

THE

AUTOMATIC TELEPHONE



SCIENCE MUSEUM

TECHNICAL PAMPHLET N° 2.

PRICE SIXPENCE

INTRODUCTION

THE automatic telephone has developed so rapidly in recent years that it is apt to be regarded as a relatively new idea. Actually the first patented proposal for an automatic switchboard dates from three years after the introduction of the Bell telephone in 1876. Messrs. Connolly and McTighe were the patentees, in America. The multiple switchboard was patented by Scribner earlier in 1879.

The first patents of Strowger, which form the basis of the present step-by-step system used by the Post Office, were taken out in 1891. There are at least two other major systems in wide use in other countries, each with its own peculiar advantages. The Strowger system was adopted in this country as being most suitable to our conditions after trials of various designs of apparatus on 25 different provincial and rural exchanges between 1912 and 1924. The first automatic public exchange in this country was opened at Epsom in 1912. Discussion of systems other than that adopted by the Post Office is outside the scope of this pamphlet.

There have been numerous important developments, both mechanically and electrically, since Strowger's first apparatus was made. The principle still remains. The motions of the switches are accomplished by the attraction of the armatures of selected electromagnets, ratchet and pawl action converting the attraction into a rotary or vertical motion of the switch arms, as required (Fig. 5). After many refinements the system is now economically sound and very reliable. The possible outlets from each switch are arranged in relatively small groups, selected in a straightforward decimal progression as the subscriber sends a succession of electrical impulses from the dial on his telephone.

The Science Museum is indebted to the Post Office for a comprehensive demonstration equipment which has been erected in Gallery XXVI. The following notes are intended to supplement the demonstrations given on this equipment, which can reproduce the various conditions in making a call on the Post Office system. The diagrams illustrate the routing of various types of call.

The times of demonstration in the museum are :—

Weekdays and Saturdays : 11.30 a.m., 3.15 and 4.15 p.m.

Sundays : 3.15 and 4.30 p.m.

No demonstrations are given on Bank Holidays.

THE PROCESS OF MAKING A CALL

GENERAL.

It would be uneconomic to have a complete set of automatic equipment for each subscriber, as that would only be necessary if all the subscribers wanted to participate in a call at the same time.

Each subscriber therefore has the minimum amount of equipment at the exchange necessary to search for unoccupied instruments from the common banks of equipment. This enables a relatively small amount of equipment to be installed for the use of whatever subscribers happen to be trying to make a call at any one time.

If more subscribers than the number of common equipments are calling at the same time, the excess number do not obtain the "dialling tone," or obtain the "busy" tone at some later stage in the process of getting through, and have to wait until some equipments are freed before they can proceed with their call. The number of common equipments provided is such that not more than one call in 500, on the average, is likely to be delayed for this reason.

Subscriber's Equipment.

Telephone and bell set—At subscriber's end.

L and K relays	} At the exchange.
Uniselector	
Meter	

When the subscriber lifts his receiver to make a call the **L relay** completes the battery loop across his line and causes the uniselector to operate.

The **uniselector** (Fig. 2) is a rotary switch with 24 outlets each connected to one of the first common switches at the exchange. If other subscribers are using these switches the uniselector keeps stepping round until it finds a switch which is not being used. It then stops and holds this switch for the use of the caller.

If all the first common switches connected to the uniselector at the exchange are in use the subscriber does not hear the dialling tone, and in these circumstances dialling is useless. He must then wait for the common equipment to be freed by other subscribers before he can make his call. This is done by hanging up the receiver for a short time and then trying to obtain the "dialling tone" again.

UNTIL THE UNISELECTOR FINDS A FREE EQUIPMENT THE DIALLING TONE IS NOT HEARD.

When a free common circuit has been found it is held for the use of the caller by the operation of the **K relay** and the subscriber's loop. The dialling tone is now heard and the caller may proceed to dial the number he requires.

The **meter** records completed calls made by the subscriber and is not operated until the distant subscriber lifts his receiver to answer.

Common Exchange Equipment.

There are far less circuits than subscribers, as explained above, and a subscriber must obtain a free circuit before he can continue with a call.

ON HEARING THE DIALLING TONE THE SUBSCRIBER KNOWS THAT A FREE CIRCUIT IS AVAILABLE AND MAY THEN BEGIN TO DIAL. THE PROCESS OF DIALLING MAY LATER INVOLVE THE USE OF ADDITIONAL APPARATUS WHICH MAY OR MAY NOT BE FREE WHEN REQUIRED.

The Dial.

The dial is a device which sends numbers of electrical impulses into the equipment, the first three trains of impulses selecting the appropriate exchange and the next four selecting the required subscriber's number out of the 10,000—i.e. 0000 to 9999—subscribers who may be connected to that exchange.

Dialling MUS is the same as dialling 687, but it is easier to remember MUSEum 2333 than 687—2333. Electrically, however, there is no difference between the two, MUS being a sequence of 6, 8 and 7 impulses.

When the dialling tone is heard it means that the following operations have taken place :—

1. The uniselectors has found a free switch out of 24 switches known as **1st Code Selectors**, with which it can make connection.
2. The 1st code selector has been held for the later use of the subscriber, provided that a further switch is found to be free.
3. Finding a 1st code selector has caused another switch to be operated. This is similar to the uniselectors and is known as the "**A**" **digit hunter**. It has 24 outlets, each of which may be connected to a switch known as an "**A**" **digit selector**.
4. If one of these "**A**" **digit selectors** is found to be free it is seized for the use of the subscriber and the "dialling tone" is heard.

The reason for obtaining the use of all these switches before beginning to dial will be explained later.

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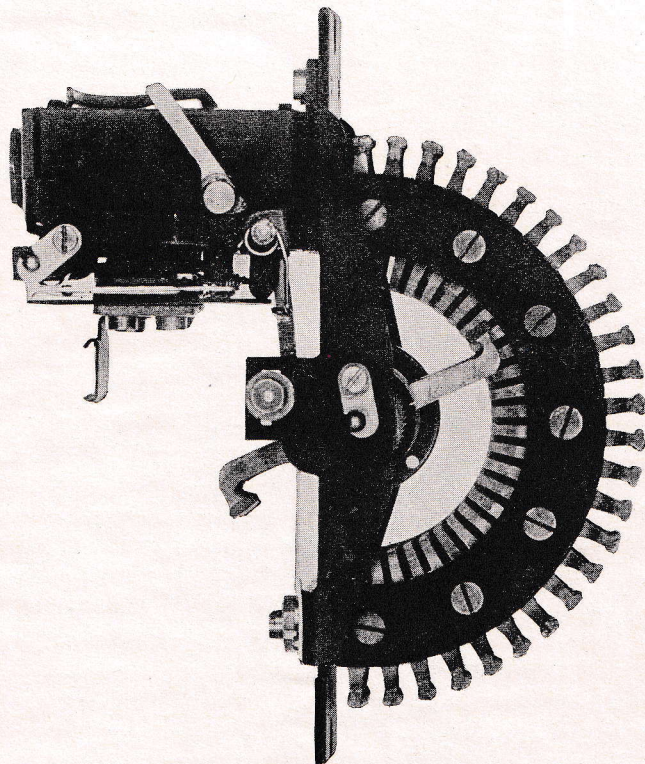


FIG. 2.—Typical Uniselector.

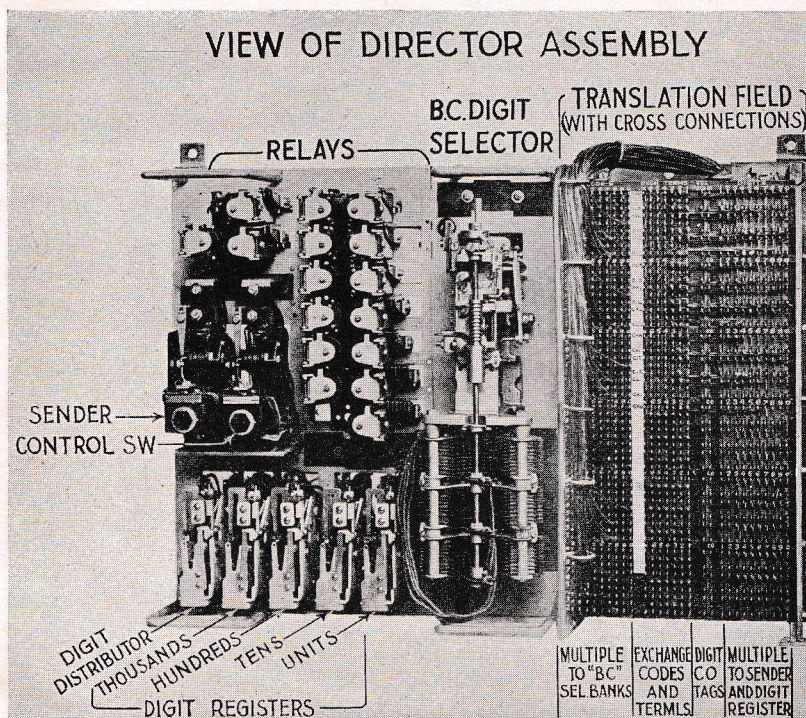


FIG. 3.—Typical Director.

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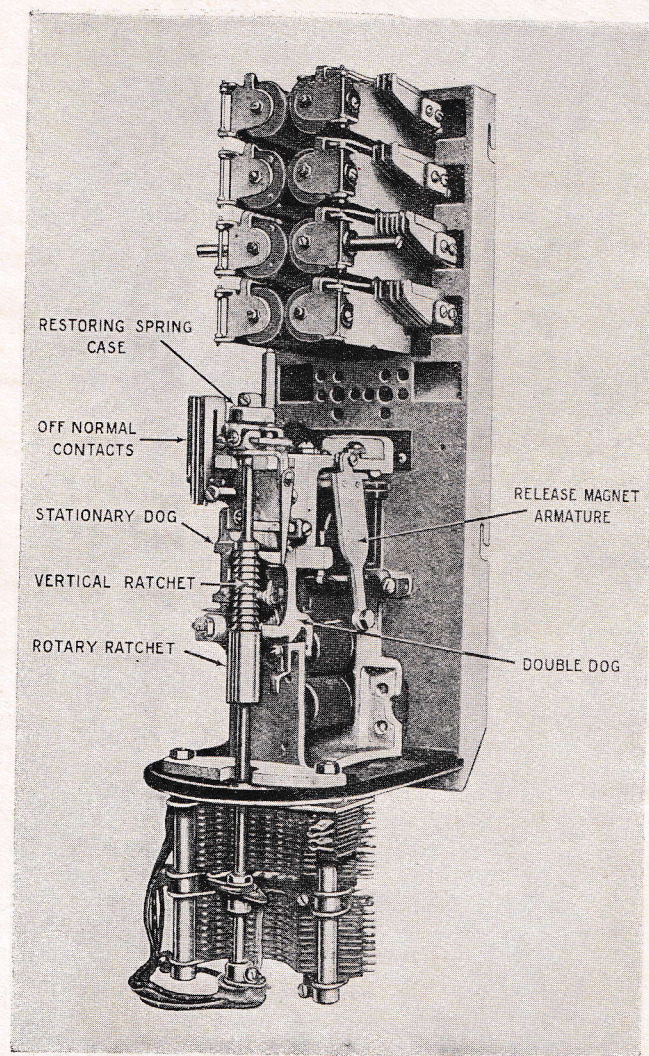


FIG. 4.—Typical Selector.

"A" Digit Selector (see Figs. 4 and 5).

When an "A" digit selector has been found the dialling tone tells the subscriber to begin to dial. If he is wanting, say, MUSEum exchange, he first dials M, thereby sending six impulses through to the "A" digit selector.

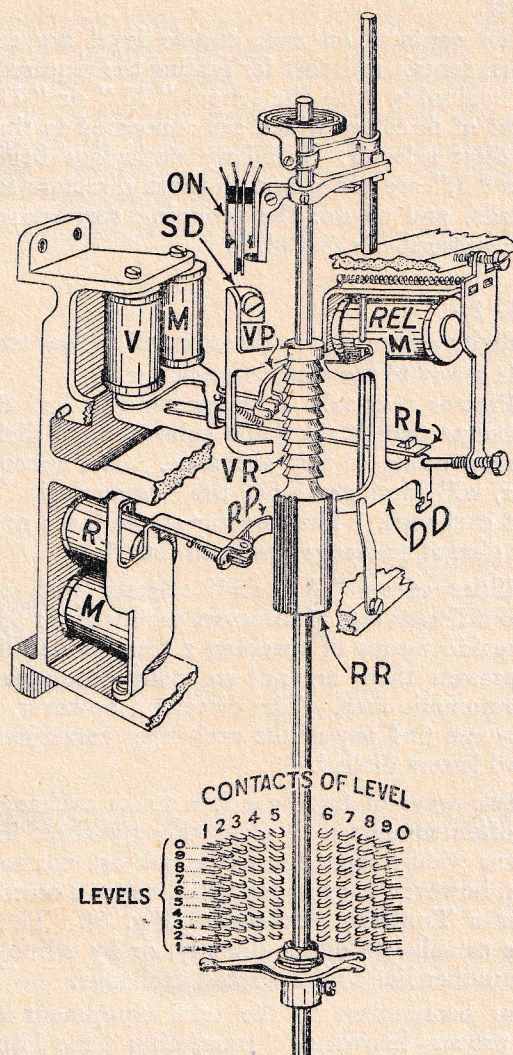


FIG. 5.—Diagram of Selector mechanism.

VM=vertical magnet operating a ratchet and pawl (VR and VP), lifting a shaft carrying the switch wiper.
 RM=rotary magnet operating a second ratchet and pawl (RR and RP) giving a rotary motion to the shaft.
 DD=double dog acting as a detent against gravity for the vertical ratchet during the vertical movement, and against the coiled spring during rotary movement.
 REL M=Release magnet which knocks the double dog out of the ratchets when the call is finished.
 RL=a release link holding the double dog out of engagement when the release magnet operates.
 ON="Off-normal" contact springs closing an electrical circuit on the first vertical movement of the switch and therefore preparing a circuit for operation of the release magnet at the end of a call.

[Extracted from P.O. technical pamphlet E.1.

By means of relays this switch steps up to the 6th level on its bank of contacts and then the switch blade or "wiper" begins to travel round the contacts on this level until it finds a free outlet. If there is no free outlet from the first ten contacts the switch wiper reaches the eleventh contact which causes the "busy tone" to be sent to the caller.

The first ten contacts on each usable level are connected to **Directors** which contain switches for finding the required exchanges. All exchanges beginning with the letters "M" or "N" are connected to the set of directors which are connected to the sixth level on the "A" digit selector. Similarly exchanges beginning with "G," "H," or "I," are connected to those directors to which the fourth level leads, and so on, the grouping corresponding to the lettering on the subscriber's dial plate.

Directors (Fig. 3).

The "A" digit selector finds a director which does two things :—

1. It finds a way to the wanted exchange.
2. The director may take a longer time to find the required exchange than it takes the subscriber to dial the letters corresponding to this exchange. The subscriber, however, will continue to dial the "numericals" required at that exchange. The director stores these numbers until the distant exchange has been found.

The capabilities of an "A" digit selector with eight usable levels leading to different sets of directors each with 81 usable outlets is clearly to provide means of reaching a total of 648 different exchanges. At present there are not so many automatic exchanges in use in any automatic area. The directors, however, are so connected that they can find any of the exchanges corresponding to the second and third letters dialled.

There are two ways of finding a line to an exchange. Nearby exchanges are often connected to each other by direct lines, but for economic reasons widely separated exchanges are not so connected. Every exchange, however, is provided with lines to a central switching point known as a **Tandem exchange** (Fig. 6). Therefore connection may be established either directly, or by a line to Tandem and thence by another line to the wanted exchange.

The director economizes in the total equipment and cabling required by a process known as "translating" the letter impulses received. It receives two trains of "letter" impulses through the "A" digit selector and may send out any number from one to six trains of impulses to find a path to the exchange required. These impulses operate switches known as **code selectors**. Before the director was brought into circuit the subscriber's uniselector had already seized a free **FIRST code selector** for subsequent use, and the director now sends out a train of impulses back into this switch, causing it to step up to an appropriate level.

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First Code Selector.

The "translated" impulses from the director step the switch up to any one of its ten levels, each with ten outlets. If a nearby exchange is being called it may be directly connected to one of these levels and the contact arm searches round for a free line among the ten connected at this level. If it finds one, the director may now proceed to transmit the stored "numericals" to find the wanted subscriber at the exchange to which connection has now been made.

It may be that the wanted exchange is not connected to one of these ten levels, as many more than ten exchanges may have to be linked up. In that case the translation at the director takes the form of two or more trains of impulses.

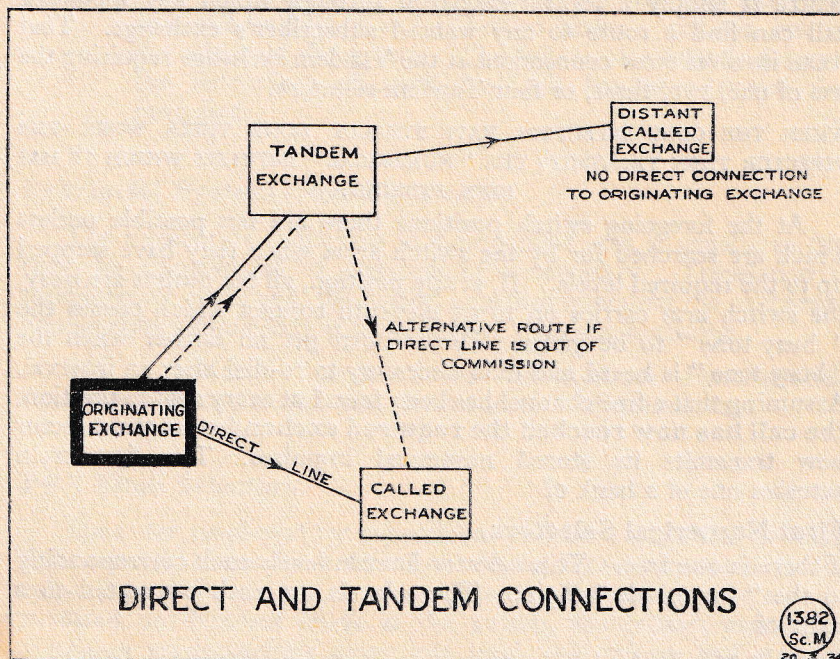


FIG. 6.—Direct and Tandem Connections.

With two trains, the first steps the 1st code selector up to an appropriate level along which the switch arm searches for a free outlet to the

Second Code Selectors,

which also have ten outlets on each of ten levels. The 2nd code selector is operated by the second train of impulses from the director. The wanted exchange may be connected at one of these levels, or a **third code selector** and a third train of impulses from the director may be required.

The 1st code selector has ten levels. 2nd code selectors, each with ten levels, may be connected to each of the ten original levels,

giving 100 connections in all. With a 3rd code selector group at the exchange we may connect to any number from 101 to 1,000 exchanges, depending on the number of 3rd code selectors used.

So far we have only considered a directly connected exchange. If there is no direct connection the call must go through **Tandem**. The translated impulses from the director which refer to exchanges for which there is no direct line, automatically find a level at the code selectors which is connected to the **Tandem** exchange. Succeeding trains of impulses from the director then operate further code selectors (**first, second, third and fourth Tandem selectors**) at the Tandem exchange. These selectors finally find a channel out from the Tandem centre to the wanted exchange. The Tandem centre is simply a central exchange through which any incoming call can find a route to any wanted subscriber's exchange. That route involves cross connections at the Tandem exchange requiring the use of one, two, three, or four Tandem selectors.

WHEN THE CODE SELECTORS HAVE FINALLY DONE THEIR WORK THE DIRECTOR THEN TRANSMITS THE "NUMERICAL" IMPULSES WHICH IT HAS BEEN STORING.

At the foregoing switch positions there are ten possible outlets which are searched for by the switch arms when they have stepped up to the required levels. If, at any position, all ten outlets are busy, the switch arm carries on to an eleventh contact which causes the "busy tone" to be given. The call can get no farther when the "busy tone" is heard and it is necessary to re-dial after an interval. Assuming that a free channel has been found at every switch position, **the call has now reached the required exchange** and the director now transmits its stored numerical impulses. The first train actuates one of a bank of

First Numerical Selectors,

if there is one free. This selector has ten levels each corresponding to the "thousands" digits. These levels are each connected to a bank of

Second Numerical Selectors,

and if one of these is free it operates in accordance with the train of impulses corresponding to the "hundreds" digits. The switch reaches a level which selects a free

Final Selector

which steps up to a level corresponding to the third train of "numerical" impulses corresponding to the "tens" digits, and steps round that level to a position determined by the fourth set of "numerical" impulses corresponding to the "units." The wanted subscriber is connected at this position. When it is reached, a group of relays either give the "busy tone" if the line is engaged, or the "ringing conditions" if the line is free. When the called subscriber answers and lifts his receiver a relay operates the meter at the originating subscriber's exchange equipment.

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ALTERNATIVE LINE-FINDER SYSTEM

Instead of providing a **uniselector** for each subscriber a **line-finder**, consisting of a switch with 200 outlets, each outlet being connected to a subscriber, may be used. Several line-finders are provided for each group of 200 subscribers. Each group is provided with a distributor which finds a free line-finder, if available, for the use of any calling subscriber.

This alternative to providing a uniselector for each subscriber has two advantages :—

1. It is economical.
2. As several line-finders are grouped together the failure of one still enables a subscriber to make a call via one of the others of the group. The failure of a uniselector cuts the subscriber off until the fault has been traced and remedied.

Provincial System (Non-director).

The number of exchanges in a provincial area is usually so few that the employment of directors is unnecessary. Translation is therefore not employed, the dialled impulses operating the exchange-finding selectors directly if there is more than one exchange.

The " provincial " positions on the museum demonstration equipment are fitted with line-finders instead of uniselectors.

PBX Final Selectors.

These are employed for subscribers who have a number of lines. The selector hunts for a free line among those connected to the subscriber. If there are so many lines that they have to be accommodated on different levels at the switch, the contact arm, after searching unsuccessfully along one level, will release and step up to the next level where it will begin to search again. It continues to search until a free line is reached, at which point it stops, or, if all lines are busy it reaches a position from which the " busy tone " is obtained.

Amount of Apparatus Required.

In making a call the " A " digit selectors and directors are held only until the final selector has reached the wanted subscriber's line. They are then released for the use of other subscribers.

All other apparatus used in obtaining a line between the originating and called subscriber is held until the call has been completed. More of this apparatus is thus required.

The amount of apparatus installed in a typical London exchange in a part central, part suburban area is :—

Uniselectors —	—	—	6,500	one to each subscriber.
" A " digit selectors	—	—	100	
Directors —	—	—	129	Extra directors installed
1st code selectors —	—	—	693	at particularly busy
2nd code selectors —	—	—	483	levels.
3rd code selectors —	—	—	63	
1st numerical selectors	—	—	816	
2nd numerical selectors	—	—	1,100	
Final selectors	—	—	1,078	

SPECIAL CONDITIONS

(1) **Premature Dialling.**—The subscriber should not dial before dialling tone is heard, i.e. when the " A " digit hunter has seized a free " A " digit selector. Should the subscriber dial while the hunter is hunting—Number Unobtainable (N.U.) tone will be transmitted to the caller.

(2) **Delayed or Incomplete Dialling.**—A period of between 30–60 seconds is allowed for dialling. The " A " digit selector having been seized, the subscriber should dial within the specified period of 30–60 seconds. If he fails to dial within this period, a special " time pulse " circuit is put in operation which alters the conditions of the lines and N.U. tone is transmitted to the calling subscriber. The " A " digit selector is then released for the use of any other calling subscriber.

(3) **Directors. Forced Release.**—When the director is seized, the time pulse circuit is prepared. Should the subscriber delay (which includes very slow dialling, and not completing the operations in the time specified), the time pulse relay will operate, disconnecting the pulsing out loop and so cause N.U. tone to be transmitted to the calling subscriber. This is a similar case to (2) above, but applies only after the " A " digit selector has found a free director.

(4) **Spare Codes.**—Should the second and third digits received from the subscriber not correspond to an exchange code, then no translation will be wired up. The sender switch will continue to step until a position is reached that causes a relay to operate, the contacts of which cause N.U. tone to be sent to the caller. The director and " A " digit selector is released. That is, all unoccupied levels at the director are wired up to give the N.U. tone if reached.

(5) **Director with Manual Board Facilities.**—Should the subscriber dial " O," the lines from the " A " digit selector are reversed and so cause a special " D " relay in the director to function. The connecting wires are joined to special manual board terminals on the translation board. According to the routing necessary, the director can now send out any number of trains of impulses from 1 to 3 to connect the call through to a manual switchboard.

a typical London exchange

one to each subscriber.

Extra directors installed
at particularly busy
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(6) **Code Only Calls.**—For trunks, tolls, telegrams, etc., the connections are similar to the "O" call except that relay "D" is not used. The wipers of the "A" digit selector, and the B.C. switch of the director are standing on their bank contacts according to the dialled impulses sent out by the subscriber. The contacts of the B.C. switch, on which the wipers are standing, are brought on to the translation field, and as no numerical digits are received the circuits are arranged so that after the translated code is transmitted, the homing of the sender and control switches is carried out, and the director and "A" digit selector released.

(7) **Metering.**—The 1st code selectors are equipped with what is known as a "vertical marking bank" traversed by an auxiliary contact as the switch steps up. The code selector is wired so that exchanges to which the tariff is a double call are connected at a level which ensures a double metering pulse to be sent via the circuits connected to the marking bank. Similarly a triple tariff call would be routed through a level which would make the subscriber's meter operate three times.

On the demonstration equipment.

MUSEum to MUSEum meters once.

MUSEum to EAST meters three times.

MUSEum to WEST meters twice.

(8) **Dialling too quickly.**—If the dial plate is pulled back instead of being allowed to return at its own speed, the correct number of impulses is still obtained, but usually at a speed faster than the relays can respond. The response of the relays may therefore be erratic and a wrong number or an unobtainable level will be reached by the switches in trying to follow the impulses received.

