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## Post Office Engineering Department

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# TECHNICAL PAMPHLETS FOR WORKMEN

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*Subject:*

## Automatic Telephony: Step by Step Systems.

ENGINEER-IN-CHIEF'S OFFICE,  
1919.

*Revised and re-issued December 1925. Previous issues cancelled.  
(Reprinted March, 1929, incorporating Correction Slips to date).*

LONDON:

PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE.

To be purchased directly from H.M. STATIONERY OFFICE at the following  
addresses:

Adastral House, Kingsway, London, W.C. 2,  
120, George Street, Edinburgh,  
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*[Continued on page iii. of Cover.]*

# AUTOMATIC TELEPHONY: STEP BY STEP SYSTEMS.

(E. 1)

*The following I.P.O.E.E. Papers  
are of kindred interest :—*

- No. 45. "Machine Switching in Telephony." By B. O. ANSON.  
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 By G. F. O'DELL.  
 No. 90. "Automatic Telephony in Multi-Office Areas." By G. F. O'DELL.  
 No. 100. "Siemens No. 16 Automatic Equipment." By C. W. BROWN.

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Fig. 1.

## AUTOMATIC TELEPHONY : STEP BY STEP SYSTEMS.

### I.—GENERAL.

**Introductory Notes.**—An automatic telephone system is one in which the calling party is enabled, without the aid of a telephonist, to complete a call through remotely controlled switches. As distinct from the automatic system of telephony the switching systems which require operators to manipulate plugs and cords are called manual systems. The most up-to-date manual exchanges are worked on the common battery system, *i.e.*, one large battery is provided at the exchange for the supply of talking and signalling current, instead of the older practice in which batteries were provided at each subscriber's office. There are now several automatic systems in general use and, like their immediate predecessors of the manual type, they are all worked upon the common battery principle. The *Step by Step* system is the one most widely used in this country and is now being adopted by the Department as standard. Step by Step systems are supplied by various manufacturers who employ circuits and mechanisms of their own design though they all accomplish selection of a called line by successive stages—or *steps*—which correspond to operations performed by the caller, known as *dialling*.

These dialling operations consist of the manipulation of a dial which is part of the subscriber's apparatus and is shown at the foot of the telephone in Fig. 1. The dial and the manner of dialling may be seen from Figs. 2 and 3. Numbers can be seen appearing behind a series of holes in a movable finger plate. In order to make a call the subscriber lifts the receiver from the switch-hook and inserts his forefinger into one of the holes and pulls the finger plate round until the progress of the finger is arrested by a stop which is shown beneath the finger in Fig. 3. The disc is then released and, whilst being driven back to its original position by a main spring located within the dial, disconnects the subscriber's line a certain number of times corresponding to the digit shown on the number plate near the hole into which the forefinger was inserted. This operation is repeated for each digit of the number called. The dial is arranged so that the disconnections occur on the return journey of the dial, not on its forward journey, in order that the system may be rendered reasonably independent of any peculiarity in dialling on the part of the calling subscriber, such as hesitation in the middle of a digit. In order to avoid trouble which would occur if the dialling circuit included the variable resistance of the transmitter, and also to avoid annoyance to the subscriber

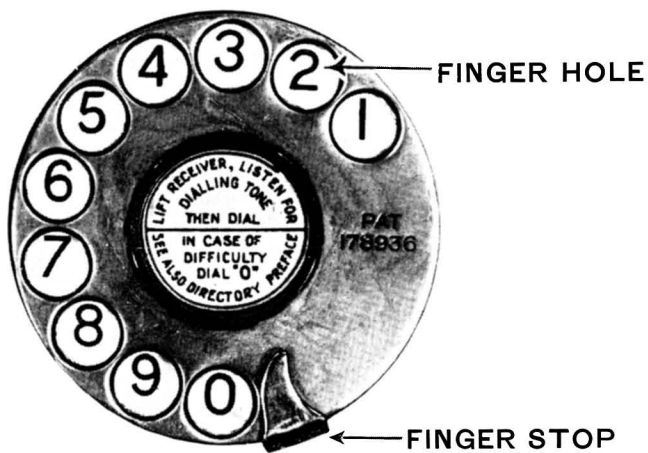


Fig. 2.



from clicks in the receiver, it is usual to switch the speaking apparatus out of circuit during dialling.

A large amount of work has been done in developing a satisfactory dialling circuit. The principle employed in the various circuits that have been proposed is illustrated in Fig. 4. Springs (b) close and short-circuit the telephone as

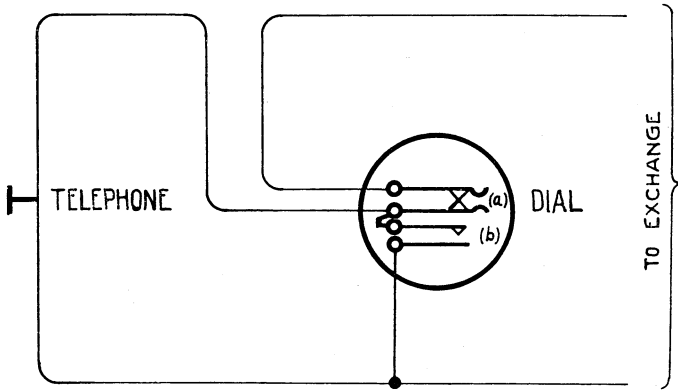


Fig. 4.

soon as the dial is moved off normal, while springs (a) are the contact springs whose intermittent operation provides the train of disconnections or impulses that control the automatic apparatus. Fig. 4 is diagrammatic only and does not show the actual circuit changes effected by the springs (b). The latest telephone circuit follows the principles of the standard C.B. subscriber's circuit and requires a more complex dial than that illustrated in the figure.

Before studying the description of the apparatus employed, the requirements to be satisfied by the automatic system should be considered.

(a) When the subscriber lifts his receiver he must be provided at the exchange with a circuit to the automatic apparatus which will later respond to the impulses he dials.

(b) When the subscriber has sent impulses he must be connected to the line whose number he has dialled.

(c) When the called line is found and is disengaged the called subscriber's bell must be rung.

(d) When the called subscriber answers the telephone the ringing current must be disconnected, talking current supplied, and the call registered against the caller.



(e) While the conversation is in progress the lines connected together must be rendered engaged to other calls and safeguarded against interference.

(f) When the calling subscriber replaces his receiver both subscribers must be left free to make or receive calls and the apparatus restored to normal so as to be available for use on further calls.

(g) When one subscriber calls another whose line is engaged the calling subscriber must receive a distinctive engaged signal to acquaint him with the fact.

**Description of 100-line Exchange.**—When a subscriber lifts his receiver he is placed (by means that will be described later) in direct connection with a mechanism called a selector. A selector consists of a movable element called a *wiper*, which can travel over a fixed element called a *bank*. The bank consists of 100 sets of contacts which are joined permanently to 100 corresponding subscribers' lines. The bank surface is a portion of a cylindrical area (see Fig. 5, *A, B, C, D*). The wipers correspond to the line *XY*, and the contact end *X* of the wiper must be moved to some point *Z* on the bank corresponding to the called line. The 100 sets of contacts are in 10 rows (or *levels*) of 10, and the numbering scheme is shown in Fig. 6. There are 3 contacts in each set; two *line* contacts and one *private* contact. These correspond to the "tip," "ring" and "sleeve" contacts of jacks and plugs in the manual system. The private contact holds the connection after it is established and guards it against interruption.

The wiper moves from its home position to *Z* (Fig. 5) by two stages; one, **vertical**, up to the proper level, and the other, **rotary**, reaching the actual contact set in the level. The *release* at the end of the conversation occurs similarly in two stages, but in the reverse order; the first, rotary, under the influence of a coiled spring and the second, vertical, in falling by gravity from the level to the normal position. Referring to Figs. 5 and 6 it will be seen that *Z* is the set of contacts for subscriber 78. To call 78 the originating subscriber first dials "7" and then "8." The dialling of digit "7" disconnects the line 7 times and at each disconnection the wiper is lifted one step. The wiper is thus raised to the 7th level of contacts. The disconnections control the selector by causing impulses to be delivered to electro-magnets which operate ratchets and pawls in a manner to be described shortly. At the end of the first train of impulses—7 in number in the case quoted as an example—changes are effected in the selector circuit which cause the succeeding train of impulses to rotate the wiper over the contacts of the level to which it has been

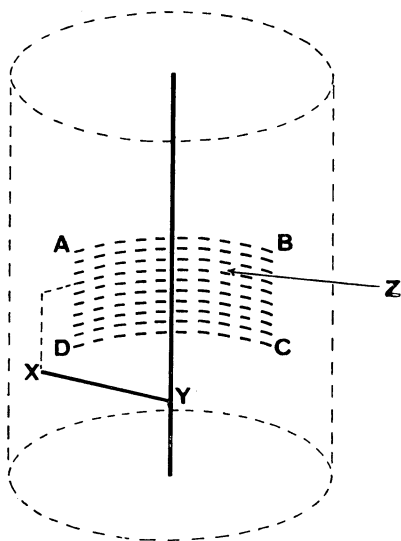


Fig. 5.

Level "0"	<u>01</u>	<u>02</u>	<u>03</u>	<u>04</u>	<u>05</u>	<u>06</u>	<u>07</u>	<u>08</u>	<u>09</u>	<u>00</u>
" "9"	<u>91</u>	<u>92</u>	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>	<u>98</u>	<u>99</u>	<u>90</u>
" "8"	<u>81</u>	<u>82</u>	<u>83</u>	<u>84</u>	<u>85</u>	<u>86</u>	<u>87</u>	<u>88</u>	<u>89</u>	<u>80</u>
" "7"	<u>71</u>	<u>72</u>	<u>73</u>	<u>74</u>	<u>75</u>	<u>76</u>	<u>77</u>	<u>78</u>	<u>79</u>	<u>70</u>
" "6"	<u>61</u>	<u>62</u>	<u>63</u>	<u>64</u>	<u>65</u>	<u>66</u>	<u>67</u>	<u>68</u>	<u>69</u>	<u>60</u>
" "5"	<u>51</u>	<u>52</u>	<u>53</u>	<u>54</u>	<u>55</u>	<u>56</u>	<u>57</u>	<u>58</u>	<u>59</u>	<u>50</u>
" "4"	<u>41</u>	<u>42</u>	<u>43</u>	<u>44</u>	<u>45</u>	<u>46</u>	<u>47</u>	<u>48</u>	<u>49</u>	<u>40</u>
" "3"	<u>31</u>	<u>32</u>	<u>33</u>	<u>34</u>	<u>35</u>	<u>36</u>	<u>37</u>	<u>38</u>	<u>39</u>	<u>30</u>
" "2"	<u>21</u>	<u>22</u>	<u>23</u>	<u>24</u>	<u>25</u>	<u>26</u>	<u>27</u>	<u>28</u>	<u>29</u>	<u>20</u>
" "1"	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>10</u>

Fig. 6

raised. Thus, the 8 impulses corresponding to the dialling of the second digit of 78 step the wiper to the eighth contact in the seventh level.

It will be noticed that the "O" level for the 10's is situated at the top and the "O" contact for the units at the right-hand end of the bank. This arrangement is adopted because, although it is possible to use one impulse for "1," two for "2," and so on up to nine impulses for "9," "0" impulses cannot be used for "0" and produce a mechanical effect, so ten impulses are adopted for "0" which drive the wiper ten steps each time "0" is dialled.

To effect the necessary mechanical processes, each selector consists of the following essential parts (*see* Fig. 7) :—

(1) A vertical magnet (*VM*) which operates a ratchet and pawl (*VR* and *VP*) and lifts a shaft carrying the wiper.

(2) A rotary magnet (*RM*) which operates a second ratchet and pawl (*RR* and *RP*) and so rotates the wiper shaft.

(3) A double dog (*DD*) which acts as a detent against gravity for the vertical ratchet and against the coiled spring for the rotary ratchet.

(4) A release magnet (*Rel. M*) which, at the end of the call, knocks the double dog out of the ratchets, so permitting the coiled spring to rotate the shaft.

(5) A stationary dog (*SD*) which engages with the circular notch of the vertical ratchet and so holds the shaft against gravity during the rotary portion of the release when the double dog has been knocked out of engagement with the ratchets. The stationary dog normally rests in a slot in the vertical ratchet, thus allowing the free upward and downward movement of the shaft when the wipers are clear of the bank contacts.

(6) A flat steel spring called the release link (*RL*) which holds the double dog out of engagement with the ratchets once the release magnet is operated. This link is struck upwards on the first kick of the vertical magnet, allowing the double dog to re-enter the ratchet.

(7) Off normal contact springs (*ON*) which close an electrical circuit on the first vertical movement of the switch. These contacts prepare a circuit for operating the release magnet at the end of the call.

Fig. 8 shows a complete selector mechanism.

The foregoing assumes that any one of the 100 subscribers can obtain the use of a selector when he originates a call.

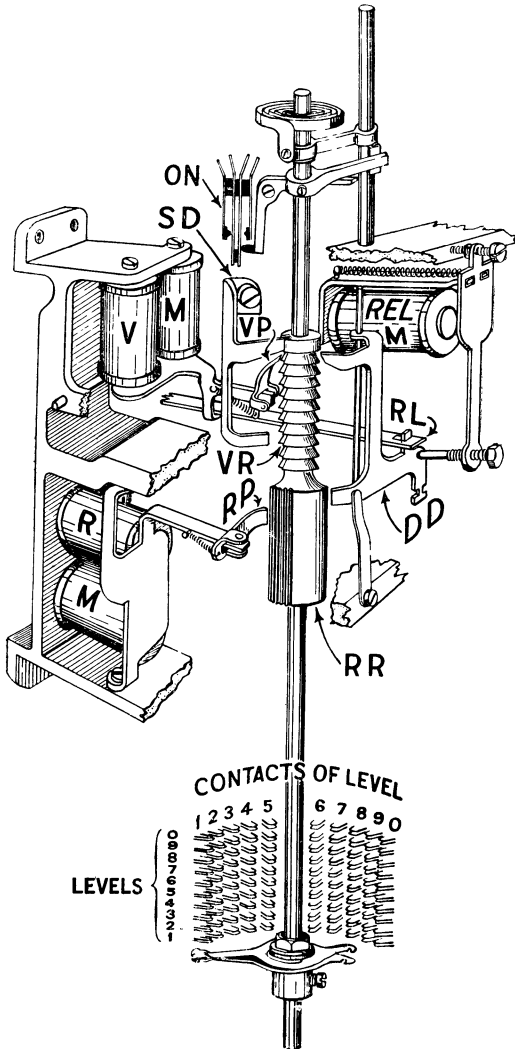


Fig. 7.

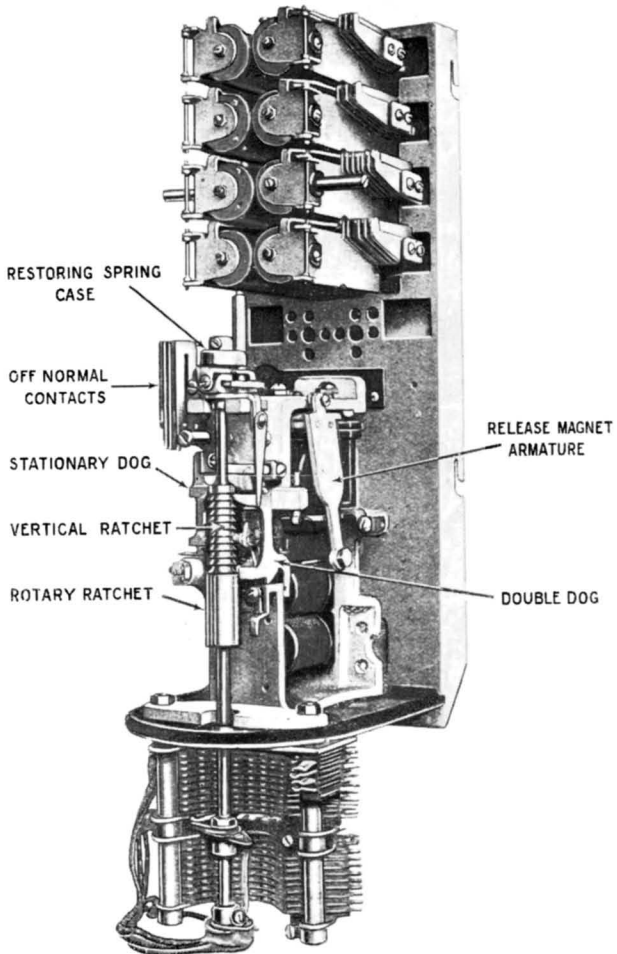


Fig. 8.

II

It would obviously be a very expensive matter to provide one selector for the exclusive use of each subscriber. Selectors like cord circuits, are provided to carry what is regarded as the reasonable maximum traffic load of the unit. It is customary therefore to provide from 10 to 30 selectors per 100 lines according to the traffic requirements, but, of course, special cases might demand either fewer or more than this. To enable the calling subscriber to gain access to an idle selector a simple form of cheap individual switch called a *line switch* is customarily provided.

Fig. 9 shows a typical line switch the wipers of which move over the semicircular contact bank carrying circuits

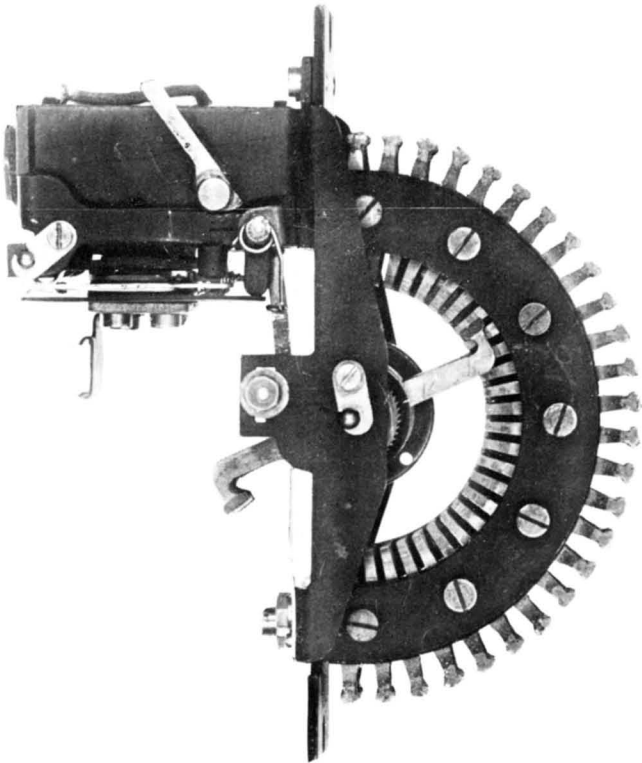


Fig. 9.

extended to selectors. This movement takes place automatically as soon as the subscriber raises his receiver.

A single connection in a 100-line exchange may be represented diagrammatically as shown in Fig. 10. The symbol for the selector in this figure shows ten horizontal lines representing the ten levels of ten contacts each. This symbol will be frequently used to represent a selector mechanism and bank. One only of the line switch contacts is shown connected to a selector which is one of a number whose bank contacts are multiplied to the 100 subscribers' lines.

**Larger Exchanges.**—The selector described is capable of selecting within a group of 100 lines only. 1,000 lines may be divided into 10 groups of 100 lines each. These groups of 100 lines can then be regarded as small exchanges in which selection takes place as described in the preceding paragraphs. Thus, there will be 10 groups of selectors corresponding to the 10 groups of 100 lines and for a particular line to be selected it is necessary to determine from which group of selectors one must be taken into use, *e.g.*, if the required number is 345, it is necessary that No. 45 found by the selector shall be the 45th subscriber in the **particular hundred required, viz., the 3rd hundred**. This discrimination is effected by employing an additional switch called a *group selector* since it determines in which group of 100 lines selection shall proceed. In distinction from the group selector, the switch that searches within the 100-line groups under the control of the last two digits is called a *final selector*.

In the case of calling No. 345, the first train of three impulses is received by a group selector which thereupon raises its wipers to the 3rd level and immediately, without waiting for further digits to be dialled, rotates them over that level, the contacts of which have access to final selectors whose bank contacts are extended to the 100 subscribers in the 3rd group. As soon as the wipers of the group selector reach a circuit to a disengaged final selector they come to rest and the succeeding trains of impulses are directed to the final selector which proceeds to seek for the 45th subscriber in the 3rd hundreds group, *i.e.*, subscriber 345. A single connection on a 1,000 line exchange may be represented diagrammatically as shown in Fig. 11.

Another rank of switches is again added to extend the system to 10,000 lines, the additional selector discriminating between the 10 separate 1,000 line groups within which selection may be made. Connection is established, therefore, by a chain of switches represented by Fig. 12 in which there are shown a 1st and 2nd group selector and a final selector.

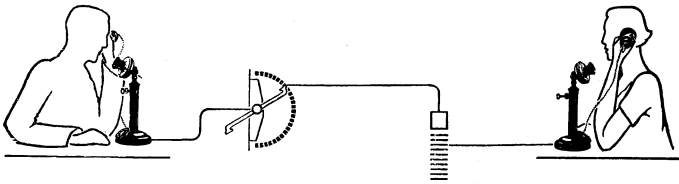


Fig. 10.

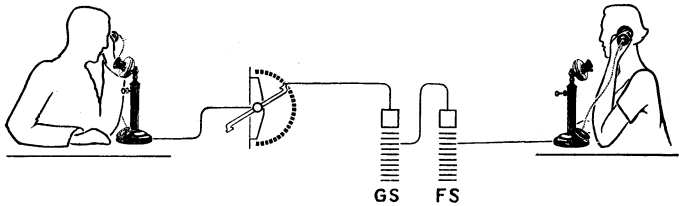


Fig. 11.

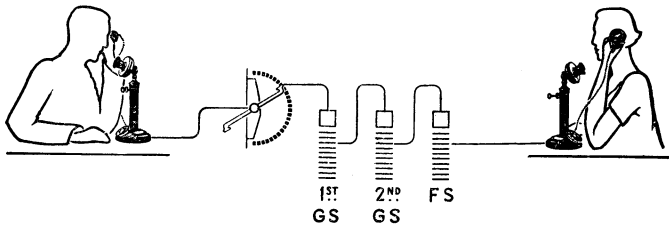


Fig. 12.

**Summary of the Processes of making a Call.**—The process of establishing a connection is summarised below :—

(1) The subscriber lifts his receiver and listens. The line switch extends the connection to a disengaged first group selector. "*Dialling tone*" is transmitted to the calling subscriber advising him that dialling may be commenced. Dialling tone is a continuous characteristic purring sound.

(2) The number is dialled. The successive selections extend the connection to the called line. The dialling tone is cut out of circuit when the first digit has been completed. The final selector sends out "*ringing current*" to the called line and "*ringing tone*" to the calling line. The ringing tone is induction from the ringing current and is, therefore, easily recognised by its periodicity and may be represented thus—

Burr—Burr———Burr—Burr———Burr—Burr.



(3) When the called subscriber lifts his receiver the ringing current is disconnected and the lines are connected for conversation. Also, on the call being answered the calling subscriber's meter is operated.

(4) On the completion of the conversation the replacement of the calling subscriber's receiver causes the selectors to return to their normal condition.

(5) Had the called line been engaged "*busy tone*" would have been transmitted to the calling subscriber on the completion of dialling. The busy tone is a high pitched tone interrupted at regular intervals thus—

Buzz—————Buzz—————Buzz—————Buzz.

The above description assumes that all the calls dealt with are calls which may proceed satisfactorily and no mention has been made of any provision for a subscriber calling a ceased or unallotted number. Arrangements are made whereby all irregular calls which can be anticipated will result in "*number unobtainable tone*" being transmitted to the calling subscriber. Number unobtainable tone, or "*N.U. tone*" as it is called, is a note like the busy tone, but continuous instead of interrupted.

Busy tone indicates that the call cannot be completed at the moment but may be obtained by dialling later.

Number unobtainable tone indicates that the number dialled cannot be obtained at all.

The calling subscriber's meter is not operated on calls that encounter the busy or N.U. conditions.

In the case of London and cities having similar arrangements, N.U. tone will also be transmitted if the caller fails to complete the dialling of a number and in the event of apparatus becoming faulty during the setting up of a call.

**Private Branch Exchange Lines.**—In manual practice the presence of a coloured line under consecutive multiple jacks indicates to the operator that those are the exchange lines of one P.B.X. and she can, therefore, complete the connection over any free line although the called number may be engaged. On the automatic system P.B.X. lines are given numbers served by a special group of P.B.X. final selectors. The circuits of these are so arranged that should the first of a series of P.B.X. lines be engaged the wipers are automatically rotated until a disengaged line is found, busy tone being transmitted only if all the lines serving the P.B.X. are engaged. Arrangements are made by which the selector can search over all the lines of a group too large to be accommodated by the 10 contacts of one level. Should it be desired to plug through to an extension any exchange line at

night when the P.B.X. board is unattended it is arranged that any line other than the first in the group can be called without the automatic hunting action taking place.

**Junction Calls.**—The particular needs of large telephone areas, such as London, are referred to later in this pamphlet, the foregoing description applying more particularly to areas served by one automatic exchange. Not every call originated on that exchange, however, will be for another automatic subscriber but may be for a subscriber in another exchange area, or a call may be for "Trunks." Circuits are therefore provided to enable the subscriber to obtain the attention of an operator. It is usually arranged that a call to the manual board is made by dialling "o."

*Dialling-out to Manual Exchanges.*—In some cases there is heavy junction traffic to a particular manual exchange in the neighbourhood. It is then arranged, by allotting a certain level for the purpose, that the manual board in this exchange shall be reached by dialling a particular number in the same way as the local manual board is reached by dialling "o." In the case of dialling either the local or a distant manual board the attention of the operator is gained by a lamp signal, and the subsequent control of the call is uniform with standard manual practice. Metering is generally effected automatically by the transmission of a supervisory current from the cord circuit on the reply of the called manual subscriber.

When provision is made for dialling out direct to other exchanges, the junction over which a call is routed may be available both on the selector levels and on the operator's outgoing junction multiple at the manual board. In such cases an "engaged" lamp is associated with each outgoing junction jack, and this lamp lights if the junction is taken into use either by the automatic apparatus or by an operator.

*Dialling-in from Manual Exchanges.*—In the case quoted of heavy outgoing traffic from an automatic to a manual exchange, it is probable that there is also considerable traffic from the manual exchange incoming to the automatic exchange. These calls may be handled without the intervention of an operator at the automatic exchange by providing each "A" position at the manual exchange with a dial. On receiving a call for the automatic exchange she takes into use a junction terminated on a selector at the automatic exchange and dials the wanted number in the same way as the number would be dialled from an automatic telephone. This may not only be done in the case of local junction calls but on trunk circuits when justified by the traffic. The metering and ticketing

will, of course, be effected in each case by the operator on the completion of the call in the usual way.

*Keysending "B" operating.*—Where there is a large amount of incoming traffic and where, for various reasons, dialling-in is impracticable, it is necessary to provide the operator with some more expeditious means of establishing the connection than dialling from the local manual board. In this case the operator is provided with a strip of digit keys of the type shown in Fig. 13. The "B" operator receives the request



Fig. 13.

for the call over an order wire and assigns a junction as in manual practice. She then associates automatic sending apparatus with the junction by the depression of an assignment key and sets up the call by depressing in succession the digit keys corresponding to the wanted number. The sending apparatus operated by the digit keys then transmits the requisite trains of impulses as though the number had been dialled. It will be appreciated that this method is much quicker than that of dialling but the additional apparatus involved is justified only where there is a large volume of this traffic.

**Multi-Office Areas.**—Certain large cities, of which London is the outstanding case, present problems which will be dealt with later, but there are many areas that may be dealt with in a manner which is an extension of the ideas already presented. There might be in the area several self-contained automatic exchanges of the type described above and if the junction traffic were completed manually, no addition would need to be made to the arrangements already described.

It has already been stated that a call may be dialled-out to a distant manual exchange. If the exchange be automatic, however, it may be arranged that the dialling of additional digits extends the call to the required number on that exchange. Take for example the system illustrated in Fig. 14. All subscribers in the area are included in one numbering scheme, each subscriber being reached by dialling a five figure number. In this scheme any subscriber dialling 2 obtains connection with South exchange. Similarly the dialling of 5 extends a connection to East exchange. When the connection has

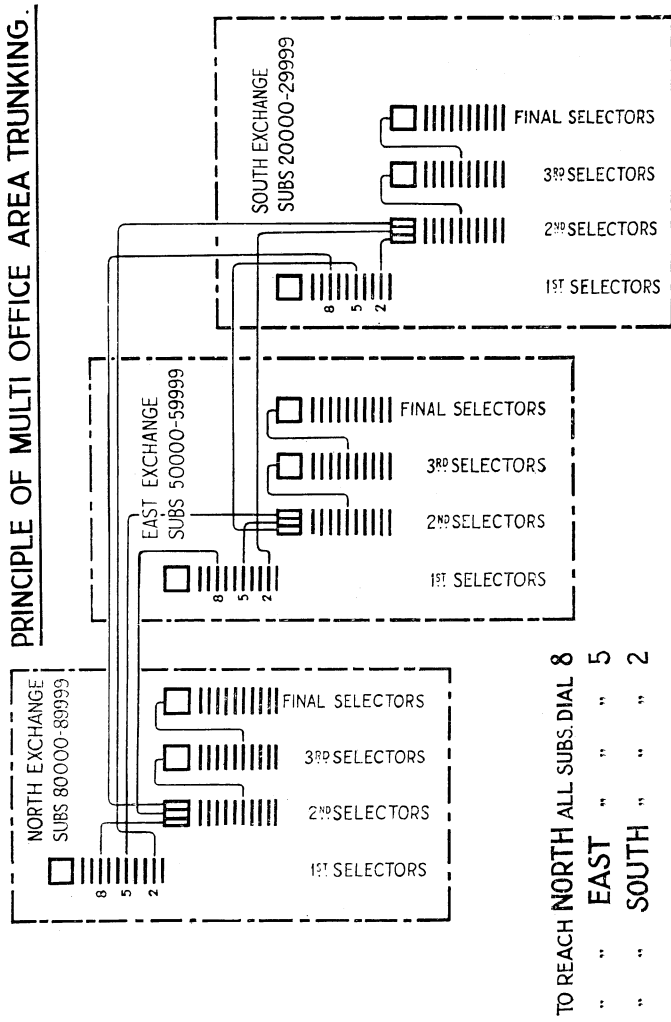


Fig. 14.

been established to the required exchange, selection proceeds exactly as in a self-contained exchange.

## II.—LONDON AND OTHER LARGE CITIES.

**The Lettered Dial.**—In the preceding section a method of working a multi-office exchange area has been described, and it has been shown how the dialling of the first digit of a 5-figure number selects a junction line to the required exchange. A 6-figure numbering scheme would be required in a larger area where 2 digits were necessary to select a junction to one of a number of 4-figure exchanges. The London area contains so many exchanges that a 7-figure numbering scheme is necessary, the first 3 digits serving to select a junction. A 7-figure number, being more difficult to remember than a 4-figure number, is also more likely to be incorrectly dialled. Exchange names are, therefore, retained and letters added to the dial number plate as can be seen in Fig. 15. The numbering scheme is so arranged that connection is made with any particular exchange by dialling the first three letters of the exchange name. Thus, to call Central 2345, the letters CEN are first dialled as an exchange code followed by the number 2345. The directory is printed in such a manner as to indicate clearly the code that must be dialled, the first three letters

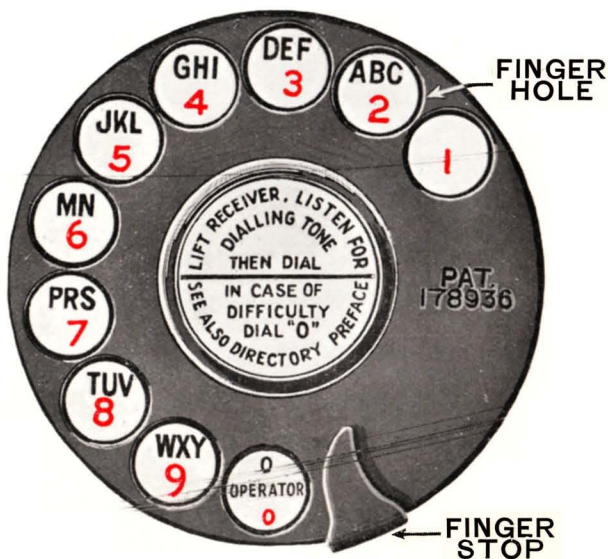


FIG. 15.

of the exchange name appearing in heavier type as can be seen in Fig. 16.

King, F. J. L., Elm Dene, Green, F.4 .....	Chingfrd ...	179
King & Flack, Sign Ticket Writers, 230 Hornsey rd, N 7. ....	<b>NOR</b> th .....	<b>3868</b>
King, F. L., L.D.S., R.C.S. (Fng), Dental Surgeon, 1A Peterborough rd. ....	<b>HAR</b> row ..	<b>0119</b>
6 Cavendish pl, W.1 .....	<b>MAY</b> fair ..	<b>0541</b>
King, F. N., Limes School, 13 Pk rd, W 4 .....	<b>CHI</b> swick .	<b>2038</b>
King & Foa, Billbrokers, .....	<b>CIT</b> y .....	<b>0911</b>
11 George yd, E C 3 .....	<b>AVE</b> nue ..	<b>1454</b>
King F. R., 5 College rd, Isleworth .....	<b>HOU</b> slow	<b>0372</b>
King Mrs. Frances K, 202 Marylebone rd, N W 1 .....	<b>LAN</b> gham	<b>3254</b>
King Francis E., 26 Rotherwick rd, N.W 11 .....	<b>SPE</b> edwll ..	<b>3776</b>
King, Francis F. & Son, Accountants & Auditors, 143 High Holborn, W C 1 .....	<b>MUS</b> eam .	<b>2712</b>
King Fras. J. L., 17 Church hl, E 17 .....	<b>WAL</b> tmsto	<b>1061</b>
King Frank, 8 Leamington gdns, Seven Kings .....	<b>ILF</b> ord .	<b>0077</b>
King Frank, 112 Wembley Hl. rd. ....	<b>WEM</b> bley	<b>1537</b>
King Frank A., 6 Wellmeadow rd, S E 13 . ....	<b>LEE</b> Gn ..	<b>3044</b>
King Frank, E.F.I.C., Analytical Consulting Chemist, 32 Brooke st, E.C 1. ....	<b>HOL</b> born	<b>1832</b>
King Frank H., 6 Cromford rd, S W 18.....	<b>PUT</b> ney ...	<b>4684</b>

Fig. 16.

The three initial letters of each exchange name must represent combinations of digits different from those of every other exchange in the area. Obviously, therefore, the two names "HAMmersmith" and "HAMpstead" must not exist together in the same area nor may that area contain together two such names as "VICtoria" and "THAMes," as the pulls of the dial represented by VIC are identical with those of THA, both these codes corresponding to the number 842.

**Director System.**—The adoption of the lettered dial imposes restrictions on the numbering scheme since the impulse trains dialled are dictated by the name of the called exchange and unless some special provision is made, the exchange name, being a definite numerical code, will therefore determine on which specific level of bank contacts the junctions sought must be found. Such a scheme would be very costly as it would be necessary always to operate three group selectors before finding a junction line. This, however, is not the only serious difficulty to be overcome in a large area. The success of the scheme illustrated in Fig. 14 is dependent on the provision of direct junctions, *e.g.*, a caller dialling "8" whether he be an "East" or a "South" subscriber must be provided at once with a junction to "North." In an area such as London, the cost of providing direct junctions between every two exchanges would be prohibitive. Fig. 17 represents an area in which the traffic is to be carried over the routes shown. In order to do this, a NORTH subscriber when he dials EAS must obtain a junction direct to the EAST exchange. When a WEST subscriber dials EAS however, he must take into service a junction to NORTH as though he had dialled NOR and must then borrow a junction from

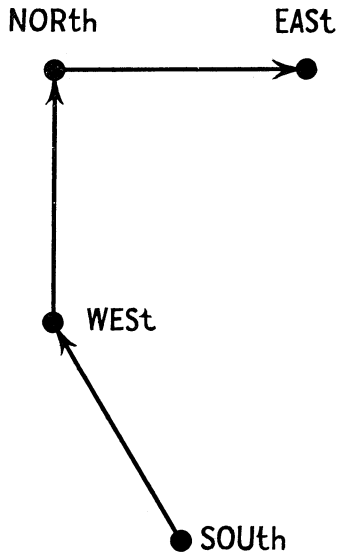


Fig. 17.

NORTH to EAST. In the case of a SOUTH subscriber dialling EAST still another selection must be made **although the same three digits have been dialled**. This means that the switching operations resulting from the dialling of a particular code will not be the same in all exchanges. In other words, the trunking must be independent of the numbering scheme, and for this purpose a piece of apparatus called a *director* is introduced at each exchange. When a subscriber dials, say EAST, the director at his exchange receives the dialled impulses and translates them into such trains as will **direct** the call to the required exchange by the route dictated by cabling and apparatus economics. In every case, the director apparatus receives three trains of dialled impulses corresponding to the exchange code. The routing of the call may be best effected by either a larger or smaller number of switching operations than three and the director is, therefore, so designed that although three trains of impulses are dialled, anything from one to six trains may be delivered to the selectors. A further extension of this idea is given in the section dealing with the mechanical tandem exchange.

The purpose of the director has been shown by illustrating the need for avoiding the provision of direct junctions. There is, however, another difficulty which is overcome by the use of the director. Referring again to Fig. 14 and the relevant paragraphs, it will be seen that the area is considered to be wholly automatic. Now a very large area cannot be converted to automatic working in one operation and, for a time, there will be manual and automatic exchanges working in the same area. Suppose, for instance, that the three exchanges in Fig. 14, *viz.*, "North," "East" and "South," were two of them automatic, say "North" and "South," while "East" were manual. If a "North" subscriber wished to call subscriber 4568 on the South Exchange, he would have to **dial** "24568," while an "East" subscriber would have to **ask** for "South 4568." Thus, two directories would be required in the same area, one for the use of automatic subscribers and another for manual subscribers. Moreover, if a subscriber made a call from a telephone other than his own, he would have to make sure he used the appropriate directory and did not call from memory a number with which frequent calls from his own telephone had made him familiar.

The use of the director apparatus, which translates the dialled impulses, enables subscriber "South 4568" to appear as "SOUth 4568," and the same directory serves for both manual and automatic subscribers, since both the **dialling** of SOU and the **verbal request** to an operator for a South number result in a junction to the South Exchange being taken into use.

**Operation of the Director.**—Fig. 18 (see end of pamphlet) shows in skeleton form the components of the director apparatus and the manner in which it effects impulse translation. The lifting of the subscriber's receiver takes into use a selector known as a 1st code selector since it responds to the first of the trains of translated impulses used to route the call to the required exchange. The 1st code selector makes no response to the dialled impulses which are diverted to the director *via* a switch called an "A" *digit selector*. The "A" digit selector and director are taken into use and employed only during the time that the call is being established and they are together known as the *director apparatus*. The first train of impulses corresponding to the first letter dialled, say C, is received by the "A" digit selector, the wipers of which rise to the corresponding level, and are automatically rotated like the wipers of a group selector. The bank contacts of the level over which hunting is taking place are extended



to directors, all of which are reserved for dealing with codes commencing with A, B or C, *i.e.*, digit 2. Thus, if the next two letters dialled were EN, the translation effected by the director employed would be such as to route the call to the exchange, the code of which corresponds to the number 236.

The director is a composite unit consisting of a *BC digit selector, digit distributor, digit registers, control switch and sender*. The BC digit selector is so called because it deals with the second and third digits of the three letter code. This selector, like the final selector described previously is controlled both in its vertical and rotary movement by dialled impulses. On the completion of the dialling of the code, therefore, the wipers of the BC digit selector are standing on certain of its bank contacts. These bank contacts are cross-connected to the contacts of the sender, *via* a cross-connection terminal block. At the end of each train of impulses, the digit distributor steps and directs the succeeding trains of impulses to the switches concerned. Thus at the end of impulsing, the dialled impulses have set the BC digit selector and the four digit registers, the contacts of which are also cross-connected to the sender bank. Only the code is translated; the numerical digits are merely **stored** on the four-digit registers. As soon as the director has received the impulses corresponding to the exchange code, it is ready to commence sending out the translated impulses to the code selectors. In the meantime, however, it is necessary to provide for the digits corresponding to the numerical portion of the number now being dialled, and it is for this reason that the digit registers are provided to store these digits until the director is ready to deal with them.

The impulses have now been traced **into** the director and it remains to see how they are translated and transmitted **out** to the selectors of the switching network. The impulses which step these selectors are derived from a machine-driven interrupter contact and the number of impulses delivered is counted off by the sender. As soon as the code impulses have been received by the BC digit selector, the sender commences to rotate in search of the contacts to which the BC digit selector wipers are cross connected. The BC digit selector carries six wipers and the circuits of these are completed successively by the stepping from position 1 to position 6 of a control, or sequence, switch which afterwards completes in succession circuits over the wipers of the digit registers. The sender first rotates in search of that one of its bank contacts to which the first BC digit selector wiper is cross connected. During this search a machine-driven interrupter contact transmits to the 1st code selector as many impulses as the

sender makes steps. Thus the cross-connection from the BC digit selector bank to the sender bank has determined the number of impulses to be sent to the 1st code selector. As soon as the sender finds the contact for which it is seeking, the relay shown connected to the sender wiper is operated over the circuit completed at the earth connected wiper of the control switch. This relay cuts off the impulses being delivered to the 1st code selector and causes the sender to return to normal. This process is repeated in each of the first six positions of the control switch, thus actuating the subsequent code selectors after which the circuits of the digit register wipers are completed successively. The dialled code can thus be translated into a maximum of six trains of impulses. If fewer than this number are required to route the call, the wipers not in use are cross connected to a DCO (digit cut off) relay which causes the control switch to step past the circuits of these wipers and to continue at once with the process of completing the circuits of the wipers of the digit registers, thus causing the numerical portion of the number to be transmitted. The code has thus been translated and the numerical portion of the number re-transmitted.

Fig. 19 shows the actual arrangement of the director.

**Calls between Manual and Automatic Exchanges.**—*Call from Automatic to Manual Exchange. (Call Indicator Working.)* When a subscriber connected to an automatic exchange requires to make a call to a manual exchange he dials the number of the wanted line in the usual way but on the connection reaching the manual exchange, it must be completed by an operator. The number of the called party is displayed before the operator as shown in Fig. 20. The display consists of a stencil, covered by a strip of green glass which does not permit any of the stencil numbers to be seen until illuminated from behind. Fig. 21 shows the arrangement of the stencil figures. Number 4932 is shown displayed while the remaining unilluminated figures can be seen more faintly. When a number is displayed before the operator, she selects any one of 36 single cords with which the position is equipped, and inserts it in the multiple jack of the displayed number. This action associates the cord with the displayed call, and the number is thereupon extinguished. Should other calls on the position be waiting attention, the extinguished number is immediately replaced by the number required by the next waiting caller. 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

# VIEW OF DIRECTOR ASSEMBLY

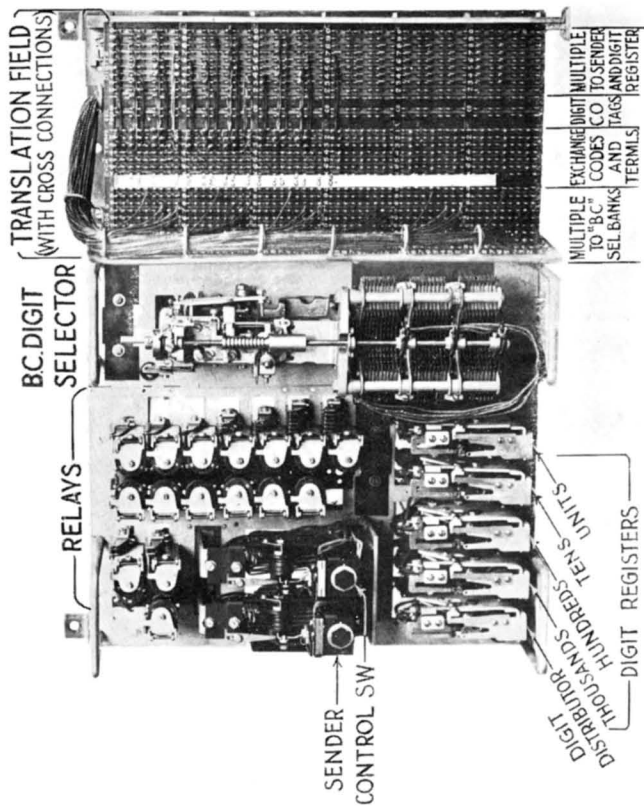


Fig. 19.

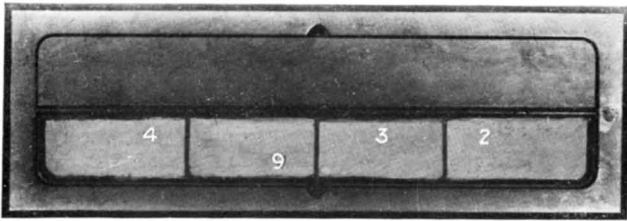


Fig. 20.



Fig. 21.

one of the right hand cords when the number is in the right of her multiple thus reducing the interlacing of the cords over the face of the multiple. The termination of a call is indicated by the glowing of a supervisory lamp associated with the cord. Should the called subscriber wish to originate a call before the operator has taken down the connection the supervisory lamp automatically flashes when the subscriber raises his receiver, thus calling the attention of the operator who withdraws the plug. The subscriber's calling equipment in the relative "A" position then comes into action in the normal way. A permanent glow on the supervisory lamp is given if the operator withdraws the plug accidentally before the subscribers have hung up their receivers. The operator then inserts the plug in a monitor's jack and particulars of the call are taken from the subscriber and the call re-established.

*Call from Manual to Automatic Exchange.*—A call incoming to an automatic exchange is completed at a Keysending "B" position as described in the earlier section headed "Junction Calls."

**Centralised Manual Boards.**—Although the majority of telephone calls may be completed automatically there are

certain classes of calls that require the intervention of an operator. Keysending "B" positions for dealing with incoming calls originated at manual exchanges have already been described. Further positions need to be provided for dealing with traffic such as :—

- (a) Fee junction calls.
- (b) Toll calls.
- (c) Trunk recording calls.
- (d) Enquiries and complaints.
- (e) Calls from subscribers to whom trunk traffic is barred.
- (f) Coin Box originated traffic.

These positions constitute the auto-manual board and, at large exchanges, are located in the same building as the automatic equipment. It is possible to serve a number of small exchanges in one area from a centralised manual board. When the traffic conditions and plant economics favour such an arrangement, great saving in the cost of automatic exchange buildings may be realised, due to the elimination, from these exchanges, of manual switchrooms and operators' quarters. The economy effected in the building design also permits subdivision of the automatic plant into smaller exchange units and so enables the economy resulting from a reduction in the average length of subscribers' lines to be realised.

#### **Mechanical and Semi-Mechanical Tandem Exchanges.—**

The idea of automatic tandem working has been referred to briefly in an earlier portion of the pamphlet, where the need for the employment of the director apparatus was explained. It was shown how it had been necessary, in the scheme of multi-office working already described, to provide direct junctions between all the exchanges, if direct dialling was to be adopted. Fig. 17 showed a case where traffic did not justify the provision of direct junctions. Many cases have occurred in London where there have been small groups of junctions between small exchanges and also between them and larger exchanges. The percentage irregularity of traffic over these small groups of junctions is greater than over a larger group and it is, therefore, necessary to provide a greater percentage margin of circuits to cater for the maximum load that is to be carried by these small groups. The traffic capacity of a junction in a small group is, therefore, low. It is also uneconomical to provide an order wire for working a very small group. The introduction of one or more manual tandem junction exchanges has, therefore, been considered frequently in the past with the object of concentrating junctions to and from the smaller centres in

those exchanges and thus forming a large group suitable for order wire operation. Hitherto, such schemes have not been very successful, as the cost of introducing a third operator into each connection, and the difficulty of working order wires in tandem, have discounted any other advantages. The call indicator " B " operating scheme already described produces an increase in the average speed of " B " position operating and at the same time avoids the use of an order wire, as the demand is not received orally, but displayed so that it may be seen by the operator. Advantage has, therefore, been taken of this system to introduce manual tandem working on a semi-automatic basis. This should result in much quicker and more accurate operating than is possible with a tandem order wire system.

Traffic originating with the " A " operators at the various manual exchanges is passed forward to the semi-mechanical tandem positions by order wire in the ordinary way. On receiving a demand over the order wire, the Keysending " B " operator at the tandem exchange sets up the call on her key-set. The key-set is shown in Fig. 22 which is similar to Fig. 13, but with the addition of the letter engravings. Since the exchange code, in addition to the subscriber's number must be set up, and junction selection is involved, the " B " operator is provided with a sender that is equipped with means for translating the code in a manner similar to that adopted in the director. If the call is for a manual exchange, the junction selection at the semi-mechanical tandem centre is

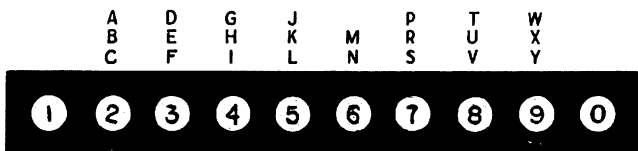


Fig. 22.

such that a line to a call indicator " B " position at the required exchange is taken and the impulses set the display at that exchange, as already described. If the call, however, is for an automatic exchange, a junction is selected and impulses are passed forward into the distant automatic exchange in order that the numerical portion of the call can

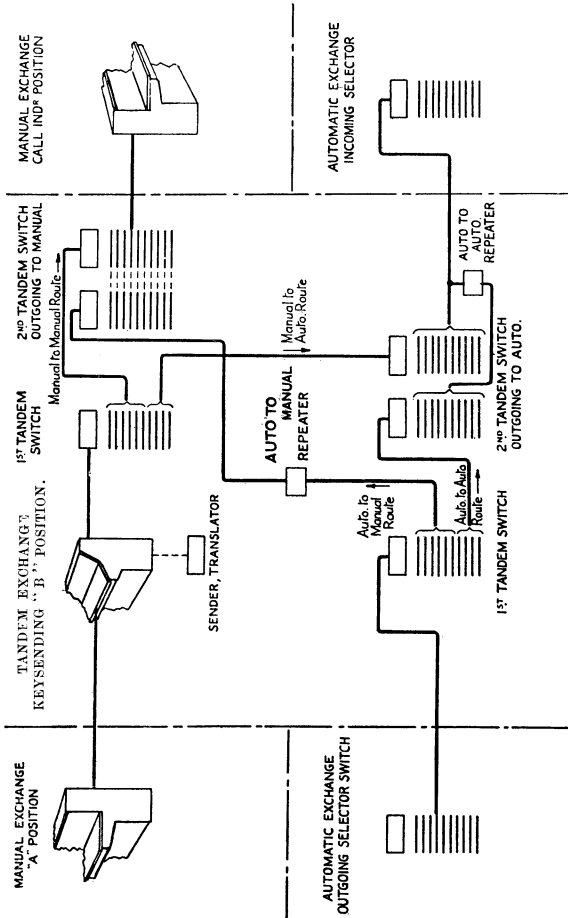


Fig. 23.

be effected there in the usual manner. Traffic originating in an automatic exchange will also be transferred, where necessary, to the mechanical tandem exchange, where it will be taken direct from the levels of the tandem selectors and passed forward to automatic or to manual exchanges, as described (for manual traffic) in the preceding paragraph.

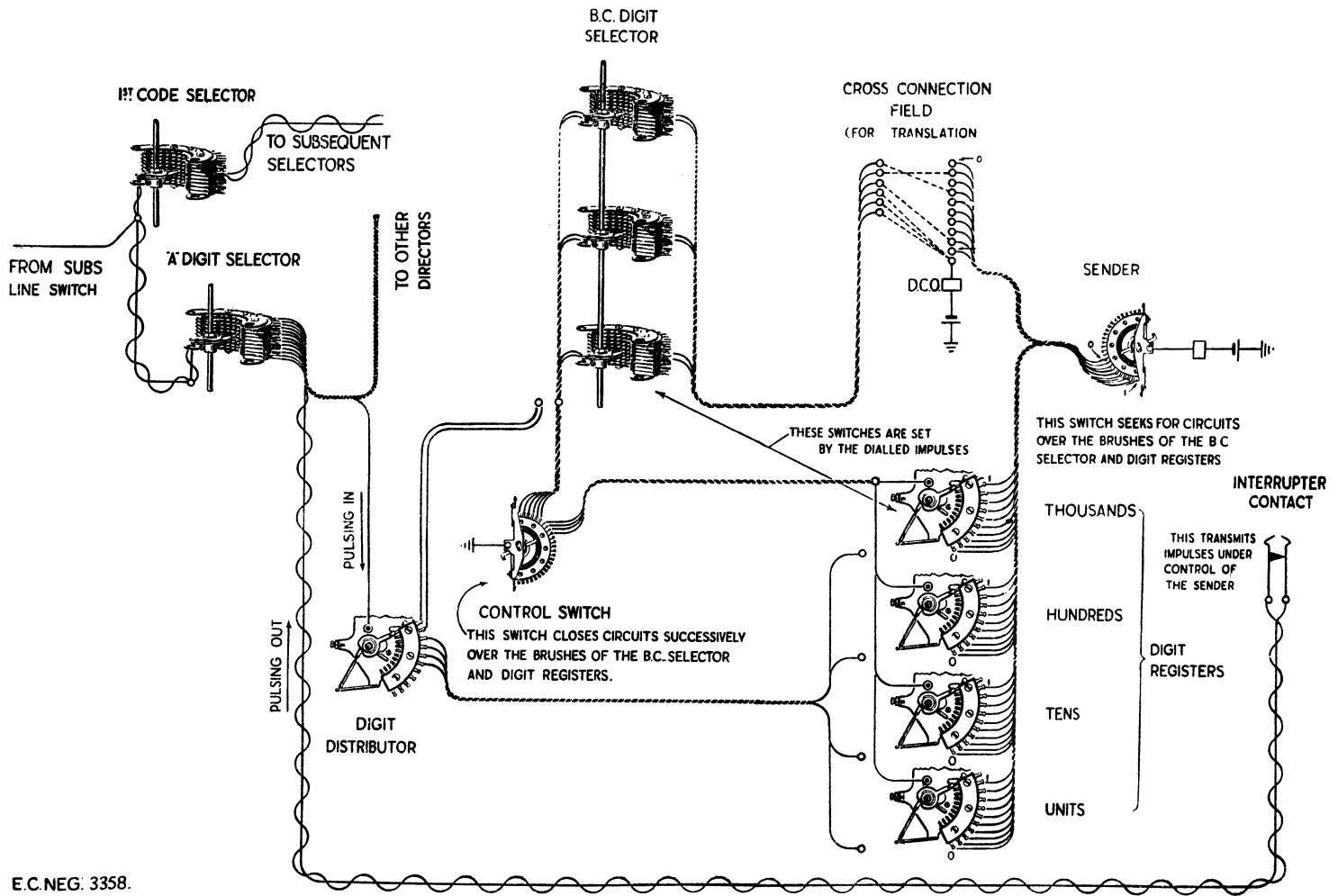
The method of handling traffic, as detailed above, is illustrated in Fig. 23.

The engineering advantages to be obtained under the semi-mechanical and mechanical tandem schemes are appreciable, as the collection of sufficient traffic to justify large groups of junctions radiating from the tandem exchange allows an orderly design of external plant to be adopted. There are also important operating advantages to be derived from this system, as it is possible to concentrate upon the tandem exchange the night and Sunday traffic between **all** the manual exchanges with the result that, during these periods, all incoming traffic will reach manual exchanges at call indicator positions. By this means it is possible to close the order wire " B " positions during such periods, and so provide means for giving a rapid and accurate night and Sunday service.

As the conversion of London to automatic working proceeds, the traffic incoming to the mechanical tandem exchange from manual exchanges and the traffic outgoing to call indicator positions will decrease and will ultimately fall to zero. The whole of the traffic at the mechanical tandem exchange will then become purely automatic and will be routed direct through the switches, as a result of the dialling operations of the subscribers.



### SKETCH TO ILLUSTRATE THE OPERATION OF THE DIRECTOR



E.C.NEG. 3358.

Fig. 18.

==== **LIST OF** ====

# Technical Pamphlets for Workmen

(continued)

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## **GROUP E.**

1. Automatic Telephony. Step by Step Systems.
2. Automatic Telephony, Code Call Indicator (C.C.I.) Working.
3. Automatic Telephony. Keysending "B" positions.

## **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.