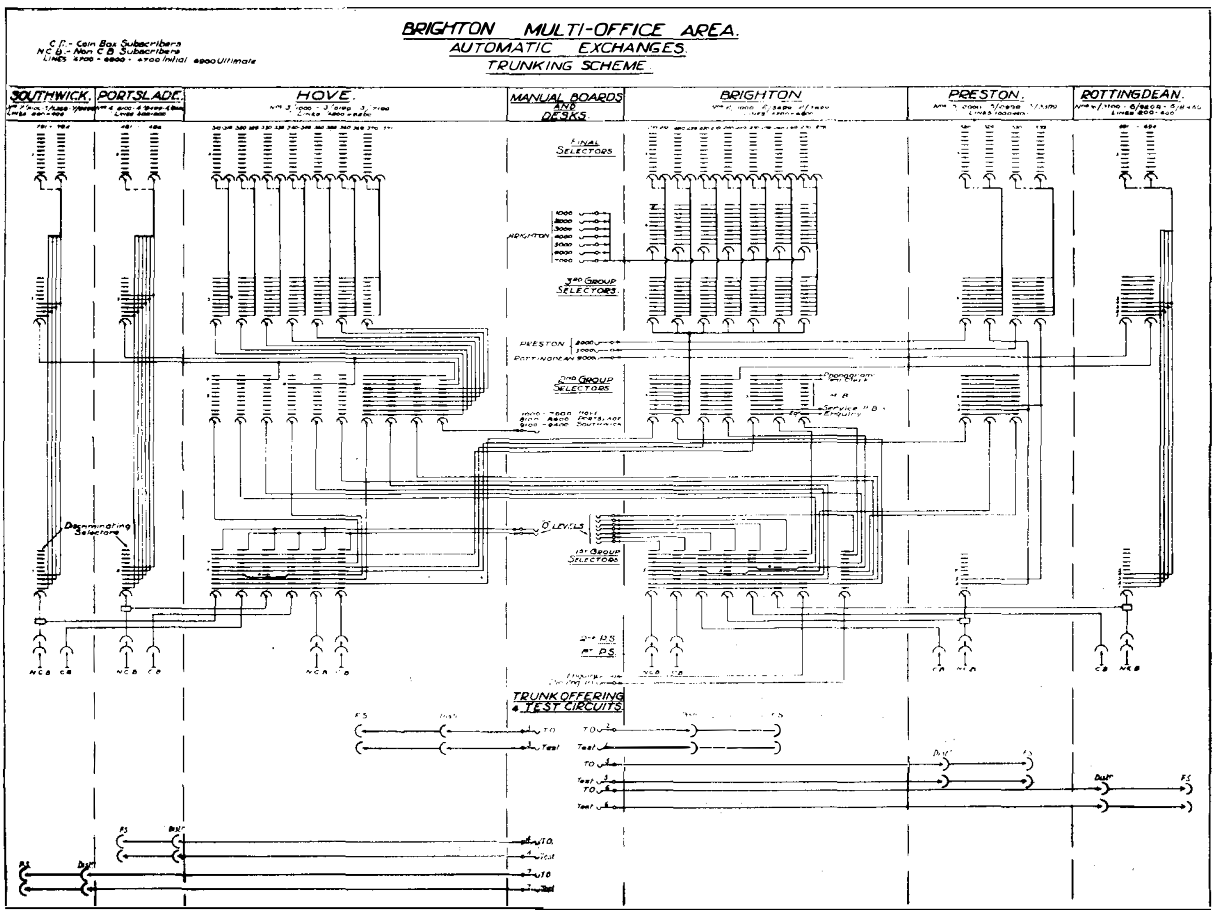


FIG. 3.—BRIGHTON MULTI-OFFICE AREA. TRUNKING DIAGRAM.

associated incoming selectors at the respective parent exchanges.

The numbering scheme, known as the "Brighton Scheme" (this area being the first in which it has been used), is similar to the ordinary full 5-figure scheme as far as the switching operations are concerned. It differs, however, in one important respect, viz., that, instead of the full 5 digit number being dialled by the subscriber, the exchange name takes the place of the 1st, or ten-thousands, digit. The exchange names appear on the dial number plate, as shown in Fig. 4, each exchange name being associated with a particular digit, *e.g.*, Brighton 2, Hove 3, etc.

The subscriber therefore dials first the name of the exchange required and then the 4 digit number. It will be obvious, of course, that in dialling, say, Brighton 2345, the number actually dialled is 22345; similarly Hove 4567 would be 34567.

Subjoined is a schedule showing full details of the numbering scheme, initial and ultimate, the initial digit, as stated above, corresponding to the exchange name, the 4 digit numbers only appearing in the directory.

FIG. 4.—"BRIGHTON" DIAL.

Exchange.	Numbering Scheme. Initial.	Ultimate.	
Brighton ...	2/1000—2/5699	2/7899	Main Exchange.
Hove	3/1000—3/5199	3/7199	,, ,,
Preston ...	5/2000—5/2999	5/3399	Satellite on Brighton.
Portslade ...	4/8100—4/8499	4/8699	,, on Hove.
Rottingdean ...	6/9100—6/9299	6/9499	,, on Brighton.
Southwick ...	7/9100—7/9299	7/9499	,, on Hove.

Although the instructions to subscribers are quite distinct regarding the dialling of the Exchange name on the dial before the 4 digit number, many cases of incomplete dialling occurred owing to subscribers failing to observe this procedure.

On the general question of subscribers' mis-operation it is considered that too much importance cannot be attached to comprehensive and intensive publicity and to the education of telephone users before the transfer, in order to ensure the minimum amount of abnormal congestion on the first few days following transfer, due to incorrect dialling methods, curiosity calls, non-recognition of distinctive tone signals, etc.

The common manual board for the area is situated in the same building as the Brighton automatic exchange and comprises the following positions:—

Position 1. Key sending position. Spare unequipped.
,, 2. Key sending position. Equipped. On this position terminate the circuits incoming from the London Toll Exchange.
,, 3. Service P.B.X. position.
,, 4 & 5. Jack ended junction positions.
,, 6-23. "A" positions. For subscribers' O level traffic.

The outgoing junction multiple comprises 120 circuits with V.E.S. and 260 circuits without V.E.S.

In addition, the following service desks have been provided:—

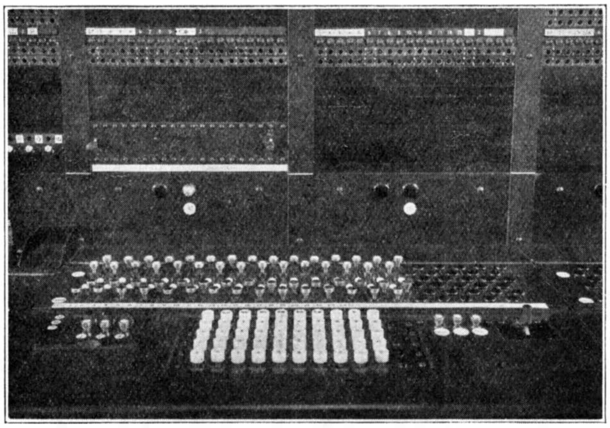


FIG. 5.—BRIGHTON. MANUAL BOARD. KEY-SENDING POSITION.

6	Position	Test Desk.
2	,,	Supervisor's Desk.
6	,,	Enquiry Desk.
1	,,	Observation Desk.

Both the testing and observation arrangements for the whole area are centralised on the Brighton Test Desk and Observation Desks respectively.

Fig. 5 shows the Keyboard equipment of the Cordless "B" Key-sending position.

The remaining illustrations may be briefly referred to as follows:—

Fig. 6. General view of Brighton Central Exchange, showing group selectors on left, portion of protector side of M.D.F. at end of aisle, and rear view of a 1st Preselector Rack and sectional I.D.F. on right.

Fig. 7. General view of Preston Exchange showing M.D.F. on left, 1st P.S. Rack bottom centre and 2nd Selector Rack on right.

Fig. 8. General view of Portslade Exchange, showing Power Panel and Interrupter on left followed by a partially equipped Final Selector Rack, a 1st P.S. Rack and a partially equipped 2nd P.S. Rack.

As a matter of interest it might be mentioned that the controlling officer directing the transfer operations was located in a room remote from the automatic switchroom. The necessary instructions to the staff engaged on the transfer were therefore given over the various control circuits radiating from the Control room without risk of disturbance or interruption. A listening-in circuit connected across the controlling officer's telephone was provided for the use of the supervising officers in the automatic switchroom.

The usual abnormal traffic conditions arose on the Monday morning, the first working day after the transfer. Subscribers' dialling and other difficulties were handled very expeditiously by the staff located at the 1st Selectors and by the early afternoon the congestion had disappeared. There was a perceptible recrudescence on the following morning, but in no case was there any reason to doubt the adequacy of the provision made either as regards the number of switches or the trunking arrangements; in fact, the exchanges appear to have settled down to normal working conditions in a remarkably short time.

The complex external plant conditions, the exhaustion of manual plant in the various exchanges from time to time, necessitating a large number of lines being connected to out-of-area exchanges, and the concurrent work in connection with development schemes have, together, produced a very complicated network of subscribers' cables and open wires and in the

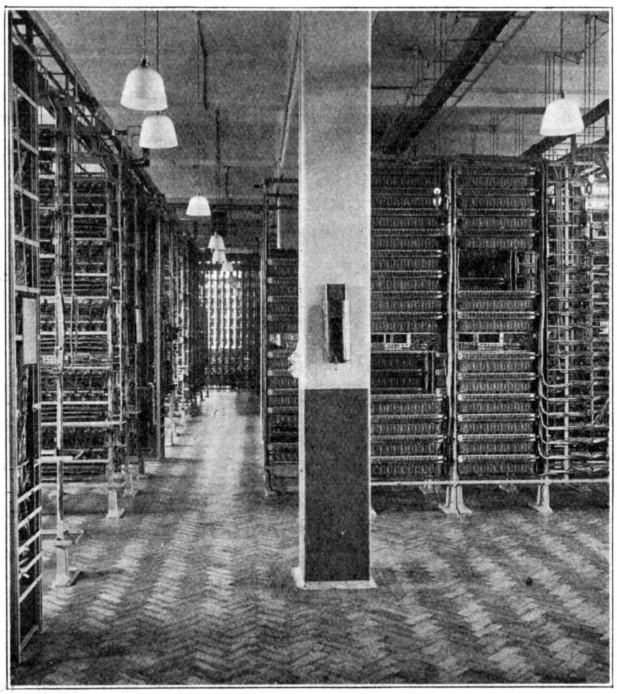


FIG. 6.—BRIGHTON. GENERAL VIEW OF AUTO. SWITCHROOM.

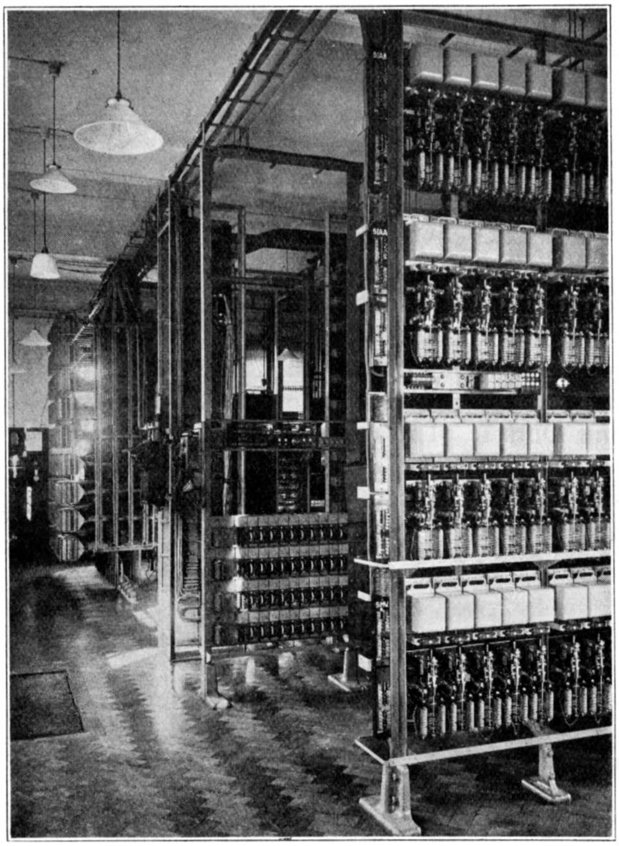


Fig. 7.—Brighton. General view of Preston Auto. Switchroom.

absence of adequate cable capacity the use of a large number of change-over strips was required. The local engineering officers recognised from the outset that these strips would have to remain in use for a considerable period and that the large amount of connecting and disconnecting for the purpose of testing out the system, particularly as regards the call through tests, would be much facilitated and risk of interruption to service avoided by making a substantial job of the change-over arrangements. It was therefore decided to instal the strips and cabling in as permanent a manner as possible, having due regard, of course, to their ultimate recovery. The wisdom of this course, as distinct from the employment of purely temporary measures, was evidenced both during the progress of the work and at the transfer. The ironwork supports for the strips were designed with a view to their further use on recovery at other exchanges.

Southwick Exchange. At the date of writing, Southwick Exchange had not been transferred to automatic working owing to delay in building operations. The particulars of this exchange have, however, been included in this article for convenience of record and reference, as the exchange will be opened during December, 1927.

In view of the large number of successful transfers taking place nowadays, no claim is made for anything of a special nature in the way of achievement but, at the same time, it should be recorded that the success attending this transfer was only made possible by the most careful organisation of the arrangements by the local supervising officers and by the thorough and efficient manner in which all ranks responded to demands made upon them.

The writer's thanks are accorded to Messrs. Siemens for the photographs accompanying this article.

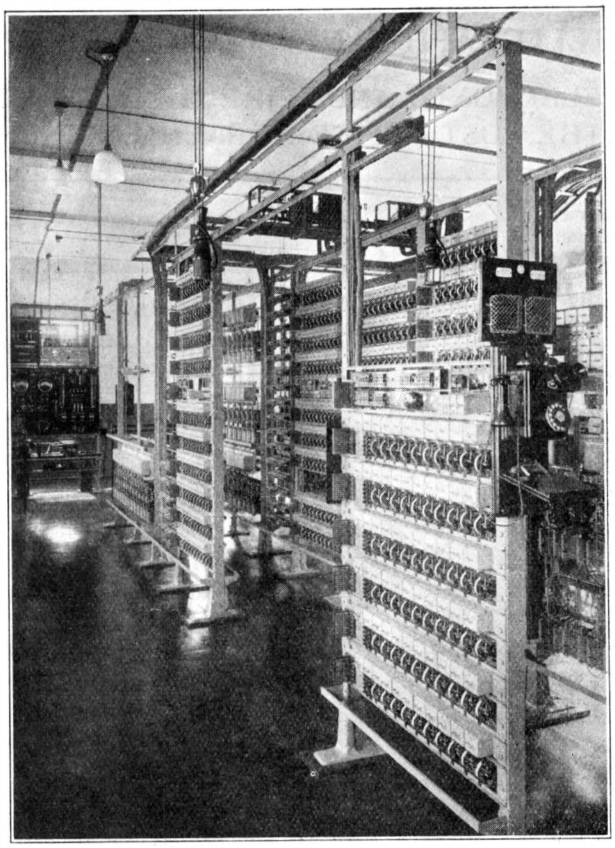


Fig. 8.—Brighton. General view of Portslade Auto. Exchange.

EXETER AUTOMATIC AREA.

THE above area, which comprises the Exeter Main exchange installed in the new wing of the old exchange premises in Castle Street, Exeter, and the Topsham Satellite exchange, which is housed in the old exchange premises at Topsham, was transferred to automatic working at 2 p.m. on 19th November, 1927.

The equipped capacity of the main exchange is for 2,100 lines, with an ultimate of 3,500. The satellite exchange has an initial equipment of 200 lines, but floor space is available for 400 lines.

The change-over was successfully carried out in the short period of 1.5 minutes, the number of working lines in the area at the transfer being:—

		Exeter.	Topsham.
Subscribers	...	1689	96
Junctions	...	104	26

The manual board suite consists of 15 positions designed to handle Enquiry, Trunk and "0" level traffic. Dialling-in facilities have been provided from 26 exchanges scattered over a wide area comprising towns in Devon, Somerset and Dorset. The manufacture and installation of the exchange equipment was carried out satisfactorily by the General Electric Company, and is up to the usual Post Office standard.

A.B.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 30TH SEPT., 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.
553,707	537	4,197	52,029	139	London	23,504	61,792	2,069,002	134,878
69,132	2,133	20,927	63,306	1,760	S. East	3,871	43,831	168,355	15,226
73,800	4,373	30,059	51,825	2,457	S. West	17,161	10,474	131,462	60,766
57,077	5,901	34,605	54,657	4,781	Eastern	22,495	35,195	90,246	73,853
90,916	8,752	44,173	56,059	3,661	N. Mid.	23,247	48,796	223,502	120,472
71,630	4,807	29,057	67,755	3,769	S. Mid.	13,108	21,171	152,451	88,987
55,579	4,704	29,258	50,606	2,786	S. Wales	5,838	25,405	103,408	69,824
96,576	8,292	25,818	48,205	4,452	N. Wales	12,946	40,970	235,370	60,271
148,791	1,590	17,057	42,871	2,636	S. Lancs.	13,087	75,823	439,469	46,339
87,943	6,186	30,731	45,188	3,065	N. East	10,573	43,639	209,531	58,581
60,219	3,515	23,713	36,165	2,163	N. West	8,194	32,074	148,251	37,884
45,043	2,468	15,867	23,937	2,777	Northern	4,614	14,361	98,362	50,054
20,402	4,726	7,832	13,332	353	Ireland N.	130	2,302	36,766	1,215
61,587	5,492	24,809	35,636	1,486	Scot. East	3,635	11,991	142,006	47,277
83,364	7,344	24,099	41,834	922	Scot. West	12,147	24,383	211,887	35,117
1,575,766	70,820	362,202	683,405	37,207	Totals.	174,550	492,207	4,460,068	900,744
1,552,329	70,324	360,234	671,744	37,350	Figures at 30th June, 1927.	173,149	484,449	4,349,216	894,575

MANCHESTER AUTOMATIC SCHEME.

A. S. A. JOHNSON, A.M.I.E.E.

As Manchester will be the first provincial telephone area in which the Director system will be used—although Birmingham will follow it very closely—a preliminary outline of the scheme together with some notes on certain features of the proposed trunking arrangements may be of interest.

Plan of Area.—Fig. 1 shows the proposed lay-out of the area under automatic conditions. The circle enclosing the area is 14 miles in diameter, with its centre at Manchester Town Hall, and the plan shows the approximate positions of the 37 automatic exchanges which, on the basis of the present estimate of develop-

FIG. 1.—MANCHESTER AUTOMATIC AREA.

ment, constitute the most economical method of serving the area. The requirements of the central portion of the city will be met by means of six 10,000 line exchanges, three of which—to be known as Blackfriars, Deansgate and Victoria—will be located in a new 7-story building at Chapel Street; the other three—City, Central and Medlock—will be accommodated in the existing York Street building which now contains the City and Central manual exchanges.

It is anticipated that the total capacity of the automatic exchanges in the area will ultimately amount to not less than 150,000 subscribers' lines, and an extensive network of junctions will be required to link up these exchanges.

Programme of Work.—It will be appreciated that for various reasons the conversion of an area of this size and character cannot be completed in one operation, but the programme for Manchester provides for a substantial proportion of the scheme being undertaken within a comparatively short period, as will be seen from the following summary.

Initial Stage.—Three new exchanges of the Director type will be brought into use at Ardwick, Collyhurst and Moss Side. The buildings for these exchanges are in course of erection and the manufacture of the equipment will be commenced very shortly. The building at Chapel Street, already referred to, will accommodate in the first place an auto-manual board to deal with Toll calls and enquiries from the automatic exchanges. The auto-manual board will include a number of order wire "B" positions equipped with key-sending facilities, for keying-up large blocks of traffic from City, Central, and certain other manual exchanges to the automatic exchanges. Other traffic from manual exchanges to the automatic exchanges will be "dialled-in," either from Chapel Street, or from the originating exchange itself where direct dialling-in junctions are justified. Arrangements will be made to provide call indicator positions at the City and Central manual exchanges for the receipt of calls directly from the automatic exchanges, the code and number being dialled by the subscriber as for an automatic call. Other manual exchanges in the area will not be equipped with call indicator positions during the initial period of automatic working; automatic subscribers requiring these exchanges will obtain connections *via* the auto-manual board.

Main Conversion Scheme. — The major portion of the programme for Manchester is due to follow within a year or two after the first three exchanges have been opened. During this second stage of the operations about 20 additional automatic exchanges will be provided, including the first 10,000 line unit (Blackfriars) at Chapel Street, and the exchanges in the area at which manual working is to be continued for a time are, with a few exceptions, to be equipped with call indicator positions on which all calls from automatic subscribers will be displayed. Tandem switches will be installed in the Blackfriars exchange to deal with traffic for which direct junctions between the exchanges concerned would not be justified. Although the bulk of the manual traffic complementary to the automatic system will be concentrated at Chapel Street, two subsidiary auto-manual boards will be established in the Manchester area, one at Oldham, and the other at Ashton-under-Lyne, as an economy in line plant costs will result from dealing with a part of the Toll and enquiry traffic at those places.

The existing Manchester Trunk Exchange will be maintained and will provide communication with places outside the range of the Toll area. In order that the transmission on these long distance calls may be as efficient as possible, direct dialling-in circuits will be provided from the trunk exchange to all automatic exchanges in the Manchester area.

The Stockport automatic exchange, where the present equipment is of non-director type, will be converted to Director working.

Replacement of remaining Manual Exchanges.—The final phase of the scheme will be the transfer to automatic working of the remaining thirteen manual exchanges, one by one, as each becomes due for replacement. These exchanges are equipped with up-to-date manual plant which will give good service for several years.

Exchange Codes.—A primary consideration in any Director area is the choice of suitable names for the exchanges, and in this connection the question arises as to whether it would be possible in the case of Manchester to use two letters only for the exchange codes. The grouping of letters and figures on the dial plate is given below for reference:—

1	2	3	4	5	6	7
—	ABC	DEF	GHI	JKL	MN	PRS

8	9	0
TUV	WXY	O

Since "O" is to be used as a single digit for enquiry calls, only the 8 dial spaces 2 to 9 are available for the first code letter for other calls. For the second code letter, the 9 dial spaces 2 to 0 may be used, so that 72 numerical combinations would theoretically be available for a series of two-letter codes. Some reduction in this number is necessary, however, owing to the fact that the digits 5, 6, 7 and 9 correspond to groups of consonants only, and the choice of suitable exchange names beginning with an available combination of two consonants in these groups would be very restricted. Assuming, for example, that no combination of these digits alone could be usefully employed, the total number of available combinations is reduced by 16, *i.e.*, to 56. Now already 41 codes will be required in Manchester (including those for Trunks, Toll, Directory and Telegrams) and some allowance must be made for the additional exchanges and services which will doubtless be necessary as the scheme develops. Also, under a two-letter code scheme, some of the existing exchange names would have to be changed. For example, only one of the names CHeetham Hill, CHorlton and CIty could be used. It will be seen, therefore, that it would hardly be practicable to use a two-letter code in Manchester, and the Post Office Administration have decided to make the three-letter code standard for all Director areas in this country.

Since "O" is used for enquiries, and therefore cannot be used as the first letter of an exchange code, the exchanges at Oldham and Openshaw will be known under the automatic scheme as "Main" and "East" respectively.

Grouping of Directors.—It will be recollected that when one of the three-letter codes in a Director system is dialled, the first digit steps up the "A" digit switch to one of the levels 2—9. The "BC" digit switches are thus divided into eight distinct groups, but if in two or more of these groups, the "BC" digits have all a different numerical significance, they could clearly be combined by "commoning" the "A" digit levels concerned. In the Manchester area, it has been found possible by a suitable choice of the new exchange names so far required to reduce the number of groups of Directors ("BC" switches) to three, as tabulated below, and illustrated in Fig. **5**.

GROUPING OF "A" DIGIT LEVELS IN THE MANCHESTER AREA.

Level 2.		Levels 3, 8, 9.		Levels 4, 5, 6, 7.	
NAME.	Numerical equivalent.	NAME.	Numerical equivalent.	NAME.	Numerical equivalent.
ARDwick	2 7 3	DEAnsgate ...	3 3 2	GATley	4 2 8
ASHton	2 7 4	DENton	3 3 6	HEAtonmoor ...	4 3 2
BLAckfriars ...	2 5 2	DIDsbury ...	3 4 3	HYDe	4 9 3
BROughton ...	2 7 0	DIRectory ...	3 4 7		
CHEetham ...	2 4 3	DROylsden ...	3 7 0		
CENtral	2 3 6	EASt	3 2 7	LONgford ...	5 0 6
CHOrlton ...	2 4 0	ECCles	3 2 2		
CITy	2 4 8	FAIlsworth ...	3 2 4	MOSs Side ...	6 0 7
COLlyhurst ...	2 0 5			MAIn (Oldham)	6 2 4
				MIDleton ...	6 4 3
		TRAfford Park...	8 7 2	MEDlock ...	6 3 3
		URMston ...	8 7 6		
		VICtoria ...	8 4 2	PENdleton ...	7 3 6
		TRUnks ...	8 7 8	PREstwich ...	7 7 3
		TELegrams ...	8 3 5	RADcliffe ...	7 2 3
		TOLl	8 0 5	RUSholme ...	7 8 7
				SALe	7 2 5
		WALkden ...	9 2 5	STOckport ...	7 8 0
		WHItefield ...	9 4 4	SWInton ...	7 9 4
		WOOdley ...	9 0 0		

The effect of this grouping will be a reduction in the number of Directors required at the various exchanges of from 15 to 20 per cent.

Reference has already been made to the use of " O " for obtaining the assistance of a telephonist. When an ordinary, *i.e.*, non-coin box subscriber dials " O " he will obtain an outlet on level " O " of the " A " digit switches to a Director switch which has been arranged so as to route the call at once to the Monitors desk. At the Ardwick, Collyhurst and Moss Side Exchanges, the Directors in the last group (levels 4, 5, 6 and 7) will be equipped for " O " level service and the " O " level will be included in the group. The circuit conditions demand that the positive and negative wires in the strapping from level " O " shall be reversed.

The arrangements for dealing with coin box calls on level " O " are referred to later.

Satellite Working.—The discriminating equipment designed for use at Satellite exchanges in Director areas provides for the division of originating traffic into the following groups:—

(*a*) Calls for local subscribers.
(*b*) Calls to be routed *via* the parent exchange.
(*c*) Toll calls.
(*d*) Calls for one or more nearby exchanges.

These facilities will, it is anticipated, render it economical to work a number of exchanges in the Manchester area as satellites. On the basis of the data at present available, the grouping of these exchanges will be as shown below, although it should be mentioned that this scheme may be somewhat modified later, as the forecast of future development in portions of the area is under review.

Parent Exchange.	Satellite Exchanges.
Blackfriars ...	Cheetham Hill, Eccles, Failsworth, Broughton, Middleton, East, Pendleton, Prestwich, Radcliffe, Swinton, Walkden, Whitefield.
Ardwick ...	Denton, Droylsden, Gatley, Heaton Moor, Hyde.
Trafford Park ...	Chorlton, Longford, Sale, Urmston.
Stockport...	Woodley.

Fig. **2** illustrates the facilities provided by the discriminating selector repeater equipment for satellite exchanges in a Director area. In the case shown (Swinton), the coin box lines are to be worked on a simple satellite basis, discriminating equipment being provided for ordinary —*i.e.*, non-coin box—traffic only. For local calls, the code SWI is " absorbed," and the discriminating selector then functions as a first numerical selector, level 1 being connected to second selectors serving the group of numbers 1000-1999. For calls to Eccles, Toll and Pendleton, the levels brought into use correspond to the third code or " C " digits, *i.e.*, C, L and N, respectively. The spare discriminating selector levels are available, of course, for additional direct routes, or an extension of the local numbering scheme, if required.

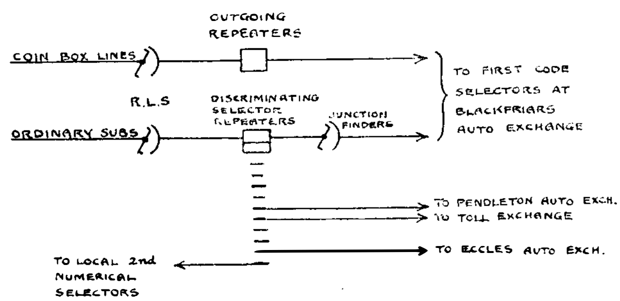


FIGURE 2 TYPICAL TRUNKING ARRANGEMENTS AT A SATELLITE EXCHANGE (SWINTON) [OUTGOING ROUTES ONLY]

Coin Box Traffic.—The coin collecting boxes used in Manchester will be of the prepayment multi-coin type now adopted as standard for automatic areas. To make an automatic call the caller at a coin box telephone, after inserting the 2d. fee, will dial the exchange code and number of the wanted subscriber, and the call will then be routed in the same way as a call from an ordinary subscriber. For other calls, the coin box user will dial " O," and such a call will appear on distinctively labelled calling equipment on the manual board, thus notifying the operator that the call is made from a coin box telephone, in order that the proper fee may be collected. The segregation of this class of coin-box traffic from that originated by ordinary subscribers necessitates the provision, for coin box lines, of a separate group of first code

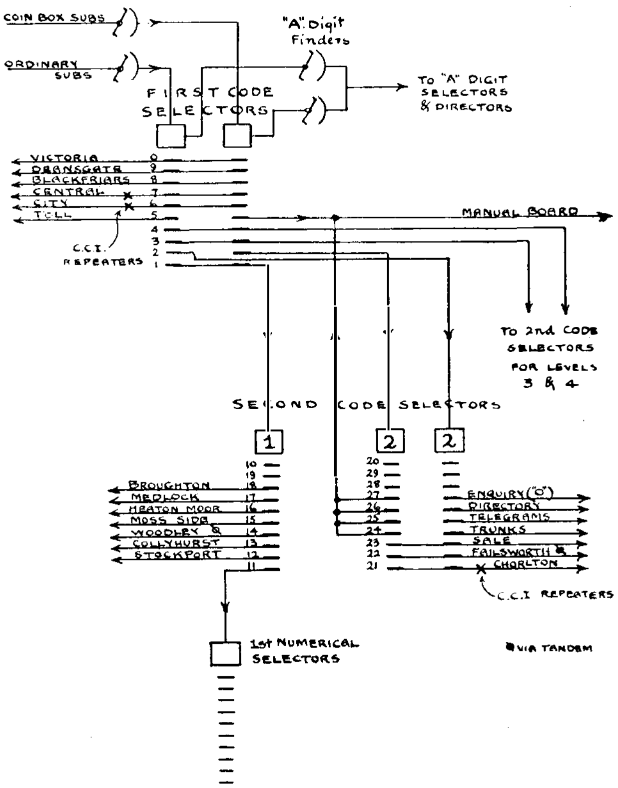


FIGURE 3. EXTRACT FROM TRUNKING DIAGRAM FOR ARDWICK EXCHANGE, SHEWING THE ROUTING OF COIN BOX CALLS.

selectors, and a separate group of second code selectors on the level used for manual board services, as illustrated in Fig. **3**, which is perhaps self-explanatory. It will be seen that provision will be made for the possibility of a coin-box caller inserting 2d. and dialling TOL, TRU, TEL or DIR, although this would be an incorrect procedure on his part.

Junction Fee Calls.—As the Manchester telephone area will extend to a distance of 7 miles from the centre of the City, junction fees will be payable on calls between certain exchanges in the area. These calls must therefore be routed to the auto-manual board, where they will be recorded and completed by an operator. In the case of an exchange which is the parent for a number of satellite exchanges at various distances from the centre of the area, the question arises of providing, at the parent exchange, some means of effecting the necessary discrimination between one satellite exchange and another in regard to the routing of these calls. A method devised by the Department's engineers is illustrated in Fig. **4**. It involves the provision of separate groups of 2nd code selectors, and a special scheme of level allotments to suit the particular case. The diagram shows the arrangements at Ardwick exchange in connection with the 2nd code selectors on level 4 only, those relating to levels 1, 2 and 3 being omitted for the sake of clearness.

As an example of the operation of the scheme, consider two calls to Longford, the first from Droylsden, and the second from Denton. In each case the exchange code LON will be translated in the common group of Directors at Ardwick into the digits 47. The call from Droylsden, however, will be routed direct from the second code level at Ardwick to a first numerical selector at Longford, whereas that from Denton will be sent *via* one of the special group of junctions to the manual board at Chapel Street.

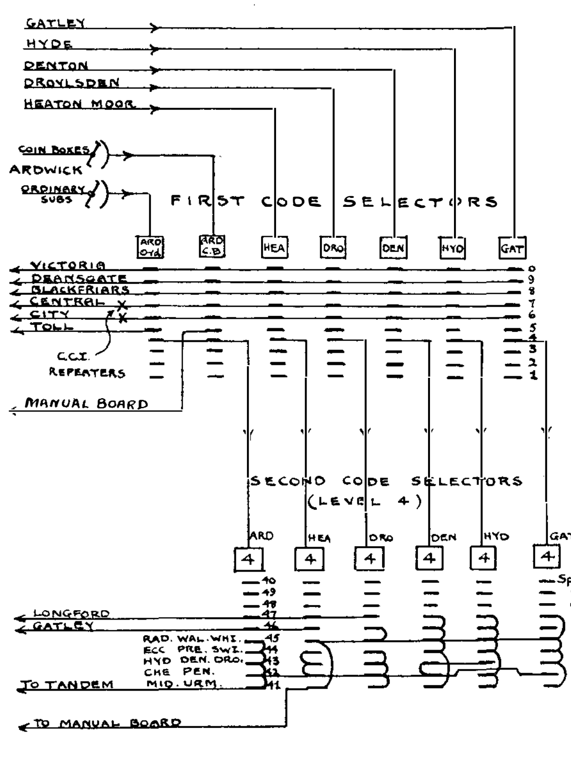


FIGURE 4. ARDWICK AUTOMATIC EXCHANGE. EXTRACT FROM TRUNKING DIAGRAM TO ILLUSTRATE ARRANGEMENTS FOR ROUTING EXCESS FEE CALLS TO MANUAL BOARD

Taking another example, a call from Droylsden, to Prestwich will be routed from Ardwick *via* Tandem as a unit-fee call, with the translation 448 (the digit 8 taking effect at Tandem, where Prestwich will be served from a first tandem level), while a similar call from Denton will reach the manual board (the digit 8 in this case being ineffective) as in the previous example.

Blackfriars Exchange.—As already indicated, Blackfriars will be the parent exchange for a number of satellite exchanges, and will also contain tandem switches for cross-area traffic. A considerable amount of equipment will therefore be required for this installation, as will be seen from the following summary of the main items :—

For Traffic from :—	Subs. Pre-selectors.	Code or Tandem Selectors.		Numerical Selectors.		
		1st	2nd	1st	2nd	Final
Blackfriars Subs.	9440	1580	2000	220		
Satellite Exchanges	—	1180				
Auto Exchange and Tandem Groups...	—	380	2060	1040		
Key Sender Positions	—	1520	340	—	1640	2608
Other Manual Board Positions ...	—	—	—	200		
Dialling-in Exchanges	—	—	—	280		
Total	9440	4660	4400	1740	1640	2608

" A " Digit Switches 300
Directors 400
Senders 50

Fig. **5** shows in outline a portion of the proposed grouping arrangements for the Blackfriars, Tandem and Auto-Manual switches at Chapel Street. The code, tandem and numerical switches shown in the diagram will all be equipped with 20-contact levels. With the exception of the 1st code levels 1 and 0, the proposed allotment of levels has been omitted from the diagram. The first code levels 6 to 9 will carry traffic to the Central, City, Deansgate and Medlock exchanges respectively; the remaining exchanges will be reached *via* second code selectors on levels 1 to 5, and the second code switches on similar levels at Deansgate and Victoria (the other two exchanges which are to be installed in the same building) will eventually be ranked up with those for the Blackfriars equipment, so as to facilitate the grouping of outgoing junctions.

It will be observed that switches in connection with key sender positions are associated both with first code and first numerical selectors, the former being outlets for the 7-digit positions and the latter for the 4-digit positions. Experimental development is at present in progress with the object of making provision for key-sending direct from " A " positions at manual exchanges to automatic exchanges. An article on this subject, by Mr. J. Hedley, was published in the Journal for April, 1926 (pp. 18 to 21). Where this method of working can be adopted key-sending " B " positions at the auto-manual boards will not be necessary.

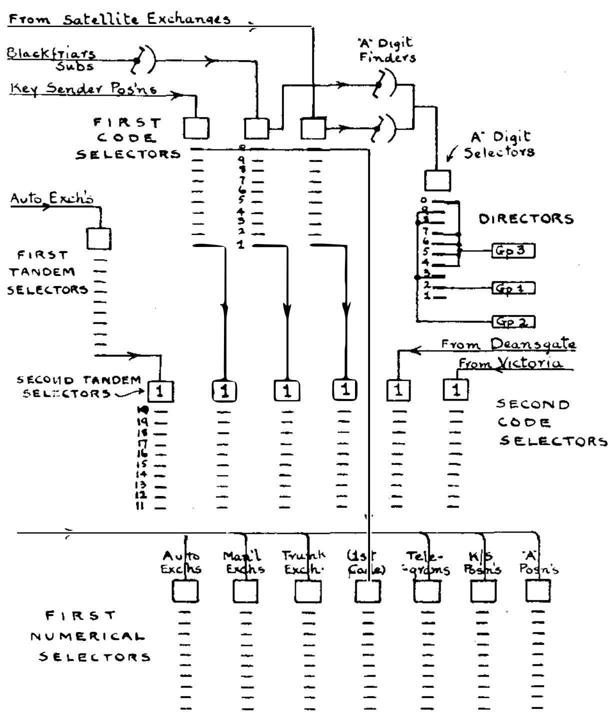


FIGURE 5 BLACKFRIARS AUTO EXCHANGE. EXTRACT FROM TRUNKING SCHEME

SUBSCRIBERS' APPARATUS IN AUTOMATIC AREAS.

H. G. S. PECK, B.Sc. (Hons.), M.I.E.E.

PART II. EXTENSION ARRANGEMENTS.

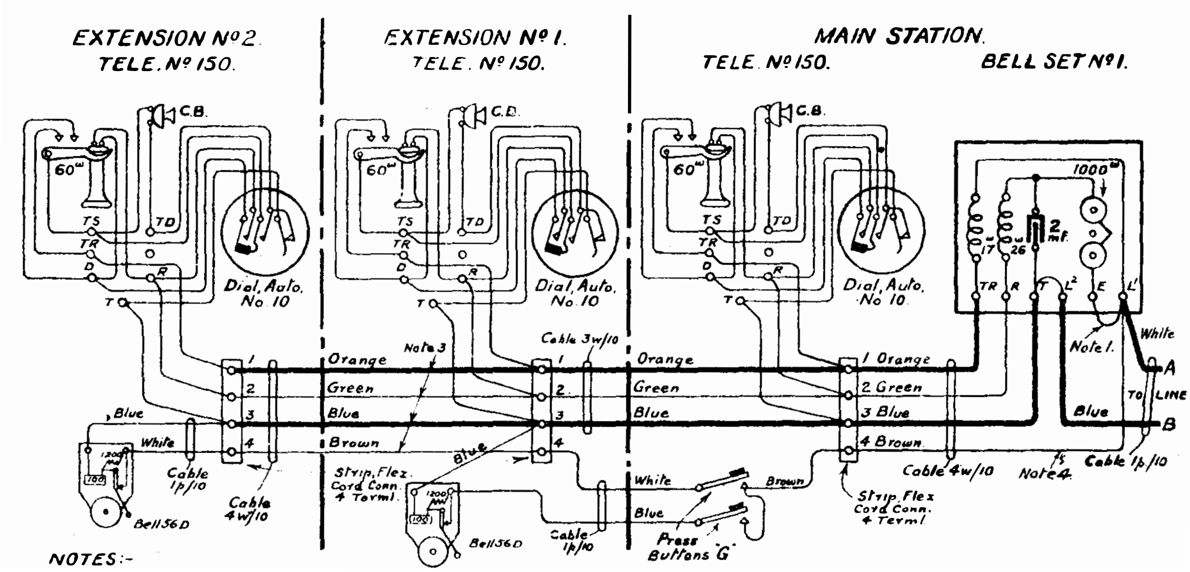
A NUMBER of combinations of telephones and bells have been standardised to meet the needs of subscribers who rent a few extensions only and do not in general require intercommunication between them. These combinations are known to both the commercial and engineering staffs as "Plans," and have been given a series of numbers which refer to the arrangements and not to the type of telephone, which is specified separately for each station.

To avoid an undue increase in the number of through switching points, the arrangements that may be fitted on extensions from branch exchange switchboards are limited to those that do not involve any further switching through of a connection, and it may be noted that dials are not fitted on manual private exchange extensions in automatic areas unless direct night service is required. External lines are only provided when not more than two wires are required for each circuit.

The station at which an incoming ring is received when all switches and keys are normal is known as the main station, the others being extension stations. A magneto extension bell can be added in any case where it is desired at any time that an incoming ring should be heard at a point remote from the main station.

Wherever possible, a parallel arrangement of telephones has been adopted, using a common induction coil and connected so that the operation of the dial at any one station does not tinkle the bell at another. When secrecy is required, a switch is fitted to disconnect the unwanted telephone at will, and where intercommunication is to be available, generators and other additional apparatus are necessary.

A typical detailed diagram of an installation of parallel telephones is shown in Fig. 6. This particular arrangement is known as Plan 1, and if the wiring to the extension and to the press button be omitted the connections of the main station are those of a simple direct exchange line.



NOTES:-

1. Omit strap and connect extension bell when required.
2. Extensions from Manual P.B.X. Equipment will be connected as for C.B. working if night service is not required.
3. These connections may, if more convenient, be made at the main station and 4-wire cable used for both extensions.
4. Connect this wire to earth when connection to L' gives insufficient current to actuate bell.

FIG. 6.—MAIN SET AND 2 EXTENSIONS.

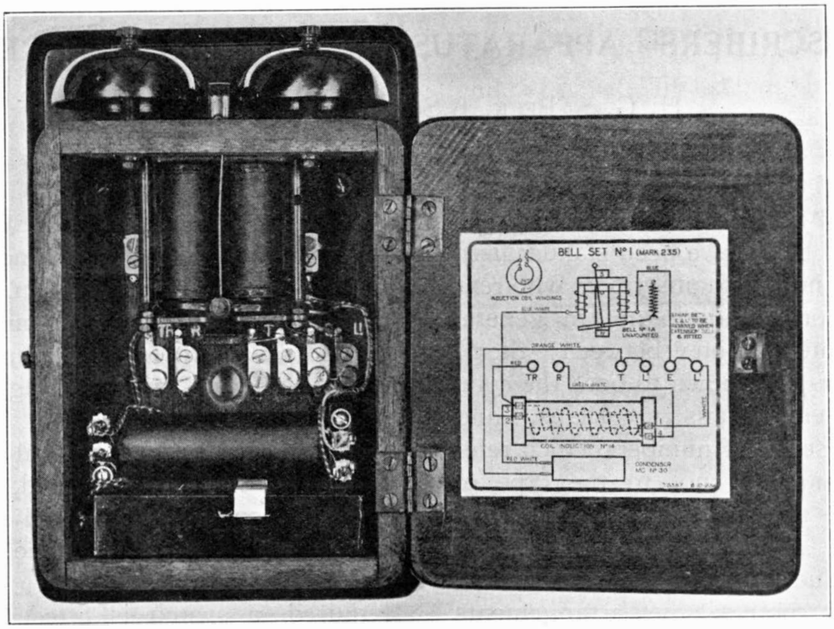


FIG. 7.—BELL SET NO. 1, SHOWING INTERIOR.

Table telephones are shown in this diagram and the common induction coil, condenser and bell are included in one case known as a "Bell Set No. 1" and illustrated in Fig. 7. The transmitter, receiver, bell, switch-hook and cord are known as a "Telephone No. 150" and this is illustrated in Fig. 8. Back and front views of the dial, showing the number ring and label used in Director areas are shown in Fig. 9. A wall telephone is shown in Fig. 10.

It will be seen that the connections of all the telephones in Fig. 6 are the same, and that the removal of any receiver from its hook loops the line and establishes the condition illustrated in Fig. 3 of Part I. of this article. No tinkling of the bell occurs whichever dial is used, a condition which is of particular importance with such arrangements, as should tinkling occur and be mistaken by the main station for a calling signal, the removal of the receiver to answer the call there might mutilate the train of impulses being dialled from an extension.

A simple parallel arrangement such as this has its chief application when several telephones in one room are to be connected to one line, a local bell circuit then being unnecessary. The arrangement can also be used when the telephones are in separate rooms and the local call bells shown are then required. These bells

FIG. 8.—TELEPHONE NO. 150. STANDARD TABLE TELEPHONE.

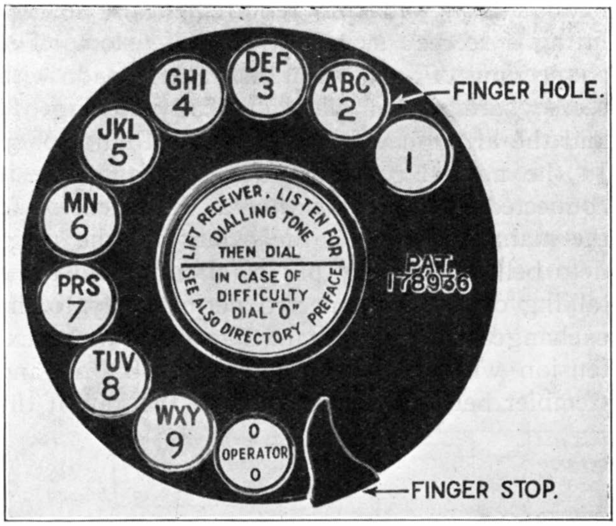


FIG. 9.—DIAL FOR MULTI-OFFICE AREAS. FRONT VIEW.

are rung by current drawn from the line and are usually connected across the loop, so avoiding the need for earth connections which, however, become necessary when the line resistance is excessive. It was found that when an ordinary trembling bell connected in this manner was rung for the purpose of extending an incoming call the noise created in the receiver at the distant end of the line was objectionably violent. To avoid this the break contacts of the bell have been bridged by a non-inductive resistance.

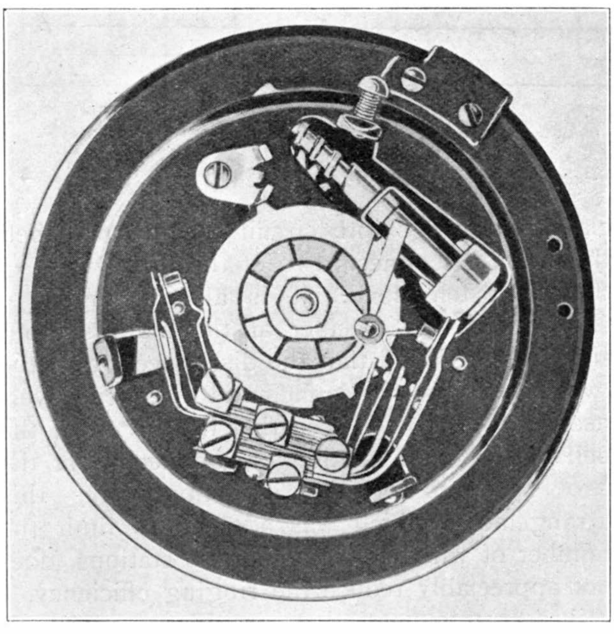


FIG. 9a.—DIAL FOR MULTI-OFFICE AREAS. BACK VIEW.

The best value for this purpose was found to be 1,200 ohms; too low a resistance would retain the bell armature in the operated position and a high resistance would not sufficiently reduce the noise. A bell of this type in which the resistance bobbin is included is shown in Fig. 11. As a matter of policy, the number of instruments that may be connected in parallel in this way is limited to three on business lines and to six on residential lines.

The conditions when a busy or important person wishes his incoming calls to be filtered

FIG. 10.—WALL TELEPHONE. MULTI-OFFICE AREAS.

by a secretary after having been answered in an outer office are met by connecting the local bell circuits in tandem, that is to say, the bell at the first extension is actuated by the press button at the main and the bell at the second extension can only be actuated by press button from the first. Such an arrangement is known as Plan No. 11.

When two telephones (the main station and one extension) are required on one line and it is desired that incoming rings shall be received at the extension when the main station is unattended, a magneto bell with a short-circuiting switch is fitted at the extension and connected in series with the bell at the main station. The telephones are connected in parallel and a local bell circuit is not included. The arrangement is known as Plan No. 1A.

An arrangement of two exchange lines with one extension that can be connected in parallel with the terminal telephone of either line is known as Plan No. 8. Each main station has a press button connected to a bell of distinctive tone at the extension and a key is provided at the extension for transferring the telephone from one line to the other as desired.

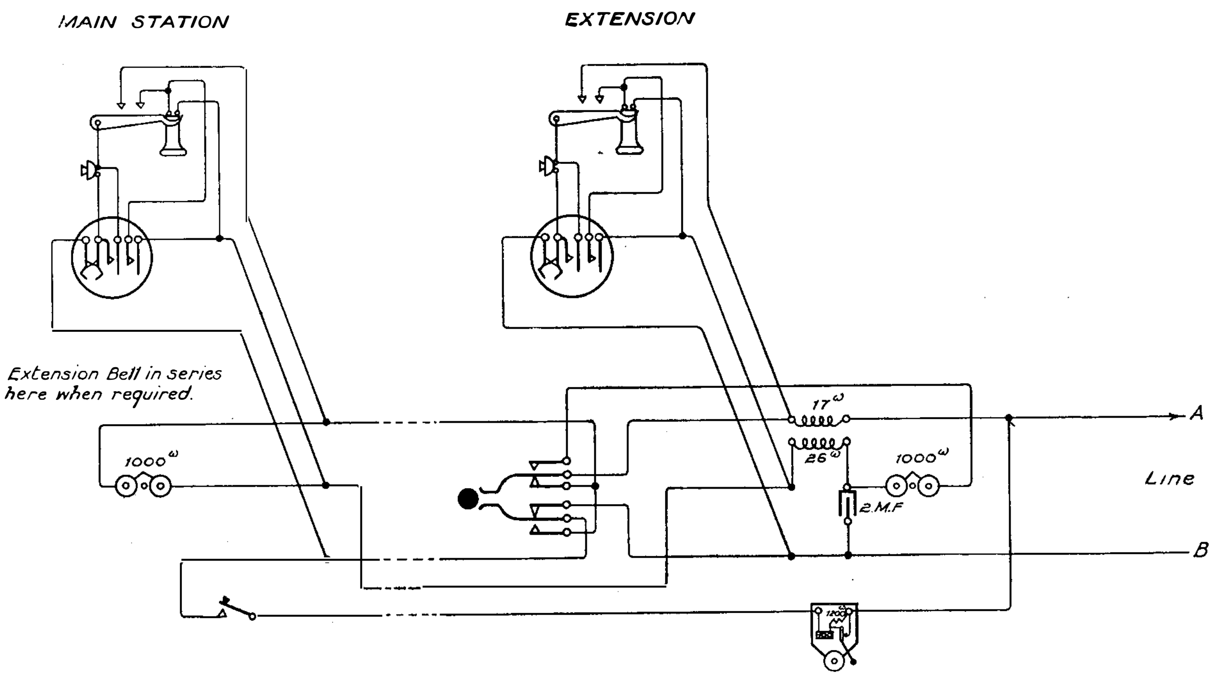


FIG. 11.—MAIN STATION WITH ONE EXTENSION HAVING SECRECY AGAINST THE MAIN.

Parallel arrangements of telephones such as already described do not provide secrecy, since it is possible for a conversation carried on from any telephone to be overheard on any other telephone on the same line, nor are they suitable for use when intercommunication between one telephone and another is required, since the line relay at the exchange is actuated by the removal of the receiver from the hook at any telephone.

It is often necessary in business that a manager or other important member of the staff on an extension telephone shall be able to carry on a conversation that is secret as regards the main station and this requirement is met by fitting a secrecy switch at the extension. The connections of a main station and extension with secrecy are shown diagramatically in Fig. **11** and the arrangement is known as Plan No. 3. In the normal condition the exchange line is connected through the switch at the extension to the main station. At the extension, the magneto bell is normally out of circuit, whilst the talking circuit is connected permanently to the exchange line. The main station calls the extension when required by a press button and trembler bell. The operation of the key at the extension brings into circuit the magneto bell there and disconnects two of the three wires to the main telephone. It is also arranged to short-circuit the receiver at the main station, since it was found that the disconnection of the two wires was not sufficient to prevent overhearing. It will be seen that the circuit of the bell at the main station is completed *via* the two windings of the induction coil; this arrangement, which was adopted to limit the number of wires between the two stations, does not appreciably reduce the ringing efficiency.

An arrangement that provides a common

extension on two exchange lines, with secrecy is known as Plan No. 8A and is shown in Fig. **12.** Each exchange line is connected to a separate main telephone *via* a combined switch and signal at the extension point. The movement of the switch in either direction disconnects one of the exchange lines from its main station and connects it to the extension telephone. A signal is provided in series with each line at the extension station to avoid interruption by the operation of the switch when a line is engaged. The bell at the extension station is in circuit when the receiver is on the rest, and if the key be left in the operated position any incoming ring is received at the extension station. In the normal condition all incoming rings are received at the main stations, and, to enable the extension to be signalled when required, press buttons are fitted at the main stations and connected to trembler bells of different tones at the extension.

When an extension with both intercommunication and secrecy is required, more complicated switching and signalling apparatus must be installed. This comprises a generator, magneto bell, indicator-relay, condensers and a four position switch, which are mounted together in one case as shown in Figs. **13** and **14** and are known as a "Bell Set No. 20."

Signalling between the main station and the extension is by hand generator in both directions and four positions of the switch give the following conditions:—

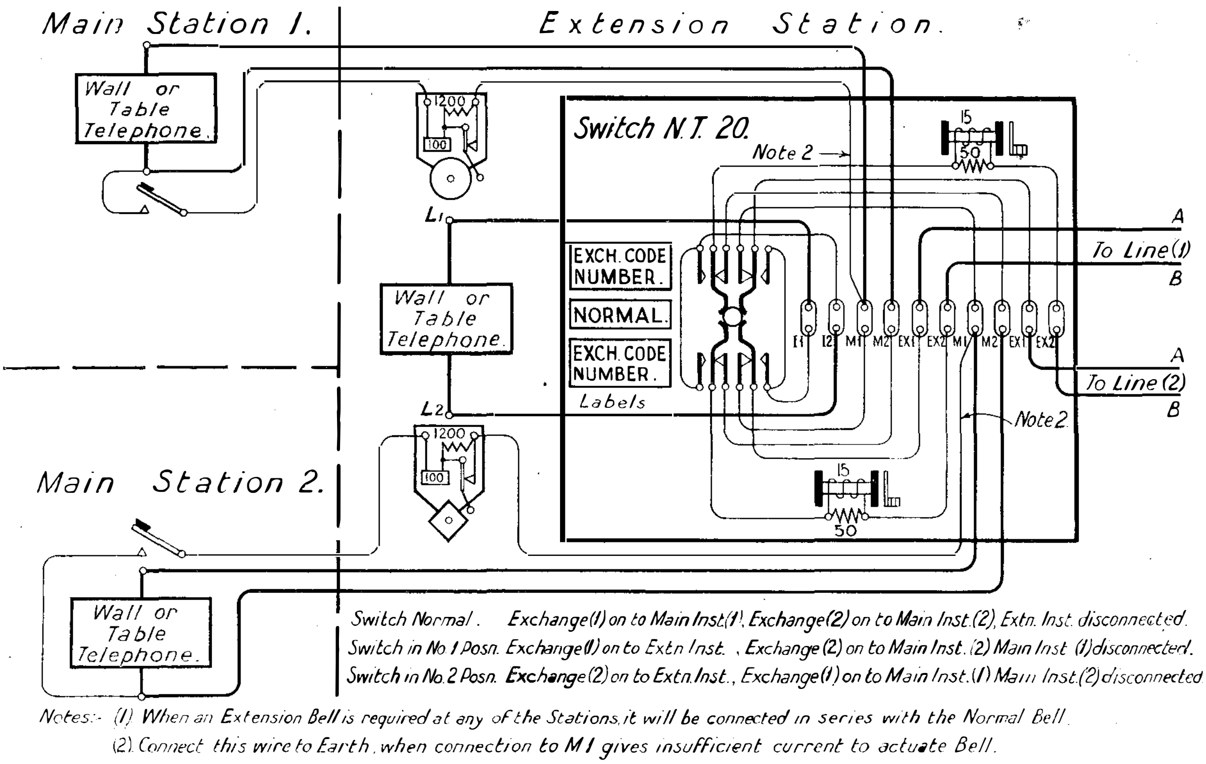


FIG. **12.**—TWO LINES AND COMMON EXTENSION WITH SECRECY.

(1) Exchange line connected to telephone. Extension connected to bell in bell set.
(2) Exchange line connected to bell in bell set. Extension connected to telephone.
(3) Lines connected as in position (2), but the exchange connection is "held."
(4) Exchange line connected through to extension.

The connections of the arrangement are shown in Fig. **15.** With the switch in the first position all springs are normal and the indicator-

FIG. 13.—BELL SET NO. 20.

relay is out of circuit. In the second position, spring sets Nos. 2 and 3 are operated, the indicator-relay still being out of circuit, but two cells for local talking are connected in series between the main station and the extension. In the third position, spring set No. 1 is operated also; this short-circuits the one microfarad condenser and half the bell coils, thus bridging the exchange line by a 500 ohm loop consisting of the other half of the bell coils, so providing a means for holding an exchange connection whilst a " secret " conversation is being carried on between the main and the extension. In the fourth position spring set No. 4 only is operated; the indicator-relay is in series with the extension and, if terminals A and A1 and B and B1 have been strapped as shown in the figure, the main telephone is in parallel with the exchange line. Conversations between the extension and the exchange are not then secret and the arrangement is known as Plan No. 7. If these terminals are not strapped, such conversations are secret and the arrangement is known as Plan No. 7A.

The bell of the telephone at the main station is disconnected by springs on the key when in the through (fourth) position and the bell of the bell set is disconnected by the action of the indicator-relay. All bridges are thus removed from the circuit when a conversation is in progress between the exchange and the extension and the condenser shunt across the winding of the series relay is increased by its own action to 3 microfarads. The transmission losses have thus been reduced to a minimum as indicated by the following:—

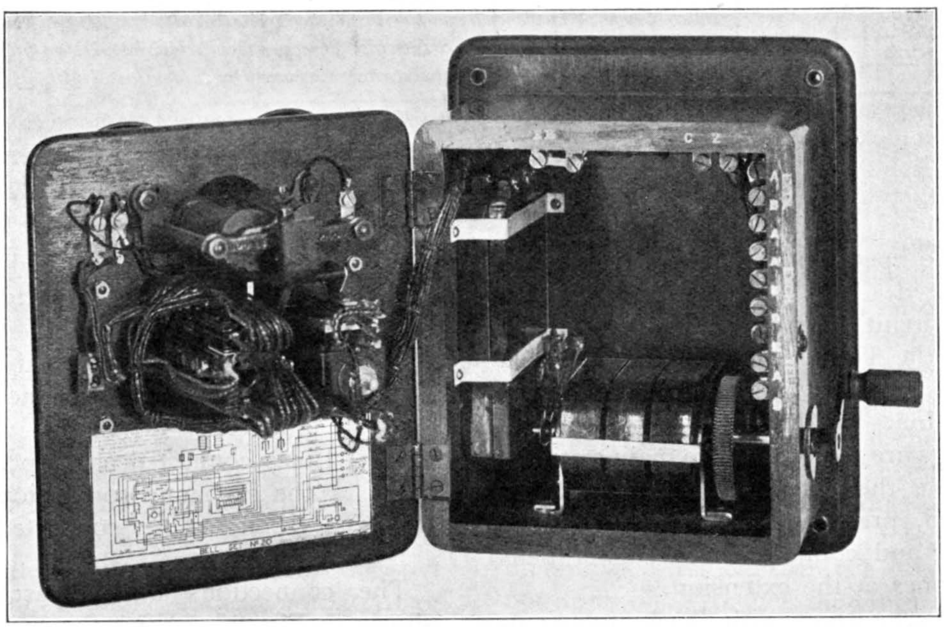
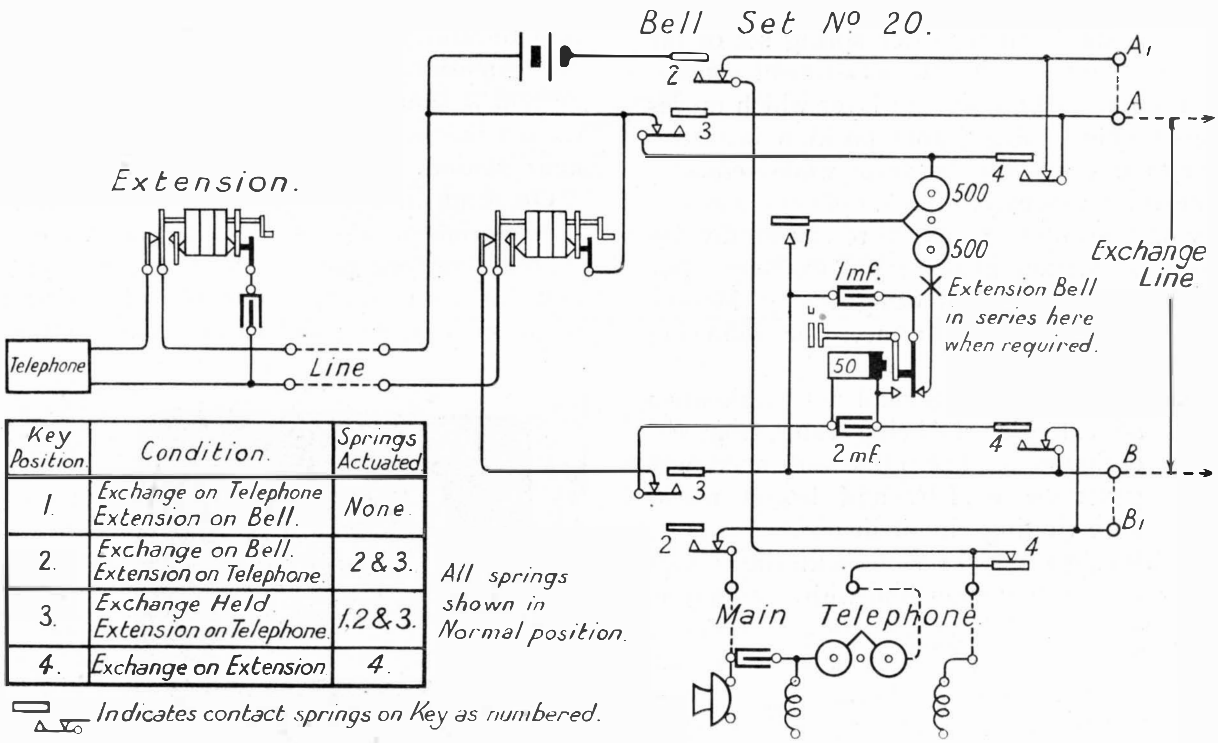


FIG. 14.—BELL SET NO. 20, SHOWING INTERIOR.



Key Position	Condition	Springs Actuated
1.	Exchange on Telephone Extension on Bell.	None
2.	Exchange on Bell. Extension on Telephone.	2 & 3.
3.	Exchange Held Extension on Telephone.	1.2 & 3.
4.	Exchange on Extension	4.

FIG. 15.—CONNECTIONS OF BELL SET NO. 20.

Sending loss 0.8 miles standard cable.
Receiving loss 0.4 ,, ,, ,,

The former figure includes the loss due to the reduction in the transmitter current by the introduction of the 50 ohms series resistance.

The indicator-relay, a side view of which is shown separately in Fig. 16, consists of a 50 ohm relay of the pendant armature type having

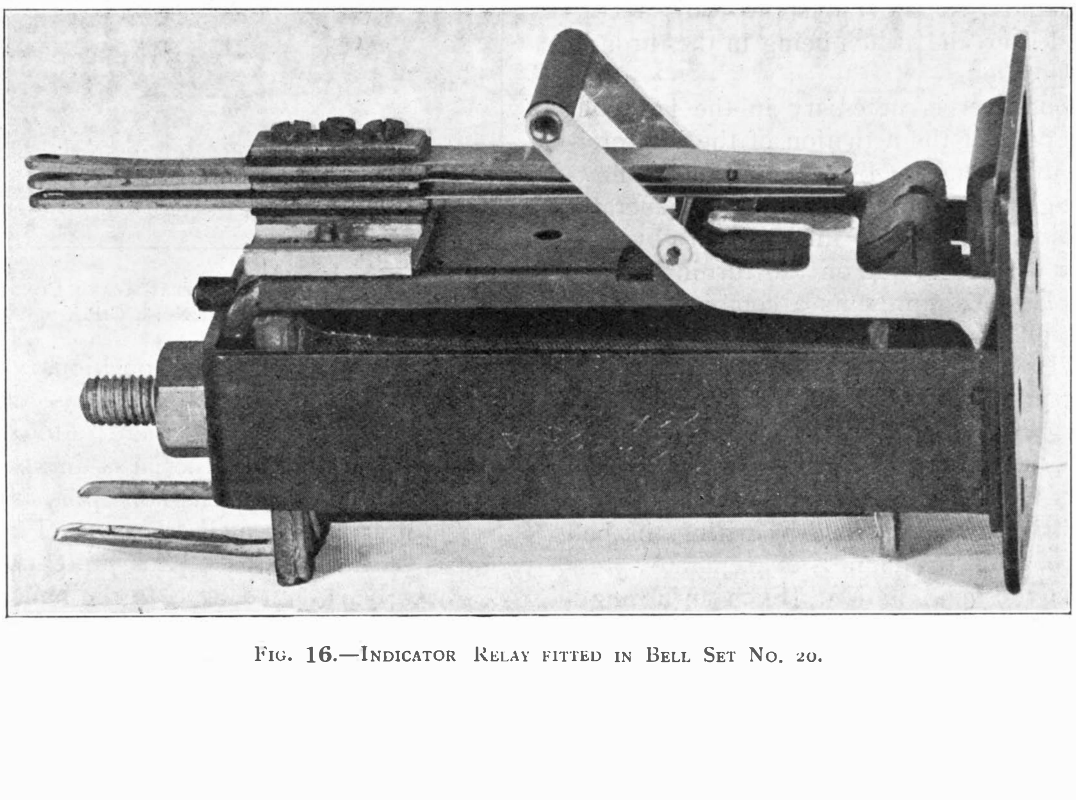


FIG. 16.—INDICATOR RELAY FITTED IN BELL SET NO. 20.

a copper sleeve on the core. The armature actuates a single change-over spring set of the usual type and an indicator attachment consisting of a balanced aluminium lever which moves an aluminium "flag" into position behind a rectangular window 1″ × 5/16″ when actuated.

The indicator-relay, which operates satisfactorily on lines up to 750 ohms resistance divided in any proportion between the exchange line and the extension, was designed by Messrs. Siemens Bros. & Co. to meet the following conditions:—

1. The relay contacts shall not break when an extension is being rung from the exchange on a zero line with maximum generator E.M.F. and lowest resistance ringing circuit in use.
2. The signal shall operate with the current over a maximum line with a minimum P.D. on the main exchange battery.
3. The relay having operated as in (2) shall retain during dialling at minimum speed, *i.e.*, the bell in the bell set shall not tinkle.
4. The relay shall release after operation as in (2) or (3) on a 10 ohm line and with maximum P.D. on the main exchange battery.
5. The relay contacts shall not break when the extension rings the main station by hand generator in series with a condenser, the switch being in the through position.

The condenser is necessary in the last condition to prevent the actuation of the indicator-relay by direct current from the exchange flowing through the winding of the hand generator when this is brought into circuit by the operation of the cut-out on the turning of the handle. Fig. **17** represents a combined generator and condenser which is known as Generator No. 4 C.P.

A second extension may be connected with its talking circuit in parallel with the first on a Bell Set No. 20 and the arrangement is then known as Plan No. 5 (or with secrecy No. 5A). Selective ringing is obtained by wiring the bell circuits of the telephones to separate press buttons at the main station. Such an arrangement avoids the necessity for fitting a branch exchange switchboard when one exchange line and two extensions are required, but intercommunication is limited to the extent that if one extension is talking on an exchange connection a simultaneous conversation cannot be carried on between the other extension and the main station.

On residential lines with only one telephone, the instrument has often to be moved as required from one part of the house to another, and this requirement is met by connecting the telephone to a plug and terminating the line on

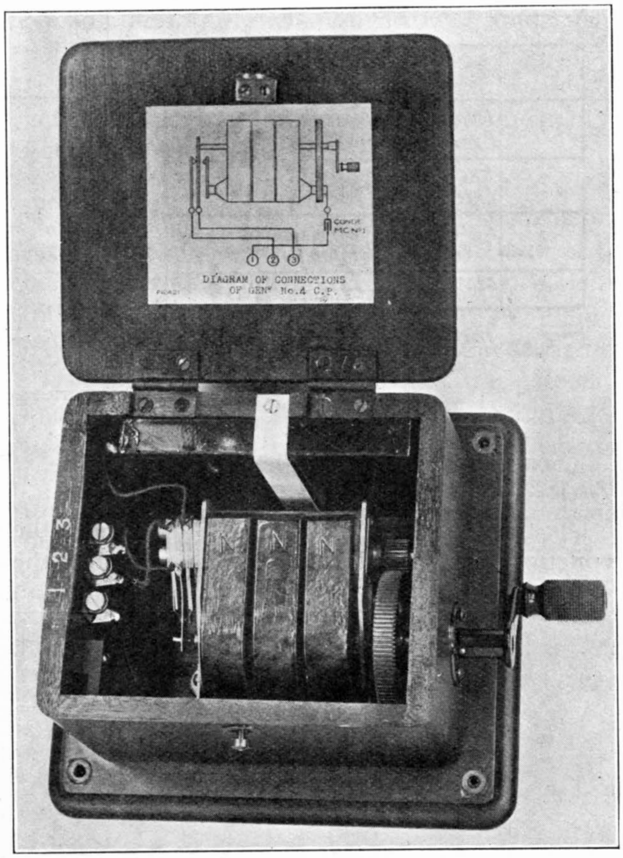


Fig. **17**.—Combined Generator and Condenser. "Generator No. 4 C.P."

jacks fitted in convenient positions. The bell set is fitted near one of the jacks and all incoming rings are received there; additional bells can be fitted at any of the jacks and be brought into circuit when the telephone plug is inserted. Such an arrangement is known as Plan No. 4, and is particularly useful for professional men, one jack being fitted, say, in the hall, a second in the office or surgery and a third in the bedroom.

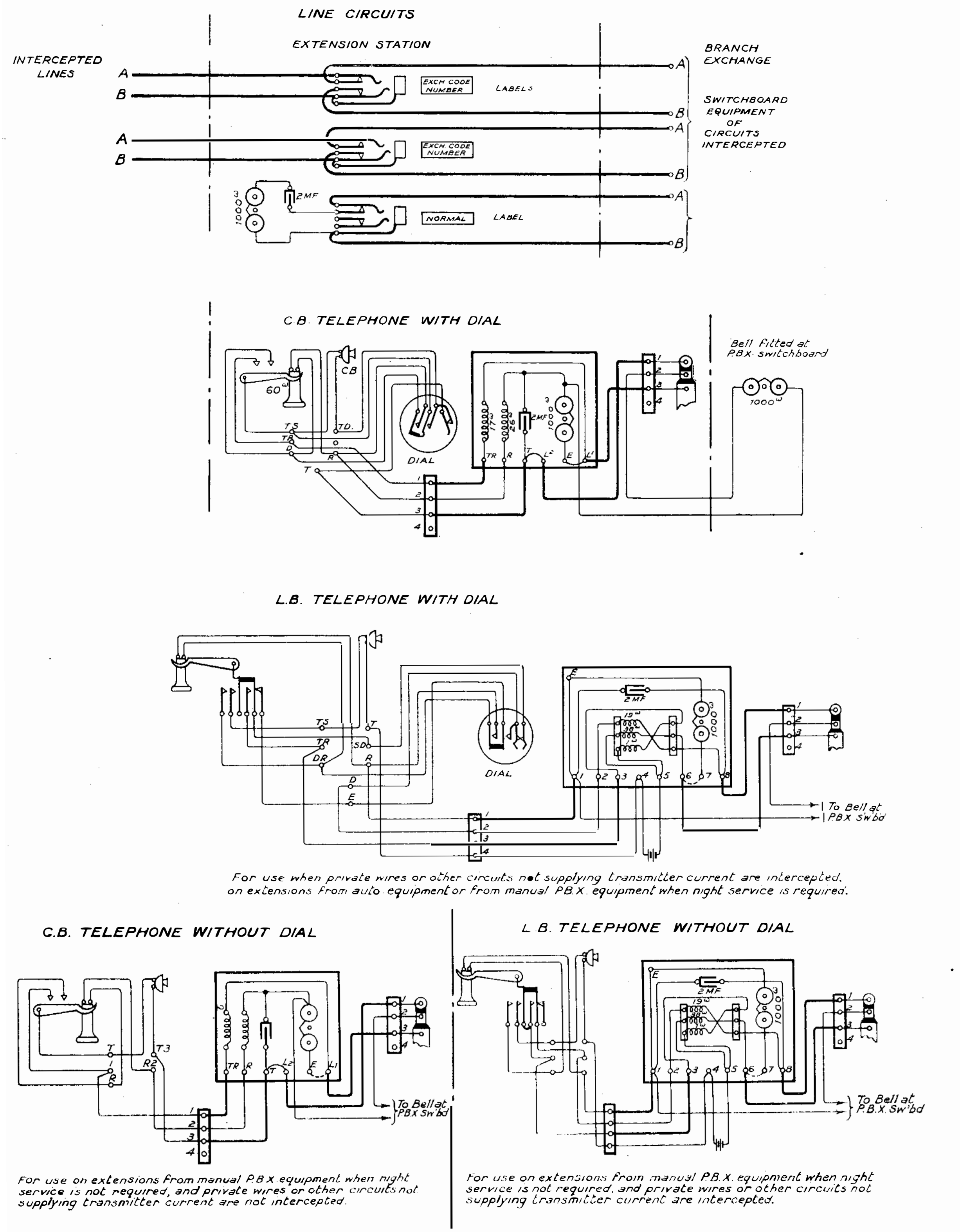


Fig. 18.—Branch Exchange Extension with Secrecy.

In addition to the foregoing there are two arrangements designed specially for use on extensions from private branch exchanges either manual or automatic.

The first of these, known as Plan No. 9, includes a telephone and two lines from the branch exchange, one of which is used for all normal calls and is connected through a key to the telephone. Should it be desired to make an independent inquiry whilst a correspondent is waiting on the line, then the throwing of the key connects a holding loop across the first line and transfers the telephone to the second, which is reserved exclusively for originating such calls.

When extensions in accordance with this plan are connected to a private automatic branch exchange, they enable the fullest use to be made of the equipment, and facilities which are often obtained by the fitting of a separate house telephone system can be procured by the use of the one telephone fitted for the public service.

The last arrangement to be described is Plan No. 10, which is intended for use when secrecy against the private branch exchange operator is desired at an extension from a switchboard. The arrangement is shown in Fig. **18**, the particular connections of the plugs and jacks being adopted to avoid any liability to false impulses.

Except when a "secret" conversation is being carried on, the plug is kept in the jack marked "normal" and the extension line then terminates on the telephone in the usual way. All calls must be passed *via* the private branch exchange and tne operator instructed when secrecy is desired; she will inform the extension user of the line on which the connection has been established, the telephone plug then being transferred to the corresponding jack. It is not intended that calls shall be originated by plugging immediately into an exchange line jack, as such a proceeding would lead to the interruption of other calls and to exchange lines being intercepted without the knowledge of the branch exchange operator. An extension bell is fitted in the switch-room to give an alarm should an incoming call mature on a line on which the telephone plug had inadvertently been left in the secrecy jack at the extension.

On occasion it is desired that private wires or other circuits not operated on a C.B. talking basis shall be intercepted in this way for the purposes of carrying on secret conversations and it then becomes necessary to fit a local battery telephone in place of the usual C.B. talking instrument. Also, whilst, as stated earlier, dials are not fitted on manual private

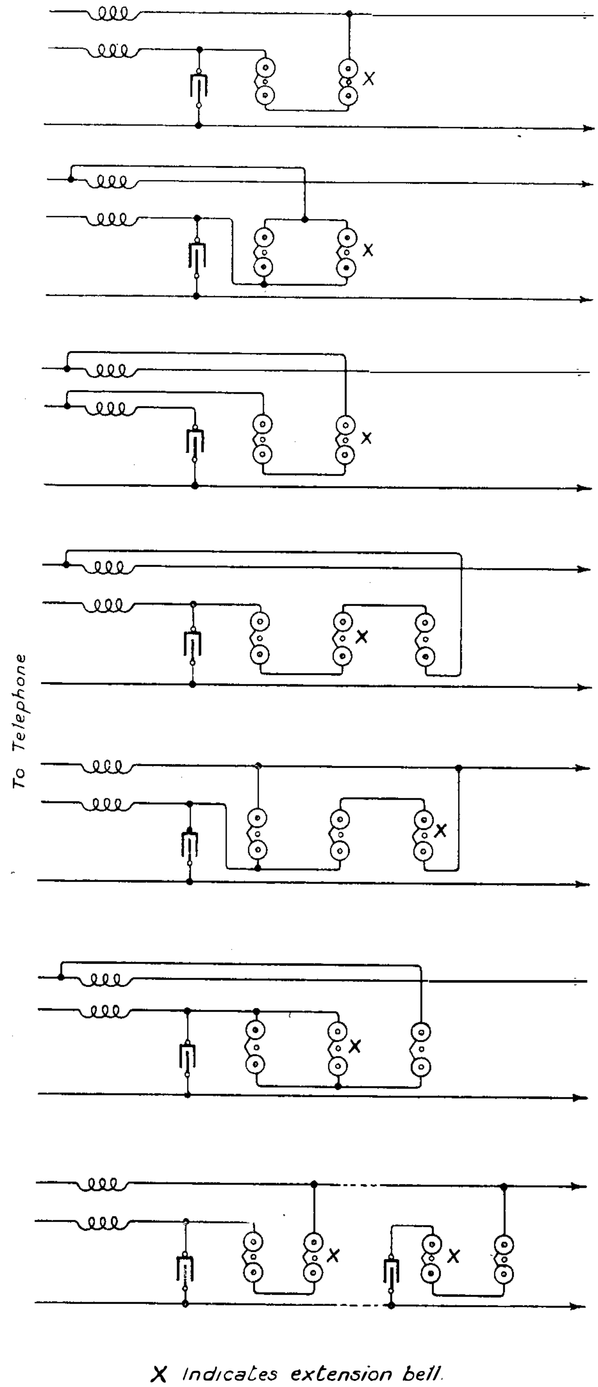


FIG. **19**.—VARIOUS ARRANGEMENTS OF BELL CIRCUITS.

branch exchange extensions in automatic areas unless direct night service is required, they are required on all extensions from automatic equipment. The telephone circuits included in Fig. **18** are designed to meet these various conditions. Fig. **18** also serves to show the detailed connection of the local battery telephones referred to in Part I. and shown schematically in Fig. **5**.

In conclusion, it is interesting to collect in Fig. **19** the various arrangements of bell circuits to which economy in wiring has led. In each of these the item starred is the "extension bell" and may be a 2½″ or 6″ diameter magneto bell, a drop indicator giving a continuous alarm on a local bell circuit until the indicator is restored, or an A.C. relay giving a dis-continuous signal on a local bell in synchronism with the ringing from the Exchange.

AIDS TO THE STUDY OF IMPULSING IN AUTOMATIC TELEPHONE SYSTEMS.

By W. H. Grinsted and D. A. Christian.

As everyone concerned with automatic telephony knows, there are limits to the speed at which the selectors of a step-by-step system will operate reliably. A common requirement is that connections shall be correctly set up with impulsing speeds varying from 7 to 14 impulses per second, with certain specified line conditions. In applying this requirement it is necessary to consider the type of impulse, that is to say, the proportion of the total impulse period during which the circuit is open compared with that during which it is closed. This proportion can be expressed as the ratio of "break" to "make" or as the percentage of "break." For example, the dial standardised by the British Post Office delivers impulses at the rate or speed of 10 per second, having a ratio of break to make of 2 to 1 (B : M = 2 : 1), that is a mean percentage of break of $66.\dot{6}\%$.

Unfavourable line conditions, variations in the exchange battery voltage, incorrect relay adjustments, the presence of shunt circuits, and a number of other factors all affect the operation of the impulse relays and prevent the accurate repetition of the impulse delivered by the dial to the selector magnets. These factors introduce varying amounts of distortion, altering the ratio or percentage of break, as received at the switch being operated. Further, dials cannot be regarded as delivering perfectly uniform impulses of standard ratio at the standard speed. In commercial service all dials cannot be accurately adjusted to the ideal, and even if a dial be adjusted to give impulses having a speed of 10 per second and a mean percentage break of $66.\dot{6}\%$, the individual impulses of one train will depart somewhat from this standard.

It is therefore very important to consider how great the departures from standard conditions may be before the operation of setting up the number dialled becomes unreliable.

If the selectors are to perform accurately it is essential that their magnets should be energised and de-energised for certain minimum periods. This requirement fixes the higher limit to the speed of reliable operation. It is also essential that the period during which the release relay receives no current but holds by virtue of its slow releasing properties should not be too prolonged, and that the dialling relay which releases at the end of a train of impulses should receive sufficient energisation during the break period of the impulse to enable it to hold over the make period. These requirements fix the lower limits to the speed at which the system will accept impulses reliably.

It is clear that these limiting speeds are very considerably affected by the impulse ratio and therefore by the amount of distortion, and that the one factor (speed) cannot be considered without the other factor (ratio) and *vice versa*.

This interdependence makes it difficult to measure and state in a concise form the breakdown limits of any system or combination of circuits, and still more difficult to obtain any clear idea of the margin of safety between the performance which is to be guaranteed and that of which the system is capable.

There are broadly three divisions under which the question can be considered—(i) the nature of the impulses delivered by the dial, (ii) the nature of the most extreme impulses with which the system will operate, and (iii) the margin of safety existing between (i) and (ii). This is the margin which provides against loss of adjustment of dials, relays or switches, unfavourable line conditions, etc. We felt very early in the development of our automatic systems the need for some means of representing these three in such a way that the relation of one to the other could be readily grasped, and after some efforts in other directions we developed the method about to be described, which has been in use for the past twelve years in the laboratories of Messrs. Siemens Brothers & Co., Ltd., and has proved of great value.

This method enables one to read off at once the nature of an impulse either in terms of its speed and ratio or of its break and make periods. It gives a clear picture of the relation between the impulses delivered by the dial and the

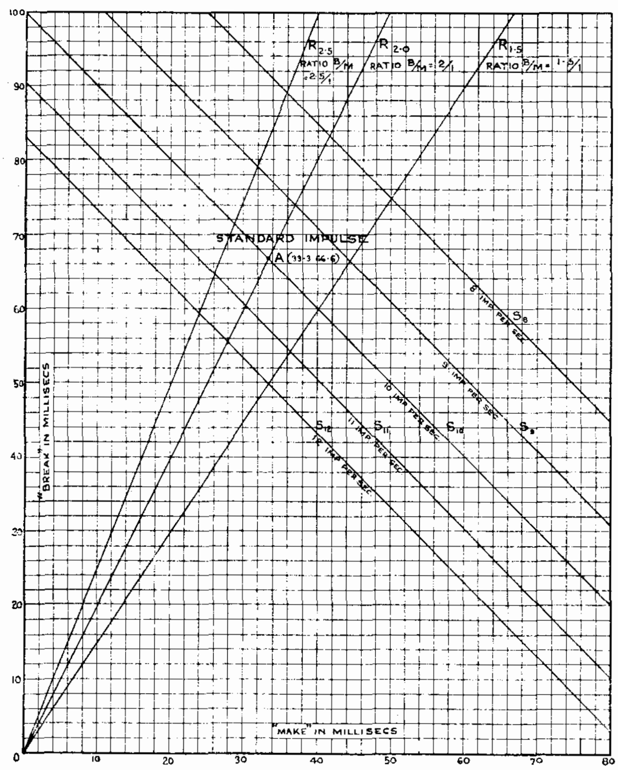


FIG. 1.—IMPULSE SPEED AND RATIO CHART.

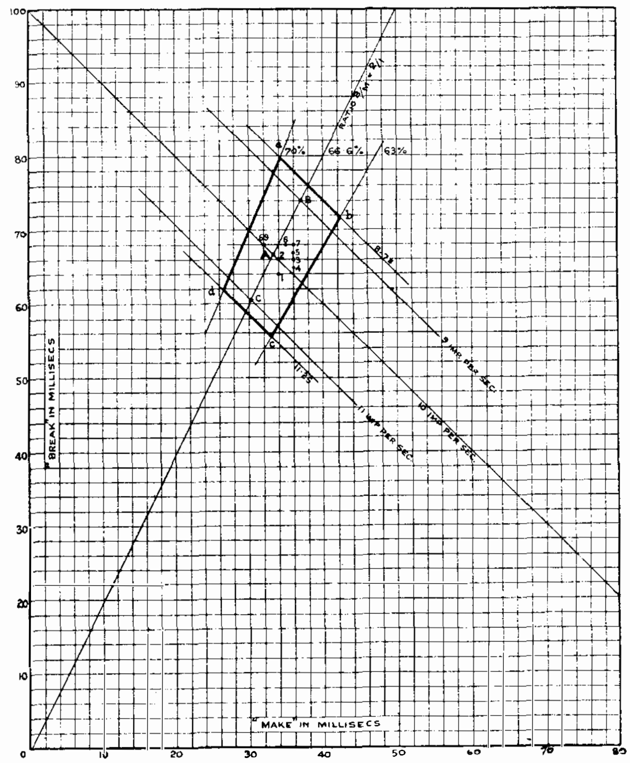


FIG. 2.—STANDARD DIAL TARGET.

breakdown limits of the system, and of the margin of safety between these two.

It is necessary in the first place to regard impulses as defined not so much by speed and ratio, which are secondary or derived quantities, as by their more fundamental elements, namely, the absolute length of the make and break periods in milli-seconds. For example, standard impulses having a speed of 10 per second and a ratio of break to make of 2 to 1 are thus defined as impulses of $66.\dot{6}$ m.s. break and $33.\dot{3}$ m.s. make. When impulses are measured in this way they can be plotted as points on squared paper, the abscissa representing the make period and the ordinate the break period. Thus in Fig 1, point A ($33.\dot{3}$, $66.\dot{6}$) represents the "standard impulse." Lines such as $R_{1.5}$, etc., for which B/M = a constant, are lines of equal ratios. For example, for all points on $R_{2.0}$ the ratio $B/M = 2$. Lines such as S_8, S_9, etc., for which $M + B$ = a constant, are lines of equal speeds. For example, for all points on S_{10} the sum of the make and break periods is 100 m.s. and the corresponding speed is 10 impulses per second. By plotting an impulse on a chart

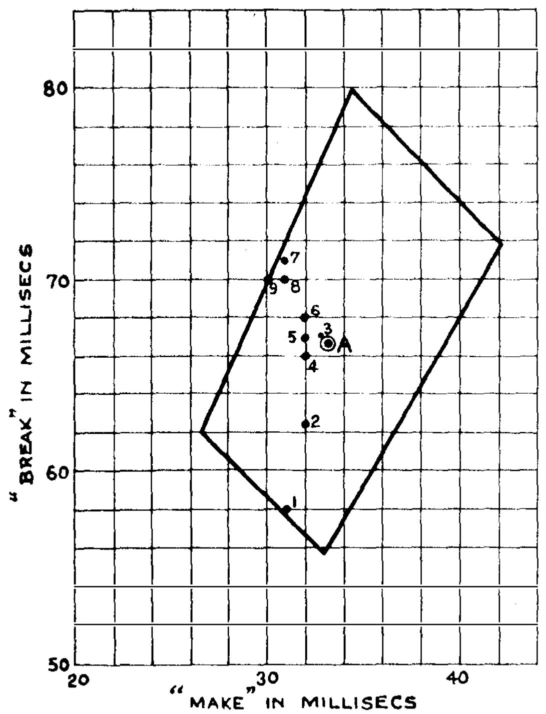


FIG. 3.—TARGET OF DIAL TENDING TO SLOW DOWN.

such as that in Fig. 1 therefore we have represented it completely.

Fig. 2 shows plotted in this way the train of impulses given by a standard Post Office dial when O is pulled.

Only nine points are shown, since when the contacts make after the tenth break the circuit is closed for an indefinite time. It is not possible, therefore, to measure the make period corresponding with the tenth break.

It will be realised that this group of points enables the ratio, the average speed and the degree of regularity of the impulses to be appreciated at once.

The limits allowed by the Post Office specification are shown by the quadrilateral *a b c d*. This is known as the "dial target." The specification calls for percentage break of 66.6% with tolerance limits of 63% to 70%. These limits to the ratio are represented by lines *bc* and *ad*. The dials are required to be adjusted so as to send not less than 9 nor more than 11 impulses per second. These are average or group speeds and, as pointed out above, a dial may send impulses at the desired rate and yet individual impulses of the train may differ from one another in their periods of make and break. The group speeds are represented by points B, C, but to make allowance for the variations of individual impulses the speed boundaries to the target, *i.e.*, the lines *ab*, *cd*, are taken as those corresponding with 8.75 and 11.25 impulses per second respectively. These figures are based upon the requirement originally proposed for the performance of the standard dial, namely, that no individual impulse should have a total length greater than that corresponding with a speed of 8.75 imp. per sec. or less than that corresponding with a speed of 11.25 imp. per sec.

The shape of the group of impulse points often reveals troubles due to the faulty design or construction of a dial; an example is given in Fig. 3, which reproduces the target diagram for a dial which has a tendency to slow down.

Fig 4 shows target diagrams for a Post Office standard dial adjusted to (average or "group")

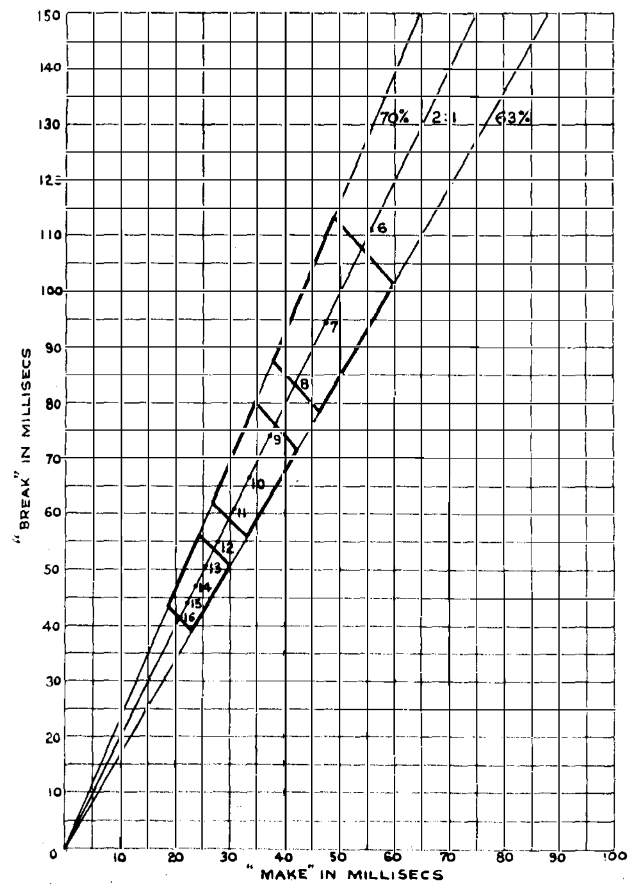


FIG. 4.—DIAL TARGETS FOR 7, 10, 14 IMPULSES PER SECOND.

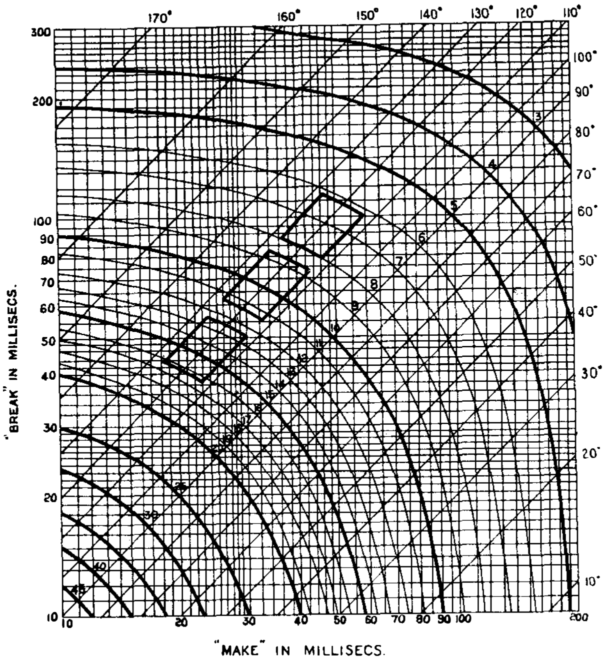


FIG. 5.—IMPULSE CHART—LOGARITHMIC SCALES.

speeds of 7, 10 and 14 impulses per second respectively, and allowing the same percentage variations as specified for a speed of 10 i.p.s. The permissible variations reckoned in milliseconds are, of course, correspondingly smaller for the high speed and larger for the low speed. This causes differences in the areas of the targets and so tends to give an impression of disproportion.

For all cases therefore where considerable ranges of speed or ratio have to be dealt with we use logarithmic scales as shown in Fig. **5**.* The lines of equal ratio now become parallel while the lines of equal speeds become curves. The effect of the logarithmic division is that a certain distance between the points representing two impulses always represents the same proportionate change no matter on what part of the chart the points occur.

Fig. **5** then represents fully the nature and degree of variability of the impulses delivered by a standard dial at its normal speed of 10 and at the extreme speeds of 7 and 14 impulses per second at which reliable operation of the system is required. It illustrates graphically the impulses which will be applied to the system under the specified conditions.

The next step is to ascertain with what impulses the system is capable of operating reliably. To determine this we carry out impulsing tests on the system or set of circuits to be tested, subjecting it to impulses generated by an accurate interrupter and varying the speed and ratio progressively until signs of unreliable operation become noticeable. For this purpose actual breakdown, that is definite selection of a wrong level or contact, premature release or cutting in of the hunting action, may be taken, but preferably we use the first indication of incorrect operation, such as chattering of the slow relays or signs of overshooting of the switch, even although incorrect selection does not occur. A series of tests of this kind, in which the speed and ratio are progressively varied, enables us to plot the most extreme impulses with which operation is reliable and by joining up the points representing these impulses we obtain a closed figure similar to that shown in Fig. **6**. This diagram we know

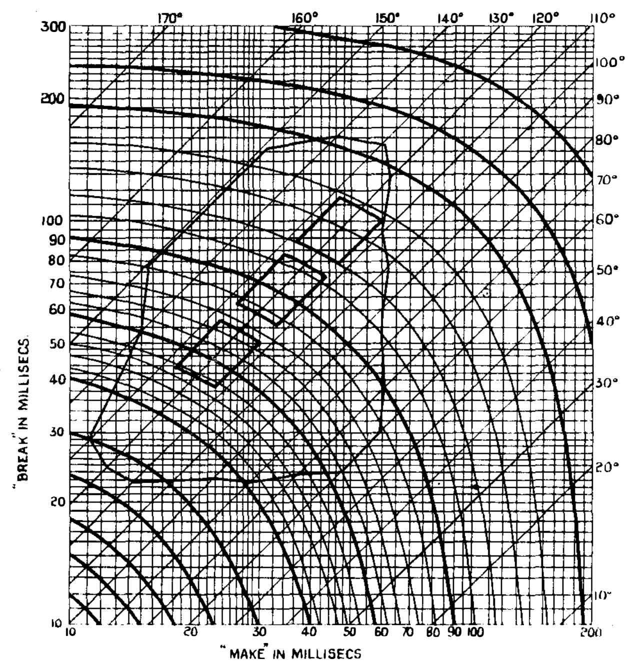


FIG. 6.—SYSTEM TARGET.

* *In this figure the ratios are indicated by the number of degrees of break out of a total impulse of 180°, as a matter of convenience, the interrupter referred to later having a scale marked in degrees.*

as the "System Target." The system will accept and operate reliably with all impulses represented by points within the area enclosed by the system target but its operation is unreliable on impulses falling outside that target. By reference to the speed and ratio lines the range of the system in speed and in ratio can be ascertained. By reference to the vertical and horizontal ones the limiting operating conditions can be read off as the lengths of the break and make periods in milli-seconds. The area of the target measures in a general way the range and reliability of the impulsing elements of the system.

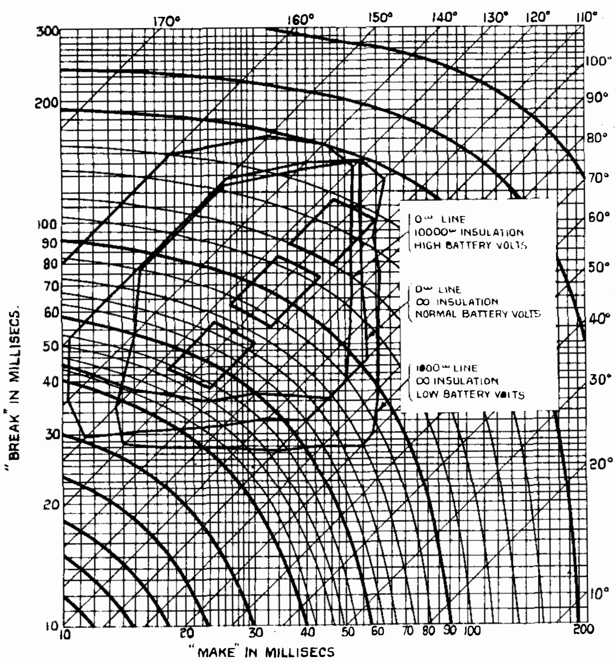


FIG. 7. SYSTEM TARGETS FOR DIFFERENT CONDITIONS.

The separation between the dial targets and system target gives at once a clear mental picture of the margin of safety and on account of the logarithmic scales the impression conveyed is in correct proportion. In a complete study of a system, system targets are taken for all the extreme conditions of varying battery voltage, line resistance and insulation, junction resistance and insulation, etc. Three such system targets are reproduced in Fig. 7 and show the performance of a system under "normal," "long-line" and "low insulation" conditions. In this case, also, each figure represents at each point the performance of the worst of three sets of circuits. Such targets are therefore known as composite targets.

The particular manner in which breakdown or unreliable operation occurs is, of course, different for different parts of the boundary of the system target. By recording against each part of the boundary the manner in which breakdown occurs, we can indicate at once which elements of the system need attention in cases where there is insufficient margin and direct our efforts to extending the boundary at that part.

In such a complicated subject as automatic telephony any device which enables one to display in a concise and readily appreciated manner the relations between a large number of varying factors is extremely useful. We have found this to be particularly true of the targets described in this article. They condense into a single diagram information which cannot be satisfactorily conveyed in words or figures. In simpler engineering matters the degree of safety is measured by the ratio of the breakdown condition to the working condition. Such a definition presumes only one main variable. It is hopeless to try to measure the margin of safety of an automatic system in any such way. As a result of this, ideas on the subject of safety margins on automatic systems tend to be vague and confused. Yet it is of the greatest importance that there should be a margin and that we should know how much it is. The targets we have described have given us clearer ideas and a definite means of measuring our margins. It is with the hope that they may be of equally great assistance to others that we have, with the kind permission of the Board of Editors, brought them to the notice of the readers of the Journal.

THE PHONIC CHRONOMETER FOR THE MEASUREMENT OF RELAY TIMES.

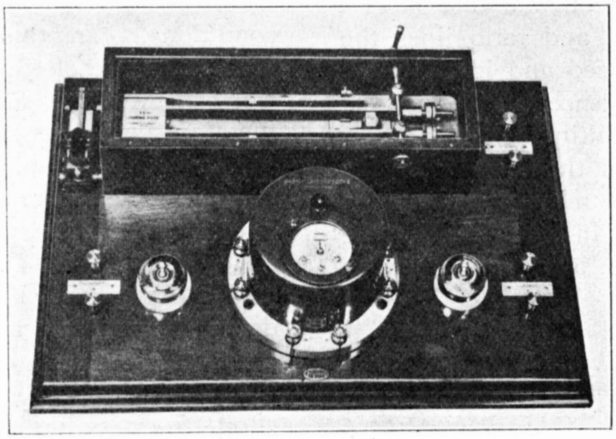


Fig. 1.—The Phonic Chronometer.

It has long been realised that the accurate measurement of operating and releasing times of telephone relays is a vital factor in the design of automatic telephone circuits and up to the present, this class of measurement has always been looked upon as one which can only be carried out by technical engineers with delicate and expensive apparatus. Nevertheless, it has often been suggested jokingly that the Post Office ought to produce an apparatus of the type in which one can " put a relay in a box, turn a handle, and get the operating and releasing lags indicated directly on a dial." The Phonic Chronometer Timing Set has no claims to such an ideal, but it has been so developed by the E.-in-C.'s Circuit Laboratory that it can be handled with ease by the minor staff and can give direct readings which are accurate to a few milliseconds.

The actual measuring chronometer is shown diagramatically in Fig. 2. The essential part of the mechanism is a phonic motor which is driven at constant speed by an electrically controlled tuning fork, the fly wheel of the motor being marked " W " in Fig. 2. Situated a short distance away is a small friction wheel F which can be brought into contact with the flywheel by means of a magnet M. The spindle of the friction wheel is extended to carry a light pointer moving over a scale which is suitably graduated in milliseconds to give a direct reading of the period of contact between the two wheels. In the normal position the friction wheel rests against a back stop B, which also acts as a brake to arrest the rotation of the wheel

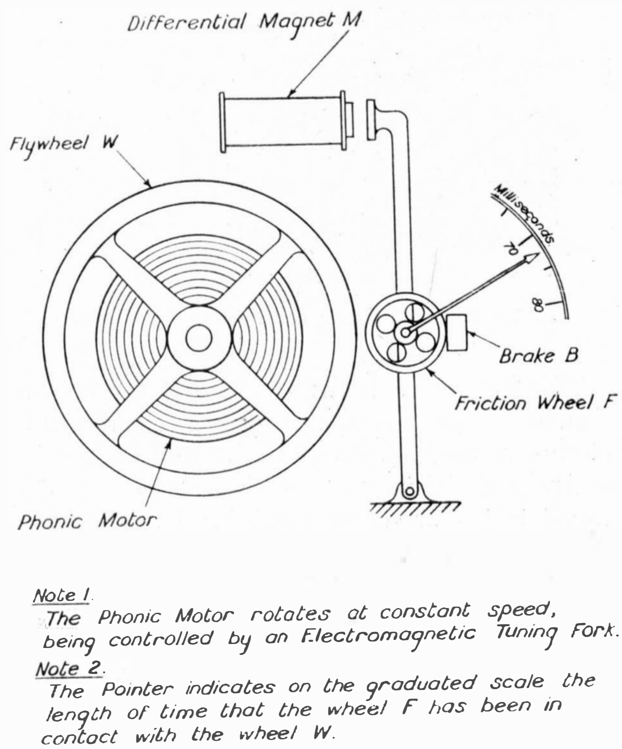


Fig. 2.—The Principle of the Chronometer.

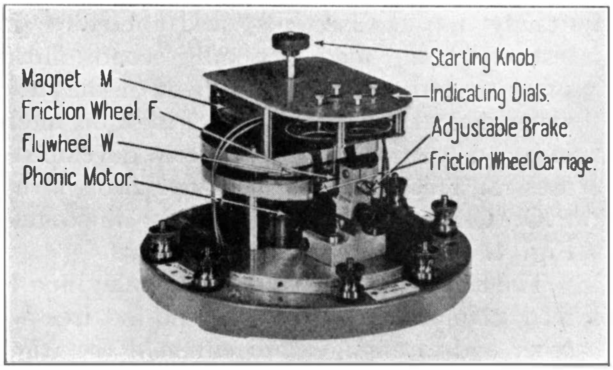


FIG. 3.—THE CHRONOMETER MECHANISM

when the magnet M is released. In order to reduce errors due to differences between the operating and releasing times of the electromagnet M, the magnet is differentially wound and is so connected that when current is flowing in both coils, the fluxes produced cancel each other and the friction wheel is allowed to remain against the back stop. When one of the differentially wound coils is disconnected, the magnet operates and starts the rotation of the pointer, and when the other coil is disconnected the magnet is released and the pointer is immediately arrested by the brake. It will be seen therefore that the pointer indicates the time period between the disconnecting of the first circuit and the disconnecting of the second, provided that the electrical lags in the magnet are the same at starting as at stopping.

In order to obtain the required accuracy in an instrument of this nature it is necessary to incorporate many refinements to eliminate possible errors such as slip, inertia, eccentricity, magnet time-lags, residual flux, etc. Attention has been paid to each of these points, and a photograph of the actual chronometer manufactured by Messrs. Tinsley & Co. is given in Fig. 3. The various components of the apparatus are indicated and it is seen that the friction wheel and the carriage which holds it are of a very light construction, the travel of the friction wheel being approximately 5 mils. Instead of a single dial and pointer, the instrument illustrated has a train of 4 dials giving readings from 1 m.s. to 100 seconds, the pointers being reset by hand between successive tests. The complete instrument is very compact and only measures $7\frac{1}{2}'' \times 7\frac{1}{2}'' \times 5\frac{1}{2}''$ high.

The part of the apparatus so far described would give time measurements between successive breaks of any two independent circuits with 1 m.s. accuracy, but in order to adapt it to give measurements of relay lags with the required simplicity of operation, it is necessary to add a separate assembly of auxiliary apparatus con-

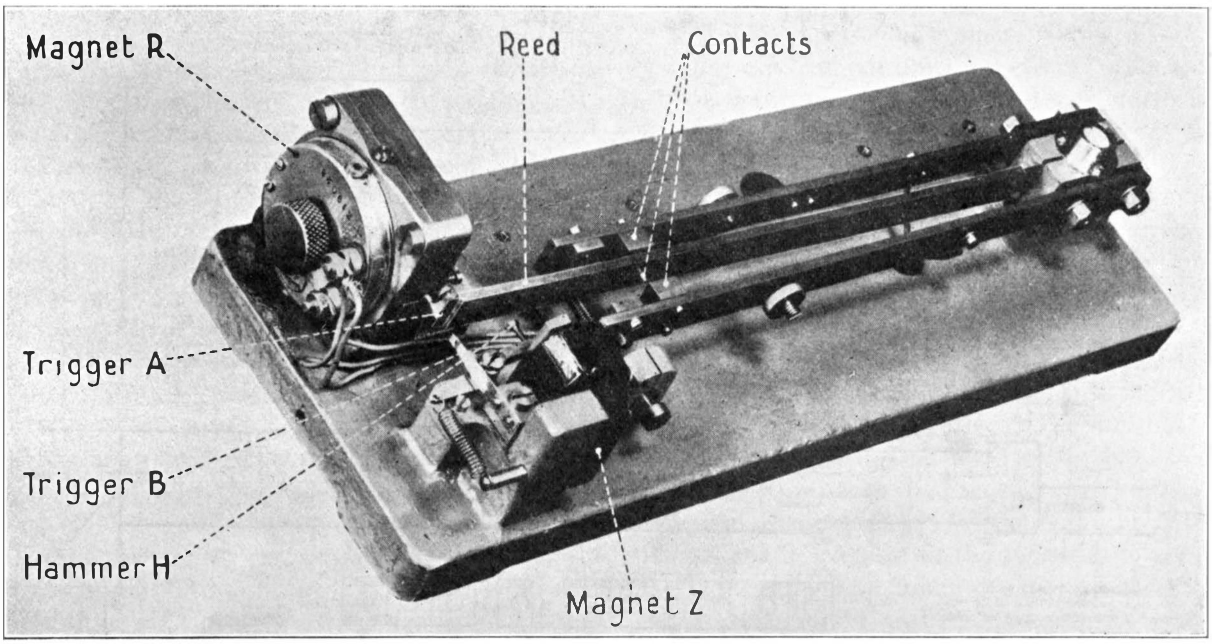


FIG. 4.—AUXILIARY 100 M.S. RELAY.

sisting of keys, relays, etc., as shown schematically in Fig. **5**. The complete timing set shown in that diagram provides the following facilities :

(*a*) Measurement of operating and releasing lags of relays with either "make" or "break" contacts.

(*b*) Measurement of the duration of earths or disconnections in any simple circuit.

It will have been observed that there will be an appreciable operating lag in the chronometer itself (approx. 40 milliseconds) and therefore it will be impossible to get a reading on the chronometer dial in the case of an interval of less than this value. As, however, there are many occasions when quite small time lags have to be measured, the auxiliary apparatus has incorporated in it a special relay designated SZ for the purpose of adding a fixed time interval to any period that is being measured. This relay is designed to have an operating lag of exactly 100 milliseconds, and therefore when tests are being made 100 milliseconds must be subtracted from the reading given on the chronometer dial. This special relay is of an interesting construction and has been developed by Messrs. Tinsley & Co. in co-operation with the P.O. Circuit Laboratory. It is illustrated in Fig. **4**.

The armature of this auxiliary relay is a long reed, clamped flexibly at one end but free at the other end to engage with either of the triggers A or B. In the normal position the reed is held by trigger A, but when the magnet R is energised the trigger is raised and the long reed is allowed to swing over with a speed corresponding to its natural frequency. It operates the contacts shown and is held in position by the trigger B which is allowed to come into engagement when the coil Z is energised. The two coils Z and R are therefore connected in series so that when the relay is energised, trigger A is

RELAY TIMING SET USING PHONIC CHRONOMETER.

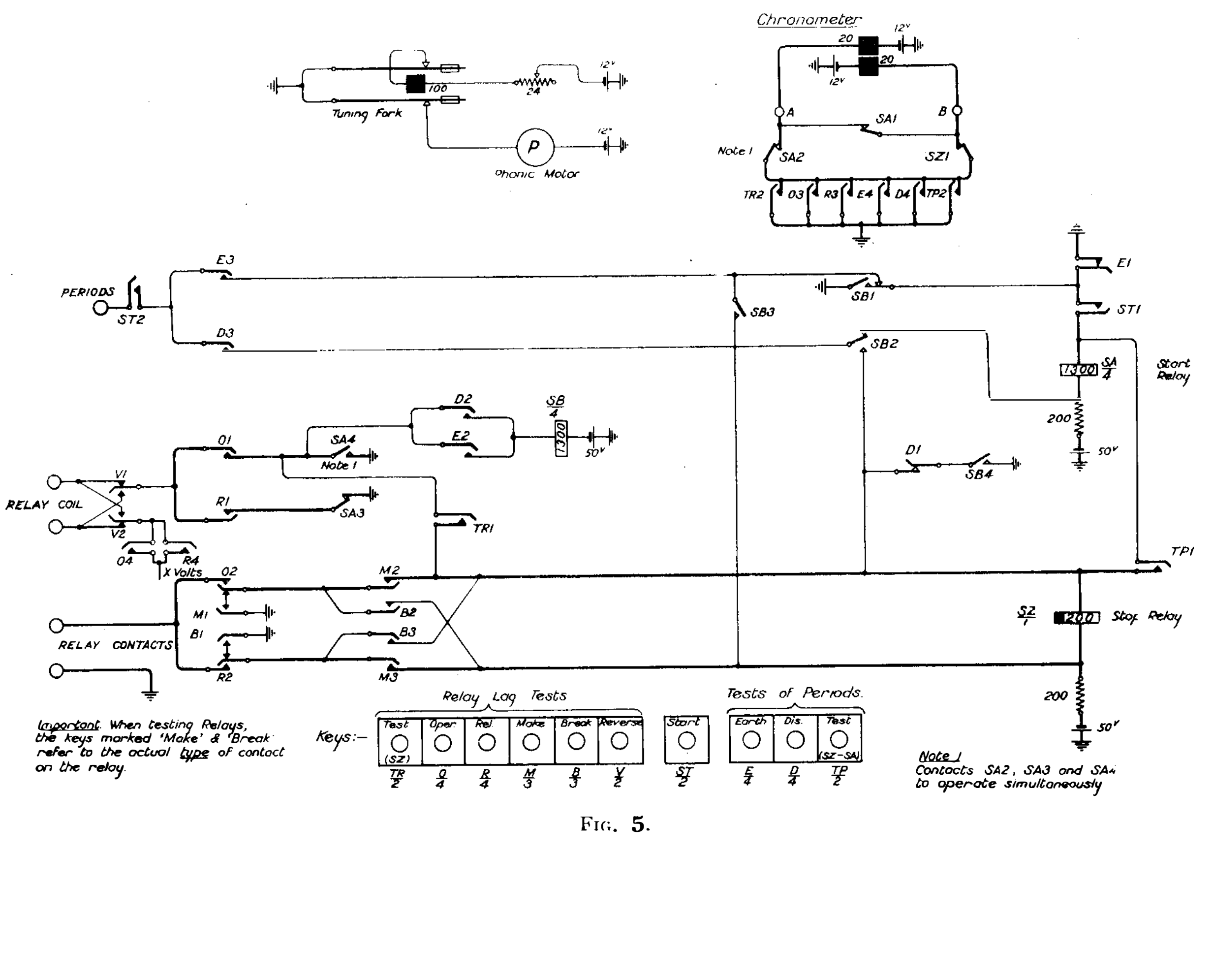


FIG. **5**.

lifted and trigger B is engaged. It follows therefore that when current is cut off from the relay, the trigger B will be raised by the action of the Z magnet and, with the help of the small hammer H, the reed will return to the trigger A which will have been restored. The relay is therefore self-restoring and the " follow " of the break contact can be adjusted to give the required operating lag of 100 milliseconds.

Referring to the circuit diagram in Fig. **5** it will be of interest to follow the functions of this auxiliary relay SZ when making some particular test. For example, suppose it is desired to measure the releasing lag of a relay having a break contact. The coil and contacts of the " test " relay will be connected to the terminals shown on the L.H. side of the diagram, the point marked " X volts " being connected to a suitable battery voltage (usually 50v.) and it will also be necessary to throw the " releasing lag key " R and the " break contact key " B. The R3 contact provides earth connections to both of the differential magnet coils in the chronometer and the R1 contact provides a path which keeps the relay under test in the operated position. Included in this " test " relay circuit, however, are the break contacts of the " start relay " SA and this relay will be operated when the " Start Key " is thrown. As the relay under test is in the operated position, its break contacts in this case are open, but as soon as the " test " relay has released there is a circuit for the " stopping " relay SZ *via* the contacts R2 and B3.

With these circuits in mind it will be easily understood that the operation of the start relay SA will simultaneously disconnect the test relay circuit and also the first differential coil of the chronometer; the test relay will then proceed to release and, as soon as its break contacts have closed, the SZ relay will be energised. The SZ1 contacts, however, will not be opened until 100 milliseconds have elapsed and therefore the chronometer will have received a time interval equal to the releasing lag of the relay under test plus the 100 millisecond operating lag of the SZ relay. Similar circuits are provided for the measurement of operating lags and in every case the timing set will give correct readings whether the relay contact be a " make " or a " break." It should be remembered when making relay measurements that the words " make " and " break " refer to the type of contact on the relay and not to its actual function during the testing operation. Provision is made for checking the 100 m.s. operating lag of SZ directly on the chronometer by throwing the " test " key TR.

It is also possible to measure the duration of any earth or the duration of a disconnection period in a circuit which is normally earthed, by using the terminal marked " Periods." In the case of an " earth " period in a circuit, the " earth " Key E is thrown, and then when the " start key " is operated the SA relay is connected to the " Periods " terminal *via* SB1 and E3. When the earth is connected, the SA relay operates and starts the chronometer at contacts SA2, but the relay SB is also operated *via* E2 and SA4. Relay SB switches the " Periods " terminal over from the SA relay to the SZ relay, but now the earth connection being tested is allowed to short-circuit SZ *via* SB3, a separate operating earth being provided *via* D1 and SB4. When the test earth connection is removed, the SZ relay operates and after 100 milliseconds delay the chronometer is stopped. In this class of test the chronometer is only reading higher by an interval equal to 100 milliseconds minus the operating lag of SA. This interval can be measured on the chronometer by throwing the key TP. In this case the SA and SZ relays are connected in parallel and, as soon as the start key is thrown, the chronometer is started by the SA contact and stopped by the SZ contact. The interval between these two operations is the difference between the operating lags of the SA and SZ relays and this is the time interval which would have to be subtracted from the previous chronometer reading. The subtraction of this odd amount detracts from the simplicity of operation, but it is not considered so important as the retention of the exact 100 milliseconds subtraction in the case of the more frequent relay measurements.

Compared with the oscillograph this apparatus has many advantages for general relay work and one of the greatest is the fact that a number of readings can be taken in quick succession by the re-operation of the start key, giving a record of the relay variations from time to time under the same external conditions. It is interesting to note that an ordinary telephone relay will often give readings varying by as much as 10% between successive operations.

The complete instrument has been checked against the oscillograph with results that show an accuracy of approximately 5 milliseconds on intervals up to 500 milliseconds and this is very satisfactory for general relay work. Coupled with this accuracy, however, is the important factor of simplicity of operation, which enables the instrument to be used by the minor staff as well as by the engineers. It may be said that with its aid the measurement of relay times has become as simple and as rapid as the measurement of operating currents.

R. W. PALMER.

THE ACCOMMODATION OF P.B.X. LINES IN A FINAL SELECTOR MULTIPLE.

R. J. HINES, B.Sc.

(I.) STATEMENT OF THE PROBLEM OF DESIGN.

A STUDY of the P.B.X. final selector circuits in use does not reveal all the factors which have been taken into account in designing the scheme. Moreover, it needs considerable experience in circuit analysis to form a clear understanding of the accomplishments and limitations of a particular circuit. Such an understanding is dependent upon the formation of a clear conception of the fundamental principles upon which the circuit operation depends, and it is the intention of this article to provide a summarised description of the facilities afforded by the various P.B.X. final selector circuits working in this country.

No circuit at present in use can be said to be ideal and the present designs have been the outcome of an examination of the ideal requirements followed by an attempt to provide as many of these facilities as could be concurrently provided in one circuit. This article is therefore divided into two parts, the first of which enumerates the considerations which should be taken into account, whilst the second part describes the existing schemes and shows to what extent the desirable features are incorporated.

The fundamental requirement of a final selector in the multiple of which appear P.B.X. lines, is that the busy tone shall not be transmitted to the calling subscriber until all the lines of the called P.B.X. are found to be engaged.

Before commencing to develop a circuit which will meet this requirement, it is necessary to consider how the P.B.X. lines may be grouped, *e.g.*, will the groups all consist of lines having consecutive numbers, or will they be scattered throughout the numbering scheme? The scheme developed for dealing with such groups should place as few limitations as possible on the numbering. The first restriction, nearly always found to be unavoidable, follows from the fact that in general not all the final selectors provided in the exchange are enabled to deal with P.B.X. groups, *i.e.*, the Directory number allotted to P.B.X. groups must be limited to a block of numbers served by special final selectors known as *P.B.X. final selectors*. The reason for employing a special type of P.B.X. final selector is that since additional facilities are to be obtained with these switches a greater number of relays is required in their circuits and they are, consequently, more costly. Hence an economy is obtained by providing no greater number of these more expensive switches than are required to carry the P.B.X. traffic on the exchange in question. The P.B.X. groups of final selectors should not be adjacent, but should be distributed throughout the numbering scheme, so avoiding congestion through certain channels.

The great majority of P.B.X.'s have fewer than 10 exchange lines, and it is therefore desirable that the scheme adopted shall permit the accommodation of more than one P.B.X. group in a final selector level, due regard being paid, however, to the possibility of development and an adequate number of spares, therefore, being left for the growth of each P.B.X. In order that provision shall be made for meeting the needs of subscribers who, though renting one exchange line only, are potential P.B.X. subscribers, it should be possible to place their lines also on P.B.X. final selectors and thus avoid the necessity for number changes when the additional lines mature.

If the total number of P.B.X. groups working on an exchange be very small it may be desirable for direct exchange lines to be interspersed between the lines of one group in order to use the bank capacity to an advantage and yet allow for unexpected development of P.B.X. groups. This facility is at present provided at Southampton only, and is there accompanied by the disadvantage that one P.B.X. group only can be accommodated in a level.

Allowance must be made for the possibility of P.B.X. exchange lines being plugged through to extensions when the P.B.X. board is unattended. In these circumstances it must be possible for individual lines in such a group to be called, *i.e.*, definite advice must be given if the called line is engaged without first testing the remainder of the group. If the automatic hunting of the selector were allowed to take place when the called line is engaged, the call would either be routed to an extension which was not required, or the selector would ring on a line which was not extended to a point where attention would be given and a false "no reply" condition would result. In circumstances when the night service is sufficiently extensive to make this a serious disadvantage, it follows that night service cannot be given by dialling the directory number, as the selector would inevitably hunt when this number was found to be engaged. A night service number must therefore be advertised. This number may be either in the consecutive series allotted to the P.B.X. or may be a special number on a regular final selector bank and jumpered to one of the exchange lines. A special rental is charged when this facility is given.

A further important consideration is that it should be possible to leave spare contacts in the bank multiple and so allow for future growth and yet do so in such a manner that no wastage occurs in the numbering scheme, *i.e.*, provision is made for development without the reservation of numbers which may be required for allocation to direct lines.

The preceding paragraphs deal with the facilities which should be provided for P.B. X. subscribers and does not discuss the practicability of providing all these facilities concurrently. It therefore becomes necessary to consider whether an ideal scheme can be provided and, if so, whether the advantages obtained justify the cost of provision. If an ideal arrangement involves a great deal of difficulty, it is necessary to estimate the value of each facility and balance this value against the difficulty of providing it.

Night service.—As already stated the engagement of the first line of a P.B.X. group must normally result in final selectors rotating over the remaining lines of the group. If a particular exchange line be required, *e.g.*, an exchange line which has been connected to an extension, final selectors must refrain from hunting when that line is found to be engaged and must instead report the engaged condition by connecting busy tone to the calling line. The final selector must therefore be given some indication when it is required to suspend its P.B.X. hunting function. Hence, some variation in the conditions must be made to distinguish between a call to the P.B.X. board and a call to a particular extension. If the call to a particular extension is to be routed by the dialling of the directory number some alteration must be made to its exchange line circuit at the time that the change from normal to night service conditions is required. This obviously involves either co-operation between the subscriber and the exchange staff or some engineering complexity added to the exchange line circuit, enabling the subscriber to vary the condition at the exchange. Either of these alternatives is unsatisfactory, and special night service facilities are not given over the first lines of a group except in special circumstances. It is evidently possible, however, to arrange that night service may be obtained by dialling some number other than that entered in the directory. This number may be a spare number which is teed to the exchange line required, and which is not such as will set up the hunting condition in the final selector circuit, or it may even be one of the auxiliary lines of the P.B.X., so long as this also is a line which will not cause the final selector to hunt. It is possible to adopt this latter arrangement since the normal method of calling the P.B.X. is to dial the directory number and this is the only line that need be arranged to set up hunting conditions in the final selector circuit.

It has already been stated that when it is necessary to provide for P.B.X.'s with large groups of lines, it is very desirable that these lines should not be among those to which numbers in the regular numbering scheme are allotted, *i.e.*, these lines cannot be reached individually by dialling their numbers. If this requirement be satisfied, the only way of providing night service over particular exchange lines is by employing a spare number in the regular numbering scheme and teeing this to the exchange line in question. It is thus apparent that there is a fundamental incompatibility between the requirements that numbers in the regular numbering scheme shall not be alotted to auxiliary lines, and that any line may be called individually.

P.B.X.'s with more than 10 *exchange lines.*—Groups of P.B.X. lines more than 10 in number cannot be accommodated on one level of bank contacts on a final selector of the usual type. In consequence these groups present more difficulty than groups of 10 lines or fewer, as it is necessary either for the final selectors concerned to rotate their wipers over the levels in succession or alternatively to reach these lines by some other channel than usual. Hence these switches are more costly than those which can deal with small groups only. Since the number of P.B.X.'s with more than 10 lines usually form a small percentage of the total P.B.X.'s, it is usual to provide one type of P.B.X. final selector for dealing with small groups, and provide other means for dealing with large groups.

Availability.—It is obvious that large groups of lines may be dealt with by splitting the multiple, *i.e.*, whereas any one switch may hunt over the 10 lines in one level, the 10 lines available to one switch will not be the same 10 lines in the corresponding level of other switches. Such an arrangement, however, results in the reduction of the efficiency of the service given to the subscriber and is not adopted except to a limited extent in special circumstances. (See description of the standard 2-10 line P.B.X. final selector).

Number wastage.—In order to avoid the allocation of large groups of numbers to the auxiliary lines of P.B.X.'s it is sometimes arranged to interpose a special 3rd selector between the 2nd selector and the P.B.X. final selector, *i.e*, the 2nd selector, which normally has access to 10 groups of final selectors, is given access to 100 groups. The 3rd selector is operated by the 3rd dialled digit which would normally define the 10 lines within which the required line or group was situated. The final selector reached, however, has access to more than 10 lines and may either be of a type which first accepts the 4th digit and then, having located the required P.B.X., proceeds to find a disengaged line, or it may be exclusive to one P.B.X. and commence searching over the corresponding group without waiting for the 4th digit, which it will ignore. The use of a special 3rd selector scheme will be dependent upon there being a sufficient saving in exchange numbers to justify the provision of the additional apparatus.

Special P.B.X. line switches.—Schemes have been devised which involve the use of two types of line switch, viz., one type for ordinary lines and another type for P.B.X. lines. Although such a scheme involves little engineering difficulty, it is generally recognised as a principle that any line switch should be available for use with either ordinary lines or P.B.X. lines.

Dialling-in to P.A.B.X.'s.—The schemes at present in use do not provide for dialling P.A.B.X. extensions direct from the public system.

Allocation of Numbers in P.B.X. Units.—The fact that a subscriber rents a P.B.X. indicates that his line will be more busy than those of subscribers with single lines. Congestion through certain channels in the exchange would occur if the P.B.X. lines were placed in units fitted with nothing but such lines. It has therefore been agreed between the Engineering and Traffic Departments that switches to accommodate ordinary lines as well as P.B.X. lines shall be allocated numbers on the following basis:—In every 100 ordinary numbers in the exchange multiple it is assumed that there will be 3% unavailable spares and that in 100 P.B.X. numbers there will be 18% unavailable spares. For example, if the ultimate development be anticipated as 2,051 ordinary lines and 186 P.B.X. lines, the actual numbers will be calculated as follows:—

	Lines.		Factors.		Numbers.
Ordinary lines ...	2,051	÷	0.97	=	2,114
P.B.X. lines ...	186	÷	0.82	=	227
	2,237				2,341

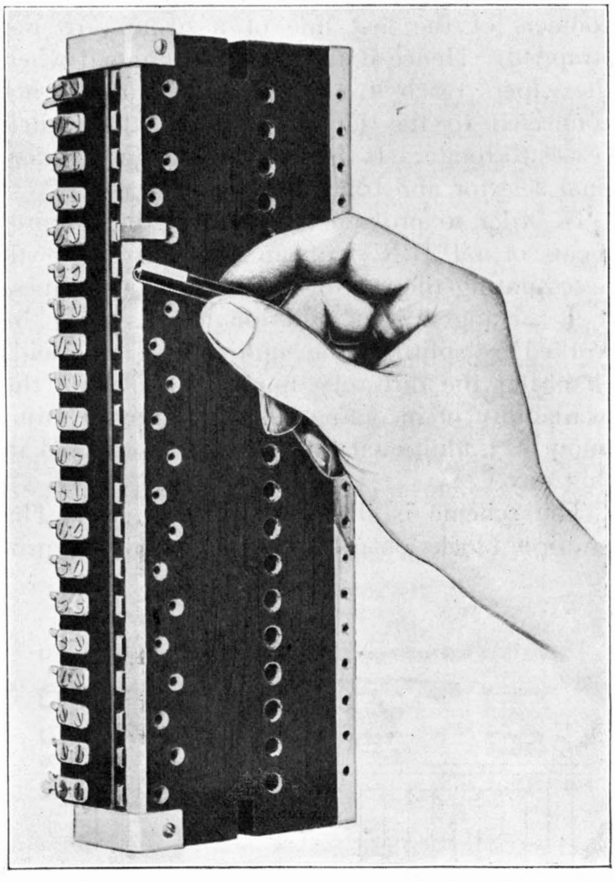


FIG. 1.—STRIP OF BUSYING JACKS.

The number of P.B.X. units is estimated as follows:—

To each P.B.X. unit are allocated 60 P.B.X. numbers and 40 ordinary numbers. Thus, in the example above, the number of P.B.X. units will be $\frac{227}{60} = 4$. The estimate that in the ultimate there will be 97% of the ordinary numbers working and 82% of the P.B.X. numbers working, thus implies that there will be 60 × 82% = 49 working P.B.X. lines and 40 × 97% = 39 working ordinary lines per unit = 88% of the total capacity of the unit.

A further provision is that when the extension is final and when the multiple capacity limits the capacity of the exchange, 86 working lines per 100 P.B.X. numbers should be allowed for, giving a factor of 0.86 instead of 0.82. When this stage is reached there will be 60 × 86% = 52 working P.B.X. lines per unit.

Engaging faulty lines.—If one line in a group be faulty, it is necessary that during the time that the line is receiving attention it should be engaged to final selectors which will therefore pass on to the remaining lines in the group. In order to achieve this end, a strip of jacks of special design is fixed to the verticals of the main frame to which the privates of the P.B.X. units are wired. In order to engage the line a peg is inserted in the jack and this earths the private. A main frame fanning strip fitted with a strip of busying jacks is shown in Fig. **1**.

In the case of Siemens No. 16 equipment, the pegs are normally in position and are withdrawn to disconnect the "C" wire, thus rendering it engaged.

(II.) GENERAL DESCRIPTION OF WORKING SCHEMES.

A.—THE STANDARD SCHEMES.

Types of selector used.—The schemes now standardised involve the use of three tpyes of selector, viz., one for dealing with groups of 10 lines and fewer, a second for dealing with groups of 11-20 lines and a third for dealing with groups of more than 20 lines.

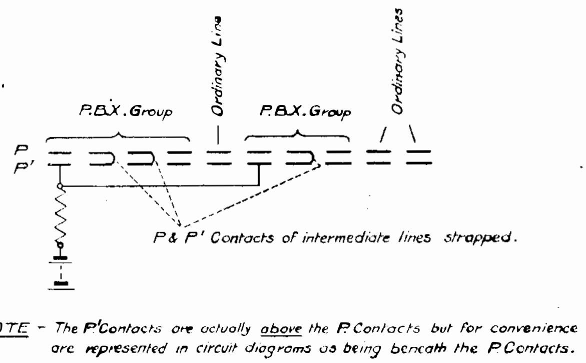
The 2-10 line P.B.X. final selector.—The characteristics of this selector are as follows:—

(*a*) All the lines in one P.B.X. group are accommodated in one level of contacts.

(*b*) More than one P.B.X. group may be accommodated in a level.

(*c*) Any line may be dialled and hunting will only take place if the number dialled is the first line in the numerical sequence of a P.B.X. group and is found to be engaged.

(*d*) Ordinary lines can be interspersed between the P.B.X. groups.



2-10 LINE P.B.X. FINAL SELECTOR.
Arrangement of P&P' Contacts.

FIG. 2.

In addition to the above the usual ringing and supervisory functions associated with final selector circuits are performed.

From the above it is obvious that some distinction must exist between ordinary lines and P.B.X. lines and, further, between the first and subsequent lines of a P.B.X. group. The distinguishing characteristics are provided by an auxiliary private circuit. The private bank is constructed like an ordinary line bank and a double private wiper is used, *i.e.*, a wiper having the two halves insulated from each other in the manner of line wipers. The lower wiper completes the normal private circuit to the line switch and the upper wiper completes the local circuit to determine the class of the line called. The private contacts are arranged as shown in Fig. **2**.

The circuit is such that if the first line of a P.B.X. group is called and the private contact is found to be connected to earth, signifying that the line is engaged, the battery on the P1 private contact will complete a circuit to step the switch to the succeeding line. The continuance of hunting over engaged lines is dependent upon the two private contacts associated with each line being strapped together by which means the earth on the private circuit is communicated to the P1 contact. The P and P1 contacts of the last line of a group are not strapped. Hence if this line be engaged when the wipers reach it, the engaging earth is not connected to the P1 contact and the switch ceases to rotate. It then behaves as an ordinary final selector and transmits the busy tone.

In order to provide for meeting the requirements of a P.B.X. with an unexpected growth necessitating the renting of more than 10 lines, it is arranged that additional lines may be worked by splitting the multiple. This avoids changing the directory number, but since the availability of incoming calls is limited a minimum of 3 additional lines only are provided in this way.

The scheme is illustrated in Fig. **3**. The multiple blocks on the top of each unit are pro-

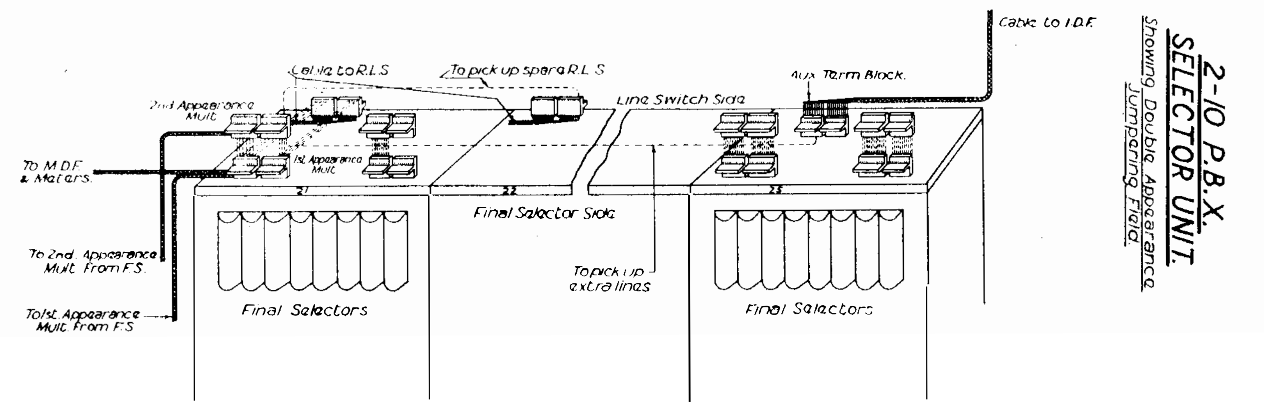


FIG. 3. *When extra line is required 2nd Appearance Multiple is jumpered to any spare Line Switch and to Terminal Block to pick up auxiliary line*

vided in duplicate, the multiple from half the final selectors in the unit being cabled to the lower block, while the multiple for the remaining switches is cabled to the upper block. The lower block only is cabled to the main frame, the upper block being normally jumpered to the lower block. On the line switch side of the unit can be seen the block to which the line switches are cabled and the line switches are normally connected to their proper position in the multiple by jumpering from these blocks to the first appearance multiple block. All the line switches of a P.B.X. group of 10 lines are thus available to the whole of the final selectors in the unit. Should an additional line be required, the jumper connecting the 10th line between the first and second appearance block is removed. The 10th line is thus available to the first half of the multiple only. It is now necessary to connect the 10th circuit on the upper block to an additional line and associate this line with a spare line switch. In the figure it will be seen that the upper block has been jumpered to a line switch and also to a miscellaneous terminal block. This latter jumper serves to connect to an extra line, the miscellaneous block being cabled to the I.D.F.

There are thus two lines corresponding with the last outlet on the level and the additional line is, therefore, allotted a number outside the regular numbering scheme of the exchange. A special group of meters is provided for such lines and connection with these meters is made at the I.D.F.

One miscellaneous terminal block is usually provided per suite of units—generally 5.

The 11-20 line, P.B.X. Final Selector.—The characteristics of this selector are as follows:—

(*a*) Each level accommodates 20 lines (by means of two banks as described below).

(*b*) One P.B.X. only can be accommodated per level.

(*c*) The wipers are not dialled into the level but rotate automatically as soon as the vertical stepping is completed.

(*d*) Although 20 lines are allotted to each P.B.X. 10 numbers only are sacrificed since there are two lines for every possible position of the wipers.

(*e*) It follows from (*c*) that individual lines

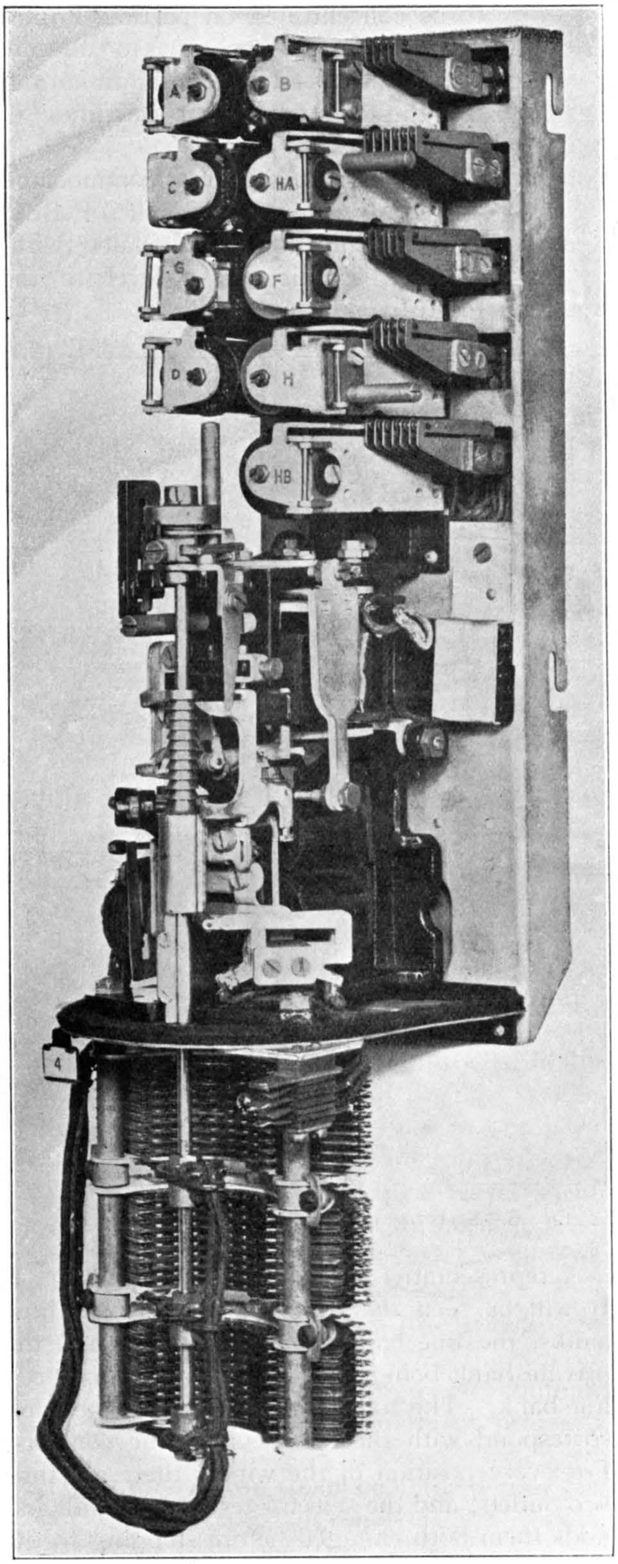


FIG. 4.—SELECTOR FOR GROUPS OF 11-20 LINES.

cannot be dialled and for night service to be concentrated on particular lines it is therefore necesary to allocate special numbers in regular units and tee these numbers to the lines in question.

(*f*) Ordinary lines cannot be accommodated on this selector. Small P.B.X. groups cannot be accommodated (without the sacrifice of a level to the group).

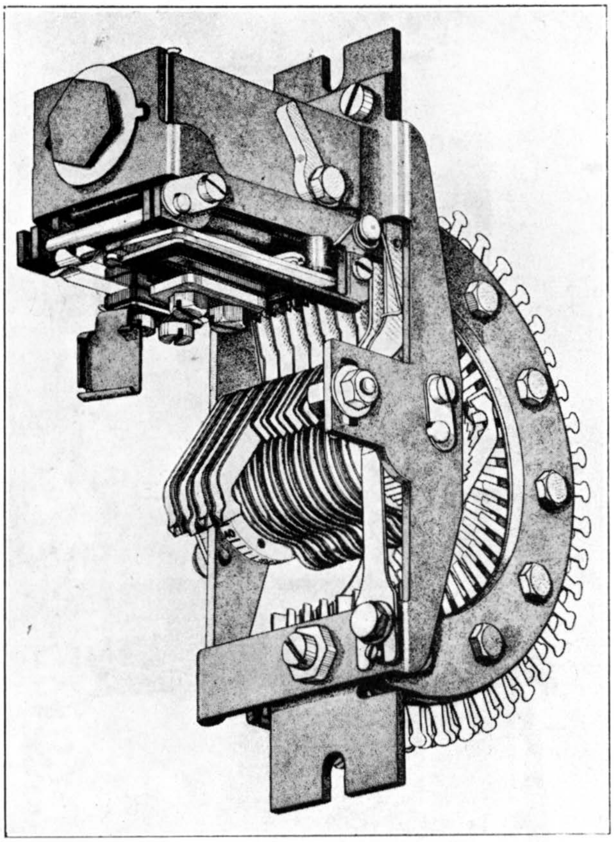


FIG. 5.—SELECTOR FOR GROUPS EXCEEDING 20 LINES.

A representative selector is shown in Fig. **4.** It will be seen that this selector carries three banks, the line bank being duplicated and the private bank being similar in construction to a line bank. The 200 contacts of the private bank correspond with the two sets of line contacts. For every position of the wipers there are thus two outlets, and the selector tests both these and finds them both engaged before stepping to the next position. If both the outlets are found to be free, the selector seizes the lower circuit and does not interfere with the upper circuit. For the convenience of the Maintenance Staff, these selectors are provided with 6-point test jacks, the two extra springs being for the purpose of indicating whether it is the upper or lower outlet that has been seized. If the upper outlet has been taken by the selector these springs, when brought into contact, complete the circuit of a buzzer.

Selectors for groups exceeding 20 lines.—Groups of lines exceeding 20 in number are dealt with by a final selector which is individual to the P.B.X., *i.e.*, the *P.B.X.* is identified when the wipers of the penultimate selector have been raised to the required level, all the outlets of which have access to final selectors allocated to the P.B.X. required. The final selector is not controlled by dialled impulses but as soon as seized proceeds to rotate its wipers in search of a free line. This selector is illustrated in Fig. **5** and will be seen to be of the R.L.S. type, from which it differs, however, in that it possesses two sets of wipers. These wipers travel in succession over two adjacent sets of bank contacts. The two sets of wipers are at 180° to each other, so that when one set has completed its travel over the left bank of contacts the other set then commences to hunt over the right hand set of contacts. Since there are 24 outlets in each set of contacts the selector thus gives access to a maximum of 48 outlets. P.B.X. groups exceeding this number of lines may be dealt with by two such selectors operating in series, the second of the pair continuing the search when the first has found all its outlets to be engaged.

If these final selectors are reached from the levels of 2nd group selectors, it will be apparent that their use involves a number wastage since each level of 2nd group selectors normally gives access to a 100 lines, whereas large groups P.B.X. final selectors will be used for all groups exceeding 20 lines. Should the number of such large groups be sufficiently great to involve an excessive number wastage special 3rd selectors may be interposed between the 2nd group selectors and the final selectors.

Night service over predetermined exchange lines can be given only by the use of spare numbers in regular units, as in the case of the 11 to 20 P.B.X. final selectors.

B.—Siemens No. 16 System.

Messrs. Siemens Bros. standard system for large public exchanges is known by them as the No. 16 equipment. This has been described in Mr. C. W. Brown's paper before the I.P.O.E.E. The relays controlling the selector operations are not assembled on the selector mountings but are carried in separate cradles. Conversion of an ordinary final selector is effected by changing the relay set and making a small attachment to the mechanism. The changing of the relay set is effected by lifting the existing set from its cradle and substituting it by the P.B.X. circuit. The attachment to the mechanism consists of a metallic arc clamped to the top of the bank, a wiper assembly and, in the case of selectors for groups of more than 10 lines, a release magnet controlling the rotary motion only. A selector for groups of lines up to a 100 in number is shown in Fig. **6**.

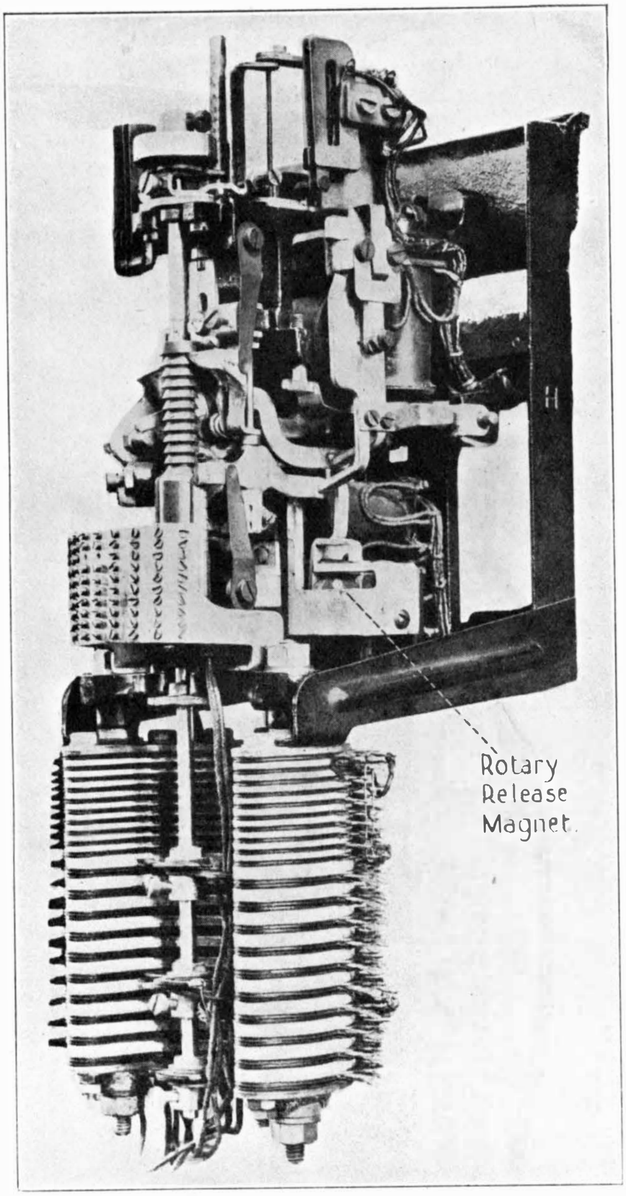


Fig. **6**.—Selector for large P.B.X. Groups. Messrs. Siemens No. 16 Equipment.

The P.B.X. arc will be seen to carry a number of screws. Mounted on the shaft is a wiper which makes contact with the tip of the screws as it rotates. The arc is drilled to carry 100 screws, each screw hole corresponding with one of the lines accommodated in the bank. The fact that the wiper is earthed when it makes contact with one of these screws constitutes an indication that the line being called is one of a P.B.X. group and the selector will hunt if this line is found to be engaged. If no screw be placed in the hole corresponding with the last line of a group, the P.B.X. hunting condition in the circuit is released and the wipers will come to rest, busy tone being transmitted if the whole group has been found to be engaged. The auxiliary wiper assembly actually consists of two wipers—one trailing behind the other. When the selector is stepped from the first to the second line, both auxiliary wipers are therefore earthed. If an intermediate line be dialled, the fact that both wipers are earthed prevents the hunting action from commencing.

Selectors for large groups are fitted with the rotary release magnet shown in Fig. **5**. When the selector has tested all the lines in one level and found them to be engaged, the rotary release magnet is energised. The wipers travel backwards over the level are raised to the next level and proceed to continue the search. In this way the whole bank may be covered.

The characteristic features of the scheme are summarised below:—

(1) No special bank design is required, addition being made to an ordinary mechanism.

(2) Ordinary lines can be interspersed between P.B.X. groups.

(3) More than one P.B.X. group can be accommodated per level.

(4) Any line may be dialled and hunting

will only take place if the number dialled is the first line in the numerical sequence of a P.B.X. group and is found to be engaged.

(5) The large group selector will accommodate groups of any size from 2—100 lines and also direct exchange lines.

(6) The small group final selector is readily convertible into a large group switch.

C.—Siemens P.B.X. Selectors for the Director System.

Selector for groups of 2-10 lines.—It will be realised that the small group final selector of the No. 16 equipment provides the same facilities as the standard scheme and Messrs. Siemens Bros. have therefore retained the circuit principles of the No. 16 switch. A double private bank is used and in this respect the switch is standard, but the second private circuit is not connected as in other contractors' circuits (*i.e.*, P1 contact of first line of a group to battery; P and P1 contacts of intermediate lines strapped). Instead, the P1 contacts of all except the last line of a P.B.X. group are connected to earth. A trailing wiper is employed as in the No. 16 system and the dialling of an intermediate line, therefore, brings both P1 wipers in contact with earth. In these circumstances, the selector will not hunt if the line dialled is found to be engaged.

The features distinguishing Messrs. Siemens scheme are as follows:—

Messrs. Siemens Circuit.

All P1 contacts but the last of a P.B.X. group are earthed. P1 contacts of ordinary lines and of the last line of P.B.X. groups are dis.

Night service given on lines other than the first due to the fact that the trailing wiper is earthed, short-circuiting the hunting element of the circuit.

Other Contractors' Circuits.

First P1 contact of group to battery; intermediate P1 strapped to P; last P1 dis. P1 of ordinary lines dis.

Night service given on lines other than the 1st by virtue of the fact that there is no battery on the P1 contacts to start hunting.

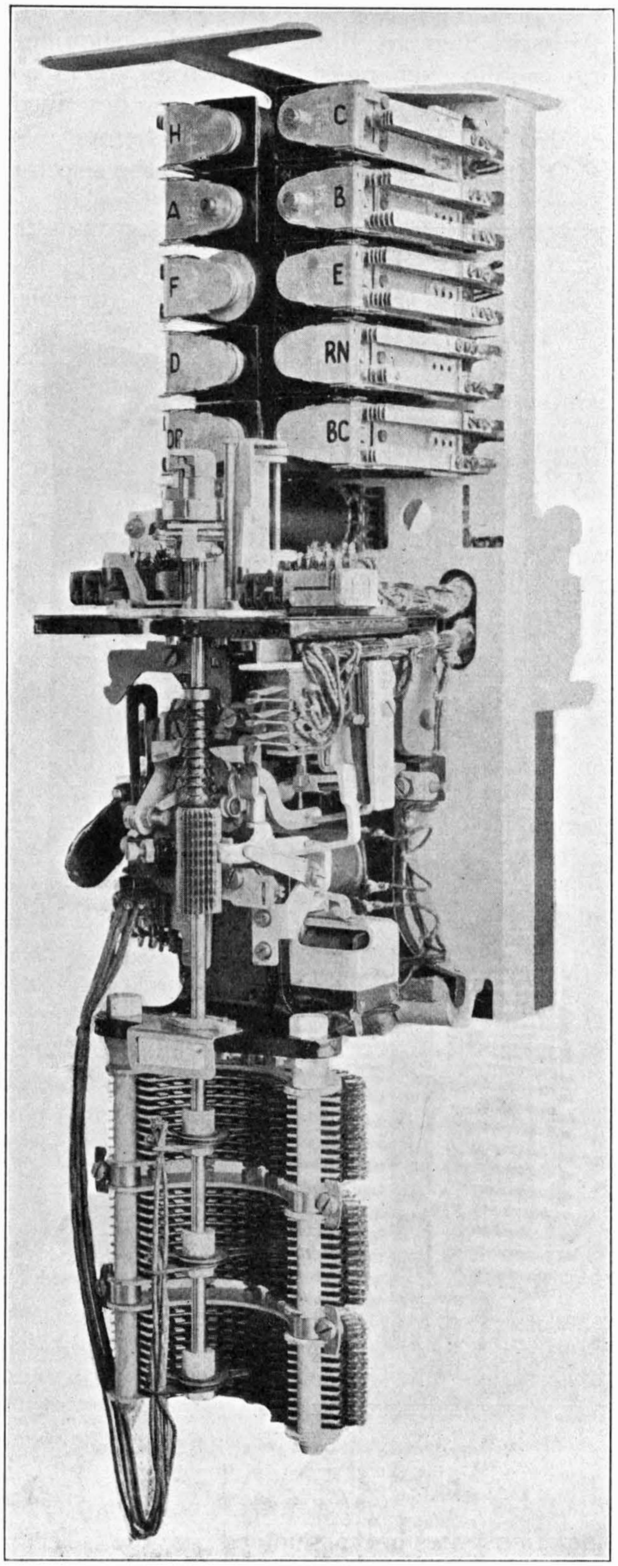
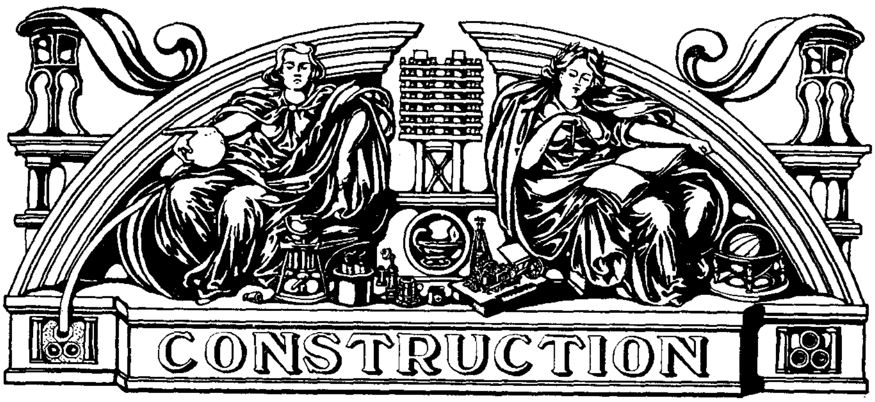


Fig. 7.—P.B.X. Final Selector over 20 Lines. Messrs. Siemens Switch for the Director System.

Selector for groups of 11-20 *lines.*—This selector provides the facilities obtained with the switch described under A, but differs in the method of operation. Two line banks are provided, but instead of a search being conducted over the two banks simultaneously, the wipers enter the bank twice to complete the hunting over 20 lines. One set of wipers is connected in circuit each time and if after the first rotation over the level no outlets are found disengaged in that bank, the wipers are released from the bank and a second search takes place, this time over the lines in the other bank.

Selector for groups of over 20 *lines.*—This selector gives access to a maximum of 200 lines and differs entirely from those of other contractors. It will be recalled that these employ a rotary line switch type of selector individual to the P.B.X. The Siemens selector is a 2-motion switch carrying two banks and will accommodate a maximum of 10 P.B.X. groups. The operation resembles that of the switch for groups of 11-20 lines in that the wipers enter a level twice to complete the search over 20 lines. If the called P.B.X. has further lines in the next level, the wipers are once more released, raised to the next level and the search continued. If all lines to the P.B.X. are engaged, the wipers are driven to the 11th contact of the level containing the last choice and remain there while the busy tone is transmitted.

Fig. **7** is an illustration of this selector. The author is indebted to Mr. Grinsted, of Messrs. Siemens Bros., for this photograph.



CONSTRUCTION OF MANHOLES IN WET SITUATIONS.

THERE are in the South Lancashire District, adjacent to the Mersey Estuary, considerable areas of country where the sub-soil consists entirely of sand, and in these districts water is frequently encountered at 2 ft. or even less from the surface. The construction of concrete manholes in such ground often presents considerable difficulties. The use of a tarpaulin to keep the water away from the concrete until setting has taken place is not found to be entirely satisfactory, chiefly because (1) it is necessary to cut the tarpaulin to allow new and existing ducts and cables to enter the excavation, (2) a satisfactory sump hole cannot be provided in the manhole when a tarpaulin is used, and (3) it is usually necessary to excavate an independent temporary sump hole, the bottom of which must be lower than the manhole excavation. As regards (3), the additional excavation, if the ground be very bad, increases the displacement of sand in the area adjacent to the work, and consequent risk to adjoining buildings and in the best circumstances adds appreciably to the cost of the work. In such conditions the method of construction described below has been found satisfactory.

The excavation is, of course, close timbered on all sides. In certain cases tongued and grooved timber has been used, but this is hardly necessary and is, of course, more expensive than the method employing ordinary timber. The running boards used are of sufficient length to go two or three feet below the bottom of the excavation. It is found that by driving them to at least this depth below the level to which, at any moment, the excavation has been carried, the removal of the contained sand is greatly facilitated, and the displacement of sand around the excavation is much diminished. As the boards are driven in, straw is packed tightly in behind them by means of a

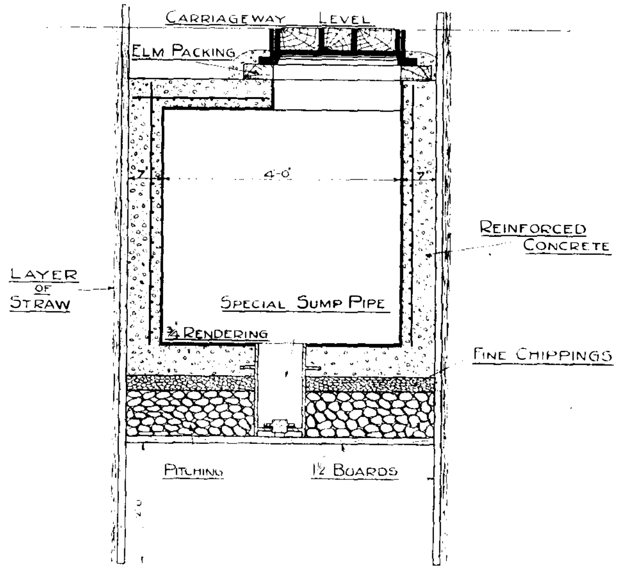


Fig. 1.—Manhole for Wet Situation.

spade, and this straw is carried down with the boards. This tends to ensure that only water will ooze through the joints in the timbering, the sand being held back. When the proper excavation depth has been reached, and this may conveniently be $19\frac{1}{2}''$ below the finished floor level, a tightly fitting floor of $1\frac{1}{2}''$ boards is hammered down, covering the entire surface between the running side boards. For this flooring tongued and grooved boards may be usefully employed. On this floor the special sump pipe (Fig. 2) which, as will be seen, is provided with a screw plug, is placed, the plug being for the present omitted. The floor is

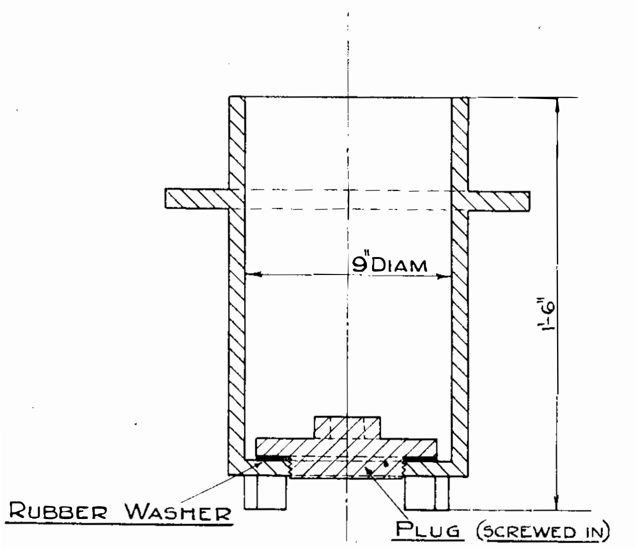


FIG. 2.—ENLARGED VIEW OF SPECIAL SUMP PIPE SHOWN IN FIG. 1.

then covered with a layer of 9" of stone pitching. On this is placed a 3" layer of fine stone chippings to keep the concrete out of the pitching, and finally the concrete of the floor, 6" thick, is placed in position. The nose of the flood-gate pump is kept in the sump pipe and it is found that in the conditions described the pump draws only water, no sand reaching the sump pipe. The pump is kept going while the concrete is being put in and for about 24 hours thereafter. When all is in readiness for rendering, the screw plug is screwed into position in the sump pipe, the latter then being partially filled with concrete in the usual way. In some earlier cases the sump pipe used was an open pipe, the partition and screw plug being omitted and the pipe being finally closed by means of a wooden plug tightly driven home. This was seldom quite satisfactory, as difficulty frequently arose in getting the plug to fit tightly in the rather roughly cast pipe, and on the whole the use of the more expensive screw plug pipe is found to be the more satisfactory practice.

Absolutely water-tight manholes have been constructed in very bad ground by the method described.

A point worthy of notice is that this method largely avoids the displacement of sand by the pump from the ground adjacent to the manhole site. Where manholes have to be constructed close to the foundations of buildings, this is of course of very great importance, as unnecessary disturbance of the adjacent sand may endanger the buildings.

TRANSFORMATION OPERATORS IN SCHEDULED JOINTING PRACTICE.

A. MORRIS, A.R.C.Sc., D.I.C., Wh.Ex., M.I.E.E.

SYNOPSIS.—Introduces the method of Transformation Operators for dealing systematically with crosses between the wires of communication circuits. Explains the use of such Operators by applying them to the Selecting and Scheduling processes involved in cable balancing for interference elimination purposes. Illustrates the simplification which they effect, with consequent lesser liability to error. Points out their great advantage in cases of multiple selecting for normal balancing and their especial utility for the selections involved in rebalancing work. States that they may also be used for the selections involved in rendering circuits electrically uniform, and in dealing with unbalance characteristics in general.

Introduction.—The object of this article is to describe certain Transformation Operators and the method of applying them to the crossing of wires in communication circuits. In their application to wire crossings for interference elimination purposes, such operators considerably facilitate not only normal scheduling and selecting procedure, but also and particularly that involved in any rebalancing work rendered necessary by reason of cable diversions or during the course of ordinary cable maintenance proceedings. Their use may be extended to wire crossings for rendering circuits electrically uniform, as in the jointing of cables for mutual capacity uniformity. Wire crossings for the purpose of dealing with interference characteristics in general can also be similarly dealt with. These operators have been embodied in British Post Office circuit jointing practice, in varying degrees, during the last five or six years.

The general method of balancing referred to in this article for the purpose of illustrating the use of Transformation Operators is known as the "crossing method." In this method the unbalances of one cable length are neutralised by those of other cable lengths which, for the sake of uniformity, should preferably be consecutive lengths. Neutralisation of, for example, the whole of the capacity unbalances of every circuit is thereby effected, over as short a length as possible, by means of the insertion of suitable crosses between the wires at cable joints. Conductor resistance, electrostatic capacity, inductance, etc., unbalances can be separately dealt with by this method, the appropriate wire crosses for their elimination being suitably chosen. With cables of modern manufacture this method permits of practically perfect balance. In Pupinised cables, balance is effected over a length of cable equal to the spacing of the loading coils, *i.e.*, a loading coil section; the capacity balance being almost complete over each group of four standard lengths. Balance secured in this manner, at such relatively short intervals, is essentially uniform and is accordingly independent of frequency.

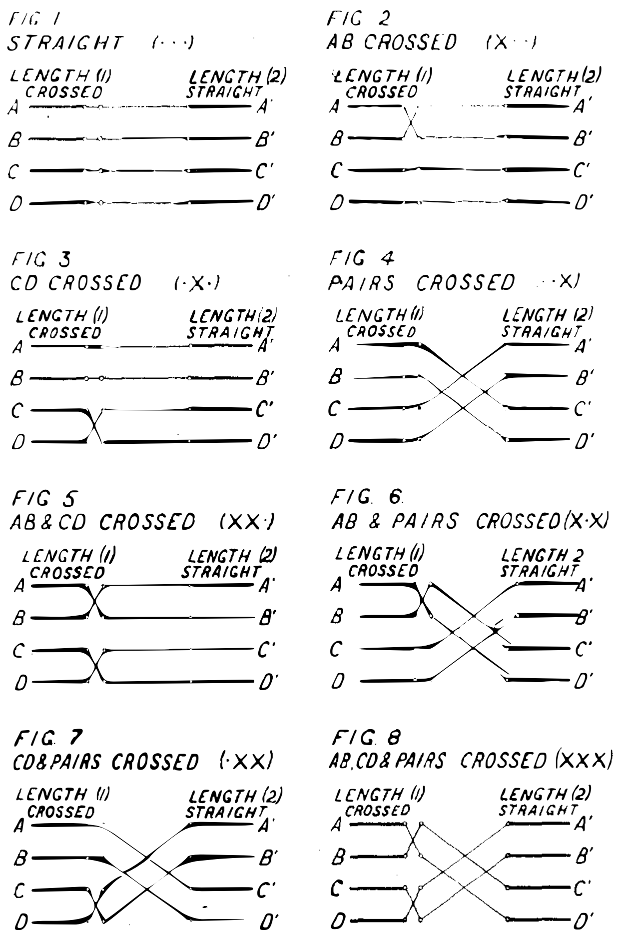
In principle the crossing method is the same as that devised by Tremain and Martin in 1899 for the elimination of cross-talk between the side circuits of Quad type cables, although it is applied in a somewhat different manner. Whereas originally the best type of cross was determined by experimental trial involving measurements of disturbance, both before and after jointing the cable lengths together, the present practice of measuring those electrical characteristics which are contributory to cross-talk enables the best mode of connection to be pre-determined and the final result accurately forecasted. This is rendered possible not only on account of the completeness of the knowledge of the effects of each and every type of cross, but also by virtue of the accuracy of the analysis and measurement of the electrical unbalances of cable cores. Upon this knowledge is based the systematic method of scheduling and selecting test results, which forms one of the important features of this method of balancing.

The crossing method is in general use in the United Kingdom, the United States and in most European countries excepting Germany. The details of application of the method differ in different countries. The principles of the method are described in articles contributed to the Journal, *I.P.O.E.E.*, Vol. VII., Part 1, of April, 1914, and Part 4 of January, 1915, by Mr. S. A. Pollock. The British P.O. Technical Instruction XIX., of July, 1914, amended March, 1919, describes in detail the whole procedure adopted by that Administration. British Patent Specification No. 2508 of 1913 (Convention date 11th April, 1912); O. B. Blackwell and G. A. Anderegg, deals with the procedure adopted by the American Companies. British Patent Specifications No. 2009 of 1913 (Convention date 11th April, 1912); G. A. Campbell, O. B. Blackwell and E. H. Colpitts, and No. 203,870 of 1922, W.E. Co., and D. Nunn deal with the measurements made in accordance with the American practice.

Methods of joining Cores together.—In joining the wires of cable lengths together, the core units must remain intact. Thus complete four-wire cores must be joined together, whilst complete pairs of one core, whether of the twin type as in M.T. cables or of the diagonal-pair type as in Quad type cables, must be joined to complete pairs of the other core. Departure from this arrangement would violate one of the main principles of cable construction, whereby the association of the two halves or limbs of a circuit by the simple process of twisting them around each other, is fundamental to the absence of interference from electromagnetic and electrostatic effects.

Even with the limitation in regard to the preservation of core type, there are eight possible ways of jointing two four-wire cores together.

Figs. (1) to (8) illustrate all the permissible methods of joining the four-wire cores of dry core cables by means of various crosses between the wires. For the purpose of accurately describing each mode of connection it is necessary to regard all the crosses between wires of any two cores as being made from one side of the joint only, *i.e.*, it is necessary to "refer" the cross to one length or the other. The cable



FIGS. ILLUSTRATING TYPES OF CROSSES.

length on the side from which the crosses are regarded as being made is called the "crossed length," that on the other side the "straight length." The necessity for this convention arises in the two cases illustrated in Figs. (6) and (7). In Fig. (6) the crosses introduced are accurately and fully described as "AB and pairs." If, however, there had been no indication as to which was the crossed length, the crosses may have been variously described as "AB and pairs" or "C'D' and pairs," according as length (1) or length (2) was considered the crossed section. Similarly for the crosses illustrated in Fig. (7). The convention described above has been made solely for the purpose of accurately describing in as few words as possible, or for describing symbolically (see next paragraph) the particular mode of connection of the wires of two cable cores. For any particular mode of connection, the crosses are actually neither on the one, nor the other set of wires. This conventional idea is necessary to the theory of cable balancing; it is totally unnecessary in furnishing instructions to a cable jointer as to the required mode of connection of two cores. Fortunately, in this latter connection the colour scheme of the cable is adequate to the purpose and full use should be made of it.

Symbolical representation of wire crosses.—In order to facilitate the writing down of the various types of cross between the wires of cable cores, a symbolical method of representing the crosses is adopted, the basis of which is as follows:—

Fig. (1). Straight. Represented thus:— (. . .)
,, (2). AB crossed. ,, ,, (X..)
,, (3). CD crossed. ,, ,, (.X.)
,, (4). Pairs crossed. ,, ,, (..X)

The symbols for the other types of cross are derived from the foregoing thus:—

Fig. (5). AB and CD crossed.
Represented thus:— (XX.)
,, (6). AB and pairs crossed.
Represented thus:— (X.X)
,, (7). CD and pairs crossed.
Represented thus:— (.XX)
,, (8). AB, CD and pairs crossed.
Represented thus:— (XXX)

With the method of connection of the wires illustrated in Figs. (1), (2), (3), (4), (5) and (8) the particular symbolical method of representation adopted in each case will apply whichever cable length is regarded as the crossed length. In the case of the connections represented in Figs. (6) and (7), however, if length (2) be regarded as the crossed length, *i.e.*, if the crosses are referred to the A'B'C'D' core of length (2), the symbolical representation will be (.XX) and (X.X) respectively.

Crossing Operators.—The symbols described above are given a greater significance than the mere representation of the type of cross between the wires of two cores. They are regarded as operators which perform certain changes in the regular order of the wires of a core of a cable length before it is jointed to the wires of a core of the preceding cable length. The regular order of the wires of a core, whose pairs are AB and CD respectively, being arbitrarily fixed as A,B,C,D, the Crossing Operators are defined and written down as follows. Thus:—

(1). ABCD (. . .) ≡ ABCD .
(2). ABCD (X..) ≡ BACD .
(3). ABCD (.X.) ≡ ABDC .
(4). ABCD (..X) ≡ CDAB .
(5). ABCD (XX.) ≡ BADC .
(6). ABCD (X.X) ≡ CDBA .
(7). ABCD (.XX) ≡ DCAB .
(8). ABCD (XXX) ≡ DCBA .

If to the wires A′B′C′D′ of the straight length, the wires ABCD of the crossed length are jointed with, for example, an AB and pairs cross, then A′ will be jointed to C, B′ to D, C′ to B and D′ to A. Symbolically and making use of the Crossing Operator, these connections may be represented thus:—

Core A′B′C′D′ to core ABCD with an AB and pairs cross on the latter core,

≡ A′B′C′D′ to ABCD (X.X)
≡ A′B′C′D′ to CDBA
≡ A′ to C, B′ to D, C′ to B, D′ to A.

A further and much more important use of Operators for the purpose of effecting transformations in core unbalances and core interference characteristics now follows.

Transformation of Core Unbalances and Core Interference Characteristics.—The normal unbalances and the normal interference characteristics of a core are perfectly definite and invariable quantities for that core. They are always defined in reference to a certain regular identification and order of arrangement of the wires of a core, taken in conjunction with their associated electrical features. Thus for a four-wire core in which AB is one pair and CD the other pair, the regular or straight order of the wires will be ABCD, whilst the normal capacity unbalances and interference characteristics (which refer to the core when straight) will be in accordance with definition, *e.g.*, as in British Post Office T.I. XIX., for the case of within-core unbalances. Referring to within-core unbalances for the purpose of illustration, if for the purpose of connecting a core to another core in one of the recognised modes, its wires at one end are regarded as being crossed in an appropriate manner, there will be a new arrangement of its wires and consequently a transformation of its unbalances and interference characteristics; *i.e.*, the unbalances and interference characteristics of the core, referred to the new arrangement of the wires at one end, will be the result of some transformation of its normal unbalances and interference characteristics. In order to obtain the transformed unbalances and interference characteristics of a core for any particular type of cross, *i.e.*, to obtain the unbalances and interference characteristics referred to the crossed end of the core, it is necessary to consider the effect of the cross on:—

(i) The arrangement of the wires.
(ii) The arrangement of the associated capacities, w,x,y,z,a,b,c,d.
(iii) The arrangement of the wire to wire unbalances, $(w - x)$, $(z - y)$, $(w - z)$, $(x - y)$ and of the wire to earth unbalances $(a - b)$ or u, $(c - d)$ or v, $(a + b - c - d)$ or f.
(iv) The arrangement of the interference characteristics, $(p - q)$ or $(r - s)$ or γ, $[2(p + q) + u]$ or α, $[2(r + s) + v]$ or β.

Table No. 1 has been compiled to show the whole of the transformations effected by each of the various types of cross which may be applied to a core for capacity balancing purposes. The Table is derived absolutely from first principle considerations. A detailed study of the table in conjunction with fundamental definitions, supplemented by longitudinal diagrams of the core showing the associated capacities, will make an understanding of the transformations much clearer than would a lengthy written description. Similar Tables may be prepared for resistance and inductance balancing purposes.

Unbalance and Interference Characteristic Transformation Operators.—Operators similar to those which have already been described in connection with the re-arrangements effected in the order of the ends of the wires consequent upon the application of the various types of cross, are used to effect transformations of the unbalances and of the interference characteristics of a core. Each of the eight operators are, for within-core capacity balancing purposes, defined as in Table No. 2, which is, of course, in accordance with the results of Table No. 1. Table No. 2 may be extended to include between-core unbalances and interference characteristics. Tables similar to Table No. 2 may also be prepared for resistance and inductance balancing purposes.

Rules relating to the application of Transformation Operators.—Tables 1 and 2 form the basis of the crossing method of cable balancing. The results expressed in these tables are in constant use for selecting and scheduling purposes, and it will obviously be of the greatest convenience if the transformations, effected by any type of operator, can be written down at once without reference to the Tables or to first principle considerations. In order to assist in attaining this object, attention is drawn to the following rules which are applicable to capacity balancing, namely:—

Rule (1). Cross AB. The operator (X..) changes the sign of the pair-to-pair interference characteristic (γ), of the AB to phantom interference characteristic (α) and of the AB to earth unbalance (u). There are no other changes within the core.

Rule (2). Cross CD. The operator (.X.) changes the sign of the pair-to-pair interference characteristic (γ), of the CD to phantom interference characteristic (β) and of the CD to earth unbalance (v). There are no other changes within the core.

Rule (3). Cross Pairs. The operator (..X) changes the sign of the phantom to earth unbalance and interchanges the AB to phantom (α) and CD to phantom (β) interference characteristics, as well as the AB to earth (u) and the CD to earth (v) unbalances. There are no other changes within the core.

Rule (4). Any other type of cross will be a combination of any two of the types dealt with in (1), (2) and (3) or of them all; rules (1), (2) and (3) will accordingly be successively applied, care being taken always to apply (1) or (2), or (1) and (2) before applying (3).

Calculation of Residual Unbalances and Interference Characteristics.—The residual unbalances and interference characteristics for two lengths of cable joined together will depend not only upon the normal unbalances and interference characteristics of the individual lengths, but also upon the manner in which the wires are connected together. The calculation of the residual unbalances and interference characteristics for a section of cable composed of two cable lengths, each with definite unbalances and interference characteristics, joined together in any of the eight possible ways is obviously the essence of capacity balancing, and will now be considered.

If two cores of cable are joined together straight, the residual unbalances and interference characteristics of the combination will be the algebraic sum of the relevant unbalances and interference characteristics of the individual cores. This will be obvious from considerations of the wire-to-wire and wire-to-earth capacities existing in the combined length. Thus with the usual notation, undashed letters referring to one length, dashed letters to the other length:—

(1). The combined capacities will be:—

$(w+w')$, $(x+x')$, $(y+y')$, $(z+z')$, $(a+a')$, $(b+b')$, $(c+c')$, $(d+d')$.

(2). The residual unbalances will be:—

$(w+w') - (x+x') = (p+p')$; $(z+z') - (y+y') = (q+q')$; $(w+w') - (z+z') = (r+r')$; $(x+x') - (y+y') = (s+s')$; $(a+a') - (b+b') = (u+u')$; $(c+c') - (d+d') = (v+v')$; $(a+a') + (b+b') - (c+c') - (d+d') = (f+f')$.

(3). The residual interference characteristics will be:—

$(\gamma + \gamma')$; $(\alpha + \alpha')$; $(\beta + \beta')$.

If two cores are joined together with any of the recognised types of cross, the residual unbalances and interference characteristics can be determined from an analysis similar to that given above for two cores joined together straight. It is recommended that this be done for each of the various modes of connection between two cores. Examination of the results will show that irrespective of which of the regular modes of connection of two cores is adopted, their unbalances and interference characteristics will combine in such a manner that the residuals of the combined cores will be the algebraic sum of the relevant unbalances and interference characteristics respectively of the individual cores; the normal or straight values being considered for the straight length, the transformed or "referred" values being the relevant ones for the crossed length.

The following rule has been deduced with the object of rendering the determination of residual unbalances and interference characteristics in practice a perfectly systematic process; thus:—

Rule (5). To determine the residual unbalances and interference characteristics for the combination of two cores ABCD and A′B′C′D′, jointed together in any of the recognised modes, proceed thus:—

(i) Write down the normal unbalances and interference characteristics of the core A′B′C′D′.

(ii) Operate upon the unbalances and interference characteristics of the core ABCD with the operator expressing the cross applied to the core ABCD prior to jointing it to the core A′B′C′D′, *i.e.*, write down the unbalances and interference characteristics of the core ABCD referred to its crossed end.

(iii) Add the relevant unbalances and interference characteristics algebraically. The result will be the residual unbalances and interference characteristics of the combination.

From the mode of their derivation, it will be obvious that the residual unbalances and interference characteristics so obtained will be the normal values of the combined section at the free end of that length which has been regarded as straight. This is more simply expressed in the statement: "The calculated residual unbalances and interference characteristics refer to the straight length of cable."

Example (1)—Symbolical.

A′B′C′D′ (. . .)	γ'	α	β'	u'	v'	f'
ABCD (XXX)	γ	$-\beta$	$-\alpha$	$-v$	$-u$	$-f$
Residual, referred to length A′B′C′D′	$(\gamma'+\gamma)$	$(\alpha'-\beta)$	$(\beta'-\alpha)$	$(u'-v)$	$(v'-u)$	$(f'-f)$

Example (2)—Numerical.

	γ	α	β	u	v	f
A′B′C′D′ (. . .)	+ 10	+ 45	− 30	− 60	+ 50	− 100
ABCD (. . .)	− 5	− 20	+ 30	+ 40	− 75	− 120
ABCD (XXX)	− 5	− 30	+ 20	+ 75	− 40	+ 120
Residual, referred to length A′B′C′D′	+ 5	+ 15	− 10	+ 15	+ 10	+ 20

In the example given above the core A′B′C′D′ is regarded for the purposes of the calculation as the straight core. The residuals accordingly refer to that core. If for any reason it is desired that the residuals refer to the core ABCD, then it will be regarded as the straight core, the mode of connection of the cores being interpreted as an appropriate crossing operation performed upon the wires of core A′B′C′D′. In these circumstances the referred unbalances and interference characteristics of the core A′B′C′D′ will be added algebraically to the normal unbalances and interference characteristics of the core ABCD, the result being the normal residuals for the combined section, referred to the core ABCD. Generally for the connection of two cores, ABCD and A′B′C′D′, if (***) represents the cross applied to the wires of the core ABCD before connection to the wires of the core A′B′C′D′, then the appropriate crossing operation to be performed upon the wires of the core A′B′C′D′ before connection to the wires of the core ABCD, in order to secure the same result, will be written $\overline{(***)}$. It will be obvious from what has previously been stated that $\overline{(***)}$ is identically the same as (***) excepting in the two cases where $\overline{(X.X)}$ ≡ (.XX) and $\overline{(.XX)}$ = (X.X).

Referring Residual Unbalances and Interference Characteristics from one end of a Combined Length to the other.

From the foregoing explanation, but perhaps more readily from an examination of the capacity system of a combined core, consisting of two cores jointed together, it will be seen that the normal unbalances and interference characteristics of the combinations as determined at one end will, in the general case, be different from those of the remote end. They can be separately calculated for each end in the manner already indicated, provided the values for each length are known. In some cases, however, and particularly when the combined length consists of a number of jointed cores, it is necessary to refer the residual for the whole length from one end of the section to the other, without reference to the values of the individual lengths. The conversion may be readily effected by means of the following rule, which affords a striking example of the utility of Transformation Operators. Thus:—

Rule (6). To refer the residual capacity unbalances and interference charcateristics from one point (K) of a cable section to another point (L), through a number of intermediate crossed joints, proceed as follows:—

Write down the residuals referred to the joint K and operate upon them successively by means of the operators which express the crosses at each of the intermediate joints between K and L. The operators used must in every case refer to the system of crosses on that side of the joint which is nearer the end K to which the residuals initially referred. Further, the operating must commence with the operator for the joint nearest to K, proceeding from thence in order to L, and care being taken in operating with any particular operator to perform the wire crosses before the pair crosses.

In reference to the last sentence, it is pointed out that a series of operations performed in a given order upon a set of unbalance and interference characteristics will, in the general case, produce a different result if performed in some other order. Thus, in the following, the same series of crosses is employed, but the order of their occurrence in the second example is different from that of the first:—

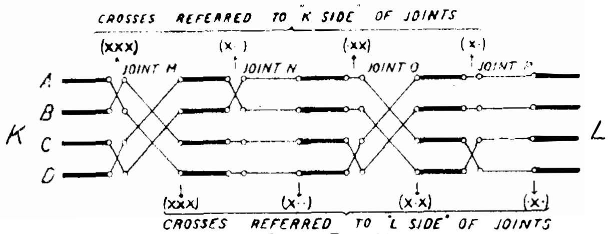


FIGURE (9)

Example (1). Fig. **9** refers.

ABCD (XXX) (X..) (.XX) (.X.)
≡ DCBA (X..) (.XX) (.X.)
≡ CDBA (.XX) (.X.)
≡ ABCD (.X.)
≡ ABDC
≡ ABCD (.X.)

and consequently:—

$(\gamma, \alpha, \beta, u, v, f)$ (XXX) (X..) (.XX) (.X.)
≡ $(\gamma, \alpha, \beta, u, v, f)$ (.X.)
≡ $(-\gamma, \alpha, -\beta, u, -v, f.)$

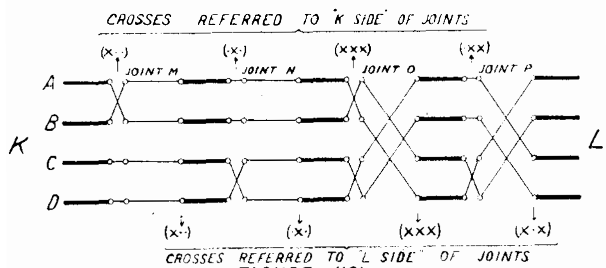


FIGURE (10)

Example (2). Fig. **10** refers.

ABCD (X..) (.X.) (XXX) (.XX)
≡ BACD (.X.) (XXX) (.XX)
≡ BADC (XXX) (.XX)
≡ CDAB (.XX)
≡ BACD
≡ ABCD (X..)

Use of Operators in Selecting and Scheduling for the Rebalancing of Loading Coil Sections of Cable.

The maintenance of balanced trunk cables sometimes involves the replacement of a length (F), which may be faulty, by a new length (N) of cable. The following methods are employed depending upon the circumstances of the case:—

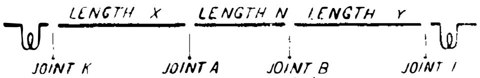


FIGURE (11)

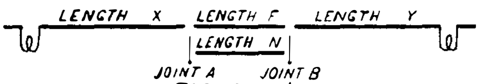


FIGURE (12)

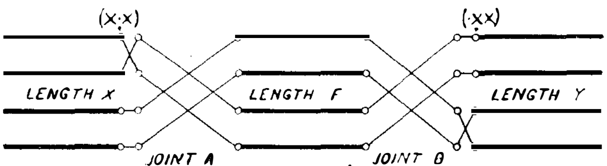


FIGURE (13)

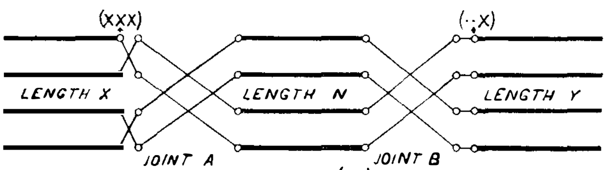


FIGURE (14)

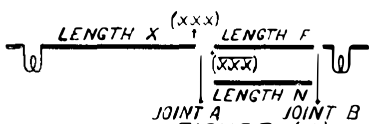


FIGURE (15)

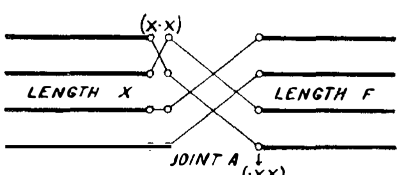


FIGURE (16)

(1) *General Method.*—Fig. **11** refers. N is the new or replacing length of cable. X and Y are jointed cable lengths on either side of N to which N is required to be connected at the joints A and B. The procedure is as follows:—

(i) Test length X from joint A, after disconnecting the loading coil at joint K.

(ii) Test length Y from joint B, after disconnecting the loading coil at joint L.

(iii) Test length N from either joint A or joint B.

(iv) Make a triple selection from the results of (i), (ii) and (iii) for best balance. If the values so obtained for the loading coil section exceed those specified it will be necessary to open a cable joint either in length X (or in length Y); test the separate portions of that length and make a Quadruple Selection. The test results for one of the portions of length X (or of length Y) will generally require to be referred, through all the crossed joints in that portion, before the jointing schedules can be prepared from the Quadruple Selection.

(2) *Substitution Method.*—Fig. **12** refers. F is the faulty or replaced length of cable. N is the new or replacing length of cable. X and Y are jointed cable lengths on either side of N to which N is required to be connected at the joints A and B. If the core unbalances of length N are similar in magnitude, type and class to those of length F, *i.e.*, if the core unbalances of length N exactly or approximately simulate those of length F, and if full particulars of the original joints at A and B are known, the procedure is as follows:—

(i) If the length X was crossed originally on to the length F with the system of crosses represented by (†††).

(ii) If the length Y was crossed originally on to the length F with the system of crosses represented by (‡‡‡).

(iii) If (***) represents the operator necessary to transform the unbalances and interference characteristics *of a core of length F to those of a core of length N, i.e.*, if (F) (***) ≡ N, then:—

(iv) Length X will require to be crossed on to the length N with the system represented by (†††)(***).

(v) Length Y will require to be crossed on to the length N with the system represented by (‡‡‡)(***).

Example, Figs. (13) and (14) apply. If for particular cores, (†††) ≡ (X.X); (‡‡‡) ≡ (.XX), and (***) ≡ (X..), then for such cores :—

Joint A ≡ (†††)(***) ≡ (X.X)(X...) ≡ (XXX) on the wires of X.

Joint B ≡ (‡‡‡)(***) ≡ (.XX)(X..) ≡ (..X) on the wires of Y.

The operators must of course be used in the order stated for reasons previously given.

(3) *Deduced Joint Method.*—Fig. (15) refers. F is the faulty or replaced length of cable, N is the new or replacing length of cable. X is a jointed cable length on one side of N, to which N is required to be connected at the Joint A. If in addition to the unbalances of the cores of F, full particulars of the original joint at A as well as the original residual core unbalances of the complete length (X and F jointed together) are known, the procedure is as follows :—

(i) If R represents the original residual unbalances of a core of the complete length (X and F jointed together) referred to Joint B.

(ii) If r represents the unbalances of a core of the length F.

(iii) If the core of length X was crossed originally on to the core of length F with the system of crosses represented by (†††), then :—

(iv) (R − r) $\overline{(\dagger\dagger\dagger)}$ represents the normal residual unbalances of the core of length X where (R − r) represents the algebraic subtraction of r from R and $\overline{(\dagger\dagger\dagger)}$ is the operator which represents the original cross on length F at the joint A.

(v) Select the residual unbalances (R − r) (†††) of the length X (at joint A) and the unbalances of the length N for the new joint at A.

Example, Fig. (16) refers.

If R ≡ + 10 + 30 + 10 − 50 − 20 − 100,
r ≡ + 20 − 70 + 90 + 100 − 130 + 250,
and (†††) ≡ (X.X);

Then (R − r) ≡ − 10 + 100 − 80 − 150 + 110 − 350.

and
(R − r) $\overline{(\text{X.X})}$ ≡ (R − r) (.XX),
≡ + 10 + 80 + 100 − 110 − 150 + 350.

The author is much indebted to Mr. L. C. Voss for the preparation of the illustrations.

Table No. 1.

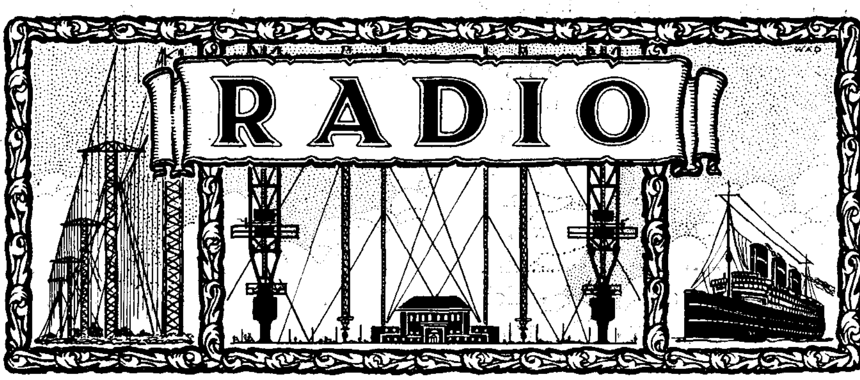
TRANSFORMATIONS EFFECTED BY THE CROSSING OF THE WIRES OF A CORE FOR WITHIN-CORE CAPACITY BALANCING PURPOSES.

Type of Cross.	(. . .)	(X..)	(.X.)	(..X)	(XX.)	(X.X)	(.XX)	(XXX)
Arrangement of wires and of associated capacities.	A Z W D C Y X B ABCD	B Y X D C Z W A BACD	A W Z C D X Y B ABDC	C X W B A Y Z D CD AB	B X Y C D W Z A BA DC	C W X A B Z Y D CD BA	D Y Z B A X W C DC AB	D Z Y A B W X C DC BA
Direct wire to wire capacity of other pair.	w x y z	x w z y	z y x w	w z y x	y z w x	x y z w	z w x y	y x w z
Wire to Earth capacity.	a b c d	b a c d	a b d c	c d a b	b a d c	c d b a	d c a b	d c b a
Wire to wire of other pair, capacity unbalance.	p q r s	$-p$ $-q$ s r	q p $-r$ $-s$	r s p q	$-q$ $-p$ $-s$ $-r$	s r $-p$ $-q$	$-r$ $-s$ q p	$-s$ $-r$ $-q$ $-p$
AB to Earth capacity unbalance.	u	$-u$	u	v	$-u$	v	$-v$	$-v$
CD to Earth capacity unbalance.	v	v	$-v$	u	$-v$	$-u$	u	$-u$
Phantom to Earth capacity unbalance.	f	f	f	$-f$	f	$-f$	$-f$	$-f$
AB to CD interference characteristic.	γ	$-\gamma$	$-\gamma$	γ	γ	$-\gamma$	$-\gamma$	γ
AB to Phantom interference characteristic.	α	$-\alpha$	α	β	$-\alpha$	β	$-\beta$	$-\beta$
CD to Phantom interference characteristic.	β	β	$-\beta$	α	$-\beta$	$-\alpha$	α	$-\alpha$

Table No. 2.

DEFINITIONS OF TRANSFORMATION OPERATORS FOR WITHIN-CORE CAPACITY UNBALANCES AND CAPACITY INTERFERENCE CHARACTERISTICS.

OPERATOR.	Capacity unbalances.							Capacity interference characteristics.		
	Wire to wire.				Wire to Earth.					
(Normal Value) (. . .) … … …	p	q	r	s	u	v	f	γ	α	β
(do. do.) (X..) … … …	$-p$	$-q$	s	r	$-u$	v	f	$-\gamma$	$-\alpha$	β
(do. do.) (.X.) … … …	q	p	$-r$	$-s$	u	$-v$	f	$-\gamma$	α	$-\beta$
(do. do.) (..X) … … …	r	s	p	q	v	u	$-f$	γ	β	α
(do. do.) (XX.) … … …	$-q$	$-p$	$-s$	$-r$	$-u$	$-v$	f	γ	$-\alpha$	$-\beta$
(do. do.) (X.X) … … …	s	r	$-p$	$-q$	v	$-u$	$-f$	$-\gamma$	β	$-\alpha$
(do. do.) (.XX) … … …	$-r$	$-s$	q	p	$-v$	u	$-f$	$-\gamma$	$-\beta$	α
(do. do.) (XXX) … … …	$-s$	$-r$	$-q$	$-p$	$-v$	$-u$	$-f$	γ	$-\beta$	$-\alpha$



ATMOSPHERICS.

[*An extract from Lt.-Col. A. G. Lee's chairman's address to the Wireless Section, I.E.E., on the 2nd November, published with the permission of the Institution.*]

THE question of "atmospherics" is one which is of interest in all wireless communications. The subject is a very wide one and I have preferred to confine myself, so far as the practical aspects are concerned, to one particular problem upon which we have been engaged, that of transatlantic telephony, and to draw upon that problem for practical illustrations.

SECTION 1.

NATURE OF ATMOSPHERICS.

Our information on the nature of atmospherics is obtained from a series of valuable reports by Appleton, Watson Watt, and Herd.* These investigators, using the cathode-ray oscillograph, were able to obtain pictures of the potential induced by atmospherics in an antenna. Generalizing from their reports, one may say that an atmospheric is either of aperiodic or quasi-periodic form, it has a peak voltage of the order of 0.1 volt per metre, and has a duration of the order of 0.003 sec. Considerable variations from these figures occur and, in particular, atmospherics were observed which had a fine ripple structure superposed upon the main wave-form.

* *Proceedings of the Royal Society, A*, 1923, *Vol.* 103, *p.* 84; *ibid.*, 1926, *Vol.* 111, *p.* 615; *ibid.*, 1926, *Vol.* 111, *p.* 654.

DISTRIBUTION OF ATMOSPHERICS IN AZIMUTH.

The cathode-ray direction finder, kindly lent by the Radio Research Board, has been used at Cupar, Fife, to determine the direction of arrival of atmospherics at that place. The apparatus consists of two frame aerials set at right angles and connected through similar amplifiers to the four plates of the cathode-ray oscillograph. The beam of light in the oscillograph acts like a pointer to indicate the magnitude and direction of the fields set up by an individual atmospheric. An observer notes the angle and the magnitude of the flash caused by an atmospheric, and calls out the figures to an assistant who writes them down. Samples of the results of some observations of this kind at Cupar are shown in Fig. 1. The instrument used gave an ambiguity of 180° in the direction of arrival of atmospherics, but this caused no real difficulty because the approximate direction was known by the behaviour of the directive receiving arrangements normally in use at the station at Cupar. The crosses in the diagram indicate comparatively light atmospherics, while the circles indicate heavy atmospherics. The diagram is a composite target diagram of all the observations made during the months of July, August and September, 1927.

It is convenient to refer the direction of arrival of atmospherics to the direction of the signal, with its directive receiving arrangements, in lieu of the more usual use of the geographical direction. In this particular case the signal to be received arrives from a direction 11° north of west, and the direction of arrival of atmospherics is given with reference to this direction as a base line. The angle between 140° and 260° is found to be the subject of attack from atmospherics at different times during the working period of the circuit, which is open for traffic from midday to 11 p.m., whilst the angle between 310° and 130° which includes the signal is relatively very free from atmospherics. The worst directions are between 170° and 230°.

obtained at Wroughton, whilst at Thurso in the extreme north of Scotland it is nearly 8 times better. It was finally decided to locate the receiving station at Cupar on account of its proximity to the underground cable system.

The Spectrum of Atmospherics.

Lord Rayleigh showed many years ago that an aperiodic pulse can be represented by the Fourier integral of an infinite spectrum of continuous sinusoidal components. If we assume that the atmospheric is wholly represented by an aperiodic or quasi-periodic disturbance, then

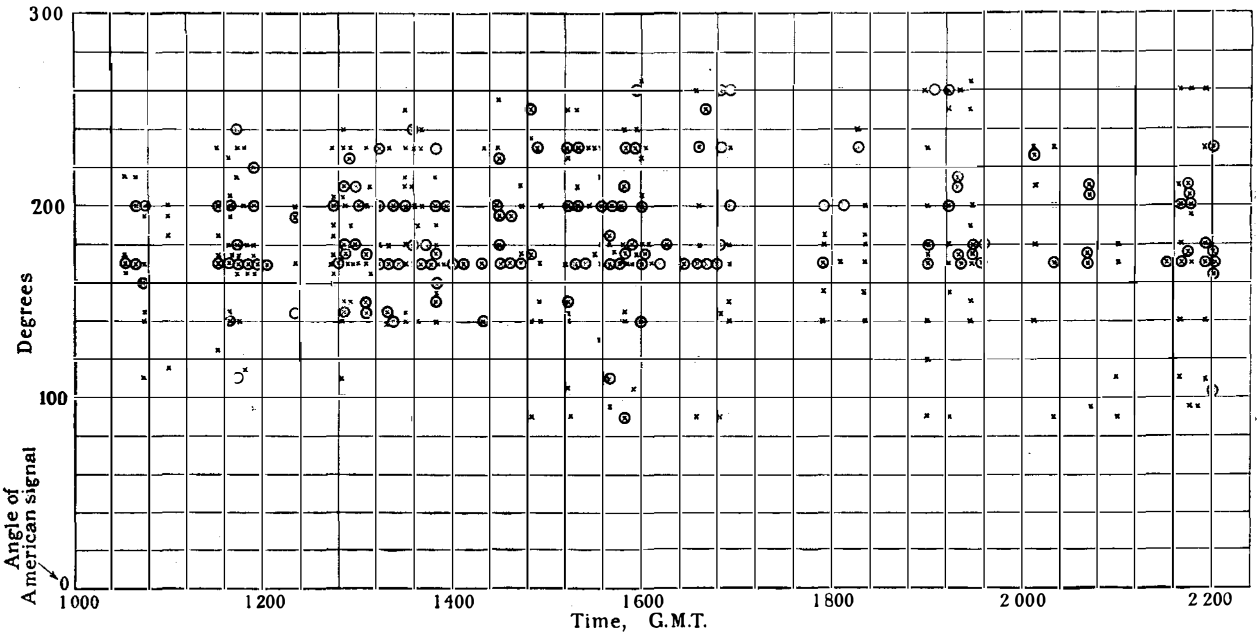


Fig. 1.—Distribution of Atmospherics at Cupar during months of July, August and September, 1927.

Distribution of Atmospherics with Latitude.

Measurements of the strength of atmospherics, carried out in connection with the preliminary work on transatlantic telephony, were made at Stranraer, Cupar, Ellon and Thurso, in addition to those normally made each week at Wroughton in the south of England. These measurements showed that the atmospherics were generally weaker in Scotland than in the south of England. In addition, the Scottish locations are slightly nearer America and the signal strength obtained there was greater than that at Wroughton, so that the signal noise ratio at Cupar, near Dundee, is nearly 4 times better than that

it follows that the effect of an atmospheric on a wireless circuit is such that if the latter is designed to admit a signal with just sufficient of its side bands due to modulation to render it intelligible, the circuit will also admit the sinusoidal components of the atmospheric pulse which lie within the resonance curve of the apparatus, and it is impossible to exclude them by processes dependent upon selectivity. This theory therefore removes from the discussion the numerous atmospheric eliminators which have been patented in the past, and enables one to concentrate on the design of a straightforward filter circuit which will allow of the reception of the signal with a minimum exposure to atmospheric attack.

Before commencement of the transatlantic telephony service a large series of measurements was made, extending over several years, of the strength of signals and atmospherics at different times of the day. The atmospherics were measured on a receiver with a band width of 2,500 cycles, so that, in effect, a measurement was made of the attack of the spectrum on a receiver with the band width necessary for telephonic communication. The measurements were made at different frequencies and, as a result, it was concluded that the optimum wavelength for transatlantic communication of this particular kind lay between 5,000 and 6,000 metres, having regard to the ratio of signal strength to atmospherics at different times of the day. The problem is to some extent a commercial one as well as technical, as it involves the production of the best circuit conditions for the time of day when the commercial use is greatest.

and it will then possess its maximum defence against atmospherics. Any process depending upon selectivity, which still further reduces atmospherics, will also reduce the intelligibility.

In the problem under discussion—the reception of transatlantic telephony—the signal consists of a single side band, the carrier 58.5 kilocycles, and the other side band not being transmitted. The side band is also subjected to a certain amount of filtering before transmission from the sending antenna, and we are left to deal with high frequencies corresponding, after detection, to frequencies in the voice range extending from 400 to 2,800 cycles. It has been found that the frequencies below 400 and above 2,800 are not essential to intelligibility, though they add to the naturalness of the speech. The frequencies below 400 demand a relatively much larger amount of energy than those above 400, and hence their omission allows of the power available being used for the

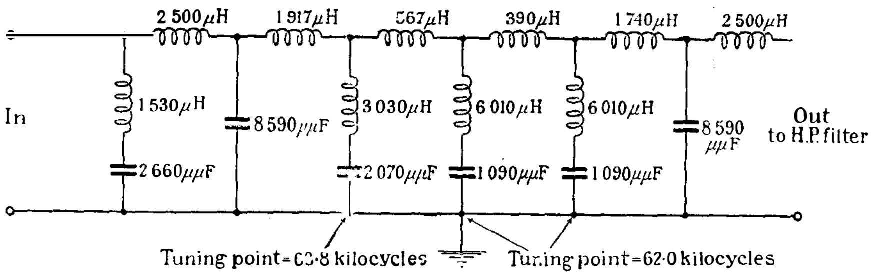


FIG. 2.—HIGH FREQUENCY LOW PASS FILTER.

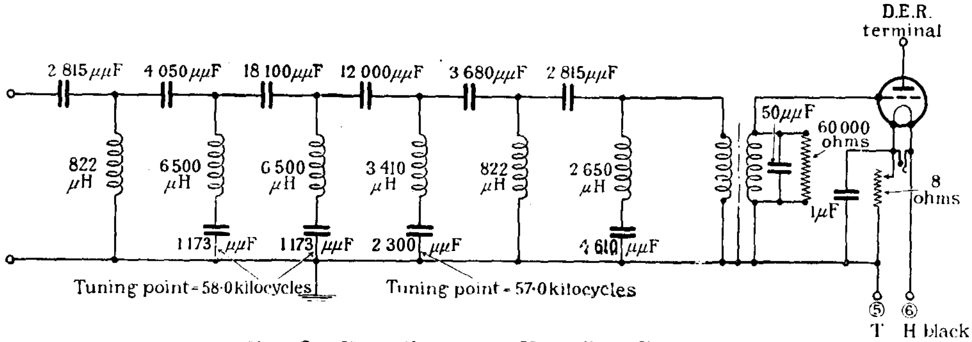


FIG. 3.—HIGH FREQUENCY HIGH PASS FILTER.

SECTION 2.

THE RECEIVER PROBLEM.

It has been pointed out in the previous Section that a receiver should be designed to admit only just sufficient of the signal and its modulation products to ensure intelligibility,

frequencies which carry the intelligibility, without making so much demand on power. Further, the cutting off the edges of the band in this manner reduces the exposure to atmospherics at the receiving end. The suppression of the carrier and one side band also saves a large amount of energy and at the same time reduces the exposure to atmospherics. It is necessary, however, to reintroduce the carrier at the receiving end before the detector in order to render the single side band intelligible.*

The receiver to be described is one which was designed by the Post Office. It is of the single detection type and in that respect differs from the American receiver which employs the double detection principle. There is no essential difference in the results, but as the receiver is one in which nearly all the filtering is effected at 60 kilocycles it may form an interesting example of what can be done at that frequency. It may as well be admitted at once that the design of filters for high frequencies is difficult, and assistance is obtained in cutting off the edges of the band sharply by the employment of low-frequency filters at a later stage in the receiver.

The first condition to be met was the design of a filter for insertion before the first amplifying valve. Although the valve has a so-called straight characteristic, it will perform the function of modulation if the largest of the unwanted signals and atmospheric components are not removed before passing into the amplifying system.

This filter consists of a low-pass and a high-pass filter in tandem, giving the equivalent of a band-pass filter. The circuit conditions of the low-pass filter are given in Fig. **2** and that of the high-pass in Fig. **3**, whilst Fig. **4** shows the results obtained by the filter. This system was chosen because the values of the components for the normal type of band-pass filter for a width of 3,000 cycles and at a midband frequency of 60 kilocycles were awkward to obtain and maintain. The coils were made of stranded wire wound into pancake form and each shielded in a copper box. The inductance of each coil was measured at 60 kilocycles and adjusted by unwinding turns. The final adjustment of the condensers was performed by removing plates from small fixed air condensers. The low-pass unit consists of two ordinary sections designed to cut off at 61.8 kilocycles, two sections with a cut off at 61.5 kilocycles and theoretical zero impedance point at 62 kilocycles, and another section with a cut off at 61.8 kilocycles and tuning point at 63.8 kilocycles. Both filters were designed for input and output impedances of 600 ohms. This panel is followed by the high-pass filter of similar construction to the above, the ordinary sections cutting off at 58.2 kilocycles, the tuned sections being resonant at 58 kilocycles and 57 kilocycles. The filter terminates in a valve input transformer stepping up from 600 ohms to 60,000 ohms on the grid of the first valve. As the filters are only used on a small portion of their pass frequencies the imput impedance is about 1,100 ohms, but this is rectified by using a step-up transformer in front of the filter. It will be seen by inspection of Fig. **4** that the cut-off at 500 cycles on either side of the band is about 40 transmission units (T.U.).

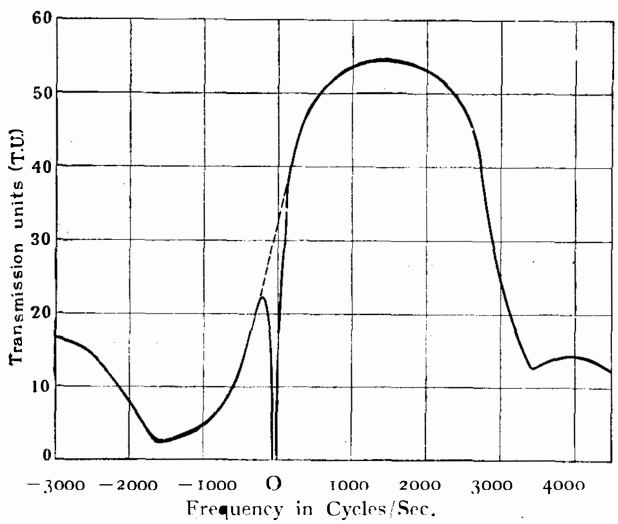


FIG. **4**.—FREQUENCY CHARACTERISTICS OF HIGH FREQUENCY FILTER.

The filter is followed by two amplifying stages which have band filters consisting of two simple circuits coupled together, giving the well-known double-humped curve. The filter curve has rounded corners and the effect of the double-humped curves following the filter is to lift up the rounded corners to a more or less square form. Further amplifying stages, having potentiometer control of the amplification, follow the band filters, then the local carrier is inserted before the detector, and following the detector is a low-frequency low-

* *H. W. Nicholls: "Transoceanic Wireless Telephony," Journal I.E.E., 1923, Vol. 61, p. 812.*

pass filter and a high-pass filter and further low-frequency amplification with potentiometer control.

The overall frequency characteristics of the complete receiver including both high- and low-frequency filters is given in Fig. **5**. It will be seen that the curve approximates to a rectangle with the top nearly, but not quite, flat.

The available overall amplification is about 100 T.U. and an output of + 15 T.U. above one milliwatt can be taken without distortion.

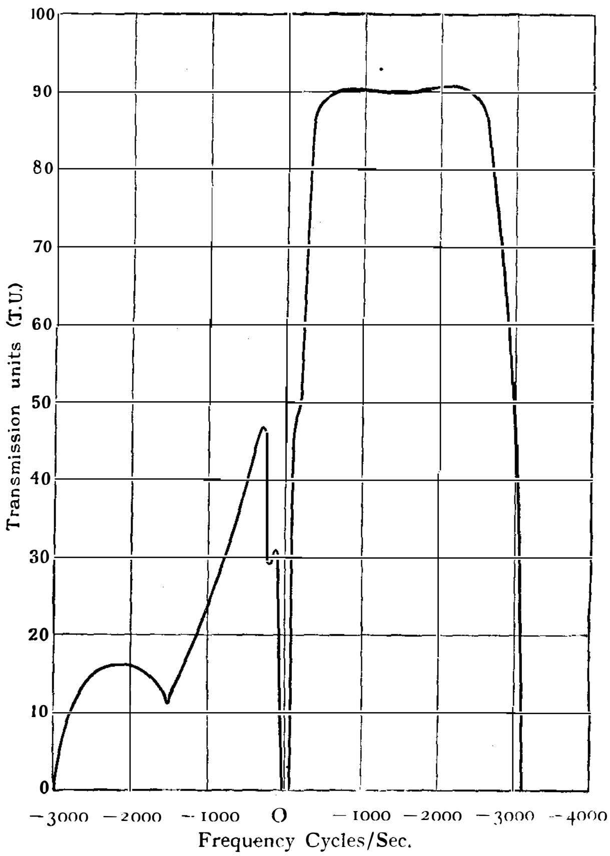


FIG. **5**.—OVERALL FREQUENCY CHARACTERISTIC OF COMPLETE RECEIVER.

SECTION 3.

DIRECTIVE RECEPTION WITH WAVE ANTENNA.

Having done all that is possible at the receiver to reduce the exposure to atmospherics, the next step is the development of directive reception. Seeing that atmospherics may arrive from all possible directions, we can reduce the exposure by employing a directive system of reception which allows of the signal being received, but which is relatively insensitive to signals or atmospherics received from other directions. We have seen in Section 1 that the transatlantic service is favoured by most of the atmospherics coming from the sector opposite to that from which the signal arrives.

The early experiments on the wave antenna* in this country having proved extremely favourable it was decided to adopt that system for the antenna at Cupar.

The wave antenna, as used, consists of two parallel wires carried on ordinary telegraph poles a distance of just over 3 miles, which is one wave-length for this particular communication. The antenna picks up the horizontal component of the electric field passing over it, which gives rise, by a process of summation, to a current in the wires which is greatest at the end opposite to that from which the signal arrives. A transformer is placed at this point to transfer the current to the two wires, considered as a transmission line, which carry the current back to the near end where the receiver is connected. At the receiver a certain amount of the wire-to-earth current can be combined with the current from the far end of the antenna to produce zero reception at a selected angle in the back sector, a process known as compensation. One such system constitutes a wave antenna, and combinations of such systems, spaced apart at a distance of 0.62 wave-length, are used to give additional directivity. The wave antennæ are properly terminated at each end to avoid reflections, and the currents are carried from the wave antennæ to the receiving hut by means of transmission lines, precautions being taken to avoid cross-talk between the various lines.

It will be realized that the directive properties of the wave antenna, and the amount of signal, depend to a large degree on the tilt of the electric waves, as it is designed to utilize the horizontal component of the electric field. So far, we have built three systems of wave antennæ in this country, at Chedzoy (Somerset), Wroughton (Wilts) and Cupar (Fife), and the tilts obtained at these places were 0.1°, 0.7° and

* *Beverage, Rice, and Kellogg. Journal of the American I.E.E., 1923, Vol. 42, p. 215.*

1.0° respectively, as against values of between 2° and 3° which were obtained on the wave antennæ built in America. The differences are probably due to the nature of the soil. At Chedzoy the soil is swampy, at Wroughton the ground-level is high with a chalk subsoil close to the surface, and at Cupar the subsoil is sandstone. The differences between the tilts in this country and America may also be accounted for by possibly moister conditions of the soil here. This lack of tilt leads to the vertical effects of the antennæ becoming large relatively to the desired horizontal effects and tends to reduce the directivity of the system. That is to say the antenna may be regarded as a rather long antenna which picks up the field by virtue of its that is, with the vertical and therefore non-directive elements negligible compared with the horizontal effects. Curve B shows the calculated results combining the horizontal and vertical effects actually present, and small squares and circles near this curve represent actual measurements on signals arriving from the directions indicated. These observations check moderately well with the calculated curve, but it will be seen that the two antennæ which have so far been completed are not exactly alike, which renders their combination into a still more refined directive system less perfect than it should be. Although built with extreme care, the ground conditions in the two cases are not identical, and it appears difficult to secure

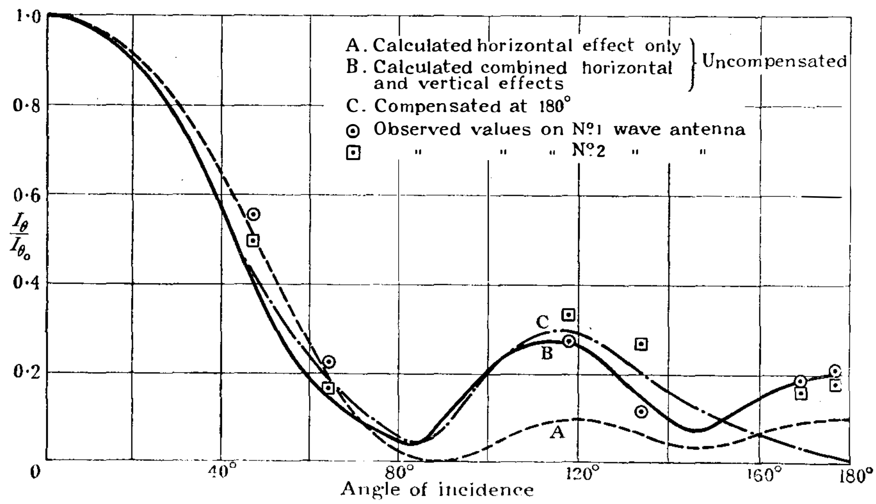


FIG. 6.—DIRECTIVE CURVES FOR ONE WAVE ANTENNA AT CUPAR.

height above ground, whereas the horizontal effect is not directly dependent upon the height above ground. In the normal wave antenna on suitable terrain the horizontal effects preponderate and the vertical effects may be neglected in comparison. Also, undulations in the ground tend to have a bad effect on a system of small tilt and it becomes difficult to build several antennæ with the same electrical results, leading again to loss of directivity when the antennæ are combined. Fig. 6 shows the calculated and observed results for the wave antennæ at Cupar. The curve marked A is the calculated result if the antenna were perfect, this in the ordinary type of country in England or Scotland. In countries with more highly resistive ground conditions the disturbing vertical effects are of much less importance and much better results should be obtainable. This statement does not exclude the fact that excellent results are obtained at Cupar with these wave antennæ, the improvement over ordinary frame reception being most marked. Experiments are, however, being made at the present time with other systems of directive reception which do not depend essentially upon the tilt of the wave front, and these systems are described later in this address.

SECTION 4.

Antenna Arrays.

Directive systems of transmission and reception depending upon the distribution of antenna systems in space with prearranged phase relations were invented in quite the early days of wireless.

S. G. Brown* was, as far as is known, the first to suggest spaced antennæ to obtain directivity. Bellini† in 1914 extended the spacing system, giving a large number of diagrams by which very sharp directivity could be obtained. Foster‡ has also extended the series of diagrams still further to collections of antennæ which he refers to as antenna arrays. Beverage, Rice and Kellogg§ have given a very extensive bibliography of this subject in connection with their paper on the wave antenna. Reference may perhaps be made to these papers for fuller information on the subject. The Marconi antennæ used for the beam stations are amongst modern examples of antenna arrays.

For the purpose of the present paper it is proposed to refer to two only of the many possible diagrams in the papers referred to, because these two diagrams stand out prominently as representing the maximum amount of directivity to be obtained with the simplest possible arrangements.

The first diagram represents the result of spacing two vertical aerials $\frac{1}{4}$ wave-length apart and combining them with a phase difference of 90°, the result being nearly a cardioid diagram. This combination is extremely useful for producing zero reception at the angle opposite the signal. This particular diagram will be referred to as the "staggered" arrangement. The other diagram, known as the broadside arrangement, is the result of combining with equal phases two vertical antennæ at a distance of 0.6 wave-length apart on a line at right angles to the signal, this distance apart being chosen as giving the maximum reduction of area from the original circle diagram of each vertical aerial. These two diagrams have been selected from a large number of possible combinations as giving very marked directivity, and the further combinations or arrays which are made utilize these directive properties in a simple fashion.

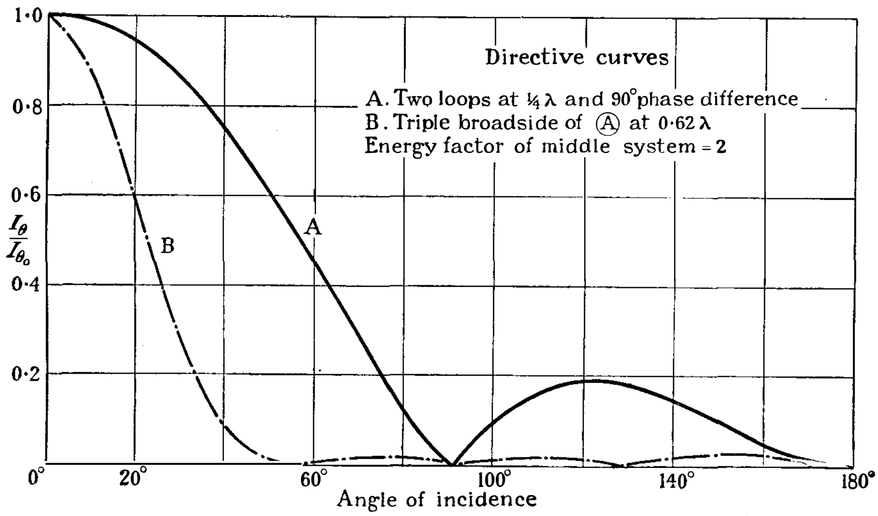


Fig. 7.—Directive Curves.

It has been pointed out by Foster that using any type of directive system as a unit which is distributed in phase and space, we can calculate the directive diagram for a system of vertical aerials so distributed, and the product of the unit diagram by the directive diagram of the array of vertical aerials gives the result of making an array of the particular type of directive system.

With the broadside combination of two

* *British Patent No.* 14449/1899.

† *Electrician*, 1914, *Vol.* 74, *p.* 352.

‡ *Bell System Technical Journal*, 1926, *Vol.* 5, *p.* 292.

§ *Loc. cit.*

antenna systems the reduction of area is very marked. So large is this reduction that where a number of antennæ are to be combined it is better to combine them in pairs and then to combine the pairs again in pairs rather than employ the plain paralleling of the ordinary antenna array.

In the antenna systems at Cupar the ratio of energy supplied by the middle antenna to that from the outside antennæ is adjustable to meet particular conditions of atmospheric distribution.

The Cupar system was designed to employ a broadside arrangement of three wave antennæ, but up to the present only two of these antennæ have been completed.

In view of the difficulty in regard to the small tilt of the wave front in this country, we are at present engaged on experiments with combinations of frames and vertical aerials, for which calculations indicate marked directive effects. Fig. 7 is the diagram for a triple broadside of staggered frames, using an energy factor of two for the middle system. The staggering proposed is $\frac{1}{4}$ wave-length with 90° phase displacement. This diagram gives results of a similar order to the triple broadside of wave antennæ. Fig. 8 employs as the unit a staggered combination of two cardioid arrangements, each consisting of a frame and vertical aerial, the cardioids being at $\frac{1}{4}$ wave-length separation. The diagram gives the result of a triple broadside of these units, again using an energy factor of two for the middle units. It will be seen that the diagram is nearly zero from 120° to 240°. The curve C in the same figure is the result of using an energy factor of 1.6 for the middle unit. Comparison of this curve with Fig. 1, giving the distribution of atmospherics at Cupar, shows that if it is possible to attain the correct combination of the several frames and vertical aerials very considerable improvement should be obtainable.

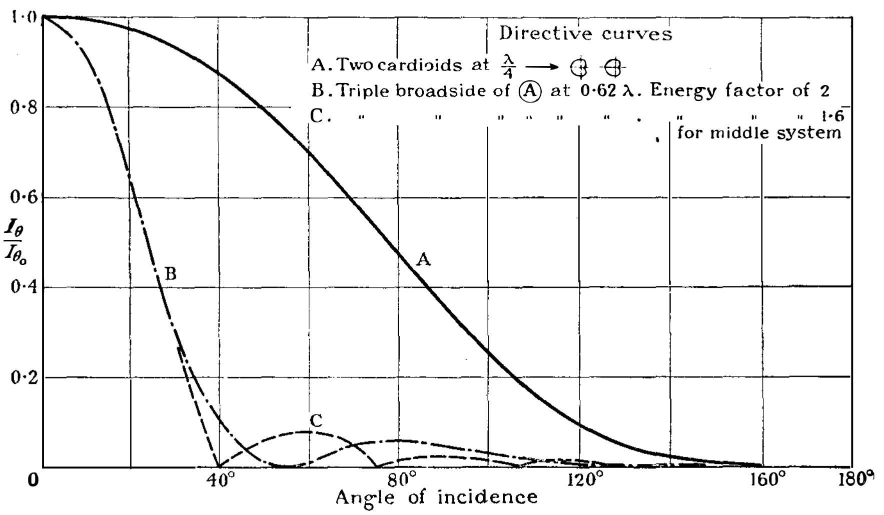


FIG. 8.—DIRECTIVE CURVES.

The success of such combinations depend, however, in very great care being exercised in making all the elements of the combination exactly alike. This process must cover not only the amplitude but also the phase at every frequency within the band of reception. Also for telephony reception there must be no undue attenuation of signals at the edges of the band owing to the tuning of the circuits being too sharp. The frames and verticals require either to be constructed with identical reactive and resistive components or to be combined with circuits which will produce the same effect of equalizing the phase and amplitude at all points in the frequency range.

PROPAGATION AROUND THE EARTH.

ALTHOUGH it is now well known to radio engineers that etheric waves of the order of 20,000 kilocycles per second can pass completely round the earth and still be received with normal apparatus, some examples of this phenomenon observed on the Beam installation working between this country and South Africa and India respectively may be of general interest.

The possibility of signals traversing the longer path between two stations and arriving with sufficient strength to affect the reception of signals directly received has been experimentally demonstrated by E. Quack, of Berlin, who has published records showing not only signals arriving by the longer path from America but also signals which have encircled the earth more than once.

The records here illustrated were obtained not as a part of an investigation into this phenomena, but in an attempt to fix the cause of complaints of bad received signals which arose intermittently and at rare intervals on the South African Beam service.

On the Beam services both the transmitting and receiving stations are equipped with reflectors, the purpose of which, in the case of the former, is to conserve the propagation of the energy in the short path direction, and in the latter, to make the receptivity greatly more sensitive to waves arriving *via* this short path. Signals, therefore, which travel *via* the backward and longer path, are attenuated by the action of the transmitting system and upon arrival at the receiving station are received with much less sensitivity than waves arriving by the forward path.

It is interesting to note that none of the records so far obtained at Bridgwater from South Africa indicates the reception of signals arriving *via* the backward path.

In order to obtain slip which would act as a record of doubly received signals and at the same time allow of a computation of the path traversed by the secondary signal, it was arranged that slip should be punched up consisting in the main part of letters " A " spaced twenty centre holes apart: and that this slip should be sent at a checked speed of 150 words per minute. At this speed the blank space between the letters on the received tape would represent a time interval of one-third of a second, which interval was chosen as allowing of a clear record, if received, of signals either back path, once round, or twice round the earth.

The first slip so punched up was sent *via*

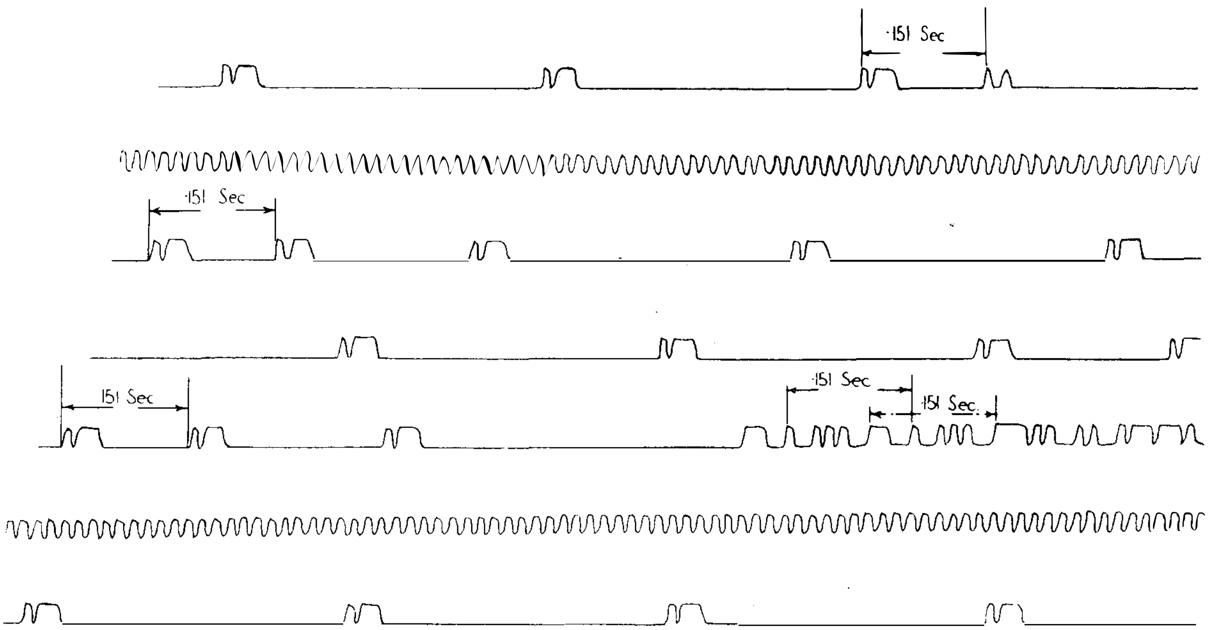


Fig. 1.

Klipheuval, the South African transmitting station of the system, and received at Bridgwater, the English receiving station, at 1758 on the 11th November. This slip yielded results illustrated in Fig. 1 on page 307, and clearly showed the intermittent presence of a second "A" amongst those directly corresponding to the transmitted slip. The interval between the two signals, which was constant in all the cases, was equal to .151 second; which clearly indicates that the wave, after making its primary record at the receiving station had then encircled the earth and arrived with sufficient energy to again make a record. This slip also illustrates the

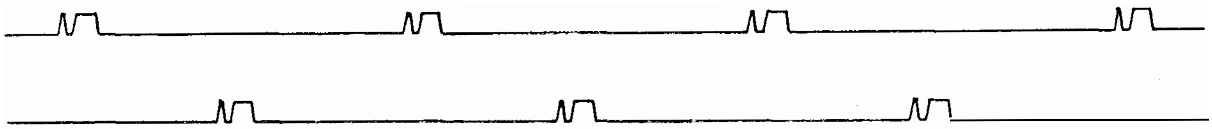


Fig. 2.

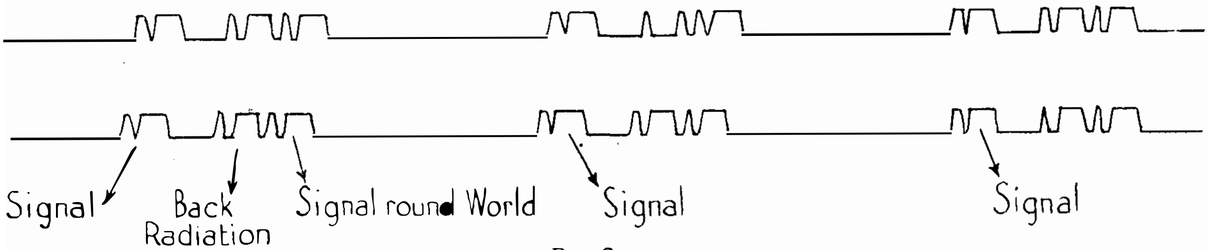


Fig. 3.

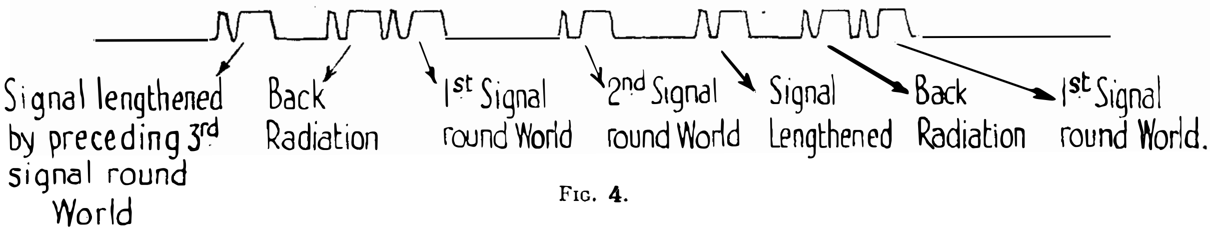


Fig. 4.

type of mutilation which can occur from double signals intermittently received, *e.g*, the extra dot after the word "Test," and the joining together of the dot dash of the letter "l" in the word slip.

Other slips obtained during the week ended 19th November yielded similar results, all the cases giving a double signal arising from the wave traversing the path around the earth, after being once received. The time interval, although constant for any one slip, varied each day, the difference being ascribed to the speed of sending not being accurately adjusted to 150 words per minute.

All the above mentioned records were obtained during the period 1700-1800 GMT, *i.e.*, soon after the total path between South Africa and England was in darkness, with the exception of one on November 19th which was obtained between 1900 and 2000 GMT.

Similar observations have been taken at Skegness on signals arriving from the Indian Beam Station. Fig. 2 is a sample of normal reception of slips signalling the letter A at spaced intervals.

This slip is perfectly clear. The receiver coupling was then increased above that required for normal reception and the following slip (Fig. 3) shows the signalled letter and then a complete duplication of it in the spaced portion due to back radiation from the Indian aerial. This is followed immediately by a third letter, which has been produced by signals encircling the world and back to England.

One sample (Fig. 4) was obtained which shows not only the above effect but a fourth reception of the letter A after the signal had gone round the world a second time. Further, the dot and dash of the succeeding letter A appear to have been lengthened, suggesting that a third encircling signal of the preceding letter has been received which has come nearly into phase with it.

NOTES & COMMENTS

OWING to the extraordinary demand for last April number, the issue has been completely sold out, in spite of the fact that what was thought to be ample provision had been made. In addition to many outstanding orders which cannot be met, it is understood that many Australian subscribers did not receive their copies, owing to some mishap to the mail by which the journals were despatched. We should like to meet all calls upon us, especially those from the Antipodes, and in order to do so we are prepared to buy in copies, in good condition, of the April issue. Full price will be paid. Will district subscribers who do not desire to retain their April copies please send them to their local agents; those at headquarters should hand the copies to Mr. H. Riddle, Lobby, Alder House.

Not a few of the older members of the engineering staff will regret the death of Mr. H. W. Sidney Rentall, editor of "Electricity," who passed away quietly in his sleep on Saturday morning, 22nd October. For many years he catered for the P.O. student by publishing telegraph and telephone matters in his paper, which he took over in 1894, and the firm also published many books on these and kindred subjects which were exceedingly helpful in the early days. He was a man of the most genial disposition, an enthusiastic Freemason, and known to almost everybody in the electrical industry.

In "Annales des Postes, Télégraphes et Téléphones," for October, 1927 (Vol. 16, No. 10), there appears under the title "Apercu du Probléme des Liaisons en Téléphonic Automatique," an article by Mr. G. F. O'dell, of the Engineer-in-Chief's Office, whose contributions to the literature of automatic telephony are well known to our readers. The article is prefaced by an editorial note, of which the following is a translation:—

"Mr. O'dell, an engineer in the British Post Office service, who is an authority on the question of automatic telephony, read a paper on this subject in London on the 2nd December last at a meeting of the Institution of Electrical Engineers, which has been published in full in the February number of the Institution Journal. The meeting discussed, fully and authoritatively, all the main up-to-date points of interest on the subject of automatic telephony, and we are particularly pleased that Mr. O'dell has himself prepared for our Annales the resumé which follows. We return to him our best thanks. Those of our readers who are not acquainted with the English language will thus be able to appreciate the views of Mr. O'dell."

A summary of the same paper appeared in our July issue. For this paper Mr. O'dell was awarded the Fahie Premium by the Institution.

The November issue of *Les Annales* is a particularly interesting number, having excellent articles on (*a*) Thunder and Lightning in its different forms, by E. Mathias, Director of the observatory of the puy de Dôme, (*b*) a generalisation of diagrams of Kennelly, by J. de Goer, (*c*) Tele-photography, by Georges Kette and Walter Kiel, and (*d*) the present state of the problem of Television by G. Valensi. The first article occupies 43 pages and includes several very good illustrations of lightning in France, England and elsewhere; the third article is a study of new methods in the electrical transmission of pictures translated from an article which appeared in the *Telegraphen und Fernsprech Technik* of February, 1927; the fourth article covers 21 pages with numerous illustrations.

Colonel T. F. Purves and Mr. E. H. Shaughnessy have just returned from the United States, where they had been attending the Radiotelegraph Conference at Washington. The Engineer-in-Chief was the Head of the British delegation, which included also among its members Messrs. F. W. Phillips, J. Louden and A. J. Waldegrave of the Secretary's Office. The Chief and his Assistant took the opportunity of inspecting the latest developments in communication engineering in the States, and their visit will no doubt bear fruit in the home service.

We regret very much having to record the death of Mr. M. Ramsay, late head of the Equipment Section at Headquarters, who retired from the service early in the year. A sketch of his career appeared in our July issue, and in it the writer expressed the hope that free from the cares and worries of office Mr. Ramsay would be enabled to prolong his life for years and that his latter days would be free from anxiety and pain. The hope was not realised, however, and another good man has gone to his rest. He collapsed rather quickly in the end, and passed away at three o'clock on the morning of the 6th December. The esteem in which he was held was evidenced by the large gathering which attended his funeral on the 9th ult. at the Great Northern Cemetery. Many of his colleagues from headquarters were present and they were pleased to see prominent representatives from the several contractors' firms who had been closely associated with him in the telephone business. Some forty wreaths were sent as tokens of remembrance of a very able engineer and of a man whose straightforward qualities of mind and heart endeared him to all who knew him. The sincerest sympathy is offered to Mrs. Ramsay and family.

This autumn has taken another toll from the list of retired P.O. engineers in the person of Mr. C. H. Chapman, who spent all his engineering service at Holloway and Studd Street, and who had been receiving his pension for only about three years. C.H., who was the elder brother of A.E., of Bristol, enjoyed good health after his retirement, but succumbed suddenly to a stroke of paralysis. He is buried in Marylebone Cemetery; the funeral service was attended by many of those colleagues who had gone through the test rooms earlier in their careers and by friends in North London, in addition to members of the family.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Burnley	New Auto.	1650
Cheltenham	,,	1120
Fforestfach	,,	140
Gillingham	,,	570
Hereford	,,	1040
Oxford	,,	1060
Syston	,,	130
Headingley	Auto. Extn.	500
Hurley	,,	30
Bearsden	New Manual	720
Belfast Relief	,,	3610
Hatch End	,,	386
Horley	,,	660
Merstham	,,	340
Lee Green	Manual Extn.	2240
Malvern	,,	200
Norwich	,,	720
Paddington	,,	1060
Sevenoaks	,,	640
Streatham	,,	1480
Walton (Liverpool)	,,	420
Wilmslow	,,	340
Barrow Corporation	P.A.B.X.	40
Carl, F., Ltd.	,,	30
Carlisle Co-op.	,,	30
Cumberland Council	,,	40
Daily News	,,	30
Hall & Co.	,,	100
Meccano Ltd.	,,	50
Newcastle Corporation ...	,,	130
Ocran Coal Co....	,,	10
Pendleton Co-op.	,,	30
Shell Mex (Aberdeen)	,,	20
,, ,, (Birmingham) ...	,,	20
,, ,, (Newcastle-on-Tyne)	,,	20
Shropshire etc. Power Co. ...	,,	40
Synthetic Ammonia	,,	200
Waring & Gillow	,,	170

Orders have been placed for the following new works :—

Exchange.	Type.	No. of Lines.
Edgware	New Auto.	1300
Hipperholme	,,	347
Ilford	,,	2850
Leeds Auto. Power Plant ...	,,	Rearrangements
Primrose Hill	,,	6900
Shepherds Bush	,,	4100
Sowerby Bridge	,,	440
Gosport	Auto. Extn.	270
Halifax	,,	Rearrangements
Oxford	,,	,,
Portsmouth	,,	,,
Southampton	,,	540
Ashford	New Manual	500
Bramhall	,,	1040
Emberbrook	,,	1660
Godalming	,,	780
Haywards Heath	,,	540
Molesey	,,	2280
Norbury Relief	,,	1900
Chiswick	Manual Extn.	2140
Queens Park	,,	1080
South Shields	,,	1360
Waterloo (Liverpool)	,,	960
Wavertree	,,	1040
Weybridge	,,	300
Weymouth	,,	240
Bristol Corporation	P.A.B.X.	50
Bristol Tramways	,,	210
Brysilka	,,	20
Carl & Co., F.	,,	30
Heelas & Sons	,,	30
Huntley & Palmer	,,	170
Jaeger & Co.	,,	10
Kingham & Sons	,,	30
Morris Cars (Smethwick) ...	,,	80
Phillips, J. & N.	,,	30
Rochdale Corporation	,,	160
Shell Mex (Barton)	,,	20
Wolverhampton Union ...	,,	30

THE FOURTH CONFERENCE OF THE INTERNATIONAL TELEPHONE COMMITTEE ("C.C.I.").*

THE conference at Como from 5th-13th September, 1927, was the first to be held under the reorganisation whereby the "Permanent Commission" was abolished and the work of the annual conference confined to the approbation, discussion, or rejection of the reports prepared, by the various commissions of reporters, upon the groups of questions detailed for investigations at the last conference.

These reports were considered in sections comprising :—

(1) Questions dealing with the general organisation of the Committee.

(2) Telephone engineering questions upon the transmission efficiency, maintenance, and supervision of lines and installations.

* *Committee Consultatif International des Communications Téléphoniques à Grande Distance.*

(3) Questions of telephone traffic and exploitation.

(4) The protection of telephone cables from corrosion due to electrolysis and chemical action.

At the opening session Dr. Di Pirro (Italy) was unanimously elected President of the Conference, and Dr. Breisig (Germany) and M. Van Embden (Holland) were elected Vice-Presidents; M. Milon (France) being appointed Hon. Vice-President.

Questions of General Organisation.

The General Secretary, M. Valensi, submitted his report upon the work of the Committee since the last Conference, and reports upon actual expenditure for the year 1926 and the proposed expenditure for the years 1927 and 1928, the latter including the expenditure due to the installation and operation of the European Master Reference System for the calibration of telephone apparatus. The Conference agreed upon certain measures to give effect to economy in the administration of the " C.C.I."

The expenditure incurred by the " C.C.I." is met by the distribution of costs among the Nations represented at the Committee, the scale of contributions corresponding to that adopted by the International Telegraph Union:—

1st Class. Germany, France, Great Britain, Union of Sovietic and Socialistic Republics.

2nd Class. Spain, Poland.

3rd Class. Belgium, Finland, Norway, Holland, Rumania, Jugo-Slavia, Sweden, Czecho-Slovakia.

4th Class. Austria, Denmark, Hungary, Switzerland.

5th Class. Esthonia, Latvia.

6th Class. Luxembourg, Mozambique.

The only European countries not represented on the " C.C.I." are Albania, Bulgaria, Greece and Turkey.

It was decided that the chief reporter of each commission of reporters will be elected by the plenary assembly and that members of these commissions need not necessarily express the views of their respective Administrations, since such official views, in connection with each question submitted for study, are sought by the General Secretary of the " C.C.I." The " C.C.I." is solely an advisory body and Administrations are not bound to accept its recommendations.

A special travelling commission was appointed to deal with inter-bourse traffic procedure and other traffic problems.

Telephone Engineering Questions.

The Unit of Transmission. The nomenclature for the unit of transmission was finally settled by adopting the title " Néper " for the natural logarithmic unit and " Bel " for the common logarithmic unit. The symbols for these units have not been selected and it will be necessary to employ the names in full for the present. In international service and in documents of the " C.C.I." transmission and cross-talk values will be expressed in both units.

By the general definition proposed by the "C.C.I." the unit of transmission serves to express the ratios of apparent or real powers, voltages or currents in transmission systems. In practice the number of units for a given case is determined by a logarithmic expression as follows:—

(1) If the two powers P_1 and P_2 are concerned, the number of Népers = $\frac{1}{2} \log_{nat} \frac{P_1}{P_2}$, and the number of Bels = $\log_{10} \frac{P_1}{P_2}$. The " Decibel," which is 1/10th of the Bel and is the renamed " T.U.," will be more conveniently employed in practice. Hence the number of Decibels = $10 \log_{10} \frac{P_1}{P_2}$.

(2) If two voltages V_1 and V_2 or two currents I_1 or I_2 are concerned, the number of units become $\log_{nat} \frac{V_1}{V_2}$ or $\log_{nat} \frac{I_1}{I_2}$ in Népers, $2 \log_{10} \frac{V_1}{V_2}$ or $2 \log_{10} \frac{I_1}{I_2}$ in Bels and $20 \log_{10} \frac{V_1}{V_2}$ or $20 \log_{10} \frac{I_1}{I_2}$ in Decibels. The fact that the new name for the basic unit was chosen as that of the inventor of the telephone is not apparent on account of the spelling adopted.

Permissible limits of transmission loss due to apparatus in circuit. The Conference dealt in detail with the report of the 3rd Commission of Reporters and, after resubmission of certain questions, made the following recommendations:—

(i) It is desirable that the transmission equivalent between two subscribers on an international circuit should not exceed 3.3 népers or 28.6 decibels.

(ii) The transmission equivalent of an international circuit, including the line terminals, should not exceed 1.3 népers or 11.0 decibels.

(iii) In order to ensure that any subscriber may be connected to any subscriber in another country, it is necessary that losses resulting from the whole of the connections joining the subscriber to the terminals of the input transformer of the international circuit should not exceed 1 néper or 8.7 decibels.

This figure shall include the whole of the losses in the connections used to join the subscriber to the terminals of the input transformer of the international circuit, the secondary trunk line, the intermediate exchanges and the accessory apparatus in series or shunt, and the subscribers' lines, but shall not include the losses due to the reduction in the current supplying the microphone from the central battery of the exchange.

(iv) When the master reference system for the calibration of telephone apparatus and working standards is available it will be necessary to define the transmission equivalent of the complete connection between the subscriber and the terminals of the output transformer of the international circuit. The permissible limit of maximum transmission loss at a junction point on an international circuit, due to signalling and monitoring apparatus (electro - magnets, resistances, condensers, keys, including the internal wiring of the trunk exchange) should not exceed 0.20 népers or 1.7 decibels within a frequency range of 300 to 2,500 periods per second, the loss due to signalling apparatus being reckoned at approximately 0.05 népers or 0.43 decibels, those due to monitoring apparatus being taken as 0.09 népers or 0.78 decibels, the internal wiring of the trunk exchange being put at 0.06 népers or 0.52 decibels.

General Conditions to be satisfied by Overhead Lines used for International Circuits. While it is not possible to define immutably and generally the geometric and mechanical constants of the configuration of overhead lines, the choice of these values being a function not only of electrical factors but also of economic factors, which vary according to the season of the year and according to the country where they are constructed, it is recommended that for the construction of international long distance telephone lines conductors of a gauge equal to or more than 3 mm. and offering a mechanical resistance sufficient to reduce causes of rupture to a minimum should be used. It is also recommended that the stability of a pole line should be such that it is able to resist as far as possible the maximum strain due to storms, hail and snow.

(i) So far as the electrical qualities of aerial lines are concerned the conductors employed should consist of copper or copper alloy in which the conductivity does not vary by more than 10% from that of copper of high conductivity or a metal or alloy affording the same advantages and satisfying the following conditions:—

(ii) In a repeater section or between a repeater station and an adjacent terminal office, the metal, gauge of conductors and the distance between the conductors on a long distance telephone circuit should always remain the same in order to ensure satisfactory uniformity. In order to ensure this uniformity, the variation of the impedance-frequency characteristics of the mean curve should not exceed 5%.

(iii) All the joints in an overhead line should be made in such a manner that they do not introduce variable resistance.

(iv) In any section of overhead line between repeater stations or between a repeater station and an adjacent terminal office, the difference of resistance between two conductors of any pair, measured by direct current, should not exceed 2 ohms.

(v) In order to avoid cross-talk interference and the disturbing effects of high power installations and telegraph circuits, the wires of long distance international telephone circuits should be crossed or rotated in such a manner that the section over which anti-induction is complete between any two circuits of the network shall be less than $\frac{1}{4}$ of the wave-lengths of the telephone circuits; in the case of high frequency carrier current telephony, and also where disturbing effects, due to high power installations, occur, or in the vicinity of telegraph circuits, it may be desirable to reduce the crossing or rotation periods.

(vi) So far as concerns danger or interference due to high power installations, telephone circuits should satisfy the conditions indicated in the " Directives " relating to protection already promulgated by the C.C.I.*

(vii) The insulation of each of the wires with respect to earth should not fall below the value of 1 megohm per kilometre, which experience in various countries has shown to be a practicable value under normal conditions of the atmosphere, from the point of view of humidity; the maintenance of this insulation is possible by using double-shed insulators, suitably constructed. This value may be reduced in districts where the climate is exceptionally humid.

(viii) The transmission equivalent between two repeater stations or between a repeater station and the adjacent terminal office should not exceed 1.6 népers or 13.9 decibels.

(ix) Circuits should be provided with test-in points in accordance with the C.C.I.'s recommendation contained in white book, page 100.†

The recommendations relating to the testing points on international circuits are:—

(*a*) The number of leading-in points should be reduced to a minimum compatible with local requirements.

(*b*) The testing points enabling precision tests to be effected should be installed approximately 200 km. apart.

(*c*) Tests for conductivity and insulation of the conductors shall be made at least once a month by the terminal exchanges or the repeater stations nearest to the frontier and the results of these tests shall be exchanged between the services concerned.

Cable Sections of Overhead Lines. General conditions were settled in respect to the construction and loading of aerial cables to limit transmission losses and impedance irregularities.

Simultaneous use in the same Cable of Telephone and Telegraph Circuits. The Conference provisionally accepted the following conditions which should satisfy the present technique regarding simultaneous, or co-existent, telegraph and telephone installations in order that the transmission quality of telephone circuits may not be prejudiced.

1. The E.M.F. produced in the line circuit by the telegraph transmitter must not exceed 50 volts.

2. When the terminals of the telegraph transmitter are closed through a resistance of 30 ohms substituted for the line, the current through the resistance must not exceed 50 m.A.

3. The increase in attenuation of the telephone line due to infra-acoustic telegraph installations must not exceed 0.06 Népers or 0.5 Decibels for a line section between two succes-

* *Space will not permit the publication of these instructions at present.*

† *The official publication in French of the Comité Consultatif International.*

sive repeaters and over the frequency range of 300 p.p.s. to the maximum telephone frequency transmitted.

4. The variation of the line impedance of 4-wire circuits must not exceed 10 per cent. in that frequency range; as regards 2-wire cicuits the variation must not exceed the values prescribed by the " C.C.I. " for the exact simulation of the impedance of the line by balancing networks.

5. Interference noise produced in telephone circuits by telegraph apparatus must not exceed, for a transmission level of −1.0 Népers or −8.7 Decibels on a circuit of 800 ohms impedance, a value which corresponds to an interference voltage of 0.1 *m*V.

6. The increase in cross-talk produced by infra-acoustic telegraph installations shall be determined as follows:—

The cable quads are replaced by artificial lines free from cross-talk and reproducing, within the closest possible limits, the impedance of the circuits. Under these conditions the attenuation corresponding to the cross-talk measured from the telephone office side must not be inferior to the following values:—

a. For 4-wire circuits: 7.5 Népers or 65 Decibels for the cross-talk between any two speech circuits in the same quad.

b. For 2-wire circuits: 8.5 Népers or 74 Decibels for the cross-talk between any two speech circuits in the same quad.

c. For 4-wire and 2-wire circuits: 10 Népers or 87 Decibels for cross-talk between two speech circuits in different quads.

7. For international communications the total length of circuit sections employed simultaneously for telephony and infra-acoustic telegraphy must not exceed 450 km.

8. The infra-acoustic telegraph systems must not introduce an unbalance to earth in excess of the value prescribed by the " C.C.I."

In the case of co-existent telephony and telegraphy over separate conductors conditions 1, 2 and 5 above must be fulfilled for loaded conductors but condition 1 only for non-loaded conductors.

In the case of voice-frequency telegraph systems, the sum of the effective voltages corresponding to the frequencies used simultaneously on the same circuit should be less than 2 volts and the sum of the corresponding effective currents should be less than 2 mA. When it is required to use currents or voltages exceeding these values it is preferable to choose circuits allotted to telegraph purposes in the outer layers of the cables and to balance them in separate groups. The final decision in these matters will be taken on the completion of tests at present being conducted by the various Administrations.

The choice of frequencies for carrier current telegraphy will probably be decided exclusively by the " C.C.I. Telegraphs."*

The Standard Reference System.

On the motion of the British delegation, it was decided to convey the unanimous and cordial thanks of the " C.C.I.." to the American Telephone and Telegraph Company for having generously made a free gift of the costly European Master Reference equipment, and for their proposal to send to Paris at the beginning of the year an engineer to supervise its installation, and at the same time to convey the thanks of the Committee to the French Government, as represented by the Post Office Administration and the Conservatoire des Arts et des Métiers, for having placed at disposal, without charge, excellent accommodation in the centre of Paris for the European Master Reference System.

International Circuit Maintenance.

Amongst the miscellaneous matters dealt with by the engineering section was the recommendation to apply experimentally a programme of maintenance testing designed to ensure maximum efficiency in the maintenance of long distance international circuits. This programme was elaborated by the British, Dutch and German Administrations some time ago, and met with the entire approval of the Conference.

* *Internation Consultative Telegraph Committee.*

LONDON DISTRICT NOTES.

TELEGRAPHS.

Central Telegraph Office.—Creed Start-Stop apparatus has been fitted on the following circuits:—

Carlisle.
Colchester.
Croydon.
Norwich (two sets).
Leather Cloth Company's P.W. (London).

A school for training skilled workmen in the maintenance of machine telegraphs has been fitted up within the C.T.O. The equipment includes:—

6 Teletypes, No. 1-A.
6 ,, No. 2-A.
6 Transmitters, Creed No. 1.
6 Receivers, Creed No. 4,
and Auxiliary apparatus,

and facilities are given for loop, or universal, power working.

Central Radio Office.—Sixteen perforators of the new Creed type have now been installed in the Central Radio Office.

A weight-driven, but motor-wound, Wheatstone transmitter has been fitted to one of the Beam stations in the Central Radio Office and the four services—Australia, Canada, India and South Africa—have been provided with Wheatstone checking sets.

Typewriters have now become engineering items and seventy-two of the new design have already been brought into use for the Beam Services.

Pneumatic Tubes.—The last of the tubes to the War Office Pneumatic Tube Centre * namely, that to Charing Cross Railway Station, has been completed and is working. The Station portion of the Tube is of brass and is run from the platform telegraph-office by way of the roof trusses and the wall adjacent to the railway lines, to the lead street tube beneath the railway bridge. The route is very tortuous, but in spite of this, the transit time is only thirty seconds over a distance of 552 yards.

* *See Vol. XIX., Part 1, page 4, Apl.,* 1926.

TELEPHONES.

The changes in the number of Exchange Lines, Extensions and stations during the quarter and the totals on 30th September, 1927, were as follows:—

	Increase.	Total.
Exchange Lines ...	4,823	319,074
Extensions ...	3,907	271,375
Stations	8,324	538,184

EXCHANGE WORKS.

Toll Exchange A.—This exchange, situated in the G.P.O. (South), Carter Lane, E.C., was opened on December 3rd and marks an important stage in the provision of additional facilities for London Toll traffic. Its capacity is 5,250 lines, and the equipment consists of 158 control positions and 29 through positions. The main object of the exchange is to handle outgoing traffic, leaving the original Toll Exchange (in Norwich Street, Fetter Lane) now known as Toll B, to deal with the remaining traffic.

Holborn Automatic Exchange.—The first automatic exchange to be opened subsequent to Tandem (Junction Exchange) was cut in on November 12th, shortly before midnight. The change-over was entirely successful and 4,792 subscribers were transferred from old Holborn Manual Exchange to the new system. During the few days immediately following the opening there was considerable congestion due mainly to the abnormal amount of traffic and to dialling errors and other mistakes. The successful way in which the traffic was handled by the switching apparatus augurs well for the success of the change of London's telephone system from manual to automatic working.

Other Automatic Exchanges.—Steady progress has been made with the installation of automatic exchanges at:—

Bishopsgate, Sloane, Western, Bermondsey, Monument, Maida Vale, Temple Bar, Langham, Edgware.

The Bishopsgate and Sloane Exchanges will be opened early in the New Year and the remainder, it is hoped, at various dates during 1928-29.

C.B. Exchanges.—C.B. Exchanges are on the point of completion at:—

Hatch End (C.B. No. 10, 400 lines).
Merstham (C.B. No. 10, 340 lines).

A C.B. Exchange at Barnes to be known as "Prospect" is also nearing completion and will afford much needed relief to the Richmond Exchange.

A temporary C.B. Exchange, to be known as "Ambassador," is being installed in the Paddington Exchange building and will afford relief to the Mayfair Exchange.

Extensions of C.B. exchanges have been completed at:—

Finchley	for	1740	lines.
Lee Green	,,	2240	,,
Mountview	,,	980	,,
Purley	,,	600	,,
Streatham	,,	2480	,,

Extensions of other C.B. exchanges to be completed early in 1928 are in hand at:—

Chiswick	for	2140	lines.
Riverside	,,	1380	,,
Wanstead	,,	1540	,,

EXTERNAL PLANT.

The changes in mileage during the three months ended 30th September, 1927, and the totals on that date were as follows:—

Single Wire Mileage.

Telegraphs.—A nett decrease in open wire of 10 miles and a nett increase in underground of 111 miles.

Telephones (Exchange).—A nett decrease of open wire (including aerial cable) of 137 miles, and a nett increase in underground of 59,511 miles.

Telephones (Trunk).—A nett decrease in open wire of 23 miles, and a nett increase in underground of 550 miles.

Pole Line.—A nett increase of 52 miles, the total to date being 5,779 miles.

Pipe Line.—A nett increase of 364 miles, the total to date being 9,250 miles.

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

Telegraphs	24,789
Telephones (Exchanges) ...	2,121,818
Telephones (Trunk) ...	67,185
Spares	135,017

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

Programmes, 1927-28.

LONDON CENTRE.

1927.

11 Oct. F. I. RAY, B.Sc., D.F.H., A.M.I.E.E. "Satellite Working in Automatic Areas."

8 Nov. T. FEWSTER and F. JOHNSTON, A.C.I.S. (*Northern Centre*). "Accounting as a function of Management."

13 Dec. A. H. JACQUEST, A.M.I.E.E., and L. H. HARRIS, M.Sc. (Lond.), A.C.G.I. "Sparking and Arcing at Relay Contacts and the use of Spark Quench Circuits."

1928.

10 Jan. P. G. HAY, F.S.I., M.I.E.E., and J. N. HILL. "The Evolution of an Exchange Area."

7 Feb. C. W. BROWN, A.M.I.E.E., and R. J. HINES, B.Sc. "The problem of the P.B.X. converted to a public Automatic Exchange."

6 Mar. A. B. HART, M.I.E.E. (*Title of paper not yet available*).

8 May. Capt. B. S. COHEN, M.I.E.E. (*Title of paper not yet available*).

Informal Meetings.

1927.

25 Oct. Capt. J. C. HINES, M.I.E.E. "The Telephone Engineer and his job."

22 Nov. Major H. BROWN, M.I.E.E. "Some things we all think we know."

1928.

24 Jan. G. T. EVANS. "Some small current Rectifiers and their Characteristics."

21 Feb. W. DAY, M.I.E.E. "The Philosophy of Engineering."

20 Mar. H. E. MORRISH. "My idea of the functions of a Technical Section."

24 Apl. E. P. NEATE. "Fault Location in Local Lines."

NORTH EASTERN CENTRE.

1927.

11 Oct. T. P. BARLOW. "Railway Signalling—Automatic."

8 Nov. W. H. THORNBURN. "New Promotion Scheme."

13 Dec. E. H. FARRAND, M.I.E.E. "Telephones in Spain."

1928.

17 Jan. H. TRICKETT. "External Work in connection with the Halifax Exchange Transfer."

27 Feb. F. I. RAY, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*). "Satellite Working in Automatic Areas."

Date not yet fixed. T. B. JOHNSON, M.I.E.E. "P.O. Engineer, Past, Present and Future."

NORTH WESTERN CENTRE.

1927.
10 Oct. T. Kenyon.
"Motor Transport."
7 Nov. W. G. Morris and A. J. Ross.
"Office Filing Economics."
5 Dec. A. S. Carr, B.E. (Cantab.), A.M.I.E.E.
"Automatic Telephony in Southport Multi-Exchange Area."
1928.
16 Jan. A. L. Barclay. (*Telephone Traffic Dept.*).
"Traffic Arrangements as they apply to Automatic Exchange Transfers."
13 Feb. T. Woodhouse, A.M.I.E.E.
"Rebalancing a Cable."
12 Mar. W. S. Procter.
"Some Experiences in Loading and Final Tests of Main Trunk Cables."

NORTHERN CENTRE.

1927.
14 July. Visit to Cowgate Repeater Station.
19 Oct. F. G. C. Baldwin, M.I.E.E.
"Telephone Switching."
16 Nov. F. W. Longmore.
"Trunking in Automatic Telephone Systems."
21 Dec. T. Fewster and F. Johnston, A.C.I.S.
"Accounting as a function of Management."
1928.
18 Jan. G. F. Bellwood, A.M.I.E.E.
"Through Signalling on Trunk and Junction Circuits."
15 Feb. W. Weightman.
"Laying of Holy Island Cable."
21 Mar. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."

SOUTH LANCS. CENTRE.

1927.
17 Oct. W. J. Medlyn, M.I.E.E.E.
"Progress and Development in the P.O.E.D."
14 Nov. C. W. Brown, A.M.I.E.E. (*E.-in-C.O.*).
"The Director—its application and the Functions Performed."
12 Dec. T. Cornfoot, M.I.E.E.
"The Administration of an Engineer's Section."
1928.
24 Jan. H. C. Gunton, M.B.E., M.I.E.E. (*E.-in-C.O.*).
"Recent Applications of Power in the Post Office."
(*Joint meeting with I.E.E.*).
6 Feb. T. Fewster and F. Johnston, A.C.I.S. (*Northern Centre*).
"Accounting as a function of Management."
5 Mar. Capt. W. Cowburn, A.M.I.E.E.
"Telephone Engineering Economics."
2 Apl. F. E. Bentley, A.M.I.E.E. and L. H. Crane, A.M.I.E.E.
"U.G. Cable Maintenance. Notes on results of 3 years special testing."

NORTH WALES CENTRE.

1927.
12 Oct. R. T. Robinson, A.M.I.E.E. (*E.-in-C.O.*).
"Motor Transport."
9 Nov. J. Ree. (*Mullard Wireless Services Co.*).
"Thermionic Valves and Distortionless Amplification."
8 Dec. Capt. J. Coxon, M.I.E.E.
"Exchange Power Plant."
(Meeting at Birmingham and visist to Exchange).
1928.
11 Jan. C. G. A. McDonald. (*Leafield Radio Station*).
"The running of a large Wireless Station."
1 Feb. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
22 Feb. R. Sheppard.
"Exchange Construction."
14 Mar. E. A. Pearson, A.M.I.E.E.
"Waste."

SOUTH WALES CENTRE.

1927.
10 Oct. A. S. Renshaw. (*E.-in-C.O.*).
"Some General Considerations relating to the Clerical Organisation of the Engineering Department."
14 Nov. T. R. Tombs.
"Gloucester Automatic Transfer, including Development."
12 Dec. Col. A. G. Lee, O.B.E., M.C., B.Sc., M.I.E.E. (*E.-in-C.O.*).
"Wireless."
1928.
9 Jan. R. G. Allcock.
"Estimates."
S. E. Hailes.
"H. Relay."
H. R. Mullis and T. L. Peacock.
"Motor Transport."
13 Feb. W. Cruickshank, M.I.E.E. (*E.-in-C.O.*).
"Voice Frequency Telegraphs."
12 Mar. H. C. A. Linck.
"Multi-Office Relay Automatics."

SOUTH WESTERN CENTRE.

1927.
20 Sept. Chairman's Address.
17 Oct. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
13 Dec. J. Innes, B.Sc. (*Scot. East Centre*).
"Edinburgh Auto. Multi-Office Transfer."
1928.
17 Jan. W. Vickery.
"Trench Restoration."
14 Feb. C. W. Brown, A.M.I.E.E. (*E.-in-C.O.*).
"The Problem of the P.B.X. Subscriber Connected to an Automatic Exchange."
20 Mar. Visit to Exeter Automatic Exchange.

NORTH MIDLAND CENTRE.

1927.
10 Oct. J. Coote.
"Junction Working to Automatic Exchanges."
7 Nov. C. H. Thatcher.
"Auxiliary Power Plant Services, Sheffield Automatic Exchange."
5 Dec. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
1928.
16 Jan. B. Glen.
"Tests applied to Underground Main Cables."
6 Feb. R. H. Hunt.
"Traffic Meter Readings."
5 Mar. J. R. Milnes.
"Power Interference."
26 ,, C. A. Carpenter.
"Transmission on Low Power."
Visit to Nottingham Super Power Station.

SOUTH MIDLAND CENTRE.

1927.
24 Oct. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
"Satellite Working in Automatic Areas."
30 Nov. J. Innes, B.Sc. (*Scot. East Centre*).
"Edinburgh Automatic Multi-Office Transfer."
21 Dec. V. Smith.
"Electrolytic Action."
1928.
25 Jan. S. D. Pendry.
"Repeater Station Test Desks."
29 Feb. C. E. Moffatt, A.C.G.I.
"Line Plant Formulæ and Calculations."
28 Mar. W. H. Arnold.
"Thrust-borers and Thrust Boring."

EASTERN CENTRE.

1927.
26 Oct. F. I. RAY, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
" Satellite Working in Automatic Areas."
29 Nov. J. INNES, B.Sc. (*Scot. East Centre*).
" Edinburgh Automatic Multi-Office Transfer."
1928.
17 Jan. R. T. ROBINSON, A.M.I.E.E. (*E.-in-C.O.*).
" Motor Transport in the Engineering Department).
20 Feb. F. GUEST.
" Youths, Their Recruitment, Training and Technical Education in the P.O.E.D."
20 Mar. L. G. SEMPLE, B.Sc.
Subject to be arranged.

SCOTLAND EAST CENTRE.

1927.
24 Nov. F. I. RAY, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
" Satellite Working in Automatic Areas."
20 Dec. R. T. ROBINSON, A.M.I.E.E. (*E.-in-C.O.*).
" Motor Transport."
1928.
17 Jan. Short papers and informal discussions.
21 Feb. E. H. SHAUGHNESSY, O.B.E., M.I.E.E. (*E.-in-C.O.*).
" Rugby Radio Station."
(*Joint meeting with I.E.E.*).
20 Mar. J. McINTOSH.
" Forms and Methods in preparing Estimates."
17 Apl. J. INNES, B.Sc.
" Service Observation Equipment in Auto. Exchanges."

SCOTLAND WEST CENTRE.

1927.
4 Oct. R. T. ROBINSON, A.M.I.E.E. (*E.-in-C.O.*).
" Motor Transport."
7 Nov. J. INNES, B.Sc. (*Scot. East Centre*).
" Edinburgh Auto Multi-Office Transfer."
5 Dec. A. ARNOLD.
" Glasgow Repeater Station " (*or alternative*).
1928.
Feb. *To be arranged.*
Mar. *To be arranged.*

NORTH IRELAND CENTRE.

1927.
8 Nov. Major G. H. COMPORT, M.C., M.I.E.E., R.E.
" Motor Transport."'
6 Dec. Capt. F. G. C. BALDWIN, M.I.E.E. (*Northern Centre*).
" Scientific Organisation and the P.O. Engineering Department."
1928.
10 Jan. G. BAILEY, A.M.I.E.E. (*North Eastern Centre*).
" Preparation of Underground Development Schemes."
14 Feb. N. ASHBRIDGE, B.Sc., A.M.I.C.E. (*B.B.C., London*).
" Broadcasting."
6 Mar. Visit of Inspection of Harland & Wolff's Belfast Shipbuilding Yards.
23 Mar. F. I. RAY, B.Sc., D.F.H., A.M.I.E.E. (*E.-in-C.O.*).
" Satellite Working in Automatic Areas."
10 Apl. J. CLEAVER, A.M.I.E.E. (*S. Lancs. Centre*).
" Problems in large Underground Works."

LOCAL CENTRE NOTES.

NORTH WESTERN CENTRE.

Chairman, J. M. Shackleton; Vice-Chairman, J. Sinclair Terras; Committee, S. Upton, W. Beattie, R. A. Jones, R. A. G. Chambers, E. Hopper, and H. S. Turner; Hon. Librarian, H. Howarth; Local Secretary, D. Barratt.

The opening meeting of the 1927-28 Session was held in the Lecture Hall of the Preston Scientific Society, Fishergate, Preston, on the 10th October, 1927, when a paper entitled " Motor Transport " was read by Mr. T. Kenyon, of the South Lancashire Centre. Mr. Shackleton presided.

Mr. Kenyon opened his paper with a review of the evolution of the motor transport services in the Engineering Department and proceeded to deal with the subject under the following headings:—Constitution of Department's Fleet, Organisation and Uses, Running Costs, Statistics, Hired Transport, Staff Co-operation, Observations and Suggestions. The lecture was illustrated by an excellent set of lantern slides, and a useful discussion followed.

On the 7th November, 1927, a paper, entitled " Office Filing Economics," was read at Preston by Messrs. W. G. Morris and A. J. Ross.

The objects in view were the reduction of filing work in offices in which filing had become more laborious than circumstances warrant and the introduction of a simplified system in offices in which filing had lapsed on supposed economic grounds. The existing filing arrangements in the various groups of the District Headquarters Office were reviewed and this was followed by proposals for filing in the Sectional Engineers' Offices and at outlying Inspectors' stations.

Diagrams illustrating the arrangement of filed matter in the office presses and the most suitable positions for card cabinets were projected by Electric Arc Lantern. There was an interesting discussion, when many points were raised and replied to.

D. BARRATT, *Secretary*.

SOUTH LANCASHIRE CENTRE.

The Session opened on October 17th with an Address by the Chairman, Mr. W. J. Medlyn, in which, under the title of "Progress and Development in the Post Office Engineering Department," he gave an interesting review of the various activities of the Engineering Department during the past year and an outline of the latest Telephone and Telegraph Engineering developments.

The address was followed by a cinematograph film illustrating the use of the "Simplex Jack" on pole recoveries. This was succeeded by a film entitled, "Beyond the range of Vision," showing the wide activities of the American Bell Telephone interests. A Simplex Jack was supplied for demonstration purposes by Mr. W. Tuke Robson, M.B.E., A.M.I.E.E., of the Equipment and Engineering Company. The film illustrating the American Telephone practice was loaned by the Engineer to the Bradford Corporation Electricity Department, through the good offices of Mr. J. Shea.

The thanks of the members was suitably expressed to Messrs. Robson and Shea, both of whom were present, for their interesting and instructive additions to the proceedings.

NORTHERN CENTRE.

The opening meeting of the Session was held on the 19th October, when Mr. F. G. C. Baldwin, M.I.E.E., delivered a lecture, entitled "The Early Development of Telephone Switching," before a well attended gathering.

The lecturer took his audience through the various stages of switching from the earliest days of the first telephone exchange to modern methods of accomplishing intercommunication and the numerous slides which he introduced rendered the address not only interesting and instructive, but easy to follow.

The Committee for the Session has been elected as follows:—

Chairman, J. R. M. Elliott, M.I.E.E.,; Vice-Chairman, F. G. C. Baldwin, M.I.E.E.; Committee, G. A. Peck, M.I.E.E., Jas. A. Motyer, C. P. Kay, W. Weightman, H. J. Millett, A. H. Wade; Local Librarian, T. E. Preston; Local Secretary, A. C. Smith, A.C.I.S.

NORTH WALES CENTRE.

[From the *Shrewsbury Chronicle*, 11-11-27.]

PRESENTATIONS TO MR. T. PLUMMER.

On Wednesday two presentations were made to Mr. Thomas Plummer, of Shrewsbury, who retired last July from the post of Superintending Engineer of the North Wales District of the General Post Office, after a total service of 42 years.

The occasion was a tea held in Morris's New Ballroom, Pride Hill, Shrewsbury, attended by about 140 members of the engineering staff of the district. Mr. H. A. Jackson, Assistant Superintending Engineer, was in the chair.

Mr. Jackson said they were all sorry to lose Mr. Plummer, because he had endeared himself to them to an exceptional degree. His chief mottoes throughout his official period must have been "Be just and fear not" and "Honesty is the best policy." They admired his devotion to the department he so faithfully served, the straightforwardness and fairness of his decisions, and the kindly interest he took in the welfare of the staff.

They deplored his late breakdown in health, but noted with pleasure that he was now on the road to recovery, and trusted that he would be spared for many years to enjoy his retirement.

Mr. B. J. Gill, head of the clerical staff in the North Wales District, said that he had been associated with Mr. Plummer for over nine years. He had had opportunities of judging him both as an official and as a man, and had the highest admiration for him in both capacities. The whole of the clerical staff would remember him for his kindness, his great industry, his devotion to duty, and his desire to be just to everyone.

Mr. Jackson then presented Mr Plummer with a solid silver breakfast service, including a tray, which bore the inscription, "Presented to Thomas Plummer, Esq., M.I.E.E., Superintending Engineer, by his staff in the North Wales District, as a mark of esteem on his completion of 42 years' service in the Engineering Department of the General Post Office." The presentation had been subscribed to by members of the staff "down to the very lowest."

Mr. W. J. Medlyn, Superintending Engineer for the South Lancashire District, presented Mr. Plummer with an inscribed silver rose bowl and a silver-mounted tea set from the superintending engineers, staff engineers, and members of the headquarters staff of the G.P.O. He said that it gave him particular pleasure to make the presentation, because he had known Mr. Plummer personally for nearly 40 years, both at headquarters and as a near neighbour at Liverpool and Shrewsbury.

Mr. Plummer, who was received with loud applause, returned thanks in a witty speech.

NORTHERN IRELAND CENTRE, BELFAST.

Mr. H. Deeny, Inspector, an Associate Member of the Institution, retired from the service in November, having reached the age of 62.

His last day of duty was the occasion of a gathering of the staff at headquarters, presided over by the Superintending Engineer, Major G H. Comport, M.C., M.I.E.E., R.E., to say good-bye to him. Mr. G. Laslett, Executive Engineer; Mr. J. Davidson and Mr. H. H. Broomhead, Assistant Engineers; Mr. W. S. French, Inspector, and Mr. J. T. Sims, Chief Clerk, having spoken eulogistically of Mr. Deeny, Major Comport, in felicitous terms, conveyed to him the good wishes of his colleagues and congratulated him very heartily on the esteem with which he was held by all grades in the Service, as evidenced by the large attendance.

In handing to Mr. Deeny a wallet of notes as a tangible expression of the good wishes of the District Staff, Major Comport referred to Mr. Deeny's useful service and clean record, expressing the wish of all for a continuance of the excellent health and vigour which characterised Mr. Deeny, and which he would take with him into his well-earned leisure.

With the Staff's presentation Major Comport also handed to Mr. Deeny the Departmental gratuity.

Mr. Deeny suitably responded.

SOUTH WESTERN DISTRICT.

Presentation to Mr. E. J. Eldridge.

There was a large gathering of the staff of the Post Office, South Western District, Engineering Department, at a garden party held on September 20th, 1927, at No. 8, Woodland Road, Tyndall's Park. The event was arranged in connection with the retirement of Mr. E. J. Eldridge, Superintending Engineer of the South Western District, and among those present were the Assistant Engineer-in-Chief, Mr. A. L. de Lattre, Mr H. Wilson, Superintending Engineer, Cardiff, Mr. C. G. Roach, Assistant Superintending Engineer, Cardiff, and also Mr. W. Pugh, Postmaster-Surveyor, Bristol, and Mr. W. Millar, District Manager, Bristol.

Tea was served indoors and then the company adjourned to a marquee erected in the garden, where the presentation, presided over by Mr. A. E. Chapman, Assistant Superintending Engineer, took place.

Messages of farewell and good wishes were delivered by various representatives of the staff and the presentation, which consisted of a Solid Silver Tea and Coffee Service and a set of Golf Clubs, was made by Mr. A. L. de Lattre, the Assistant Engineer-in-Chief.

An evidence of the general esteem in which Mr. Eldridge was held by his colleagues and staff of the Engineering Department of the Post Office, subscriptions were received from the staffs of the District, the Engineer-in-Chief's office and from the Superintending Engineers of the country.

Music was provided by Mr. Gould's Orchestra and vocal items were contributed by several members of the staff, and a very pleasant evening was wound up with community singing and a spirited rendering of "Auld Lang Syne."

SCOTLAND WEST CENTRE.

The first meeting of the current Session was held in the Societies' Room, Technical College, Glasgow, on 4th October. The lecturer for the day was Mr. R. T. Robinson, A.M.I.E.E., Engineer-in-Chief's Office, who delivered a lecture on "Motor Transport." The subject proved to be one of considerable interest and there was a good attendance and discussion.

For our November meeting the lecturer was Mr. J. Innes, B.Sc., of the Scotland East District, who took for his subject "Edinburgh Auto. Multi-Office Transfer."

There was a large attendance and on conclusion of the lecture several questions were raised, to which the lecturer suitably replied. It is understood the paper is being printed for circulation.

A combination of circumstances prevented Mr. Arnold's fulfilment of the programme fixture for 5th December, but the item may be regarded as postponed, not abandoned. We were fortunate, however, in getting Mr. F. G. C. Baldwin, M.I.E.E., of the Northern District, to fill the gap with his lecture on "The Early Development of Telephone Switching." The lecture drew a large attendance of members and a number of visitors from the Commercial side.

About fifty slides illustrative of the evolution of telephone switching were shown on the screen, and in some cases these had a personal as well as a technical interest. The lecture was very interesting throughout and the subsequent discussion was contributed to by visitors as well as members.

BOOK REVIEWS.

"Theory of Thermionic Vacuum Tube Circuits," By L. J. Peters. McGraw Hill Publishing Company. Price 15/-.

The scope of this book is even more limited than the title suggests as it deals almost entirely with the usual triode and associated circuits. This will be clear when it is stated that the book does not deal with diode rectifiers and the "screened grid" valve is dismissed in a paragraph.

The book can be commended as a reasoned mathematical statement of the action of the three-electrode valve in its various uses for radio transmission and reception, but it is only suitable for the electrical engineering student who has already covered the usual mathematical groundwork associated with a degree course in electrical engineering.

Prof. Peters deals with the subject throughout his book mainly from the view point that a triode is a means of resistance neutralisation and, as he states in the preface, "This idea is then used as a unifying thread. . . . . " In consequence, it is a book for the student to read as a whole in order to adapt himself to this particular and useful line of argument.

The reading of an American book usually brings with it the interesting discovery of terms which appear novel on this side of the Atlantic. On the ground that we have enough mis-named quantities already, Prof. Peters refuses to use the expression "mutual conductance" with reference to a valve in his book. Following Prof. E. Bennett, he refers to this constant as the "controlled plate conductance" with the symbol G_{cp}, but the reviewer fears that the expression "mutual conductance" has become so universal that there is little hope of its eradication. However, the term "mutual elastance," used by Prof. Peters for the mutual reactance between two circuits with capacitative coupling, would appear to need a good deal of justification.

The book is clearly written and the mathematical portions are set up in type which is easy to follow; the few misprints noticed are fairly obvious and will cause no difficulty. There are a few useful exercises in circuit calculation throughout the work with which the student can check his progress. The student who reads this book will generally wish to pursue his studies in particular directions elsewhere, and for this reason the book would have been improved by references to other sources of information. The absence of such references is always a handicap to the reader, but the vague reference to a paper, without any indication of title or source, as occurs on page 120, is irritating.

The engineer-graduate who, as a part of his training as a radio engineer, wishes to apply and exercise his electrical theory by a consideration of the circuits associated with triodes should read this book.

R.V.H.

" Principles of Radio Communication." By John H. Morecroft (assisted by A. Pinto and W. A. Curry). Chapman & Hall. Price 37/6. (*Second Edition*).

It is a stupendous task to write a comprehensive treatise on radio engineering; that Prof. Morecroft and his colleagues have made a great attempt is witnessed by the fact that the second edition of this book has 1001 pages and 831 figures. The book has been thoroughly revised; several chapters have been considerably lengthened by the addition of up-to-date information and in consequence it has been necessary to omit several chapters of the first edition.

It must be a great problem to the writers of such a book to know the stage at which such a general treatise should start in its description of elementary science and where it should stop in its elaboration of the details of a particular phase of radio engineering. It used to be the practice for many engineering books to commence with a mathematical introduction, but fortunately it has been realised that the engineer cannot afford to study his mathematics on the basis of a few introductory chapters of a book on engineering. The reviewer is looking forward to the time when writers of books on radio engineering will refrain from using their first chapters to explain to their readers the elementary facts of magnetism and electricity, such as the nature of an electric current, the capacity of a condenser, etc., etc. If Prof. Morecroft had omitted some of the elementary portions of the work and some of the simple figures (such as those showing the use of a fence as a receiving antenna, and of a tree, with nail, as a possible means of support) it would have probably been unnecessary to omit any chapter on " radio-measurements " — which Prof. Morecroft hints may be issued as a separate volume. In view of the fact that the great advances made by radio engineering in recent years have been due largely to the development and use of precise measurements, it is a matter of regret that the chapter on this subject should have been jettisoned instead of some of the pages dealing with the more elementary electrical facts of general knowledge.

It is thought that, even in a general treatise, the " wave antenna " for reception and the " multiple-tuned antenna " for transmission are worthy of more explanation, and that in dealing with the question of elimination of atmospherics a book on modern practice should have given prominence to the advantages of directional reception in increasing the signal/noise ratio.

These remarks, however, merely emphasise the difficulty of the task. Opinion must necessarily differ as to the relative importance of the items omitted and included. Generally speaking, the book is a splendid compendium of knowledge in regard to the subject of radio engineering; it is well written, is illustrated with an adequate number of clear diagrams and can be recommended as a general treatise and book of reference to those who wish to study the subject.

R.V.H.

" Electric Rectifiers and Valves." By A. Guntherschulze. Translated and revised by Norman A. de Brune. Published by Chapman & Hall, Ltd. Price 15/- net.

The publication by Messrs. Chapman & Hall of a second treatise on rectification within a year naturally invites a comparison between the two books.* It is probably sufficient to say that Mr. Jolley's book treats the subject from the engineering standpoint whilst the book under review deals with it more briefly from the physical standpoint.

The subject matter is presented in a thoroughly readable manner, although the author is rather fond of making references to particular types of rectifier in chapters which are applicable to several types. The book is divided into Physical and Technical Sections, the latter including a brief mathematical survey of rectifying circuits.

Any book on rectification published in this country should contain more than a passing reference to thermionic rectifiers as these are now being used in large numbers and are of general interest. In his introduction, the author refers to the fact that " this book is primarily concerned with rectifiers for currents bigger than

* *" Alternating Current Rectification," L. B. W. Jolley. Reviewed in P.O.E.E. Journal, Vol. 20, No. 1.*

those encountered in high frequency work." This may be so, but thermionic rectifiers are frequently used for powers far exceeding those for which mechanical, glow, discharge and electrolytic rectifiers are used, although these last types occupy quite a large portion of the book. The irony of this failure to do justice to the thermionic rectifier is completed by the reference (by the translator) in the last chapter to the Moullin thermionic voltmeter.

As a reference book on the physics of rectifiers, particularly of the mercury vapour type, this book will be welcomed, but an engineer seeking information on thermionic rectifiers will be disappointed.

"A Classified Guide to the Literature relating to the Engineering and Mechanical Industries." F. and E. Stoneham, Ltd., at the Librarian's Room, London, E.C.

A list of books published between August, 1926, and September, 1927, for the Annual Conference of the Library Association, Edinburgh, 1927.

IMPORTANT NOTICE.

The Board of Editors has decided to reduce the price of the Journal, beginning with the April number, to one shilling and threepence per copy. This arrangement will bring the purchaser of single copies into line with the annual subscriber who has been paying the round sum of five shillings per annum. Although no relief is being given to the annual subscriber, our readers will realise that another step has been taken in the return to pre-war prices, and the Board hopes that the growing circulation will continue apace, as therein lies the hope of a further reduction in price.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to.	Date.
Bartholomew, S. C.	Executive Engineer, E.-in-C.O.	Acting Assistant Staff Engineer, E.-in-C.O.	26-10-27
Gravill, W. E.	Assistant Engineer, S. Mid. District.	Executive Engineer, London District.	23-10-27
Neate, E. P.	Assistant Engineer, London District.	Executive Engineer, London District.	To be fixed later.
Parker, T. T.	Repeater Officer, Class II., E. District.	Repeater Officer, Class I., E. District.	10-9-27
Mylius, W. A. J.	Repeater Officer, Class II., S.W. District.	Repeater Officer, Class I., S.W. District.	8-11-27
Furneaux, E. G....	Repeater Officer, Class II., E. District.	Repeater Officer, Class I., E. District.	19-10-27
Wood, J.	Inspector, Northern District.	Chief Inspector. Northern District.	30-10-27
Gawthorne, G. J.	Inspector, London District.	Chief Inspector, London District.	26-10-27
Deakin, R. E.	Inspector, N. Wales District.	Chief Inspector, N. Wales District.	2-1-27
Colston, A. S.	Inspector, Scot. W. District.	Chief Inspector, N. Ireland District.	To be fixed later.
Morvan, A. R.	Inspector, N. Wales District.	Chief Inspector, N. Wales District.	9-10-27
Clothier, W.	Skilled Workman, Class I., Northern District.	Inspector, Northern District.	17-7-27
Tomkinson, G.	Skilled Workman, Class I., N. Wales District.	Inspector, N. Wales District.	21-5-27

Deaths.

Name.	District.	Grade.	Date.
McCall, D.	London.	Inspector.	30-9-27
Sanders, A. E.	N. Midland.	"	27-6-27

Retirements.

Name.	District.	Grade.	Date.
Eldridge, E. J.	S. Western.	Superintending Engineer.	30-9-27
Trezise, J. M. G.	Met. Power.	Superintending Engineer.	31-12-27
Hunt, J. A.	London.	Executive Engineer.	30-9-27
Cardrey, A. G.	London.	Executive Engineer.	30-11-27
Latimer, F. D.	S. Eastern.	Assistant Engineer.	
Sorrell, J. E. A.	Eastern.	Repeater Officer, Class I.	18-10-27
Kemplay, R.	S. Western.	Repeater Officer, Class I.	7-11-27
Farrar, S.	Eastern.	Repeater Officer, Class I.	9-9-27
Ashbee, A. W.	S. Western.	Chief Inspector.	24-11-27
Jenkins, W. J.	S. Eastern.	Inspector.	28-8-27
Bull, C. E.	London.	Inspector.	17-9-27
Dolman, R. A.	N. Wales.	Inspector.	19-11-27
Deeny, H.	N. Ireland.	Inspector.	22-11-27
Linder, W.	S. Midland.	Inspector.	15-11-27
Hann, F.	Northern.	Inspector.	15-11-27

Reversion.

Name.	From.	To.	
Green, W.	Chief Inspector, S.E. District.	Inspector, East District.	At own request.
Read, H. W.	Chief Inspector, S.W. District.	Inspector, S.W. District.	

APPOINTMENTS.

Name.	From.	To.	
Ackerman, H. M. W.	Inspector, London District.	Probationary Assistant Engineer, London District.	Limited Competition.
Potts, E.	Inspector, London District.	Probationary Assistant Engineer, London District.	
Hibberd, W. A.	Inspector, E.-in-C.O.	Probationary Assistant Engineer, E.-in-C.O.	
Luxton, W. G.	Inspector, E.-in-C.O.	Probationary Assistant Engineer, E.-in-C.O.	

CLERICAL ESTABLISHMENT.

PROMOTION

Name.	Grade.	Promoted to	Date.
Paddon, R. C.	Clerical Officer, London.	Higher Clerical Officer, London.	20-9-27
French, J. J.	Clerical Officer, London.	Acting Higher Clerical Officer, London.	29-9-27

COMMUNICATIONS.

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

Binding covers and copies of the Contents for Vol. 3 to 19 are available, and may be obtained from the local agents for 1*s*. 6*d*. and 3*d*. respectively. Subscribers can have their copies of Vol. 20 bound, with index included, at a cost of 3*s*. by sending the JOURNALS to the local agents. Orders for bindings, Vols. 1—19, should indicate whether the original binding with black lettering, or the later pattern in gold, is required. Covers with gold lettering will be the only type stocked from Vol. 20 onwards.

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Institution of P.O.E. Engineers,
G.P.O., Alder House, E.C.1.

CENTRAL LIBRARY.

The following books have been added to the Central Library. Applications for the loan of same should be addressed to the Librarian, Institution of P.O. Electrical Engineers, Alder House, E.C.1.

LIST II.

No.	*Title.*	*Author.*
843	Essai sur l'Electricité des Corps...	Abbé Nollet.
844	The Post Office	Sir Evelyn Murray.
845	Elements of Telephone Transmission	H. H. Hamson.
846	New Electricity Act	W. S. Kennedy.
847	Elementary Electrical Engineering	A. E. Clayton and H. J. Shelley.
848	Up-to-date Motor Road Transport for Commercial Purposes ...	J. Phillimore.
849	Automatic Telephony	C. W. Wilman.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

BOOTH-BAUDOT AWARD.

The Council wishes to call attention to the "Booth-Baudot Award" of £5 which is now offered annually for the best improvement in Telegraph, Telephone or Wireless Apparatus or Systems. The award for the year 1927 is governed by the following conditions:—

1. The Award will be restricted to employees of the British Post Office.
2. Applications for the Award should be made between 1st January and 31st March, 1928, and such applications should refer to improvements made, or suggested, during the twelve months ending 31st December, 1927.

   Attention is drawn to the fact that recipients of Awards *via* the Post Office Awards Scheme in respect to any improvement in telegraph, telephone or wireless apparatus or systems are eligible to apply for the Booth-Baudot Award in respect thereto.
3. The Award may be withheld at the discretion of the Council of the Institution of Post Office Electrical Engineers if, after full consideration of the applications received, the adjudicators appointed by the Council are of the opinion that no award is warranted.
4. Applications for the Award, accompanied by full details of the improvement, should be addressed to the Secretary, The Institution of Post Office Electrical Engineers, G.P.O. (Alder House), London, E.C.1.

R. V. HANSFORD,
Secretary.

December, 1927.