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START-STOP PRINTING TELEGRAPH SYSTEMS.

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DURING the last decade there have been extensive developments in the use of Type-Printing Telegraph Systems on inland circuits in this Country. Most of the circuits, carrying comparatively heavy traffic between zone centres, have been equipped with multiplex systems, and the working capacity of these is being increased by the substitution of automatic transmission for the direct hand transmission such as is still employed on a number of Baudot circuits. On the less heavily-worked circuits, over which the peak hour load does not exceed 100 to 120 average messages per hour in each direction, the tendency at the present day is to use Start-Stop Printing Telegraph Systems, and it is proposed in this and subsequent articles to describe such of these systems as are in extensive use. No attempt will be made to trace their historical development.

Start-Stop Principles.—All start-stop systems use a standard keyboard similar to that of a typewriter, and transmit signals direct to line through the agency of a mechanical distributor. The latter merely consists of a battery of cams, arranged to operate a number of transmitting contacts at certain regular intervals. At the receiving end, a single electromagnet controls, through another mechanical distributor, the action of the selecting and printing mechanism.

Both the sending and the receiving distributor are at rest, normally, but immediately a key is depressed at the sending end they are set in rotation. They are both stopped after completing one revolution. It is essential, of course, that the two distributors should rotate at the same speed, and this is ensured by governors and speed setting devices. If the speeds are set correctly and the governors function properly, very little phase displacement can occur between the distributors during each revolution; the slight changes of phase that may occur are insufficient to cause indifferent working and cannot accumulate because the distributors are brought into phase, automatically, each time they stop, which as explained, is on the completion of each revolution.

A five-unit code is used for the actual character combinations, but each is preceded by a " start " impulse, which is of the same length as each character unit, and followed by a " stop " impulse, which has a length of $1\frac{1}{2}$ units. From a line transmission point of view each character, therefore, has a code length of $7\frac{1}{2}$ units; hence start-stop systems have a slight advantage over Morse, in which the average length of a character is 8 units. The " start " and " stop " impulses are essential in order to ensure that the receiving distributor shall start and stop for each character signalled.

The application of the foregoing principles to the start-stop systems in use in this Country will now be described.

(i.) The Morkrum Teletype No. 1a. — A

general view of this instrument is shown in Fig. 1. The cover has been removed in Fig. 2 to show the mechanism. The Transmitting and Receiving units are mounted on one base

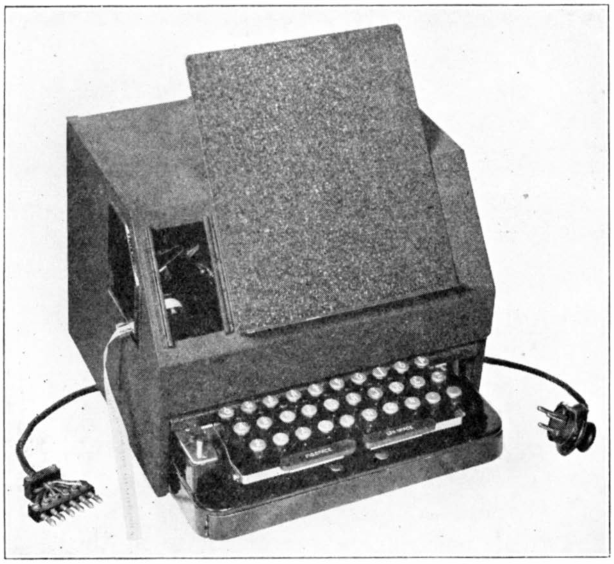


Fig. 1.—Morkrum Teletype No. 1a.

and driven by a single series-wound motor of 1/40th H.P. Plugs and cords are fitted, which make connections with sockets mounted on the instrument tables, to facilitate the changing of the apparatus in the event of faults. The working speed is 40 words per minute, and printing is effected by bringing a paper tape into rolling contact with a rotating typewheel in a manner similar to that of the Baudot Receiver.

Fig. 2.—Morkrum Teletype No. 1a, with cover off.

Morkrum Code

		1	2	3	4	5			1	2	3	4	5
A	:	●	●	○	○	○	Q	1	●	●	●	○	●
B	?	●	○	○	●	●	R	4	○	●	○	●	○
C	(	○	●	●	●	○	S	'	●	○	●	○	○
D	2	●	○	○	●	○	T	5	○	○	○	○	●
E	3	●	○	○	○	○	U	7	●	●	●	○	○
F	1/	●	○	●	●	○	V	)	○	●	●	●	●
G	3/	○	●	○	●	●	W	2	●	●	○	○	●
H	5/	○	○	●	○	●	X	£	●	○	●	●	●
I	8	○	●	●	○	○	Y	6	●	○	●	○	●
J	7/	●	●	○	●	○	Z	·	●	○	○	○	●
K	9/	●	●	●	●	○		+	○	●	○	○	○
L		○	●	○	○	●	/	/	●	●	●	●	●
M	!	○	○	●	●	●	–		○	○	○	●	○
N	-	○	○	●	●	○	FIGURES		●	●	○	●	●
O	9	○	○	○	●	●	LETTERS		○	○	●	○	○
P	0	○	●	●	○	●	BLANK		○	○	○	○	○

● Denotes "Marking" Units.

Each Character is prefaced by a start signal (spacing) & terminated by a stop signal (marking). The diagram below shows the signals sent out for one revolution of the Transmitter spindle for the letter "R"

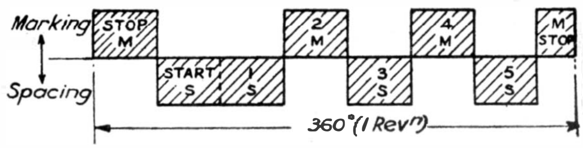


Fig. 3.

The five-unit code used is shown in Fig. 3. It will be seen that the " start " impulse is a spacing unit, and the " stop " impulse a marking one of length 1½ units. Letter Shift and Figure Shift signals are employed, so that one particular combination of units may be made to represent either a letter or a secondary character

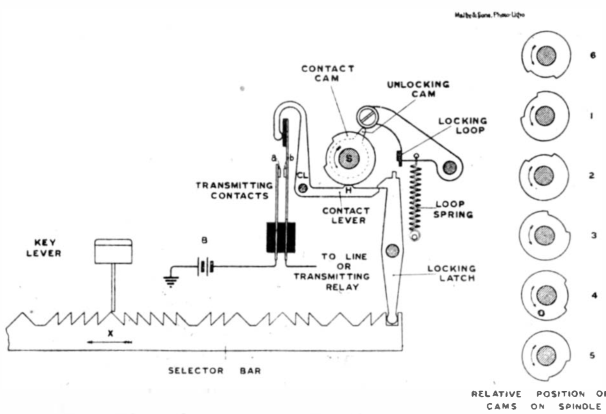


Fig. 4.

(such as figures, etc.) by preceding it with the " letter shift " or " figure shift " combination, respectively.

Transmitting Mechanism.—Referring to Figs. **4** and **5**, it will be seen that there are 5 selector bars directly underneath the key levers of the keyboard. The upper edges of these bars are notched in a definite manner to suit the code, and when a key is depressed it causes one or more of these bars to move either to the right or to the left according to the oblique side of the notch in each bar acted upon by the key lever. Thus in Fig. **4** the operation of the key lever shown would cause the selector bar to move to the left. The movement of any bar to the right represents a spacing unit of the code, and movement to the left a marking unit. For example, if key R be depressed, the code for which is 1, 3, and 5 spacing, and 2 and 4 marking, selector bars 1, 3, 5 will be moved to the right and bars 2, 4, to the left. Each Selector Bar acts on a Locking Latch, which, in conjunction with a Contact Lever, controls a Transmitting Contact. There are five such Contact Levers and Transmitting Contacts corresponding with the five Locking Latches. A sixth Contact Lever placed at the rear of the others controls a sixth set of Transmitting Contacts, which give the " start " and " stop " impulses.

Simultaneously with the setting of the Selector-bars, which takes place when a key is depressed, a Universal bar is actuated bringing into operation a clutch mechanism and causing the Transmitter Cam spindle S to make one complete revolution. The six cams mounted on this spindle together with the associated contact levers and transmitting contacts, constitute the mechanical distributor of the Transmitter.

The contact spring *b* of each set of transmitting contacts acts on the end of its controlling contact lever and forces it to ride on the rim of its associated contact cam. The mechanical arrangements are such that when a selector bar is moved to the left, the upper end of its locking latch is positioned so as to be clear of the end of the associated contact lever and the projection H on the latter can rise into the notch in the cam on which it rides, thus allowing the contacts *a* and *b* to close and to send out an impulse. If, however, a selector bar is moved to the right, its locking latch will be moved to such a position as to prevent the contact lever from rising into the cam notch and the corresponding transmitting contacts will remain open.

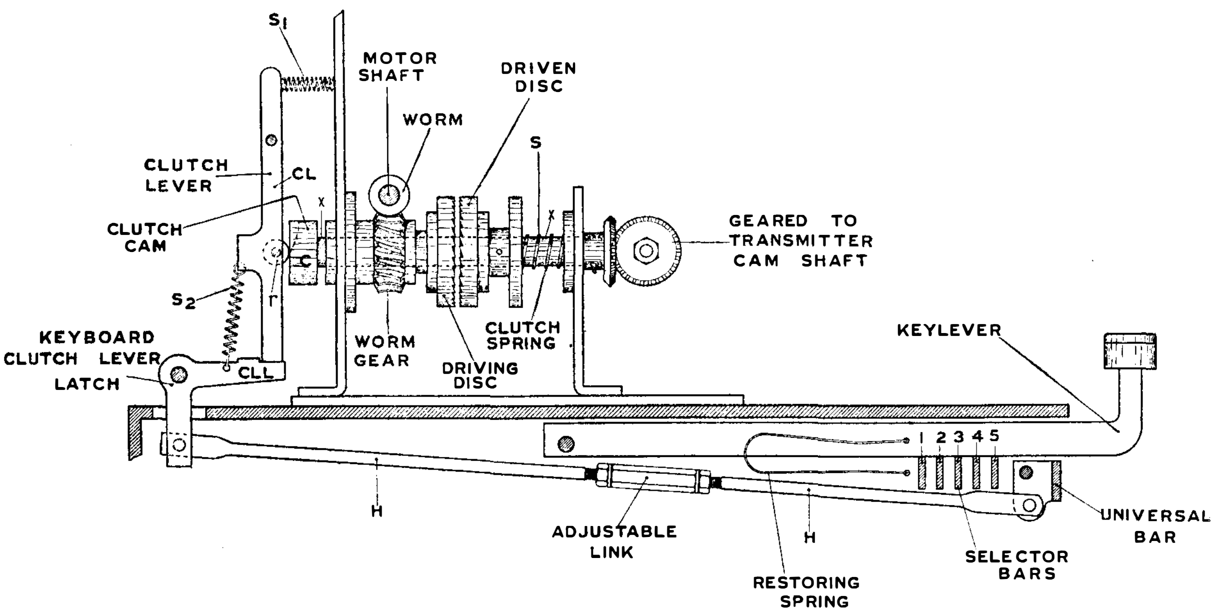


Fig. 5.

All the six contact springs *a* are electrically connected to one pole of a battery B, while all the back contact springs *b* are connected to the line or to a transmitting relay, according as the circuit is to be worked single or double current. It is not possible for any two of the contacts to be closed simultaneously because the notches in the six cams are staggered as shown in Fig. 4.

When the cam spindle is at rest the sixth contact lever, which is not controlled by a locking latch, rises into the notch in cam 6 and closes the sixth set of transmitting contacts. Immediately the cams start to rotate, this lever is forced out of the notch and the contacts open. The circuit is not closed again until another contact lever rises into a cam notch. This break in the circuit, the duration of which is never less than the time of one unit, is the " start " impulse. After the five units representing the signal have been sent out by the cams, the sixth contact lever again closes its contact springs, sending out the " stop " impulse.

The locking latches are held in their set positions by the Locking Loop, which drops and engages with their upper ends when the cam spindle starts to rotate. This locks the selector bars and prevents the depression of another key until the character selected has been transmitted. The Unlocking Cam raises the Locking Loop and frees the latches just before the cam spindle completes its revolution.

Clutch Mechanism.—The clutch mechanism for driving the Transmitter Cam Spindle is shown in Fig. **5**.

The spindle XX, to which is fixed the Driven Disc, is normally at rest, but the Driving Disc which is mounted on a sleeve on XX rotates continuously. The Universal Bar is operated when a key lever is depressed and, in actuating the rod H, trips the Clutch Lever Latch CLL, thus unlocking the Clutch Lever CL and allowing the Clutch Spring S to move the spindle XX to the left. This brings about the engagement of the Clutch Discs setting in motion the Transmitter Cam Shaft. Fixed to the end of XX is a cam C, which bears against a roller *r* mounted on CL. Towards the end of the revolution of XX, spring S1 causes *r* to drop into a notch in the face of cam C, and CL is then re-engaged by CLL, which was restored to its original position by spring S2 immediately the key lever was released. As XX and the cam C continue to rotate, *r* rides out of the notch, but as CL is now locked by CLL the effect is to force C and therefore XX to the right and to uncouple the clutch discs. A jockey roller drops into a notch in the cam, fixed to XX, at the end of a revolution to ensure that the cam shaft will always come to rest in its proper position.

Receiving Mechanism.—This resembles in many respects that of the Baudot Receiver; only one electromagnet, however, is used for the reception of incoming signals. The principle of the selecting mechanism is shown in Fig. **6**. EM is the electromagnet, the armature of which is attracted when signalling is not taking place, because normally the sixth Transmitting Contacts at the Sending Station are closed and send out a marking current. On the receipt of the " start " signal, which precedes a character combination, this marking current ceases so that EM is de-energised and its armature is pulled upwards by the spring S3.

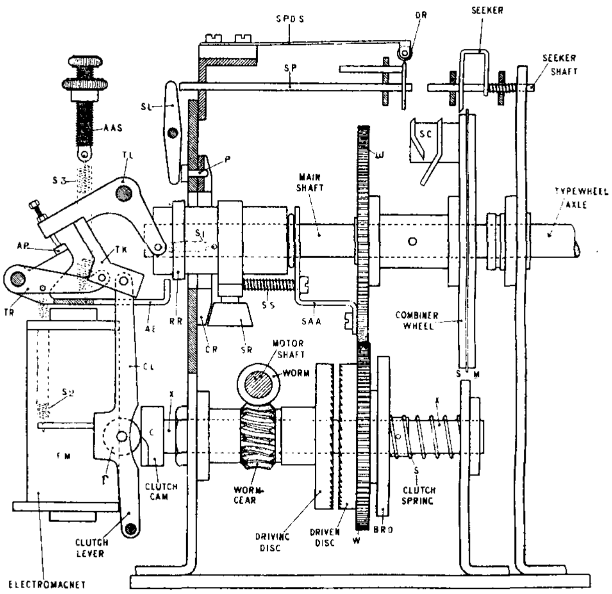


FIG. **6**.

The typewheel axle gears with the clutch spindle XX, which is normally at rest. When the armature of EM moves upward on the receipt of the " start " impulse, the armature projection AP trips the Toggle Latch TL and releases the Toggle TK. The clutch spring S then moves XX to the left and causes the clutch discs to engage in a similar manner to that described for the Transmitter. The " stop " impulse re-energises EM and the attraction of its armature allows TK to be re-engaged by TL. Cam C acting on roller *r* brings about the disengagement of the clutch discs and the typewheel shaft comes to rest after it has completed one revolu-

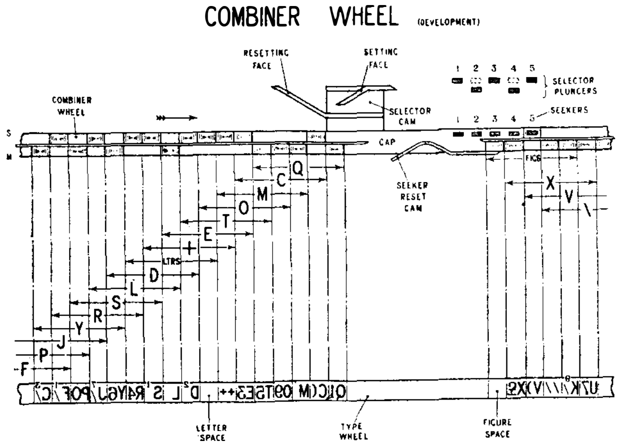


FIG. 7.

tion. A brake mechanism is provided to ensure that the rotating parts shall come to rest without undue shock.

The movements of the armature, after its release by the " start " impulse, depend upon the incoming character combination of signals. They control the action of a shuttle roller SR, which rotates with the typewheel shaft. This roller presses on a circular cam ring CR under the action of spring SS. There are five indents in the surface of this ring and projecting through a hole in the bottom of each is a Selector Pin P.

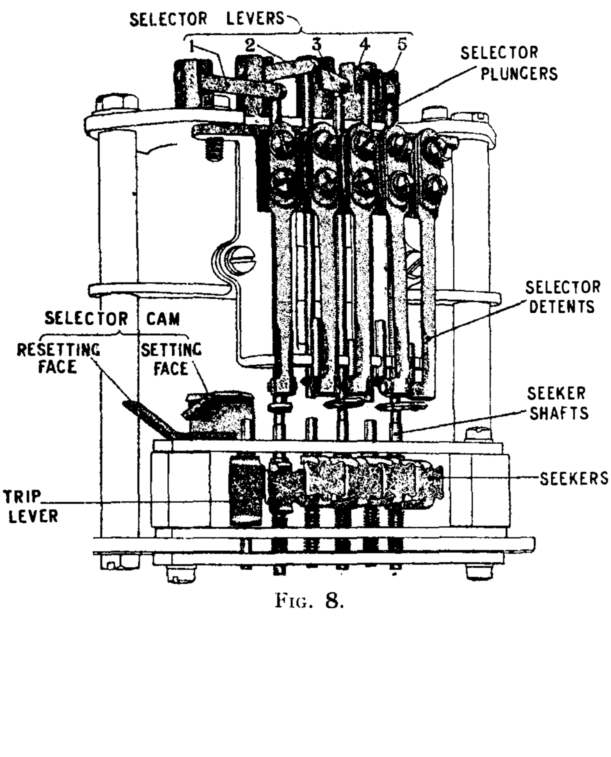


FIG. 8.

While the armature is in its attracted position, SR is free to drop into the indent over which it may be passing, causing the pin P to move backwards and actuate an associated Selector Lever SL. If, however, the armature is in its upward position, its extension AE comes behind the raised ring RR on the sleeve which carries SR, and thus prevents the latter from dropping into an indent. The corresponding selector pin and selector lever will not be actuated in these circumstances. This arrangement forms the mechanical distributor of the Receiver.

The five selector levers control five Selector Plungers SP, which in turn set five Seekers. Each selector plunger is held firmly in either of its two positions by a Detent Roller DR mounted at the end of a flat spring SPDS.

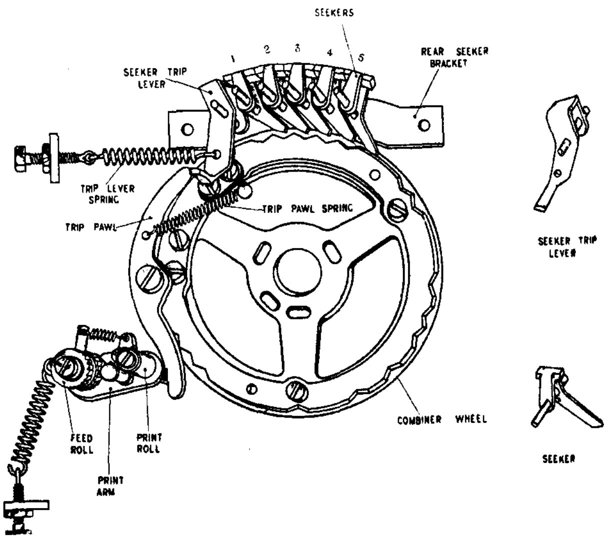


FIG. 9.

Setting of Seekers.—Mounted on the typewheel axle is the Combiner Wheel consisting of two discs S and M, between which is a Separator Plate. On the rims of S and M are cut, in definite positions, a series of notches, those on the front disc M representing marking units of the code and those on the back disc S spacing units. The arrangement of the notches (shaded) for several successive characters on the typewheel is shown in Fig. 7.

The five seekers with the aid of the combiner translate the incoming impulses into movement of a paper tape against the typewheel for printing the desired characters. Each seeker has a square flat head which presses against the heads of the adjacent seekers. Normally the toes of all the seekers press on the rim of disc S of the combiner, under the action of the Trip Lever Spring attached to the Trip Lever. The latter is pivoted in the same manner as a seeker and its head presses against the head of No. 1 Seeker (see Figs. **8** and **9**).

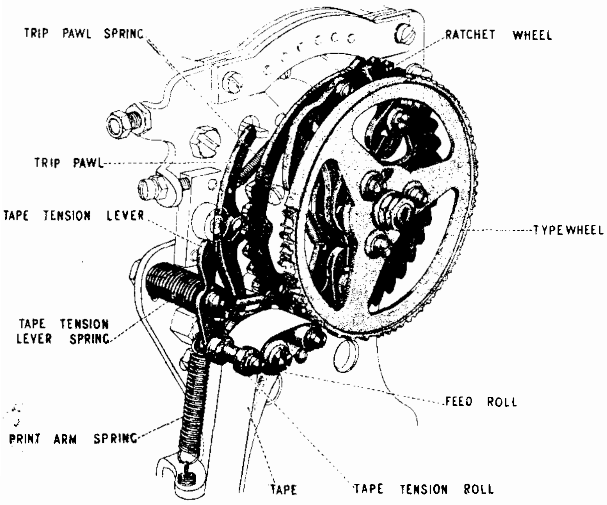


Fig. **10**.

When a character is being received, the five selector plungers are pushed forward, or not, according as the incoming impulse is a marking or a spacing unit. Fixed to the back of the combiner is the Selector Cam SC, and immediately opposite it there is a gap in the separator plate (see Fig. **7**). As SC moves with the combiner its setting face catches the lower end of a selector plunger, if it has been pushed forward, and forces it to strike the end of the shaft of the corresponding seeker. As the gap in the separator plate is, at this instant, passing the toe of the seeker, the latter is moved to disc M of the combiner. In this manner the five seekers are set, some being forced on to disc M and some allowed to remain on disc S according to the character being received. Immediately a seeker has been set, its selector plunger is restored to its normal position by the re-setting face of SC (see Fig. **8**).

Print Arm Release.—At a particular part of the revolution of the combiner, and therefore of the typewheel, there is for each character a combination of notches on the two discs, into which the toes of all the seekers can drop under the action of the Trip Lever spring (see Fig. **9**). The trip lever head moves to the right with the seeker heads and its lower end moves to the left, striking the Trip Pawl. The latter then disengages from a projection on the Print Arm, which accordingly moves in an anti-clockwise direction under the action of the Print Arm spring.

Paper Feed and Printing (see Figs. **10** and **11**). —A drawer is fitted in the base of the instrument to accommodate a roll of paper tape. The tape passes over the Tape Guide Post, round a Print Roller mounted at the end of the Print Arm and thence between a Feed Roller and a Tape Tension Roller. The Feed Roller is mounted on the same spindle as the Feed Ratchet and turns with it. When the print arm moves upwards on being released, the Feed Pawl engages with the Feed Ratchet causing it and the Feed Roller to turn and the tape to move forward with the Print Roller. While the print arm is being returned to its horizontal position the Check Pawl holds the Feed Ratchet and thus prevents the tape from moving back. Consequently the tape is fed forward on the Print Roller the space of one letter.

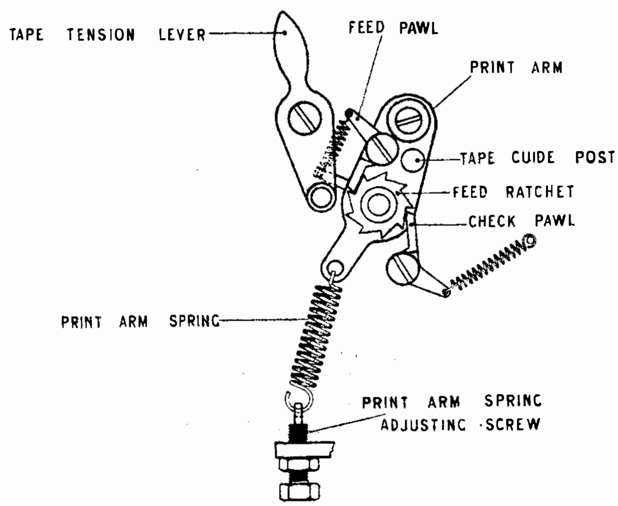


Fig. **11**.

Mounted behind the typewheel and on the same shaft is a Ratchet Wheel. When the Print Arm is released a pointed projection from it, termed the Print Dog, enters a notch in the Ratchet Wheel corresponding with the character to be printed, and is carried by the wheel to the left until clear of it. The tape is thus brought into rolling contact with the inked typewheel and the desired character is printed.

Immediately printing has been effected, the Re-set Cam attached to the front of the Combiner restores all the seekers to disc S. It should be noted that the Selector Plungers are set during one revolution of the Typewheel axle, but the seekers are set and printing takes place during the next revolution.

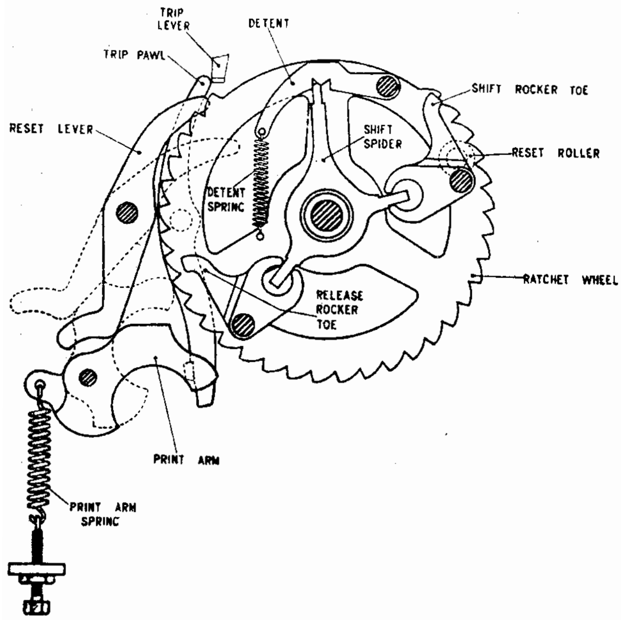


FIG. 12.

Re-setting of Print Arm (see Fig. **12**).—When the Print Arm is released it forces the lower end of the Re-set Lever to the left, thus moving its upper end so that it lies within the path of the Re-set Roller mounted on the back of the Ratchet Wheel. This roller subsequently acts on the upper end of the Re-set Lever, causing its lower end to move to the right and force the Print Arm back to the horizontal position where it is held again by the Trip Pawl. The re-setting of the Print Arm takes place during the time that the smooth portions of the rims of the typewheel and Ratchet Wheel are opposite the Print Arm in order to prevent the printing from being smudged and the Print Dog from fouling the Ratchel Wheel.

Shift Mechanism.—The typewheel has on its rim the letters of the alphabet alternated with figures and other secondary characters, amounting in all to 56 characters, but is normally in such a position on its axle that only letters are printed. It must be angularly displaced by about $4\frac{1}{2}^{\circ}$ in order that secondary characters may be printed. The Shift Mechanism is shown in Fig. **12**. The typewheel is fixed to a hub which is loose on the main shaft. A Shift Spider is attached to this hub and its pointed extension engages with one or other of two notches in a Detent fixed to the Ratchet Wheel. This provides the coupling between the Ratchet Wheel and the Typewheel.

When the spider engages with the left hand notch of the Detent, the typewheel is in its correct position for printing letters. If it is desired to print figures, the distant station sends the Figure Shift signal. The ordinary process of selection and release of the Print Arm occurs, but no printing takes place because the corresponding position on the Typewheel is a blank. The Print Dog, however, enters the space between two teeth of the Ratchet Wheel which is occupied by the Shift Rocker toe. The latter, which is pivoted on the Ratchet Wheel, will therefore be turned and will cause the Shift Spider to move from the left hand notch to the right hand notch of the Detent, thus displacing the Typewheel relatively to the Ratchet Wheel sufficiently to bring the secondary characters into the positions previously occupied by the letters. The change back to letters is effected by sending the Letter Shift signal from the Distant Station; in which case the Print Dog acts on the Release Rocker Toe, thus bringing the spider and therefore the Typewheel back to its normal position.

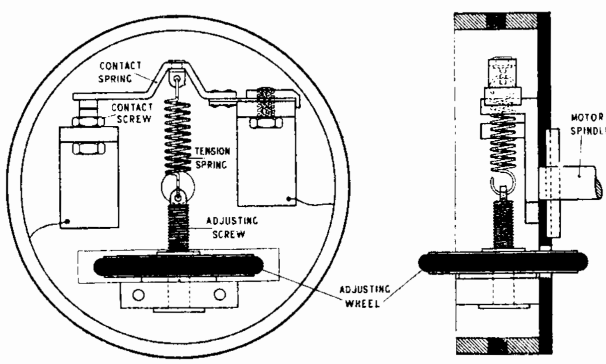


FIG. 13.

The Governor (see Fig. **13**).—The speed of the instrument is kept steady by a centrifugal governor mounted on one end of the spindle of the series wound driving motor. It consists of a hollow flywheel containing a contact spring, which, when it is held against a contact screw by the tension spring shown, short-circuits a governing resistance in the motor circuit. When the governor rotates, the speed increases until the centrifugal force acting on the contact spring is sufficient to cause the latter to

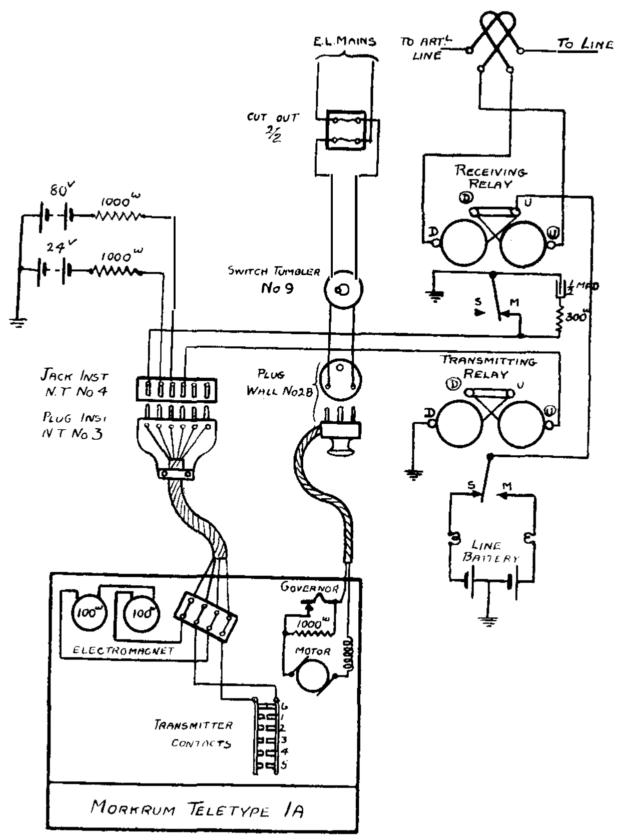


Fig. **14**.

move away from the contact screw, and immediately this occurs the governing resistance is inserted into the motor circuit causing the speed to decrease. The contact spring is accordingly pulled back to the contact screw and the short-circuiting of the governing resistance which results causes the speed to increase again. This making and breaking of the contacts take place very rapidly and an average speed is maintained depending on the tention of the controlling spring. The motor circuit is connected to the contacts by two carbon brushes which press on brass rings let into the periphery of the flywheel.

The speed is set by observing the alternate black and white bands, painted on the edge of the flywheel, through slits in the shutters of a tuning fork. If the speed be correct the bands will appear stationary; if it be fast, however, the bands will appear to be moving in the direction of rotation; but in the reverse direction if the speed is slow. The speed may be decreased by slackening the tension spring by means of the adjusting wheel, or increased by tightening the tension spring.

Circuit Connections.—The majority of the circuits in this Country are worked duplex, the differential system being employed as shown in skeleton form in Fig. **14**; both ends are joined up alike. Two standard polarised relays are required, one for the reception of signals and the other for transmitting purposes. The Transmitting Relay is joined in series with the Transmitter Contacts and a 24 volt battery, and its tongue is held to the spacing contact, normally, because the sixth contact of the Transmitter is closed. The negative current thus sent to line passes through the D to U coil of the neutrally adjusted Receiving Relay at the distant station and holds its tongue to the marking contact. This closes the circuit through the electromagnet of the Morkum Teletype at that end. The home Receiving Relay is not affected because the outgoing current divides through it differentially. The Transmitting Relay at each end is set with a marking bias, so that it will respond to the breaking and making of the Transmitter Contacts when a key is operated and thus sends out signals to the line.

(*To be continued.*)

AN INTERNATIONAL TIME SIGNAL.

A. O. Gibbon, M.I.E.E.

THE linking together of the Royal Observatory at Greenwich with the Post Office Radio Station at Rugby for the distribution of Greenwich Mean Time is an event of outstanding interest.

Two hundred and fifty years have passed since the establishment of the Observatory in Greenwich Park in 1675. It was erected in the reign of Charles the Second and the terms of the original appointment are as follows:—

"*Warrant for the Payment of Mr. Flamsteed's Salary.*
CHARLES REX.

Whereas, we have appointed our trusty and well-beloved John Flamsteed, Master of Arts, our astronomical observator, forthwith to apply himself with the most exact care and diligence to the rectifying the tables of the motions of the heavens, and the places of the fixed stars, so as to find out the so-much-desired longitude of places for the perfecting the art of navigation. . . . ."

Now, in December, 1927, the direct distribution of Greenwich Mean Time to the whole world has become an accomplished fact, through the cooperation of the Admiralty, the Board of Trade and the Post Office.

This development is worthy of special consideration, seeing that, for the first time, a signal of extreme accuracy is available from the prime meridian for all who are able to receive it.

There is no need to emphasize the importance of an accurate time service. Practically all of the ordinary, everyday happenings in life depend upon correct time. If the postman be late with the morning mail;—if the newspaper boy finds some diversion on his round and the "Times" fails to be pushed under the door;—if the alarm clock fails to operate,—what a difference these minor things make in the outlook for the day! Our railway organization, also our telephone and telegraph services depend upon exact time keeping,—indeed, the list could be extended almost indefinitely — from personal to international spheres of action.

A digression from the main subject of this article will be excused, in order that reference may be made to the different measures of time in use at the present day.

Solar Time is the time registered by a correctly placed sun-dial. Solar time cannot be employed practically however, because the intervals from noon to noon are not of the same length, occasioned by the path taken by the earth in its motion round the sun. This variation is eliminated by a process of averaging and, as a result, *Mean Solar Time,* giving days of equal length, is obtained.

Sidereal Time, or star time, is the natural standard of time, a sidereal day being the time taken for one complete revolution of the earth on its axis. As a result, a particular star will cross the meridian of any place at intervals of 23 hours, 56 minutes, 4.1 seconds. This law applies because the stars are so far distant from the earth that the motion of the stars may be regarded as negligible. This is not the case with the sun, which is nearer the earth and results in the mean solar day being 3 minutes, 56 seconds longer than the sidereal day.

It is obvious, as a result of the earth's rotation, that the time shown on mean solar clocks will only agree with each other, where such clocks are set up in the same meridian. East or west of that meridian, the clocks will be fast or slow, varying with the longitude in which the clocks are working. Hence, there is a further measure in use known as *Local Time,* depending upon the place concerned. Local time has several serious disadvantages and these need not be stressed here.

The inconvenience caused by this measure of time led to its practical abolition in favour of *Standard Time.* This has been established by International agreement, whereby the whole world has been divided into "Time Zones," with the meridian of Greenwich as the prime meridian or "zero" point. As a result of this arrangement, *Greenwich Mean Time* is regarded as the standard for the world. The general scheme is that the minutes and seconds of the prime meridian are maintained and hours only are changed in successive time zones.

There is still *Summer Time* to be remembered, but as this movement of the hands of the clock forward or backward is merely a trick we play upon ourselves — for many good and sufficient reasons—there is no need to say more here!

Fig. **1** is a view of the South East side of the courtyard at Greenwich Observatory, showing the building containing the Transit instrument working on the prime meridian. The instrument is housed immediately behind the doorway reaching to the roof.

The large dome contains the biggest Refractor in the British Isles and is used for the measurement of double star working.

A general view of the exterior of a portion of Greenwich Observatory is shown in Fig. **2**. The famous Time Ball is clearly seen. It is mounted on the turret of the original Flamsteed building, erected in 1675. This Time Ball was set up in 1833 and was the first to operate in this country. The ball is released electrically and drops at 1 p.m. G.M.T. daily. The Time Ball is the most important of visible signals and is used by observatories to announce an exact moment of time to observers within visible range. The Time Ball at Greenwich has been in regular use since 1833 and the ball has dropped daily at the appointed hour, except on the very rare occasions when weather conditions have interfered and rendered it unsafe to lift the ball.

In order to introduce the International Time Signal, which is of the highest grade of scientific registration, it has been necessary to provide clocks and other mechanism at the Observatory, also for the Postmaster-General to provide the connecting lines between Greenwich and Rugby; special switching apparatus at the General Post Office in London and also the use of the wireless transmitter at Rugby.

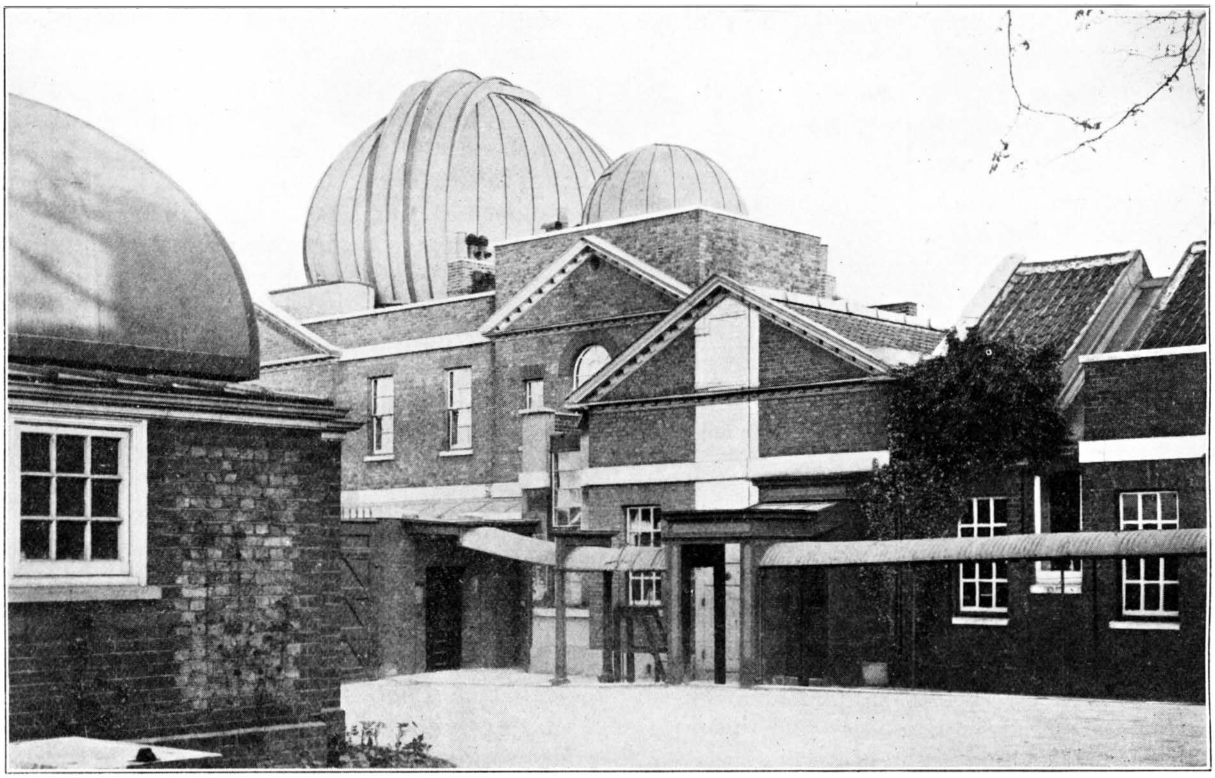


Fig. 1.—Greenwich Observatory building containing Transit Instrument working on prime meridian.

A special chamber has been adapted at the Observatory for the accommodation of the apparatus. The high grade mechanism at Greenwich has been supplied by the Synchronome Company, under the personal direction of

Mr. F. Hope-Jones, a great authority on electrical clock installations. The apparatus consists of a " Free Pendulum," a " Slave " clock and a Signal Transmitter.

A general view of the chamber and the assembled apparatus is shown in Fig. **3**, whilst a closer view of the intricate mechanism of the Signal Transmitter is shown in Fig. **4**.

In clock mechanism as generally designed, there is a certain lack of exactitude due to the energy lost by the pendulum in having to unlock

Fig. 2.—Time Ball at Greenwich Observatory.

some form of mechanism before it can receive the impulse required to maintain its action. These operations rob the pendulum of a certain amount of energy and consequent lack of precision for scientific time keeping.

By means of an ingenious invention of Mr. W. H. Shortt, M.Inst.C.E., in conjunction with the Synchronome Company, a " Free Pendulum " has been devised. In this arrangement, a separate and subsidiary clock known as a

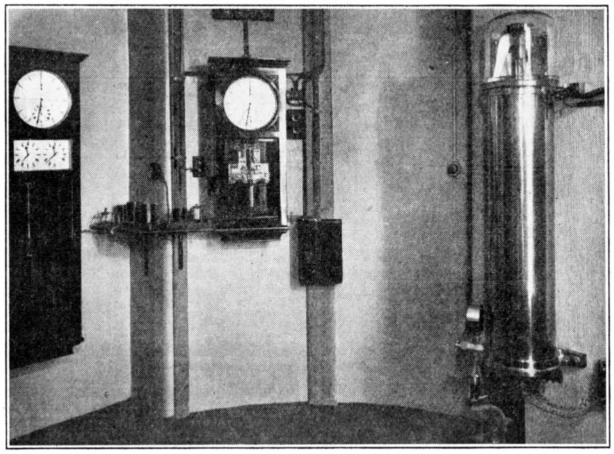


Fig. 3.—Special Apparatus at Greenwich Observatory for International Time Service.

" Slave " undertakes all the work and at the same time the " Slave " is so accurately controlled by the Free Pendulum that perfect synchronism between the two sets of mechanism is maintained. Air friction has also been practically eliminated from the Free Pendulum by enclosing it in an air-tight case and reducing the air pressure inside the case from the normal atmospheric pressure to a working point of approximately 35 milli-metres. The pendulum of this clock is made of Invar, an alloy having a very minute co-efficient of expansion with temperature changes.

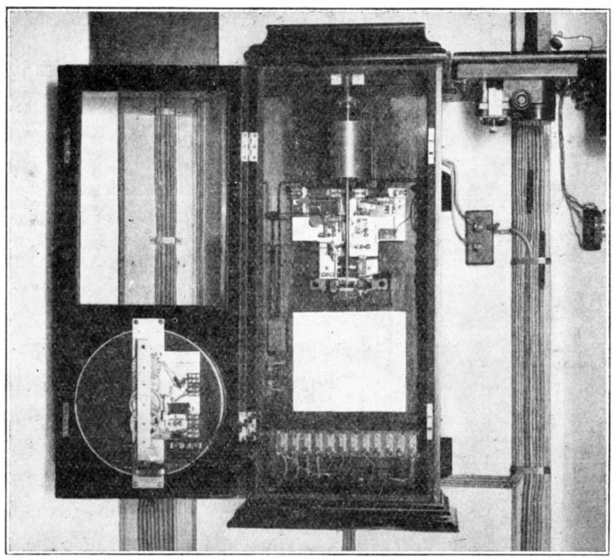


Fig. 4.—View of mechanism of special Signal Transmitter at Greenwich Observatory used on International Time Service.

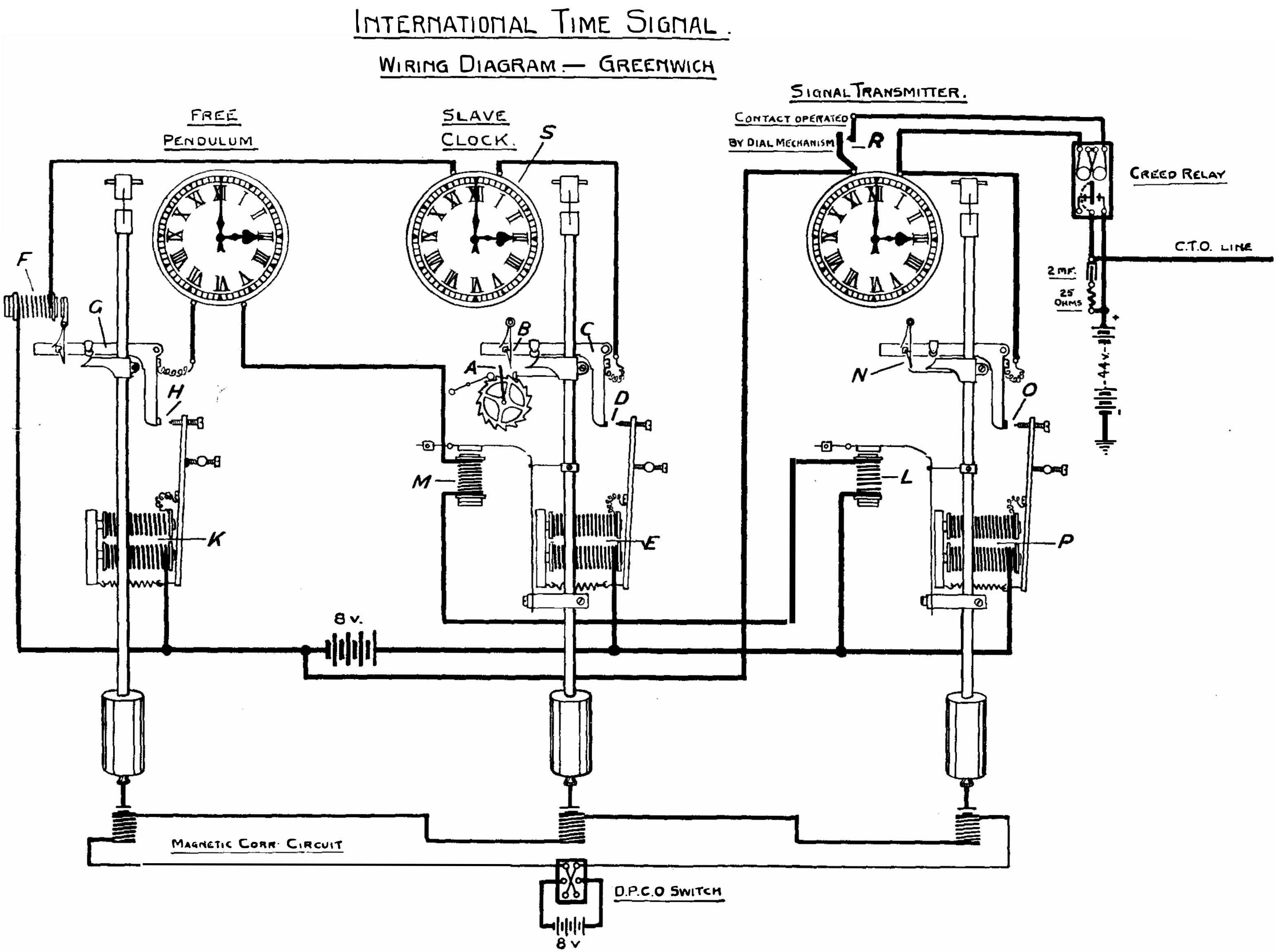


FIG. 5.—SCHEMATIC DIAGRAM OF THE CONNECTIONS OF FREE PENDULUM, "SLAVE" CLOCK AND SIGNAL TRANSMITTER USED ON THE INTERNATIONAL TIME SERVICE AT GREENWICH OBSERVATORY.

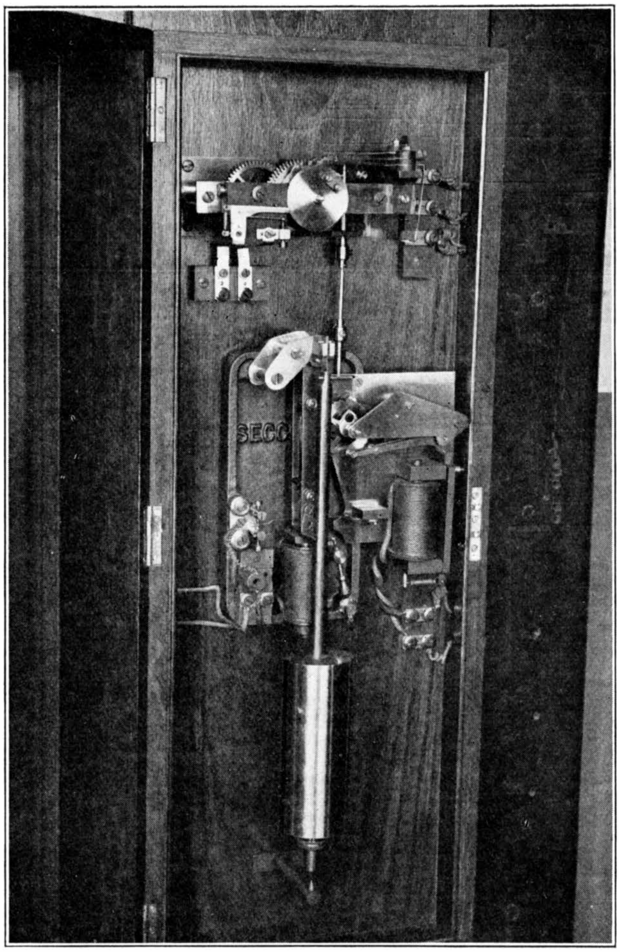


FIG. 6.—VIEW OF MECHANISM OF SPECIAL TIME SWITCHING CLOCK IN G.P.O. TEST ROOM, USED ON INTERNATIONAL TIME SERVICE.

Fig. **5** is a skeleton diagram of the connections of the Free Pendulum, the Slave Clock and the Signal Transmitter at Greenwich. The action is as follows:—In the Slave Clock, the pendulum, in swinging to the right, pulls round the count wheel, and at each revolution of this wheel, the arm A. engages with the small trigger B. The trigger is opened, allowing the impulse lever C to fall, thus giving an impulse to the pendulum by sliding down the inclined plane. At the end of the fall of the impulse lever C, the contact D is closed. The electrical circuit is therefore from D through the electro-magnet and armature E, *via* the battery, electro-magnet release of the Free Pendulum F, back through the dial indicator of the "Slave" clock S.

The current in passing through E, pulls over the armature and re-sets the impulse lever C, also releases the trigger holding the impulse lever G of the Free Pendulum and puts the fingers of the Slave dial S forward one $\frac{1}{2}$ minute. The cycle of operations in the Free Pendulum corresponds with that explained in the case of the Slave clock.

The impulse on re-setting the lever of the Free Pendulum is as follows:—When contact is made at H, the current flows through the armature and coil K, *via* the battery to the Synchronizer L of the Signal Transmitter, also the Synchronizer M of the Slave clock, completing the circuit through the dial mechanism of the Free Pendulum.

The object of this Synchronizing arrangement is to keep all three clocks in exact phase. It should be added that the contact H closes at a definite time interval after the impulse is given, in order that the synchronizing action may occur at a suitable position in the swing of the Slave pendulum.

The Signal Transmitter receives an impulse every alternate swing of the pendulum by means of the gathering click N; this releases the trigger in a manner similar to that of the Slave clock.

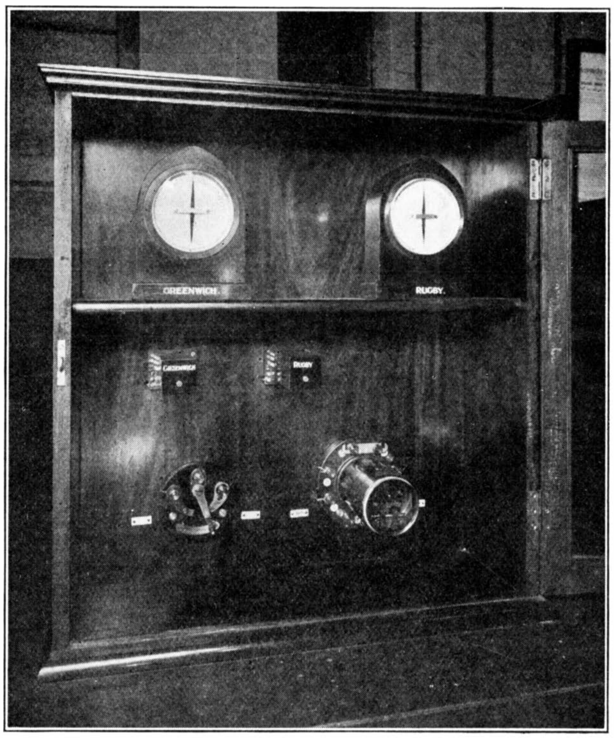


FIG. 7.—SWITCHING PANEL USED FOR INTERNATIONAL TIME SERVICE IN G.P.O. TEST ROOM.

The electrical circuit, after the impulse is given, is *via* the impulse lever, contact O, armature and electromagnet P, *via* the battery to the dial mechanism of the Signal Transmitter and, if the contact arm R is closed, through the transmitting Creed Relay, operating the C.T.O. line on its local contacts.

The Magnetic Corrector is shown at the bottom of Fig. **5** and is put into operation when it is necessary to set the three clocks to time. Its action is to increase or decrease the gravity action on the pendulum for a short period.

hours and the front cam the minutes. The cuts or slots in the cams operate the contacts at the appointed times in morning and evening and energise the two Relays No. 90A, which act simply as locking devices on the Greenwich and Rugby sides, taking the apparatus side of the Rugby line from the Central Radio Office and putting the Greenwich Observatory line through direct to the Rugby Radio Station. The Time Signal passes through the coils of the standard B relay on the switching panel, bringing the local contacts of the relay into play and

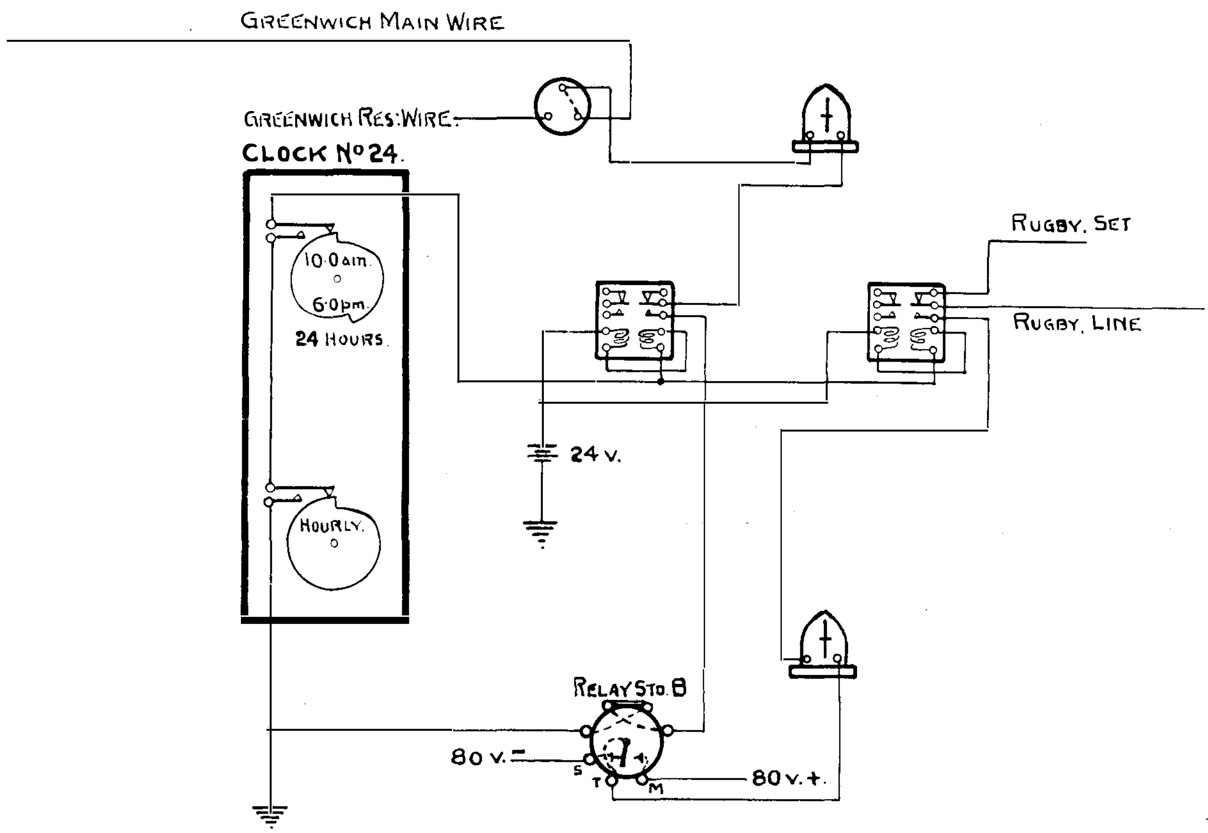


FIG. 8.—SCHEMATIC DIAGRAM OF THE APPARATUS IN USE FOR INTERNATIONAL TIME SERVICE IN G.P.O. TEST ROOM.

The apparatus in use in the Test Room of the G.P.O., London, is shown in Figs. **6** and **7**.

Fig. **6** is a view of the Master Clock (No. 24) and Fig. **7** is a photograph of the switching panel.

A schematic diagram of the connections at the G.P.O. is shown in Fig. **8**. There are two cams fitted in the Master Clock; the front one revolves once hourly and the rear cam revolves once in every 24 hours. The rear cam registers the

applying the necessary voltage to operate the land line apparatus of the Rugby transmitter. The arrangements at Rugby Radio Station are shown diagramatically in Fig. **9**, where the normal arrangements for wireless transmission apply. The same apparatus is in use at Rugby as is required for commercial traffic. The Time Signal is sent out from Rugby on a wave-length of 16 kilo-cycles or 18,740 metres.

Several interesting problems concerning the extent and effects of mechanical and line lags, etc., have been investigated in connection with the new time signal. The physical circuit includes an underground line from Greenwich Observatory to the G.P.O., a standard B relay in the G.P.O. test room, an underground line from the G.P.O. to the Rugby Radio Station and the operation of two relays (1 standard B; and 1 Creed), also the operation of the large group of valves in the radio transmitting circuit.

The total lag measured through the whole of this network amounts to 0.04 second and the lag has remained practically constant. This stability has been an unsolicited testimonial to the behaviour of the relays, which have been called upon to work to a degree of exactitude beyond their ordinary range of action.

The presence of this lag involves the sending out of the time signal from Greenwich Observatory .04 second in advance of exact time in order that the signal may be emitted at the right instant. An arrangement has also been set up at Greenwich whereby the signal emitted from Rugby is registered on a syphon recorder associated with a Wireless Receiver at the Observatory. Normally, the incoming signal at Greenwich is recorded within .01 of a second of the time calculated for the emission of the signal.

The time signal is of the modified rhythmic type recommended by the International Time Commission of 1925. This consists of a rhythmic signal of 306 beats or dots (.) in 300 seconds of mean time, or at the rate of 61 beats or dots per minute. The commencing signal, also that at the end of each minute, is sent in the form of a dash (—) and is exactly on the minute of Geenwich Mean Time.

The signal is sent twice in each day, at 09.55.00 in the morning and at 17.55.00 in the evening. These times have been selected as the most suitable for reception in any part of the world. Signals 1, 62, 123, 184, 245 and 306 are single dashes of 0.4 second duration and commence at the exact minute. Each dash is followed by 60 dots of 0.1 second duration. By the use of this type of signal, comparisons of extreme accuracy are obtained, the method employed being to count the number of intervals from the first dash until coincidence occurs between one of the rhythmic signals and the beat of the chronometer or other type of clock.

A similar type of signal is sent out daily from Bordeaux and the Eiffel Tower. In each of these cases, and at other stations emitting a similar signal, a preliminary warning or prefix is sent, giving the station of origin, also a signature or " SN " at the end of the signal.

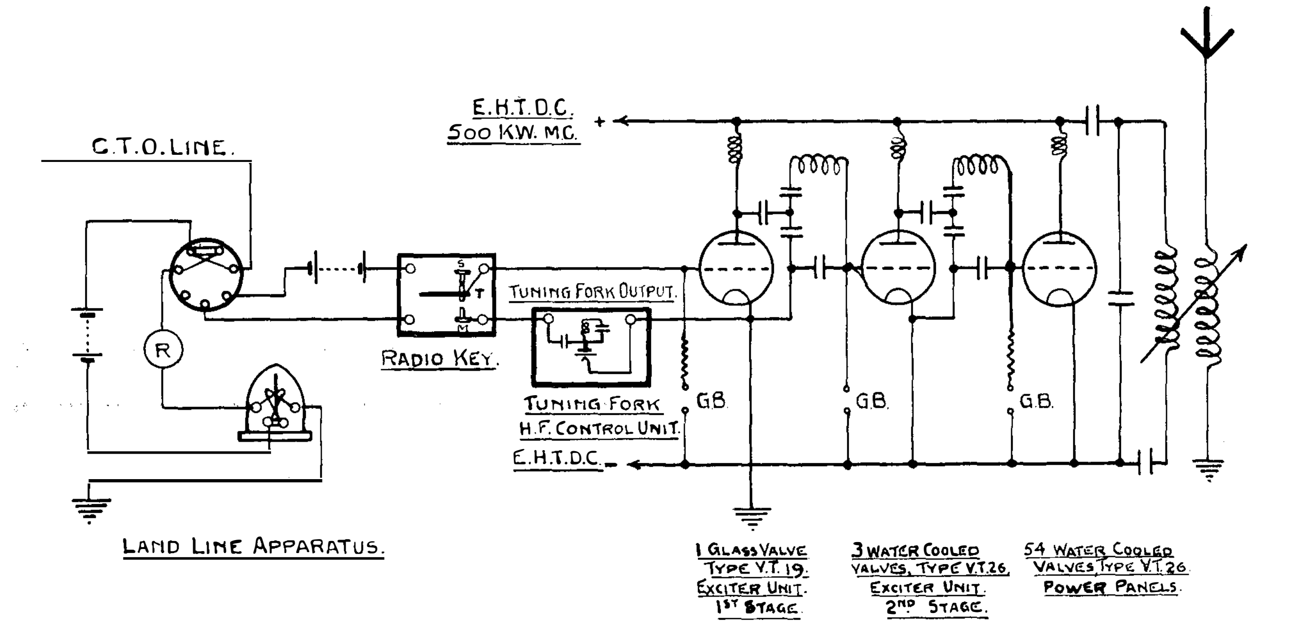


FIG. 9.—SCHEMATIC DIAGRAM OF THE ARRANGEMENTS AT RUGBY RADIO STATION.

This procedure is not followed with the British Time Signal. The connecting lines between the Observatory and Rugby are switched over automatically a few moments before the signal is due to commence and are also retained for a few moments after the signal has passed. The interruption to commercial traffic, together with the short periods of silence, are the only indications of the approach and termination of the time signal. This is a departure from the usual method of signalling "CQ, CQ, DE, DE, GBR, GBR," to warn listeners to be ready, nor do we hear such a cheerful signature as that frequently given by the Annapolis station, "OK NSS," at the conclusion of the American time signal.

In concluding this review of an interesting engineering operation, the writer wishes to express his appreciation of the valuable assistance rendered to him by Sir Frank Dyson, the Astronomer Royal, and also by Mr. W. Bowyer, of the Greenwich Observatory Staff.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST DEC., 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.
565,641	538	4,113	52,344	181	London	23,698	64,367	2,140,885	104,065
71,280	2,122	21,076	63,611	1,719	S. East	3,870	44,358	175,733	14,567
75,373	4,406	30,259	53,071	2,491	S. West	18,179	10,889	135,063	59,238
58,926	6,037	37,039	56,020	4,985	Eastern	22,210	34,559	92,510	75,512
92,326	8,799	44,763	56,505	3,583	N. Mid.	23,138	50,426	231,628	119,973
72,868	4,825	29,085	68,924	4,058	S. Mid.	13,117	21,670	158,566	89,307
56,267	4,680	29,288	50,515	2,841	S. Wales	5,992	25,565	105,604	70,275
98,195	8,225	26,163	48,331	4,361	N. Wales	13,254	40,513	250,459	62,143
150,978	1,564	17,043	42,551	2,523	S. Lancs.	13,117	76,344	451,512	47,087
89,157	6,113	30,894	45,765	3,100	N. East	11,067	44,283	214,488	61,435
61,255	3,512	23,595	36,654	2,351	N. West	8,180	32,469	153,837	37,398
45,414	2,460	15,989	24,184	2,748	Northern	4,639	14,677	98,766	51,451
20,638	4,680	8,313	13,521	491	Ireland N.	130	2,306	36,770	1,211
62,794	5,472	24,943	36,190	1,478	Scot. East	3,640	12,021	142,723	47,643
84,489	7,336	23,968	42,319	1,047	Scot. West	12,101	24,493	215,548	35,034
1,605,601	70,769	366,530	690,505	37,957	Totals.	176,404	498,940	4,604,092	876,339
1,575,766	70,820	362,202	683,405	37,207	Figures at 30th Sept., 1927.	174,550	492,207	4,460,068	900,744

TELEPHONES

HOLBORN.

IN the previous issue of the Journal it was indicated that some technical details of the system would be given. The object of the notes that follows is in general terms to outline the salient features of the *Director* equipment.

The underlying principles of Director working are now well known, but it may be well to emphasise that the main reason for introducing the system into large networks such as London is to enable routing and numbering to be dissociated, thus permitting the use of a freely flexible trunking scheme; hence the existing cabling arrangements may be used to the maximum advantage. It follows also that indirect routing *via* a Tan-

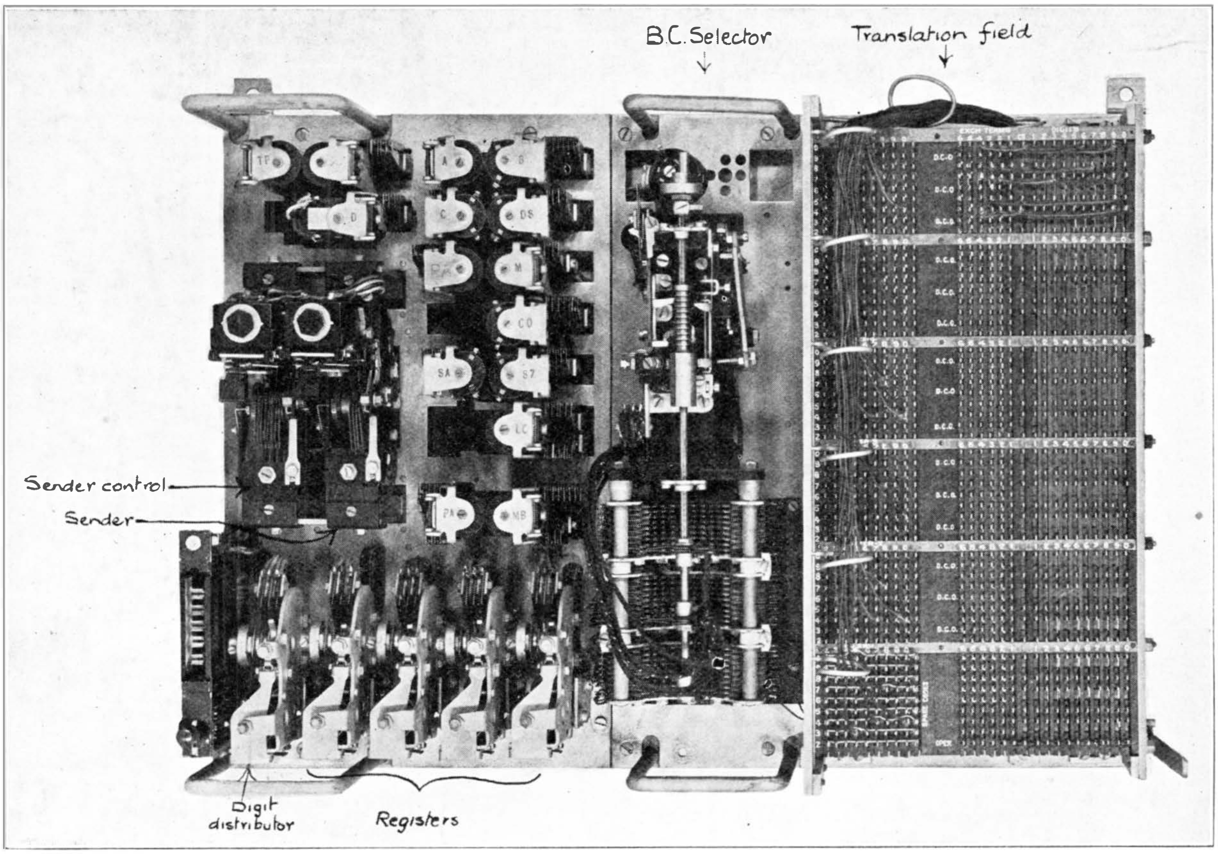


FIG. 1.—A DIRECTOR.

dem switching point is possible. The function of the *director* apparatus therefore is " to convert the impulse trains of the code letters dialled by a subscriber into other impulse trains suitable in number to direct the call to the required exchange, *i.e.*, to translate the call. The *director* and associated equipment is thus in use only during the setting up of a call, the average occupation time being 18 secs. per call.

Fig. **1** shews a director as installed in Holborn Exchange, and is typical of those to be used generally in the London system.

Fig. **2** is a rack of directors. In Holborn and other early exchanges the *directors* are fitted back to back as shown in the illustration, but this type of construction may be modified in the light of experience and single sided racks used in later exchanges to provide better accessibility to the apparatus when dealing with faults *in situ*.

Fig. **3** is a schematic diagram that indicates the relative position of the various selectors in the scheme; the figure clearly shows the relationship between routing and numbering. The selectors used, with the exception of the A digit and first code selectors, are standard two-motion switches and do not call for special comment. The A digit selector, from the levels of which *directors* are reached, is fundamentally similar to the standard selector, but has a " time pulse " feature associated for the purpose of " forced release " when the selector is seized but not operated; the principle of the " time pulse " arrangement will be seen from Fig. **4**. As the operating current (time pulse earth) is connected for 1 second at 30 second intervals, the " forced release " relay (M in sketch) will be operated in approximately 29 seconds as a minimum, or approximately 59 seconds as a maximum.

The disposition of *directors* on the levels of A digit selectors is shown in Fig. **5**, from which it will be seen that level 1 is not connected (there are no letters in the digit hole of the dial containing the figure 1), the selector therefore releases if it be inadvertently operated to the first level. Level O is not provided with individual *directors*, but makes use of *directors* on other levels. The connection between the bank contacts of level O and the bank contacts of the selected levels is reversed to enable the operation of the scheme shown in Fig. **6**. The *directors*

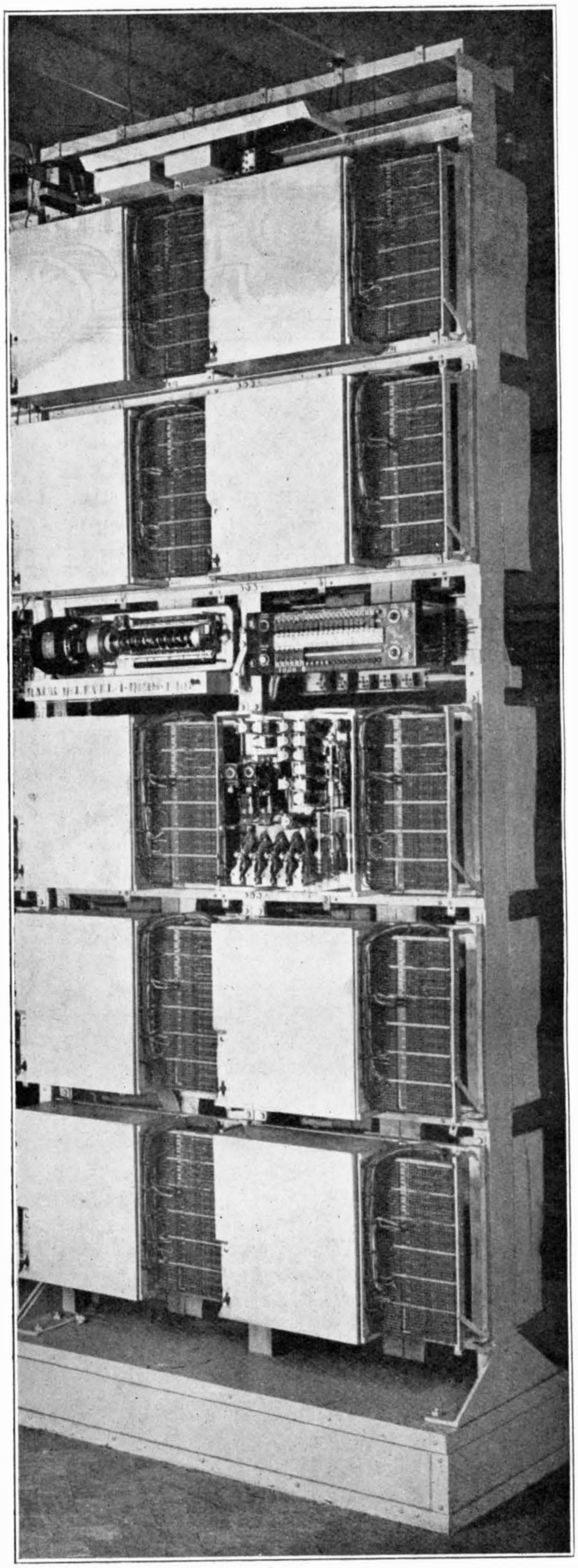
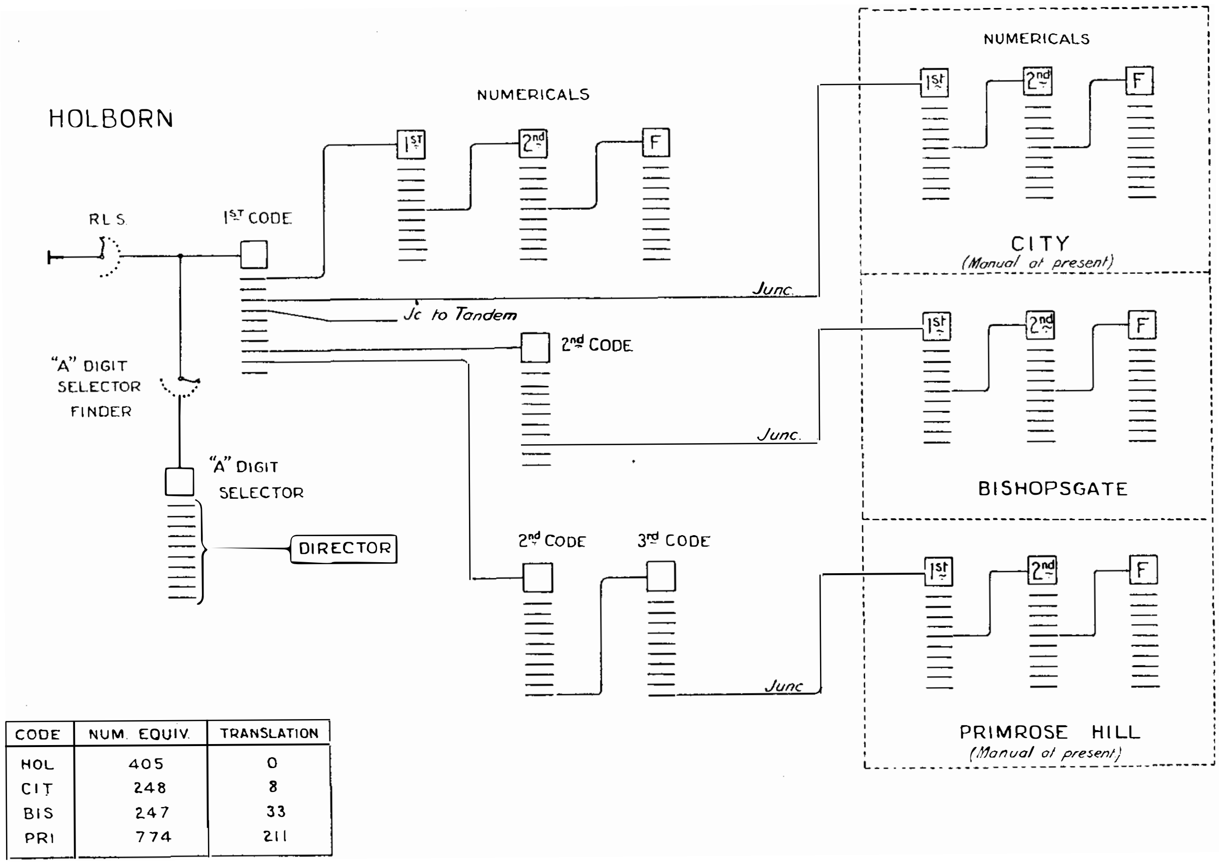


FIG. 2.—A RACK OF DIRECTORS.



CODE	NUM. EQUIV.	TRANSLATION
HOL	405	0
CIT	248	8
BIS	247	33
PRI	774	211

FIG. 3.—SCHEMATIC DIAGRAM SHOWING RELATIVE POSITION OF SELECTORS.

reached from level O are provided with a special relay MB, which is energised only when the shunt field relay D is operated. This occurs when the direction of the current through its operating winding is reversed, (hence the reversal of wires between level O bank contacts

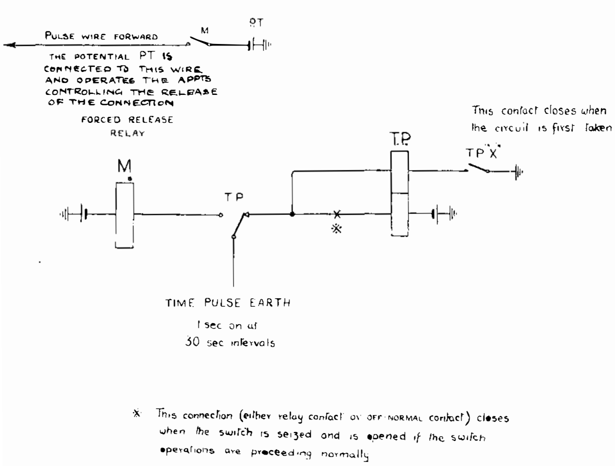


FIG. 4.—THE PRINCIPLE OF THE TIME IMPULSE.

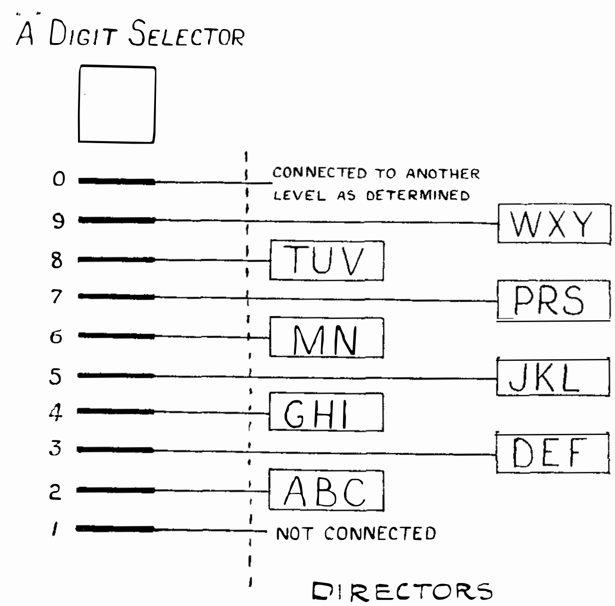


FIG. 5.—DISPOSITION OF DIRECTORS ON LEVELS OF A DIGIT SELECTORS.

and the bank contacts of the selected level). The operation of relay MB thus gives access to the translation field without the need for transmitting second and third code letters (B C digits).

The first code selector, as will be seen from Fig. **3**, is in use for every class of call, regardless of its ultimate destination. It incorporates a transmission bridge which makes it unnecessary to provide relay sets (repeaters) in the junction circuits connected to the bank contacts. Full supervision is provided by the selector, which is also used to advise subscribers of irregularities and fault conditions as indicated in the following schedule:—

Nature of Abnormal Condition.	*Resultant Effect.*
Subscriber dials prematurely (*i.e.* all "A" digit switches busy).	Caller receives N.U. tone.
Apparatus or line fault engaging on A digit selector.	(*a*) A digit selector released in 29-59 secs. (*b*) Faulty line connected to 1st code selector, lamp glows.
Subscriber removes receiver and delays to dial.	(*a*) A digit selector released in 29-59 secs. (*b*) Sub. left on 1st code selector. (*c*) When sub. dials N.U. tone given.
Subscriber dials a portion of the code and then delays.	(*a*) A digit selector and Director released in 29-59 secs. (*b*) 1st code selector transmits N.U. tone to subscriber.
Subscriber dials the code and then delays.	The translated code impulses have passed out, code selectors have operated and a 1st numerical selector has been taken. (a) A digit selector and Director and all selectors except the 1st code released and the junction freed in 29-59 secs. (b) 1st code selector transmits N.U. tone to subscriber.
Subscriber dials code and a portion of the numerals.	As above including the release of the numerical selectors that have been operated.
Subscriber dials non-existent code.	(*a*) A digit selector and Director released immediately. (*b*) 1st code selector transmits N.U. tone to subscriber.
Director seized, but impulsing equipment fails to function.	(*a*) A digit selector and Director released immediately. (*b*) 1st code selector transmits N.U. tone to subscriber. (*c*) Director made "busy." (*d*) Director supervisory lamp flashes until attention is given.

As is generally known, the impulses passed into the switching network from *directors* are derived from machine operated cams. Fig. **2** shows an impulse machine in position on the

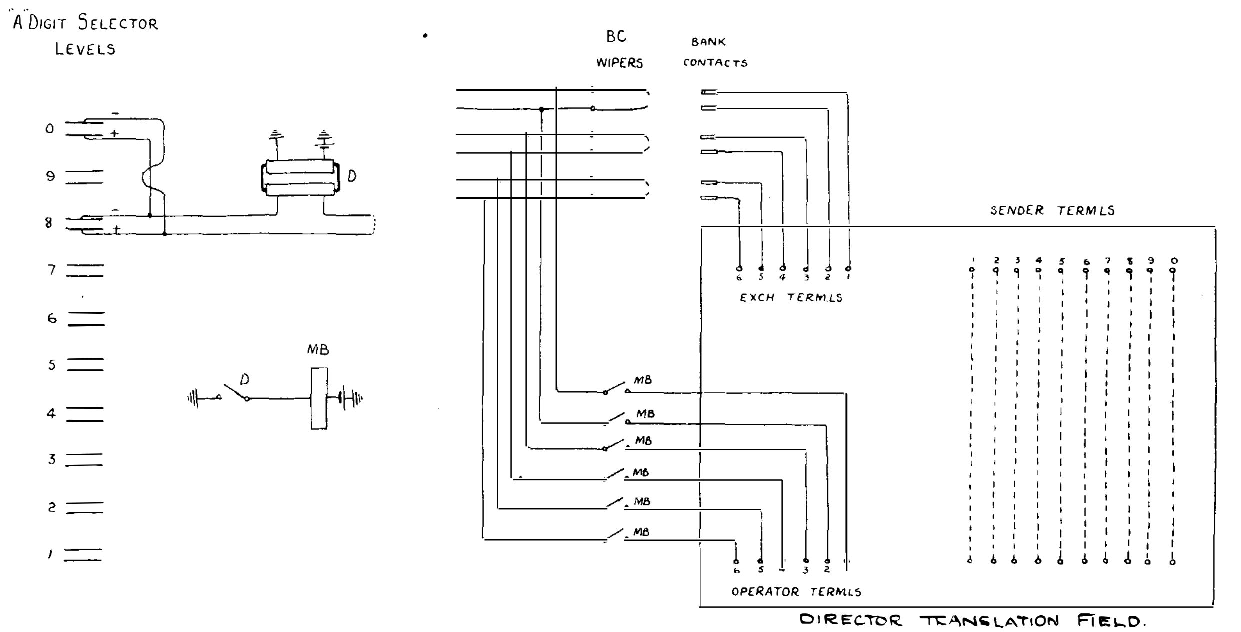


FIG. **6**.—SHOWING REVERSAL OF BANK CONTACTS OF LEVEL O, SHUNT FIELD RELAY AND SPECIAL RELAY MB.

rack and Fig. 7 is a separate view of a typical machine. At Holborn one such machine serves 10 directors, 5 back and 5 front. As the directors serving a particular A digit selector level are located on one side of the rack, the rack impulse machine thus serves a portion only of the *directors* associated with different levels, so that the failure of a machine does not result in the breakdown of the whole of the directors associated with a specific A digit selector level. The Holborn machines are designed for speed regulation by means of a centrifugally governed slipping clutch, so that the speed of the cam shaft is maintained at 600 R.P.M.; thus impulses are delivered at an uniform rate of 10 per second.

As each *director* requires two sets of interrupter springs, the machine is provided with 20 cams (spring sets), 10 sets adjusted to deliver impulses having ratio "break" to "make" 2 : 1, and 10 sets with ratio "break" to "make" 1 : 2. The former type of impulse is required to operate selectors and the latter to step the sender switch of the director. As the result of synchronism between the two types of impulses the sender steps during the period when the selector magnet is operated and the shaft is "stepping." The sender "counts" the number of impulses transmitted to the selector network, the actual impulses, as already indicated, being derived from impulse cams. The method of controlling the series of impulses supplied is shown schematically in Figs. 8 and 9. When the sender switch steps initially, relay SA (Fig. 8) is operated *via* one of the sender arcs, a contact of SA connecting the "line" cam to the outgoing portion of the circuit; when the sender wiper reaches the contact marked (*via* digit distributor, sender control switch, BC digit switch wiper, No. 1 contact of sender bank in Fig. 9) relay SZ operates, a contact of which short-circuits the cam, thus stopping the supply of further impulses. Subsequent operations cause the sender control switch wiper to step to the next contact. The sender switch returns to a "home" position and again starts the cycle of operations. This process continues until the whole of the necessary impulses are passed out, when the director and A digit selector are released.

A "time pulse" feature similar to that described in Fig. 4 is provided to forcibly release the director in the event of delays arising or faults occurring when the apparatus has been seized.

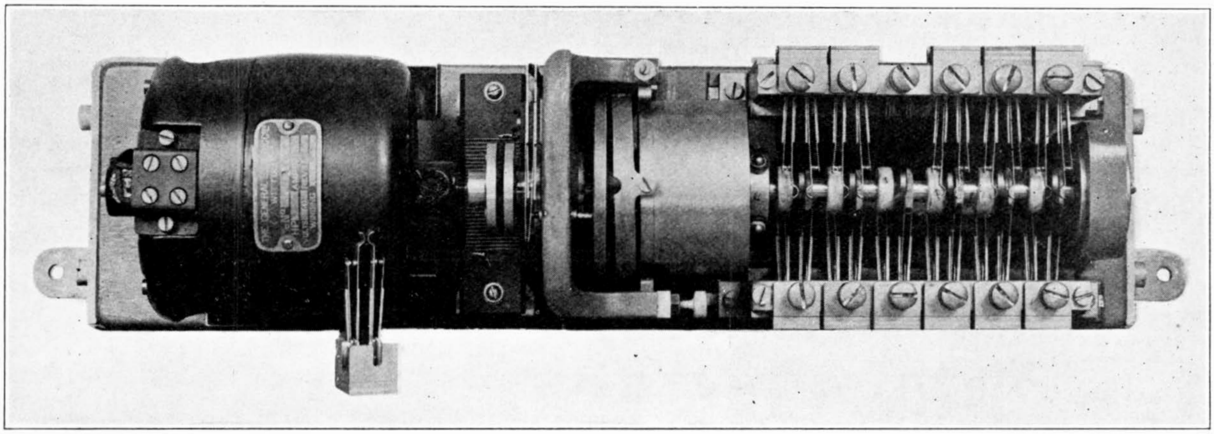


Fig. 7.—An Impulse Machine.

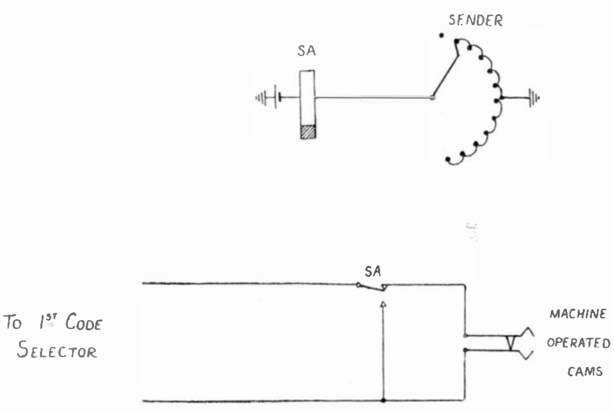
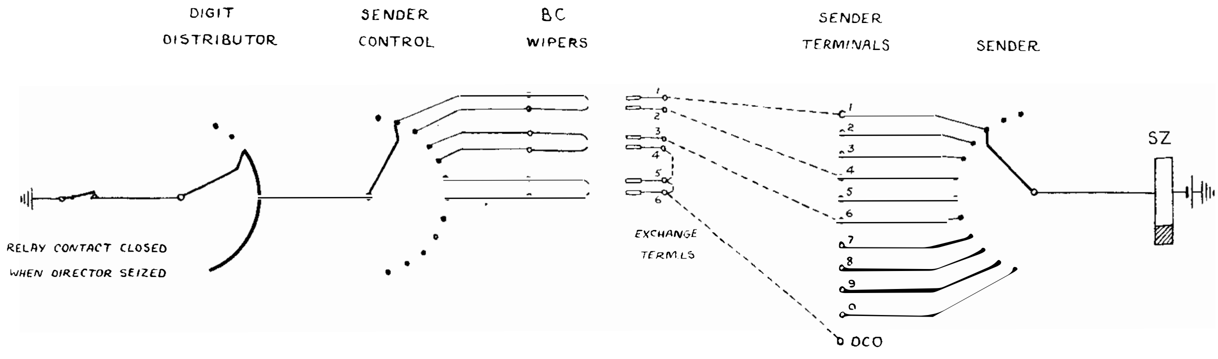


Fig. 8.—Method of controlling series of impulses.



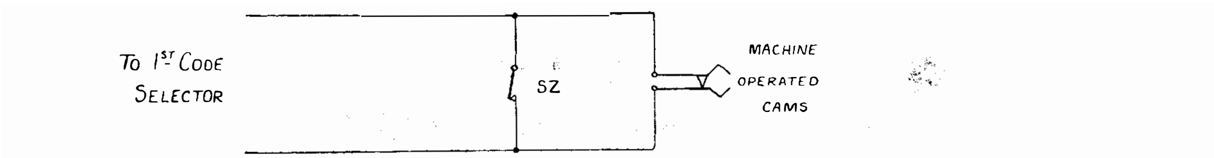


FIG. 9.—METHOD OF CONTROLLING SERIES OF IMPULSES.

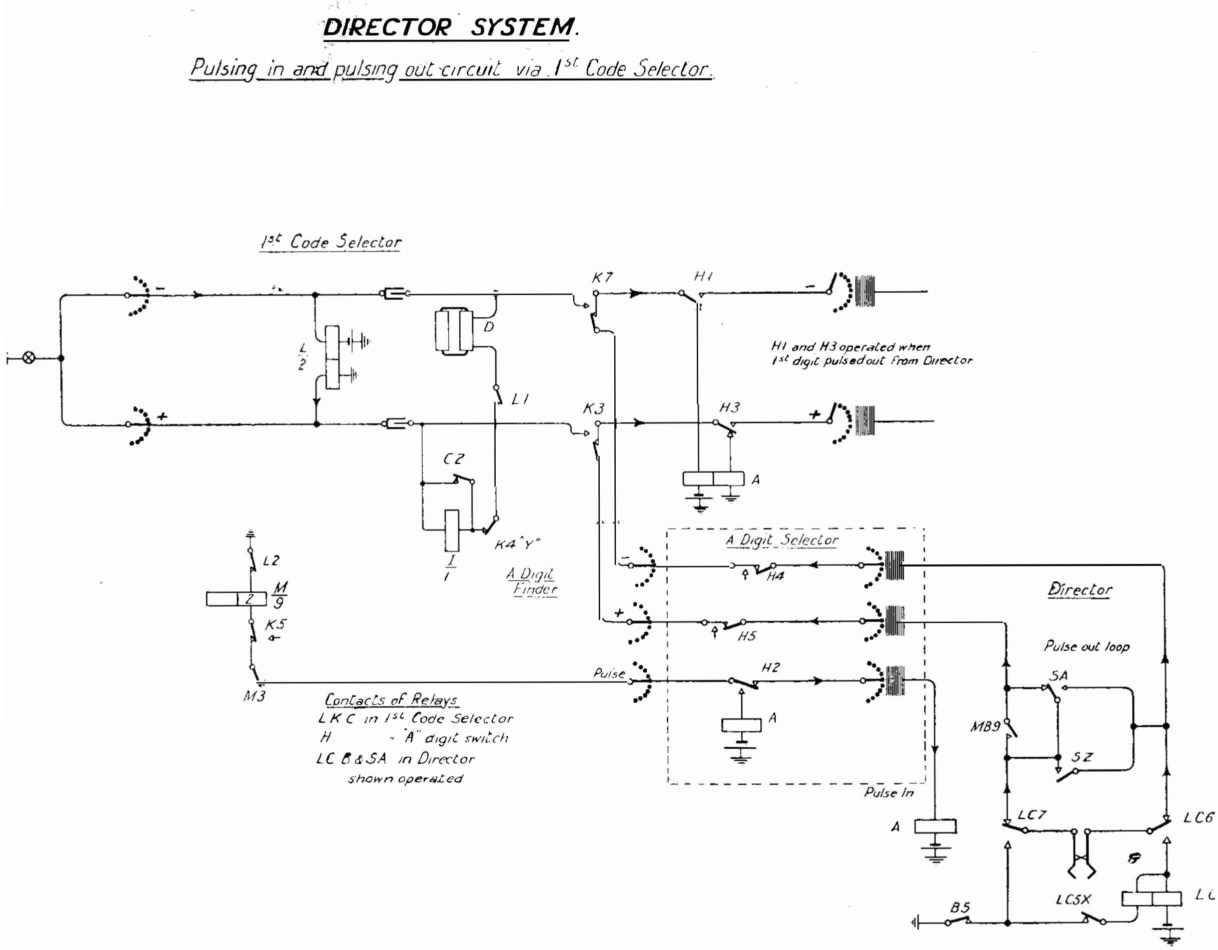


FIG. 10.—ELEMENTS OF CIRCUIT DURING RECEIPT AND DESPATCH OF IMPULSES.

No attempt has been made to explain the operation of the Holborn circuits in detail, but rather to indicate a few of the interesting circuit features. In subsequent issues of the Journal the apparatus used and the facilities afforded by it will be given.

Fig. **10** is interesting, and shows the "elements" of the circuit during the simultaneous receipt and despatch of impulses.

At the time of writing the Holborn apparatus is settling down to its job and is working smoothly. The Holborn staff are to be congratulated upon the efficient manner in which the apparatus is maintained and to them lies the credit of handling the first Director Exchange in what is probably the most complicated city telephone network in the world.

C.W.B.

HANLEY AREA AUTOMATIC TELEPHONE EXCHANGES.

W. IRELAND, A.M.I.E.E.

At midnight, 26th November, 1927, practically the whole of the telephone system in the Hanley Multi-Exchange Area was successfully changed over to automatic working. Six manual exchanges, namely, Hanley, Longton, Newcastle-under-Lyme, Chesterton, Trentham and Wolstanton were closed down and seven automatic exchanges simultaneously brought into use along with the manual board at Hanley, the main exchange, to which all calls requiring the attention of a telephonist are routed by dialling the prescribed codes ("0" for trunk and junction calls to manual exchanges and "91" for inquiries, etc.).

FIG. 1.—HANLEY BUILDING.

The superseded manual exchanges were worked on the call key, ring-through system and were the last exchanges of this type in the country. The old Hanley Exchange was brought into use in 1901, so has many years of useful service to its credit.

The exchanges in the automatic area with their present equipment, ultimate capacities, and numbering scheme are as follows:—

Exchange.	Present Equipment.	Ultimate Capacity.	Numbering Scheme.
Hanley	2,000	2,000	2,000—2,899 5,000—5,899 29,000—29,199
Burslem	1,100	2,200	7,000—7,999 8,000—8,799 88,000—88,399
Longton	700	1,100	3,100—3,899 39,000—29,299
Newcastle	700	1,000	6,100—6,699 67,000—67,399
Stoke	900	1,500	4,100—4,799 48,000—48,799
Trentham	200	500	49,000—49,499
Chesterton	100	200	68,000—68,199
Endon	Manual	400	29,000—29,399
Kidsgrove	Manual	500	89,000—89,499
Silverdale	Manual	500	69,000—69,499

The Hanley new equipment has been installed in the existing building which housed the old exchange, this building having been adapted to meet the requirements of the new apparatus, while all the other automatic exchange equipments have been accommodated in new buildings provided by H.M. Office of Works.

Fig. **1** shows the Hanley Exchange building. This was erected in 1900 by the National Telephone Co. and was the headquarters of the Potteries District staff. (This figure has been reproduced from an old photograph taken, as will be noticed, when part of the building was let.)

One old exchange in the area, Wolstanton, has been closed down and two additional exchanges, Burslem and Stoke, introduced, the lines which previously worked on the former having been transferred to Burslem, while the latter two exchanges have relieved Hanley of lines which it accommodated before the transfer. Also a few of the Longton lines have been transferred to Stoke.

Endon, Kidsgrove, and Silverdale, which are in the Automatic Area, are remaining as manual for the present, the intention being to convert them to automatic working later.

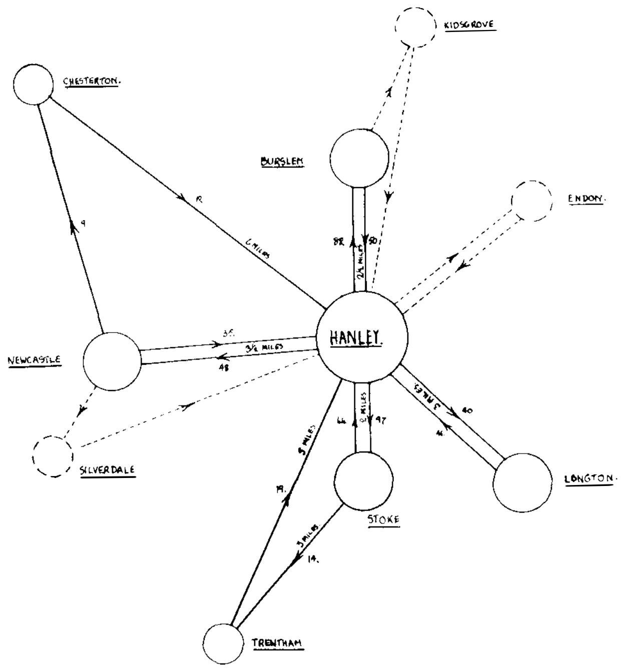
It will be seen from the above schedule that Burslem will ultimately be the largest exchange as regards number of subscribers' lines, but Hanley has been made the main exchange by virtue of its geographical position and thus contains all the first selectors for the area as well as those for manual exchanges outside the area which dial in.

The whole of the exchange equipments are of the Strowger step-by-step system adopted by the Post Office as standard for non-director areas, and were manufactured and installed by the General Electric Co. (Peel-Conner Telephone Works), Coventry.

The preselectors are of the homing type, which permits the outgoing trunks to the 1st selectors being graded, this grading being carried out on a special link frame, while the grading between the different ranks of selectors is done at the terminal assemblies associated with the selector racks.

Fig. **2** is a diagram of the Area showing how the various exchanges are connected by junctions, the number of working junctions, the approximate mileage, and the direction in which the calls are routed being indicated. It will be seen that all calls between exchanges except calls from Stoke to Trentham and from Newcastle to Chesterton are routed *via* Hanley.

In Fig. **3** are shown the routings of four typical calls. From case (*d*) it will be seen that a Trentham local call passes through Hanley and Stoke Exchanges and employs three junctions of an approximate length of 10 miles, five selector switches, and three repeaters. This type of connection is the most complicated to be met with in the Hanley Area and possibly anywhere outside London. The necessity for well-designed and efficient apparatus to avoid inferior transmission and distortion of dialled impulses can be appreciated.



HANLEY AUTO EXCHANGE AREA.

Fig. **2**.

Switching selector repeaters are fitted at Burslem, Longton, Newcastle, and Stoke, those in the last three cases having drop back facility on the first digit, which enables these switches to function also as second selectors for local calls. The operation of this switch was fully described in the article on Leeds Telephone Area in the April, 1926, issue of this Journal, and it is unnecessary to give particulars here.

As the percentage of local traffic at Chesterton and Trentham is small, switching selector re-

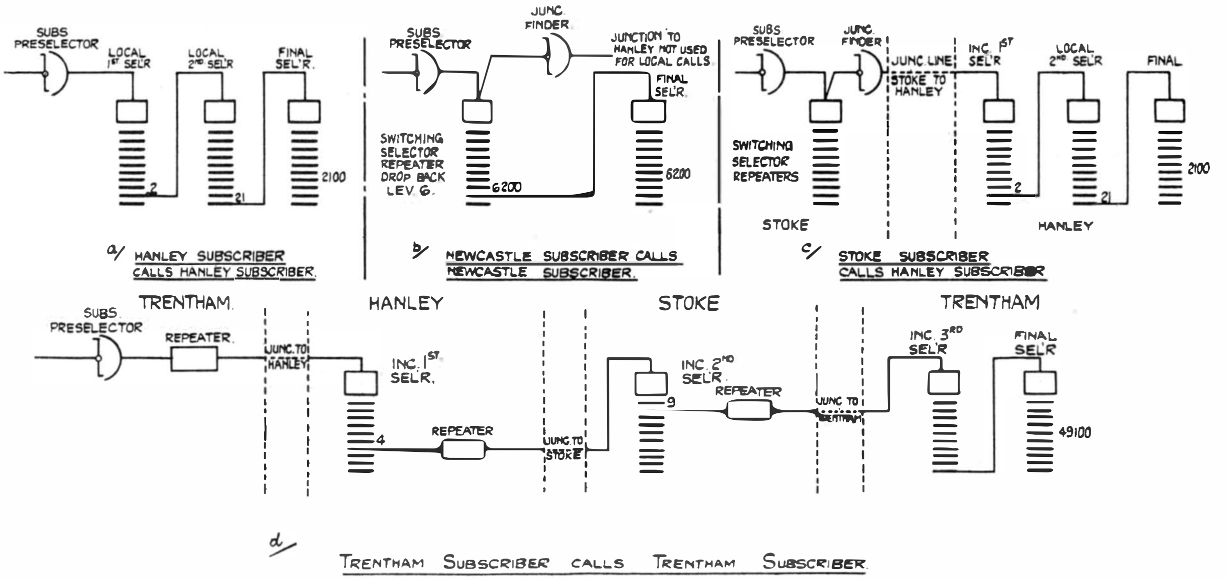


FIG. 3.—ROUTING OF TYPICAL CALLS.

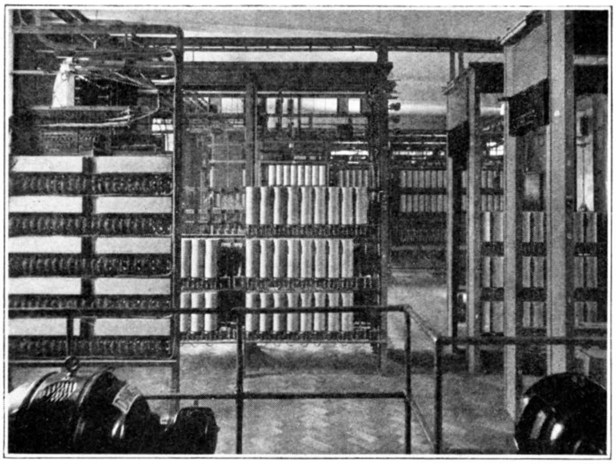


FIG. 4.—BURSLEM EXCHANGE.

peaters have not been provided and the first selectors for these exchanges are fitted at Hanley.

It may be mentioned that first selectors are also provided at Hanley for the Coin Box and Call Office lines on the Satellite exchanges in the Area.

Test Desks are provided at Burslem, Longton, Newcastle, and Stoke, while the testing at Chesterton and Trentham is done from the test desk at Hanley by means of the test distributors and test final selectors.

Arrangements have been made, as is now standard practice, for the extension to Hanley of the fault alarms at all the Satellites at such times as these are unattended; also for automatic start of the ringing machines at the Satellites, so that these machines only run while actually required.

Figs. 4, 5, and 6 are views in the apparatus rooms at Burslem and Stoke and show typical arrangements of equipment at such exchanges.

The manual switchroom is situated on the top floor of the Hanley building. The equipment is as follows :—

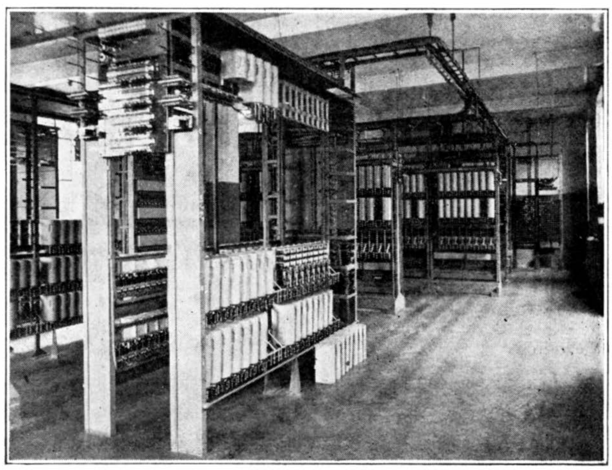


FIG. 5.—STOKE EXCHANGE.

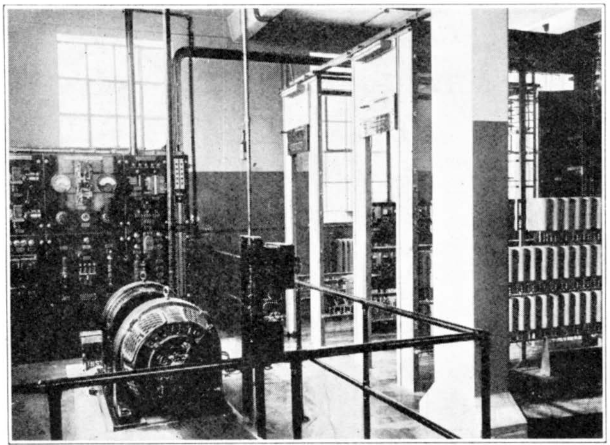


FIG. 6.—STOKE EXCHANGE. ANOTHER VIEW.

Manual Board consisting of
- 1 Plug-ended Keysender Order Wire Junction position.
- 3 Trunk Signalling positions.
- 2 Jack ended Junction positions.
- 13 " A " positions.

6 position monitors desk.
1 position supervisors desk.
1 position service observation desk.

On the keysender position are terminated busy groups of trunks from Liverpool and Manchester. For calls to automatic subscribers the telephonist, after assigning the junction, keys out the digits of the required number on a strip of 10 press keys numbered 1 to 0 fitted on the keyboard. At the finish of the call the connection is automatically cleared and all the switches released. For through calls the plug is used. When this is inserted into an outgoing junction jack a sleeve relay is operated which causes the automatic apparatus to be cut out, leaving the junction as an ordinary manual circuit. The clearing signal is received on a lamp associated with the plug. This method of dealing with through calls differs from the usual arrangement whereby such calls are transferred to another position by the operation of a transfer key.

Fig. 7 shows part of the front of the manual switchboard. The keysender position is at the extreme right-hand side. The strip of ten digit keys is the row nearest to the telephonist. At the top of the right-hand panel is the equipment to which the alarms at the various exchanges are extended when the Hanley apparatus room is unattended.

The service observation equipment provides facilities for observing service on 15 subscribers' lines at Hanley, 15 at Burslem, 10 at Longton and 10 at Stoke. One junction from each of these exchanges terminates on the Desk, and selective apparatus associates the junction in each case with the lines under observation.

This desk has been fitted temporarily in the switchroom, but will be removed to its permanent position after the old exchange equipment has been dismantled and the premises rearranged.

Thanks are due to Messrs. The General Electric Co. and Mr. J. S. Tebbitts, Sectional Engineer, Hanley, for photographs with which this article is illustrated.

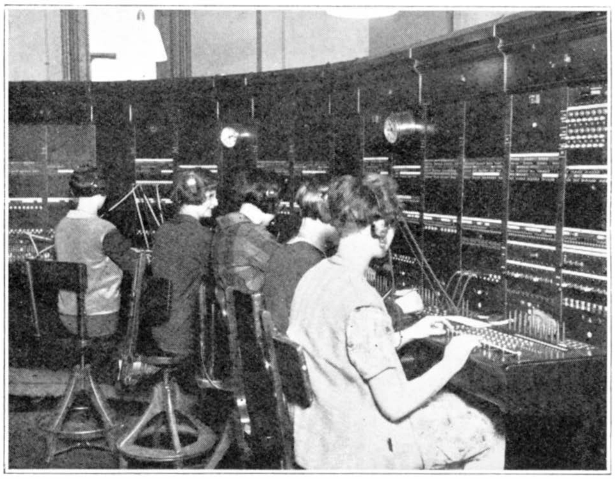


FIG. 7.—MANUAL SWITCHBOARD, HANLEY.

TIME SAVING TESTERS

FOR AUTOMATIC EXCHANGES.

By W. PRICKETT and H. S. SMITH.

THE Testing of Subscriber's Line Equipment (Homing Type Lineswitches).— The equipment individual to a subscriber's line circuit in an automatic exchange, as distinct from the remainder of the apparatus, which is common, is comparatively simple and consists of a lineswitch jumpered to the multiple banks, which are in turn cabled to the protector on the M.D.F. Simple as the equipment is individually, its numerical preponderance when considered collectively causes it to assume great importance when the question of testing-out a new exchange is under consideration. If, therefore, an undue proportion of the total testing time is not to be absorbed by lineswitch tests, it becomes necessary to deal with this equipment in a wholesale manner and it is to this end that Tester No. 58 has been developed.

The tester is arranged to cater for the tests required on a complete unit of one hundred line equipments and to perform most of the tests without further attention when once started. Access to each line is obtained by way of a spare multiple bank on which a special final selector is mounted. This selector forms part of the equipment of the tester and is arranged to connect testing circuits automatically to each line in turn. The access so provided caters for tests on each lineswitch and on each line circuit to the M.D.F. In addition, by making use of the normal final selectors mounted on the multiple banks, the wiring of the latter can be tested on every contact.

It will perhaps be of interest if details are given of the tests which are required for acceptance tests and a list is accordingly given below:

Line circuit to M.D.F.

Continuity, A & B wires	2		
Reversal	2		
Contact	2		
	6	per 100 ccts.	600

Bank Multiple.

Continuity, +, − and P wires	3		
Reversal	3		
Contact, P wire	1		
Wiper connection with bank contacts	3		
	10		
	per 16 banks 160	per 100 ccts.	16,000

Note: When P.B.X. units are concerned, this figure is increased by one third.

Lineswitch.

Operation, release and spring tension of line relay	3		
Operation, release and spring tension of C/O relay	3		
Continuity of +, − and P circuits	3		
Hunting and homing ...	24		
Wiper connection with outlets	72		
Continuity of outlet multiple	72		
Reversal of outlet multiple	72		
	249	per 100 ccts.	24,900

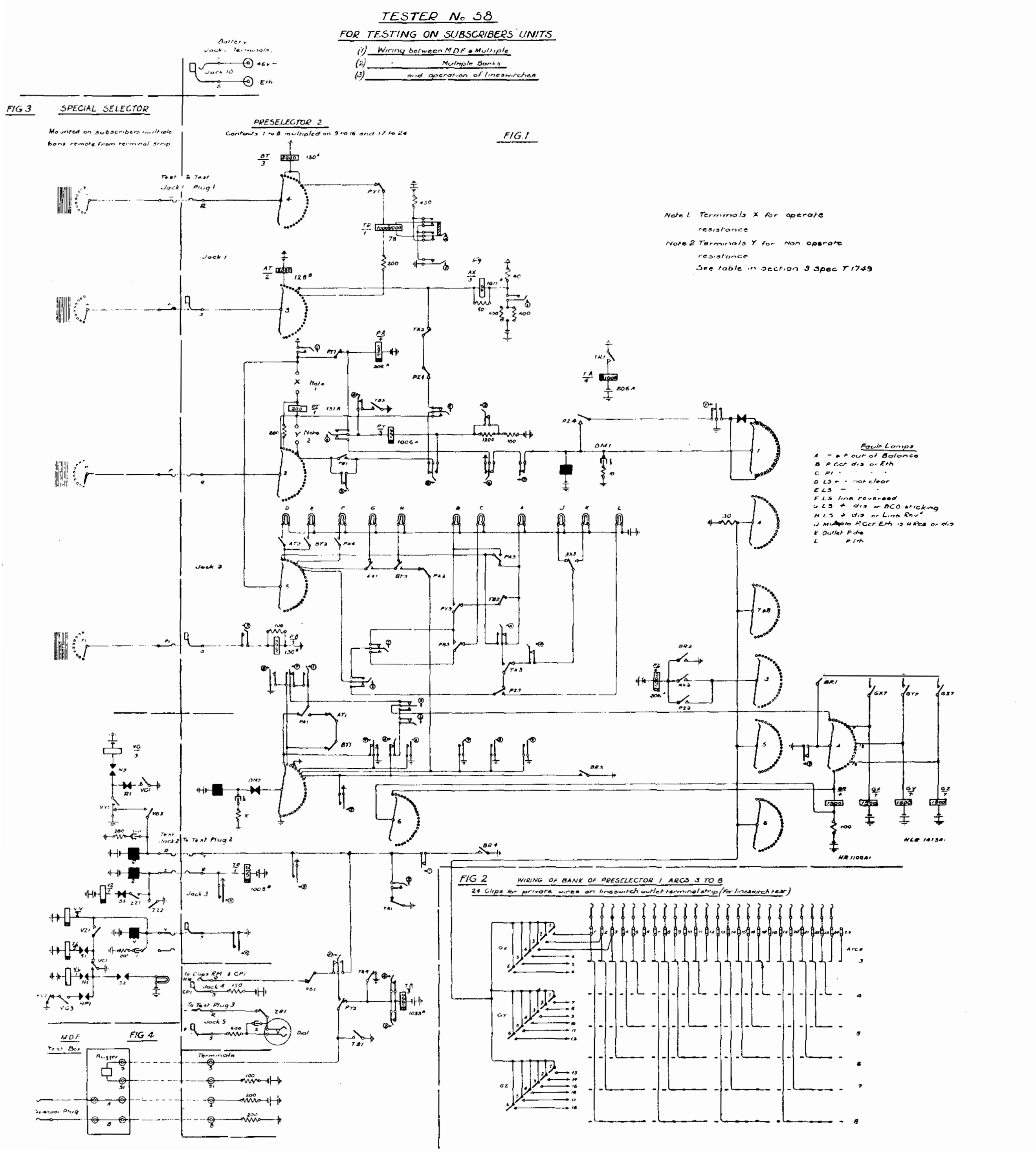
Outlets to Selectors.

Continuity of +, − and P wires	3		
Contact	3		
Acceptance and release of call	2		
	8	per 24 ccts.	192
Total			41,692

The time taken to make the forty thousand or so tests with the aid of the tester is about three hours.

It is now proposed to give a brief description of the tester and to show its method of operation.

Tester No. 58.—The tester consists of a container in which two preselectors are associated with a number of relays and lamp signals. A special selector is also provided to enable connection to be made automatically to each of the



hundred subscribers' equipments on the unit under test. This selector is mounted on a spare multiple bank on the unit and is connected to the tester by means of plugs and cords. A terminal box containing a buzzer is used in addition during the test of the line wiring to the M.D.F.

The circuit arrangement of the tester is shown in the diagram. It should be mentioned that the release magnet of the selector only affects the rotary action. Vertical release is made by hand when required at the end of the test.

To enable the tests to be proceeded with, the tester is set up on a convenient support such as a portable cord repair table, adjacent to the unit under test on which the special selector is mounted, and connection is made to the exchange battery supply *via* the power jack fitted on each suite of units. Connection is also made to the P conductors of the outlet circuits on the unit terminal assembly by means of a set of twenty-four clips and cord provided for the purpose. The keys on the tester are then operated according to the test desired and cause the required conditions to be applied automatically to each line in turn. The tester ceases to work and displays an appropriate lamp signal when a fault is encountered.

The action which takes place is shown in the following extract from the "Notes on the Tester" which form part of the instructions supplied to exchanges where the tester is to be used.

(1) *M.D.F. Test.*—The M.D.F. test box, which contains the signalling buzzer, is connected to terminals S, S1, A and B and is located conveniently to the M.D.F.

Keys 1 and 4 are then operated and Preselector 2 in the tester is set to contacts 8 by depressing key 8. The special selector is set to contacts "11" by means of key 6.

The operation of key 1 energises the polarising coil of relay TR. TR operates and actuates relay TA at TR1 op. .

Key 4 completes the circuit from battery, *via* 100 spool, for relay PY, which together with relay PA operates to earth *via* PT1 nor. and key 1 op. . Relay PY disconnects the line testing circuit at PY1 op. .

Key 6 energises the vertical magnet of the special selector, which steps up to level 1, relay VV is operated in parallel with the vertical magnet and when the switch is stepped off normal, closes the circuit of relay VG at VV1 op. . Relay VG locks to earth *via* VG1 op. and the rotary interrupter springs R1. When key 6 is released, relay VV releases and the rotary magnet is energised *via* VG2 op. and VV1 nor. . The selector cuts-in to contact 1 on level 1, relay VG releasing when its locking circuit is broken at R1.

When the special selector wipers make connection with the line circuit connected to contacts "11" of the multiple bank, a circuit is completed for the lineswitch cut-off (BCO) relay *via* the P wire and wiper, contact 8 of arc 2 of Preselector 2, keys 3 and 2 nor., key 4 op., and relay PT to Earth at key 1 op. The BCO relay should now operate to provide a clear line circuit for the test to the MDF circuit and PT should operate to release relay PY. Should the P circuit be disconnected, relay PT will not operate, and lamp B will glow *via* PA3 op., key 4 op., TA3 op., PZ3 nor., key 2 nor., contact 8 of arc 5 and earth at key 1 op.

Connection is now made by means of a plug attached to the M.D.F. box, *via* the protector tags to each line of the 100 concerned in turn, but in bank order, *i.e.*, commencing with "11" and finishing with "00"

On each connection, momentary operation of the buzzer occurs if the line conditions are correct and the plug may then be moved to the next line.

The buzzer is operated as follows:—The application of the special plug to the line circuit on which the special selector wipers are resting, connects the 200 ohm spools A and B in the tester. Receipt of battery and earth of correct polarity and strength *via* the A and B lines to the unit, + and − wires to the bank, + and − wipers of the special selector, contacts 8 of arcs 3 and 4 of tester preselector 2 and PY1 nor. by relay TR, causes the latter to balance and release. Relay TA then releases also and operates relay TB at TA4 nor. Relay TB locks to earth at TB1 *via* PY2 nor. and key 4 op., actuates the M.D.F. buzzer and operates relay PY at TB3 op. Relay PY operating energises the rotary magnet of the special selector *via* key 4 op., PY2 op. and TB1 op. Relay TB releases when its locking circuit is broken at PY2 op. and the buzzer circuit is interrupted at TB1 nor.

Failure of TR to release, provided PT has operated, is due to a line fault and is indicated by lamp A which glows *via* PA3 nor., etc.

When the ten lines on level 1 have been tested O.K., the rotary action steps the special selector wipers off the bank and actuates the cam springs. The circuit of relay ZZ is now completed *via* S1 op. and VC1 nor. to earth. ZZ, operating, completes the release magnet circuit at ZZ2 op., releasing the selector shaft for rotary action only. Relay VZ is also operated at ZZ1 op., but being slow to operate allows the release to be completed before actuating the vertical magnet and relay VV by earth from VC1 nor. at VZ1 op. The shaft is now stepped up to level 2; relay VG is operated *via* N2 op. and VV1 op. and locks to earth at VG1 op. When VZ releases, the vertical magnet also releases, followed by relay VV. The rotary magnet circuit is now completed at VG2 op. *via* VV1 nor., and the wipers are cut-in to contacts " 21." Relay VG releases when its circuit is broken by the interrupter springs R1. The tests then proceed as for level 1 until level 0 is reached, when relay VC operates *via* the normal post contacts NP1, VG3 op. and VV2 nor. to earth and locks *via* N1 and VC1 op. On the completion of the tests on level " 0," the wipers are stepped off the bank as before, but as the circuit for relay ZZ is now broken at VC1 op. no further movement takes place. The special selector supervisory lamp glows, however, to indicate the conclusion of the test.

Keys 1 and 4 are now released.

It should be specially noted at this stage that, as after each line has been tested, the corresponding lineswitch makes a half revolution on the removal of the test plug from the protector tags, the wipers are now in the correct alternative position in readiness for completing the " clear line " test in Test 3. Care should be taken, therefore, to ensure that if any lineswitch on the unit under test is accidentally moved off normal, with the consequence that another half revolution is made when the wipers return home, it should be again operated to reset the wipers to the required position.

Release of Special Selector.—To release the special selector in readiness for the next set of tests, key 5 is first operated to actuate the rotary release, then the vertical dog is released by hand. This allows the shaft to fall back to normal. (Should it be necessary during the progress of the tests to retest any contacts, the selector may be reset to the beginning of the level concerned by the depression of keys 5 and 9 in turn).

(2) *Multiple Bank Test.*—Keys 1 and 2 are operated and test plug 3 is inserted in the test jack of the first final selector on the unit. Clip " RM " is also connected to the rotary magnet of this selector, the " G " relay of which should be wedged to prevent operation.

Note.—This selector is referred to as the " Selector under test." It should be understood, however, that the test is being made on the bank and that the selector is only being utilised for this purpose. Separate instructions are issued for the final selector tests.

Key 8 should be depressed in order to ensure that tester preselector 2 is on contacts 8, and key 6 to set the special selector to contacts " 11."

A circuit is now completed from battery, 100 and 1200 ohm spools, relay PY to Earth at Key 2 op.

Relay PY operates to disconnect relay TR at PY1 op.

The digits " 11 " should now be dialled to step the final selector under test to a position on the first bank corresponding to that occupied by the wipers of the special switch.

The selector under test now operates in a normal manner and applies Earth to the " P " wire *via* the 125 ohm winding of relay H. Relay H is operated by the battery from the lineswitch cut-off (BCO) relay, and, locking, applies a full Earth to the P wire. This earth short-circuits tester relay PY, and the latter releasing completes the loop circuit for the − and + lines *via* relay TR. The operation of relay H applied ringing current to this loop circuit, and the completion of the circuit *via* relay TR causes the selector relay F to trip and connect relay D to the line circuit.

If the current now received from the latter be of correct polarity and strength, relay TR releases and disconnects TA at TR1 nor.

Relay TA, releasing, completes circuits:—

(1) From earth, TA4 nor. and key 2 op. for Relay TB, which operates and locks to earth *via* PY2 nor. and TB1 op.

(2) From earth, TA1 nor., key 2 op., to the rotary magnet of the special selector. The latter rotates to contacts 2 on the

bank and so removes the *s/c* from PY, which re-operates.

(3) From earth, TB1 op., PY2 op., PB2 nor., to the rotary magnet of the selector under test which also rotates to the next contacts.

Failure on the line or private circuits is denoted by a continuous glow on lamp A or B, *via* contacts PY3 nor. and TB2 nor., or PY3 op. respectively.

If the wiring between the contacts now connected be O.K., relays PY, TR and TA, which operated in the interval during which the wipers were rotating, again release. In this way both switches continue to rotate until contact 0 has been tested, when the wipers of the special selector will be stepped off the bank.

Relay ZZ now operates as before and causes:

(1) the special switch to rotate back, step up and cut-in to contacts " 21 " and

(2) relay ZR to operate to release the switch under test at ZR1 op.

The sequence of operations is repeated on levels 2 to 0, by dialling in turn digits " 21 " " 31 " and so on to " 01."

When the whole of the 100 sets of contacts has been tested O.K., the special selector does not release but remains on level " 0," with its wipers off the bank and supervisory lamp glowing, indicating the conclusion of the test on the first bank.

The special selector should now be released as before, the connections transferred in turn to each of the final selectors on the unit and the test repeated on each of the banks so equipped.

The spare banks may be covered by mounting a spare switch thereon for the duration of the test.

P.B.X. Units.—When the banks to be tested are of the P.B.X. type, key 3 should also be thrown in addition to keys 1 and 2, and clip CP1 should be attached to the P1 wiper tag on the wiper cord connection block of the selector under test. The effect of key 3 is to make the operation of the P wire testing circuit dependent on contact PB1, controlled by relay PB, which is operated by current received from battery *via* 150 spool, clip CP1 and the P1 bank wire.

Failure on the P1 circuit is indicated by lamp C, which glows *via* PB3 nor.

(3) *Line Switch Test.*—The 24 clips provided for making connection to the outlet P wires should be connected in order to the wiring on the tags of the line switch bank multiple terminal strip.

The tester preselectors should now be set to contacts No. 1 by operating key 7 and the special selector to contacts " 11 " by operating key 6.

Key 1 should also be depressed to operate relay TR. Relay TR operates in turn relay TA at TR1 op.

A circuit is now completed from earth, key 1 op., relay PT, contact 1 and wiper 2 of preselector 2, P wiper of special selector, bank wiring, jumper, BCO relay K and DM of line switch under test to battery.

The BCO should operate in series with relay PT and the " operate " resistance " X " and disconnect the line switch line relay and earth from the − and + lines. Relay PT releases PA at PT1 op., completing a circuit to earth for DM2 *via* wiper 1, contact 1, PA1 nor., key 1 op., key 7 nor., key 9 nor., wiper 2 of preselector 1 and key 7 nor. to E.

Preselector 2 steps to contacts 2 and relay PT, releasing, re-operates PA. Relays BT and AT are now brought into circuit, but will only operate if the line relay or earth have *not* been disconnected by the BCO. If either BT or AT operate, the circuit for DM2 is interrupted at BT1 op. or AT1 op., lamp D and/or E glows *via* AT2 op. or BT2 op., and no further rotation takes place, but if the + and − lines are now clear, preselector 2 rotates to contacts 6 and the BCO is released.

Relay PT is now connected *via* the additional " non-operate " resistance " Y " to the BCO, which should not operate at this figure. Relay PT, however, operates, releasing relay PA to complete the circuit of DM2 *via* contact 6 of arc 1, key 7 nor., PA1 nor., key 1 op., key 7 nor. and key 9 nor. to earth *via* wiper 2 and key 7 nor. Preselector 2 steps to contacts 7, *via* which relays BT and AX are connected to the − and + lines in order to test for correct calling conditions. If these relays operate satisfactorily, earth is applied to DM2 *via* PA2 nor., BT3 op., AX1 op., contact 7 of arc 5, wiper 5 and key 1 op. and preselector 2 rotates to contacts 8. If, however, one or both do not operate, lamp G or H glows *via* AX1 nor. or AX1 op. and BT3 nor. respectively, to indicate a line switch fault.

A 1200 ohm loop is now applied to the + and – lines *via* relay TR and PY1 nor., to operate the line switch. The line switch should now rotate to its first outlet and should switch through to the selector connected thereon. The selector, operating in turn, should earth the P wire to which connection is made by No. 1 clip on the terminal strip.

If a current of correct polarity and strength be received from the selector A relay by relay TR, the latter releases and breaks the circuit of TA at TR1 nor. Lamp A glows to indicate a failure in these conditions.

A circuit is now completed from Battery, *via* 300 ohms (two 600 spools), key 1 op., relay AX, TA2 nor., PZ1 nor., key 4 nor., key 2 nor., key 3 nor., contact 8 of arc 2 and wiper 2 to the multiple P wire.

If the latter has been correctly " busied " by the selector, relay AX, which operates only to an earth of low resistance, completes the circuit of relay PZ from battery, AX2 op., wiper 3 and contact 1 of arc 3 of preselector 1, clip 1 and P wire to the first choice selector earth.

Lamp J indicates a failure of this condition or an earth of too high a resistance.

Relay PZ now operates and:—

(1) Locks *via* its own contact PZ2 op. to the " busy " earth.

(2) Completes the circuits of DM1 and relay PY at PZ4 op.

(3) Disconnects lamp K at PZ3 op.

(4) Disconnects relay AX at PZ1 op.

Relay PY, operating, breaks the calling loop *via* relay TR at PY1 op.

The selector on outlet 1 should now release and remove the earth from the private, causing relay PZ to release and the line switch to rotate " home."

DM1 being disconnected at PZ4 nor., now de-energises and steps preselector 1 to contacts 2.

An earth fault on the private circuit is indicated by relay PZ failing to release and by lamp L glowing. If this earth be of low resistance the line switch will also skip the outlet concerned. This fault may be caused by a faulty selector " B " relay.

Lamp K indicates that the line switch has not made connection to the correct outlet or that the clip has become detached.

The P wire of the first outlet is now " busied " against further use by an earth of 30 ohms resistance applied from wiper 8 of preselector 1 to contact 2 of arc 8 and so to clip 1.

Relay PY also releasing, re-connects the loop *via* relay TR to the + and – lines at PY1 nor.

The line switch again operates and as outlet 1 is now engaged should rotate its wipers to the second choice, the P wire of which should be duly made " busy " when the selector is seized.

Relays PZ and PY are again operated as before, causing the earth on the P wire of the first outlet to be maintained *via* contact 3 of arc 8. Earth is applied to the P wire of the second outlet *via* contact 3 of arc 7.

The sequence of tests continues until each of the 24 outlets has been tested, the application of the busy earth to each of the first three sets of six being taken over in turn by the locking relays GX, GY and GZ, which are actuated by preselector wiper 2 in passing contacts 7, 13 and 19 on the completion of the tests on outlets 6, 12 and 18 respectively.

When the 24th outlet has been tested O.K., preselector 1 steps to contacts 25 and circuits are completed for:—

(1) Reliay BR *via* wiper 2. BR operates and releases relays GX, GY and GZ at BR1 op. All outlets are now disengaged.

(2) The rotary magnet of the special selector *via* key 7 nor. and BR4 op. The selector steps forward and connects the test circuit *via* its wipers to the next subscriber's line in the multiple.

(3) Relay PZ *via* BR2 op. PZ energises DM1 *via* PZ4 op. and key 7 nor.

(4) DM2 *via* interrupter springs, wiper 1, contact 8 and BR3 op. Preselector 2 rotates to contact 9, where the multiple of contacts 1 to 8 recommences and short circuits relay BR at contact 1 of arc 6. Relays BR and PZ now release and preselector 1 rotates to contacts 1 in readiness for recommencing the series of tests.

The sequence of operations is repeated for each of the jumpered lines in the 100.

In the case of unjumpered lines (usually 46-49 and 95-99) to which no line switch is connected, it is necessary to rotate the special switch to the next jumpered circuit. This is effected by operating key 9 the appropriate number of times (generally 5), allowing an interval between each operation to enable the tester to perform a partial test.

When the whole of the 100 lines on the unit have been tested, the special selector will come to rest with its wipers off the bank and the supervisory lamp glowing.

FAULT INDICATING LAMPS.

Lamp.	Test.	Fault indicated.
A	1, 2 & 3	Line circuit out of balance, *i.e.*, Reversed, dis., contact, etc. In Test 1 may be due to cut-off relay failing to operate.
B	1 & 2	Private circuit dis. or earthing.
C	2	P1 circuit dis. or earthing.
D	3	Lineswitch + line not cleared by operation of cut-off relay.
E	3	Lineswitch – line not cleared by operation of cut-off relay.
F	3	Lineswitch line circuit reversed.
G	3	Lineswitch + line dis. or cut-off relay sticking or contact faulty.

FAULT INDICATING LAMPS—(*continued*).

Lamp.	Test.	Fault indicated.
H	3	Lineswitch – line dis. or cut-off relay sticking or line circuit reversed.
J	3	Multiple P circuit busy earth is high resistance or dis.
K	3	Outlet P circuit dis. or lineswitch has overstepped.
L	3	Outlet P circuit earthing.

RESISTANCE TABLE.

Exchange.	46 V Test.	Scheme.				
		C	E	H	S	W
Director.	Operate.	200		200		100
	Non-operate.	600		600		1400
Non-Director.	Operate.	0		0		0
	Non-operate.	450		450		800

NOTES ON THE EFFECTS OF HUMIDITY ON C.B. TRANSMITTERS.

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THE peculiar behaviour of carbon granular transmitters used in C.B. systems in tropical countries, where warm humid conditions exist, has long been one of the special problems before the telephone engineer in these countries. In the East, and in the far East, some telephone administrations have followed continental practice in favouring a telephone of the hand combination type, which has certain advantages, and now appears to be returning to favour in other countries. The transmitters used with these sets are usually of the inset type, carbon diaphragm, but a solid back type of inset has also been used. The difficulties met with arise from the fact that transmitters of different types which appear to be quite satisfactory under European conditions are in many cases unable to stand up to the extremes of heat and humidity met with in the tropics without change.

In all cases the failure is due to the fact that in those tropical countries which enjoy a rainy season, the humidity reaches an extraordinarily high figure, and during those seasons, unsuitable transmitters show a large increase in resistance (often 100%) and an inabiliy to carry their normal working current, which may develop into "frying," rendering the transmitter useless. It is well established that the effect is due to humidity, for, in the particular case under the writer's notice, the year is divided into two well defined seasons: a dry season with very low humidity (minimum indoors about 30—40%) from November to May, followed by a rainy season, during the remaining months, when the humidity reaches 80 to 90%. The manner in which the humidity varies is shown in the graphs which are from records taken by the Meteorological Dept., Government of India. The figures differ from the ordinary published records, which are taken in the open air. The latter show much larger differences. The figures of the graphs represent the humidity in an average ventilated building, being the conditions under which a telephone usually operates. The reason for this is, of course, that the heat absorption of a building tends to flatten out humidity variations, by the lag in temperature variation as compared with the open air, in which the diurnal temperature variations may be very large. Each point on the graph is the average of seven days reading, eliminating daily variations, which are also considerable. It was found by experience that the 10 a.m. reading is the average daily humidity in an ordinary building.

The first fact which emerged was that the type of inset standard in Europe behaved normally during the months of low or moderate humidity, but became abnormal as soon as the humidity became excessive, returning to normal with the return of drier conditions. This variation was undoubtedly present formerly in the L.B. transmitters used on the old magneto system, but did not lead to trouble because the L.B. transmitters were used in a circuit where an increase of transmitter resistance would at once produce a decrease of transmitter current, since the transmitter resistance was the only important resistance in circuit; whereas under C.B. conditions a relatively large increase in transmitter resistance has but little effect in decreasing the current which the transmitter is calld upon to carry. What follows applies to C.B. systems.

When it has become clear that the presence of damp in the transmitter was the origin of the trouble, a number of attempts were made to produce a sealed damp proof inset. Although these insets were proved to be damp proof in the sense that they could be put under water without ill effect, they showed no improvement over the original insets, which were not waterproof, when put into use during the season of high humidity. This made it obvious that the transmitters were not being affected by moisture in liquid form condensed from the air outside the inset, but by water vapour in its true gaseous state penetrating to the granules and thereafter condensing to liquid form. As points are favourable to condensation, the carbon granules lend themselves admirably for the purpose and the result is a reduction in their current carrying capacity.

On consideration, it is clear that an inset sealed under conditions of normal humidity in the factory, and afterwards used under conditions of much higher temperature and humidity, is then subject to internal pressure, and unless it is truly gas-tight and not merely water- proof, the damp air will eventually mix with that inside and thereafter condense, since a small drop in temperature will cause considerable condensation when the humidity is approaching saturation for that particular temperature. So far, attempts to produce a gas- tight inset have not succeeded, but manufacturers interested have the problem in hand.

In order to obtain further information two batches of 13 different types of transmitters were put under daily observation and test over a period of about 18 months. Each transmitter was tested daily in a suitable telephone on the cord circuit for which it was designed. Tests were made for transmission against a standard W.E. type set, on the standard cord circuit with 300 ohm local line, followed by a measurement of transmitter resistance. At the same time, some hundreds of resistance tests were made on transmitters after actual use.

Since there seemed to be no means of excluding the damp air, an attempt was made to arrive at a solution from a fresh angle, suggested by the observation that whereas some transmitters, notably those of a low resistance relative to the cord circuit current supply resistance used, never became very much higher in resistance, and afterwards in drier weather returned to normal resistance; others (and here notably those of high normal resistance) showed 100% increase in resistance, became noisy, and remained permanently high resistance, even after the damp conditions had disappeared. These were, in fact, burnt out. As examples, one type of inset supplied to operate on a Stone circuit, 24 volt, with relay-retard feed $400^{\omega} + 400^{\omega}$ ohms, maximum transmitter current about 20 m.a., had a nominal resistance of 400 ohms which became, in the humid season, 600 to 800 ohms in many cases, with frying and permanent injury to the transmitter. Similarly, a solid back transmitter of standard size, adapted for use on an H.M.T. set, operating on a standard W.E. type cord circuit, had a nominal resistance of 150 ohms, which increased to 300 to 400 ohms in many cases, again with frying and pitting of the polished electrodes. Here an improvement was obtained by using a smaller size of carbon granule, and making up the cells to a lower resistance. Different transmitters were affected in the same manner, with differences in degree; transmitters on short lines were most affected, and the trouble could be reduced by reducing the current supply to the transmitter.

Bearing this in mind, we may regard a transmitter, for present purposes, merely as a fixed resistance required to carry a certain current, depending on the cord circuit with which it is to be used, and consider what variations may be expected with change in humidity and change in design of the transmitter. We may regard a transmitter as consisting of a resistance made up of r rows of granules, in each row n granules. In any one row there will be $n + 1$ contacts, including those between the end granules and the front and back electrodes. Call the average contact resistance between granules (or granule and electrode) x, and the average internal resistance of a granule y; then the resistance of any one row is

$$ny + (n + 1)x \quad \ldots\ldots\ldots\ldots(1)$$

and the resitance of the whole transmitter is

$$\frac{ny + (n + 1)x}{r} \quad \ldots\ldots\ldots\ldots(2)$$

But if the transmitter is not " packed " and is ordinarily efficient then $(n + 1)x$ must be large compared with ny since it is on the variation of $(n + 1)x$ that the transmitter operates. We may say then that the transmitter resistance is approximately

$$R = \frac{(n + 1)x}{r} \quad \ldots\ldots\ldots\ldots(3)$$

Suppose now that the condensation at points on the granules is the cause of increase of contact resistance from x to $x + dx$. Then the transmitter resistance becomes

$$\frac{(n + 1)(x + dx)}{r} \quad \ldots\ldots\ldots\ldots(4)$$

and the increase of resistance due to damp is

$$\frac{(n + 1)x}{r}$$

which is proportional to the dry resistance $\frac{(n + 1)dx}{r}$

It follows from this, if there are no secondary effects, that the transmitter may be expected to increase in resistance by an amount which will be proportional to its initial resistance, and therefore a high initial resistance is to be avoided, This agrees very well with observed results. There are, however, secondary effects. The above is the ideal case where all rows are affected equally. Actually it will happen that in some rows the increase in contact resistance will be much more than in others. In such a case the high resistance rows cease to be effective as current carriers, and as the current to be carried remains practically the same, the effective rows are called upon to carry an excess load which leads to burning in the effective rows, and these in turn become defective, and react on others. It appears then that there is a cycle of effects which becomes cumulative under bad conditions. Thus if a transmitter is badly designed, so that the current which it must normally carry is near its maximum current carrying capacity (without frying) and is operated later under warm humid conditions, we have the following effects: (1) the transmitter resistance is increased due to damp; (2) the current carrying capacity is reduced; the current flowing remaining nearly the same; (3) frying begins, reducing the number of current paths; (4) transmitter resistance is further increased; (5) the effect of (4) is now added to (1) and the cycle repeats until the transmitter becomes useless. There will be no building up to the point of frying if the cycle is broken at its third stage, and this will be the case if the transmitter under damp conditions and in spite of its damp-increased resistance can still carry the maximum current for which it is designed without burning.

In order to do this the transmitter must carry in a dry atmosphere a current at least 50% more than the maximum of the circuit on which it is to operate. In the case of hand combination sets the margin should be 100% to allow for the fact that they may be used in non-vertical positions. From the expression given for the total resistance there are several obvious ways in which the current carrying capacity of the transmitter could be increased. If the cross section of the cell is increased then r is, and also the current carrying capacity, but this can not be pushed too far. R may also be reduced by reducing n, *i.e.*, by reducing the distance between electrodes; but this does not improve the current carrying capacity of a row, which depends only on $x + dx$. The conditions are improved if the size of the granules is reduced. The effect of this on R should be nil, while r, the number of paths, is increased directly with benefit. The resistance of a single row is also increased directly, but this does not affect its current carrying capacity, which depends only on $x + dx$. The reduction in size of the granules cannot, of course, be carried too far since very small granules tend to pack.

This conclusion agrees very well with observed results in that the best results obtained so far have been with a type of inset using small granules, and the worst with another type using coarse granules. These results are brought out in the curves taken from the daily observations over eighteen months mentioned above. Curve No. 1 shows the results obtained on an inset which has proved satisfactory. It has a normal resistance of 100 ohms and is used on a C.B. system where the cord circuit is Stone type with relay-retard impedance 400 + 400 ohms and voltage 24 volts. The weekly average transmission value on 300 ohm loop and the weekly average transmitter resistance are shown against the weekly average relative humidity. The number of these sets under test was four and the number of observers two. Each point on the transmission curve represents the average of twenty-four measurements by two observers and may be taken as free from all accidental variations. Similarly, the transmitter resistance curve is the average of daily readings and is representative. The remarkable agreement between the variation in humidity and the variation in transmitter efficiency will be noticed. There is also a close agreement between the variation in transmitter resistance and humidity variation, with maximum resistance during the period of maximum humidity. It will be noticed that these insets rarely vary more than 25% above and below normal resistance, and that with the disappearance of abnormal humidity returned to normal or lower. This transmitter has been used to replace former types and continues to give satisfaction, as would be expected.

The second set of curves refer to a type of inset under trial which was not satisfactory, and represents the effects in a poorly designed transmitter, possibly satisfactory in Europe, under tropical conditions. These insets were designed to work on the standard W.E. type cord circuit, 22 volts, and the figures on which the curves are based were obtained as in the first case. These curves show that this transmitter was unstable under damp conditions, as may be seen from the abrupt variations in transmission value. These insets became noisy during the damp season and thereafter their transmission values are nominal. The transmitter resistance steadily increased during this period from normal (35 ohms in this case) until, during the weeks of maximum humidity, the resistance had become 100% more than normal. At this point the two principal causes of increased resistance began to react on one another and the resistance rapidly increased to an abnormal figure, at which the inset became defective and was no longer able to recover its normal value, even when the humidity again became low.

The results obtained from the remaining types of transmitters tested show effects which lie between the two extremes given, and confirm the general conclusion that special care is required in selecting a transmitter for tropical use, and that allowance must be made in the design of the cell, and in the type of granule used, to minimise the changes in resistance which are apparently inevitable.

It is interesting to note that the standard solid back pedestal sets used as references, themselves showed variation in resistance with change of humidity. The standard set (from necessity, on account of the high value of the current which it must carry on zero loop) is well able to carry the working current on ordinary subscribers' loops of say 100 ohms to 300 ohms on which the current is much less than maximum; and for this reason administrations in the East using this

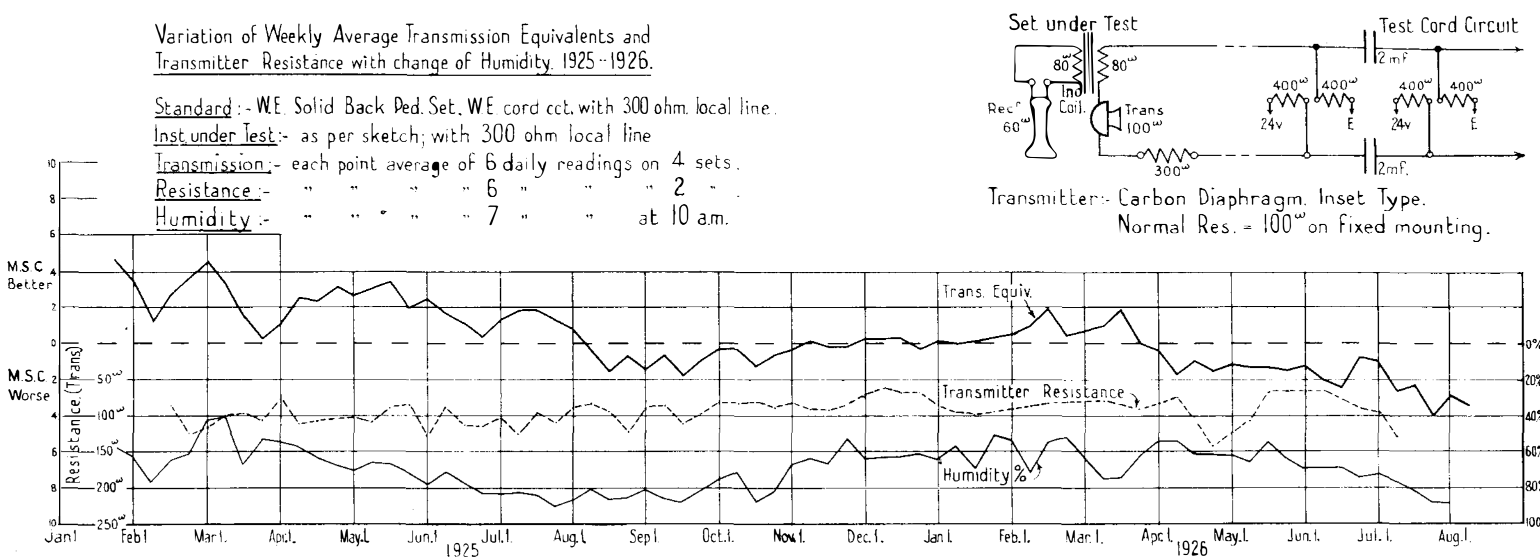

Variation of Weekly Average Transmission Equivalents and
Transmitter Resistance with change of Humidity. 1925 - 1926.
Standard :- W.E. Solid Back Ped. Set. W.E. cord cct. with 300 ohm. local line.
Inst. under Test :- as per sketch; with 300 ohm local line
Transmission :- each point average of 6 daily readings on 4 sets.
Resistance :- " " " " 6 " " " 2 "
Humidity :- " " " " 7 " " at 10 a.m.
Set under Test
Test Cord Circuit
Rec^r 60^ω
Ind Coil.
Trans 100^ω
300^ω
2 mf
Transmitter :- Carbon Diaphragm. Inset Type.
Normal Res. = 100^ω on fixed mounting.
M.S.C. Better
M.S.C. Worse
Resistance (Trans)
Humidity
Trans. Equiv.
Transmitter Resistance
Humidity %
Jan.1 Feb.1 Mar.1. Apl.1. May.1. Jun.1. Jul.1. Aug.1. Sep.1. Oct.1. Nov.1. Dec.1. Jan.1. Feb.1. Mar.1. Apl.1. May.1. Jun.1. Jul.1. Aug.1.
1925
1926

FIG. 1.

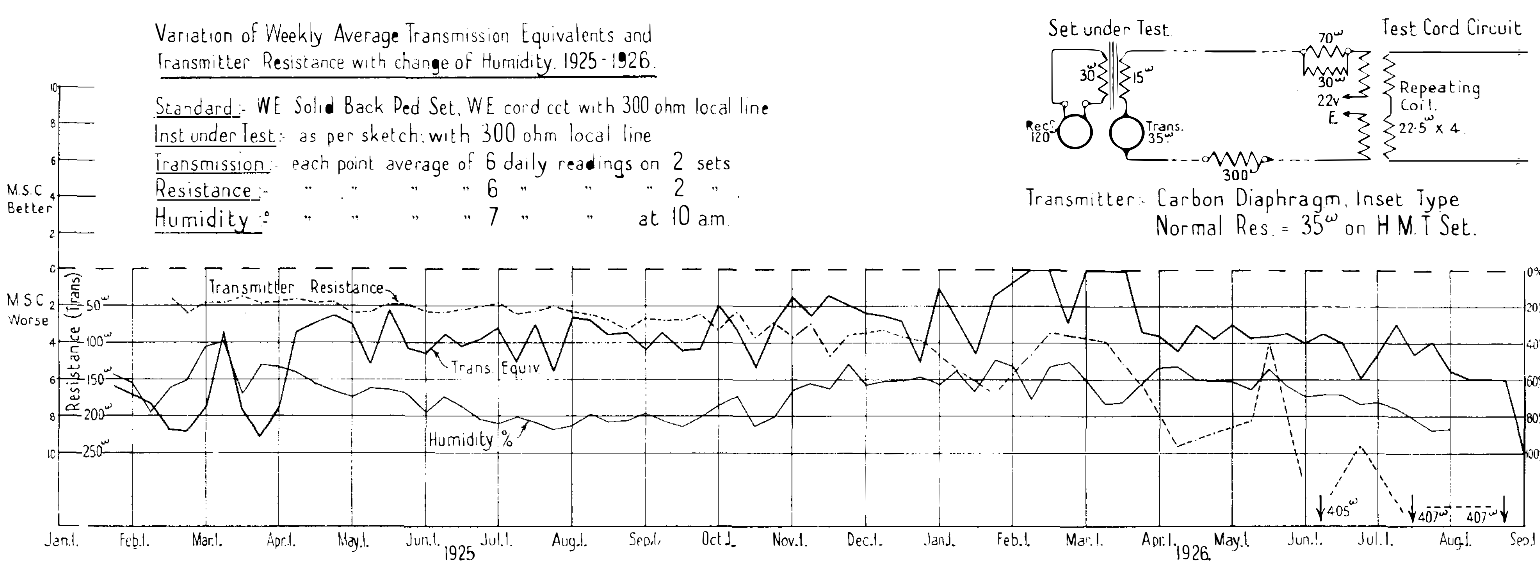

Variation of Weekly Average Transmission Equivalents and
Transmitter Resistance with change of Humidity. 1925 - 1926.
Standard :- W.E. Solid Back Ped. Set. W.E. cord cct. with 300 ohm local line
Inst. under Test :- as per sketch; with 300 ohm local line
Transmission :- each point average of 6 daily readings on 2 sets
Resistance :- " " " " 6 " " " 2 "
Humidity :- " " " " 7 " " at 10 a.m.
Set under Test.
Test Cord Circuit
Rec^r 120
Trans. 35^ω
Repeating Coil. 22.5^ω x 4.
300
Transmitter :- Carbon Diaphragm, Inset Type
Normal Res. = 35^ω on H.M.T. Set.
M.S.C. Better
M.S.C. Worse
Resistance (Trans)
Humidity
Transmitter Resistance
Trans. Equiv.
Humidity %
405^ω
407^ω
407^ω
Jan.1. Feb.1. Mar.1. Apr.1. May.1. Jun.1. Jul.1. Aug.1. Sep.1. Oct.1. Nov.1. Dec.1. Jan.1. Feb.1. Mar.1. Apr.1. May.1. Jun.1. Jul.1. Aug.1. Sep.1
1925
1926

FIG. 2.

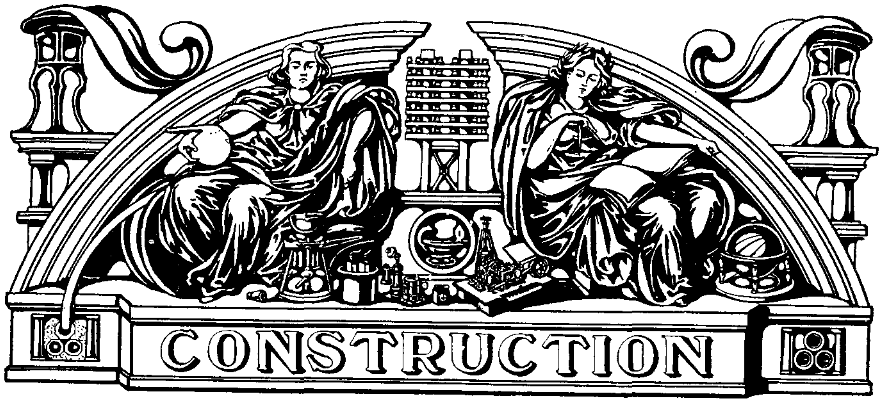
type of telephone have not experienced any general trouble. The standard solid back transmitter is, in fact, a good example of a type designed to carry its working current without burning even under severe conditions.

Nevertheless, one of the working standard telephones used as references developed frying between September 2 and 4, 1925; that is, during the period of maximum humidity. A permanent cure was effected by violently shaking the transmitter. Similar trouble is not uncommon with this type of set under these conditions on very short lines, *e.g.*, service lines within the exchange building where the transmitter current is nearly maximum. In spite of the apparent superiority of the solid back transmitter, it is quite unsuitable in its standard form on exchange systems such as that mentioned above, where the maximum current supply on zero loop is not more than 30 mA, on account of the high resistance of the current supply circuit, and it is for this reason that the high resistance inset is preferred, as well as for its superior articulation. In countries where the parties to a call are commonly conversing in a language or dialect which is foreign to one, or even both, the provision of a good grade articulation is of the greatest importance, and it is the writer's experience this gives the greatest general satisfaction even if the improvement is made at some expense in volume. A reference to this point, which has received little attention in countries of one language, will be found in part 3, Vol. 20, of the *I.P.O.E.E. Journal*, pages 208 and 213, as applied to long distance lines, but the remarks of Dr. Luschen apply with equal force to apparatus used on local calls in countries where the listener has not the association of familiar words and phrase to help in reception, and where the user is frequently without any developed telephone sense.

The fact that the standard of reference in the above tests was itself variable makes the transmission results purely relative, and the effect on the curves is to mask, in some unknown degree, the variations in efficiency with humidity, since there is no reason to suppose that the standards were exceptions to the general rule. Since completing the curves it has been found by comparison with calibrated working standard transmitters received from London that the transmitters used in these tests as standards were 3 m.s.c. worse than the accepted standard. This correction should be applied to the transmission equivalents, although the curves correctly illustrate the variations which it is intended to show.

The atmospheric conditions necessary to produce these effects on transmitters depend largely on temperature and its variations. Thus, during the dry season in Bengal the relative humidity in the open air commonly reaches 90% between sunset and sunrise, the cause being the large drop in temperature. Transmitters remain unaffected since there is no corresponding drop in temperature indoors on account of the heat stored in the buildings during the day. Similarly, relative humidity reaching 90% is not unknown in temperate climates during wet periods of low temperatures (winter months), but the effects here noted are not present because of the great difference between the humidity in the open air and in buildings, which results from the use of artificial heating and less ventilation. During the wet season in the tropics the temperature is not only high but remarkably constant, with little difference between night and day temperatures. During these months the temperature inside buildings is on the whole less than in the open air, and hence the humidity indoors tends to be higher. As the air is allowed to circulate with the utmost freedom, transmitters (and all telephone equipment for that matter) may be said to be fully exposed to outside atmospheric conditions; and it is under these conditions, maintained over a period of time, that transmitters may become defective. The time element is most important, and should be carefully considered in any test reproducing tropical conditions artificially.

In order to indicate more graphically to the home reader the effects of high temperature and humidity it may be added that a relative humidity of 85% with a temperature of 80 to 90 degrees F. produces fungus in one's clothes and shoes in 24 hours, expands key spring assemblies sufficiently to break the clamping screws if the insulating material is at all hygroscopic, and makes the maintenance of insulation of exchange equipment a matter of the greatest difficulty.



SOME ECONOMIES IN CONCRETE.

[We propose in this volume to devote some space to the external constructional side of the Department's activities and to begin with we have pleasure in publishing extracts from a pamphlet bearing the above title, issued by the long-established firm Messrs. G. and T. Earle (1925), Ltd., Hull, and compiled by their Chief Chemist, Mr. J. E. Worsdale, A.R.C.S., B.Sc., A.I.C., A.M.I.Struct.E. The contents of the pamphlet are followed by a laboratory report upon the chemical processes that operate during the setting of cement. It is not claimed that the report is complete and conclusive; the mechanism of the setting and hardening of cement is a matter about which a considerable divergence of opinion exists, even among experts. It will serve, however, to give our readers, who have not the time to make an intensive study of the subject, some indication of what is thought to be happening during the critical period just after the concrete has been mixed and laid.—EDS., *P.O.E.E. Journal.*]

Making of Concrete.—Concrete is made up of three constituents, aggregate, cement and water, of which the aggregate can be divided again into coarse and fine. These separate constituents are all essential to concrete, and the good quality and proper use of each reflects itself in the quality of the finished concrete, whilst on the other hand the unsuitability or misuse of any one of them can result in poor concrete.

Each of the materials will be dealt with separately in an attempt to show how a study of these can be made to improve the quality of concrete and also to lessen the cost.

Coarse Aggregate.—Coarse aggregate usually consists of gravel, broken brick or broken stone. It should be hard and have no tendency to split, like, for example, shale.

The strength of concrete is largely dependent upon the strength of its aggregate, and if the aggregate is weak it limits the strength of the concrete made from it. The size of the aggregate is of great importance in relation to the use of the concrete, since very large aggregate cannot be used with complicated reinforcement, or to produce thin concrete sections. The aggregate should particularly, not be of a uniform size, but should be well graded in the size of the particles, which should vary evenly from the largest to the smallest. This grading has a very great influence upon the strength and watertightness of the concrete and also upon its cost. At this point it will be of interest to show to what a large extent the grading of an aggregate can influence the cost per cubic yard of concrete. It is, of course, well-known that to produce one cubic yard of concrete, considerably more than a cubic yard of dry materials are required, but it is probably not generally known what a great influence the grading of the aggregate has upon these quantities. If the aggregate is composed of evenly sized particles, a given volume will shrink on being made into concrete very much more than if the aggregate had been graded. The following practical test will illustrate this point:

Aggregate A consists of $\frac{3}{8}$ in. chips of even size.

Aggregate B consists of $\frac{3}{8}$ in. chips down.

In making concrete the proportions 4 : 2 : 1 by volume were employed and the same sand was used in each case.

QUANTITIES IN CUBIC YARDS TO MAKE 1 CUBIC YARD OF CONCRETE.

	Aggregate.	Sand.	Cement.	Total.
Aggregate A...	.96	.48	.24	1.67
Cost	13/3½	6/7½	16/9½	36/8½
Aggregate B...	.82	.42	.21	1.45
Cost	12/7½	5/11	14/8½	33/2½

Below the figures for quantities, are put the prices of these quantities at the following rates:

Aggregate and Sand, 14/6¼ per ton.

Cement, 72/7 per ton.

It is seen that when aggregate A (ungraded) is used, 1.67 cubic yards of dry material are required to produce 1 cubic yard of finished concrete, but when aggregate B (graded) is used, only 1.45 cubic yards are required and a saving in price of materials alone, of 3/5d. per cubic yard of concrete is shown.

The foregoing results of actual tests are extracted from a paper by Mr. B. Price Davies, published in the *Structural Engineer,* and give a practical demonstration of how a thorough understanding of concrete materials can save money.

Fine Aggregate.—This usually consists of sand or crushed stone screenings, the particles of which should be graded in size as in the case of coarse aggregate. It is preferable for the dust to be present only in minute quantities, and for the main bulk of the material to be coarser than will pass a 50 mesh sieve. The presence of fine dust has a very considerable weakening influence upon concrete and the good effects of the removal of this material from fine aggregate may very considerably repay the cost of washing, and when comparing two materials for suitability, the amount of fine dust or dirt should never be neglected. Sand often contains organic matter, which has a very harmful action upon the cement, and a way of testing for this is to shake up some of the sand with a dilute solution of Caustic Soda, and noting the colour produced.

If sand is shaken with an equal volume of 3% solution, and the colour of the liquid, after 24 hours standing, is no darker than amber, the sand may be considered satisfactorily free from organic matter.

Aggregate in General.—There are certain substances used as concrete aggregate which are quite unsuitable by reason of their chemical composition, of which a noteworthy instance is that of some qualities of Blast Furnace Slag. This material often contains sulphur compounds, and these have a very harmful, disintegrating action upon cement. The bad effects of sulphur compounds, however, are not immediate, and some months or ever years may pass before the disintegration becomes apparent.

If the slag is comparatively free from sulphur, it can produce excellent concrete, but the absence of sulphur cannot be guaranteed, and before any batch is used, a chemical test should be applied.

Certain types of Spar and Chert also need careful chemical examination before use, since, if the Spar comes from zinc bearing rocks, there is the likelihood of the impurities in the Spar rendering the concrete very slow setting. Our experience of this type of aggregate has shown that the danger is that the concrete should dry out before the set has taken place, but if the concrete is kept wet, it will ultimately set and harden satisfactorily. We have had a number of experiences of this nature, and we would advise that small pats be made of the aggregate and cement and examined carefully to see that they harden satisfactorily. When considering the use of a fresh supply of aggregate of which one has had no previous experience, the small trouble entailed will always be repaid by the knowledge that the materials are satisfactory; or if the tests should show the material to be unsuitable, considerable sums of money may be saved.

Cement.—It is, of course, the cement which gives concrete its strength, and it follows that the stronger the cement, the stronger will be the concrete. The British Standard Specification calls for cement to have a certain strength, and the adoption of this specification has done an immense amount of good in raising the quality of Portland Cement to a reasonable level. Now when certain proportions for the concrete are specified on a job, unless a particular brand of cement is also specified, B.S.S. cement is meant.

If a cement on testing, exhibits, say, double the strength of B.S.S. requirements, surely a leaner mix using this cement will produce concrete of equal strength.

The extent to which economical mixes can be obtained by the use of a high class cement is illustrated by the following schedule of tests of 6″ concrete cubes at 28 days, expressed in lbs. per sq. inch. The conditions of preparing and storing the cubes prior to testing were the same in each case.

Cement.	Concrete Proportions.				
	6 : 1	7 : 1	8 : 1	9 : 1	10 : 1
Sample A ...	4850	3780	2690	2130	1900
Sample B ...	2050	—	—	—	—
Sample C ...	2290	—	—	—	—

It will be seen that concrete made 6 to 1 with sample " B," has less strength than that made 9 to 1 with sample " A " and 6 to 1 with sample " C " is weaker than 8 to 1 with sample " A."

All three cements are above the requirements of the British Standard Specification of 325 lbs. per sq. inch, for the 3 to 1 sand and cement mixture tested at the age of 7 days, as shown below:—

Cement.	Lbs. per sq. inch.
Sample A	615
Sample B	350
Sample C	370

High testing cement is manufactured by choosing the proper raw materials and carrying out each process of the manufacture very thoroughly. One of these processes is the grinding of the clinker to cement, and thoroughness in this part of the manufacture produces a very finely ground cement. Now for a given weight, a finely ground cement will occupy a greater bulk than one coarsely ground, and since it is usually proportioned by volume, a distinct saving is brought about. The difference in bulk is often as much as 5%, which represents a saving of 1/- in the £. Moreover, the coarse material which does not pass through a 180 mesh sieve has practically no cementitious properties, and is of as much value as so much sand; the buying of cement residue is therefore a very dear way of buying sand. A finely ground cement is thus shown to be a better cement and a cheaper cement in use.

Water.—We now come to the last constituents of concrete, viz.: water. This, however, is by no means the least important, since a wrong use of water can effectively negative the good properties of aggregate and cement. It is a fact, now probably undisputed, that excess of water in concrete reduces its strength, and that the less used in mixing, provided the mix is plastic, the stronger will be the resulting concrete. Tests have shown that the employment of a richer mix, say a 5 : 1 in place of a 7 : 1 may not produce a stronger concrete if an excess of mixing water is present. The concrete must always be plastic when put in place, but the degree of " sloppiness " must depend largely upon the use for which the concrete is required. For example, the mix for mass concrete can be made much less sloppy than for thin reinforced beams. In the past there has been great difficulty in gauging the sloppiness of concrete, and the degree of sloppiness has had to be left largely in the hands of the workmen. We have now available a method of measuring the sloppiness of concrete, known as the " Slump Test." The Slump Test apparatus consists of a mould of galvanised iron in the form of a cone with the base 8 inches in diameter, the top 4 inches in diameter, and the height 12 inches.

The mould is placed on a flat non-absorbent surface and filled with the freshly mixed concrete in four layers, each layer being puddled with a bullet nosed bar, and the top is struck off so that the mould is exactly filled. The mould is removed by raising vertically immediately after being filled.

The moulded concrete is then allowed to subside until quiescent and the amount in inches the concrete has decreased in height is the Slump.

With given materials, the amount of water required per batch can be determined by means of the Slump Test and then this amount of water can be measured for each batch. The Slump Test is easily carried out and can be performed by the foreman.

The following results from our own experience will illustrate the use of this test:—

A reinforced concrete silo was being built for us and throughout the work samples of the concrete were taken as it came from the mixer and made into test cubes which were broken at various ages. At first we found the men mixing concrete of such a sloppy nature that a slump of $10\frac{1}{2}$ inches was obtained. We got into touch with the consulting engineers responsible for the work, and asked for the water to be cut down. They arranged this and smaller slumps of 4 to 6 inches were obtained. The compression tests of the cubes made from the concrete showed the stiffer concrete to have *more than double the strength of the sloppy concrete.*

The use of the excess water was doing nothing more or less than *wasting half the value of the cement.*

The following table shows the average results of the tests made :—

Slump in Inches.		Crushing Strength in pounds per square inch. 7 days.	28 days.
$8\frac{1}{2}$—$10\frac{1}{2}$	...	666	1460
$5\frac{1}{2}$—$6\frac{1}{2}$	...	1340	2770
$4\frac{1}{2}$	...	2010	3005

The separate constituents of concrete have now been briefly dealt with, but their dependence one upon another should be emphasised. Poor aggregate or poor cement needs a richer mix to produce the same strength as when good quality materials are used, or the concrete must be made more massive to give the same service A good quality cement will produce a good job with very questionable aggregate, but if the other constituents of the concrete are first-class, leaner mixes can be adopted or less massive concrete can be used.

The subject cannot be left without one or two words on the treatment of concrete after it has been laid. It is possible for concrete to be made out of first-class materials used in the right way, and yet fail, if it is not given proper treatment after it has been laid. For example, concrete, if subjected to frost while the first hardening is taking place, may fail; thin renderings subjected to hot, dry conditions without adequate protection, may fail through rapid drying out. The rapid drying out of floors will tend to bring on " dusting." These two causes of failure, out of many similar, can be readily prevented by a man who understands the nature of the materials he is dealing with.

Adulterants.—There is a tendency for adulterants to be added to the cement or water to obtain some particular effect; these additions frequently being made by the workmen without the authority of the Contractor. In many cases these admixtures are ill-advised, doing actual harm to the concrete, whilst in other cases the results may not be worth the extra cost.

In rendering work, cement mixed with certain sands may produce a very harsh-working mixture. The addition of Hydrated Lime, not exceeding 10% of the weight of the cement will facilitate the working attempt at the expense of a slight decrease in the strength of the material.

The addition of Plaster (*i.e.*, a Gypsum Plaster) should on no account be made, since it will bring about the disintegration of the rendering.

The use of salt in the mixing water to lower the freezing point is not to be recommended since the desired effect is only very slight and the strength of the concrete is greatly impaired. It should under no circumstances be added for reinforced work. The addition of Soda to quicken the set, reduces the ultimate strength of the concrete.

In conclusion we want to repeat our conviction that the study of concrete materials by the users would very much improve the standard of concrete work, as it would also reduce the cost. The cheapening of the cost would bring concrete construction into a still more favourable position in competition with other building materials, and the whole effect would be to hasten the development of the " Concrete Age " which is now most certainly beginning.

Laboratory Report.

Portland Cement consists essentially of tri-calcium silicate, di-calcium silicate, tri-calcium aluminate, 5—3 calcium aluminate and di-calcium aluminate. The addition of water to tri-calcium silicate results in its partial decomposition to the di-calcium salt with the liberation of lime and since both the tri- and di-calcium materials are only soluble in water to an infinitesimal extent, the reaction is favourable to the formation of colloidal substances.

Regarding the aluminates, the tri-calcium aluminate is the stable one in contact with water and the lower lined salts are converted by the action of water into the tri-calcium product, with the liberation of alumina. Here again the products of reaction are in a colloidal state including the liberated alumina. These colloidal bodies are of the nature of a mineral glue, and absorption of water from them by the inner parts of the grains of cement causes the gradual contraction and stiffening of the jelly, and it is to this that the setting and hardening of the cement must be attributed.

After a period of, say, 28 days, the line which has been continuously evolved, crystallizes within the colloidal matrix, but one cannot trace to the presence of these crystals any of the strength developed by the cement. The aluminates are the first to hydrate and to them must be ascribed the setting and strength of cement up to a period of 24 hours. The tri-calcium silicate commences to hydrate after the first day, and continues till approximately the seventh, but the di-calcium silicate is the slowest to be effective, and the increase in strength after 28 days must be ascribed to the hydration of this product. Since hydration requires water, it can readily be appreciated that a complete drying out of concrete prevents further hydration and therefore prevents further development of strength, and continual growth in strength of concrete can only be obtained when there is sufficient water retained within the mass to hydrate the slowly reacting di-calcium silicate.

ECONOMIES OF LINE PLANT PROVISION.

[*The following extract, dealing with Teeing Systems, is taken from the paper on "Economies of Line Plant Provision," which was read by Mr. H. Kitchen before the London and several provincial local centres last session.*]

TEEING Systems. As mentioned earlier in the paper, a proportion of the conductors in Local Line cables are spare, and as this idle plant involves a considerable amount in annual charges, it will be agreed that any means of reducing this sum will be reflected in the financial results of the service.

With the present system of underground distribution, an ultimate efficiency of more than 75%, *i.e.*, of working to total wires in the cables, is not generally obtained with arrangements of joints. The alternative to very frequent reopening joints and rearranging the distribution of the spares is the provision of additional conductors, which increases the percentage of spare pairs, and is a more expensive and less efficient method of solving the problem.

To avoid opening plumbed joints several methods of teeing conductors have been tried, and latterly the auxiliary joint has been tentatively approved. Generally, the teeing arrangements have not proved satisfactory, and it is perhaps too early to pass judgment on the efficiency of the auxiliary joint arrangements. Auxiliary joints may, however, in some form or other, eventually become indispensable in congested areas, and there is plenty of scope for the application of a comprehensive form of teeing.

A system of teeing which has several new features and which will, it is hoped, minimise the drawbacks experienced with previously tried methods is under consideration.

In the proposed system a group of D.P.'s is formed, each D.P. being either directly or indirectly interconnected with the others in the group by means of teeing so as to form the equivalent of the one large D.P.

Approximately 50% of the circuits in the main cable from the Exchange to the teeing point should be distributed direct to the D.P.'s, the remainder being divided so that each pair is made available at two D.P.'s by teeing at a common point. This will allow one-third of the circuits terminating at a D.P. to be connected direct to the Exchange and ⅔rds to be teed with other D.P.'s. The ratio, however, may be modified, if necessary, to suit local conditions. This method should generally give sufficient interconnection of the D.P.'s in a group to ensure that, before any D.P. area is regarded as closed to further orders, approximately 90% of the circuits in the main cable to the Exchange will have been brought into use.

The full capacity of the cables serving each D.P. will be carried forward towards the Exchange to a common point for each group from which point approximately ⅔rds of the capacity will be continued towards the Exchange, the balance being teed at this point. The number of D.P.'s to be interconnected will depend to some extent on the geographical relation of the D.P.'s to each other, a group being made up of D.P.'s which are reasonably close to each other. The primary essential, however, is that a fair number of D.P.'s be included in the group, say 5 to 10, so as to give the flexibility of a large D.P.

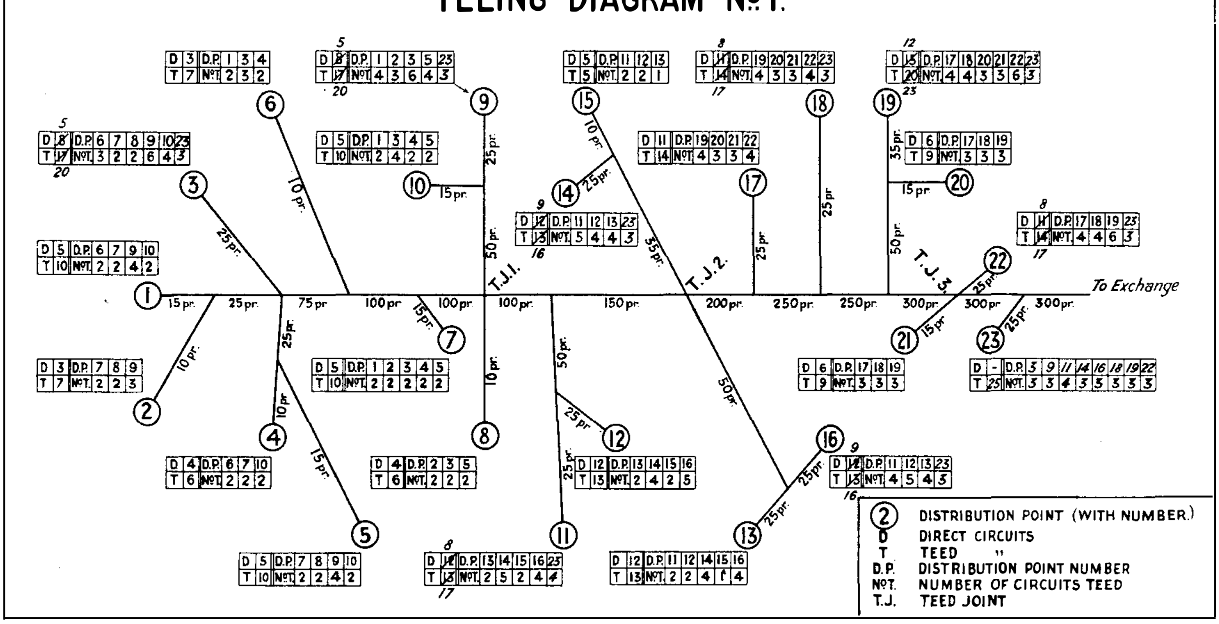
For example, a 50 pair cable might be provided to take into the Exchange 75 D.P. ends, or 100 pairs to take in 150 ends. Teed circuits from each D.P. should be spread over a reasonable number of other D.P.'s in the group and, although it is not proposed to connect each D.P. to every other D.P. in the group, the D.P.'s with

At D.P.'s, in addition to the ordinary numbering of pairs, the teed circuits should be marked by means of lead collets (compo piping) slipped over the leads and soldered in position so as to avoid the risk of being accidentally cut off when the leads are shortened.

The lead collets should be stamped with the letter "T" before being placed in position.

Examples of teeing are given in the attached diagrams, Figs. **1** and **2**.

Fig. **1** illustrates a typical case where new plant is to be provided, the total capacity of the branches being carried forward from the D.P.'s to the first teeing point, TJ1, from which 100 pairs in the main cable go forward to the Exchange.



TEEING DIAGRAM No. 1.

which it is interconnected should be teed to other D.P.'s so that it may have access directly or indirectly to all D.P.'s in the group.

The teeing point for each group should be at a convenient junction of the main and distributing cables.

Two long branches should not be teed together, a long branch should generally be connected to a short branch in order to minimise loss in transmission.

It is necessary that the ends of the leads of all teed circuits at D.P.'s should be carefully insulated by means of paper sleeves and lead caps soldered in position both initially and at any time when changes are made.

Similarly at points TJ2 and TJ3 an additional 100 pairs go forward to the Exchange to serve each of these groups in which there are 135 and 140 ends respectively.

The diagram is thus divided up into several small groups each served by 100 pairs through to the Exchange, teeing being effected generally between D.P.'s within each group.

The 100 pairs serving the first group will provide 50 Direct and 50 Teed circuits, each teed pair being available to two D.P.'s, the difference in the number of pairs at the D.P.'s and the number taken through to the Exchange being 150 − 100 = 50. From the group of D.P.'s there will, therefore, be 50 ends taken direct to the Exchange and 100 ends teed, giving at each D.P. $\frac{1}{3}$ direct and $\frac{2}{3}$rds teed.

Each Teed circuit has to be made available at two points in the group, and in order to do this, the group should be divided into two portions having the same number of teed ends in each.

In the group served from TJ1 there are 150 ends, the Teed circuits can therefore be divided equally between the two halves of the group by taking half the total ends, in this case 75.

The first portion of the group will embrace D.P.'s 1 to 5 and the second portion D.P.'s 6 to 10; the requirements will therefore be met if 50 ends in the first portion are teed with 50 ends in the second portion.

The allocation of the Teed circuits is then made as before.

The last D.P., No. 23, is provided for entirely by Teed circuits from the groups already dealt with, taking a number of pairs from each group.

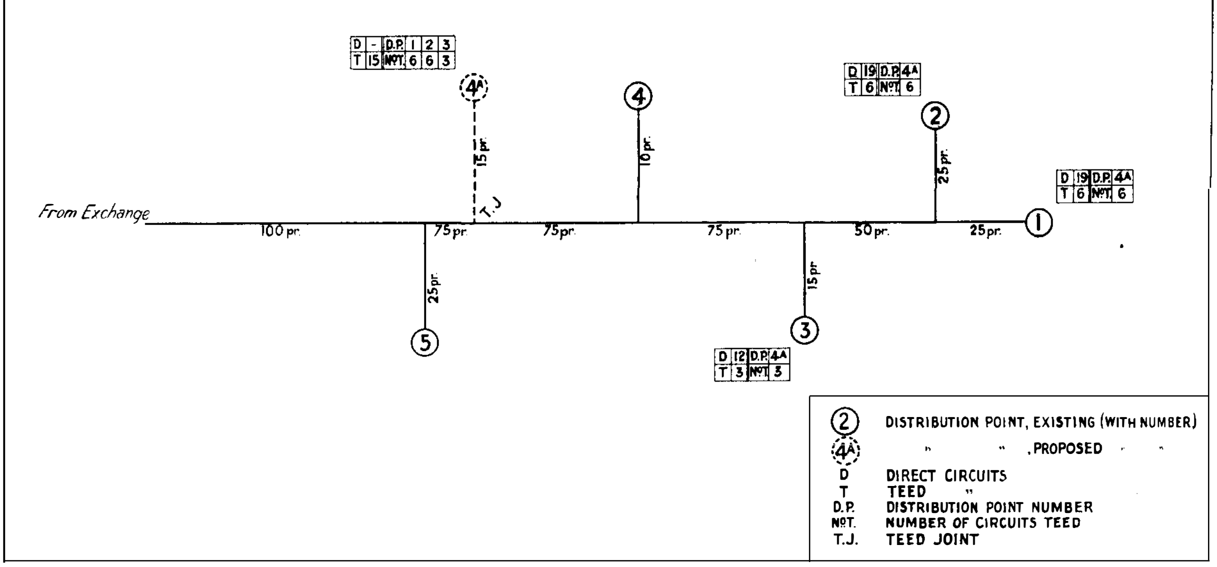
The effect of this is to reduce the number of direct pairs in each group; for example, in group No. 1 the number of direct pairs is reduced from 50 to 44, the difference, 6, being teed *outside* the group to D.P. 23.

The necessary adjustments of the figures are made at the D.P.'s concerned, as shown in the diagram.

It will be evident, therefore, that 450 pairs spread over the grouped D.P.'s are available on

TEEING DIAGRAM No. 2

D.P. 4 FULL. OPEN NEW D.P. 4A, TEED TO D.P's. 1, 2, AND 3.



In the example, this has been consecutively at D.P.'s 1, 2, 3, 4 and 5 by giving not less than two circuits to D.P.'s in the second half, in proportion to the size of the D.P.'s in the latter portion.

It will be seen that in the second group there are 135 loops taken into the Exchange on 100 pairs, carrying 35 Teed within the group, 10 Teed outside the group, and 55 Direct circuits. In this case the division of the group into two halves necessitates the division of D.P. 13 into two portions, 17 circuits of the 25 pairs at this D.P. are considered as belonging to the first half of the group, and 8 circuits to the second half.

the 300 pair main cable at the Exchange. With this arrangement it may reasonably be anticipated that the whole of the capacity in the branch cable to any D.P. will be available to meet development without re-distributing at the joints.

Where the total capacity of a group of D.P.'s is small, in addition to providing intercommunication between D.P.'s in each group, increased flexibility will be obtained by providing Teed circuits from some D.P.'s in this group to D.P.'s in another group on the same main cable, thus in effect making two small groups into one larger group.

Diagram No. **2** indicates a method of teeing designed for cases where urgent relief is required in a D.P. area.

In this case it is assumed that all the available circuits on D.P.4 are working and that immediate relief is necessary. Sufficient spares exist in the main cable serving D.P.'s 1, 2 and 3 and a new D.P.4A is therefore opened with a capacity of 15 pairs which are teed over D.P.'s 1, 2 and 3. The distribution of these teed pairs is shown on the diagram and it will be seen that relief is afforded without the provision of any additional cable in the main route. The method illustrated might be adopted with advantage in cases where an individual D.P. area requires to be relieved, as the work involved generally would be less costly than the provision of additional circuits in the mains.

Records.—Provision is made on the D.P. card (T.E. 631) for recording Teed circuits and no difficulty is anticipated in making a complete and accurate record.

For each Teeing scheme a diagram similar to Fig. 1 will be necessary, and in addition, a schedule should be prepared for each Teed joint giving details of the disposition of each main cable pair in that joint which will be numbered in the ordinary way.

The diagram and the schedules will be filed together, and retained as a permanent record.

Teeing systems have been under consideration at Headquarters for a considerable period, and it is felt that the last word on this subject has not yet been uttered. The success of teeing as described is thought to be largely on the shoulders of the officers deputed to handle the actual work, and a great deal depends upon the accuracy of the plant records, particularly those contained on Cards T.E. 630 and 631.

Reference has already been made to the Auxiliary Joint method to obtain increased flexibility.

This system has been tried with success in London.

Briefly, the scheme is to stump out a selected joint, a number of pairs, say 25% to 30% of the capacity of the main cable feeding that joint. These pairs are numbered and left sealed in the stump until required. The remainder of the pairs in the main cable are distributed amongst the respective D.P.'s in the usual manner. The spare pairs in the branch cables from the D.P.'s to the same point are also collected in another stump so that the two stumps can be brought together to form a separate joint.

When relief is required at one or more D.P.'s the stumps are opened, and an auxiliary joint is made, the necessary pairs being joined through according to the D.P.'s needing relief. Variations in the requirements of individual D.P.'s are met by opening the auxiliary joint and redistributing the pairs as required.

Details of this method are given in Mr. Harvey-Smith's paper read before the London Centre, January, 1926.

THE 1927-28 CABLE INSTRUCTION COURSE.

A. MORRIS, M.I.E.E., and G. W. HODGE.

FROM October, 1927, to January, 1928, an instructional course was held in the Research Section of the Engineer-in-Chief's Office for the purpose of training officers of the Department in the capacity balancing and maintenance testing of underground cables.

One or more officers attended from almost all the Engineering Districts. The officers were drawn from the ranks of the Department's Inspectors, Probationary Inspectors, Repeater Officers and Skilled Workmen, the total number being 26.

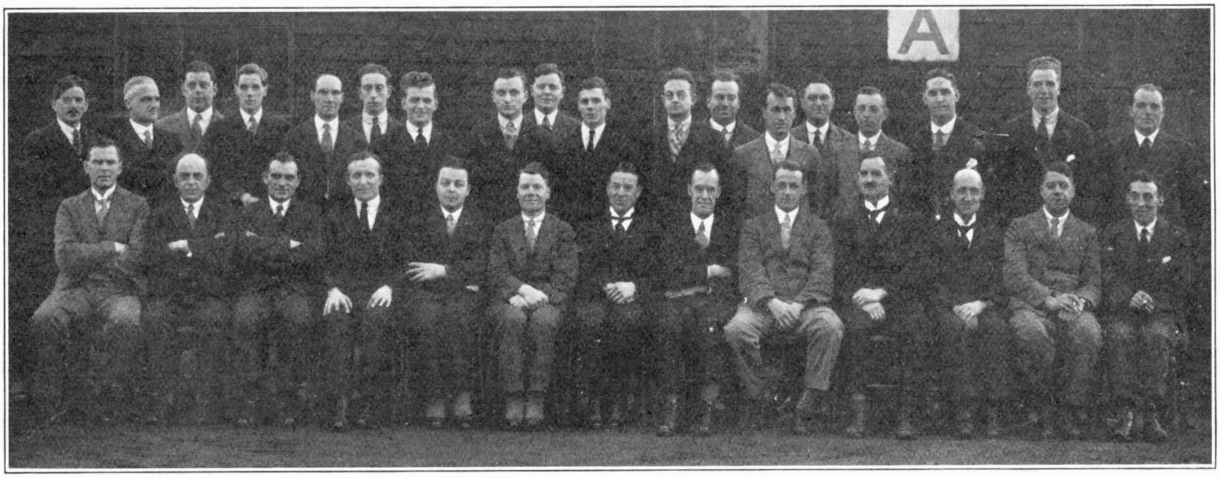
In a previous article* particulars of similar courses which have been held in the past were described. The 1927/28 course was conducted along the same general lines as those described in the above-mentioned article. The course was divided into three parts in accordance with the subjects dealt with, namely :—

* *" The training of officers of the British Post Office Engineering Department in Precision Testing of Underground Cables ": Journal I.P.O.E.E., Vol. 19, part 2, July, 1926.*

Part A. Mathematical Introduction and Elementary Alternating Current Theory.
 ,, B. Cable Balancing and Acceptance Tests.
 ,, C. Cable Maintenance Tests and Localisation of Faults.

Part A, which was the first stage of the course, was taken by all the officers. The instruction given in this part was directed entirely towards the requirements of the subsequent lectures given in Parts B and C.

Certain of the officers had attended previous courses in either parts B or C and consequently were not required to attend that part of the course in which they had previously received instruction.



THE 1927-28 CABLE INSTRUCTION CLASS.

The syllabus for each part of the course followed very closely that described in the article previously mentioned.

The instruction was afforded in the first instance by means of a series of lectures, one lecture per day being normally given. During the progress of each lecture the officers made rough notes, which they subsequently transferred in full to the note-books furnished for this purpose. Notes of the more important features of some of the lectures were dictated to the officers. During the intervals between lectures, members of the teaching staff were in attendance in the class-room for the purpose of giving additional information and assistance, as well as help in the working of examples. In this way individual members of the class were encouraged to discuss and clear up the difficulties of previous lectures.

Upon completion of each of the series of lectures involved in parts B and C, a period of practical instruction was given for the purpose of familiarising the officers with the operation of the various pieces of apparatus and the testing methods described in the respective course of lectures.

The following schedules, which enumerate the tests and measurements actually made by each officer in parts B and C, will give some idea of the scope of the practical instruction which was given during the course.

Part B.

(i) The making of a quadruple selection for a 38 pair cable, commencing with the measured unbalances and proceeding in the usual manner to the calculation of the unbalance characteristics, the selection of cores to be jointed together and type of cross to be employed, the preparation of the jointing schedule and the application of the residual check.

(ii) Upon drum lengths of 308/20 M.T. cable and by the use of standard testing sets :—

(*a*) The measurement of within-core and between - core capacity unbalance. The initial balancing of the capacity unbalance set. The use of additional condensers for measurement purposes.

(*b*) The measurement of within-core and between-core cross-talk in the open and terminated conditions.

(*c*) The measurement of loop resistance and resistance unbalance.

Part C.

(i) By means of a trunk cable resistance testing set with Unipivot galvanometer, and making use of artificial networks representing cable faults:—

(*a*) Localisation of earth fault and contact on long and short lines by Varley and Murray tests respectively.

(*b*) Localisation of conductor resistance fault on a long line by Reid test.

(ii) By means of four dial Wheatstone bridge, reflecting galvanometer and auxiliary apparatus, and making use of artificial networks representing cable faults:—

(*a*) Setting up apparatus, testing for leakage from set and determining constant of galvanometer.

(*b*) Measurement of insulation resistance.

(*c*) Localisation of dielectric fault of high resistance (*i.e.*, of an incipient fault) fault on a short line by double-ended Varley test.

(iii) By means of a 1000 ohm slide wire, reflecting galvanometer and auxiliary apparatus:—

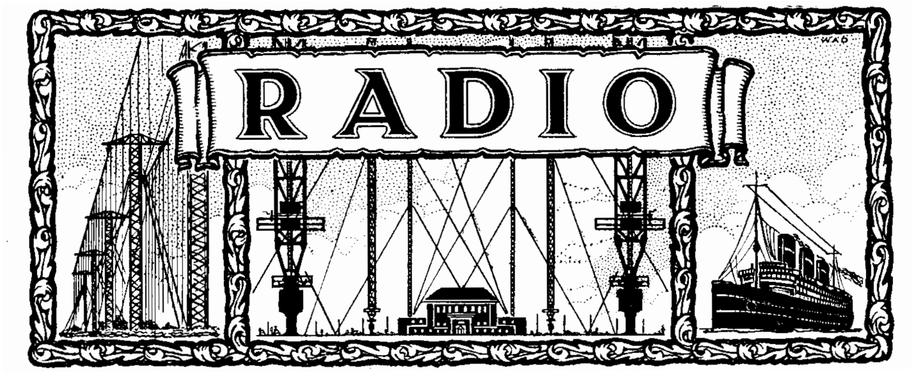
(*a*) Localisation of incipient dielectric fault on a short line by double-ended Murray test.

(*b*) Localisation of disconnection in a long line by capacity charge and discharge methods.

As the various parts of the course were completed, each officer's fair note book was handed in for reading through and correction where necessary by the teaching staff.

With regard to part A previous knowledge of the subjects dealt with varied considerably in extent amongst the various members of the course. During the time allowed for the whole work it was impossible in the form of lectures to deal sufficiently fully with the subjects contained in this part, to meet the individual needs of all the officers. It is thought, however, that the lecture notes, supplemented by individual private study, have enabled the members of the course to obtain a good understanding of parts B and C.

An interesting memento of the course in the form of a group photograph is reproduced on the preceding page.



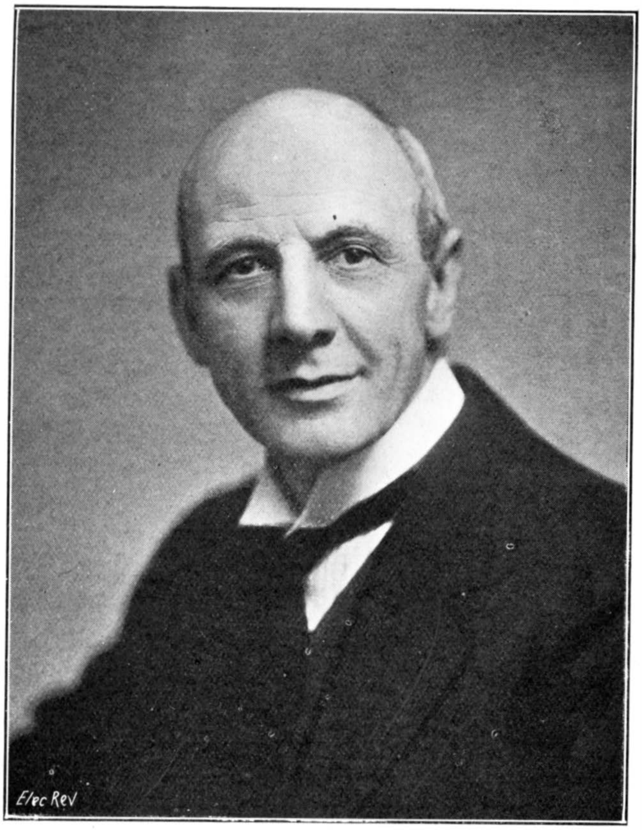
TRANSATLANTIC RADIO DEMONSTRATION.

JOINT MEETING OF THE INSTITUTION OF ELECTRICAL ENGINEERS AND THE AMERICAN INSTITUTION OF ELECTRICAL ENGINEERS.

A SIMULTANEOUS meeting of the two institutions was held on Thursday, 16th February, 1928, in London and in New York, the Transatlantic radio service forming the connecting link between the two gatherings. The London meeting began at 3 o'clock when a film entitled " Voices across the sea " was shown to a very large gathering in the large hall. The American Institution was holding its mid-winter convention in the Auditorium of the Institution in New York and at 3.25 p.m. (10.25 a.m. New York time) Mr. Waterson, of the A.I.E.E., concluded the reading of a paper on Transatlantic telephony. Mr. Charlesworth then explained the position in London to the New York meeting, while Col. Purves in the following words performed a similar service to the London audience :—

Col. Purves said : — " Mr. President and Gentlemen,—The American Institute of Electrical Engineers is holding to-day its mid-winter Convention in the Auditorium of the Institute in New York. Two papers on the subject of Transatlantic telephony are being presented there and Mr. Waterson, of the American Telephone and Telegraph Company, is now just on the point of completing the reading of the first of these papers. The joint meeting of the two institutions, in London and New York, will be held as soon as he has finished. We are using for the purpose the Transatlantic telephone system between Great Britain and the United States which has been in operation since January of last year and which provides regular public telephone service between the whole of the United States and a large portion of Canada on the one side, and the whole of Great Britain and several of the continental nations of Europe on the other. To-day we shall be using the Transatlantic radio link of about 3000 miles, and about 1200 miles of land line. The land line on this side connects us with our radio transmitting station at Rugby and with our receiving station at Cupar, in the Scottish Kingdom of Fife. On the other side it connects New York with the transmitting station Rocky Point, Long Island, and with the receiving station at Houlton, Maine. The local arrangements made at New York are exactly similar to those made here. Two loud speaking receivers are provided on each side, so that the audiences may hear the whole of the proceedings. The photograph of each speaker will appear upon the screen in the auditorium while he is speaking. I will now leave the control of the line and apparatus in the hands of Mr. Charlesworth, in New York, and he will place Mr. Gherardi, the President of the American Institute, in communication with our President, Mr. Page, here."

At 3.30 p.m. Mr. Charlesworth, having been connected to London, said " Good morning, Colonel Lee, is Mr. Page ready to talk ? " Col. Lee replied " Good afternoon, Mr. Charlesworth. Mr. Page is ready to talk and I will hand the microphone to him."



MR. ARCHIBALD PAGE.
President of the Institution of Electrical Engineers.
Chairman of the Joint Meeting.
(The photo is by Elliot & Fry. The block has been lent to us by "The Electrical Review.")

Mr. Gherardi: "Good morning, Mr. Page."

Mr. Page: "Good afternoon, Mr. Gherardi."

Mr. Gherardi: "Mr. Page, it would give us great pleasure if, as President of the Institution of Electrical Engineers—the senior Society, founded in 1871—you would act as Chairman of this joint meeting."

Mr. Page: "I regard it as a great honour to be asked to take the chair on this historic occasion; it is also a gracious compliment to our Institution, and in accepting, which I do gladly, I desire to thank you, Mr. President, and the members of the American Institute of Electrical Engineers, most heartily.

I welcome all present at the meeting now in session, and venture to predict that the proceedings will prove exceedingly interesting and likely to live not only in our memories, but to be quoted by succeeding generations of Electrical Engineers as marking an important milestone in the advancement of electerical science. I am sure I interpret the desire of those assembled if I request Mr. Gherardi to address us, which I now do."

Mr. Gherardi: "Mr. President and Members of the Institution of Electrical Engineers; on behalf of the American Institute of Electrical Engineers, I extend to you greetings and our best wishes. We are meeting here in New York at our mid-winter Convention. In the auditorium of the Engineering Society's building in New York City, from which I am speaking, there are assembled about one thousand members of our organization from all parts of the United States, from Canada, and from other parts of the New World. It is with the greatest satisfaction that, as a result of the accumulated work of the scientist, the inventor and the electrical engineer, it is possible for us to hold this joint meeting—the first of its kind. It is with feelings of deep appreciation and respect that we think of the men who have exemplied the ideas of your organization—Faraday, Maxwell, Kelvin, and of the many others, past and present, who have contributed to electrical engineering and to the scientific foundations upon which it rests. These developments have been notable and have contributed in the greatest degree to the welfare of mankind. One of these developments is the age of electrical communication—the electric telegraph and the telephone. These have made communication independent of transportation and no longer subject to all of its difficulties and delays. By the telephone, distance has not only been annihilated, but communication by means of the spoken word has become possible. Starting in 1876 with instruments and line which, with difficutly, permitted communication over distances limited to a few miles, the telephone has been improved year by year until continents have been spanned, and at last even the limitations of the Atlantic Ocean have been overcome, and to-day telephone conversation between the two great capitals of the English speaking world is a reality. We are gratified that Transatlantic communication has made this meeting possible; it has added one more to the many ties existing between our two Institutions, and has added still another opportunity for friendly communication between us."

Mr. Page responded as follows: "Mr. Gherardi and gentlemen. Please regard me for the time being, not as chairman, but rather as representing the 13,000 members of the Institution of Electrical Engineers.

My first desire is to thank you, Sir, for your most kind message of good will to us all. In turn we hail the President and Members of the American Institute of Electrical Engineers with feelings of the utmost warmth and of everything included in the term of good comradeship. Owing to the hour at which it has been necessary to hold this meeting falling within the period when the bulk of our members have to be on duty elsewhere, we have perforce had to content ourselves with a smaller gathering in London than that composing your Convention. It is, however, of a thoroughly representative character, consisting of specially invited distinguished guests, the Council of the Institution, many of whom have travelled long distances to be present, and a large percentage of the members of our Wireless Section. The telephone must rank as one of the greatest inventions of the 19th century, and it has transformed the daily life of all civilised people. Our indebtedness to Graham Bell for the boon he has conferred upon us increases with the years, and his memory, along with that of Franklin and Henry, will be cherished as becomes such benefactors of mankind. It would indeed be a gigantic task to attempt to exhaust the list of those of your Society who have contributed so largely to the progress of Electrical Science and I must content myself by paying tribute to a great Institution which has given proof time and again that Engineering is truly International.

It cannot be questioned that we are living in a period of extraordinary change due to scientific discovery, and in no field has the advance been more marked than in that of the Communication Engineer.

The Commercial Radio services thus placed at our disposal assure closer and closer association between the English speaking races, a new spice is added to life and the bonds of friendship materially strengthened. I rejoice that our two Institutions can combine in the future even more effectively than in the past and that this is the outcome of the splendid work done in one of the branches of our own profession.

I will now resume my Chairmanship and call upon Dr. Jewett, who is one of the Vice-Presidents of the American Telephone and Telegraph Company and a past President of the American Institute of Electrical Engineers."

Dr. Jewett said: "Mr. Chairman, Mr. Gherardi, and fellow members of the Institution of Electrical Engineers and of the American Institute of Electrical Engineers, the opportunity which this occasion offers of addressing jointly two widely separated groups of engineers, who in times past have addressed each other *vis-a-vis* in London and New York, affords me the liveliest satisfaction.

I am gratified to participate in an event which marks both a notable advance in electrical communication and a pioneer demonstration of a wider use for electrical communication. I am frankly pleased that in common with numerous associates on both sides of the Atlantic it has been my good fortune to play a part in the development work which has made this occasion possible.

Col. Purves and Mr. Gherardi will remember and the rest of you will be interested to know that when in London more than a year ago we were engaged in a final consideration preliminary to the opening of commercial Transatlantic Telephony, we discussed details of just such a meeting as this. That our discussion should have been serious and not a pleasant mental diversion at a time when the channels of communication were not in operation is a striking evidence of the sound basis which underlies present day electrical engineering. The fact that we saw and appraised the many obstacles to be overcome did not in the least diminish the assurance with which we talked of and planned for a distant event.

While, therefore, the present occasion is highly gratifying to the engineers whose work has made it possible, it is in no sense a surprise.

Success of this occasion is significant also in that it is the tangible evidence of a co-operation both intimate and full between men so situated as to make co-operation difficult. On behalf of my associates in America, I salute our associates in England."

The Chairman then called upon Col. Purves, Vice-President of the Institution of Electrical Engineers and Engineer-in-Chief of the British Post Office.

Col. Purves said:—"Mr. President, Mr.

Gherardi, Dr. Jewett, and Gentlemen: It is an honour and a privilege to be associated with this notable event, which, one can justly feel, is breaking new ground in the advance of nations towards closer relationship. It is a great thing that two large assemblies separated by wide expanses of ocean, can join themselves together as we are doing now and interchange their thoughts and ideas by the simple and natural medium of direct speech to a combined audience. It opens up the prospect of results which thrill the imagination and which are bound to be beneficient, and to conduce, by the way of clearer mutual understanding, to the good of mankind. On this first occasion it is inevitable that the many professional interests which our two institutions share—and which we should dearly like to talk over with each other—should be pushed a little into the background, and that we should find ourselves preoccupied mainly with the wonder of the thing itself. At our meeting here in London we have just been shown a motion picture which illustrates in a very vivid and interesting way the initiation and progress of a Transatlantic telephone conversation between San Francisco on the Pacific Ocean and Plymouth in old England. We were not able—not yet able—to place it simultaneously before the eyes of you who are sitting there in New York, but some of you, at least, have seen it already. The greater part of it was made on your side and I have to thank your President very heartily for letting us have the completed film. It helps one to recall, and to visualise, the remarkable series of new electrical developments—most of them things of only yesterday—which have combined to make this evening possible.

The Radio art has given us its essential basic principles and the high-power amplifying tubes, which over here we call "Valves"; long-distance telephony has contributed a host of new devices which are equally essential; and specialised broadcasting has given us the loud-speaking receiver.

As we sit and talk to each other our speech is launched into the air, by the radio transmitting stations at Rugby and at Rocky Point, with an electro-magnetic wave energy of more than 80 horsepower, and I may add that the combined effect of the various refinements and special devices included in the transmitting and receiving systems is to make the speech-carrying efficiency of each unit of this power many thousands of times greater than that of an equivalent amount of power radiated by an ordinary broadcasting station. Many further improvements are still being studied.

I should like to express the feelings of great personal pleasure with which I am listening this evening to the voices of my old and valued friends of the American Telephone & Telegraph Co., Mr. Gherardi, Dr. Jewett and General Carty, and to assure them and their colleagues both on my own behalf and on behalf of the engineering staff of the British Post Office, that the increased opportunities of co-operation with them which the development of the Transatlantic telephone system has afforded us, are appreciated in a very high degree. We have to thank them for much helpful counsel, in this and in many other matters, and we look forward with great pleasure to a continuance of our close association with them on the long road forward, over which we still have to travel together."

The Chairman said:—"We are delighted to have with us in New York, General John J. Carty, Vice-President of the American Telephone & Telegraph Company and a past President of the American Institute of Electrical Engineers. General Carty is widely regarded as the doyen (or, to be more correct, the dean) of the telephone engineering profession, and we shall be glad if he will say a few words and propose a resolution on the subject of our joint meeting."

General Carty then proposed the following motion:—

"Whereas on this sixteenth day of February, 1928, the members of the Institute of Electrical Engineers assembled in London, and the members of the American Institute of Electrical Engineers assembled in New York, have held, through the instrumentality of the Transatlantic Telephone, a joint meeting at which those in attendance in both cities were able to participate in the proceedings and hear all that was said although the two gatherings were separated by the Atlantic Ocean; and as this meeting, the first of its kind, has been rendered possible by engineering developments in the application of electricity to communication by telephone; therefore;

Be it resolved that this meeting wishes to express its feelings of deep satisfaction that, by the electrical transmission of the spoken word, these two national societies have been brought together in this new form of International Assembly, which should prove to be a powerful agency in the increase of good will and understanding among the nations;

And be it further resolved that a record of this epoch-making event be inscribed in the minutes of each society."

The Chairman: "Sir Oliver Lodge, who needs no introduction, is sitting beside me, and I have asked him to second the motion."

Sir Oliver Lodge said: "It is surely right and fitting that a record of the transmission of human speech across the Atlantic be placed upon the Minutes of those Societies whose members have been instrumental in making such an achievement possible, and I second the proposal that has just been made from America.

All those who in any degree have contributed to such a result—from Maxwell and Hertz downwards, including all past members of the old British Society of Telegraph Engineers—will rejoice at this further development of the power of long distance communication. Many causes have contributed to make it possible:—

That speech is transmissible at all is due to the invention of the telephone. That speech can be transmitted by ether waves is due to the invention of the valve and the harnessing of electrons for that purpose. That ether waves are constrained by the atmosphere to follow the curvature of the earth's surface is an unexpected bonus on the part of Providence, such as is sometimes vouchsafed in furtherance of human effort.

The actual achievement of to-day at which we rejoice, and which posterity will utilise, must be accredited to the enthusiastic co-operation and to the scientific and engineering skill of many workers in the background whose names are not familiar to the public, as well as to those who are well known.

The union and permanent friendliness of all branches of the English-speaking race, now let us hope more firmly established than ever, is an asset of incalculable value to the whole of humanity. Let no words of hostility be ever spoken."

The Chairman: "Gentlemen, you have heard the Motion proposed by General Carty and seconded by Sir Oliver Lodge. I now put it to the Joint Meeting.

Those in favour. All.
Contrary. None.
Carried unanimously.

The Chairman: "I suggest, Mr. Gherardi, that we now adjourn the meeting. I feel that it has been eminently successful and that we should regard it as the forerunner of many more to come."

Mr. Gherardi agreed.

The Chairman: "That is all the business, gentlemen. The meeting is adjourned. Good-bye."

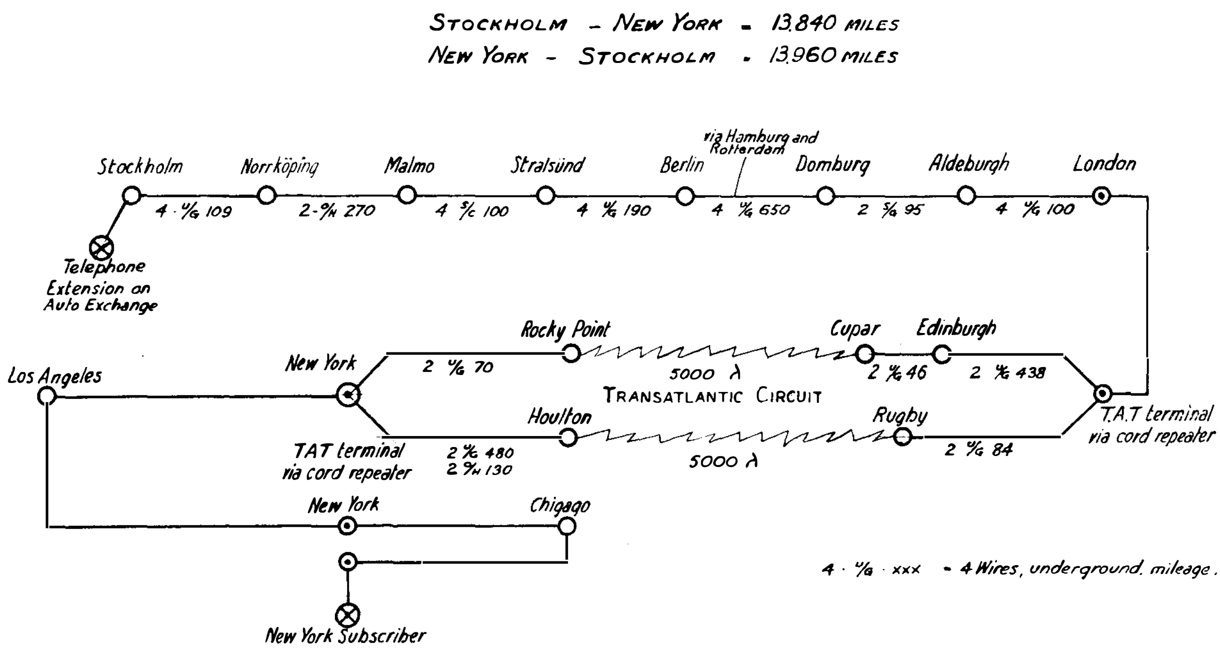
THE LONGEST TELEPHONE CIRCUIT—VIA TRANSATLANTIC SERVICE.

During a recent visit to Stockholm in connection with the extension of the Transatlantic Service to Sweden, a long distance test call was arranged by the London TAT engineers in conjunction with the A.T. & T. Co. engineers in New York. The trial was intended to determine the possibilities of interconnecting long wire circuits with the TAT circuit, and to find if there were any limit to such connections on account of transient phenomena. Accordingly, a circuit was built up which was routed from Stockholm - Berlin - London - New York-Los Angeles - New York - Chicago - New York. The technical features of this circuit include:—

Stockholm-Berlin-London.

1050 miles 4-wire U/G extra light-loaded cable.
270 miles 2-wire O/H.
100 miles 4-wire sea cable (Baltic Sea).
95 miles 2-wire sea cable (North Sea).

This circuit includes 25 four-wire repeaters with cord repeaters at London and Berlin, and with two echo suppressors.



London-New York (TAT).

This is a 4-wire circuit with

440 miles U/G medium-loaded cable
120 miles U/G extra light-loaded cable
3200 miles radio circuit
} New York to London

570 miles U/G extra light-loaded cable
130 miles O/H
2920 miles radio circuit
} London to New York

There are 9 two-wire repeaters toward London, 10 toward New York, 2 four-wire terminal repeaters and there is an echo suppressor at each end of the circuit.

New York Exension.

The special loop in the United States, comprising a Los Angeles loop and a Chicago loop, included:—

4844 miles extra light-loaded cable.
3864 miles open wire carrier.
90 four-wire repeaters.
16 intermediate carrier repeaters.
8 terminal carrier repeaters.
4 cord circuit repeaters.
4 echo suppressors.

This means that the total circuit length was some 13,980 miles toward Stockholm and 13,840 toward New York. There was a total of 115 four-wire repeaters, 24 carrier repeaters, 6 cord repeaters in the wire circuits, and 2 four-wire and 19 two-wire repeaters in the TAT circuit. The circuit included 8 echo suppressors, and finally there were the two radio transmitters and the radio receivers.

The overall circuit was approximately calibrated to be 20 TU, or 2.3 βl, and under the fairly good radio conditions existing at the time of the call the circuit was sufficiently stable for the recognition of persons by their voices. There was no marked trouble from transients, which, if present, are always emphasised by the false operation of the special switching devices at London and New York on the TAT circuit. In view of this result there would seem to be no reason why a similar composite circuit as was extended on the TAT circuit in New York could not be added at the London terminal. If so, we have reached the stage when telephone conversation with high grade lines or carrier systems, interlinked if necessary by radio-telephone circuits, is possible over a range of 21,000 miles at least.

THE "EMPIRADIO" BEAM STATIONS.

A FEW years ago the detached observer might well have formed the opinion that the stage was set for a long controversy as to the relative advantages of long wave and short wave telegraphy for long distance radio communications. There was a serious danger that the continued advancement of this country in the forefront of radio progress would be jeopardized by a failure to realise that for particular purposes each was invaluable, and that the two extremes of the art of radio communication were in fact complementary.

Fortunately, however, following the completion of the Rugby High Power, Long Wave Radio Station, it was decided to proceed with the "Empiradio" Beam Stations.

The construction of the group of stations in this country operating on the Beam system for communication with Canada, South Africa, India and Australia, is the outcome of an agreement made between the Postmaster-General and Marconi's Wireless Telegraph Co. in July, 1924, in which a guarantee was given that effective speeds both of sending and receiving simultaneously at 100 words per minute during a daily average of 18, 11, 12 and 7 hours respectively would be obtained.

The grouping of the stations is in two pairs. Bodmin is a two-beam transmitting station for Canada and South Africa with its corresponding receiving station at Bridgwater, while Grimsby and Skegness are similarly the transmitting and receiving stations for India and Australia.

In determining the location of the stations consideration was first given to the practicability of combining all the transmitters at one site and the receivers at another. The conditions to be met, on the one hand, of avoiding possible interference with broadcasting and other services, and on the other, of ensuring a free path in the immediate proximity of the aerial system clear of trees, buildings and hills were too onerous to permit this ideal solution to be found. To meet the latter condition it was stipulated that there should be no obstruction in front of the aerial subtending an angle of more than six degrees above the horizontal.

A further consideration was the necessity of locating the receiving station a sufficient distance from the transmitting station, and clear of the direct path of the outgoing beam, to avoid interference from this source. The selection ultimately made of locating the Canadian and South African Stations in the South-west of England gives a very short travel overland in the direction of the distant stations before clearing the coast line. The same conditions apply for the Indian and Australian Stations on the North-east coast, except that in the case of Australia as propagation is made alternatively in two directions 180° apart one path is necessarily across England. During the period approximately midday to midnight transmission to Australia is in an easterly direction, *i.e.*, the shorter great circle path, whilst from midnight to midday transmission is in the opposite direction, which, although longer, is chiefly over sea.

All of the sites meet the conditions of being flat, free from woods and buildings or from abrupt changes of contour in the immediate area.

Alternative wave-lengths are used for each transmitter except that for Australia. Those at present employed are:—

To Canada ...	16.574 m.	32.397 m.
,, S. Africa ...	16.146 m.	34.013 m.
,, India ...	16.216 m.	34.168 m.
,, Australia ...	25.906 m.	
From Canada ...	16.501 m.	32.128 m.
,, S. Africa...	16.077 m.	33.708 m.
,, India ...	16.286 m.	34.483 m.
,, Australia ..	25.728 m.	

Buildings.—The main buildings at Bodmin, which are steel framed with concrete walls, are divided into three sections (*a*) Power House, Battery room and offices, 116′ by 57′; (*b*) Transmitter room, 38′ by 34′; (*c*) Absorber and oil pump house, 26′ by 16′. The latter is used to accommodate the absorber resistances, Sturtevant blowers for cooling these resistances, blowers for cooling the seals of the Main Valves, pumps for the circulation of paraffin through the jackets of Main Valves.

The Transmitter room is connected to the Power House by a short covered passage, the continuity between the two buildings being broken in order to avoid the transmission of vibration from the engines and machines to the transmitters.

The buildings at Grimsby are constructed of brick and are similar to those at Bodmin, with the exception that accommodation is not required for oil engines and a separate building is provided for terminating the outside power supply.

At the Bodmin Station the main power supply is provided by three Ruston and Hornsby, three-cylinder, vertical, heavy-oil engines, each giving 165 B.H.P. at 300 revs. per minute and directly coupled to a 92 K.W. compound-wound dynamo delivering D.C. at 440 volts. These engines, which have special 7 ton flywheels, are mounted on a large concrete block supported on cork pads to minimize the transmission of vibration and carried on a concrete raft. The engines are started up by means of two air compressors driven by small auxiliary petro-paraffin engines, air being stored in two containers at 300 lbs. per sq. inch.

The Grimsby Station obtains its power supply from the Grimsby Corporation Electricity Works at 6000/6600 volts, 3-phase, 50-cycles, which is transformed to 400 volts, 3-phase, by means of three 83 K.V.A. single phase transformers. The auxiliary machines at Grimsby are driven by induction type motors, 400 volt, 3-phase, 50-cycles.

With the exception of the power supply the transmitter details are similar at both stations.

The receiving stations are each equipped with two 18 H.P. two cylinder, petrol-paraffin engines direct coupled to 10 K.W. Dynamos, supplying power at 165/110 volts for battery charging and lighting. The general design of all the receivers is the same, with the exception already noted that provision is only made for one wave-length reception from Australia.

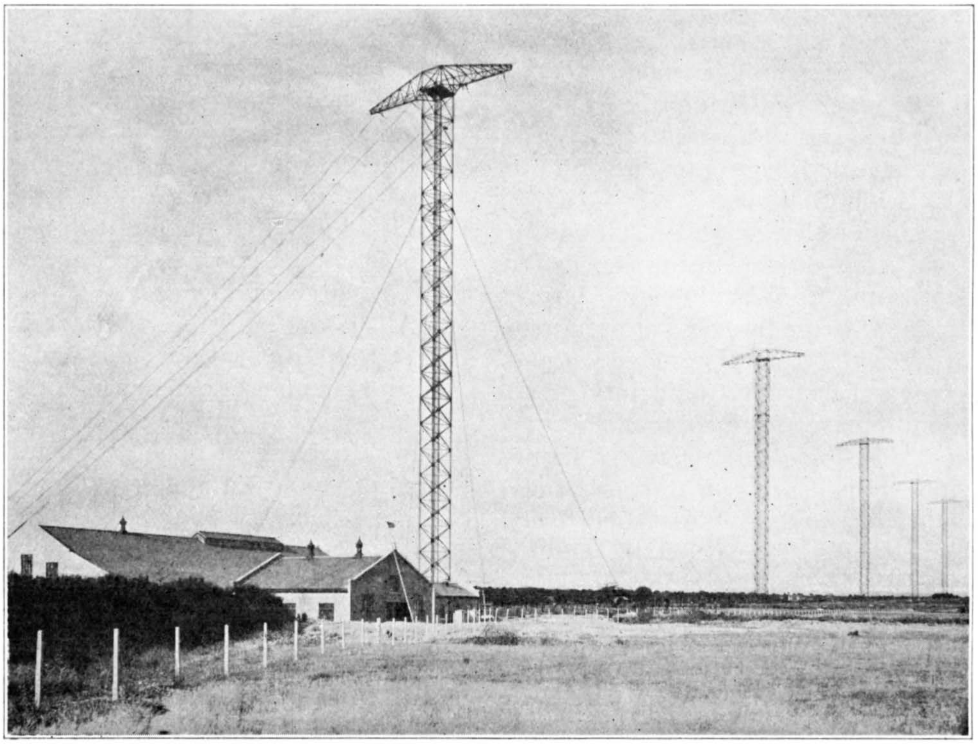


FIG. 1.—BODMIN BUILDINGS AND SOUTH AFRICAN MASTS.

The essential differences between the stations having been noted above, the detailed description will be confined to the Canadian and South African groups.

Site.—The Bodmin transmitting station is about $4\frac{1}{2}$ miles from Bodmin and borders the main road from there to Truro. The total area enclosed for the buildings and aerial system is about 43 acres.

Fig. 1 shows the buildings and the South African masts.

Water Supply.—Water for engine cooling and domestic purposes is obtained from two bore holes on the site.

Storage capacity and cooling is provided for by a ferro-concrete reservoir having a capacity of 30,000 gals.

Power.—All the auxiliary generators are driven by 440-volt direct current motors. They comprise:—

1. Three alternators, each having an output of 50 K.V.A. single phase, 1000 volts, 300 cycles, which supply the main high tension power at 7000 to 10,000 volts to the anodes of the transmitting valves after transformation and rectification.
2. Three alternators, each having an output of 1.2 K.V.A., single phase at 220 volts, 500 cycles, for high tension supply at 2000 volts to the anodes of the valves in the drive or master oscillators, and the first amplifier stage.
3. Two "rectifier filament" alternators, each having an output of 20 K.V.A. single phase at 500 volts, 300 cycles, for heating the filaments of the valves in the Rectifying Panels. The 500 volts is transformed down to 11-12 volts.
4. Two "magnifier filament" generators, each having an output of 18 K.W. D.C. at 24 volts to supply the filaments of all the oscillator valves in the main oscillators, No. 2 Magnifier, and the Main and Sub-Absorber Valves.
5. Two D.C. generators, each having an output of 8 K.W. at 100/165 volts for lighting and control circuits.

Fig. **2** shows the layout of the engine and machine room.

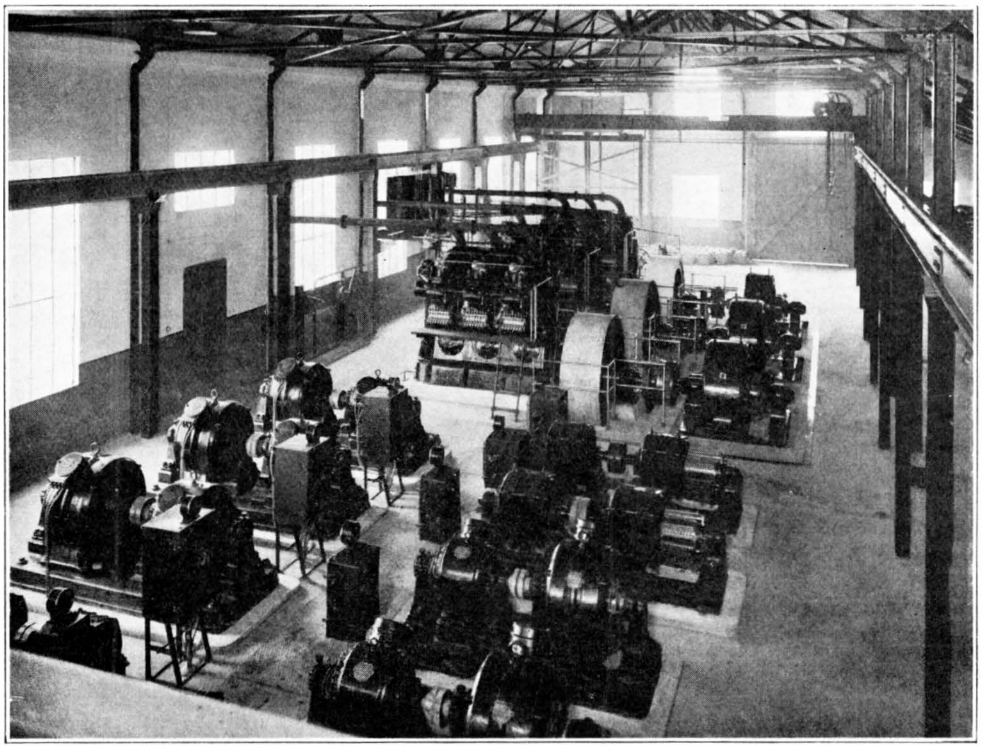


FIG. **2**.—BODMIN ENGINE AND MACHINE ROOM.

Batteries.—In addition to a stand-by lighting battery, special filament lighting batteries are installed for the master oscillator and No. 3 magnifier. These batteries are provided with a discharging resistance and are only put on load over the flat portion of the discharge curve, to ensure constancy in the master oscillator.

400 volt, 5 amp.-hour batteries are supplied for negative grid voltage to the magnifier and sub-absorber valves.

Rectifiers.—One main rectifier and one drive rectifier is provided for each transmitter. Each main rectifier comprises 16 Marconi MR 7A valves associated with smoothing chokes and condensers and step-up transformer for converting from 1000 volts at 300 cycles to 10,000 volts.

The drive rectifiers comprise 2 Marconi MR 7A valves and supply up to 3000 volts D.C.

Fig. **3** shows the Rectifier panels. The transformers and smoothing plant are mounted behind the rectifiers, and the whole is contained in a "high tension enclosure" in a corner of the Machine Room.

Transmitters.—Fig. **4** shows the Canadian transmitter on one side and the South African transmitter on the other, with the Control table in the centre.

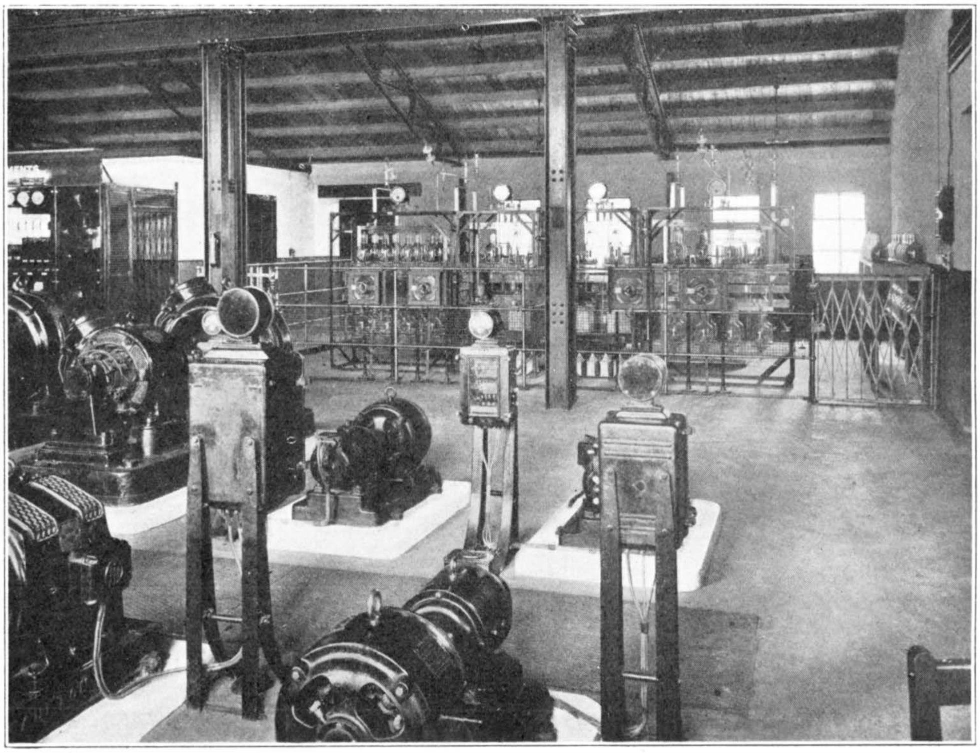


FIG. **3**.—BODMIN. RECTIFIERS.

The transmitters as shown in the photograph have the protective screening in front of the panels removed.

The transmitters are specially designed to ensure stability of wave-length and are controlled by Master oscillators. Constancy of wave-length is obtained (*a*) by careful screening of the master oscillator; (*b*) by a bridge method of connecting the amplifiers whereby the internal capacity between the grids and anodes of the valves is balanced, either by paralleling with a second valve acting in push-pull as in the second and final stages of amplification, or with a balancing condenser as in the case of the first stage; (*c*) and by an absorbing circuit which ensures constancy of load on the power supply during both marking and spacing.

The Master oscillator, which has an anode input of 160 watts, is screened in a copper box. The valve, which is air cooled of type T.250, is self-oscillating and drives the grid circuit of No. 3 magnifier.

No. 3 Magnifier, which provides the first stage of amplification, operates on an anode input of 2000 volts and a feed current of 90 milliamperes. The valve, which is a Marconi M.T.10, is effectively screened in a similar manner to the master oscillator and is coupled to No. 2 Magnifier.

No. 2 Magnifier, which supplies power to the grids of No. 1 Magnifier has two M.T.9F air-cooled valves, the anode supply being taken from the 10,000 volts D.C. supply through resistances. In the marking condition the anode voltage is about 5,500 and the feed 150 milliamperes. In the spacing condition the high

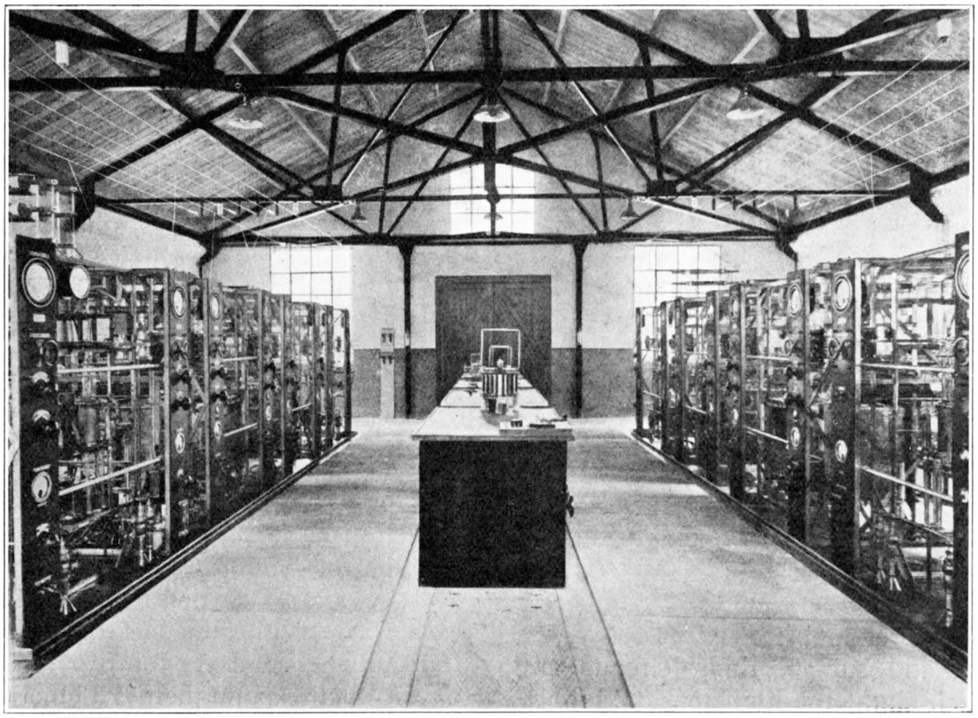


FIG. 4.—BODMIN. CANADIAN AND SOUTH AFRICAN TRANSMITTERS.

tension supply is shunted through the absorber circuits and the oscillation is so reduced that No. 1 Magnifier does not oscillate. The normal grid bias of No. 2 amplifier is approximately 200 volts.

No. 1 Magnifier, the final stage of amplification, has two Marconi type C.A.T.2 Metal-Glass, oil-cooled valves, the filament voltage being about 20 volts and a current of 50 amperes per valve, which is supplied from a 24 volt D.C. Motor Generator.

The high tension D.C. Supply is at from 7000 to 10,000 volts, the feed current being about 1.1 amperes per valve, and the negative grid bias approximately 400 volts under normal working.

The valve seals are cooled by air blast and the anodes are cooled by a closed circulating system of paraffin oil. About 300 gallons of oil, per valve per hour, is circulated and this is cooled by means of coils submersed in water tanks.

The C.A.T.2 Cooled Anode Valves are rated to take an input of 10 K.W. at 15,000 anode volts and are specially designed for short wave transmission, in particular characterised by high insulation and low inter-electrode capacity.

Fig. **5** shows (*a*) Master oscillator (bottom right); (*b*) No. 3 Magnifier (bottom left); (*c*) No. 2 Magnifier (upper half of panel).

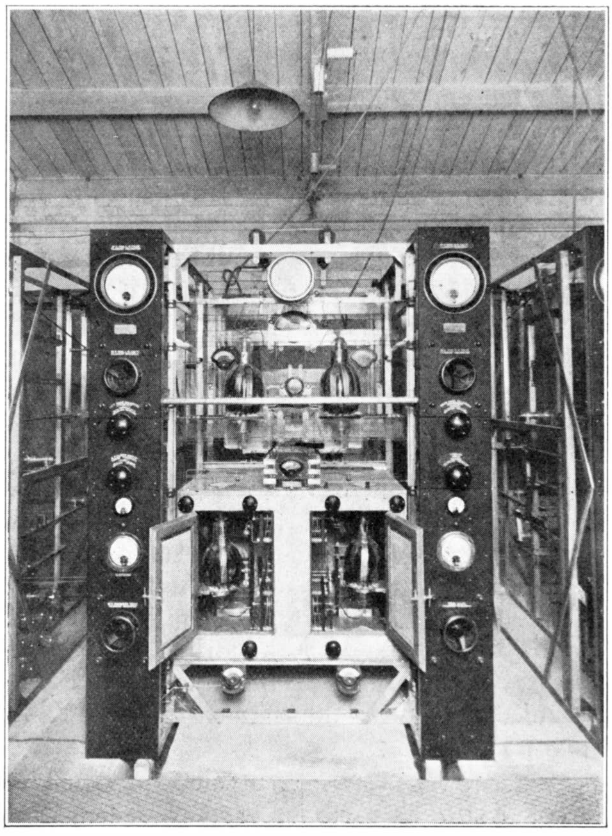


FIG. 5.—MASTER OSCILLATOR, NOS. 2 AND 3 MAGNIFIERS.

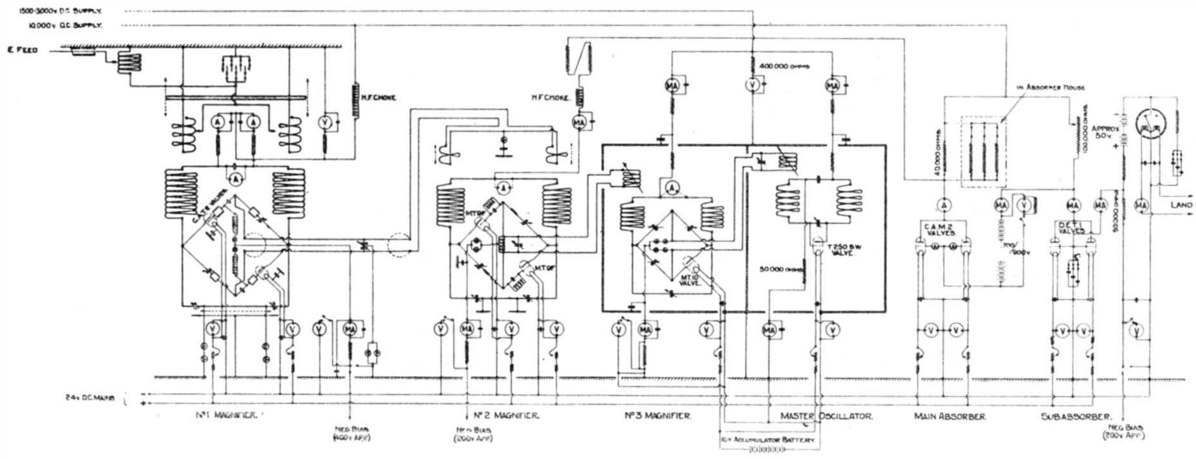


FIG. 6.—DIAGRAM OF TRANSMITTER.

Keying.—Fig. 6 is a diagram of a complete Transmitter.

The keying arrangements are designed to keep the load on the power supply constant, for which purpose main and sub-absorbing circuits are provided, which shunt the high tension supply by means of two type C.A.M.2 oil-cooled, metal-glass valves in parallel through resistances during the spacing periods, and simultaneously drop the voltage on No. 2 magnifier to about 600 volts.

The land line signals pass through an A.T.M. relay, and the spacing and marking currents are arranged to make the grid of the C.A.M.2 Valves conductive or non-conductive by throwing their grids positive or negative. These effects are stepped up through a circuit called the Sub-absorber which has two type D.E.T.1 Valves in parallel.

The main absorber resistances are housed in a separate room and are air cooled by Sturtevant blowers. These resistances are designed to dissipate from 20 to 24 K.W. of energy.

Controls. — The control tables, which are shown in the centre of the Transmitter room, carry three potentiometer type regulators for the control of the voltage of each main power alternator, and also three similar regulators controlling the voltage of the drive power alternators. In addition variable resistances are provided to control the filament current to the valves.

Feeder System.—A completely independent feeder system is used for each wave-length on each transmitter. Fig. 7 shows the two feeders serving the South African aerials at Bodmin. Two bays are allocated to the aerial system for each wave band, and one feeder runs from the transmitter room to the centre point of each pair of bays. At this point there is a junction box which divides into two branches, one going to the centre of each bay. Here there is another junction box and the feeder is again divided equally and branches as before, the process being repeated until there is one branch for each pair of aerial wires. This arrangement ensures that the length of feeder from the transmitter to each aerial wire on one particular aerial system is exactly the same. The feeder terminates at an aerial coupling box containing an auto-transformer, from which an individual feed is made to each aerial wire.

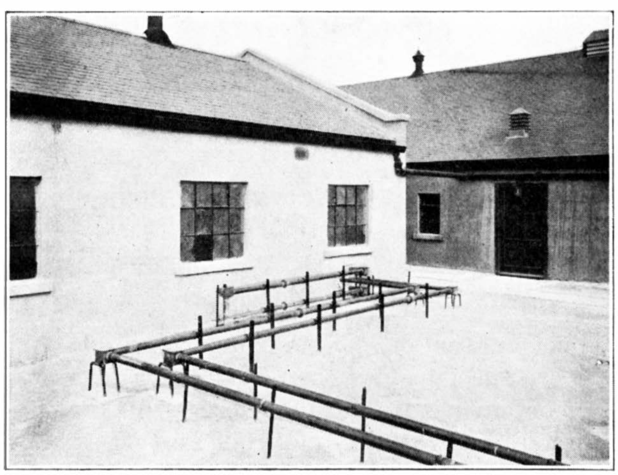


FIG. 7.—BODMIN. FEEDERS FOR SOUTH AFRICAN AERIALS.

Fig. **8** shows a typical layout of the feeder system for wave-lengths of 30-35 metres.

The aerials and feeders are so balanced and adjusted that the sum of the system acts as a pure resistance load on the transmitter so that there is no reflecting wave up and down the feeder system. To ensure this condition, at a point near the transmitter house two loops of feeder tube are so arranged that 3 high frequency thermo-ammeters come into proximity although situated at distances 32 feet apart along the feeder. Reflected waves are indicated by different readings on the 3 ammeters. The feeders consist of two concentric copper tubes air-insulated, the outer being earthed and carried on iron standards driven into the ground, whilst the inner is insulated by means of porcelain spacing insulators.

Special precautions have been taken to provide for expansion due to variations of temperature. Spun metal expansion joints are inserted every 16 ft. on the outer tubes and special boxes are provided at every 160 ft. to allow for expansion on the inner tubes.

At the Transmitting Station the outer tubes vary from $3\frac{1}{4}$ to $2\frac{1}{2}$ inch internal diameter and the inner tubes from 7/8 to 11/16 inch outside diameter.

Masts and Aerials.—Ten masts have been erected at Bodmin and Bridgwater, five being used for the service to Canada and five for South Africa, two bays being utilised for each wave-length.

At Grimsby and Skegness eight masts have been constructed, as only one wave-length is provided for communication with Australia.

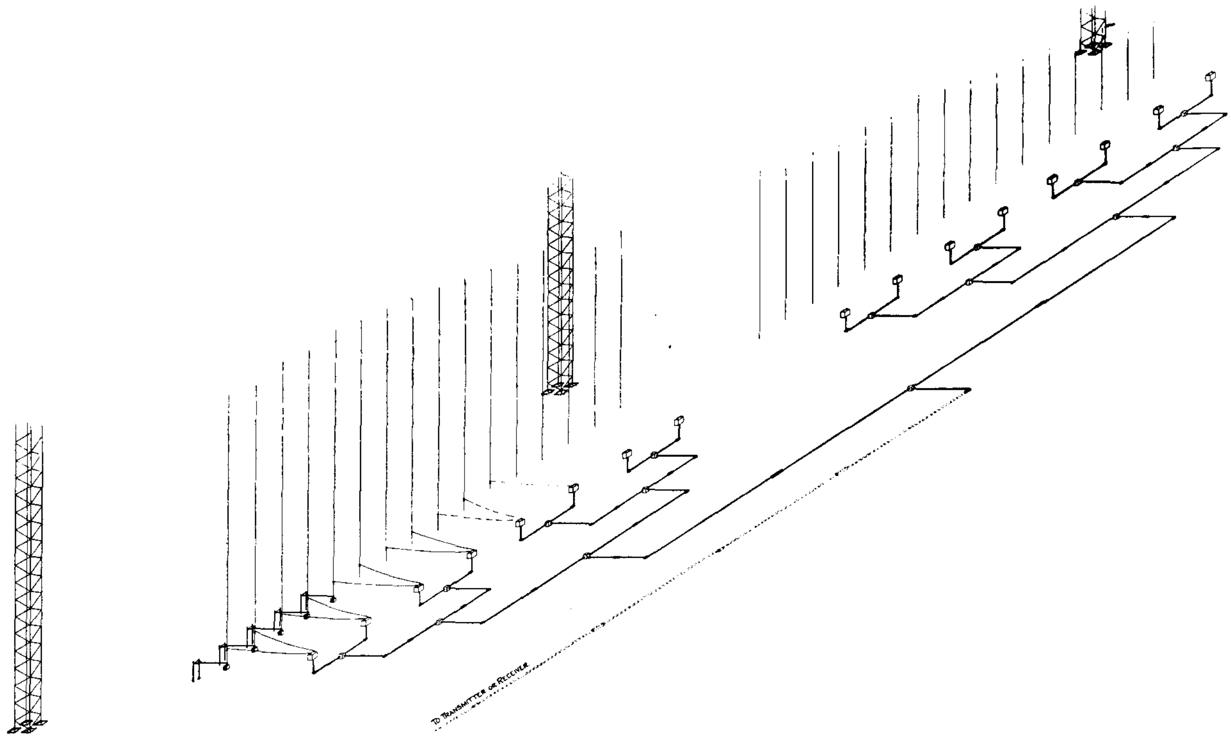


FIG. 8.—SCHEMATIC DIAGRAM OF FEEDERS, LONG WAVE BAYS.

Each row of masts is arranged in a line at right angles to the great circle bearing of the distant station. The masts are of steel-lattice construction with an overall height of 287 feet, except in the case of the Australian masts which are 260 ft. The cross arms are 90 ft. long and also of steel-lattice construction.

Each masts has four legs and cross bracing of angle section, the vertical members being made up of 5″ by 5″ by $\frac{3}{4}$″ angles. The legs are attached by holding down bolts to concrete blocks, each 8 ft. square. The centres of the concrete blocks are 12 ft. apart and the masts are 12 ft. square throughout their length.

The masts are spaced at 650 ft. and each is provided with one set of 4 stays attached at 216 ft. above the ground.

The end masts have also 4 back stays to balance the strain of the triatics.

The aerial and reflector wires consist of a number of vertical wires of No. 16 S.W.G. copper clad steel, suspended from triatics which are attached to the cross arms, the aerial wires being in front of the masts and the reflector wires behind in the direction of propagation.

Inductances are inserted in the aerial wires, and the reflector wires are broken up into insulated sections, the number of wires, their distance apart and the number of inductances being dependent on the wave-length employed.

As a typical example the following are the particulars of the Canadian short-wave bays:—

There are 24 aerial wires spaced at 19′ 0″ apart and twice the number of reflector wires; the latter are spaced at 9′ 6″ and staggered in respect to the aerials so that the projection of an aerial wire on the reflector plane is midway between two wires.

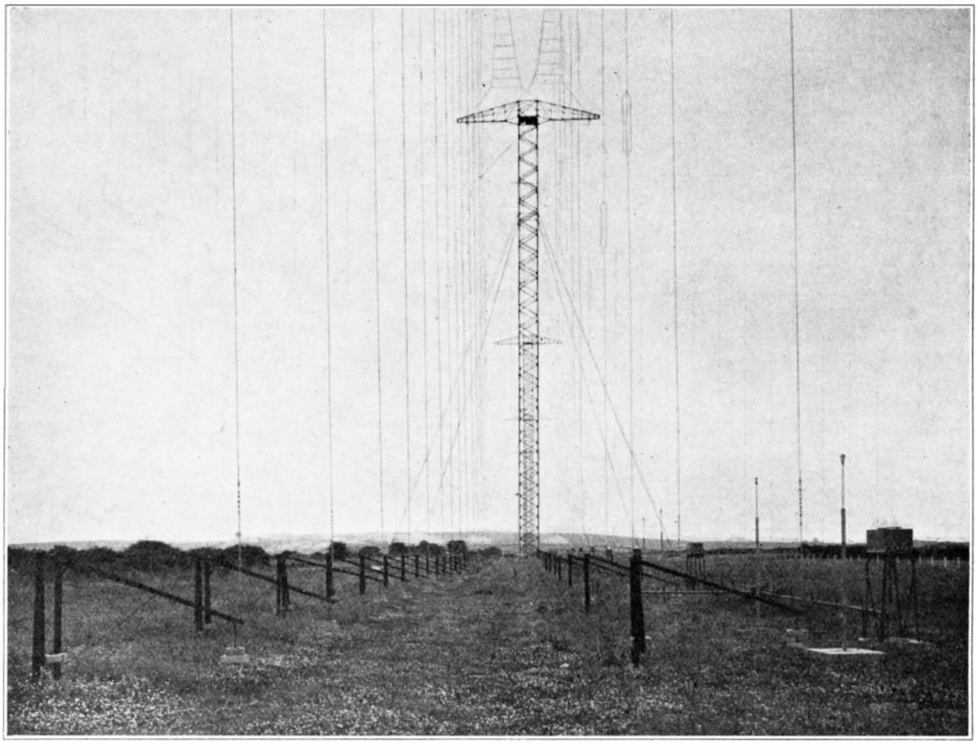


FIG. 9.—BODMIN. CANADIAN AERIALS AND BALANCE WEIGHT SYSTEM.

The triatics are suspended on the double catenary suspension system, and tails of varying length are inserted between the triatics and the aerial and reflector wires to allow for sag in the triatics and to ensure that the average height of the wires follows the contour of the ground surface.

As will be seen from Fig. **9** each vertical wire is brought down to a point within a few feet from the ground, and balance weights are provided to ensure an even tension on each individual wire and to minimise the movement of the wires during high winds.

The distance between the line of aerial and reflector wires is 40 ft., or slightly greater than $\frac{3}{4}$ of a wave-length. In the case of the longer waves the distance is reduced to about $\frac{1}{4}$ wave-length. Each vertical aerial is divided into three straight sections separated by phasing inductances. These lengths are unequal and vary from $\frac{5}{8}$ of a wave-length at the top to about $1\frac{3}{4}$ wave-length from the bottom inductance to the auto-transformer.

The reflector wires are divided into 8 insulated sections, each approx. $\frac{1}{2}$ wave-length in length.

The Australian beam system of reflectors is somewhat different, in this case the wires are in one uninterrupted length earthed at the bottom.

Receivers.—The aerial and transmission lines for the receivers are nearly identical with those used for the transmitters. The buildings for housing the receiver are in two sections, the engine room, and the receiving room and offices, which are joined by a short covered passage but with the continuity broken to avoid the transmission of vibration from the engines to the receivers.

The special characteristics of the receiver are the constancy of the output of rectified current to the line relay under varying amplitude of signal and slight changes of frequency.

It comprises 10 units, each contained in a copper screened box.

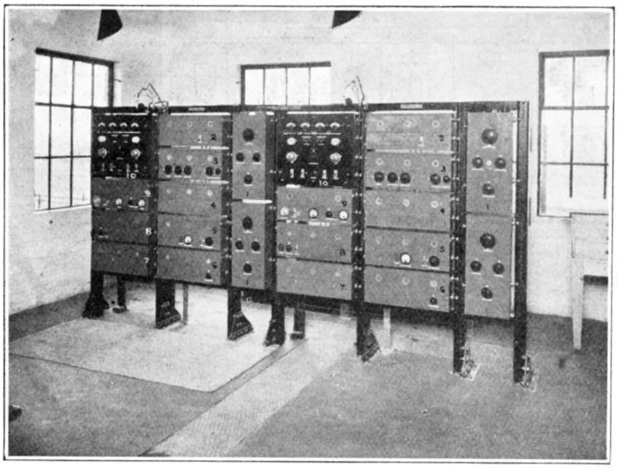


FIG. **10**.—TWO COMPLETE RECEIVERS.

Fig. **10** shows two complete Receivers. The units are:—

1. Feeder Terminal Unit. (In duplicate).
2. Modulator.
3. Incoming short-wave circuits and first hetrodyne.
4. First filter amplifier.
5. First rectifier, second hetrodyne and first listening circuit.
6. Second filter amplifier.
7. Additional second filter amplifier.
8. Main rectifier and second listening circuit.
9. Recorder and limiting circuits.
10. Switchboard for valve testing.

The units are mounted on a vertical iron rack, connections between the units being made at the back, all tuning controls and switches being arranged on the front.

Fig. **11** is a diagram of a complete Receiver.

The feeder terminal unit, where the aerial system is joined to the receiver, has two tuned intermediate circuits which can be weakly coupled together. The second intermediate circuit has a variable coupling to the input circuit of the receiver, which is tuned to the frequency of the transmitted wave and is connected to two modulating valves worked in push-pull. Coupled to this circuit is the first hetrodyne circuit which produces a beat wave of about 1600 metres. The signal on the new frequency has three stages of high frequency push-pull amplification, designed to give a constant amplification over a 10,000 cycle band with a sharp cut-off outside the band. Following the three stages of high frequency amplification, the signals are rectified and again hetrodyned. This second hetrodyne is used alternatively by means of a switch for giving an audible beat frequency or for changing the wavelength to about 10,000 metres. A further three stages of high frequency amplification follows at the 10,000 metre wave-length. This filter amplifier is similar to the first, except that the band width is only 5,000 cycles. Two additional stages of amplification can be added at this frequency if necessary. After the second amplifier the signals are again rectified and the outputs of the rectified valves work in parallel into limiting valve through a milliammeter which indicates the signal strength. The limiting valve is adjusted to give about 3-4 milliamps of plate current when the current in the plate circuit of the rectifier valve is zero. The minimum recording signal strength is that which reduces the plate current of the limiting valve to zero. Any signals of a greater intensity are dissipated in a resistance, so that the energy supplied to a direct current bridge which provides marking and spacing currents for operating the relay is constant. Means are provided for listening to the signal by superimposing an audible frequency oscillator of 1200 cycles from a valve generator on the first hetrodyne.

Land Line Circuits.—The actual operation of the services is carried out at the Central Tele-

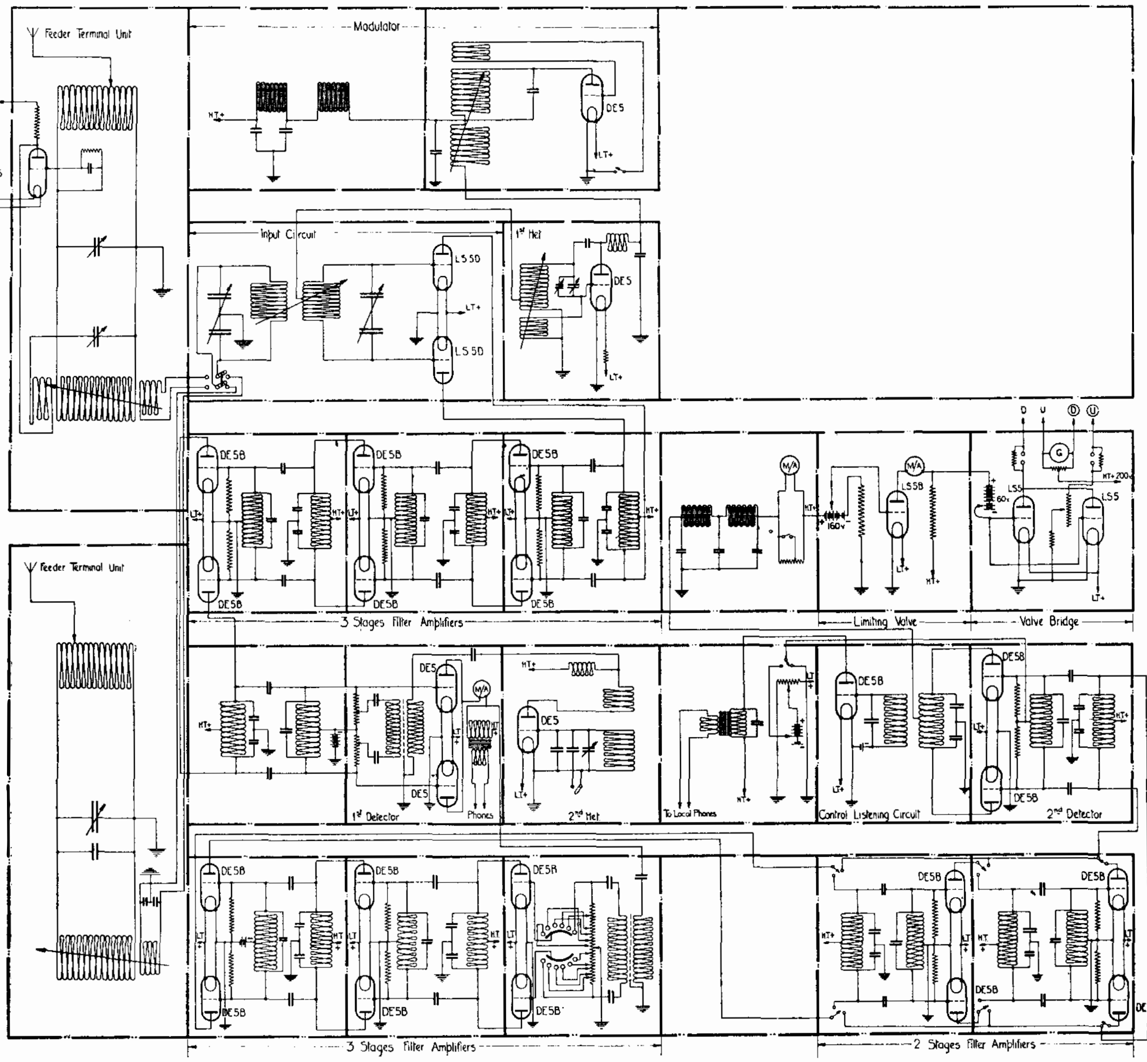


FIG. 11.—DIAGRAM OF RECEIVER.

graph Office, two Wheatstone circuits being allotted to each transmitting station and receiving station.

In addition one double current speaker is provided for each service, the transmitting Station and receiving Station being omnibus on the same line.

In order to check the land line signals at the Beam Station a Wheatstone receiver or undulator is connected in circuit on each line and constant supervision kept of the quality of the signals.

At the transmitting station a pick-up set with Wheatstone receiver is coupled to No. 1 Magnifier on each transmitter so that the signals passing to the aerial can be kept under observation.

The theoretical gain obtained from the use of Reflectors and Multiple Aerials both for the transmitting and receiving stations as employed in the "Beam" System is beyond the scope of this article. It involves the consideration of the intensity of field in the horizontal plane, *i.e.*, the polar diagram in that plane, and also the angle of propagation in the vertical plane.

In the specification governing the Beam Stations the only stipulations were that "the aerial systems to be so designed as to concentrate the emitted waves within an angle of 15° on either side of the axis of transmission; the energy of the radiations beyond this angle not to exceed 5% of those on the axis; the receiving stations to have a similar aerial system designed to have its maximum receiving power in the direction of the desired stations."

In this connection, Fig. 12 is of interest as indicating the field strengths which were measured at Bodmin at a distance of 6217 ft. from the centre of the system with the original aerials operating on a wave-length of 26.086 metres.

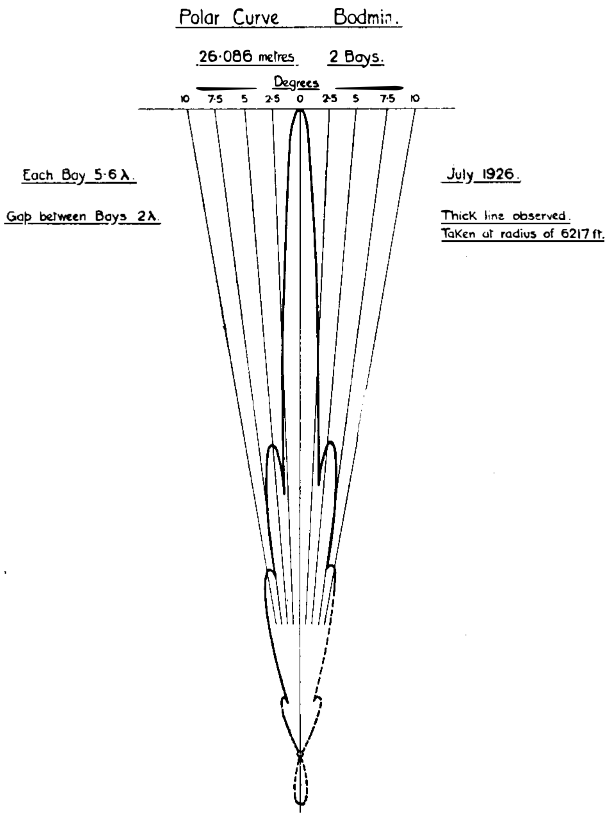


Fig. 12.—Bodmin Polar Curves.

In addition to the gain obtained by concentrating the energy in the required direction from the transmitter, the use of the beam aerial system for the receiver has other apparent advantages. The signal strength is increased proportionately to the wave front intercepted by the aerials and to the reinforcement from the reflectors, whilst the effects of fading, so pronounced at certain periods on short waves, is minimised to some extent.

The successful introduction of the Short-Wave Beam System over long distances and on a commercial basis has been an undertaking of a pioneer nature and of such far-reaching consequences as to reflect great credit on the initiative and enterprise of the Marconi Coy.

The inauguration of the Empiradio service between this country and the Dominions has been followed by the adoption of short-wave directive system on the "beam" principle by many other countries, and has undoubtedly marked a great advance in the art of long distance communication.

The photographs and drawings illustrating this article have been supplied by the courtesy of Marconi's Wireless Telegraph Coy., Ltd., to whom generous acknowledgement is made.

A.S.A.

SEAFORTH RADIO STATION

CONVERSION OF SPARK TRANSMITTER TO CONTINUOUS WAVE AND INTERRUPTED CONTINUOUS WAVE TRANSMITTER.

W. M. Osborn, A.M.I.E.E.

An important event in the history of the British Coast Radio Stations took place on the 16th August last, when the system of transmission by Interrupted Continuous Waves was brought into use at Seaforth Radio Station in place of the Spark system, which has been the system in general use for normal ship and shore communication since the inception of the service.

This innovation initiated a scheme, foreshadowed in an article by Mr. E. H. Shaughnessy on the "Post Office Wireless Services" which appeared in Volume 19, Part 1, of this Journal, for the equipment of the British Coast Radio Stations with Valve Transmitters in anticipation of the probability, which has since been realised, that the next International Radiotelegraph Conference would prohibit the use of Spark in favour of the Interrupted Continuous Wave system. The International Radiotelegraph Conference held at Washington, U.S.A., in October last agreed, subject to ratification by the Governments represented, to prohibit the use of the Spark system by land stations after January 1st, 1935, and by ship and all other stations after January 1st, 1940, except stations using less than 300 watts primary power.

The Interrupted Continuous Wave system is the equivalent of the Spark system in so far that both systems employ types of emissions which can be received on a crystal receiver or on an ordinary valve receiver without a heterodyne. Interrupted Continuous Wave transmission causes much less interference to broadcast and other services than Spark transmission; this is due to the sharper resonance curve obtained with the former as compared with the latter transmission.

It was considered desirable to gain some experience of the suitability of Valve Transmitters for the operating and range requirements of the Coast Station Service before proceeding with the general replacement of the Spark Transmitters at the Coast Stations; the Seaforth Station was selected for this purpose in view of the small amount of structural alterations required to accommodate the new plant and also on account of the desirability of minimising the interference to broadcast reception experienced in the thickly populated area around Liverpool. The Seaforth Station is situated only 4 miles, approximately, from the centre of Liverpool.

The Spark Transmitter at Seaforth Radio Station was a 1½ K.W. Set of the Radio Communication Coy.'s standard type and was installed by the Company in 1922. A contract based upon a specification prepared in the Post Office Engineering Department was placed with the Radio Communication Coy. for the conversion of the Spark Transmitter to a Valve Transmitter adapted for Continuous Wave and Interrupted Continuous Wave telegraphy. The contract provided for the utilisation, as far as possible, of the existing apparatus and for the work to be carried out without interruption to the activities of the station.

Provision has been made for Continuous Wave and Interrupted Continuous Wave equipment in anticipation that the Continuous Wave system will at some time be utilised for some purposes in ship and shore communication; the Interrupted Continuous Wave system may ultimately be reserved for calling and distress purposes.

General Description. — The new equipment comprises Main 1½ K.W. and Emergency 100 watt coupled circuit Valve Transmitters. The Main Transmitter is equipped for operation on 220, 600 and 800 metre waves and, in addition, provision is made for continous change of waves between 780 and 820 metres. The changes in wave and variations in power are effected from the operator's position by a Bowden wire system of remote control. The Emergency Transmitter is equipped for operation on a 600 metre wave only.

For Interrupted Continuous Wave transmission both Transmitters are designed for a note frequency of 1000 per second.

The main aerial of "umbrella" type, supported by a mast 150 feet high, is used for the 600/820 metres wave range. The insulation of this aerial was improved, prior to the conversion of the transmitter, by the replacement of the old type rubber strop insulators by porcelain rod insulators; this was desirable in view of the high standard of aerial insulation required for satisfactory valve transmission. For the 220 metres transmission a separate aerial consisting of a single wire, approximately 80 feet in length suspended from a pole 80 feet high, has been provided.

Power for operating the Main Transmitter is taken from the 460 volts D.C. public supply service; the Emergency Transmitter is arranged for operation from a battery of secondary cells, to ensure that the station shall not be completely out of action if the power supply service fails or for other similar reason.

Lay-out. — The duplicate motor-alternators, main transformer and power panel which formed part of the Spark installation have been retained. The motor-alternators and a motor-generator for the Emergency Transmitter are accommodated in the Machine Room adjoining the Operating Room; the power panel and the transmitting plant are installed in the Operating Room. The Transmitters are assembled behind a protecting lattice screen on an apparatus bench near the operator's position; the indicating instruments associated with the Transmitters are under the operator's observation and all control of the plant is effected from the operator's position.

Control.—Bowden wire controls working over a system of pulleys are provided for switching over either aerial to the Main or Emergency Transmitters and for wave changing. The change-over from Continuous Wave to Interrupted Continuous Wave and *vice versa* with either Transmitter is effected by hand-operated switches; an automatic starter with press button control for the motor-alternators and a hand-operated switch for the control of the emergency motor-generator are provided, and the change-over of the aerial in use from the Transmitter to the Receiver is also effected electrically by a switch at the operator's position.

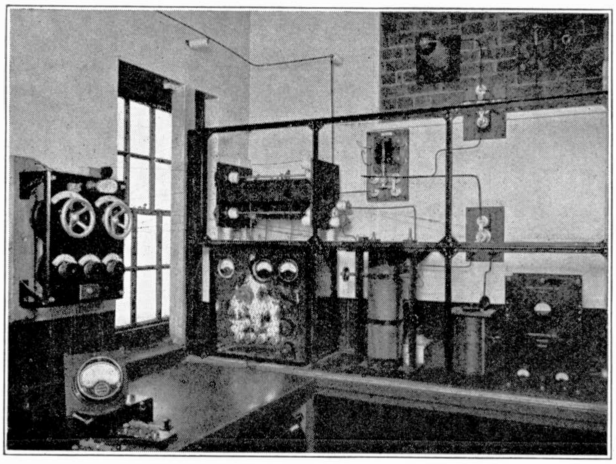


FIG. 1.—SEAFORTH RADIO STATION.

The Transmitters operate in conjunction with the Station's Valve Receiving plant and are associated with that plant by means of a " Send-Receive " switch which provides for the isolation and protection of the Receiver from the Transmitter when the latter is in operation.

Fig. 1 is a photograph of the new transmitting equipment as installed at Seaforth with the protecting screen removed and without the power panel. The Bowden wire control panel can be seen mounted on the wall over the operating bench on the extreme left of Fig. 1; the Main Transmitter is shown on the left and the Emergency Transmitter on the right assembled with their component parts on the apparatus bench; the leading-in insulators and the switching accessories can be seen mounted on the wall over the apparatus bench.

The two transmitting keys shown in Fig. 1 on the left of the operating bench are associated with the Main and Emergency Transmitters respectively. The ammeter shown immediately behind the transmitting keys indicates the aerial current for both Transmitters, and is of the moving coil type shunted across a thermo-junction in the aerial circuit.

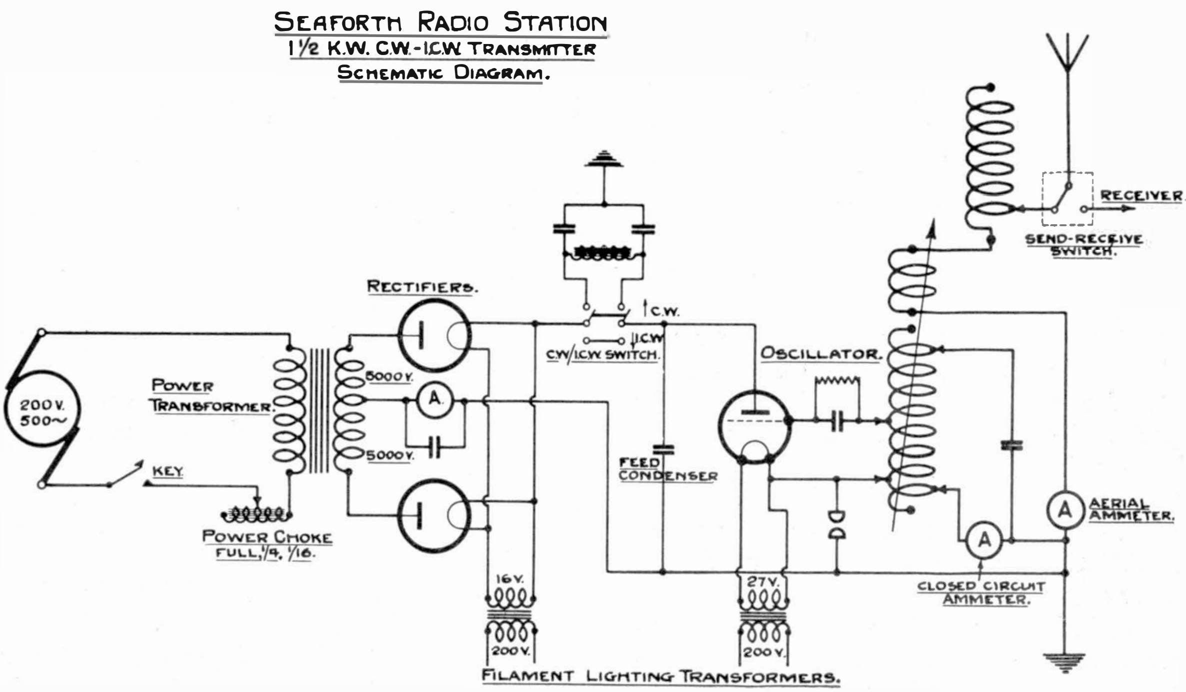


FIG. 2.

Figs. **2** and **3**, respectively, are schematic diagrams of connections of the Main and Emergency Transmitters.

Main Transmitter.—The Main Transmitter is of the Radio Communication Coy.'s standard type modified to meet the Post Office specification requirements.

The Transmitter consists of an angle iron structure with enclosing side panels and a hinged front gate, which is fitted with a safety switch so that the H.T. transformer circuit is broken when the gate is open.

The 5000 volts H.T.D.C. supply for the oscillating valve is obtained from a motor-alternator and transformer associated with rectifying valves as indicated in Fig. **2**. The motor-alternators are rated for an output of 1½ K.W. at 200 volts at a periodicity of 500 cycles per second. The rectifying unit employing two glass valves rated at 150 watts anode dissipation is of standard " full-wave " type, thus producing a ripple in the H.T.D.C. supply at a frequency of 1000 cycles per second.

The rectified H.T. supply is smoothed for continuous wave transmission by means of choke and condenser units; for interrupted continuous wave transmission the smoothing unit is disconnected, when the waves generated by the oscillating valve are modulated at the frequency of the rectified H.T. supply, viz., 1000 per second, which is the emitted note frequency of the Interruped Continuous Wave Transmitter.

The oscillating valve is of glass type rated at 300 watts anode dissipation.

The filaments of the oscillating and rectifying valves are heated by the 200 volts A.C. supply transformed down to the required filament voltages. Variable chokes for regulating the brilliancy of the oscillator and rectifier filaments and an adjustable compensating choke for the purpose of maintaining the brilliancy of the filaments during the intermittent keying load are included in the primary circuit of the transformer; for simplification, these chokes are not shown in Fig. **2**.

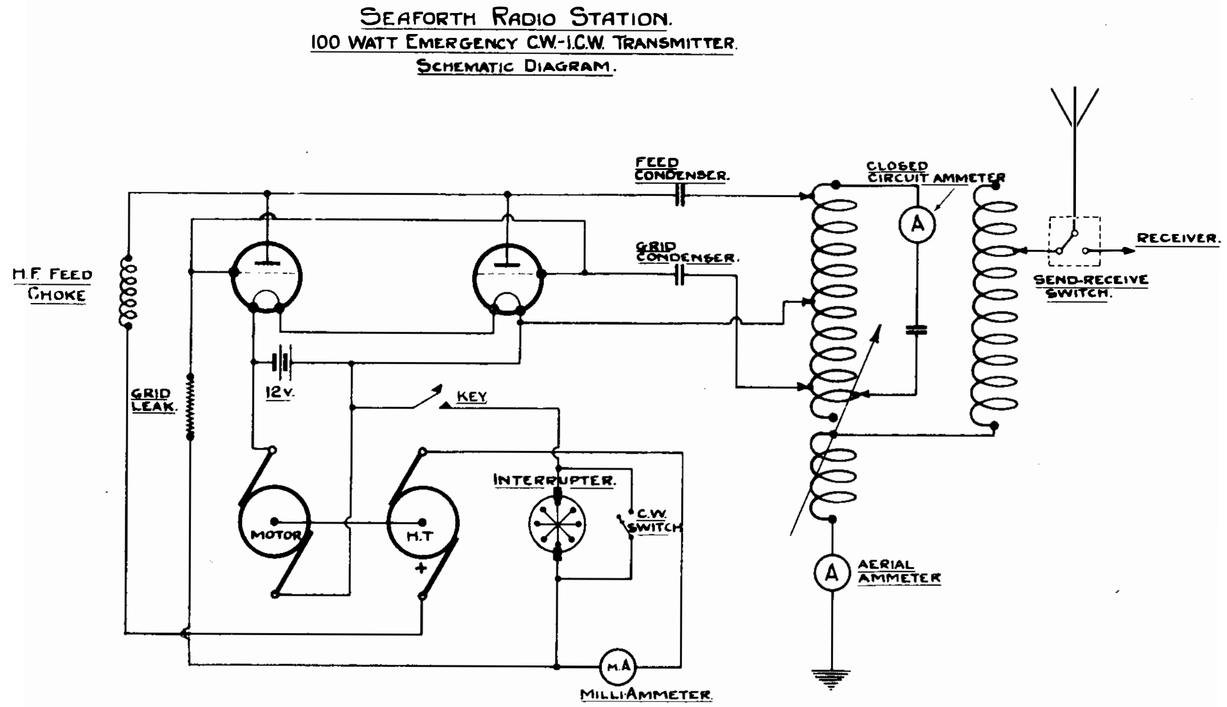


FIG. 3.

The oscillating valve is associated with a closed oscillatory circuit loosely coupled to the aerial circuit.

The closed circuit and aerial tuning inductances are of plated copper strip wound edgewise on grooved insulating supports to which connections and wave-change tappings are made by spring clips. Variometers are included in the closed and aerial circuits for continuous wave change between 780 and 820 metres.

The condensers enbodied in the Transmitter are of the mica di-electric type.

From Fig. **2** it will be seen that the signalling key and a power switch regulable to 1/16, ¼ and full power are included in the main transformer primary circuit; the power switch is provided to facilitate compliance with the Operating Regulation calling for the use of minimum power for effective communication.

Emergency Transmitter.—The Emergency Transmitter is a self-contained unit of the panel type and is designed to operate with a total power input of 100 watts from a 12 volt battery of secondary cells of 120 ampere-hour capacity.

From Fig. **3** it will be seen that two valves are employed with their filaments in series and that the battery supplies current for the filaments and also for the motor-generator which supplies the H.T.D.C. power to the anodes of the valves.

The motor-generator is designed for an input of 80 watts and an output of approximately 40 milli-amperes at 1000 volts D.C.

The Transmitter employs two glass valves as oscillators, connected in parallel; the valves are of the dull emitter type capable of dissipating 40 watts at the anodes.

The circuit employed is that of the well known Hartley oscillatory circuit associated with a coupled circuit.

For Interrupted Continuous Wave transmission, the valve oscillations are interrupted by making and breaking the grid and anode circuits at audible frequency by means of a rotary interrupter mounted on the shaft of the motor-generator and revolving at the same speed as that machine. In operation, the oscillations generated by the valves are interrupted at a frequency determined by the speed of the motor-generator and the number of insulating segments in the rotary interrupter.

For Continuous Wave transmission the brushes of the interrupter are short-circuited by a switch.

Test Results. — The valve equipment has proved eminently satisfactory as regards reliability, facility of operation and transmission range; experience has shown that 1/16 power is sufficient for the major portion of the traffic requirements of the Station.

On test, the flank Stations at Portpatrick and Fishguard reported a definite increase in signal strength over the old Spark signals, and it is generally agreed by other Stations that the Interrupted Continuous Wave transmission is very sharply tuned and that the note is clear and steady. With 1/16 power in use satisfactory tests with crystal reception have been obtained at sea ranges of over 150 miles from Seaforth.

Opinions from reliable sources are generally in agreement that a definite diminution in the interference to broadcast reception has resulted from the change-over from Spark to Interrupted Continuous Wave transmission at the Seaforth Station, especially in the case of receiving stations situated within one mile of the Station. In this connection it is of interest to note that Wireless Operators in vessels approaching the Port of Liverpool could formerly listen-in to the Liverpool Broadcast Station's programmes (6LV, 297 metres) and at the same time receive Seaforth's Spark signals on 600 metres, but since the change-over the closer tuning required for the reception of the Interrupted Continuous Wave transmission renders impossible the simultaneous reception of Seaforth's signals and the Liverpool broadcast.

Development.—Following on the successful installation of the Valve Transmitter at Seaforth Radio Station, arrangements are in train for the general adoption of this type of Transmitter at all other Coast Radio Stations in place of the existing Spark Transmitters. This reorganisation scheme will provide for 1½ K.W. Transmitters at the Niton (Isle of Wight), Fishguard, Portpatrick, Cullercoats and North Foreland Stations, a 3 K.W. Transmitter at the Wick Station and, probably, two 6 K.W. Transmitters at the Land's End Station.

Provision will be made for flank Coast Stations to have different note frequencies to avoid the possibility of confusion which might occur to ships stations receiving signals of equal strength from two Coast Stations having notes of the same characteristic and frequency.

The installation of the new plant will involve the re-modelling of the Station buildings. The North Foreland Station is to be removed to a new site at St. Peters, Broadstairs, and at Cullercoats a new building is to be erected on the existing site.

The " Humber " Radio Station at Grimsby was removed to a new site at Mablethorpe on the 6th December last; the new Station is equipped with a 1½ K.W. Transmitter of similar pattern to that installed at Seaforth. It is hoped to give a descripion of the new " Humber " Station in a future issue of this Journal.

It is interesting to recall that the last comprehensive re-organisation of the Coast Radio Stations took place over 15 years ago and was described in an article by Messrs. E. S. Perrin and F. W. Davey, published in Volume 6, Part 4 (Jan., 1914), of this Journal.

NEW DISCOVERIES, NEW TOOLS, NEW PROBLEMS.

A BRIEF REVIEW OF SOME OF THE RECENT ADVANCES IN PHYSICS.

W. G. RADLEY, B.Sc. (Hons.), A.M.I.E.E.

NEW DISCOVERIES.

BY the year 1895 a certain degree of completeness had been given to the edifice of physics. A perfectly satisfactory explanation had been found for the great majority of phenomena which had been observed in the laboratory. Following on the experiments of Faraday, Maxwell had developed a theory of light which, by presenting a value for the speed of the imagined electromagnetic waves determined exclusively from measurements upon magnetic and electric fields, had united at one swift stroke two hitherto separate branches of physics. Newton's old corpuscular theory of radiation seemed to have passed finally into the limbo of forgotten things. As far as we could see, everything was in order. But our vision was limited by the microscope. And in that same year Rontgen, looking for some form of radiation which should have a greater power of penetration than visible light, discovered X-rays. A year later and Henri Becquerel had made the discovery of the curious property of radio-activity in uranium and its compounds.

The tools which these two discoveries put into the hands of modern scientists have led to great and amazing advances in our knowledge of matter. And very much of the new knowledge —both of matter and of radiation—has proved to be incapable of explanation in terms of the old familiar theories. Ideas have had to be revised. In more ways than one, new facts which have come to light have necessitated a revolutionary change in outlook.

During the same period immense technical advances in the art of communication—the application of the thermionic valve to both cable and radio circuits to take only one example—have absorbed the full attention of the telephone engineer, and have left him little opportunity to keep abreast of those rapid developments in pure science on which the whole art of engineering is ultimately based. Perhaps, therefore, a very brief sketch of the broad outlines of modern development may be of interest to readers.

NEW TOOLS.

(i) *The X-ray Method.* The principal significance of Rontgen's discovery lay in the fact that it was to provide a means of vision which should enable us to see greater detail in the structure of matter. During the lapse of more than two hundred years that had passed since its invention, the compound microscope had been perfected almost up to its theoretical limit. This is such that, using ordinary light, we can never hope to distinguish by its aid the shape of a body much smaller than a wave length of light, *i.e.*, about .0005 millimetre. The wave-length of the rays emitted by an X-ray tube with a tungsten target are approximately 1/5000 of this, that is, of the same order as the size of atoms. An X-ray microscope is not yet available; but suppose a piece of material to be irradiated by a beam of X-rays. Each atom will act as a scattering centre for the X-ray waves falling upon it. We cannot detect the waves scattered by a single atom. However, if there is any regularity about the arrangement of the atoms throughout the body of the material, along certain directions for rays of one definite wave length waves scattered by a large number of atoms will be in phase with one another. They will then reinforce each other and produce a reflected ray of such intensity that it can be detected on a photographic plate. The principle is exactly the same as that employed by the experimenter with visible light, when by means of a closely ruled grating he splits up a beam of light into its spectral colours. If now, instead of employing a heterogeneous beam of X-rays of all wave lengths, we arrange that the beam shall contain rays of one wave length only (λ), reflection will not take place unless certain critical relationships are fulfilled. These are such that, if the atoms be arranged on a regular series of planes distant d apart, both incident and reflected rays must make with these planes an angle θ which satisfies the equation,

$$n\lambda = 2d \sin \theta \qquad (1)$$

n being any whole number.

analysis has proved to be wonderfully useful. Not only can it be applied when the material is in the form of a single crystal; it yields results whenever there is the slightest regularity about the structural arrangement, even if each separate element of regularity is ultra-microscopic in size. Fig. **1**, for example, is a reproduction of an X-ray spectrogram taken in the Research Section from carbon granules out of a telephone transmitter. Contrary to time-honoured ideas this carbon is not strictly amorphous, that is, without the elements of a crystalline structure. The fact that X-rays of one wave-length were reflected from it more strongly at certain angles than at others reveals that it has a definite structural pattern. And this pattern is the same as that of graphite, because the angles at which reflection occurs are the same for the two materials. The result obtained when graphite is substituted for the carbon granules is shown in Fig. **2**. It will be seen that the reflections correspond, though the pat-

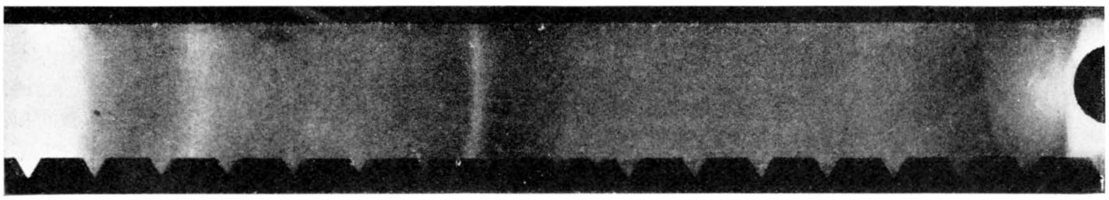


FIG. 1.

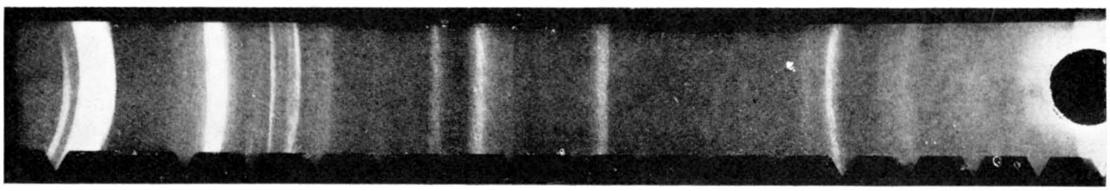


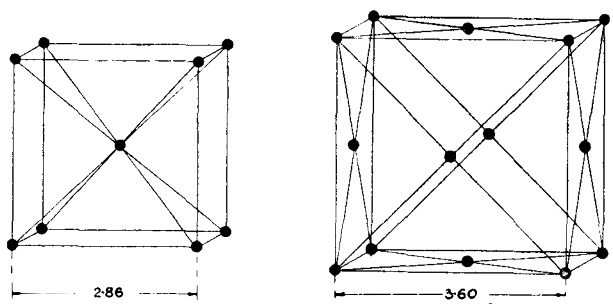
FIG. 2

This at once gives us a means by which we are able to interpret the arrangement of groups of atoms traversed by a beam of X-rays, almost as exactly as if we had an X-ray microscope. Instead of guessing the internal arrangement of its atoms from the outward form assumed by a crystal, we find ourselves able to measure the actual distance from atom to atom.

The original experiments were made at Munich by v Laue seventeen years after the first discovery of X-rays. Very much of the subsequent development of the method is due to Sir William and W. H. Bragg. This method of

tern obtained on Fig. **1** is very much more ill-defined, and only just beginning to appear as it were. This is explained very perfectly by the fact that the homogeneous fragments of graphite crystal in the amorphous granules are still exceedingly minute.

To the metallurgist the method of X-ray analysis is invaluable. Deformation of the structural arrangement due to too vigorous cold-rolling or stressing, fibreing, or the effect of annealing in causing growth of the little elements of regularity—all are revealed. It enables him to follow an atomic re-arrangement taking place within a metal as its temperature is raised. For instance, in a series of experiments Westgren found that for an iron wire at ordinary temperatures the arrangement of the atoms was as in Fig. **3**. He heated the wire to a temperature just over 900°C, and the atoms re-arranged themselves according to Fig. **4**. Iron, when heated to a high temperature, becomes non-magnetic. But we have not by chance stumbled on the secret of ferro-magnetism. The change in atomic structure cannot be made to explain the loss in magnetic properties. One does not take place until 200° C after the other with pure iron. Besides, al-



Dimensions in Ångstrom Units : 1 Ångstrom Unit = 10^{-8} cm.

FIGS. **3** AND **4**.

though iron at normal temperatures regularly crystallises according to the pattern shown in Fig. **3**, nickel and cobalt, the other two strongly magnetic elements, are magnetic when found in the pattern shown in Fig. **4**. At the most, both changes which occur when the iron wire is heated can only be the result of internal changes taking place within the atom itself.

(ii) *The use of Alpha particles.* The interior of the atom has not been nearly so completely explored. Indeed, had it not been for Becquerel's discovery of the radio-active elements, the interior might have remained completely unknown right up to the present day, for radio-active elements are the source of alpha particles. And a vast amount of theory about the internal structure of the atom rests solely on the evidence of experiments which have been conducted with the aid of these fast flying particles. It is as if the advance guard of an army of discoverers having arrived at last before the walls of the atomic citadel Nature had handed out to them just the projectiles needed to batter down those walls and disclose what was inside.

It was thought at first that the effect produced by radioactive compounds on a photographic plate held near them was due to their emitting some new kind of ray. They were firing off something of even greater value—positively electrified particles of matter with an initial velocity of over 10^9 cms. per second. Later, the mass of one of these particles was found to be equal to that of the helium atom, the electrostatic charge carried by it to $+2e$.* Losing an alpha particle, a radio-active atom transmutes itself into an atom of the element lying two places further down the periodic table. Each atom of radium gives up five of these alpha particles before it finally appears as lead; but so enormous is the velocity with which they are fired off that a single one of them is capable of producing a distinct scintillation when it hits a phosphorescent screen.

When alpha particles are fired into a gas, each one of them leaves behind it a trail of ionised atoms. If this takes place in a supersaturated atmosphere each ion formed will become the centre of a minute drop of water; so that when they are illuminated a photograph can be obtained of the track of the alpha-particle. Striking photographs taken in this way show that the tracks of the great majority of the alpha particles are perfectly straight from beginning to end; but an occasional one will show an abrupt change of direction, just as if the flying particle had come into collision with some heavy mass. Not only will the alpha particle ordinarily take an undeviating course through hundreds of thousands of gas molecules, but more remarkable still, it will pass through thin sheets of metal foil. There is obviously only a very small part of each atom which is impenetrable to these swiftly flying particles. The original experiments of Sir Ernest Rutherford along these lines established the amazing fact that the interior of the atom was mostly empty space.

The fact that a certain proportion of the alpha particles which fell upon the metal foil were scattered through definite angles gave Rutherford some evidence of the size of the impenetrable nucleus. His latest estimate of the diameter of the nucleus of the lighter atoms is approximately 5×10^{-13} cms. When we remember that the diameter of most atoms is round about 10^{-8} cms.,

* *$e = 4.774 \times 10^{-10}$ absolute electrostatic units.*

or 20,000 times the diameter of the nucleus, the amazing emptiness of the atom at once becomes apparent.

The nucleus is positively charged. That this positive charge, measured as a multiple of the natural unit charge, "is the same as the number of the place occupied by the element in the periodic table" was Moseley's splendid idea. It had been known for some time that the wave-length of X-rays should be of the order of 10^{-8} or 10^{-9} cms. To construct a ruled grating with a spacing suitable for the measurement of such tiny wave-lengths was unthinkable. But it had just been shown that the regular spacing of the atoms in a crystal would act as such a grating—as we have already seen. This enabled Moseley to measure the wave-length of the lines in the X-ray spectra of a large number of the elements. The simplicity and regularity of the steps, as he went from one element to the next, gave him invaluable evidence of the correctness of his theory. A great amount of subsequent work in every direction has gone to strengthen that theory. Under its guidance all the elements have fallen into an ordered procession which, extending from hydrogen with unit nuclear charge to uranium with a nuclear charge of ninety-two units, has now remaining only two vacant places. These correspond to the atomic numbers of 85 and 87. The atomic number has become of more fundamental importance than the atomic weight of the chemists. It specifies the positive charge on the nucleus, and the nuclear charge determines all the chemical and electrodynamical properties of the atom.

Curiously enough, Aston has recently shown that, expressed on the scale on which the atomic weight of oxygen is 16, the atomic weights of practically all the elements are whole numbers. The existence of an apparently fractional atomic weight, such as that of chlorine (35.46), is explained by the fact that this gas is in reality a mixture of two isotopes, each having a nuclear charge of 17 units and exactly identical in chemical properties but having atomic weights of 35 and 37. All chemical methods, such as those employing diffusion, entirely fail to separate these two isotopes. Aston's method was to cause ionised atoms of chlorine to pass successively through an electric and a magnetic field. Each of these fields deflects the flying atoms, the deflection given to each atom depending on its mass and also on the nett electrostatic charge carried by it. In this way atoms with a mass of 35 can be made to strike a photographic plate at a different point from those carrying the same charge but with a mass of 37. Aston's achievement was not to measure the mean atomic weight of a mixture of thousands of millions of atoms. His apparatus recorded the weight of individual atoms.

In the neutral atom of atomic number Z, the total positive charge on the central nucleus (Ze) is balanced by Z electrons each carrying a negative charge equal to $-e$. The existence of these electrons has been known experimentally since just before the beginning of the present century. Sir J. J. Thomson was their discoverer. He first observed their presence in a tube filled with a rarefied gas through which an electric discharge was being passed. It has since been shown that they can be coaxed out of all matter. They must therefore form a universal ingredient to every atom made up by Nature. This is revealed by experiment.

An individual electron can be captured on a droplet of oil, or on a minute solid particle, and the amount of its charge determined. Millikan, as a result of a series of most delicate measurements, gives this amount as 4.774×10^{-10} electrostatic units. It never varies. It is the natural unit of charge, and by convention is always denoted by the letter e. When a magnetic field is applied to a stream of electrons all moving with the same speed, the electrons are all deflected to the same degree, which shows that they all have the same mass. This is practically equal to 9×10^{-28} grammes, which is about $\frac{1}{1840}$ of the mass of the hydrogen atom—the lightest atom known.

It would take about one thousand million million iron atoms to make up a grain of dust just visible to the naked eye. If we were to construct a scale model of one of those iron atoms as big as the dome of St. Paul's Cathedral, we should still have some difficulty in finding the 26 electrons which are disposed somehow in the empty space about the nucleus. They would still be scarcely as large as pin-heads. The capture of one of those electrons and the accurate measurement of its charge and mass has been one of the most brilliant achievements of twentieth century science.

New Problems.

The existence of the electron is a definitely proved experimental fact; its mass and charge are known with a high degree of accuracy. So, too, has experiment more or less definitely established the fact that the space occupied by the atom is almost entirely empty. The disposition of the electrons within that empty atomic interior is a problem which has given a considerable amount of trouble to physicists. Even now all is still conjecture. It is comparatively easy to fire alpha particles through atoms and prove that they are mostly empty inside, or even to tear atoms to pieces in an electric discharge and so discover their constituent parts. It is when an attempt is made to fit the parts together again that the dispute arises. What is needed is not merely an advance in present technique, but another discovery opening up completely new ground, as did that of Laue. And the principle of the new discovery must be that of an ultra X-ray microscope—possibly one working on a high speed cinematograph principle that will not only reveal to us the exact positions of nucleus and electrons, but also their relative motions.

For it seems highly probable that the electrons are in rapid rotation round the nucleus. They cannot readily be imagined to be at rest. If they were, the force of attraction between unlike electric charges would rapidly cause the tiny negative electrons to fall into the more massive positive nucleus. Of course, we may assume that at the very small distances which exist within the atom the ordinary laws of electrostatic attraction and repulsion no longer hold. But many experiments, such as those performed by Rutherford, tend to the conclusion that at distances very much less indeed than the diameter of the atom the inverse square law of repulsion is perfectly valid. More acceptable is the idea that the electrons rotate, and that the force of attraction which would draw them inwards is just balanced by centrifugal force acting outwards. Indeed, the idea of a very minute sun and planets system —the nucleus, a sun around which the electrons planet-like run their courses—is very alluring. Unfortunately, the laws of electromagnetic radiation forbid it. According to these laws radiation of energy continually goes on from an accelerated electrified particle; and how then is the electron to continue giving out energy without slowly depleting its own store and spiralling its way to rest in the nucleus? If he is left with no more than the classical ideas of radiation to help him, the dilemma of the physicist is complete.

Here it becomes necessary to say a few words about that same subject of radiation; but only to point out that the idea that light consists of a wave motion is not sufficient to explain all the phenomena that are known of it to-day. In the year 1900 Planck published the results of his researches on the character of the radiation within an enclosed cavity. His results could not be explained in terms of the wave theory. They were entirely foreign to it. It was as if radiant energy of any frequency ν were concentrated into little packets, or units, of magnitude $h\nu$, h being a constant; and that these little packets were emitted, journeyed through space and were absorbed entire. Such was Planck's suggestion. It had nothing to recommend it to a generation of scientists who had witnessed a series of beautiful and striking experiments founded on the wave theory as their basis. It has nothing to recommend it to-day, except the fact that it is apparently true. For it is the only explanation there is to offer for an ever increasing number of phenomena, which range from the law of action of the feebly illuminated photo-electric cell to the peculiar character of the emission from the target of an X-ray tube bombarded with electrons at tens of thousands of volts. Disguised as fast flying quanta Newton's light-bearing corpuscles have made their re-appearance. But the new quantum theory involves the wave theory at its root; for the magnitude of the little packet of energy which is shot through space is h multiplied by its frequency, and the frequency is the speed of light divided by a wave-length. Thus have the two prevailing ideas of radiation, so apparently contradictory the one to the other, become inextricably interwoven.

This little digression on radiation is justified by the fact that there is something very characteristic about the radiation given out by excited atoms. It is restricted to certain definite frequencies, giving the familiar series of bright lines in the spectrum. And it does not matter whether this radiation has its source in the experimenter's laboratory or is flashed across millions of miles of space from the stars, the intricate pattern of glowing spectral lines peculiar to any particular element remains unaltered. For many of the elements these lines have been found to fall into groups. And sometimes a very simple numerical law can be found connecting together all the lines in a group. Balmer measured the wave-length of a number of lines in the spectrum of hydrogen, and found that the frequency of the radiation corresponding to each of these lines could be expressed by the formula :—

$$\nu = R\left(\frac{1}{n_1^2} - \frac{1}{n^2}\right) \quad \text{......(2)}$$

where n_1 equals 2, and n is given one of the whole number values 3, 4, 5, 6 . . . etc., R being a constant.

Is it possible that the whole secret of the arrangement of the nucleus and the electrons within the atom may be revealed through an intricate pattern of spectral lines recorded on a photographic plate? It seems very probable. For the whole of our modern ideas of atomic architecture—of microcosmic solar systems in which each electron traces out a definitely assigned orbit—dates from 1913, when Nihls Bohr, of Copenhagen, discovered a way of interpreting spectra.

Bohr's interpretation was based on three assumptions. They were :—

(i) That within the atom electrons can circulate in closed orbits *without radiating energy at all.*

(ii) That an electron can only circulate in a limited number of orbits permitted by certain conditions. The condition usually quoted is that the orbit must be such that the angular momentum of the electron in it is an integer multiple of $\frac{h}{2\pi}$. Thus for a given atomic system, a series of energy values E_1, E_2, E_3 . . . alone is possible, each energy value corresponding to one of the permitted orbits.

(iii) That when an electron jumps from an orbit in which the energy value of the system is E to another in which the energy is E_1, E_1 being less than E, it radiates an amount of energy equal to $E - E_1$; and the frequency of the radiation is given by :—

$$h\nu = E - E_1 \quad \text{......(3)}$$

These were Bohr's assumptions. The fact that the model of the atom, which he has constructed on them, has proved remarkably successful in a certain limited field has caused them to be widely accepted. But, if anyone could think of a reasonable explanation why an electron should only be able to rotate in certain orbits and not in others, or why, for that matter, it should be able to rotate at all without radiating energy, the present day atom model would be immensely fortified.

Let us look for a moment at the model constructed by Bohr for the atom of hydrogen (Fig. 5). Hydrogen is the first element

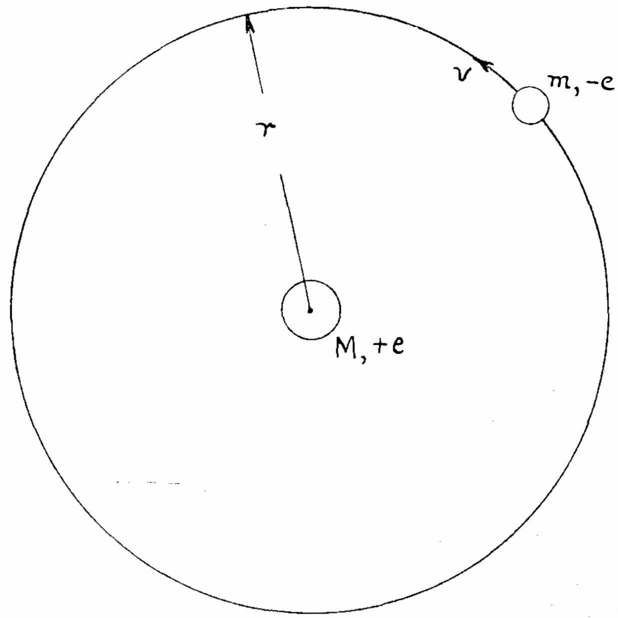


FIG. 5.

in the periodic table. Its nucleus carries a positive charge of one unit, so that one electron only is needed to complete the atom. Suppose that this electron, of mass m and charge $-e$, is rotating with a velocity v in a circular orbit of radius r. The kinetic energy of the electron is $\frac{1}{2}mv^2$. Reckoning the potential energy of the electron when it is completely removed from the atom as zero, its potential energy when it is at a distance r from the nucleus is equal to $-\frac{e^2}{r}$. Therefore the total energy (E) is given by :—

$$E = -\frac{e^2}{r} + \tfrac{1}{2}mv^2 \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

By equating the centrifugal force to the electrostatic attraction we have,

$$\frac{e^2}{r^2} = \frac{mv^2}{r} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

so that,

$$E = -\frac{e^2}{2r} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Again, from Bohr's second assumption the angular momentum of the electron is equal to $\frac{nh}{2\pi}$

$$\therefore\ 2\pi mvr = nh \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

where n is a whole number. It is termed the quantum number of the orbit.

With (5) and (6) equation (7) gives :—

$$E = -\frac{2\pi^2 me^4}{h^2}\cdot\frac{1}{n^2} \quad\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Suppose now that the electron returns from an orbit of quantum number n to another orbit, nearer the nucleus, of quantum number n_1. The difference in energy between the two states of the atom is given by :—

$$E - E_1 = \frac{2\pi^2 me^4}{h^2}\left(\frac{1}{n_1^2} - \frac{1}{n^2}\right)\ldots..(9)$$

But by Bohr's third hypothesis this difference of energy is radiated away from the atom as energy of frequency ν, where

$$h\nu = E - E_1$$

so that,

$$\nu = \frac{2\pi^2 me^4}{h^3}\left(\frac{1}{n_1^2} - \frac{1}{n^2}\right)\ldots\ldots\ldots..(10)$$

If n_1 is put equal to 2, and n to 3, 4, 5 . . . etc., a striking similarity is at once apparent between the form of this equation and Balmer's experimental formula for the frequency of the lines in the hydrogen spectrum, given at (2).

But this is not all, nor the strongest evidence for Bohr's assumptions. The value of each one of the constants on the right hand side of equation (10) outside the bracket had been previously determined. If these values, for e, h, m, etc., are inserted, the new constant formed *agrees almost exactly* with Balmer's experimental constant R. Again, if n_1 is put equal to 1, 3 or 4, new series of spectral lines should be obtained. And these have actually been found. They had been overlooked because one, the Lyman series, lies right out in the ultra-violet and the other two in the infra-red part of the spectrum.

Not for all the elements will Bohr's scheme predict so simply the results to be expected from experiment. Many of the heavier atoms with whole families of electrons surrounding the nucleus have proved quite unamenable to calculation. Nor indeed does the scheme unmodified explain such phenomena as are observed, for instance, when the radiating atoms are subjected to a magnetic field. To explain these and other facts of experience mathematical theorists have elaborated and embellished the scheme, until some of their hypermysterious specifications for the atom remind one irresistibly of the recipes of the old alchemists.

But, while this strange and yet fascinating idea of Nature arranging on the smallest possible scale solar systems of the same pattern as our own big one is still unproved by direct experiment, it is as well to emphasise again what is the sum of the definite new knowledge added to our store during the past two or three decades. The electron and the nucleus have both been established as definite physical realities. Experiment has shown that the nucleus of any atom has a mass which is an integral multiple of the mass of the nucleus of the hydrogen atom. In order to build up the nucleus of any atom we need only two different kinds of bricks—protons, which are the nuclei of hydrogen atoms, and electrons. Then again much recent work on the measurement of critical potentials has shown that there exist within the atom different energy states; such as, when we turn to theory, we associate with the orbits in Bohr's model. Lastly, Planck's constant, "h," mysterious and enigmatic, has taken its place as a definite physical constant called for in the expression of physical reality, and to become as familiar in the future as is Newton's " *g* " to-day. There have been giants in the land of physics in these days.

* * * * * *

To the engineer, as well as to the physicist, the progress of discovery should be of thrilling interest. For where the experimental physicist stands to-day the engineer will probably be established to-morrow. True, the smallest piece of material which even the telephone engineer has to deal with consists of millions and millions of atoms, his smallest amount of energy to many billions of quanta. But our whole conception of the action of the photo-electric cell depends upon the new-born quantum ideas of radiation. And it seems as if the communications engineer of the future will be very profoundly interested in the action of the photo-electric cell. Again, although many of the properties which the engineer recognises in his materials, such as strength or elasticity, are not the properties of individual atoms; some, which are the electrical engineer's most vital concern, do appear to be the properties, if not of single atoms, at the most of very small groups of atoms. Magnetism is an example. We know practically nothing about the real physical nature of the change that takes place in a steel bar when it is magnetised. By alloying nickel and iron together Elmen chanced upon a material, permalloy, which in feeble magnetic fields is tremendously more magnetic than either of these metals alone. There may be other alloys which will give equally startling properties. To the metallurgist who would set out to investigate them one by one the possible number of alloys becomes absolutely overwhelming. Did we but know what it is that makes all the difference between atoms of the three succeeding elements, iron, cobalt and nickel, and those of every other element, it would perhaps be possible to prepare an alloy having any desired magnetic properties to specification. This is only one problem. By loading the conductors with a wrapping of permalloy tape we have seen the speed of an Atlantic cable increased fourfold. But the real problem of the cable—that of the dielectric—remains unsolved. And the study of the properties of matter in a feeble electric field is practically an unexplored country for the physicist.

To-day the whole realm of physics is strewn with unsolved problems. But, looking back only to the beginning of the century, one cannot but be impressed by the confidence and success with which the scientist of to-day attacks problems which then would hardly have been thought capable of solution. It is by the solution of some of these problems that revolutionary changes in the art of engineering may be brought about.

NOTES & COMMENTS

HISTORY OF THE POST OFFICE ENGINEERING DEPARTMENT.

THE Council of the Institution has had under consideration the question of arranging for the compilation of a History of the Post Office Engineering Department, but came to the conclusion that it was not possible to undertake such a task at the present time. The Council feels, however, that it would be very unfortunate if information of historical value which is at present available should be lost merely through the lack of any organisation for the collection of such valuable literary material. The Council wishes to announce, therefore, that it has decided to arrange for the filing and indexing of any memoirs or information of historical value which may be offered to the Institution.

The period in regard to which information is most valuable is that preceding the publication of the *I.P.O.E.E. Journal, i.e.,* prior to 1908.

Any document of the nature referred to which is considered of historical value, or any notes on any particular question of historical interest will be gladly received by the Secretary of the Institution, Dr. R. V. Hansford, E.-in-C.O., G.P.O. (Alder House), London, E.C.1.

THE POST OFFICE (LONDON) RAILWAY.

This tube railway, some 6½ miles long, extending from the Eastern District Post Office in the east to the Paddington District in the west, has been constructed with a view to accelerating the letter and parcel service and at the same time to relieve to some extent the street traffic congestion in the neighbourhood of the busy offices. In addition to the terminal stations, connections are made with Liverpool Street Station, King Edward Building (G.P.O.), Mount Pleasant, Western Central Office, Western District and Western District Parcel Post. It is the intention to extend the system later northwards from Mount Pleasant to the Northern District Office and to the main northern railway stations at Kings Cross, St. Pancras and Euston, while towards the south a loop line will run from King Edward Building to London Bridge Station, thence *via* the South Eastern District Office and Parcel Office to Waterloo Station and on to the South Western District Office, from which the line running north-easterly will join the main line at the Western Central Office.

The whole of the operation of the trains is automatic, starting and stopping control being effected from switch cabins at each station; no drivers are required. The rolling stock consists of steel motor wagons, made up into trains of two or three wagons, each wagon being capable of carrying a load of half a ton. The electrical equipment of the wagons consists of two 22-H.p., 440 volt D.C. series motors, in parallel, and a set of electrically operated braking equipment and reverser. The motors are energised in the usual way from the conductor rail.

Major H. C. Gunton, Principal Power Engineer, who, in conjunction with Mr. H. H. Dalrymple-Hay, Sir John Snell and Mr. A. M.

Sellar, Consultants, has been responsible for the construction and equipment of the railway, will furnish our readers with a full technical description in our July issue.

In the Journal of the Franklin Institute for December, 1927, H. Nakamoura, of the Research Laboratory, Tokyo Electric Coy., Ltd., passes "Some Criticisms on Electric Resistance and its Derivative." There are confusions, he says, between electric resistance and differential electric resistance. In one case resistance means original electric resistance and in another case it means differential resistance. In the paper he discusses distinctions between them and concludes as follows: (1) Ordinary resistance is a mere quotient of the instantaneous value of the component which is in phase with current of the potential difference of any two points to the instántanous value of the current passing through these and has no vectorial sense. Differential resistance, however, is the first partial derivative of the former with respect to the latter and has sense and magnitude. (2) Wheatstone Bridge and its varieties, unless balancing the galvanometer or telephone circuit by constant equipotential, measure the differential resistance and not the ordinary one. (3) Alternating current bridge generally measures differential effective resistance. When the current is small or its effective resistance, differential effective resistance numerically approaches to ordinary effective resistance.

The Director of the U.S. Bureau of Standards communicates interesting notes on the Seventh International Conference on Weights and Measures (held at Paris last September) in the same issue of the Franklin Institute Journal. The United States delegates were hopeful that the conference would adopt a definite relation between the yard and the wave-length of light, or between the yard and the metre. It appears that a different relation is used in this country and in the U.S.A., the difference between the British and American yard being of the order of a few millionths of an inch. Even such a small difference is of importance in the manufacture of precision tools. It was agreed that the two countries should settle the matter between them. The question of the dimensions of electrical units received considerable attention. When the international units were adopted, certain kinds of concrete standards were accepted as a means of maintaining the values of the units, such as a column of mercury of specified dimensions for the ohm and a voltameter in which the amount of silver deposited in a second by a current is used as a measure of the ampere. We now know that the international ohm is one-twentieth of 1 per cent. too large. In order to advise the international committee as to whether the old value of the ohm should be maintained or be adjusted to accord with mechanical measurements as originally intended, a special technical commission of ten members, including representatives appointed by the several national laboratories, was appointed to report by March, 1929.

Annales des Postes, Télégraphes et Téléphones, of January, 1928, contains among other interesting subjects the following articles:—

The adaptation of the French system to the universal telephonic service, by H. Milon, 22 pages.

Search for an international 5-unit Telegraph alphabet, by E. Montoriol, 7 pages.

Belt Conveyors in Central Telegraph Office, Paris, by Jean Jacob, 15 pages.

The February number contains the following articles:—

Aerial Post, by M. Lebon. Seventeen pages with three maps, showing routes of French lines in Europe, proposed routes in France and the connection of French routes with other European routes.

The choice of a single type of apparatus for the international telegraph service, by E. Montoriol, 14 pages. The author advocates the use of the Baudot system with Quadruple simplex, Triple duplex and Sextuple simplex, according to traffic needs.

The connection of underground and aerial sections of telephone lines, by Marcel Moine, 28 pages.

The characteristics of transmission on long distance cables, by Kupfmuller. (Translation from an article which appeared in the *Europaischer Fernsprechdienst* of July 5th, 1927), 33 pages.

An important article on New Preservatives for Telegraph Poles appeared in the *Telegraph and Telephone Age* of the 16th December, 1927.

The article describes the results of experiments carried out by Dr. L. P. Curtin, chemist of the Western Union Telegraph Coy. The new preservatives developed by Dr. Curtin are founded upon an entirely new theory of wood preservation, and are claimed to be more permanent in the wood than any materials previously employed. They are inorganic salts, non-volatile and insoluble as limestone. The foundation of the developments lies in the discovery that the fungous organisms most active in rotting wood evolve acidic substances. This property has been utilised to bring into solution toxic salts insoluble in water and ordinarily inert. When brought into solution by the fungous acids, the materials become fatal to the fungus. The action is the same as that of paris green, lead arsenate, etc., in poisoning insect life. Several treatments based on this discovery have been tested, the most promising being the Zinc Arsenite treatment. Zinc chloride has already been used for preserving purposes and arsenic has long been employed in the manufacture of insecticidal compounds, but the combination of zinc-arsenic is new and its toxicity is higher than either creosote or zinc chloride. The solution is made by dissolving the chemicals in water and when ready for use is clear and nearly colourless. It is used cold and penetrates the wood nearly twice as easily as creosote, while leaving the timber practically unchanged in appearance. As soon as the treated wood is exposed to the air, the evaporation of the solution brings about the necessary chemical changes and precipitates the solution within the wood, where it remains insoluble and permanent. It is immune to loss from all weathering influences, but is ready to put an end to any infection or fungus spores that may appear. One of the outstanding characteristics of this solution is that it is not corrosive to steel treating equipment; in fact, the solution seems to be a definite inhibitor of corrosion.

Compounds of copper with arsenic have also been used, but these copper solutions are corrosive to steel and leave the wood light green in colour. Another substance, which operates on a different principle than either the zinc arsenite or the copper arsenic compounds, is barium carbonate. Inasmuch as the fungi produce acidic substances they can exist only in acidic environment. Barium carbonate, being alkaline in nature, tends to neutralise any acids with which it comes in contact and if present in wood in sufficient concentration it will completely neutralise the acids produced by fungous organism and thus make it impossible for the fungus to live. The treating solution is a clear, colourless water solution of barium hydroxide which penetrates wood with great ease. On exposing the treated wood the carbonic acid of the air converts the soluble barium hydroxide to insoluble barium carbonate, precipitating the latter within the wood structure where it will remain indefinitely, non-volatile and insoluble in water.

Results of the tests are given in the article and also descriptions of the treatment methods and plant. It is claimed that the Zinc Arsenite treatment costs only one-fourth of the creosote treatment, and also reduces the weight and being clean simplifies handling. The poles so treated can be painted with ordinary paints and can thus be used in city streets without risk to passers-by. Wood so treated will not support combustion and does not increase in electric conductivity.

Owing to the limited accommodation at our disposal, the Board of Editors is compelled to announce that single copies of Journals up to Vol. XIX. cannot be supplied after December 31st, 1928. A number of copies will be retained to make up volumes for sale, but it is regretted that only a few complete sets of volumes will be available, as several issues have been entirely sold out.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Burslem	New Auto.	990
Chatham	,,	1330
Chesterton	,,	100
Edinboro' Central	,,	8720
Exeter	,,	1990
Hanley	,,	2335
Longton	,,	680
Newcastle-under-Lyne ...	,,	490
Rainham	,,	140
Snodland	,,	130
Stoke	,,	700
Southport	,,	3000
Southwick	,,	110
Strood	,,	320
Trentham	,,	200
Topsham	,,	90
Shrewsbury	Auto. Extn.	300
Leek	New Manual	580
Maryhill	,,	480
Toll London	,,	Positions.
Finchley	Manual Extn.	1740
Giffnock	,,	800
Sale	,,	420
Salisbury	,,	460
Waterloo (Lvpl.)	,,	960
African & Eastern	P.A.B.X.	60
Brintons	,,	40
Brysilka	,,	20
Dewhursts	,,	30
Electra House	,,	170
Electrical Federation ...	,,	80
Heinemans	,,	30
Jaeger Ltd.	,,	10
Nelson Corporation	,,	60
Philips, J. & A.	,,	30
Vickers & Sons	,,	30
West Bromwich Union ...	,,	60
Wood Green Council ...	,,	40
Wolverhampton Union ...	,,	30

Orders have been placed for the following new works :—

Exchange.	Type.	No. of Lines.
Ardwick	New Auto.	3045
Colchester	,,	1140
Collyhurst	,,	1913
Mitcham	,,	1480
National	,,	9400
Cheltenham	Auto. Extn.	535
Paisley	,,	860
Paignton	,,	290
Torquay	,,	570
Byfleet	New Manual	700
Camberley	,,	260
Canford Cliffs	,,	820
Hornchurch	,,	880
Valentine	,,	1500
Ealing	Manual Extn.	2050
Hatch End	,,	300
Margate	,,	820
New Cross	,,	900
Northwich	,,	180
Old Swan (Lvpl.)	,,	1050
Port Talbot	,,	300
Speedwell	,,	2480
Sydenham	,,	400
Tandem	,,	—
Wallasey	,,	3620
Willesden	,,	1700
Woolwich	,,	480
Worthing	,,	860
Armstrong Siddeley	P.A.B.X.	125
Dunlop Rubber	,,	20
Halifax Corporation	,,	50
Pearson Dorman & Long (B)	,,	Modfcns.
Pearson Dorman & Long (S)	,,	40
Southport Corporation ...	,,	100
St. Helen's Corporation ...	,,	80

A very successful gathering took place at the Manchester Hotel on Tuesday evening, 3rd January, in connection with the second annual dinner and dance of the Headquarters Equipment Section Swimming Club.

Altogether 96 members and friends assembled, being welcomed on arrival by the President, W. J. Bailey, Esq., and Miss Bailey.

At the conclusion of an appetising menu the toast of the King and Royal family was loyally responded to and was followed by toasts of The Club; The Visitors; The Committee; The Hon. Photographer; The Hon. Secretary, Mr. G. Brown; the Ladies and the Gentlemen.

Mrs. G. Brown graciously presented the prizes which had been won by the following members after a keen competition :—

44 Yds. Handicap.

1st, Mr. Hollinghurst, a cigarette case.
2nd, Mr. S. D. Hull, case of knives.
3rd, Mr. S. J. Husband, book on gardening.

Diving.

1st, Mr. J. Reading, pipe.
2nd, Mr. H. A. Ashdown, egg boiler.

3rd, Mr. M. C. Cooper, Eversharp pencil; and Mr. S. A. Waters, jam jar.

Novices' Race.
Mr. R. W. Sawyer, rose bowl.

Two violin solos were pleasingly rendered by Mr. L. V. Gorman, who also acted as M.C. for the dance which followed and lasted until midnight. The orchestra carried out its duties very ably and responded to repeated encores.

The Swimming Club, apart from its beneficial effects to the individual member and its encouragement of the acquirement of a most useful art, has developed the sporting spirit in its best sense and has been the means of facilitating social life and intercourse outside official hours of duty and during the summer organised a pleasurable healthgiving outing to the Surrey Hills.

Professor Jarvis has been appointed Instructor and swimming practice is held summer and winter on Wednesday evenings, at the Westminster Baths, Great Smith Street.

It is suggested that other Sections might well follow their lead.

ONE HUNDRED AUTOMATIC EXCHANGES.

With the opening of Armley Exchange in the Leeds Area on Saturday, 10th March, 1928, the number of public Automatic Exchanges brought into service in Great Britain reached a total of 100. A list of the exchanges in the order of opening is given below.

(In the case of Hereford, which appears twice in the table, the original Lorimer installation has been replaced by Messrs. Siemens No. 16 type equipment).

It will be seen that initial multiple capacity has been provided for 179,360 lines with an ultimate capacity of 257,915.

	Exchange.	*Contractor.*	*Date of opening.*	*Multiple Capacity.*	
				Initial.	*Ultimate.*
1	Epsom	A.T.M. Co.	18. 5.12	1100	1500
2	Hereford (see later entry 2a)	Lorimer	1. 8.14	—	—
3	Darlington	W.E. Co.	10.10.14	1200	2800
4	Accrington	A.T.M. Co.	13. 3.15	1200	1500
5	Chepstow	A.T.M. Co.	7. 7.15	200	200
6	Newport	A.T.M. Co.	14. 8.15	2600	3500
7	Portsmouth	A.T.M. Co.	29. 4.16	5200	7000
8	Paisley	A.T.M. Co.	15. 7.16	1700	2600
9	Dudley	W.E. Co.	9. 9.16	800	1600
10	Blackburn	A.T.M. Co.	14.10.16	3400	4400
11	Leeds	A.T.M. Co.	18. 5.18	9600	15000
12	Grimsby	Siemens	14. 9. 8.	3000	3300
13	Stockport	Siemens	23. 8.19	2400	2400
14	Ramsey	Siemens	24.10.21	80	80
15	Hurley	Siemens	20.12.21	80	80
16	Southampton	Relay	15. 7.22	480	920
17	Fleetwood	Siemens	30. 6.23.	3500	5600
18	Hadleigh	A.T.M. Co.	16. 2.24	125	125
19	Dundee	G.E. Co.	15. 3.24	4500	4500
20	Broughty Ferry	G.E. Co.	15. 3.24	600	1000
21	Marton	A.T.M. Co.	22. 3.24	300	500
22	Blockley	A.T.M. Co.	28. 3.24	25	50
23	Swansea	Siemens	9. 8.24	3500	5800
24	Sketty	Siemens	9. 8.24	470	500
25	York	A.T.M. Co.	15.11.24	1600	2000
26	Risca	A.T.M. Co.	16. 6.25	100	100
27	Cwmbran	A.T.M. Co.	16. 6.25	100	100
28	Kirkcaldy	Siemens	27. 6.25	700	1400
29	Torquay	A.T.M. Co.	31.10.25	2300	3000
30	Paignton	A.T.M. Co.	31.10.25	700	1400
31	Chapeltown	A.T.M. Co.	8.11.25	2100	2100
32	Roundhay	A.T.M. Co.	8.11.25	2100	2100
33	Headingley	A.T.M. Co.	8.11.25	2000	2400
34	Stanningley	A.T.M. Co.	8.11.25	1000	1600
35	Shrewsbury	A.T.M. Co.	9. 1.26	1300	1800
36	Hayling Island	A.T.M. Co.	13. 1.26	200	260
37	Gosport	A.T.M. Co.	13. 1.26	600	800
38	Ipswich	A.T.M. Co.	20. 3.26	2000	3300

	Exchange.	Contractor.	Date of opening.	Multiple Capacity. Initial.	Multiple Capacity. Ultimate.
39	Morriston	Siemens	19. 6.26	300	500
40	Cheltenham	A.T.M. Co.	28. 8.26	1700	2800
41	West Hartlepool	Siemens	25. 9.26	1200	1900
42	Hartlepool	Siemens	25. 9.26	200	300
43	Chesterfield	Siemens	25. 9.26	1000	1800
44	Staveley	Siemens	25. 9.26	100	200
45	Bedford	S.T. & C. Co.	2.10.26	1500	2800
46	Edinburgh	Siemens	2.10.26	9300	14600
47	Morningside	Siemens	2.10.26	2500	4400
48	Murrayfield	Siemens	2.10.26	1700	2900
49	Newington	Siemens	2.10.26	2100	3600
50	Coventry	G.E. Co.	20.11.26	3300	5400
51	Foleshill	G.E. Co.	20.11.26	700	1000
52	Cosham	A.T.M. Co.	8.12.26	200	200
53	Oxford	S.T. & C. Co.	11.12.26	2500	2500
54	Gloucester	A.T.M. Co.	12. 2.27	1500	3000
55	Harrogate	G.E. Co.	26. 2.27	2900	5500
56	Sheffield	Siemens	5. 3.27	6300	9000
57	Broomhill	Siemens	5. 3.27	2800	3500
58	Sharrow	Siemens	5. 3.27	1800	2600
59	Attercliffe	Siemens	5. 3.27	1000	1500
60	Beauchief	Siemens	5. 3.27	1200	1900
61	Owlerton	Siemens	5. 3.27	800	1200
62	Ecclesfield	Siemens	5. 3.27	300	300
63	Woodhouse	Siemens	5. 3.27	200	300
64	Oughtibridge	Siemens	5. 3.27	100	100
65	Halifax	S.T. & C. Co.	18. 6.27	3400	4000
66	Colwyn Bay	Siemens	9. 7.27	1400	1700
67	Llandudno	Siemens	9. 7.27	1200	2000
68	Burnley	G.E. Co.	20. 8.27	2300	3600
2a	Hereford	Siemens	10. 9.27	800	1100
69	Wakefield	Siemens	15.10.27	1000	1800
70	Sandal	Siemens	15.10.27	300	500
71	Fforestfach	Siemens	29.10.27	100	200
72	Brighton	Siemens	12.11.27	4700	6900
73	Hove	Siemens	12.11.27	4200	6200
74	Preston	Siemens	12.11.27	1000	1400
75	Portslade	Siemens	12.11.27	400	600
76	Rottingdean	Siemens	12.11.27	200	400
77	Holborn	A.T.M. Co.	12.11.27	9800	10000
78	Exeter	G.E. Co.	19.11.27	2100	3500
79	Topsham	G.E. Co.	19.11.27	200	400
80	Hanley	G.E. Co.	26.11.27	1300	2000
81	Burslem	G.E. Co.	26.11.27	1100	2200
82	Longton	G.E. Co.	26.11.27	700	1100
83	Stoke-on-Trent	G.E. Co.	26.11.27	900	1500
84	Newcastle-u-Lyne	G.E. Co.	26.11.27	700	1000
85	Trentham	G.E. Co.	26.11.27	200	500
86	Chesterton	G.E. Co.	26.11.27	100	200
87	Southport	A.T.M. Co.	3.12.27	3700	5400
88	Birkdale	A.T.M. Co.	3.12.27	1600	2500
89	Churchtown	A.T.M. Co.	3.12.27	1000	2000
90	Southwick	Siemens	16.12.27	200	400
91	Nottingham	A.T.M. Co.	28. 1.28	7500	14000
92	Arkwright	A.T.M. Co.	28. 1.28	1000	1500
93	Basford	A.T.M. Co.	28. 1.28	1400	2200
94	Sherwood	A.T.M. Co.	28. 1.28	1200	3200
95	Leicester (Advance portion)...	Siemens	18. 2.28	3400	—
96	Wigston	Siemens	18. 2.28	400	700
97	Western Park	Siemens	18. 2.28	300	400
98	Syston	Siemens	18. 2.28	300	500
99	Bishopsgate	A.T.M. Co.	3. 3.28	8500	10000
100	Armley	A.T.M. Co.	10. 3.27	700	1200

THE LATE MR. W. BROWN.

There are still many readers who remember Mr. William Brown, Head of the Telephone Section at Headquarters from 1901 to 1911, who was laid to rest in Highgate Cemetery on the 11th January last. Able references to Mr. Brown's work and responsibility in connection with the establishment of telephone service with Paris—opened in March, 1891; with the acquisition of the Trunk Lines by the Postmaster-General in 1896; with the introduction of Post Office Local Common Battery Exchanges; and finally in 1911 with the acquisition of the National Telephone Coy.'s plant—appeared in the Journal for January, 1912, on the occasion of his retirement. His service with the Post Office commenced at the transfer of the Telegraphs to the State in 1870 when he was appointed telegraphist at Newcastle-on-Tyne. In his junior position he soon began to show that close and continual application to work which distinguished him throughout his life. He was chosen as a member of what was then known as the Local Special Staff, a group of officers selected on account of proficiency to attend on occasions when large volumes of telegraph work had to be expeditiously disposed of—at Newcastle and elsewhere. He took keen interest at this early stage, in the electrical and mechanical principles and arrangement of apparatus with which he had to deal—at a time when information was not easy to obtain, and when few troubled about it. When in the course of a few years the telephone appeared he quickly became associated with the operation of the Post Office Exchange at Newcastle, which for a long period was a prominent feature of the system of the country. His marked ability in this duty at once won for him favourable notice and appreciation in the Engineer-in-Chief's Office at Headquarters, with the result that in the early "Eighties" he was called to London to join that Staff, and he remained upon it, latterly and for many years the head of that important branch of work, to the end of his official life. He threw himself with energy into taking his share in the administration, working, and development of the Telephone System: a duty which at times placed a very heavy load of responsibility upon him. He was aided by a remarkably good memory, which made a master of detail in complicated systems of telephone work and in their history. For extended periods he worked long hours daily, with little leisure even at week-ends—a devotion to duty which probably did harm to his health, and contributed to his extraordinary susceptibility to frequent attacks of epidemic influenza. In whatever work he engaged, he secured the full confidence of those under whom, or with whom he served—successive Engineers-in-Chief, colleagues of his own rank, and officers and men of all grades. He made friends all over the country. A trusted and genial friend himself, a real worker, thoroughly informed and helpful, he was widely esteemed: and those who were intimate with him and survive him will cherish the memory of his sterling qualities and remember him with affectionate regard to the end of their lives.

E.C.

We regret to announce the death, which occurred on Sunday, the 26th February last, of Mr. F. H. Bailey, who, for many years was Executive Engineer, in charge of the E.-in-C.'s General Testing Branch, Studd Street Depôt. Mr. Bailey, who retired at the age of 60 years in 1924, has suffered indifferent health for some considerable time, but the news of his dealh will be received with regret by his many friends and colleagues.

J. M. G. TREZISE.

After completing his engineering education at King's College and being associated with the late Sir William Preece in the pioneer days of electric lighting, Mr. Trezise entered the Post Office on the 15th December, 1890, and thus completed 37 years service on his retirement on the 31st December, 1927. As showing the great developments during this period, his first employment was in charge of a steam-driven electric light station capable of a maximum output of

MR. J. M. G. TREZISE.

120 K.W. at 110 volts Direct Current, while the Headquarters sub-station at the date of his retirement had a full load capacity alone of 3000 kilowatts, the input being at 11,000 volts three-phase 50 periods.

Mr. Trezise's ability was quickly recognised and in June, 1891, he was transferred from the charge of the small station at the G.P.O. to be in charge of the Electric Light and Power Staff at Mount Pleasant, from which date commenced his long and productive association with the late Mr. M. F. Roberts. Promotion to a second-class engineership came in November, 1897, after which he took rapid strides to first-class engineer in January, 1898, second-class technical officer in December, 1902, assistant-superintending-engineer in May, 1908, first-class staff engineer in October, 1909, and Superintending Engineer in charge of the Metropolitan Power District in December, 1910, which appointment he retained until the date of his retirement.

During his stay at Mount Pleasant he was responsible under Mr. Roberts for the design of Mount Pleasant and also the Savings Bank steam-generating stations, of which the former was at that date the largest in the Post Office, and as large as many in considerable-sized towns. Having seen these developments, as well as the electric lighting and power equipment of the associated buildings, brought to successful completion, he was transferred to the Engineer-in-Chief's Office in December, 1902, after which he was soon selected to accompany Mr. Roberts on a Continental tour of inspection of High-Tension Power Stations and Transmission Lines, which were in a more forward state of development than in Great Britain owing to cheap water power and the long distance to be covered. This tour was arranged to obtain information in connection with the projected Post Office Power Station on the river-side at Blackfriars. On his return in September, 1904, Mr. Roberts and himself received the thanks of the Postmaster-General for their report and recommendations, the soundness of which is shown by the fact that they were adopted and the Blackfriars Power Station was built and successfully operated for 15 years, when economic conditions and the development of large power stations necessitated closing it down.

During these busy years Mr. Trezise found time to pursue his favourite hobby of Photometry and as early as 1896 had already produced an illumination photometer which was in advance of the time, and would bear comparison with many in use at this date; by 1914 he had developed a photometer including a device which he patented for giving a clear and distinct screen which could be largely magnified without introducing errors. The intervention of the War prevented the exploitation of this photometer, but it has not been improved upon to this day.

During the post-war period Mr. Trezise has taken a large interest in the work of the British Engineering Standards Association and has acted as the Post Office representative on many Committees. As evidence of the value of this work the Association has invited him to continue as Chairman in his personal capacity of those Committees for which he formerly acted in his official capacity.

His authoritative knowledge of illumination was recognised by his selection by the Institution of Electrical Engineers to represent them on the National Illumination Commission of Great

Britain, a position he still holds and in which capacity he attended the International Commission on Illumination at Geneva in 1924.

Sufficient has perhaps now been said of Mr. Trezise's technical achievements; suffice it to say that as a man of a somewhat reserved and unassuming disposition he was yet the staunch friend of those fortunate enough to gain his confidence, though he could be a doughty opponent when the necessity arose.

Mr. Trezise is taking a well-earned rest in the South of France and Pyrenees for the benefit of his own and his daughter's health, and the best wishes of his friends for good health and happiness in his retirement will go with him.

E.H.W.

LONDON DISTRICT NOTES.

Telephones.—The changes in the number of exchange lines, extensions and stations during the quarter and the totals on 31st December, 1927, were as follows:—

	Increase	Total
Exchange Lines ...	7,858	326,932
Extensions ...	5,092	276,467
Stations	11,728	549,912

Exchange Works.—Bishopsgate automatic exchange—the second of the "Director" type—was opened on March 3rd, 1,325 subscribers and 1,846 junctions being transferred from the existing manual exchange. On March 10th, 3,300 subscribers were transferred from Avenue, Central, City, Clerkenwell, Clissold, East, London Wall and North exchanges. The equipment, for 8,000 subscribers immediately and 9,400 ultimately, was installed by the Automatic Telephone Manufacturing Company to a specification prepared by the Engineer-in-Chief, and is similar to that of the Holborn Exchange described on page 17.

At Hatch End a new exchange (C.B. No. 10) was opened on the 7th December last and at Merstham a new exchange of similar type was brought into use on the 21st December.

At Barnes a new C.B. exchange, known as Prospect, was opened on March 14th when 700 subscribers were transferred from Richmond Exchange, 300 of whom already had Prospect numbers.

At Edgware a new C.B. exchange, installed in the building which, later, will accommodate an automatic exchange, was opened on March 8th.

The temporary Terminus exchange situated in the old Holborn building was opened on March 7th and the temporary Ambassador exchange in the Paddington premises is nearing completion.

At Finchley an extension of 1,300 lines was completed during February. Other extensions are nearing completion at Chiswick, Riverside and Wanstead.

Pneumatic Tubes.—In Lloyd's imposing new building in Leadenhall Street, E.C., opened by His Majesty the King on March 26th, a pneumatic tube service has been installed between the telegraph room on the ground floor, adjoining the magnificent marble Market Hall and Threadneedle Street Branch Office. The tube passes through the floor to the night telegraph room in the basement, through a diverting switch and thence to the street and the instrument room at the Branch Office. Separate power plant has not been provided as power for the service in both directions is obtaind from the exhaust of the C.T.O. tubes at the Branch Office, being connected to the terminal *via* a system of valves. The night service is operated from the night telegraph room in the basement direct to the instrument room at the C.T.O. by means of the diverting switch referred to above and a similar switch in the day tube connecting the Branch Office to the C.T.O., power then being obtained from the mains at the C.T.O.

A diverting switch has been fitted on a C.T.O.—West Strand-War Office trunk tube, *i.e.*, an "up" tube to the War Office Centre. By turning this switch from its normal position, and applying vacuum at the War Office, "up" working can be maintained in the event of a failure of power at the C.T.O., thus rendering the War Office Centre independent of the C.T.O. power supply.

Two docket tubes, power driven, have been installed recently at Branch Offices; one at Harrow and the other at Dover Street. Both tubes are operated by " Fans, Centrifugal," and are controlled by switches at either end which enable the power to be cut off when the tube is not working, thereby effecting appreciable economy. At Dover Street the tube replaced a Gipe Carrier, the last of this type in service in London.

External Plant.—The changes in mileage during the three months ended 31st December, 1927, and the totals on that date were as follows:—

Line Mileage.

	Increase Miles.	Total Miles.
Pole Line	45	5,824
Pipe Line	187	9,437

Single Wire Mileage.

	Overhead Miles.	Underground Miles.	Total Miles.
Telegraphs ...	—	194	24,983
Telephones (Ex.) ...	314	71,883	2,194,015
,, (Trunk).	84	2,574	69,675
Spare*	—	—	104,246

London readers will be sorry to hear of the death of Mr. J. L. Brown, formerly Executive Engineer in the London District, who retired on pension some two years ago. Mr. Brown died at his home in Alexandra Road, St. John's Wood, on the 20th February, and was buried in Hampstead Cemetery on the 24th. " Jock," as he was known to his colleagues, came over with the Company in 1912 and was greatly esteemed for his personal qualities, not only by his old colleagues but by the many friends he made in the P.O. service.

* *i.e., excluding small gauge local conductors.*

LOCAL CENTRE NOTES.

LONDON CENTRE.

The Session was opened on the 11th October by Mr. F. I. Ray, B.Sc., F.H.D., A.M.I.E.E., who read a paper on " Satellite working in Automatic Areas." The paper dealt with the development of Satellite working and was illustrated by slides and demonstration apparatus. There was a large attendance and a good discussion.

On the 8th November Messrs. T. Fewster and F. Johnston, A.C.I.S., of the Northern Centre, gave a paper on " Accounting as a Function of Management." Various phases of Accounting were considered and particular reference was made to the Department's costing systems. A good discussion followed and the many points raised were suitably replied to by Mr. Fewster.

On the 13th December Messrs. A. H. Jacquest, A.M.I.E.E., and L. H. Harris, M.Sc. (Lond.), A.C.G.I., gave a paper entitled " Sparking and Arcing at Relay Contacts and the use of Spark Quench Circuits." The paper was illustrated by slides and there was a good discussion, many visitors making valuable contributions based upon the experience of manufacturers.

The meeting of 10th January was unique. Mr. F. A. B. Lord, of Messrs. Dennis & Co., exhibiting films showing " Cable Manufacture and the Laying of the Anglo-Dutch Cable " by Messrs. Felton & Guilleaume. There was a record attendance and the interested audience showed its appreciation.

On 7th February Messrs. C. W. Brown, A.M.I.E.E., and R. J. Hines, B.Sc., gave a paper entitled " The Problem of the P.B.X. connected to a Public Automatic Exchange." The paper was illustrated and a good discussion ensued. Mr. Brown replied with his accustomed facility.

INFORMAL MEETINGS.

The Informal Meetings have so far been very successful. They deal with the more humanistic features of the Profession and the interest aroused by these subjects and the freedom of discussion has been evidenced by the increased attendances.

The first of these meetings was held on the 25th October and was opened by Capt. J. G. Hines, M.I.E.E., the subject being " The Telephone Engineer and his job." The discussion was of sustained interest throughout and only the strict enforcement of a time limit enabled the meeting to close at the usual time.

On 22nd November Major Brown, O.B.E., opened a discussion with the intriguing title "Some things we all think we know."

Fresh from his visit to Sweden, Major Brown dealt with the different methods of carrying out Construction work and the consequent saving in time as compared with this country. The subject was dealt with fearlessly and yet moderately. The subsequent discussion was very keen and the opinions expressed very varied.

On 24th January Mr. G. T. Evans opened a discussion on "Some small Current Rectifiers and their Characteristics." The talk dealt with valve rectification and the application of rectifiers for the elimination of batteries in connection with Wireless Receivers. The consequent discussion centred on the latter aspect of the subject, many speakers being desirous of obtaining information about inexpensive methods of obtaining suitable current from either D.C. or A.C. Mains.

Visits.

Successful visits have been made to
- H.M.T.S. "Monarch."
- W. T. Henley's Telegraph Co.'s Works, Gravesend.
- The Mullard Radio Valve Co., Ltd.

For the success of these visits the Committee desires to place on record its appreciation of the courtesy of those who made the visits so instructive and enjoyable. T.H.

SOUTH EASTERN CENTRE.

Mr. C. T. Crisp, Executive Engineer, Brighton North Section, South Eastern District, retired on the 23rd February, 1928, having completed 43 years' Established Service. Prior to his appointment as Sectional Engineer in charge of the Old Brighton Section he passed through the following grades:—

(1) Sorting Clerk and Telegraphist, Ipswich.
(2) Relay Clerk, Eastdean and North Walsham.
(3) Engineer, Second Class, Metropolitan North District.

Mr. Crisp is a man of fine and strong character, with a high sense of duty, and knows what he thinks and acts on it. He exerted a great and good influence on all members of his staff, who regarded him with high esteem and much affection. In times of emergency his quiet and unruffled manner dispelled feelings of funk, calmed the "windy" and inspired confidence which enabled serious difficulties to be overcome without fuss or friction.

Mr. Crisp has left behind him at Brighton a record of work performed which will be a lasting memorial to his whole-hearted devotion to duty and an example to the younger generation of engineering officers to emulate.

He always took a very keen interest in the affairs of the Institution of Post Office Electrical Engineers, and contributed several articles to the Journal. As a result of his personal efforts a record sale of the Journal was reached in the Brighton Section.

Mr. Crisp was presented by Mr. F. Tandy, Superintending Engineer, with a fine gramophone and library of records on behalf of the staff at a gathering on the 23rd February. Mr. W. McCormack, Executive Engineer, Brighton South, and Mr. E. Armstrong, Assistant Engineer, spoke of Mr. Crisp's good qualities of heart and mind. Mr. Crisp replied in a characteristic manner.

SOUTH WESTERN CENTRE.

Retirement of Mr. A. E. Chapman, M.I.E.E., Bristol.

On February 29th, 1928, Mr. A. E. Chapman, the senior Assistant Superintending Engineer of the South Western District, retired from the Service on attaining the age limit.

Mr. Chapman entered the service as a Telegraphist in the Central Telegraph Office, London, on the 25th March, 1882, where he remained until 1891, when he was promoted to North Walsham, the first Post Office Hughes Repeater Station in this country. In December, 1895, Mr. Chapman took up the position of 2nd Class Engineer at Holloway Factory, where he was engaged in testing the first Trunk Switch Sections. In September, 1896, he was transferred to Leicester. Here the substitution of Quad G.P. cables by paper core cables was successfully effected.

Promoted to 1st Class Engineer in July, 1903, he remained at Leicester until 1905, when he was transferred to Nottingham, on the amalgamation of the Nottingham and Grantham Sections. In May, 1909, as a result of a severe illness, aggravated by exposure to severe climatic conditions, during an extensive breakdown of the Department's plant, he was transferred to the newly-formed South Western District, with headquarters at Yeovil, where he remained until the acquisition of the National Telephone Co. System in 1912, when the Headquarters of the Section was transferred to Bournemouth.

In November, 1913, Mr. Chapman was appointed Assistant Superintending Engineer at Bristol, where he remained until the date of his retirement. During the War, Mr. Chapman spent the period June, 1916—June, 1918, at Reading, where he was closely associated with the Superintending Engineer of the South Midland District in the provision of Military, Naval and Air Force Systems of communications.

With the retirement of Mr. Chapman, the Department loses a valuable officer and the South Western District a good friend. His genial and generous nature appealed to all grades of the staff. Endowed with all the instincts of a true gentleman, no one has ever had to cultivate a " thick-hide," as a shield against his control. His uniformly courteous and genial disposition and his readiness with which he afforded his colleagues and others the benefit of his wide and varied experience, secured for him a large measure of esteem. In short, he was a gentleman first and an official afterwards, and in his retirement we sincerely trust that he and Mrs. Chapman will have many years of well-earned leisure and happiness in their new home at Bournemouth, whither he has already removed.

Prior to his retirement from the Service Mr. Chapman was entertained by his colleagues and friends at a Smoking Concert held at the Rotary Club, Bristol.

Mr. A. Gray, Assistant Superintending Engineer, presided over a very large company and among those present were Mr. E. J. Eldridge—as alert and young looking as ever—and other friends of the various Departments of the Post Office.

The Chairman, after extending a hearty welcome to the visitors, especially the ladies, read letters of apology for absence and expressions of good wishes from Messrs. Pugh (Postmaster-Surveyor), Millar (District Manager), Fish (District Survyor, Office of Works)) Pink (Sectional Engineer, Bristol), Wise (Sectional Engineer, Exeter), Rattue (Sectional Engineer, Canterbury), Major Cottle (Assistant Engineer, Plymouth) and others. During the evening a large and varied programme of music—vocal and instrumental—arrangd by Messrs. H. H. Brown and Emlyn Jones, Senr., was carried through, the gentlemen taking part being Messrs. Emlyn Jones, Ellis, Hodge, Chivers, Sleigh, Baker, Drew, Hall, Alexander, Hargreaves, Turner, Ross, Saunders, Aickin, Grant and the Chertsey Glee Singers, with Messrs. Emlyn Jones, Jnr., and Sutton as accompanists.

In an interval in the programme, the Superintending Engineer, Major Batchelor, D.S.O., M.C., in a very humourous and appropriate speech made the presentation, which comprised a Columbia Cabinet gramophone, suitably inscribed, and Amplion Cone Loud Speaker and a case of bowls.

Mr. Chapman, who was obviously affected by the warmth of his reception, in thanking the staff on behalf of himself and his wife, said he had a difficulty in expressing in adequate words the many kindnesses that had been shown him by the presentation of such handsome and useful mementoes. He had, he said, been in the service of the Department for upwards of 46 years and in that time had seen many changes. In again thanking the staff, he expressed the hope that the future might hold much prosperity for them all.

The concert was undoubtedly one of the most successful in the annals of the South Western District and the Committee of Management (Messrs. Weir, H. H. Brown, Cockshott and Alexander) is to be congratulated on the admirable success attending its arrangements.

The catering arrangements in the hands of Messrs. Bennett, Buckley and Bell were also of a high order. A.G.

SOUTH MIDLAND CENTRE.

At the opening meeting of the 1927-28 Session a lecture, " Satellite working in Automatic Areas," was delivered by Mr. F. I. Ray. The lecturer did not read from his typed notes, copies of which had been circulated. At the outset he defined a " Satellite Exchange," explained the application of that definition and stated that at the end of 1927 the satellite exchanges should number 63 with a total capacity of about 100,000 lines.

The arrangements at Newport, Mon., with its two satellites at Risca and Cwmbran were explained. In this area all calls from Risca and Cwmbran, including those from one subscriber at Risca or Cwmbran to another connected with the same exchange were completed by means of the junctions to and from Newport.

From the comparatively simple conditions in the Newport area the lecturer passed on to the more complex systems where it was possible to discriminate in the selection of junctions for (*a*) multi-exchange and (*b*) trunk calls. It was shown that extreme care was necessary before a numbering scheme for a particular area was adopted.

Seven distinct schemes of working, each of which had been designed for a different requirement, were described and details of the methods in use at Leeds and Hanley were outlined.

The limitations of the Brighton Multi-office Exchange area, which consisted of two main and four satellite exchanges where the names of the six exchanges in the area are printed on the dial, were explained.

The scheme designed by the Post Office staff, known as the " Post Office Discriminating Selector Repeater " system, was described and its working shown by means of a demonstration set. The lecture was illustrated by 21 lantern slides.

Mr. McMullen, of Southampton, who was unable to be present, sent a written list of questions relating to the Portsmouth area, and Messrs. Wakefield, Halton, Lewis, Atkins, Capt. Linsell and Mr. Bolton contributed to the discussion.

After the points raised by Mr. McMullen and the verbal enquiries had been answered, the Chairman passed on to Mr. Ray the hearty thanks of the audience.

The November meeting was devoted to a paper by Mr. J. Innes entitled " Edinburgh Auto. Multi-office Transfer." This helpful paper was full of pracical methods of overcoming difficulties of the change of sysem, but as it is to be printed there is no need to make a detailed record here. The slides were much appreciated.

The time left for discussion was too short to enable all members who were interested to take part, but the Lecturer briefly replied to the points raised by Major Harris, Messrs. Atkins, Halton, Nichols, and T. Martin.

There was enthusiastic applause at the end of the lecture and the Chairman thanked Mr. Innes on behalf of the members present.

The comparatively small attendance at the meeting held on the 21st December was probably due to the proximity of the Christmas holidays. Mr. V. Smith read a paper on " Electrolytic Action." It was stated in the introduction that 130 cases of cable damage by corrosion had occurred in the South Midland District during the past twelve months.

Part I. of the paper dealt with damage by chemical action. The four chief causes of damage due to soil constituents were outlined, and it was maintained that the main safeguards against the trouble are dry conduits, the liberal application of petroleum jelly and the use of specially protected cables. Hints on the selection and packing of samples for analysis were given, and this section of the paper concluded with a description of unusual and interesting cases.

In part II. the general use of Tester No. 36 for measuring the strength of a current in a cable sheath was described. The methods and difficulties experienced in detecting leakages from tramway systems were explained and then the procedure when electric lighting mains were suspected was set out. Leakages from the Department's own plant were next to receive attention. They were mainly due, it was shown, to the earth plates at Exchanges being of comparatively high resistance.

The lecture was well illustrated by a number of diagrams.

Twelve members, Messrs. Traviss, Godfrey, Reeves, Bolton, Roach, Dwyer, Halton, Major Harris, Messrs. Wakefield, H. W. Peck, Mullens and the Chairman took part in the discussion during which several points of difficulty appeared to be elucidated.

The Chairman, describing the paper as a good and practical one, thanked Mr. Smith for his work.

On January 25th, the subject taken by Mr. W. H. Arnold was "Thrust Borers and Thrust Boring." The Acting Chairman in introducing the lecturer thanked Mr. Arnold for his zeal in undertaking at short notice to read his paper two months earlier than the date arranged for it in the programme.

It was contended that the use of thrust borers in suitable situations will frequently save expenditure. The advantages of the borer were greatest when conduits had to be laid under railway level crossings or in congested thoroughfares. The best results are obtained when a man with practical experience of the machine travels with it and supervises its use. It was foreshadowed that boring would be resorted to in future even under inexpensive surfaces in rural areas.

Conclusions drawn from experience were given about the types of soil encountered and the method of overcoming obstructions.

A description of the machine known as the Mangnall Irving type G.1 was given. The successive operations were explained in connection with excavating for the pits, inspecting the machine before use, lowering into pit, fixing the pilot bar, the rough and afterwards the fine setting of the machine, launching the pilot, boring the hole and drawing in the pipes.

The paper was illustrated by twelve slides.

In the discussion Messrs. Gilpin, Lewis, V. Smith, Logan, Halton, Summers, Major Harris, Messrs. S. E. Naylor, Wakfield, Roach and Capt. Linsell took part.

The proceedings ended with hearty applause for Mr. Arnold. A.W.L.

SCOTLAND WEST CENTRE.

The fourth meeting of the current session was held in the Royal Technical College, Glasgow, on the 22nd February, the lecturer for the day being Mr. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E., who took for his subject "Satellite Working in Automatic Areas."

The lecture proved to be one of the most interesting and instructive fixtures held locally for some time. The subject was illustrated by means of lantern slides, and demonstrations were given on the working apparatus which had been set up. On conclusion of the lecture several questions were put which were productive of further information, and an opportunity was given for examination of the apparatus.

H. C. MacC.

NORTH WALES CENTRE.

The following is the Committee for the 1927-28 Session :—

Chairman—Mr. R. A. Weaver, M.I.E.E.
Vice-Chairman — Mr. C. A. Jackson, A.M.I.E.E.
Executive Engineers—Mr. G. Richardson, A.M.I.E.E.
Assistant Engineers—Mr. H. P. Lloyd.
Chief Inspectors—Mr. J. Frost.
Clerical Staff—Mr. G. H. Carrier.
Inspectors—Mr. J. C. Spiers.
Draughtsmen—Mr. A. W. Allport.
Local Secretary and Librarian—Mr. J. G. K. Donaldson.

The session was opened on the 12th October, 1927, when Mr. R. T. Robinson, A.M.I.E.E., of the Engineer-in-Chief's Office, read a paper on "Motor Transport in the Engineering Department." The lecturer, after an historical survey of the early experiments in motor transport, enlarged on the post-war expansion of this particular activity and on the various types of vehicle which have been developed in later years to meet the peculiar requirements of the Engineering Department.

The second meeting was held on the 9th November, when Mr. J. Ree, of the Mullard Wireless Service Co., Ltd., read a paper entitled "Thermionic Valves and Distortionless Amplification." The lecture, which was illustrated by a series of slides, dealt largely with the requirements in valves and couplings for good reception and particularly with respect to the comparative impedances of valves and transformers.

The third meeting was held on the 8th December at Birmingham, and was preceded by a visit of inspection to the Midland Exchange. On this occasion Captain J. Coxon, A.M.I.E.E., was the lecturer and the subject of the paper was "Exchange Power Plant." The field covered was a very extensive one and despite a prompt start it was found necessary to curtail the lecture somewhat, in order that some time might be left for the ensuing discussion.

On the 11th January, 1928, Mr. C. G. A. McDonald read a paper entitled " The running of a large Wireless Station," opening with a description of the plant at Leafield and of the difficulties which have been experienced in operating the arc transmitter. Subsequently he described the short wave transmitters at Leafield and also certain experiments which have been made in screening and focussing the transmissions so as to obtain beam effects.

The fifth meeting was held on 1st February, 1928, the subject of the paper being " Satellite Working in Automatic Areas," by Mr. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E., of the Engineer-in-Chief's Office. The lecture was illustrated by an unit demonstration set showing all the operations between a parent and two satellite exchanges, and with the aid of this and numerous slides Mr. Ray provided a very clear exposition of the discriminating schemes in Director and Non-Director areas.

The sixth meeting was held on 22nd February, 1928, when Mr. R. Sheppard read a paper entitled " Exchange Construction." In this paper a survey of the field of the Department's Staffs was made with a collection of notes on the layout and planning of small exchanges, transfer arrangements, construction details, contract works and contractors organisations.

The keen interest taken in the meetings has been marked by the discussions, which have been well maintained on each occasion.

The attendances have been from 80 to 100.

SOUTH LANCASHIRE CENTRE.

An account of the opening meeting of the Session appeared in the January issue of the Journal. Four other well-attended meetings have since been held and the interest in the proceedings has been fully maintained.

On November 14th, 1927, Mr. C. W. Brown, A.M.I.E.E., of the Engineer-in-Chief's Automatic Training School, read a paper on " The Director—Its applications and the functions performed." A particularly clear outline of the working of the Director equipment was given and the reasons were stated for its adoption in the densely telephoned area of Manchester. Keen interest was displayed by the larger number of members and visitors present, and, in the discussion which followed, many points were cleared up by the lecturer.

On December 12th, 1927, a paper was read by Mr. T. Cornfoot, M.I.E.E., entitled " The Administration of an Engineer's Section." This gave an interesting account of the various duties of administration and the difficulties attendant upon the organisation of staff, control of expenditure, etc. Several lantern slides were shown dealing more particularly with the procedure adopted in the Liverpool External Section, and the general information given in the paper was greatly appreciated by the members present.

At a meeting held on January 24th, 1928, members of the North Western Centre of the Institution of Electrical Engineers were present by invitation, together with several members of the Postmaster's staff. A joint meeting of the local Centres of the two Insitutions has now become an annual feature and has done much to strengthen the cordial relations between the memberships of the respective Institutions in the locality. On this occasion a paper entitled " Recent Developments in Power Engineering in His Majesty's Post Office " was read by Mr. H. C. Gunton, M.B.E., M.I.E.E., Chief Power Engineer of the Post Office. The paper proved to be exceedingly interesting, and a good discussion followed. An expression of thanks was moved, on behalf of the visitors, by Mr. A. B. Mallinson, M.I.E.E., Chairman of the N.W. centre of the Institution of Elecrical Engineers.

On February 6th, 1928, the fifth meeting of the session, a paper entitled " Accounting as a Function of Management," was presented by its joint authors, Messrs. T. Fewster and F. Johnston, A.C.I.S., of the Northern Centre of the Institution. The paper was read by Mr. Johnston, who dealt very fully with the subject, and certain modifications of present practice, suggested in the paper, provoked a spirited discussion. Subsequently Mr. Fewster very ably replied to the points raised by the various speakers.

NORTH WESTERN CENTRE.

The third meeting of the 1927-28 Session was held at Preston on the 16th January, 1928, when a paper entitled " Traffic Arrangements as they apply to Automatic Exchange Transfers" was read by Mr. A. L. Barclay (Telephone Traffic Superintendent).

Mr. Shackleton presided over a good attendance which included the District Manager (Mr. S. O. Allen) and a number of his staff.

Mr. Barclay took as an example the actual arrangements made in connection with the recent Southport Automatic Exchange Transfer and covered the following items: — Preliminary Traffic Data, Staffing, Control Sheets, Distribution Lists, Switchboard Lay-out, Co-operation with the Engineering Department, Visiting Subscribers' Premises, Demonstration Set, Advance Transfer, Call Offices, Main Transfer, Post Transfer, Service Inspections, etc. The lecture was illustrated by specially prepared diagrams.

On the 13th February, 1928, a paper entitled "Rebalancing a Cable" was read by Mr. T. Woodhouse, A.M.I.E.E.

Mr. Woodhouse opened his lecture with a review of the sources from which interference can be traced and indicated means of eliminating the trouble. The question of the necessity for rebalancing a cable was fully dealt with and the various tests described at length. The paper was illustrated by diagrams and schedules and was followed by a useful discussion.

D. BARRATT.

DEATH OF MR. R. A. JONES.

It is with deep regret we record the death of Mr. Robert Alexander Jones, Executive Officer Higher Grade (Staff Officer), of the Superintending Engineer's Office, North Western District, which occurred in a Nursing Home on the 13th February, after an urgent operation. Mr. Jones was taking a few days Annual Leave at his home in Southport when his sudden illness occurred, and the news of this followed quickly by the announcement of his death came as a great shock to his colleagues and friends in the North Western District.

Born on the 17th April, 1869, and appointed Sorting Clerk and Telegraphist at Liverpool in June, 1885, he had completed nearly 43 years' service, and his death adds yet another to the sad list of zealous members of the staff who have fallen out of the ranks within hailing distance of retirement.

He was promoted to the position of Junior Clerk in the Engineering Department in July, 1891, and commenced his engineering career in Manchester, the headquarters of the old North Western District. Passing uninterruptedly through the various clerical grades, and serving in many Districts (North Eastern, North Wales, North Midland), he was back again in the North Western District, at Manchester, as Chief Clerk in the beginning of 1904. In November, 1911, he moved to Preston, the Headquarters of the new North Western District, where he found full scope for his outstanding organising and administrative abilities, and where he served the Department for the past 16 years.

In his official life, R.A.J., as one of his many friends in a letter of condolence remarks, stood for a great tradition; he was first and foremost a Department's man, but in his dealings with his staff his high sense of justice was tempered by strong human sympathy, which had its foundations in his deep religious convictions.

He served on the Local Committee of the I.P.O.E.E., and from time to time contributed interesting and useful papers, notably his recent paper entitled "Accidents on Duty" and his last paper read during the last session, "Some Curiosities of Official Literature."

In his unofficial life he found time for many public activities. He was a Warden and Councillor of St. Luke's Church, Southport, and past-Chairman of the Southport Branch of the English Church Union. He also took an active interest in the Boy Scout movement. A master of pure English and possessing a keen sense of humour he was a pleasant conversationalist.

The funeral took place on February 16th. The service was held at St. Luke's Church, Southport, and the burial was at Wallasey. In addition to the Superintending Engineer and Assistant Superintending Engineer and representatives of the Surveyor's Department and all ranks of the Engineering Staff, the funeral was attended by many representative public men, including the Mayor of Southport.

He leaves a widow and son and daughter and the heartfelt sympathy of his many colleagues and friends throughout the Service will be added to that which goes out to them from within the District in their sad bereavement.

May he rest in peace.

S.U.

EASTERN CENTRE.

Mr. J. E. A. Sorrell.

Mr. J. E. A. Sorrell.

By the retirement of Mr. J. E. A. Sorrell, another well known and popular officer is lost to the Telegraph side of the Engineering Department. Entering the Post Office service as Telegraphist at the C.T.O. in January, 1884, he proceeded to qualify himself for technical duties and was a pupil of Sir William Slingo.

After considerable experience on telegraph repeater work in the C.T.O. he was transferred to the Engineering Department as a Relay Clerk (Lower Section) in 1894, serving for a short time at East Dean, after which he was stationed at Llanfair P.G. (Anglesey).

In March, 1900, he was appointed to the Engineer-in-Chief's Office as 2nd Class Engineer. After only a year's service in this capacity he returned to the repeater service for private reasons and was stationed at North Walsham. May, 1905, saw him promoted to Relay Clerk (Upper Section) and placed in charge at North Walsham. Here many strenuous years were spent in telegraph experiments between England and Germany that resulted in replacing Hughes by duplex Baudot working. In 1910 he was appointed a member of the Anglo-German Commission, a position for which, by virtue of his extensive experience, he was especially suitable.

The cessation of Anglo-German communication at the outbreak of War in 1914 resulted in the closing down of North Walsham Repeater Station, and Mr. Sorrell was sent to take charge at Warrington, where a telegraph Repeater Station had been established. November 1st, 1915, saw him back again on the East coast as officer-in-charge of the Lowestoft Repeater Station, where he remained until his retirement on the 18th October, 1927.

During the last two years of his service the Repeater Station was removed to a new building, and he had the privilege of being in charge of the most up-to-date station in the country.

Mr. Sorrell's activities in his leisure hours were numerous and he will not find the years of his retirement hang heavy.

His many colleagues past and present wish him health and happiness in his retirement. He will always be remembered as a keen servant of the Deparment yet at the same time a considerate and kindly chief.

J.A.S.M.

BOOK REVIEWS.

" Wireless Direction Finding and Directional Reception." By R. Keen, B.Eng. (Hons.), Sheffield, A.M.I.E.E. The Wireless World, Iliffe & Sons, Ltd. 490 p.p. 21/-.

This book is a second edition of a book first published in 1922 under the title of " Direction and Position Finding by Wireless." The present edition is expanded to form a comprehensive treatise on all systems of directional reception. The Wireless Direction Finder has furnished the seaman with a valuable auxiliary to the appliances on which he relies to navigate his ship. With the increasing use of radio as a means of telegraphic communication, the properties of directional reception have become of great importance to the Radio Engineer.

The author's treatment of the theoretical side of the subject is ample for the purposes of the book; a comprehensive Bibliography, to which appropriate references by numbers are made in the text, appears at the end of the book, and furnishes a useful guide to those who wish to make a more intensive study of the subject, The author deals with the practical side of the subject in the fullest and clearest manner. The book is singularly free from error, which gives evidence of careful preparation and proof reading, and can be confidently recommended to all those interested in the subject dealt with.

Chapters devoted to " maps " and " Notes on Field and Nautical Astronomy " will be found of especial use to those responsible for installing direction finding installations, and a chapter on " Fault clearing and Maintenance " should prove useful to those responsible for the maintenance of the plant, although this last chapter is particularly applicable to the Bellini Tosi system as developed by the Marconi Co.

F.W.D.

" History of Radio Telegraphy and Telephony." By G. G. Blake, M.I.E.E., F.Inst.P. Publishers: Messrs. Chapman & Hall, Ltd. 25/- nett.

The compass of this book includes both a brief historical review of the history of wireless and a compendium of inventions, schemes and proposals which have been concerned in the development of radio telegraphy and telephony.

Both sections of the work are valuable by the extensive references given to the published articles, proceedings of various societies and patent specifications which deal with the subject matter outlined by the author.

The references, which total 1,125, are conveniently tabulated in one list, and there is a good index.

Some instances may be noticed where the original article describing an improvement or invention might advantageously have been quoted instead of or in addition to later publications on the subject. In this connection original papers in the American Institution of Electrical Engineers on " Wired Wireless " and " Beverage Antennæs " has not been referred to, but later articles on the same subject are noted. The most prominent patents in modern wireless and the earlier invention and " disclosures " which are of great interest and importance to the designer and user are included in the review. One notable omission is that of Lee and Hogan's adaptation of the Fessenden Heterodyne Receiver which is not mentioned.

The method of cross-reference is generally clear, but a few obscurities or errors occur. In describing the Bellini and Tosi Direction Finding Method it is stated that an account of their work appeared in 1907, but the references given are to publications in 1919 and 1920 and an original article by Bellini published in the *Electrician* in 1914 is overlooked.

The book can be recommended to the student of wireless history, as well as to those interested in the application of patents which have now lapsed or are still in force.

A.S.A.

" Practical Radio Telegraphy." By Nilson and Hornung. McGraw Hill Publishing Coy., Ltd. Price 15/-.

This work which is of American origin is intended to serve as a text book for students who wish to pass the examination for a Radio Operator's License in the U.S.A.

The earlier part of the book deals briefly with the elementary principles of the subject, and the later chapters are confined to descriptions of ships' wireless equipments peculiar to modern American practice.

The authors state in their preface that the trend in the design of modern radio equipment is from the spark to the valve type; one could have wished therefore that a good deal of the considerable space devoted to spark might have been cut down to make room for some extension of the chapters on valve transmitters. The chapter on Direction Finding Equipment might also have been usefully extended to include further technical details of the receivers: no diagrams of either of the types described were given.

The book is profusely illustrated and for those who are interested in ships' wireless equipment can be recommended as giving a comprehensive survey of American maritime wireless practice.

H.B.T.

"The Call Indicator System of Automatic Telephony." (A. G. Freestone). Sir Isaac Pitman & Sons, Ltd. 6/-.

This book embodies concise and clear expositions of the circuit arrangements employed in this secondary, but very important, part of the scheme for the conversion of a metropolitan area to automatic working.

The descriptions are not over-burdened with detail and the uniformity of method adopted in presenting the various facilities and circuit functions is very helpful to a proper appreciation of the sequence of operations.

It is unfortunate, however, that the inset diagrams have been placed without sufficient regard to the need for continuous reference between them and the letter press, and before settling down to a study of the book readers would be well advised to remove the diagrams to the end of the respective circuit descriptions.

There are no material errors to record, and, apart from the reference to the intermittent click facility (p. 57), which has not been provided, the subject matter is thoroughly up to date.

With the exception, perhaps, of a few minor modifications either already adopted or in contemplation, the utility of the book is not likely to decrease with the lapse of time and its acquisition can be recommended both to students who desire to improve their acquaintance with the application of machine switching principles to modern circuit problems and also to those others, whose interest is of a more practical nature.

J.R.

"Wireless Principles and Practice." By L. S. Palmer, M.Sc., Ph.D. London: Longmans Green & Co. 504 pp. 18/-.

The volume under consideration is stated to be specially intended for the student and for the Electrical Engineer who wishes to become conversant with wireless.

The work is divided into twelve chapters, the first five being concerned with the principles of Radio, while the remaining seven deal with practical applications.

The first and second chapters on Wave Motion and Wireless and on High Frequency Alternative Currents and Oscillatory circuits respectively give concise but adequate treatment of the subject.

Chapter three is devoted to Wireless Circuits and Aerials for Transmission and reception. It deals with circuit components, wavemeters, decrement and selectivity and aerials and radiating systems, including a few words on the measurements of aerial constants. We should expect to find some reference to wave antennæ beyond a solitary reference in the Bibliography.

The following chapter is on the subject of Special Circuits, which are dealt with under three headings, viz.: Rejector and Acceptor Circuits, Coupled Circuits, and circuits for Duplex and Dual operation. The first and third are dealt with fairly briefly, the second very thoroughly. It is perhaps a matter of regret that the subject of filters does not receive more adequate treatment in view of the importance of such circuits in modern practice. Reference to the most informative source of information on filters, viz., The Bell Technical Journal, is also omitted from the Bibliography.

Chapter five is devoted to the theory of the wireless valve and contains sections on conduction through gases, electron emission from hot bodies, the two electrode valve characteristics, valve design and manufacture and finally four electrode valve characteristics.

Chapter six deals with spark arc and alternator methods for the generation of high frequency currents. It is noticed that the author falls into the popular error that the use of a spacing wave tends to interfere unnecessarily with other stations, whereas actual practice tends to indicate the reverse, owing to the absence of key clicks.

In the section on alternators it is surprising to find no reference to the Bethenod-Latour alternator used so widely in France at St. Assize, Lyons and Bordeaux.

The following chapter is devoted to the subject of the three electrode valve oscillator, while chapters 9 and 10 deal respectively with the detection and amplification of oscillatory currents. A description is given of a two wire telephone repeater; the author's figures for the normal spacing of repeaters are far too high.

Wireless Telephony is next dealt with, while a final chapter on Directional Wireless completes the work. In describing the single sideband suppressed carrier system of telephony the reader is rather led to infer that the main object of this system is to reduce distortion whereas the primary consideration is of course the reduction of the frequency band utilised.

The book gives a well-balanced and comprehensive survey of the whole field of radio communication, unnecessary elementary sections on electricity and magnetism, which so frequently form a goodly proportion of the contents of books on Radio communication, are absent, and the writer does not hesitate to use mathematics where the subjects call for it.

One of the most valuable features is the inclusion of a Bibliography at the end of every chapter divided into sections corresponding to the sections of the chapter. The Bibliography gives references only to articles in periodicals or proceedings of scientific societies, but does not give references to published books. In many cases references to such works would be useful to readers.

The book is undoubtedly the most up-to-date on the subject and it will have a wide sphere of usefulness as a work of reference for engineers and as a text book for students.

A.J.G.

"The Principles of Electric Power Transmission by Alternating Currents." By H. Waddicôt, B.Sc., A.M.I.E.E., A.A.I.E.E. Published by Messrs. Chapman & Hall, Ltd. 21/- net.

This book, which is published at a very opportune time in view of the many power distribution schemes now proposed or being put in hand, deals with the electrical problems that occur in designing alternating current transmission lines. It is primarily intended to be a suitable text book for students pursuing this subject, but at the same time the problems have been treated practically and it will also be found useful to designers and engineers in charge of power transmission systems. Throughout the book the reader will find a large number of practical examples worked out in detail, both mathematical and graphical methods being used where possible.

After considering elementary principles the author deals with the electrical problems involved in short and long transmission lines. As the book is written to deal with the electrical problems of transmission the mechanical construction of the line is only slightly dealt with, but it is thought that the value of the book for general use would be improved if the chapter on overhead construction were amplified in future editions from this point of view.

Following the consideration of insulation of the line the method of maintaining constant the terminal voltage of the line with varying loads by installing idle running synchronous motors and modifying the power factor by varying the excitation is dealt with fully. This chapter is followed by the consideration of underground mains and an exposition of the economic principles of design, the final chapters dealing with problems caused in operation by normal and abnormal conditions, surges, lightning, etc., and the various protective devices necessitated and employed.

The book is well illustrated and useful references are given at the end of each chapter, to a larger number of technical papers dealing with aspects of the subject.

J.McG.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to.	Date.
Arundel, D. S.	Assistant Engineer, N. Mid. District.	Executive Engineer, N. Mid. Dist.	1-2-28
Collis, S. A.	Inspector, Testing Branch.	Chief Inspector, E.-in-C.O.	1-10-27
Smith, B. J.	Inspector, S. Western District.	Chief Inspctor, S. Western District.	To be fixed later.
Cresswell, W. H....	Inspector, London District.	Chief Inspector, E.-in-C.O.	To be fixed later.
Meldrum, F. A.	Inspector, S. Lancs. District.	Chief Inspector, E.-in-C.O.	To be fixed later.
Josephs, H. J.	Draughtsman, Class II., Ldn. Dist.	Chief Inspector, E.-in-C.O.	22-12-27
Bull, S. W.	S.W.I., S. Western District.	Inspector, S. Western District.	28-1-28
Ryan, J. F.	S.W.I., S. Western District.	Inspector, S. Western District.	29-1-28
Sansom, W. S.	S.W.I., S. Western District.	Inspector, S. Western District.	21-1-28
Wilkinson, E.	Wayleave Officer, N.E. District.	Inspector, N. Eastern District.	1-2-28
Hay, H. E.	S.W.I., N. Eastern District.	Inspector, N. Eastern District.	To be fixed later.
Robinson, R.	S.W.I., Northern District.	Inspector, Northern District.	7-10-27
Scrafton, C. D.	S.W.I., Northern District.	Inspector, Northern District.	7-10-27
Madgwick, J. M.	S.W.I., Northern District.	Inspector, Northern District.	7-10-27
Pitloh, T. P.	S.W.I., Northern District.	Inspector, Northern District.	10-6-27
Hemming, M. H....	S.W.I., N. Wales District.	Inspector, N. Wales District.	20-11-27
Mason, H.	S.W.I., N. Wales District.	Inspector, N. Wales District.	24-10-27
Hargrave, A.	S.W.I., N. Wales District.	Inspector, N. Wales District.	1-1-28
Wilson, W. C.	S.W.I., N. Wales District.	Inspector, N. Wales District.	25-2-28
Rogers, A. H.	S.W.I., N. Wales District.	Inspector, N. Wales District.	24-10-27
Prichard, E. J.	S.W.I., N. Wales District.	Inspector, N. Wales District.	3-1-28
Corner, W. H.	S.W.I., N. Eastern District.	Inspector, N. Eastern District.	3-2-28
Lawrence, C. R.	S.W.I., N. Eastern District.	Inspector, N. Eastern District.	12-10-27
Porter, E. R. C.	S.W.I., Eastern District.	Inspector, Eastern District.	28-8-27
Harrison, H. W.	Tel. C.T.O.	Repeater Officer, Class II., North Walsham.	12-12-27
Hartnell, E. W. J.	S.C. & T., Bristol.	Repeater Officer, Class II., Lowestoft.	To be fixed later.
Flowers, T. H.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Brock, P. R. W.	Probationary Inspector, London Dist.	Inspector, London District.	
Boocock, R. O.	Probationary Inspector, N. Mid. Dist.	Inspector, N. Midland District.	
Bell, C.	Probationary Inspector, London Dist.	Inspector, London District.	
Lewis, N. W. J.	Probationary Inspector, London Dist.	Inspector, London District.	
Leckenby, A. J.	Probationary Inspector, London Dist.	Inspector, London District.	
Pitcairn, A. C.	Probationary Inspector, London Dist.	Inspector, London District.	
Groves, K. G. R....	Probationary Inspector, London Dist.	Inspector, London District.	
Collman, E. L.	Probationary Inspector, N. Dist.	Inspector, Northern District.	
Cawsey, A. J.	Probationary Inspector, S. Mid. Dist.	Inspector, S. Midland District.	
Ellis, H. O.	Probationary Inspector, S.W. Dist.	Inspector, S. Western District.	
Morgan, C. A.	Probationary Inspector, London Dist.	Inspector, London District.	15-1-28
Ingram, C. P.	Probationary Inspector, N. Dist.	Inspector, Northern District.	
Penney, A. E.	Probationary Inspector, London Dist.	Inspector, London District.	
Porter, J. E.	Probationary Inspector, London Dist.	Inspector, London District.	
Bucknall, F. R. B.	Probationary Inspector, N. Dist.	Inspector, Northern District.	
Hobbs, H.	Probationary Inspector, S.W. Dist.	Inspector, S. Western District.	
Cherry, D. W.	Probationary Inspector, London Dist.	Inspector, London District.	
Francis, H. E.	Probationary Inspector, N.E. Dist.	Inspector, N. Eastern District.	
Knapman, D. E.	Probationary Inspctor, S. Mid. Dist.	Inspector, S. Midland District.	
Greening, F. C. G.	Probationary Inspector, London Dist.	Inspector, London District.	
Wilcockson, H. E.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Coates, A. G.	Probationary Inspector, S. Mid. Dist.	Inspector, S. Midland District.	

Transfer.

Name.	From.	To.	
Pattison, B. C.	Inspector, Eastern District.	Inspector, N. Wales District.	1-3-28

Retirements.

Name.	District.	Grade.	Date.
Chapman, A. E.	S. Western.	Assistant Superintending Engineer.	29-2-28
Crisp, C. T.	S. Eastern.	Executive Engineer.	23-2-28
I'Anson, R.	N. Midland.	Executive Engineer.	31-1-28
Devonshire, T. E.	S. Midland.	Assistant Engineer.	31-12-27
Homfray, F. W....	S. Midland.	Chief Inspctor.	18-2-28
Crampton, G. H.	S. Midland.	Inspector.	31-12-27
Manion, J.	N. Eastern.	Inspector.	31-12-27
Chapman, O. E....	Eastern.	Inspector.	3-1-28
Davidson, G.	N. Eastern.	Inspector.	5-10-27

Deaths.

Name.	District.	Grade.	Date.
Ashbee, A. W.	S. Western.	Chief Inspector.	24-11-27
Childs, P. J.	London.	Assistant Engineer.	8-2-28
Evans, J. W.	London.	Inspector.	11-1-28
Pagan, D.	Scotland East.	Inspector.	8-1-28

Appointments.

Name.	Appointed to :—		
Jackman, A. J.	Probationary Assistant Engineer.		Open Competition.
MacWhirter, R.	,, ,, ,,		
Barron, D. A.	,, ,, ,,		
Holmes, M. G.	,, ,, ,,		
Dallow, J. E.	Probationary Inspector,	London Dist.	Limited Competition.
Birch, S.	,, ,,	London Dist.	
Joyce, R. M.	,, ,,	London Dist.	
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