WS No. 19 Mark III

P.W.—E.2.

Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject:

Automatic Telephony: Coder Call Indicator (C.C.I.) Working.

ENGINEER-IN-CHIEF'S OFFICE,
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AUTOMATIC TELEPHONY: CODER CALL INDICATOR WORKING.

(E. 2.)

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AUTOMATIC TELEPHONY: CODER CALL INDICATOR WORKING.

I.—GENERAL DESCRIPTION.

The purpose of the Call Indicator System.

A brief description of the director system of automatic telephony is given in Technical Pamphlet E1, which contains also a short account of call indicator working.

The director system is one specially designed to meet the needs of large areas, and it will be remembered that calls are made by dialling a three letter code, consisting of the first three letters of the exchange name, followed by the four digits of the wanted subscriber's number. Thus, to call **BAT**tersea 4932, the letters and digits dialled would be **BAT** 4932.

In pamphlet E1 reference is made to the method of "dialling-out" to manual exchanges, by which is meant the selection of a junction by the automatic apparatus in response to the dialling of specified digits as advertised in the directory. The junctions so obtained are terminated at "B" positions where calls are completed by operators who take particulars of the required numbers from the calling subscribers.

The application of such a scheme to the director system would mean that, during the initial stages of the conversion of the area to automatic working, while manual exchanges preponderated in number, subscribers would dial 7 digits, only to be met, in the majority of cases, by an operator's request for "Number, please." Such a procedure would not only be irritating to the subscriber, but would also greatly minimise the advantage in speed to be obtained with an automatic system.

An alternative method of handling this traffic would be the provision in each manual exchange of sufficient automatic plant of the regular type to deal with the calls originated at automatic exchanges. The switchboard multiple would be extended over final selectors and calls originated at automatic exchanges would thus be completed without the assistance of an operator. The apparatus provided would form the nucleus of the full automatic plant to be installed later. Such a scheme, however, presents many practical difficulties. The floor space required would in many cases exceed that available in existing exchanges, and this difficulty would be constantly increasing as extensions were required due to the growth in

the number of automatic exchanges. Moreover, in many cases when the life of an exchange is exhausted it is found to be no longer in the economic centre of the area, the characteristics of which may have changed considerably during the life of the exchange. In consequence, the perpetuation of that building as an automatic exchange would not be desirable and the method of gradual conversion found to bring no real advantage. It is evident, therefore, that although in some circumstances such a procedure may prove to be convenient, it does not suffice to develop the area on the assumption that this practice will always be followed.

It is for these reasons that the call indicator system has been introduced. The four numerical digits are transmitted to the manual exchange and there received by apparatus which displays the number before an operator, who then completes the call without requesting the subscriber to repeat the number he has already dialled.

When the junction has been seized it is necessary to associate it with disengaged call indicator apparatus, and it is therefore necessary to delay the transmission of the numerical impulses over this junction until the search for disengaged apparatus has been completed. The numerical impulses must, therefore, be stored at the automatic exchange, and retransmitted when apparatus is available to receive them at the manual exchange. It will be remembered that these impulses have already been once stored and retransmitted by the director, and the repetition of this process would introduce an undesirable delay in the completion of the connection. This difficulty is overcome by introducing at the automatic exchange a *coder* from the use of which is derived the expression "*coder call indicator.*" The coder receives the impulses from the director, and, when the manual exchange end of the connection is prepared, transmits them over the junction in the form of positive and negative pulses which are much more rapidly delivered than the original "Strowger" impulses. The four digits are transmitted in 1·2 secs.

At the manual exchange the junctions are not terminated at the "B" positions, but are provided with rotary line switches by means of which disengaged apparatus at a C.C.I. position is found. The outlets from the incoming line switches are distributed over the whole of the C.C.I. positions. There is in this respect a fundamental difference between the C.C.I. positions and the other "B" positions upon which actual junctions are terminated.

It is arranged that calls are distributed to the operators' positions in cyclic order. As soon as a junction is seized, it is extended to one of the call indicator positions. As one call only can be displayed on the position at one time, it is

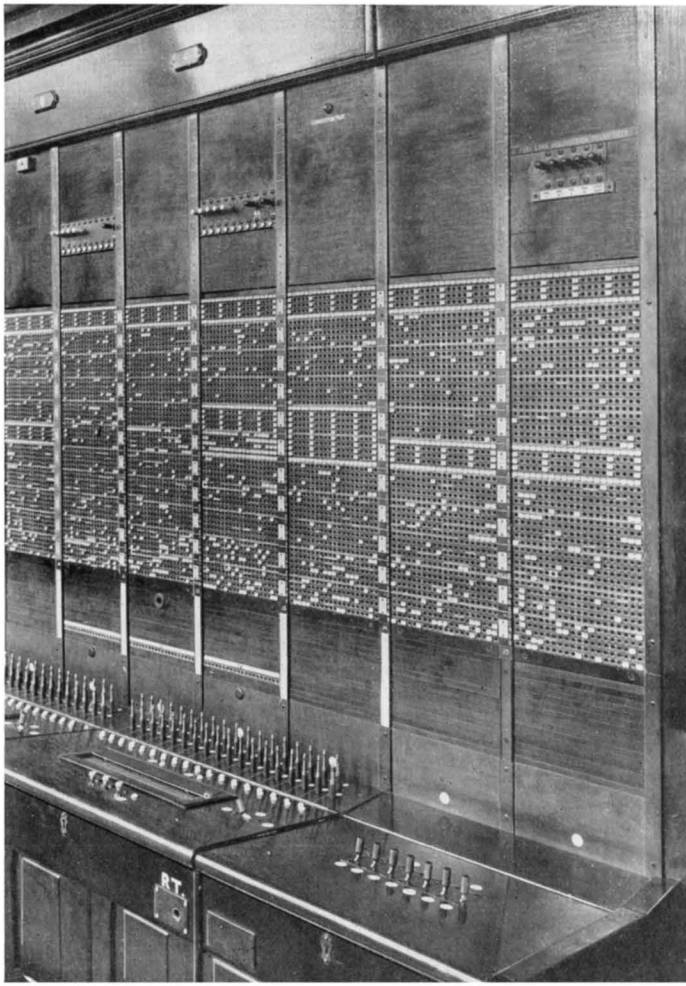

FIG. 1.

arranged that, when a call arrives, it shall be accommodated until the operator has cleared the previous display. For this purpose each position is provided with five *markers*, by means of which the display apparatus is enabled to associate itself successively with the calls waiting to be displayed. The functioning of these markers is described later, but it should be realised at this stage that by their use it is possible to arrange that the junctions shall be held until the display apparatus is available, and the calls displayed in the order in which the junctions are taken into use. The display apparatus proceeds to make connection with the marked junctions and displays the calls in as rapid succession as the operators can deal with them.

Call Indicator Operating.

A call indicator position at Battersea Exchange is shown in Fig. 1. The display itself is shown in Fig. 2, in which

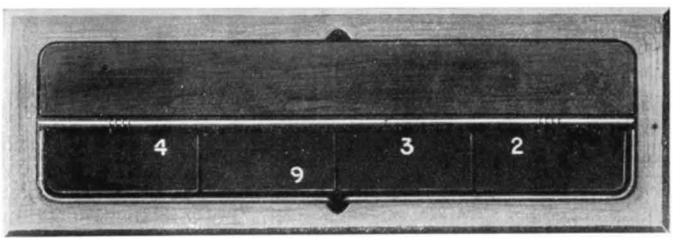

FIG. 2.

No. 4932 is shown displayed. The display consists of a stencil covered by a strip of green glass which does not permit any of the numbers to be seen until illuminated from behind. Fig. 3 shows the display panel with the green

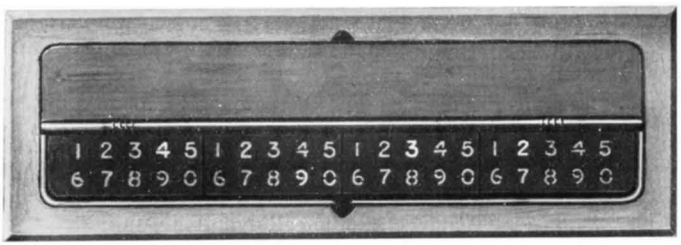

FIG. 3.

glass removed, thus revealing the arrangement of the stencil figures, number 4932, as before, being displayed. The arrival of a call on the position apparatus is indicated by the lighting of a pilot lamp (Fig. 4) followed by the display itself. When

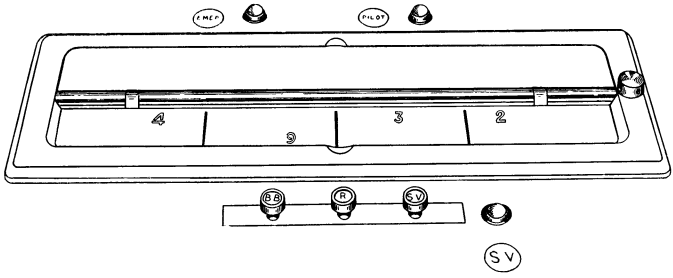

FIG. 4.

a number is displayed before an operator, she selects *any one* of the 36 single cords with which the position is equipped and if she finds the required line disengaged, inserts the plug in the multiple jack. This action associates the cord circuit with the junction carrying the displayed call and the display is thereupon extinguished. The fact that the operator may employ at will any of the cords not already in use enables her to select a cord on the left of the position when the called number appears in the left hand portion of her multiple, or she may select one of the right hand cords when the number is in the right of her multiple, thus reducing the interlacing of cords over the face of the multiple.

Associated with each cord is a supervisory lamp which lights when the calling party replaces the receiver.

Calls to engaged lines.—Fig. 4 shows that in front of the display panel are three press button keys, one of which is marked **BB.** Should the operator find the required lines to be engaged, she will depress the BB key whereupon the display will be extinguished, and busy tone transmitted to the calling line.

Special service.—In the event of the operator being unable to deal with a call, owing to the number displayed being spare, or to failure of the apparatus to display the number satisfactorily, she may divert the call to the information desk or some other point where the call will receive attention. This she may do by extending the call over a circuit appearing in the multiple or by the depression of the press button marked **SV** which can be seen in Fig. 4. By depressing this

key, the call is routed to the special service position. The SV key gives access to five special service circuits and in the event of these being all in use, the SV lamp at the right of the button is lighted. In this case the call may be routed to the information desk via the multiple.

Decoder release key.—The centre key of the three keys situated in front of the display panel is marked **R.** This is used if the lighting of the pilot lamp is not followed by a display, a circumstance that would result, for example, from a temporary loop on an incoming junction circuit. The depression of the release key restores the apparatus which is lighting the pilot lamp. In addition, the SV key is depressed in order that, if the absence of a display has been due to a failure of the apparatus, the call may receive attention.

Line out of order.—When the "out of order" tone is heard on the called subscriber's circuit the connection is extended to the testing telephonist via the special service multiple.

Calls accidentally cut off.—If a plug is accidentally withdrawn before the conversation is completed, the supervisory lamp associated with the cord will glow. The call may then be re-established by plugging the cord into a special service line.

Flashing re-call.—If, after an incoming call, a subscriber raises his receiver to originate a call before the operator has withdrawn the cord, the supervisory lamp will flash and an intermittent click will be heard in the operator's head set. If the night alarm key (Fig. 1) has been thrown a re-call buzzer will operate intermittently.

Closing of position.—Positions are closed by throwing all the marker keys at the top of the position (Fig. 2) and dealing with any calls waiting on the position. The instrument plug is then withdrawn and the marker keys restored to normal.

Coupling of positions.—A coupling key is provided on each position and by means of this key the engaged test may be coupled to the operator's head set on either of the adjacent positions, enabling her to deal with calls arriving on the position that is opened by the operation of the coupling key. The key may be seen on the right of the position in Fig. 1.

Emergency manual working.—If for any reason it is not possible to operate the position in the normal manner,

calls may be dealt with manually by throwing the emergency key at the top of the position. Incoming calls are then indicated by the glowing of the lamp marked **"EMER"** (Fig. 4) and the junction on which the call is routed is automatically connected to the operator's head set. If the caller clears before the operator's challenge the out of order tone will be connected to the head set. The apparatus can then be restored by plugging a cord momentarily into any jack in the special service multiple.

The C.C.I. Apparatus and its Functions.

The apparatus involved in the establishment of a call to a call indicator position is represented in Fig. 5. (*See* end of pamphlet.) In the following description the functions of each piece of apparatus are described, after which the process of establishing a connection is summarised.

Auto to C.C.I. Relay Set and Coder Finder.—At the automatic exchange relay sets (hitherto known as " repeaters ") are associated with the junctions to manual exchanges and associated with each relay set is a coder finder, the function of which is to take into service a disengaged coder as soon as the relay set is seized. The coder is illustrated in Fig. 6 which shows two coders mounted on one base.

Coder.—When the coder has been seized a signal is passed to the director employed in establishing the connection, whereupon the director repeats into the coder the impulses corresponding with the numerical portion of the called subscriber's number. The director is then released from the connection. A signal is passed to the manual exchange indicating that a call is awaiting attention and when the apparatus at the manual exchange is prepared, a signal is sent back into the coder which proceeds to transmit the coded pulses. The coder is then released.

Incoming Line Switch.—Each junction is terminated at the manual exchange on a rotary line switch of the non-homing type. This line switch commences to rotate as soon as the units digit has been received by the coder and searches for a disengaged trunk relay set.

Trunk Relay Set.—The trunk relay set is a group of relays which controls the manual end of the connection and associates the junction with apparatus which will display the number called. Each position is served by a maximum of 50 trunk relay sets.

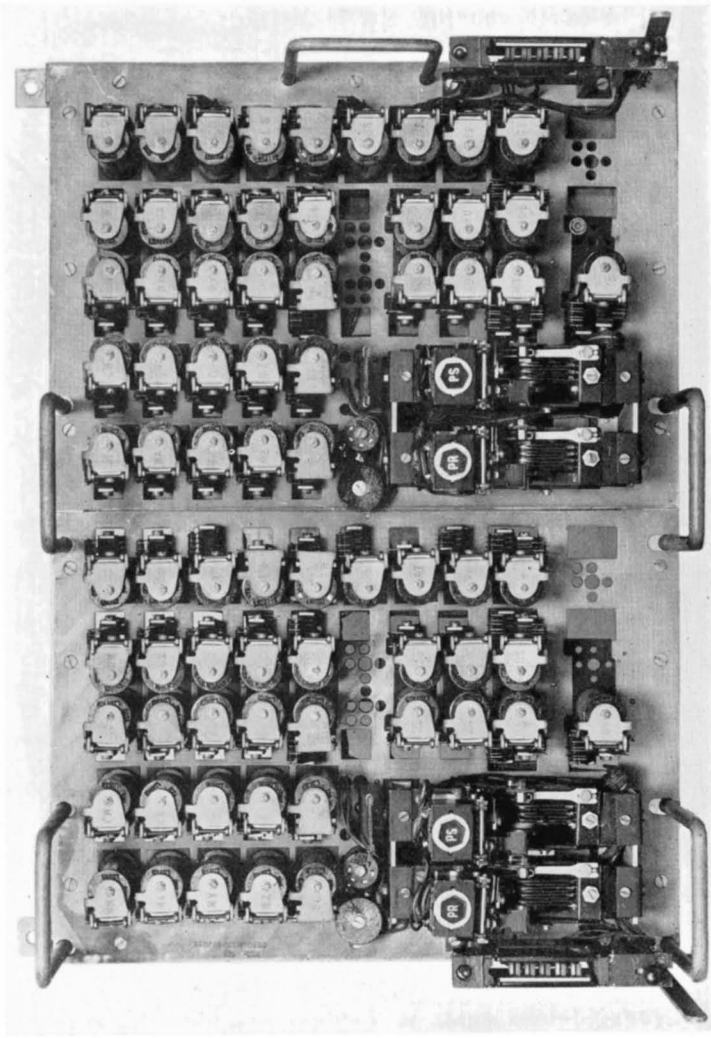

Fig. 6.

Position Load Distributor (P.L.D.)—The outlet multiple from each group of incoming line switches is distributed over the trunk sets of a suite of positions, the choice of a position being controlled by a position load distributor. This is a preselecting rotary line switch making one step forward each time a call is received. Each contact of this switch corresponds with one operator's position and the only position available for receiving calls is the one determined by the contact on which the position load distributor is at the moment standing. Thus the only trunk sets available to the hunting rotary line switch at any particular moment are those associated with the particular position indicated by the distributor at that moment. As soon as a trunk set has been seized the distributor steps and the next call is thus routed to another position. One load distributor is provided per suite of 5 positions. Unless precautions are taken, such a scheme would leave a possibility that a line switch would find no disengaged trunk set on the " open " positions, *i.e.*, the position made open to receive calls as determined by the distributor. In order that such a circumstance shall not prevent a call maturing, the circuit arrangements incorporate a " kick-off " feature which provides that if a line switch hunts continuously, the distributor will be stepped forward and an alternative choice of trunk sets offered to the line switch. Hence the line switch will not fail to find an outlet unless every trunk set to which it has access is engaged. If such a circumstance arises an audible alarm is given indicating the necessity for opening some more positions.

Positions which are not staffed are closed by the withdrawal of the operator's head set plug. Positions on which all the cord circuits are in use are also closed to the P.L.D.

Marker.—Each position is equipped with five markers which also are of the R.L.S. type. The outlets from these switches are extended to the trunk sets and as soon as a set is seized by an incoming line switch a marker rotates to discover which set has been taken and thus indicates to the display apparatus that a call is awaiting attention.

Marker Distributor.—The marker distributor, another rotary line switch, determines that the five markers are taken into use in rotation. As soon as a marker is employed, the marker distributor steps to the next position, indicating to another marker that it will be required to hunt for the next trunk set taken into use.

Decoding Control Switch.—The calls arriving on the trunk set are dealt with in order by means of a decoding

control switch. This rotary line switch makes connection with the operated markers in rotation and connects them with the decoder.

It will be seen that by means of the marker distributor, markers, and decoding control switch, calls are lined up in the position in queue formation, and are displayed before the operator in their original order.

Decoder.—This is a relay set which includes polarised relays responding to the positive and negative pulses transmitted from the automatic exchange. By means of the decoding control switch the decoder is connected to the marked trunk sets in the order in which they are seized by the incoming rotary line switches. As soon as the decoder is connected to a trunk set a signal is passed back to the automatic exchange and the coder delivers its coded impulses. These impulses are received by the decoder. The decoder operates a series of storage relays and this effects the display of the call on the operator's display panel. The storage relays remain operated until the operator deals with the call. The decoder is released and made available for receiving another call as soon as the display lamps are glowing. If the displayed call is not completed by the operator by the time the second call is decoded, the decoder will store the received impulses until the storage group is freed.

A polarised relay is shown in Fig. 7.

Cord Circuit R.L.S.—When the operator, after taking the line, inserts the plug into the multiple, the rotary line switch

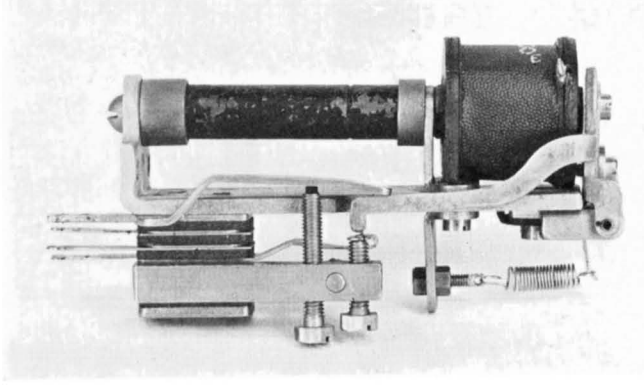

FIG. 7.

associated with the cord circuit seeks for the trunk set which is holding the displayed call and so extends the connection to the called subscriber's line. Ringing current is immediately connected to the called line, and when the call is answered, the polarity of the incoming line is reversed, effecting operation of the calling subscriber's meter in the automatic exchange.

Special Service Trunk Finder.—If the SV key is depressed, connection is made with the call by the *special service position trunk finder* (S.S.P.T.F.) instead of by the cord circuit R.L.S. Five of these S.S.P.T.F.'s are provided per position, and these switches share a group of special service circuits common to the suite of call indicator positions. The wipers of the S.S.P.T.F. are connected to the wipers of a *special service trunk finder* which seeks a disengaged outlet to a special service position.

Special Service Distributor.—The order in which the S.S.P.T.F.'s are taken into use is determined by a distributor. This is a preselecting rotary line switch that steps each time a call is routed via the special service circuit and prepares another S.S.P.T.F. for the next call. This switch is not shown in Fig. 5.

Emergency Manual Switch.—At the top of each position is an emergency manual key. When this key is thrown on emergency manual switch rotates in search of trunk sets holding calls. When such a set is found a circuit completed from the emergency manual switch to the trunk set results in the connection being extended from the trunk set to the operator's telephone circuit. Upon the arrival of a second call a trunk set is seized and the position engaged to the P.L.D. until the first call has been dealt with by the operator. Two calls may thus be held in the positions under emergency conditions, one call being attended to by the operator and the other waiting.

Summary of the Foregoing.—The sequence of events described in the foregoing paragraphs is represented diagrammatically in Figs. 8 and 9. Fig. 8A shows the marker distributor standing on position 1, thus determining that the first marker will be employed by the first call to arrive on the position.

In Fig. 8B a trunk set has been seized by an incoming R.L.S. and thereupon located by the marker. The marker distributor is stepped to prepare the next marker and since there is no other call at present being dealt with on the position or waiting, the decoder control switch has made connection

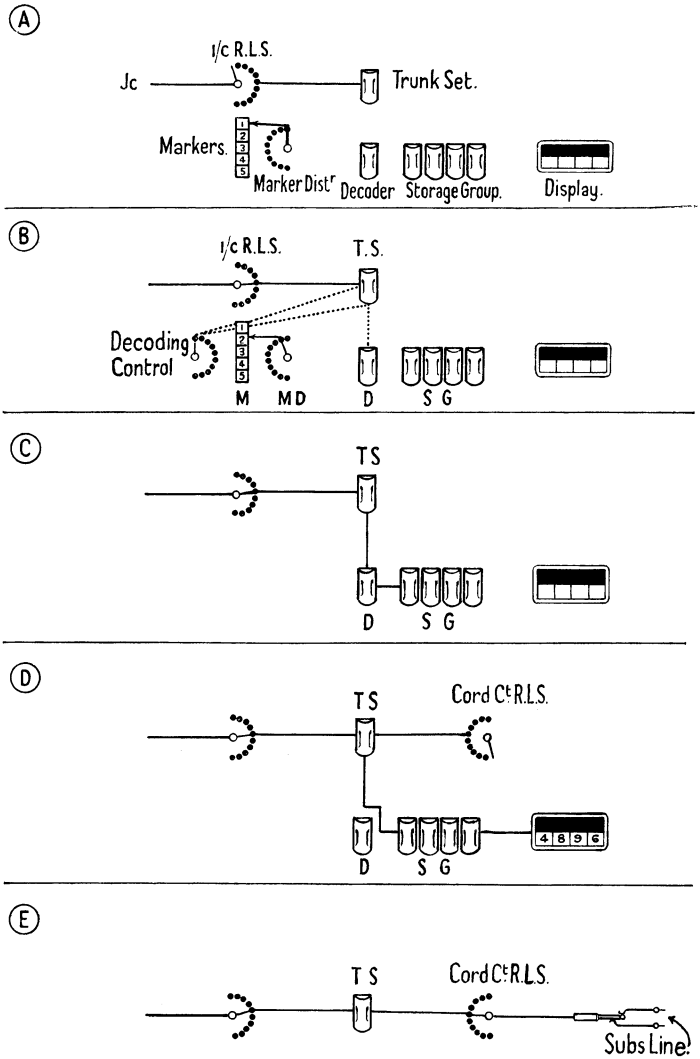

FIG. 8.

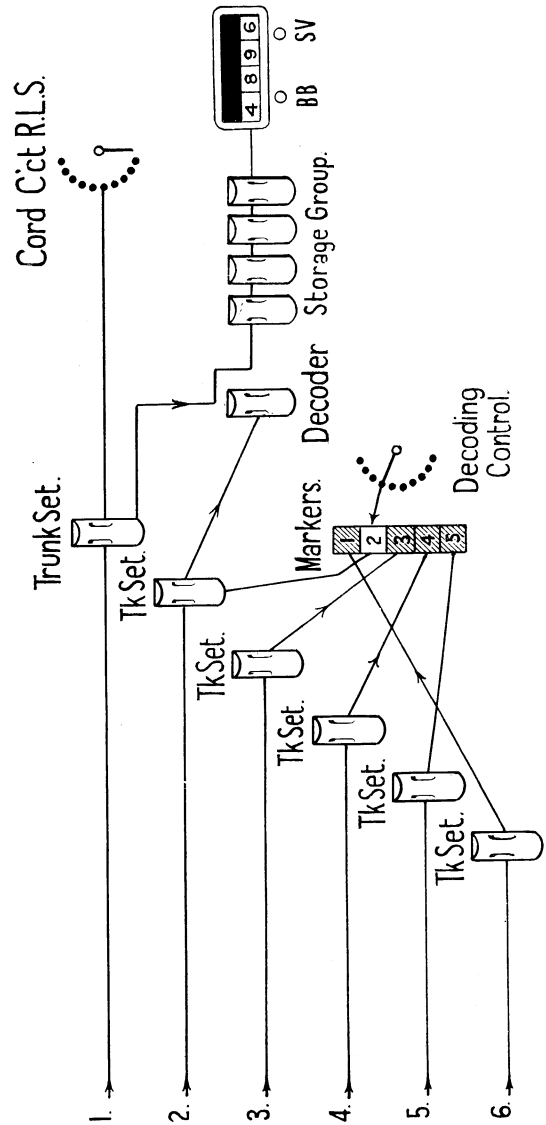

FIG. 9.

with No. 1 marker. In Fig. 8C, the call has been routed into the decoder and is being transferred to the storage group.

In Fig. 8D the decoding has been completed. The call is displayed and is waiting to be found by a cord circuit R.L.S.

Fig. 8E shows the completion of the connection, a plug having been inserted in the multiple of the trunk set located by the associated cord circuit.

Fig. 9. represents 6 calls waiting for attention. They are accommodated as follows :—

(1) Storage group and display. Waiting cord circuit R.L.S.

(2) Decoder awaiting storage group. Second marker will be available as soon as call displayed.

(3) Coder (Auto Exchange) Trunk Set seized and held by marker.

(4) Ditto.

(5) Ditto.

(6) Ditto.

There is thus one call displayed and five more calls associated with the markers. Since the markers are now all engaged the position is busy to the position load distributor which will therefore pass this position when distributing calls.

Call Distribution.

It will be recalled that the position load distributor distributes the calls to the positions by opening one position at a time. Hence, in order that a call shall find a trunk set, the 25 outlets from the incoming rotary line switch must be distributed over the whole of the suite. As the only outlets available at any one time are those to the open position it is possible that the line switch may find no trunk set disengaged although it has outlets to disengaged trunk sets on other positions. This risk is increased as the number of positions increases, owing to the fact that the number of outlets per position will be correspondingly decreased, but this difficulty is reduced by providing one position load distributor per five positions so that where there are more than five positions there will always be two or more open positions.

The provision of the " kick-off " feature to which reference has already been made ensures that the call will not be lost or unduly delayed unless every outlet from the R.L.S. is

engaged. By means of this arrangement, when a line switch has been hunting from $1\frac{1}{2}$ to $2\frac{1}{4}$ seconds, the distributors step forward and open other positions.

II.—TECHNICAL DETAILS.

The dimensions of this pamphlet prohibit the inclusion of actual circuit and cross connection diagrams and it is not possible to give more than a brief account of the method of call distribution and a skeleton outline of certain circuit elements which form the basis of the circuit scheme.

Call Distribution.

The means adopted to distribute calls are described in previous paragraphs, and in order that full advantage shall be taken of the scheme the outlets from the incoming line switches are cross connected to the trunk sets in such a way that calls are distributed over all the staffed positions in the cyclic order already described, irrespective of the exchange of origin. This cross connection scheme permits the placing of any C.C.I. position out of commission either for engineering or traffic reasons without affecting the general distribution of traffic over the other positions.

Figure 10 represents the distribution scheme at a 7-position exchange and portions of two incoming line switch multiples are shown. The outlets are distributed in the following manner.

The first four outlets of the upper shelf of line switches terminate on trunk sets of the odd* positions. The next three outlets terminate on trunk sets of the even positions This arrangement is repeated until all outlets have been terminated. The outlets from the lower shelf are distributed in a similar manner. Some of the later choices, however, will be trunk sets shared with the upper shelf of line switches. The complete distribution of the outlets from two shelves of line switches is shown in the appendix from which the cyclic nature of the distribution may be clearly seen.

It will be seen that each P.L.D. controls alternate positions. This arrangement is of advantage during concentration periods when a few adjacent positions are staffed. The

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* The position numbers shown refer to the location of the position in the C.C.I. suite. The actual position numbers will, of course, be dependent upon the numbering of the "B" board.

benefit of the provision of two P.L.D.'s is therefore felt. If one P.L.D. controlled positions 1–4 and the other controlled positions 5–7, then, if two positions only were staffed, say 2 and 3, they would both be controlled by one P.L.D. The risk of congestion due to the distribution of the outlets over all the positions would no longer be limited by the provision of two P.L.D.'s.

This arrangement of the P.L.D.'s necessitates the distribution of the line switch outlets over alternate positions, in order that the call distribution over the suite controlled by one P.L.D. shall be cyclic.

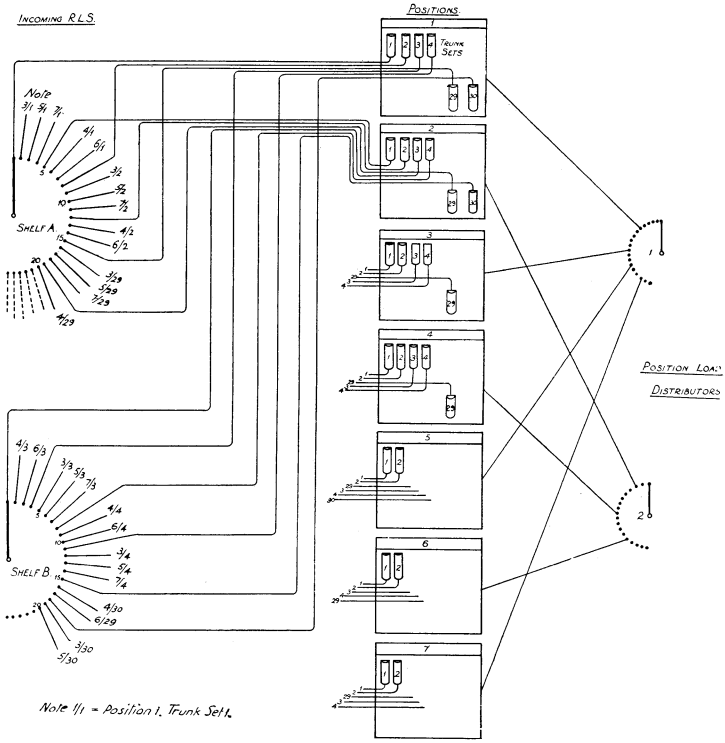

FIG. 10.

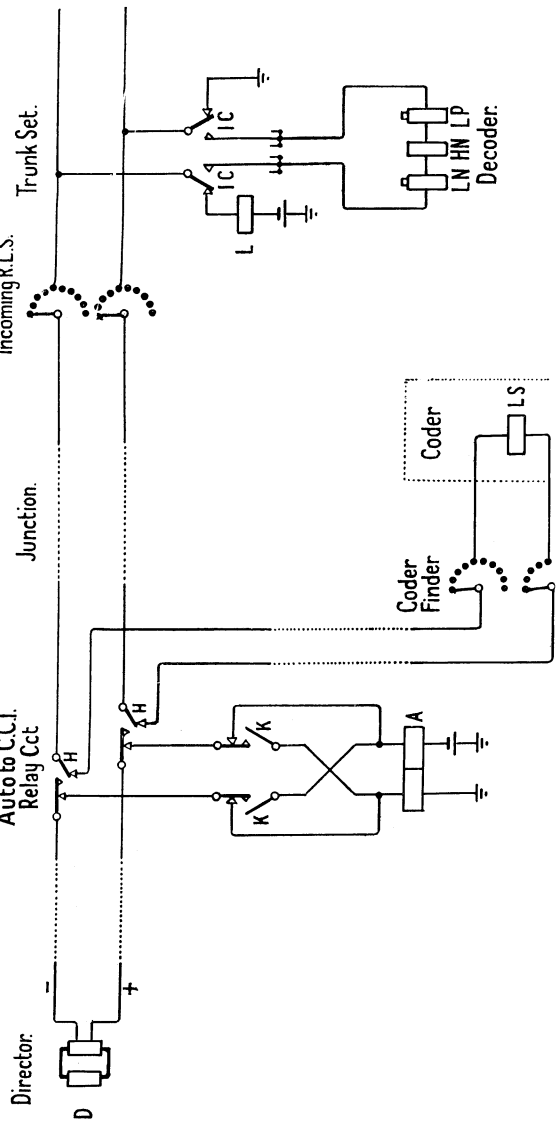

FIG. 11.

Circuit Scheme.

Impulsing delay in Director and Coder.—Fig. 11 shows the connection from the director to the trunk set and decoding group at the manual exchange. The director receives the impulses from the subscriber's dial and as soon as the first three trains have been received, *i.e.*, the impulses corresponding to the first three letters of the name of the called exchange, the director seizes a junction and an auto to C.C.I. relay set. It is necessary for the relay set to take into use a coder before the numerical trains are delivered by the director. The coder finder is a 25 point R.L.S. and the time of hunting necessitates a delay in the transmission of the numerical trains. The necessary delay is effected by means of relay D in the director. This relay is of a special type—known as a shunt field relay—and does not operate with the normal polarity of the line. It will be noticed that when the relay set is first seized, the earthed coil of the A relay is connected to the negative line and the battery coil connected to the positive line. This reversal of the normal polarity results in the operation of relay D. The operation of this relay restrains the further repetition of impulses from the director. As soon as the coder finder has found a free coder, however, relay K, not shown in the figure, operates, and its contacts reverse the connections of the A relay, so providing the correct polarity on the incoming line and allowing the release of relay D. The release of D removes the restraint of the director and allows the numerical trains of impulses to be transmitted to the coder.

When the transmission of the numerical train is completed relay LS in the coder is connected across the junction. The coder, however, must not pulse out until the apparatus at the manual exchange is prepared. This entails a delay which is effected by the operation of relay LS. When the decoder at the manual exchange is available relay IC, not shown in the diagram, is operated, removing the battery and earth connections from the line, and relay LS is released. The battery and earth are replaced by a loop through the decoding relays. The coder then transmits the coded impulses.

Digit Distribution and storing in coder.—When the coder has been seized, the director proceeds to transmit the numerical impulses. These are repeated by the Auto to C.C.I. relay set into the coder via a wire known as the pulse wire, and are received by the driving magnet of a pulse receiving switch. This switch forms part of the coder and serves to complete circuits to four sets of digit storing relays, one of which sets

is shown in Fig. 12. These four sets of relays are used to store the four numerical digits. The pulse receiving switch makes four journeys corresponding to the four trains of received impulses, and after each journey returns to its normal position. The particular combination of storing relays operated is determined by the position to which the wipers of the pulse receiving switch are driven. It will be seen, for instance, that if 4 impulses are received, relays MW and MX will be operated. If 8 impulses are received, relays MW, MX, and MZ will be operated. These relays are then locked, and the hundreds set of digit storing relays is switched to the points of the pulse receiving switch.

The storage relays which are operated are shown in the following table:—

	1	2	3	4	5	6	7	8	9	0
Relays operated	MW	MX	MW MX	MY	MZ	MW MZ	MX MZ	MW MX MZ	MY MZ	— —

These relays, MW, MX, MY and MZ constitute the thousands group. The hundreds, tens and units W, X, Y and Z relays bear the prefixes C, D and U respectively.

Code Sending Circuit.—After the director has pulsed into the coder, relay LS is connected across the junction, and the incoming line switch at the manual exchange seizes a trunk relay set (Fig. 13). When the decoder is ready, the decoding relays are connected across the junction and relay LS in the coder releases. The coder then proceeds to pulse out, the pulsing out circuit consisting of battery and earth connected to the two lines at the outgoing end of the junction, the circuit being completed through the decoding relays. The pulse given when earth is connected to the positive wire is called a "positive" pulse. When the earth is connected to the negative wire, a "negative" pulse is transmitted. Two classes of negative impulse are employed, heavy and light respectively, the light pulse being obtained by connecting 5,000 ohms in the circuit. A heavy positive impulse is not used, the only positive impulse being a light one.

The pulses are transmitted during one complete revolution of a sending switch. As will be seen from Fig. 13, two wipers of this switch are connected to the negative and positive lines respectively. The contacts of the bank are wired via contacts of the digit relays (W, X, Y, Z) to battery, some of them being taken through the 5,000 ohms spool. There are 24 contacts in the bank and each of the 4 digits is completely transmitted after 6 steps of the sender.

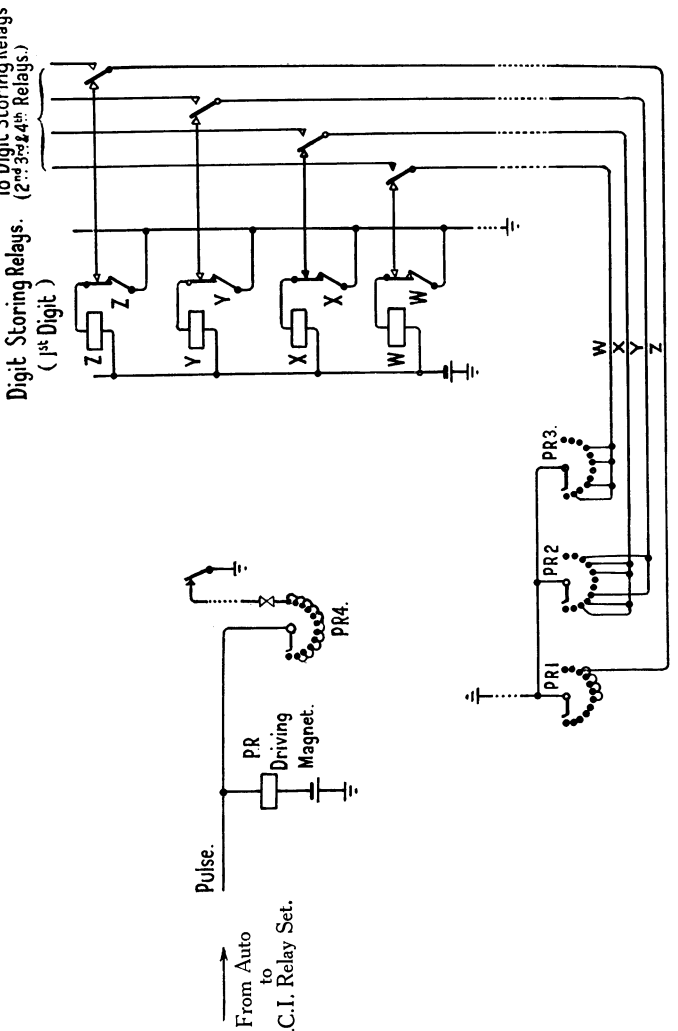

FIG. 12.

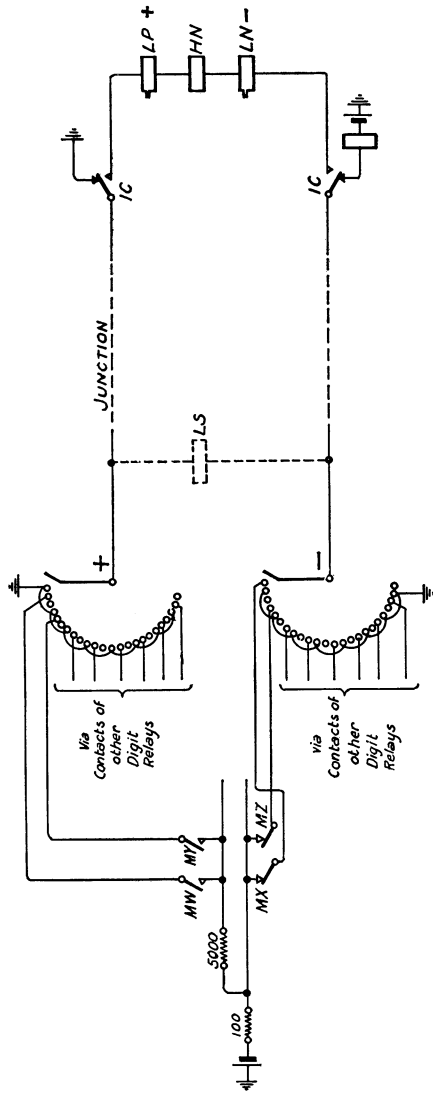

FIG. 13.

The pulses corresponding to the digit dialled are shown in the following table :—

No.	Coded pulses sent.		
1	+	−	−
2		▭	−
3	+	▭	−
4		−	+ −
5		−	▭
6	+	−	▭
7		▭	▭
8	+	▭	▭
9		−	+ ▭
0		−	−

▭ = heavy negative.

The relays LN and LP at the manual exchange are polarised. LP responds to positive impulses only and LN to all negative impulses, whether heavy or light. The polarised relay is illustrated in Fig. 7. Relay HN responds to heavy currents only (the only heavy currents received are negative).

Compensating resistance.—The distinction between a light pulse and a heavy pulse lies in the current value only, and the magnitude of these currents must therefore be such that the decoding relays can readily distinguish between a light and a heavy pulse. The strength of the received current, however, will vary with the resistance of the junctions over which they are received. It is therefore necessary that the circuit shall be so designed that light pulses received over short junctions do not approach the magnitude of a heavy pulse received over a long junction. In some cases it has been arranged that resistances shall be introduced in the circuit during the transmission of coded pulses, thus ensuring that the maximum value of light pulses is kept well below the minimum value of heavy pulses received over longer junctions.

Decoding circuit.—Fig. 14 represents in outline the circuit employed to receive the coded impulses. As already stated, relay LN responds to both light and heavy negative impulses, relay HN responds to the heavy negative impulses only, and relay LP responds to the positive impulses. It will be seen that certain of the relays MA, MB, MC and MD are operated as determined by LN, HN and LP, and it will be seen that MA and MC are operated by positive impulses, MB and MD by negative impulses.

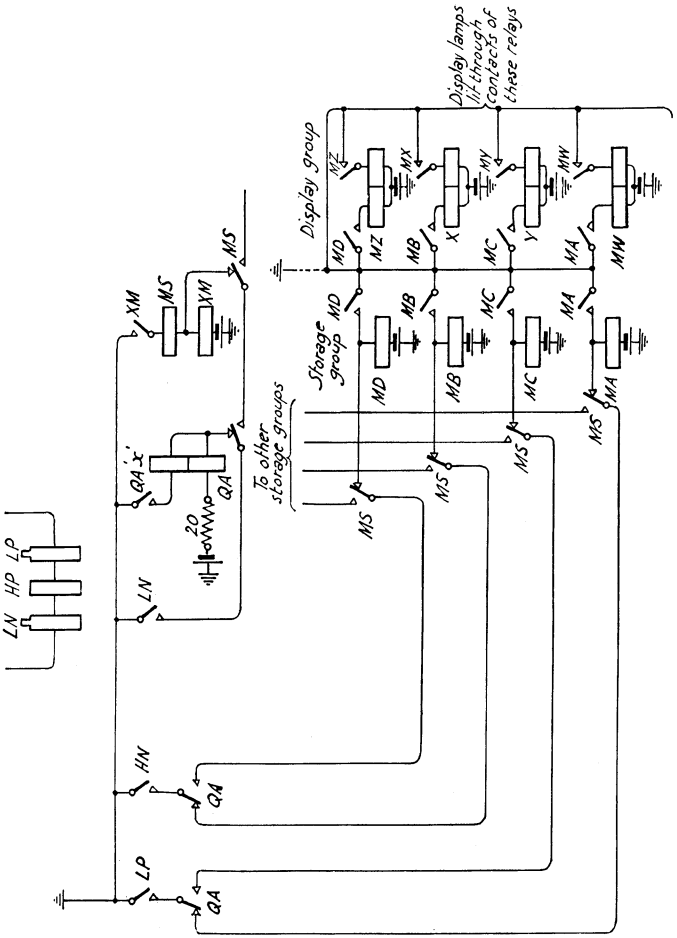

FIG. 14.

The relays MA, MB, MC and MD shown in the figure are used for storing the first digit only, and a similar set of relays is employed to store each of the remaining three digits. Each digit is represented by a combination of pulses, included in which are always two (and no more) negative impulses. The receipt of the second negative pulse is employed as a signal that one digit has been completely transmitted. The hundreds set of storage relays are then switched into circuit. This is effected in the following way. Upon the first receipt of a negative pulse, relay QA operates its '*x*' contact. The current through the QA relay at this stage is not sufficiently strong to operate the remaining contacts. With the subsequent release of LN a short circuit is removed from the second coil of QA, which thereupon fully operates and prepares the circuit of relay XM. When the second negative pulse is received, therefore, XM operates and prepares the circuit of relay MS and upon the completion of the pulse, relay LN releases, removing a short circuit from the relay MS, which thereupon operates and switches in the hundreds set of storage relays. A relay such as MS, which partially operates when earth is connected to one coil and fully operates when the earth is removed, is called a *2-step relay*.

It will thus be seen that at the end of the transmission of pulses certain storage relays will be in the operated position and will thus constitute an indication of the digits originally dialled. The storage relays, MA, MB, MC, MD, operate the display relays MW, MX, MY, MZ, which effect the display of the dialled number. As soon as the display relays are operated, the storage relays MA, MB, MC, MD are released and made available to receive another call. The storage and display relays of the hundreds, tens and units groups bear the prefixes C, D and U respectively.

The relationship between coded pulses received and the storage relays operated can be deduced from Fig. 14, and is also tabulated below:—

Digits dialled.	Coded pulses.	Storage relays operated.	Display relays operated.
1	+ — —	A	W
2	□ —	B	X
3	+ □ —	A B	W X
4	— + —	C	Y

Digits dialled.	Coded Pulses.	Storage relays operated.	Display relays operated.
5	— ▭	D	Z
6	+ — ▭	A D	W Z
7	▭ ▭	B D	X Z
8	+ ▭ ▭	A B D	W X Z
9	— + ▭	C D	Y Z
0	— —	Nil	Nil

Load Distributing Circuit.—The essential portions of this circuit are shown in Fig. 15. Each position is provided with a GC (Group Control) relay and a PB (Position Busy) relay. The operation of the GC relay opens the position, *i.e.*, the position is ready to receive a call. The PB relay operates when a call is received and steps the P.L.D. to the next position.

There is in the circuit of the trunk relay set a B relay which operates as soon as a call is received. The circuit of the incoming private wire from incoming R.L.S's is connected to a change over contact of the B relay and is terminated in earth at the contact of relay GC. The private contact of the trunk sets on the position are thus normally marked "engaged." When, therefore, the position is to be opened to receive calls, a circuit is completed for relay GC via a wiper of the P.L.D. The operation of GC removes the earth from the common and the trunk sets not already in use are thus made available to receive calls. When a call arrives, PB operates and locks. The operation of PB completes the circuit to step the P.L.D. and also to maintain the earth on the private until the release of GC.

The release of GC thus restores the normal earth to the position busy common and the position is closed, the next position being opened by the operation of its own GC relay.

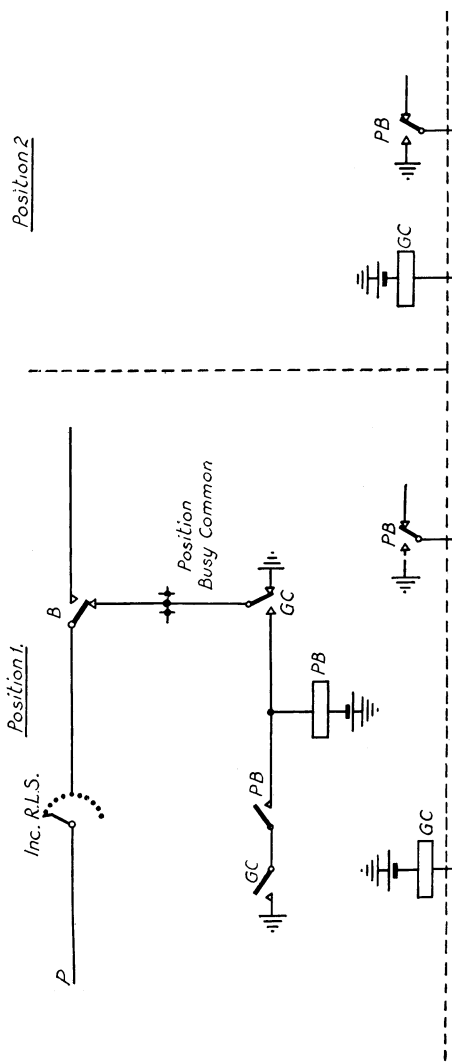

FIG. 15.

Marker Circuit.—Fig. 16 shows the connections between markers, marker distributor and decoding control switch. The markers and decoding control switch are each provided with a start and a cut off relay (S and K respectively). As soon as a trunk set is seized by an incoming R.L.S. an earth is connected to the marker start lead. This lead is connected to one wiper of the marker distributor. The S relay in a marker circuit will thereupon operate and complete the circuit of the marker magnet. The wipers of the marker then rotate until they come to rest on a contact from which the earth has been removed (by the operation of relay L). The marker K relay then operates resulting in the stepping of the marker distributor to the next position. The operation of K also completes a circuit for relay S in the decoding control switch circuit and this switch therefore rotates until it finds a contact from which the earth is removed (by relay K in the marker circuit). The connection is then completed to relay IC which connects the trunk set to the decoding apparatus. As soon as the call is displayed relay IC is released and the decoder made available for another call. The opening of the lead to the IC relay releases relay K in the decoding control switch circuit. Relay S in this circuit is thereby reconnected and if another marker is holding a call the control switch will step as already described and the above operations will be repeated.

"Kick-off" circuit.—The normal time taken by an incoming R.L.S. to find an outlet will be within $\frac{1}{2}$ sec. As explained previously, the R.L.S. may not find an outlet available to the open position. The kick-off circuit provides for this condition by stepping the P.L.D. when an incoming R.L.S. is unable to find an outlet. Four relays are employed, viz., SK, KO, MP and CO (Fig. 17). SK operates whenever an R.L.S. is hunting. KO is controlled by an intermittent earth and so takes into account the time that hunting continues. MP completes the P.L.D. circuit. CO prevents a further step being made by the P.L.D. before the incoming R.L.S. has been allowed time to complete its search over the outlets now offered.

When a line switch is hunting, the continued operation of SK results in relay KO partially operating when an earth is connected to the pulse wire. On the removal of the earth $\frac{3}{4}$ sec. later, the short circuit is removed from the second coil of KO, which thereupon fully operates. After a further $\frac{3}{4}$ sec., the interrupted earth is reconnected and relay MP operates, stepping the distributor magnet. The circuit of relay CO is completed at the same time, but this relay is

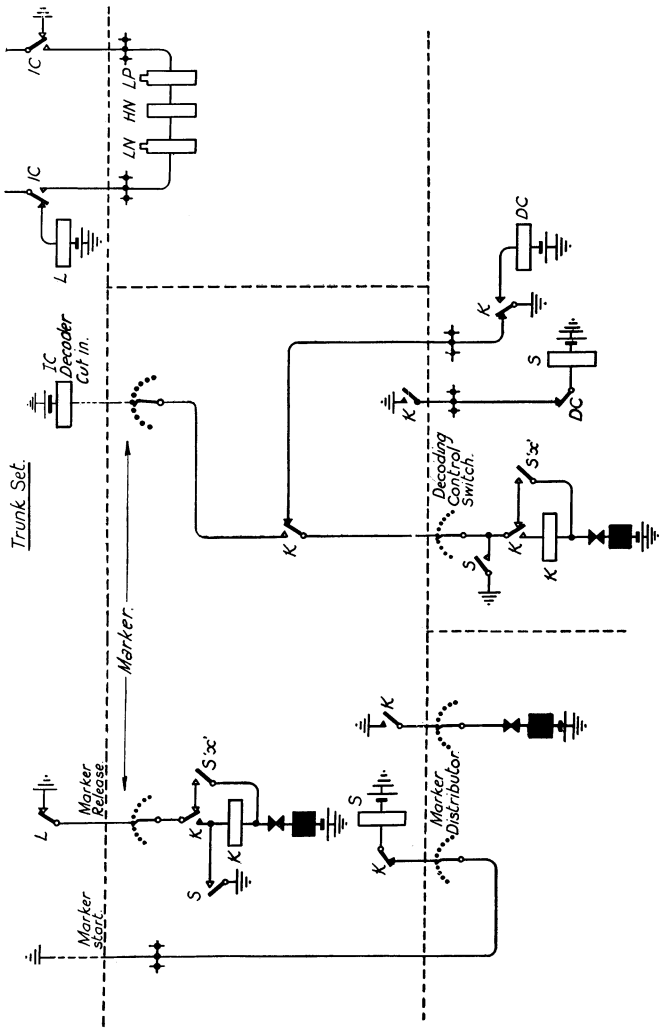

FIG. 16.

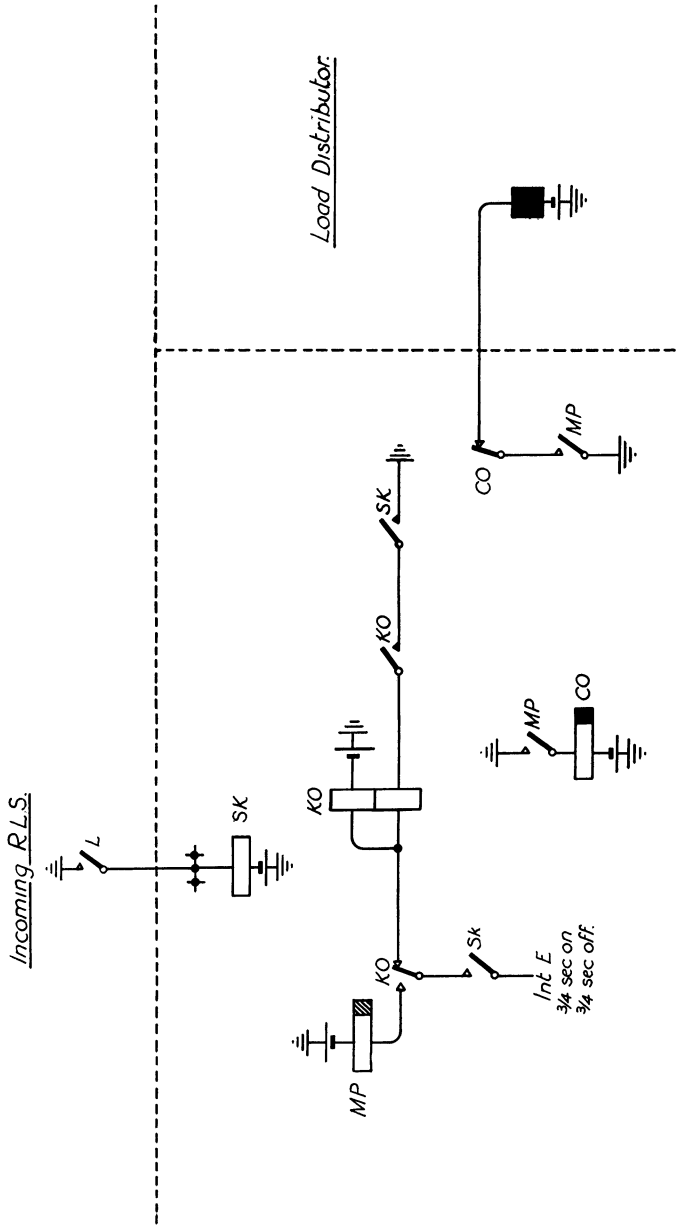

FIG. 17.

slow in operating and thus allows time for the P.L.D. to step before its circuit is opened. If an outlet is available on the newly opened position, the delay in the release of relays MP and CO allows time for the line switch to seize this outlet before the circuit of the P.L.D. is reconnected.

The General Arrangement of the Apparatus.

The C.C.I. apparatus is represented diagrammatically in Fig. 5. Most of this apparatus is installed in the apparatus room, and the extent of the plant required by two C.C.I. positions may be seen from Fig. 18, which shows the C.C.I. equipment at the London Ravensbourne exchange. The charging machine in the foreground is, of course, part of the regular exchange equipment. The only apparatus not shown in the illustration is that equipped on the positions themselves, the routiner (referred to later), the equipment for providing busy tone, and certain alarm relays.

The apparatus carried by each bay of the rack is as follows :—

Bay 1 - Incoming R.L.S.
,, 2 - Position Trunk relay sets.
,, 3 - Cord Circuit R.L.S.'s, distribution switches (markers, etc.) and their associated relays.
,, 4 - Cord circuit relay sets, decoding and display sets.

The following are some notes on the equipment :—

Incoming rotary line switches.—Bay 1. Provides for a maximum of eight shelves (A to H). 25 rotary line switches per shelf comprising one multiple. The number of incoming line switches equipped depends upon the number of incoming junctions.

Position trunk relay sets.—Bay 2. Shelves of 10. 10 shelves (A to J) per bay. 40 trunk sets per position initially equipped, capacity for 50 sets per position. Shelves A to E (above the fuse panel, E unequipped) carry trunk sets of one position. Shelves F to J (below fuse panel, J unequipped) carry trunk sets of the other position.

Cord circuit rotary line switches.—Bay 3 (Fig. 19). Bay carries maximum of nine shelves, 21 switches per shelf.

Markers, Load Distributors, etc.—The markers, position load distributors, decoding control switches, special service

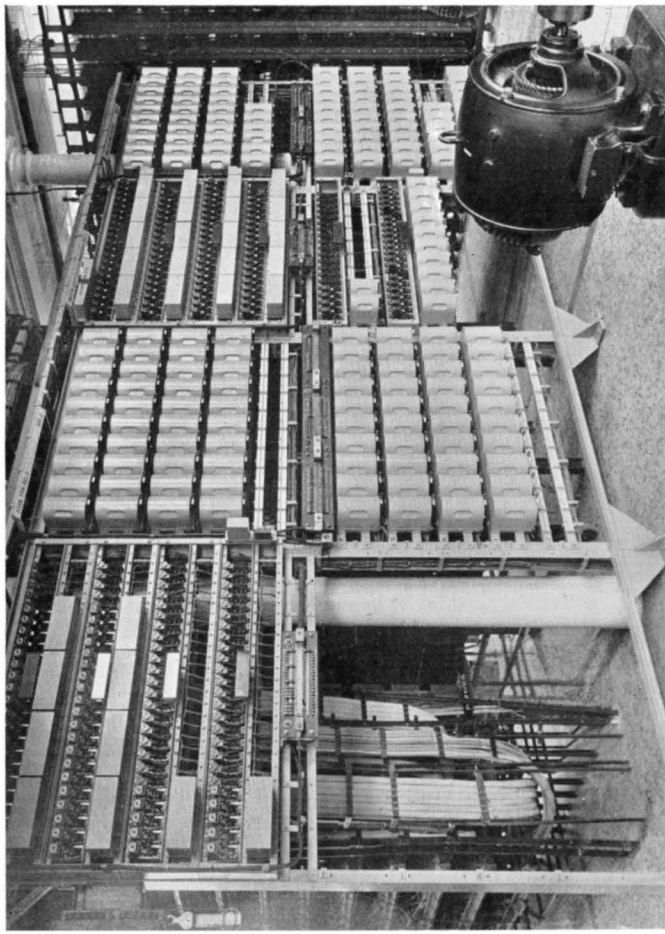

FIG. 18.

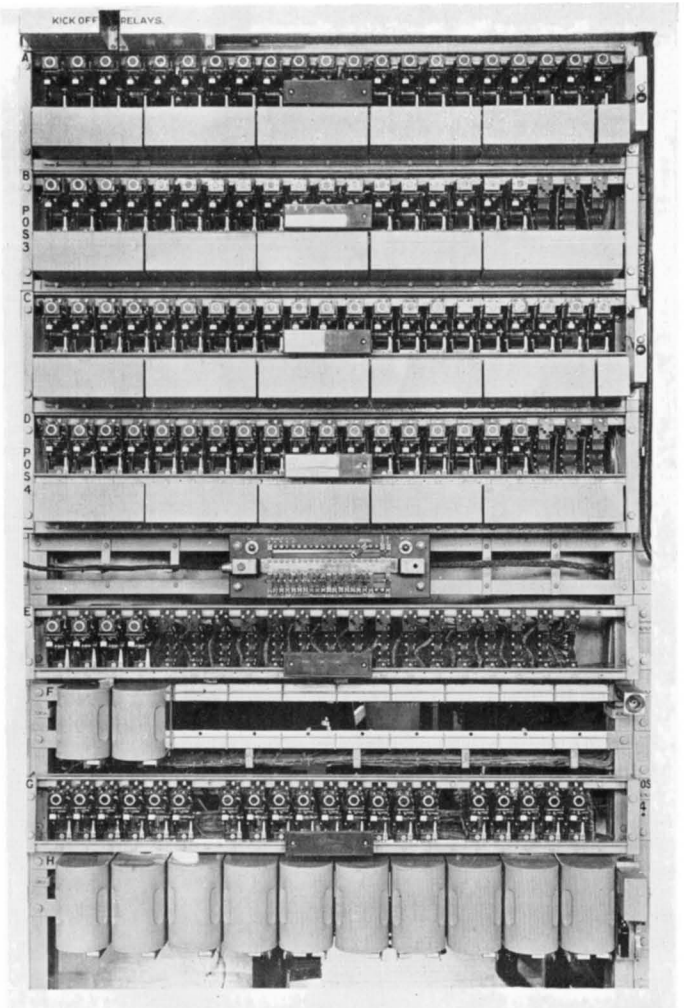

FIG. 19

switches and manual emergency switches are equipped on shelves F and H at the bottom of Bay 3 (Fig. 19).

Cord circuit relay sets.—Bay 4 (Fig. 20). 10 sets per shelf. Shelves A to D accommodate the 36 sets of one position, shelves E to H accommodate the 36 sets of the other position.

Decoding and storage relays.—Bay 4. Shelf I. Reading from left to right the 10 relay groups of this shelf are as follows :—

1.	Decoding group.		Position 3.
2.	Storage ,,	(digit 1).	,, ,,
3.	,, ,,	(,, 2)	,, ,,
4.	,, ,,	(,, 3)	,, ,,
5.	,, ,,	(,, 4)	,, ,,
6.	Decoding ,,		Position 4.
7.	Storage ,,	(digit 1)	,, ,,
8.	,, ,,	(,, 2)	,, ,,
9.	,, ,,	(,, 3)	,, ,,
10.	,, ,,	(,, 4)	,, ,,

Routine Testing Equipment.

Permanent equipment known as the C.C.I. routiner, illustrated in Fig. 21, is installed at each C.C.I. exchange. This equipment provides facilities for routine testing the position trunk relay groups, cord circuits and the associated apparatus used during the progress of a regular call. The routiner apparatus consists of one rotary line switch and one relay group per position, together with a common group of rotary switches and relays. Each position is provided with a regular jack in the multiple field and a special telephone jack for the operator's head set. This jack can be seen in Fig. 1 (R.T.).

By plugging the headset into the headset jack the routiner is made to simulate the entrance of a call into the position and a display duly appears. The display is cleared by inserting one of the plugs into the multiple test jack, by which route the artificial call re-enters the routiner, where the normal answering conditions are applied. The call is thus originated by the routiner, passed via the position apparatus and routed back into the routiner.

The testing procedure is as follows :—

The operator plugs the headset into the headset jack. This sets the routiner equipment in action and a number, *e.g.*, 1111, immediately appears on the display panel. The operator inserts the plug of cord No. 1 into the multiple test jack. Two periods of the standard ringing tone are received and at the conclusion of the second period a tone resembling a

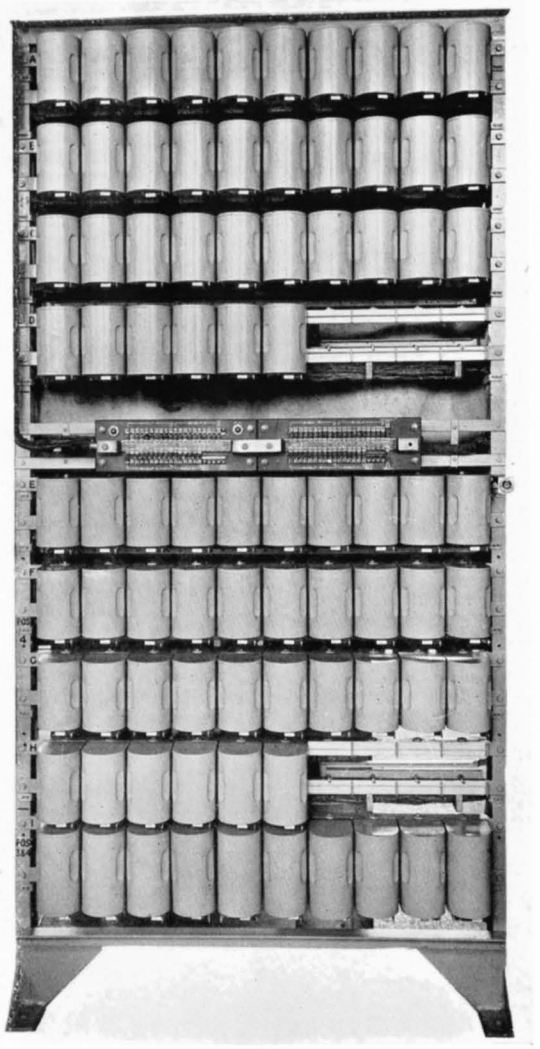

FIG. 20.

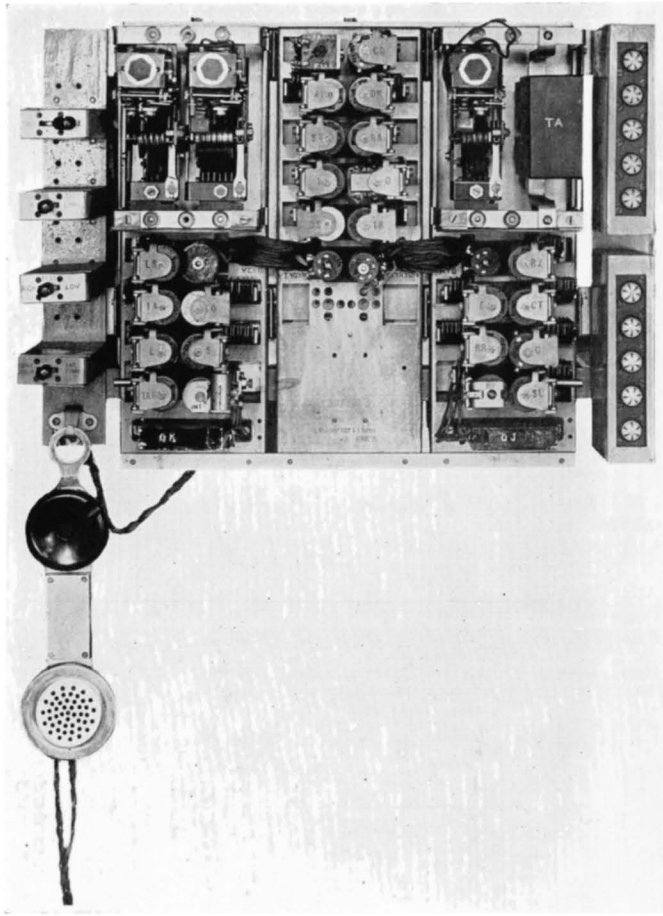

FIG. 21.

continuous busy tone is received and this serves to indicate that the operator may test for defects in the cord by moving it to and fro. After this test has been completed the operator withdraws the plug from the test jack, thus testing for the " wrong disconnect " signal. On re-insertion of the plug a further period of ringing tone is received, thus indicating satisfactory operation of the " re-ring " feature. Ringing current is then tripped and the battery reversed. The cord supervisory lamp then gives the " regular disconnect " signal, which, after a short period, changes to a " flashing recall " signal. In this way the functioning of the " disconnect " and " recall " signals is verified.

Having completed the test on the first cord the operator withdraws the plug from the test jack. The above cycle of operations is then carried out on the next cord, and the routiner makes use of the next trunk set.

This routine is repeated until all cord circuits and position trunk relay groups have been tested. Should the number of position relay groups exceed the number of cord circuits some of the latter are used more than once.

If the operator requires to make a rapid test of the decoding relay group only, withdrawal of the plug from the test jack immediately after its first insertion (*i.e.*, without waiting for ringing tone) will cause the next number to appear on the display screen.

If, during routining, a fault is encountered, an alarm is given and, after a short period covering normal delays in operating, the routiner is automatically stopped and a lamp on the common routining equipment indicates the point at which the fault occurred.

The maintenance officer in the apparatus room can communicate with the operator at the position by means of the hand-set telephone.

It should be noted that at the time of publication modifications to certain features described in this pamphlet are proposed.

APPENDIX.

TABLE SHOWING I.D.F. CROSS CONNECTIONS FOR TWO SHELVES AT 7 POSITION C.C.I. EXCHANGE.

I/c R.L.S. Trunks to P.T.R. Groups.

Shelf.	A.		B.	
Trunk No.	P.T.R.	Posn.	P.T.R.	Posn.
1	1	1	3	2
2	1	3	3	4
3	1	5	3	6
4	1	7	3	1
5	1	2	3	3
6	1	4	3	5
7	1	6	3	7
8	2	1	4	2
9	2	3	4	4
10	2	5	4	6
11	2	7	4	1
12	2	2	4	3
13	2	4	4	5
14	2	6	4	7
15	29	1	30	2
16	29	3	30	4
17	29	5	30	6
18	29	7	30	1
19	29	2	30	3
20	29	4	30	5
21	41	6	42	7
22	41	1	41	2
23	41	3	41	4
24	41	5	42	6
25	41	7	42	1

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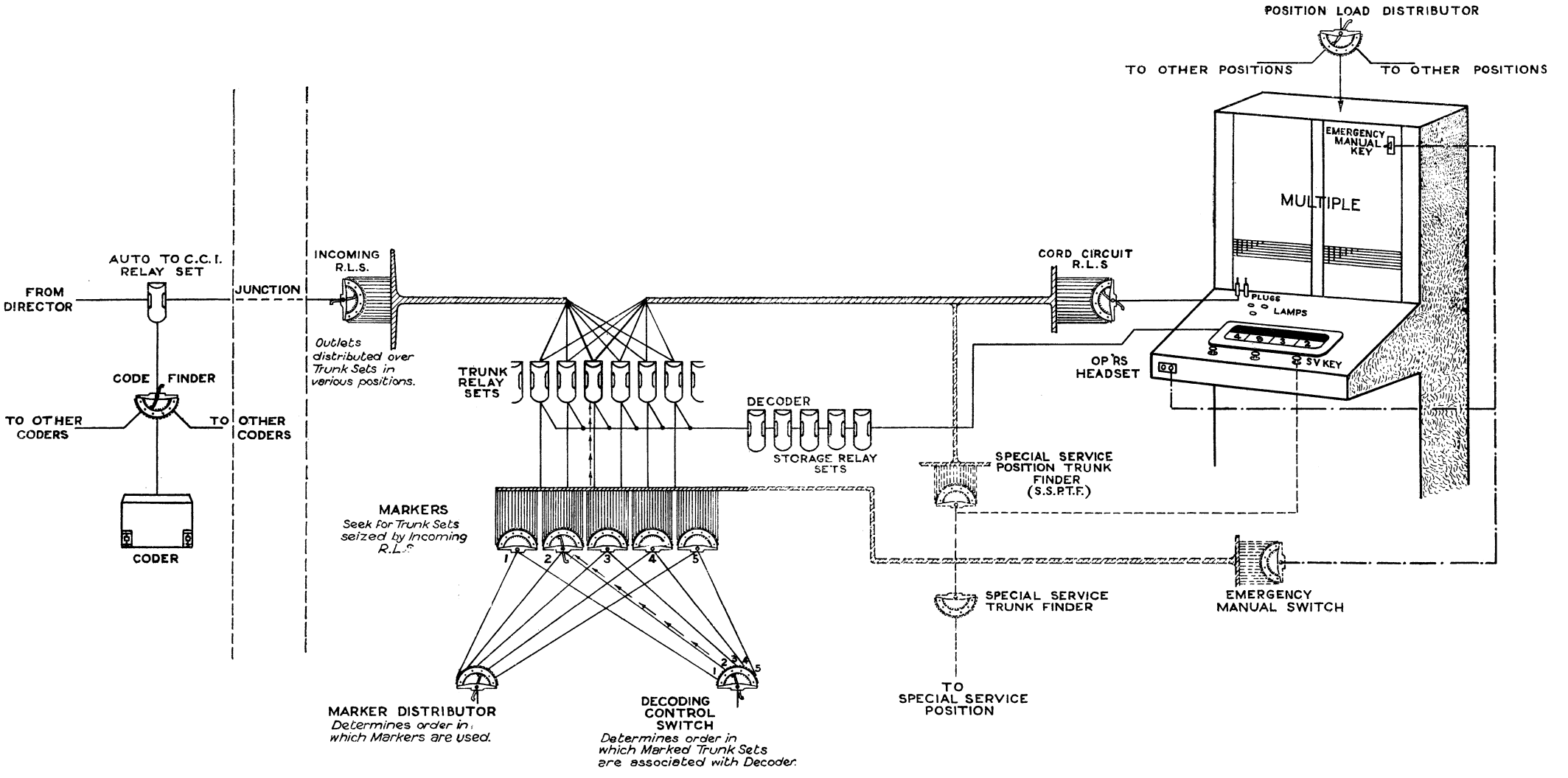

DIAGRAM SHOWING APPARATUS EMPLOYED FOR CALL INDICATOR WORKING.

FIG. 5.

LIST OF
Technical Pamphlets for Workmen
(Continued).

GROUP E.
1. Automatic Telephone Systems.
2. Automatic Telephony. Coder Call Indicator (C.C.I.) Working.

GROUP F.
1. Subscribers' Apparatus C.B.
2. Subscribers' Apparatus C.B.S.
3. Subscribers' Apparatus Magneto.
4. Private Branch Exchange—C.B.
5. Private Branch Exchange—C.B. Multiple, No. 9.
6. Private Branch Exchange—Magneto.
7. House Telephones.
8. Wiring of Subscribers' Premises.

GROUP G.
1. Secondary Cells, Maintenance of.
2. Power Plant for Telegraph and Telephone Purposes.
3. Maintenance of Power Plant for Telegraph and Telephone Purposes.
4. Telegraph Battery Power Distribution Boards.

GROUP H.
1. Open Line Construction, Part I.
2. Open Line Construction, Part II
3. Open Line Maintenance.
4. Underground Construction, Part I.
5. Underground Construction, Part II.
6. Underground Maintenance.
7. Cable Balancing.
8. Power Circuit Guarding.
9. Electrolytic Action on Cable Sheaths, &c.
10. Constants of Conductors used for Telegraph and Telephone Purposes.

GROUP I.
1. Submarine Cables.

GROUP K.
1. Electric Lighting.
2. Lifts.
3. Heating Systems.
4. Pneumatic Tube Systems.
5. Gas and Petrol Engines.