RAILWAY TELEPHONES

By S. FLINT

WHILE to some extent the communication requirements of railway companies are met by telegraph and telephone systems generally similar in principle to those employed in the public service, the special nature of problems which may concern, for example, the control of traffic in densely populated areas or over distances of hundreds of miles has necessitated the development of systems providing facilities not demanded elsewhere. Railways were amongst the first commercial undertakings to make extensive use of the telephone, and their progress in this respect has been no less marked than in others. Every opportunity has been seized to make the fullest possible use of invention in the world of communication engineering, and the equipment employed to-day bears witness to the skill of the telephone engineer in meeting a diversity of unusual requirements.

The Handling of Railway Traffic requires Special Telephone Systems

It is convenient to classify railway telephones under two headings : (1) those employed for general commercial purposes, and (2) those used chiefly by the operating staff. Of the former almost every known type will be found in service, the range embracing small "domestic" telephones, push-button intercommunication sets, and magneto, central battery and automatic instruments. The design and operation of all these are referred to in other sections of this work, and we may therefore pass at once to the types specially evolved for railway service ; namely, telephones providing facilities whereby the movements of trains and the general handling of traffic may be effectively controlled.

How Communication between Distant Stations is achieved - Omnibus Circuits

In the provision of a railway intercommunication system the problems introduced are unusual, chiefly by reason of the respective positions of the various points to be served. Whereas a public telephone network is built up of a number of exchanges or switching centres with individual lines radiating from each exchange to the local subscribers, a railway system must provide for the interconnection of stations, signal cabins, etc., situated at intervals along the track. For obvious reasons the erection of switching equipment at certain points and the connection of each station and signal cabin by an independent line would be too costly. We therefore find that the principle of party line working is adopted, the lines being commonly termed "omnibus" circuits.

Operation of Omnibus Circuits

For communication between a limited number of points not widely separated the ordinary magneto telephone may be employed, and several such instruments bridged across a common pair of line wires. The use of a ringing code then permits each station to call any of the others. Again, battery ringing sets may be used, in which case a high resistance relay is usually inserted in each instrument and the local calling bell operated from its contacts. Code ringing systems of this kind are extensively applied to serve groups of points, such as station offices, staff quarters, signal cabins, platforms, goods sidings, etc.

Using Omnibus Circuits for Traffic Control Purposes

A step further is reached when we consider the control of the operating staff and the provision of means whereby immediate connection may be established between a central control office and every point on the railway system within an area embracing both main and branch lines and extending over hundreds of square miles. Comparatively simple and inexpensive methods have been devised, the most common consisting of the extension of the omnibus cir-

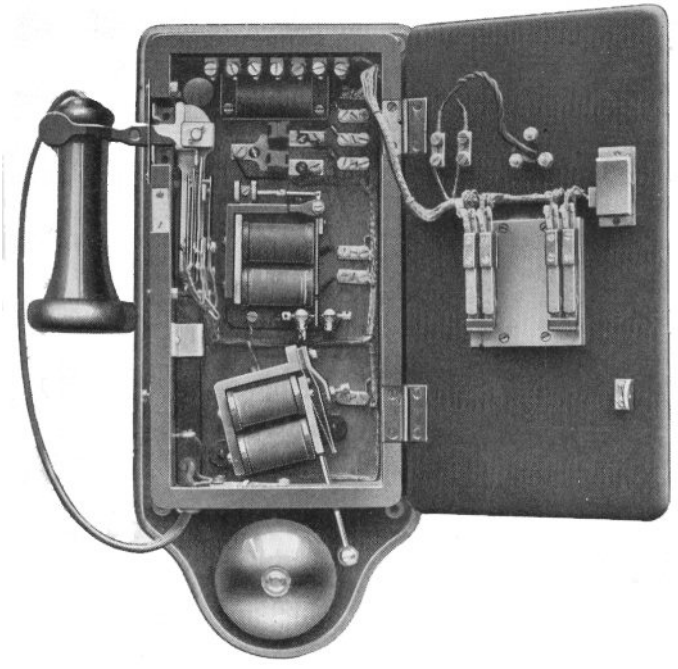

Fig 1. - WAYSTATION TELEPHONE FOR OMNIBUS CIRCUIT TERMINATED AT A CONTROL OFFICE
Telephone shown open for inspection. In this type, carbon lightning arresters are included and a lock is provided to rpevent interference by unauthorised persons. (G.E.C.)

cuits to the central point and their termination on one or more operating positions, built in the form of desks, from which " controllers " may supervise the movement of any or all classes of traffic.

This further use of the omnibus circuits for control purposes is very economical in that the expense of erecting additional line wires is avoided. It would be impracticable, however, to employ calling bells in the control office, particularly where large numbers of circuits are concentrated, and it is therefore usual for the lines to be terminated on visual or lamp indicators on each controller's desk. Such devices do not satisfactorily indicate codes as normally employed for interstation calling, and it will thus be seen that a means must be provided at each way-station for operating the control indicator, and only when attention of the controller is required.

For this purpose reverse battery calling is adopted, each waystation telephone being equipped with an additional ringing key for signalling to the control office. A typical instrument of this type is shown in Figs. 1 and 2.

Fig. 2 - WAY-STATION TELEPHONE FOR OMNIBUS CIRCUIT TERMINATER AT A CONTROL OFFICE
The calling code and full operating instructions are added on a printed card beneath the two keys. (G.E.C.)

The Dual Purpose Telephone

From the circuit diagram in Fig. 3 it will be seen that

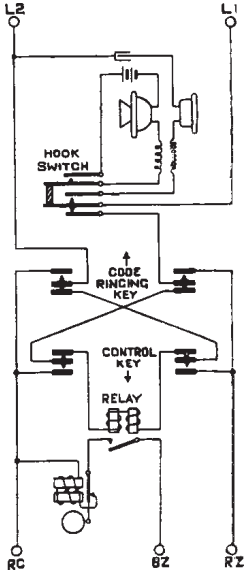

Fig. 3 (right) - CIRCUIT DIAGRAM OF WAY-STATION TELEPHONE

when the "code" ringing key is depressed positive battery is applied to Line 2 and negative to Line 1. The bells in all other way-station instruments will be operated, and, according to the code transmitted, only the wanted station will answer. If the "control" key be depressed the polarity of the ringing battery applied to the line will be reversed. At the control office a polarised relay is bridged across the line and is so connected that it will respond only to positive battery on Line 1 and negative on Line 2. This relay in turn operates the calling lamp or indicator on the controller's desk. At the control office, therefore, signals are received only when the appropriate way-station key is depressed.

When ringing current is applied to the line at the control office or any other waystation the high resistance relay shown will close the contacts of the local bell circuit. Irrespective of the nature of a call from a way-station, i.e., whenever either the "code" or "control" key is depressed, the bells will be operated at all other stations unless the relay in each instrument is polarised. It is therefore common practice to equip all sets on the circuit with polarised relays if a large number of calls is made from the waystations to control. If this were not done every telephone bell would be operated for each control call made, causing unnecessary noise and a waste of local battery current.

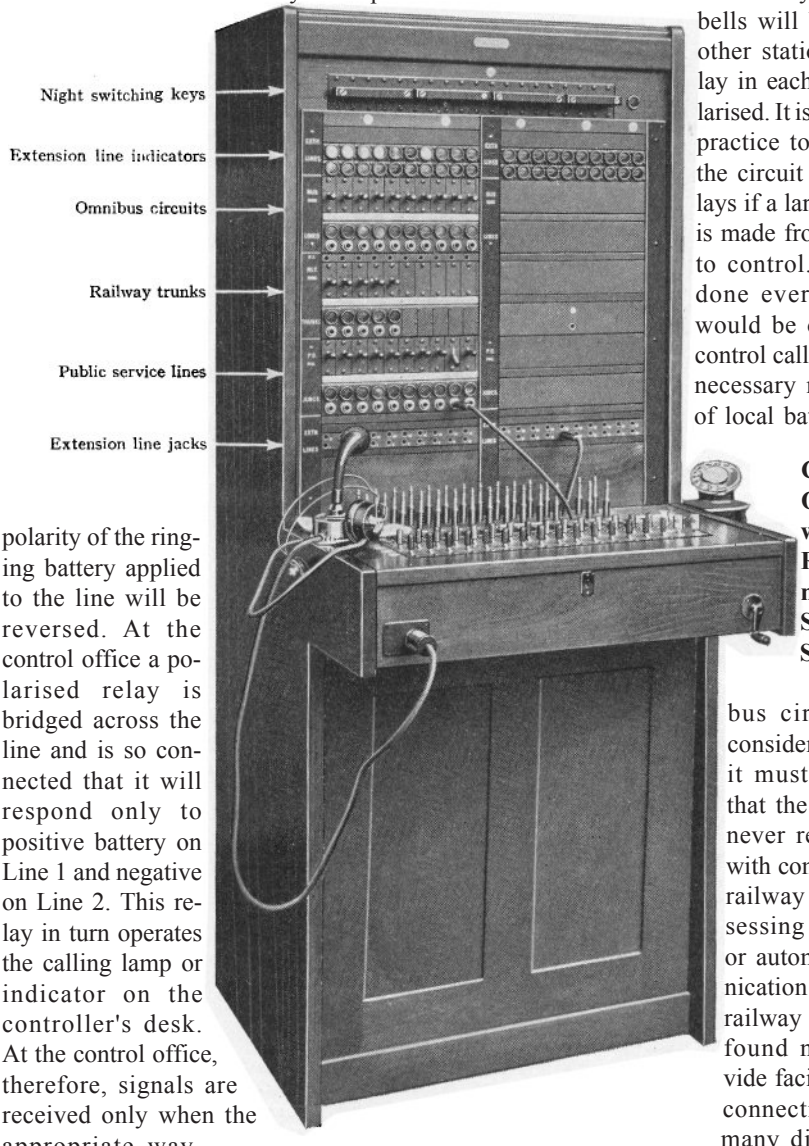

Fig 4. - TYPICAL C.B. SWITCHBOARD FOR RAILWAY SERVICE, EMPLOYING PROTECTED DISC INDICATORS
Capacity is provided for the addition of further circuits when required.

Connecting Omnibus Circuits with Ordinary Railway Intercommunication Systems - Railway Switchboards

Although omnibus circuits have been considered independently, it must not be assumed that the points they serve never require connection with commercial and other railway departments possessing ordinary manual or automatic intercommunication systems. At large railway centres it is often found necessary to provide facilities for the interconnection of circuits of many different classes, a requirement which is only satisfied by the use of entirely special types of switchboards. Such manually operated boards are

generally unique in that they are designed to meet specific local conditions, and it is safe to assume that there are no two alike. For the purpose of illustration, however, a typical example is shown in Fig. 4.

Typical Equipment

This switchboard clearly indicates the variety of lines which may be concentrated at one switching point. It is of the central battery type, employing visual disc indicators throughout, and is equipped for:

40 C.B. extensions (local office lines).
10 junctions to a public automatic exchange.
10 Railway omnibus lines.
5 Railway trunks.

Owing to the miscellaneous nature and additional quantity of apparatus necessary for a switchboard of this kind it is not possible to mount all components at the rear as in the case of an ordinary private branch exchange. Provision is therefore made for certain relays, coils, etc., to be assembled on an auxiliary rack which may be erected nearby and connected to the board by multiple cable. The apparatus rack associated with the board described is shown in Fig. 5. On this also are terminated the incoming lines via the usual protective devices.

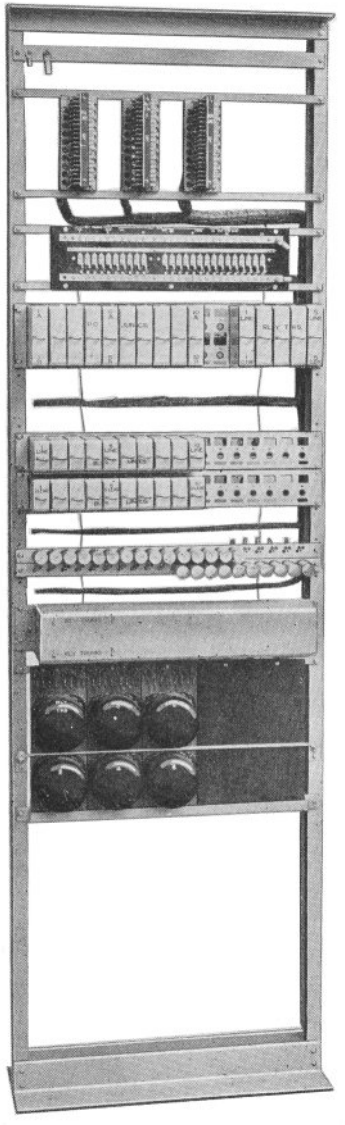

Fig 5. - APPARATUS RACK FOR SWITCHBOARD IN FIG 4.
This may be erected either in the operating room or some distance away, connection with the switchboard being effected by mutliple cable.

The Circuits and their Operation

With regard to the method of terminating various lines and the operating procedure when dealing with calls over the different circuits, we can again refer to Fig. 4. The extension line jacks will be seen at the bottom of the two panels, the associated indicators appearing at the top. These standard C.B. extension circuits operate in the regular manner, and supervision is given by disc indicators mounted in the face of the keyboard. The next group of apparatus consists of ten jacks, indicators and keys for lines to the public automatic exchange. Here it becomes necessary, when the operator wishes to call a public service subscriber, to insert in the circuit the dial seen on the right. This is effected by depressing the key associated with the line taken into use, the key being restored after the required number has been dialled. A typical connection is shown, by the two cords and plugs in use, between a local extension and a public subscriber, the dialling key being depressed ready for the operator to dial the wanted party.

In the middle of the left-hand panel are terminated five railway trunks, special long distance lines employed for the direct connection of important centres. Here again a key is associated with each indicator and jack, but in this case for ap-

plying ringing current to the line, the nature of the trunk termination not permitting the use of A.C. ringing from the cord circuits. Above these keys is an auxiliary strip of jacks whereby at night the trunks may be left plugged through to other circuits and the corresponding switchboard calling apparatus entirely disconnected. The usual night switching keys in the cord circuits appear at the top of the board.

The remaining lines, each with indicator, jack and ringing key, are omnibus circuits of the type already described. Details of their termination on the switchboard are shown in Fig. 6.

Calls over Omnibus Circuits

The line relay is of the polarised type which operates only when the appropriate key at a way-station instrument (Figs. 1-3) is depressed. Thus, when a call to the exchange is made, the line relay is momentarily energised and, at its contacts, completes the indicator cir cuit. This impulse of current through the indicator coil results in the release of the disc signal, which then remains displayed to the switchboard operator. When an answering plug is inserted into the line jack the indicator disc is automatically restored (such indicators being known as the "plug-restored" type) and the speech circuit between way-station and operator is complete. A "hold" coil is bridged across the line to give the same condition for supervision as when a call is made from a C.B. extension telephone. Condensers prevent the flow of exchange battery current (fed from the cord circuit) over the omnibus line.

After the desired switchboard connection has been established and the conversation ends, the key at the waystation telephone is again depressed to give a clearing signal to the operator. The polarised line relay operates, but now, since the answering plug still remains in the jack, the line relay contacts complete the circuit of the "clear" relay. The latter is energised, and in turn removes the "hold" bridge, thus giving a clearing signal in the appropriate cord circuit. The "clear" relay at the same time connects its own winding to earth via the tip spring of the line jack and the cord circuit. It therefore remains operated and maintains the clearing condition until the plug is removed from the jack.

To call a way-station on an omnibus circuit the operator first plugs into the corresponding line jack to ascertain if any other call is in progress (between two waystations). If the circuit is free the appropriate code is transmitted by means of the ringing key, so calling the wanted station. The clearing down of the connection is effected as before.

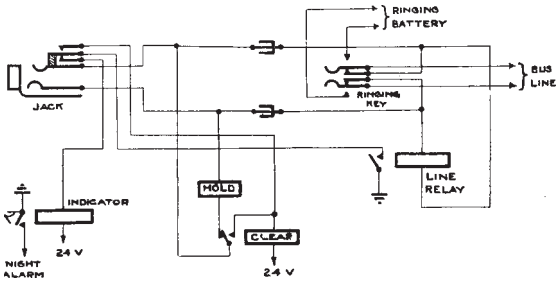

Fig 6 - TERMINATION OF A RAILWAY OMNIBUS CIRCUIT AT A C.B. SWITCHBOARD EMPLOYING PLUG-RESTORED DISC INDICATORS (24 VOLT SYSTEM)

Other Types of Switchboards

The design of a railway switchboard at which different types of circuits are concentrated depends chiefly on the system employed for the interconnection of the local extensions. In some cases local magneto systems are used, the switching equipment then being somewhat simpler. Again, if central battery working is favoured, the calling devices may consist of lamp signals in place of the visual indicators shown in Fig. 4.

A two-position C.B. lamp signalling switchboard for railway service is illustrated in Fig. 7, apparatus being provided here for 60 extensions, 10 public automatic exchange lines, 10 railway trunks, and omnibus circuits. Capacity for the future addition of new circuits is given

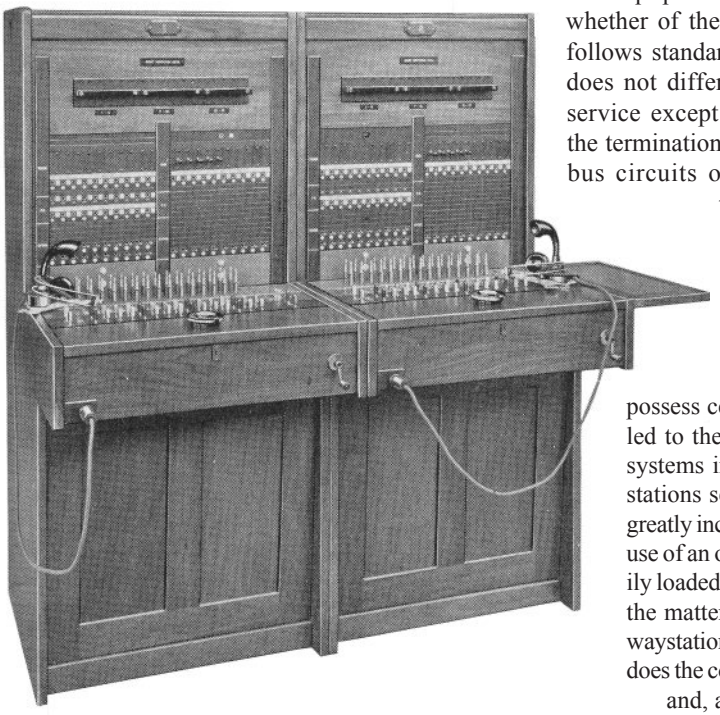

Fig 7 - TWO-POSITION RAILWAY SWITCHBOARD OF THE C.B. LAMP SIGNALLING TYPE
This type gives the greatest possible uniformity in face equipment for extension lines, railway trunks, omnibus circuits and junctions to the public automatic system

by the spaces covered by blank strips (or dummies). It will be seen that while the extension lines are distributed - thirty per position - the other lines appear on both positions, so as to give each operator direct access. On this account an extra strip of lamps is associated on each position with the public exchange lines in order to give "visual engaged" indication. A "visual engaged" lamp on position 2 glows for each circuit taken into use on position 1, and vice versa.

While only two typical small manually operated switchboards have been illustrated, it will be understood that at very large railway centres the local telephone system only may be required to serve up to a thousand lines or more. The equipment employed in such cases, whether of the manual or automatic type, follows standard practice, and, in general, does not differ from that used for public service except in the provision made for the termination of railway trunk and omnibus circuits on special operators' positions.

Control Lines with Selective Ringing

While omnibus circuits as described are widely employed in many areas, they possess certain limitations which have led to the development of still further systems in which the number of waystations served by one pair of wires is greatly increased. Difficulties arise in the use of an ordinary omnibus circuit heavily loaded with telephones, parcularly in the matter of codes. As the number of waystations increases the more involved does the code become. Traffic is heavier, and, as a result, the bells at all stations are ringing almost continually. In a number of areas selective ringing systems are therefore employed, specially designed for serving large groups of waystations by one common two-wire circuit. Such installations are used almost exclusively for control purposes, and on this account do not ordinarily provide facilities for inter-station calling.

In the latest system to be adopted the selection and calling of a way-station from the control office is effected by an ordinary automatic telephone dial. At each station a selector responds to impulses transmitted from the dial, and in this way a method is obtained whereby the bell is rung at the wanted station only.

Reverse Current Impulsing

In automatic telephony signalling is accomplished merely by interrupting the line current. This is efficient if the line resistances and capacities are of reasonably low values, but cannot satisfactorily be employed for railway control circuits which may extend over fifty miles or more and serve in some

cases up to ninety points. Selection is therefore obtained by reverse current impulsing, in which each impulse is represented by a reversal of the direction of the normal line current instead of by the usual break. This system of impulsing practically overcomes all troubles liable to be caused by wire-to-wire capacity.

Station Selection

It will be seen in Fig. 8 that the line at the control office is connected directly to the operator's telephone. When the dial finger-plate is rotated in a clockwise direction (preparatory to its release and the actual impulsing), contacts A are operated, automatically locked, and the line battery placed across the line. The dial impulse springs control a relay which, at contacts B, connects the line battery in a direction depending upon whether the relay is operated or released. Thus, when the dial finger-plate is released, the current flowing over the line is reversed a number of times according to the digit dialled.

The telephone at each way-station (Figs. 9 and 10) contains a polarised relay which operates to the current received before impulsing commences and releases at each reversal. This relay in turn controls the stepping of a rotary selector of the type shown in Fig. 11 (a local battery being employed with each instrument for operating the selector and associated relays).

Each station is allotted a two-digit number and is made to respond to this number only by the setting of strap connections inside the instrument. Thus, in calling Station No. 73, the digit 7 will first be dialled, but, although all selectors will be stepped to position 7, at only those stations having 7 as the first digit of their number will .a discriminating relay be locked and the instrument prepared to respond to the second digit. When this is dialled - in this case 3 - all selectors will step to position 3, but only at Station No. 73, where the discriminating relay is operated, will the strap connections be such that the call bell is rung. The bell will continue to ring, and superimposes on the line a tone generated by the vibration of the armature. This is fed to the controller's telephone, and ceases only when the way-station receiver is lifted and the bell disconnected. The speech circuit is then completed by the controller depressing a key to operate contacts A and remove battery from the line. The selectors at all stations are thereupon restored to normal.

Common Calls

For the transmission of time signals and general and emergency instructions to all way-stations a special number is dialled which causes all bells to ring simultaneously. Ringing tone is fed to the line from every instrument, so that when the tone received by the controller finally ceases he is aware that all way-stations have answered and are listening. This feature is sometimes termed an automatic roll call.

Control Office Equipment

When one circuit demands the continuous attention of a controller, and when, in such circumstances, his telephone is always across the line, calling facilities at the way-stations are unnecessary. If, how-

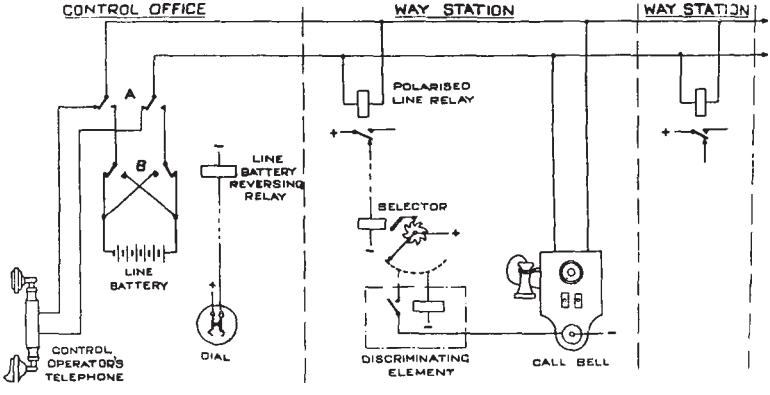

Fig 8. - Simplified Circuit Diagram Illustrating the Method of Calling a Way-Station in a Selective Ringing Traffic Control System

Any number of stations up to a total of ninety may be servied by the same pair of line wires. While such systems are normally employed for communication with the control office only, facilities for inter-station calling may be given by providing dials also at the way-stations.

line and operates a polarised relay to give a calling signal at the control point. Here the equipment may consist of special desks fitted with lamps, keys and telephones, the vertical face of the desks bearing a map of the railway network under control. For the termination of a single selective ringing circuit a more simple arrangement is used.

Connection to Omnibus Lines

The points served by a main railway control circuit do not always include stations on branch or spur lines with which communication is not often required. The selective ringing system therefore provides facilities whereby the control operator may automatically effect the connection of the main circuit with a distant omnibus circuit ordinarily giving intercommunication between local points only on a branch line. For this purpose a code ringing repeater is installed at the most convenient way-station where the two circuits meet. This may be many miles from the control office.

Fig 9. - COMPLETE WAY-STATION TELEPHONE Incorporating Selector Unit
In addition to the key provided for calling the control office, an auxiliary "speak" key is fitted whereby the transmitter may be disconnected and reception improved over exceptionally long lines.

ever, several lines are terminated at the control office, or the amount of traffic does not warrant the full time services of a controller, each way - station is equipped with a calling key. The depression of this key applies battery to the

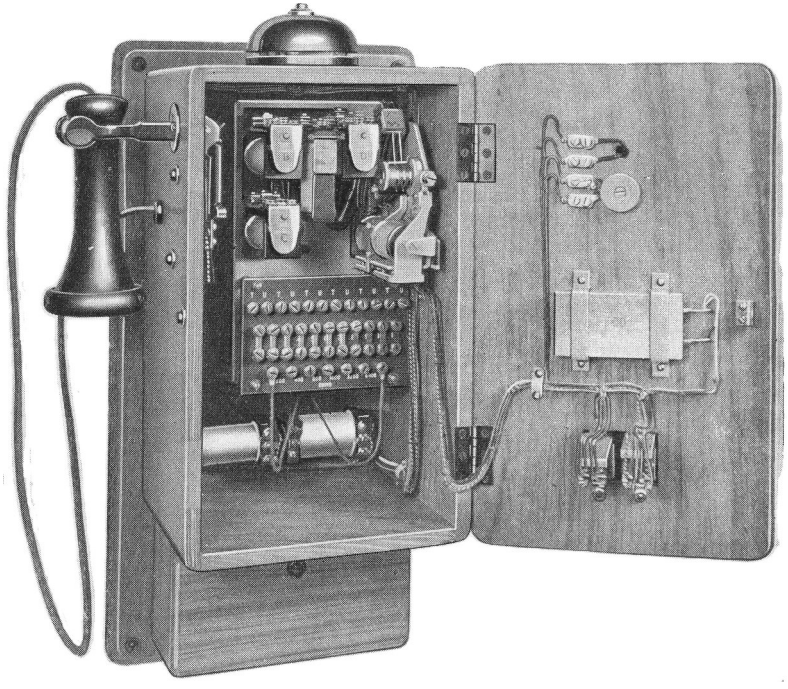

Fig 10 - WAY-STATION TELEPHONE
On the numbering panel will be seen the strap connectors for making the instrument respond only to its particular two-digit number

The repeater consists of a small group of relays which firstly effect the connection of the two lines when a predetermined number is dialled from the control office. The next operation - the transmission of a signalling code over the omnibus circuit-is carried out in an ingenious manner. The only calling device at the service of the controller is the dial used for station selection on the main circuit, while the code to be sent over the omnibus circuit must consist of a particular combination of "long" and "short" signals for calling the attention of the wanted waystation. The repeater is therefore arranged to apply battery to the omnibus line according to the number and length of the subsequent trains of impulses transmitted from the control office. The speed of the dial being ten impulses per second, the sending of the digit "0" will cause the repeater to apply battery to the omnibus circuit for a period of one second. Similarly a "short" signal (approximately one-third of a second) will be applied when the digit "3" is dialled. Thus, by dialling a combination of digits "0" and "3" the repeater is caused to transmit the way-station code over the local line.

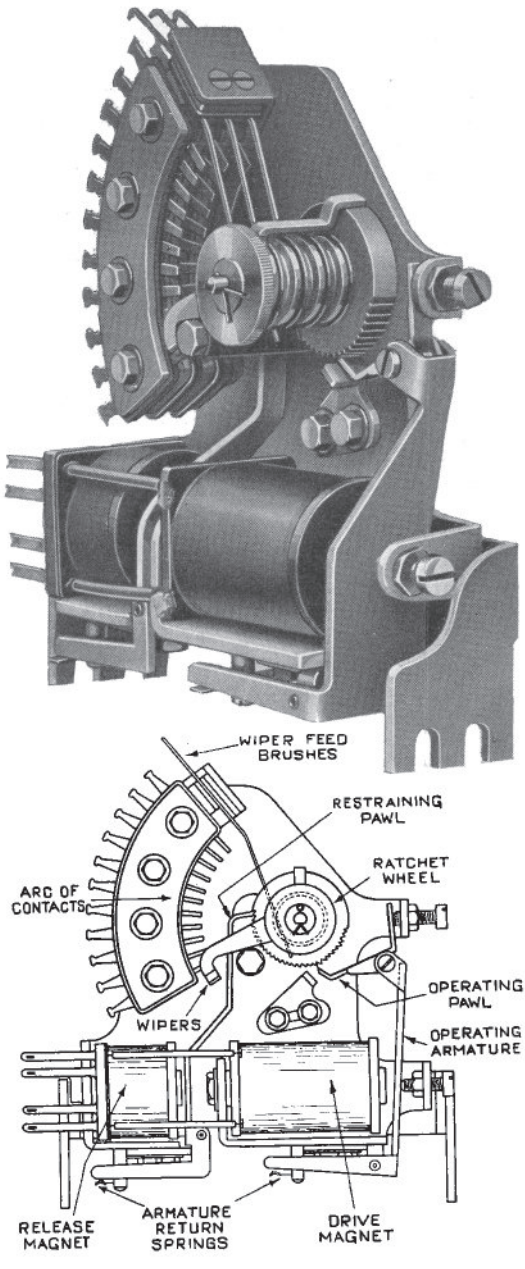

Fig 11. - WAY-STATION SELECTOR

The arc of contacts is swept by a set of "wipers" operated by a ratchet wheel and pawl. Each impulse of current applied to the drive results in one step by the wipers. The restraining pawl is pulled out of enggagement when the release magnet is erengised. A return spring is would up as the wipers advance and, when the restraining pawl is withdrawn, returns to normal

At the end of the call the omnibus circuit is disconnected at the repeater by the dialling of a further predetermined number. The complete control code of a particularway-station on a distant omnibus line, whose local calling signal is "long-short-long", would therefore consist of three parts, such as 59-030-5, where 59 is the coupling code, 030 the station-ringing code, and 5 the uncoupling digit.

The connection of the two lines at the repeater may also be effected from any way-station on the omnibus circuit, an auxiliary control key being provided on each instrument for this purpose.

We are indebted t o Messrs. The General Electric Co. Ltd. for supplying many of the illustrations in this article.