THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

VOL. 15 PART 4

JAN: 1923

Price 2/- net.

ADVERTISEMENT INDEX
see page xii.

THE RELAY AUTOMATIC TELEPHONE SYSTEM. FUNDAMENTAL PRINCIPLES AND FEATURES.

By G. H. BRYANT, A.M.I.E.E.,
Chief Engineer of the Company.

THE application of the Relay system is extending in various parts of the world, and as there is a demand for an exposition of the fundamental principles this article is written with a view to bringing out those principles in their true simplicity.

The first Relay plant was installed in London in 1910, and it has been said from time to time that the system would be limited to small switchboards on account of cost and maintenance difficulties. In this connection, however, the tracing of calls and fault locating on the largest plants installed to date is being carried out successfully, and is not proving a handicap.

Successively larger plants are being designed and installed, and the details of large Public Multi-Exchange networks are now being completed.

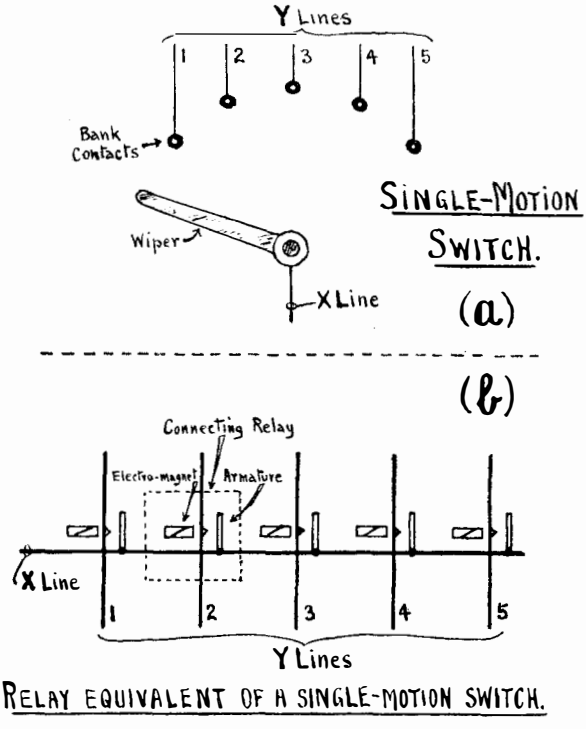


FIG. 1.

The large number of private installations fitted in Offices, Works, Institutions, etc., during the last six years has enabled much valuable practical experience to be obtained. These plants are in some cases working as single P.A.X.'s, in others as Multi-P.A.X.'s with inter-dialling; also connection is now being given to the Public Exchanges from Private Automatic Branch Exchanges. (P.A.B.X.'s).

RELAY TRUNKING SCHEME.

As most readers of this article have some knowledge of Switch systems, and will use it as a starting point for studying the Relay

system, we will first consider how a number of relays can be arranged to do the work of a switch.

Fig. **1**(*a*) shows a typical single-motion switch arranged so that the wiper can connect with any one of the bank contacts; while

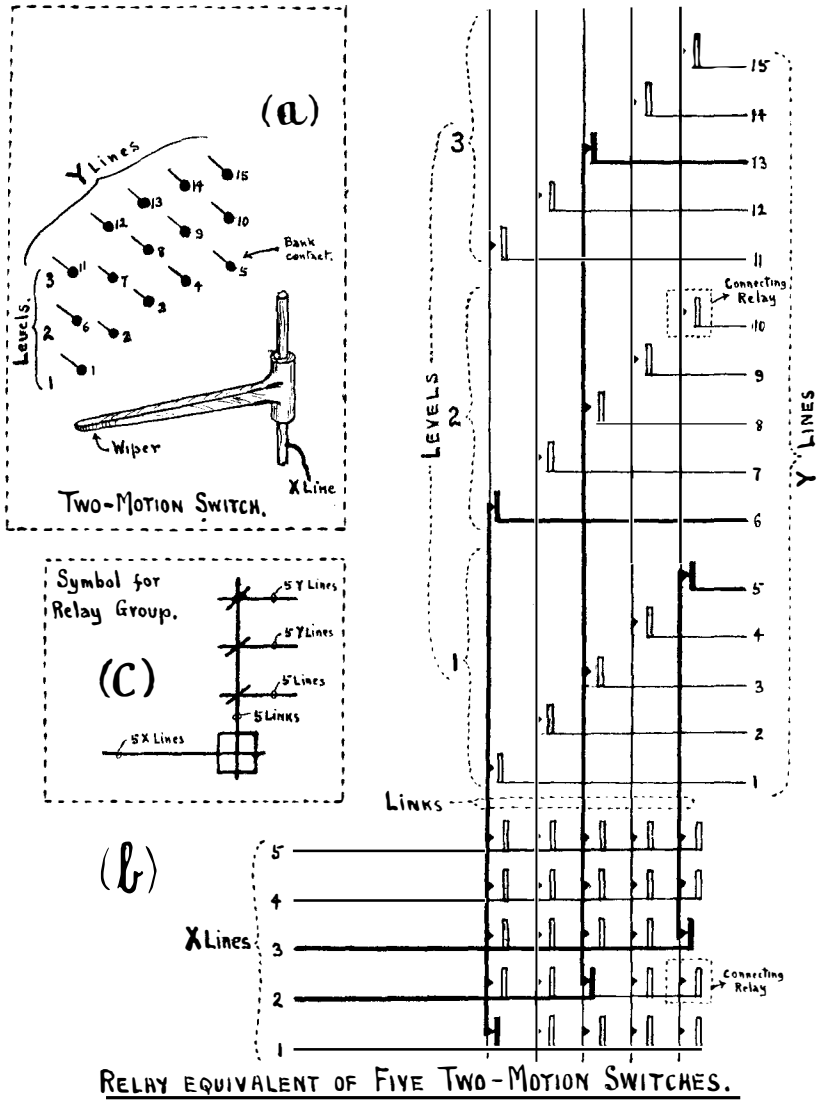


Fig. 2.

Fig. **1**(*b*) shows how a number of relays can be arranged to do similar work. In each case the circuit X can connect with any one of the circuits Y.

Fig. **2**(*b*) indicates how a group of relays can be arranged to do

the work of a number of two-motion switches. Assuming that five 15-point (*i.e.*, 3 levels of five) switches with their bank contacts in multiple are being compared, then in the equivalent relay group we shall require, as shown in Fig. **2**(*b*), 5 X lines each provided with 5 relays giving access to 5 links. At the various intersecting points connecting relays are provided so as to give access to 15 Y lines.

In the case of five switches of the type shown in Fig **2**(*a*), although each switch has 15 bank contacts, the total number of connections that can be set up at any one time is one per wiper, *i.e.*, a total of five. In the same way, in the relay equivalent, 5 connections can be set up at one time from the 5 X lines to any 5 of the 15 Y lines; three connections are shown in thick lines, X1 to Y6, X2 to Y13, and X3 to Y5.

It is convenient to indicate a group of relays as shown in Fig. **2**(*b*) by means of a symbol, Fig. **2**(*c*). (*Fleetwood Trunking Scheme* (*P.O.E.E. Journal*, *Vol.* 15, *Part* 2, *p.* 199) *illustrates the use of the symbol.*)

Whereas in a step-by-step switch (Figs. **1**(*a*) & **2**(*a*) an appreciable time is taken for the switch to pass over a number of intervening bank contacts, this is not the case with a relay group in which a search is being made for an idle circuit, for it takes no longer to connect to the last circuit than it does to the first.

It should be borne in mind that in a telephone exchange the number of conversations proceeding at any one time is usually only about 5 to 15% of the total number of working telephones, and the problem in an automatic telephone exchange is to provide the minimum of apparatus that will carry the busy-hour load without undue loss of calls.

We will now consider a simplified relay exchange, as shown in Fig. **3**, which will indicate clearly the function of the various groups in a larger plant. The subscribers' lines are provided with a number of OTC (Out Trunk Connecting) relays giving access to A and B Feeds, which are the equivalent of a number of cord circuits.

The *A and B Feeds* are provided with RC (Recorder Connector) relays, which connect the Feeds with one of two Recorders.

The *Recorder Connectors* function somewhat similarly to the listening keys of a manual board, for while the caller is giving the required number, by dialling, they temporarily connect a Recorder to his line to record his demand.

The subscribers' lines are also provided with a number of ITC (In Trunk Connecting) relays, which are energised as required by a Recorder in order to complete the connection between a Calling and Called line.

When a Caller, for instance No. 3, removes his receiver from the hook, his loop starts a searching operation for an idle Out Trunk, and assuming that No. 2ABF is free, then the OTC relay at the point of intersection between sub. No. 3 and Out Trunk No. 2 would be energised in a manner to be described later.

The Caller is now connected to ABF2 and on dialling for sub. No. 6 the six short breaks (*i.e.*, impulses) he gives to his loop, result in firstly a Recorder, for instance, No. 1, being taken into

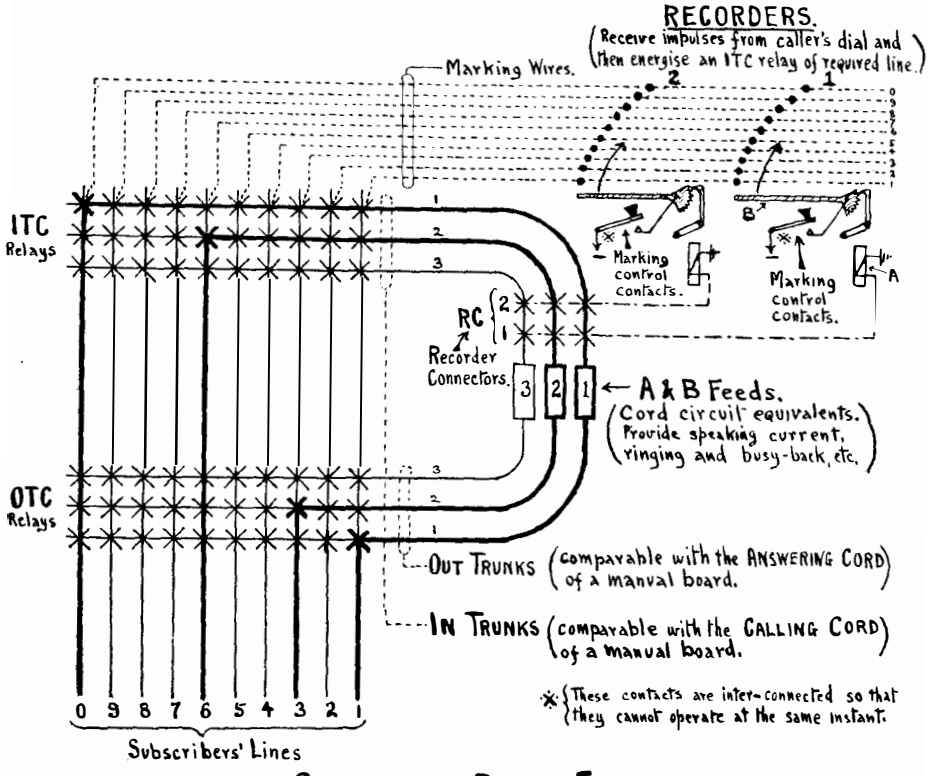


FIG. 3.

engagement with ABF2, *viâ* RC1, and, secondly, in the impulses being counted and stored in the Recorder on sets of relays. In Fig. 3 these relays are shown as a switch, the magnet A doing the counting and the wiper B the storing. The six impulses from the calling dial having ceased, the wiper will be at rest on Marking Wire No. 6. Then, provided that at that instant the other Recorder is not using the Marking Wires, the marking control contacts of Recorder No. 1 will automatically close and thus

energise the ITC relay of ABF2 which affords connection with sub. No. 6. When ITC has operated, it remains locked in a holding circuit and the Recorder instantly releases and resets ready for another call. Ringing is then applied to the called line from the ABF and ceases when the called party answers; the speaking circuit is then established.

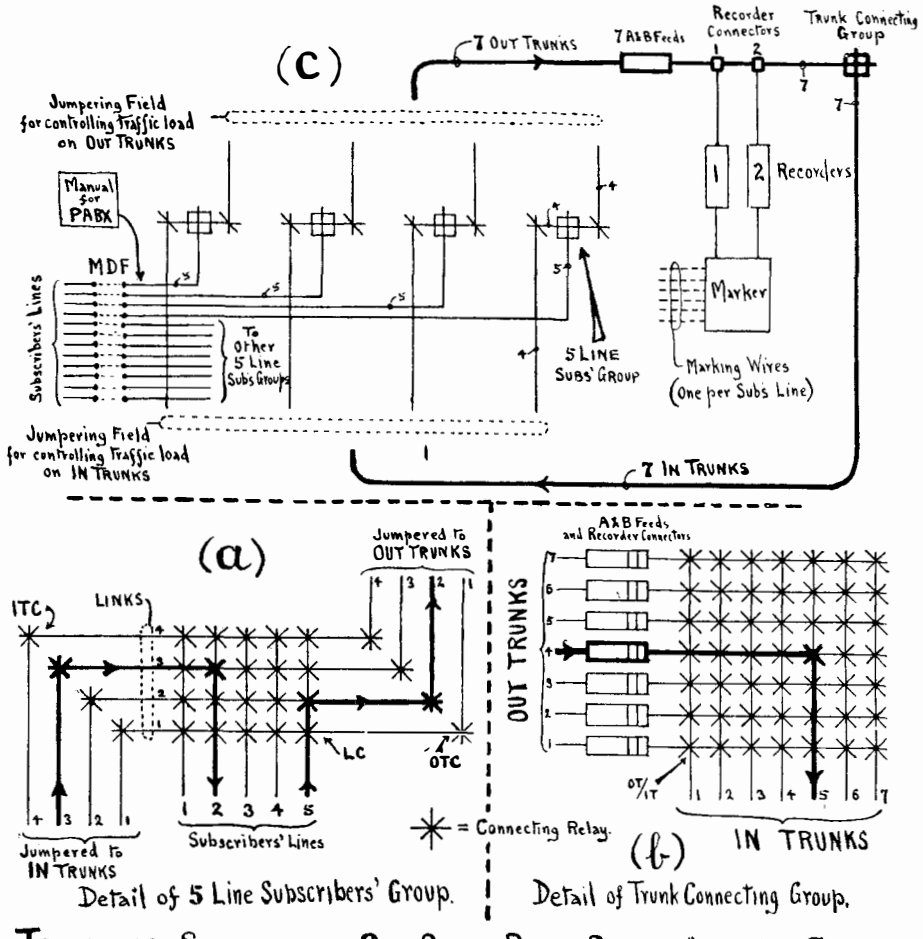


FIG. 4.

If the called line is engaged the Recorder sends a signal to the ABF, which results in busyback being given to the caller.

It should be noted that although both Recorders can be receiving impulses from different callers at the same time, they can only send current over the marking wires one at a time.

The trunking scheme shown in Fig. 3 is extravagant of connecting relays except in very small exchanges.

A typical trunking scheme as employed for P.A.X. and P.A.B.X. plants is shown in Fig. **4**(*c*). The subscribers are divided into groups of five, see Fig. **4**(*a*), with 3 to 5 links which have access to both *Out* and *In* Trunks. It is important to note that each 5 line Subs. Group has its own set of links which are used for both outward and inward calls.

Fig **4**(*c*) is used for plants of from 20 to about 300 lines. The Subs. Group are shown in symbol form and the detail of one group is given in Fig. **4**(*a*).

As each Subs. Group has access to only a portion of the *Out* and *In* Trunks the Trunk Connecting Group (TCG) is provided so that *any Out Trunk can connect to any In Trunk.*

A comparison with the simpler scheme of Fig. **3** will show that the additional features are the Subs. Group Links and the TCG; also that the number of relays individual to a subscriber's line does not increase with the size of the exchange (they are dependent upon the busy-hour load per average subscriber's line).

The sequence of operations for making a call is as follows: When the Caller removes his receiver from the hook his loop starts a search for both an idle Link and an Out Trunk. The LC (Link Connecting) relay of the first idle link energises and extends the line to the link, see Fig. **4**(*a*), at the same time the OTC (Out Trunk Connecting) relay energises to extend the link to an Out Trunk and thence to an ABF, as shown in the same Fig., where sub. No. 5 is connected *via* OTC2 by the thickened line.

The foregoing occurs prior to dialling, and assuming that the dialling and marking have been completed in a similar manner to that previously described, also that OTC is jumpered to Out Trunk 4, then at the time the Recorder sent marking current to the Called sub.'s relays, say No. 2 in Fig. **4**(*a*), it also sent a marking current to energise an OT/IT (Out Trunk/In Trunk) relay in the Trunk Connecting Group so as to connect Out Trunk 4 to an idle In Trunk 5, see Fig. **4**(*b*); this In Trunk having access to the Subs. Group containing the wanted line then connects with a free link and thence to the desired line, as shown in Fig. **4**(*a*), where ITC3 is connected to sub. No. 2.

The Caller having been connected to the Called line, the Recorder and Marker are disconnected and are free for other calls.

Subs. Groups of the same size are used for exchanges of various sizes provided that the busy-hour calling rates are approximately equal.

The *Out and In Trunks* are, however, provided in sufficient number to meet the total busy-hour load without undue loss.

A *Recorder* is only in circuit with a calling line from the time the first dialling impulse is sent until the connecting relays have

been energised on the In Trunk and Called line, a matter of a few seconds. The *total number of Recorders* required is therefore dependent upon the busy-hour calling rate and is usually 1 to 3% of the subscribers' lines.

The *Marker* is only in circuit with a Recorder for the very short time that the connecting relays take to energise.

The *Trunk Connecting Group* shown in Fig 4 is only employed

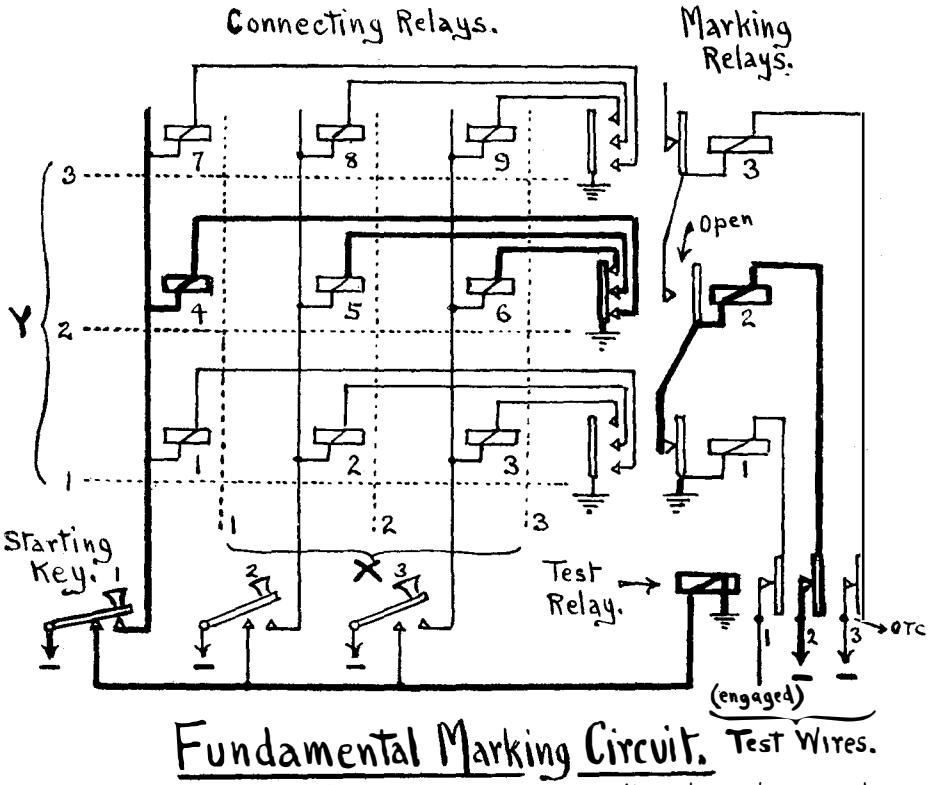


FIG. 5.

when the number of trunks does not exceed 30. When larger groups of trunks are used trunk-links, which will be explained later, are employed to keep the number of connecting relays at an economical figure.

FUNDAMENTAL MARKING CIRCUIT.

Fig. 5 illustrates the method employed to energise a connecting relay at an intersecting point. Three vertical X lines and three horizontal Y lines are shown; the speaking circuit contacts are omitted in order to simplify the circuit.

Connecting relays 1 to 9 are fitted at the intersecting points. Assume that X1 is a calling line, and that Y1, 2 and 3 are links with the first one engaged. Then if starting key 1 be depressed a circuit is completed for the test relay and it will energise. The three test wires are thereby extended to Marking relays 1, 2 and 3. As Y1 is assumed to be engaged, No. 1 test wire is disconnected from the negative pole of the battery.

The negative pole of the battery on Test wires 2 and 3 causes Marking relays 2 and 3 to commence to energise, but as soon as the armature of Marking relay 2 gets on the move it disconnects the coil circuit of Marking relay 3 and the latter does not have time to energise.

Marking relay 2 connects the positive pole of the battery to one side of connecting relays 4, 5 and 6.

It will be seen that only one connecting relay, No. 4, gets both positive and negative on its coil and accordingly energises and completes the speaking circuit from X1 to Y2 (contacts not shown).

At this stage the holding circuit of connecting relay 4 is completed through a second winding (not shown), and the starting key is released, thus de-energising the test relay and marking relay 2. The negative is at the same time removed from test wire 2 in order to make the circuit test engaged.

This *Marking Principle* is applicable to any sized group and is used extensively in the Relay system. For example, in the case of the 5 line Subs. Group shown in Fig. **4** (*a*), the Subs.' lines 1 to 3 are the X lines 1 to 3, and the links 1 to 3 are the Y lines 1 to 3, while the line relay contacts, not shown, constitute the starting keys. The marking windings of the OTC relays are inserted in the test wires at the points indicated. A second test relay serves, in a similar manner, to switch in the ITC test wires and relays for inward calls.

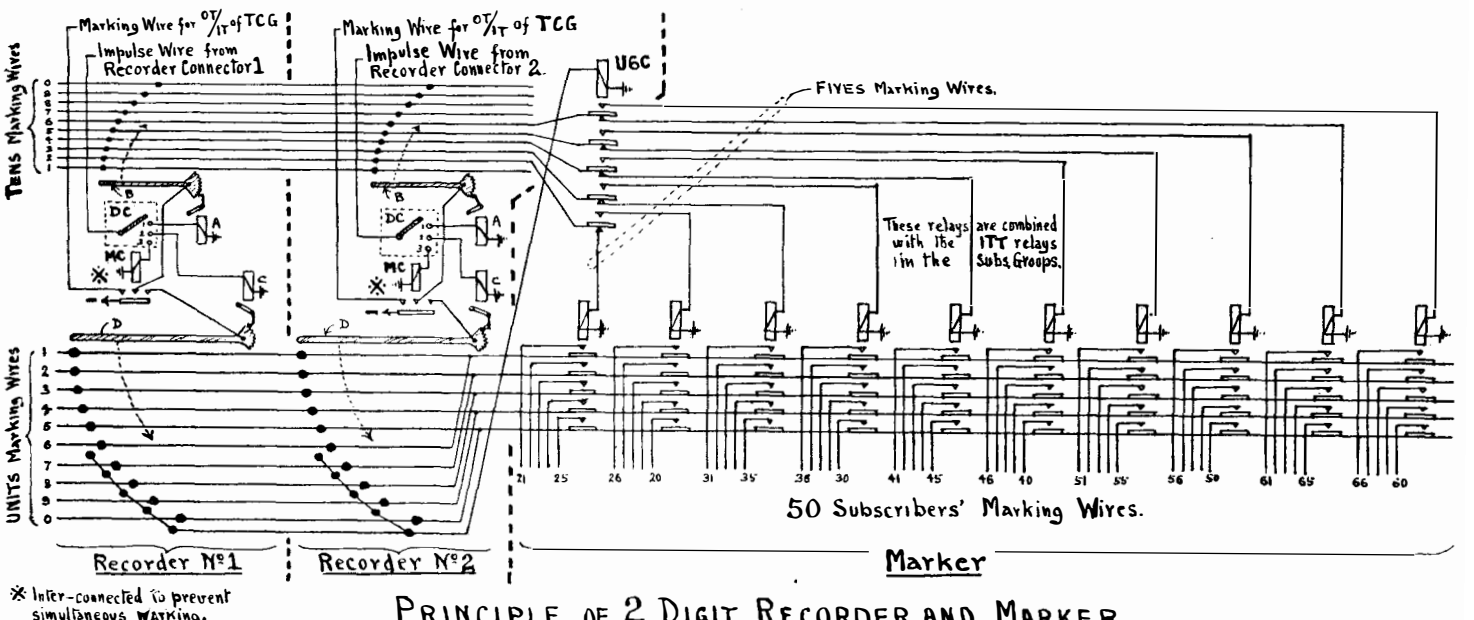
It should be noted that the searching time for connecting to the first link is the same as for connecting to the last, irrespective of the number of links.

Principle of Recorder and Marker.

Fig. **6** shows two Recorders and a Marker for 50 subscribers' lines. Switches are shown in the Recorder, instead of relays, in order to make the principle clear.

When a Calling subscriber has obtained connection with an ABF and commences to dial, impulses will be sent *via* the Recorder Connector and the Impulse Wire to the Recorder DC (Digit Control) switch which will be in pos. 1.

The Tens Impulses will actuate the counting magnet A which will step round the wiper B and thereby store the tens impulses.



PRINCIPLE OF 2 DIGIT RECORDER AND MARKER.

The Recorder Counting, Storing, and Digit Control relays are shown as switches in order to indicate their functions clearly.

FIG. 6.

When the tens impulses have ceased the DC switch moves to pos. 2.

Magnet C now counts the Units Impulses, steps round the wiper D, and thus stores the Units Impulses.

The impulses having ceased, the DC switch moves into pos. 3.

Provided that the Marker is not at that instant in engagement with another Recorder, the MC (Marking Control) relay energises and connects marking negative to a *Tens* and a *Units Marking Wire* which will result, as can be seen, in the *Called Sub.'s Marking Wire being connected to Negative*

The MC relay, at the same time, sends marking negative to energise the requisite OT/IT relay of the TCG.

These marking currents only flow for a very short time, and when the necessary connecting relays OT/IT, ITC, and LC have been energised the Recorder and Marker are released and immediately reset for another call.

It can be seen from Fig. **6** that a number of Recorders can receive impulses at the same time, and that they are arranged to wait on one another for the service of the Marker.

Sets of relays are arranged to do the work of the switches DC, AB and CD, which will be explained later.

In the case of a 3 Digit Recorder and Marker, extra storing relays are required in the Recorder for the hundreds digit, also one relay for each fifty subs. lines is added to the Marker.

The foregoing notes refer to 5 line subs. groups for P.A.X and P.A.B.X. exchanges. For Public Exchanges (excepting Village) 10 line Sub.'s Groups are used, and the Recorder and Marker are modified accordingly, although the principle remains unaltered.

Private Automatic Branch Exchanges.

The Trunking Scheme shown in Fig. **4** is employed for sizes up to about 300 lines.

When the manual board for dealing with the Public Exchange calls is located in the same building as the automatic board, extension jacks (one per line) are teed to the Sub.'s lines at the point shown in Fig. **4** (*c*). Line lamps are arranged, one per jack, and when an extension wishes to make an exchange call he dials "0"; the Recorder does not wait for other digits, but marks and lights the corresponding extension line lamp on the manual board, and in so doing releases the Out Trunk and Sub.s' Group link which were used to make the call. The call is then dealt with on the manual board in the standard way.

The Public Exchange lines terminate on the manual board, and inward calls are received by the telephonist and connected

direct to the extension jacks, without employing the automatic switchboard.

Private Automatic Branch Exchanges without local manual boards have been supplied to Administrations abroad, in which case the Public Exchange telephonist obtains the extensions by dialling over the exchange lines. The extensions call the Exchange direct by dialling "●."

[*In the foregoing, Mr. Bryant describes the principles of the Relay system with particular reference to its application to P.A.X.'s and P.A.B.X.'s; in our next issue the larger public exchanges will be dealt with.*—EDS. P.O.E.E. JOURNAL.]