A Traffic Control Party Line Telephone System with Selective Calling by Dial.

ONE of the more vital and arduous services which the telephone has been called upon to perform is in connection with the control of railway traffic where it forms the means of communication between the controller and the many signal boxes and other points through which his orders are made effective. This service is especially vital in that the whole movements of trains within the area served are dependent upon the rapid transmission of orders to the way stations and the accurate receipt of information at the control office. It is especially arduous because of the long distances to be conversed over, and the large number of stations worked on one pair of lines.

The actual routine of the working of traffic control systems varies considerably with different Railway Companies, and no attempt will be made here to describe the methods employed. It will be sufficient to mention that as trains pass over the section of line under their control, the signalmen must give information as to their movements to the control office which is usually situated at the approximate geographical centre of the system. By means of this information the controller is able to keep up to date some form of log, chart or visible indicator which thus forms a record of train movements. At the way stations instructions are received from the controller, who is responsible for the smooth running of the system as a whole.

As the points with which communication has to be established are located at intervals along the railway line, and as the distance to the most remote may be considerable, it is not economically possible to run more than one pair of wires along each section for control purposes. The telephone system therefore becomes in effect a group of very large "party lines," each having perhaps fifty stations bridged across a line sixty miles or more in length, the conductors being usually of overhead copper wire varying between 150 lbs. and 250 lbs. per mile.

In the ordinary public telephone system party lines are generally worked on the "code call" principle, a bell being connected directly across the lines at each station. To call any party a code of short and long rings is transmitted to all the bells and is answered only from that station which has been allocated the particular code transmitted. This method is not applicable to the type of system under consideration owing to (1) the impossibility of devising a code of reasonable length and clarity for each of fifty stations or more, (2) the length of time required to send out a long code when time may be a vital factor, (3) the difficulty of manipulating the means for transmitting the code, and (4) the unnecessary ringing of bells at unwanted stations.

From the above a list of the chief requirements of a train control system may be drawn up.

(1) Clear transmission and reception of speech.

(2) A means of calling which shall be simple to use and rapid in operation.

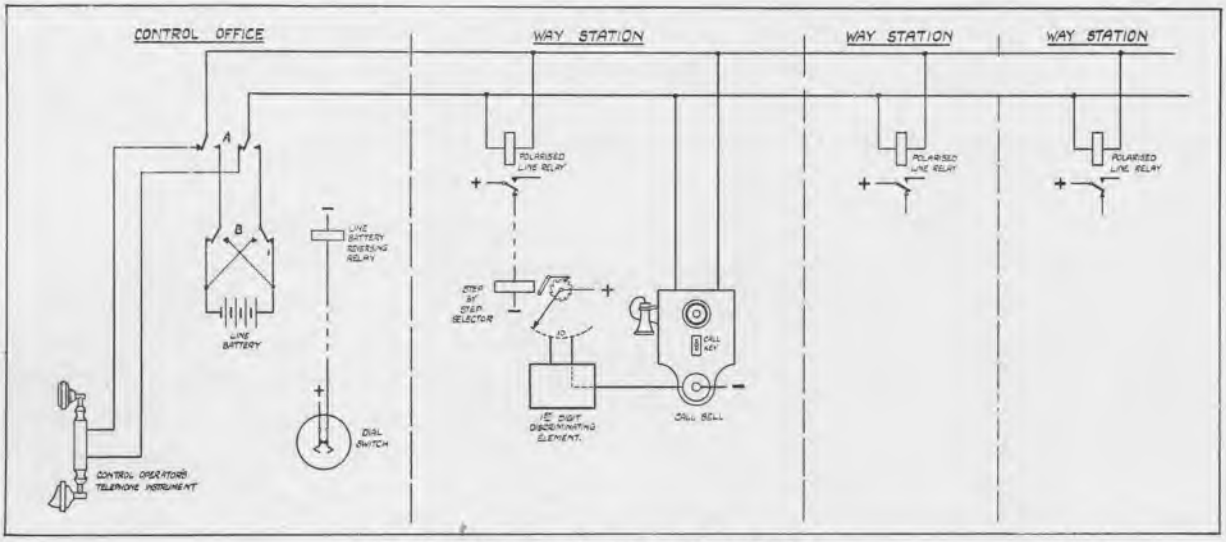

Fig. 1.—Diagram to illustrate method of selection.

(3) The bell to ring at the wanted station only.

(4) The apparatus employed throughout must be sturdy and reliable.

In the G.E.C. Selective Ringing System which it is now proposed to describe, these requirements are met in the following manner :—

(1) Special transmitting and receiving circuits and apparatus have been designed to give clear speech over long lines.

(2) The means provided for calling consists of a dial switch as used in public automatic telephone service. This device is convenient and rapid in operation. It has a further advantage in that it occupies a very small space on the controller's desk, thus allowing greater freedom in the disposition of log sheets, charts and other indicators.

(3) At each station a selector is provided which responds to impulses transmitted over the line wires by the manipulation of the dial at the control office. Only if this selector is set in the position peculiar to the station at which it is located is the call bell at that station rung.

(4) The apparatus consists of relays and rotary selectors of the types used in automatic telephone systems where their reliability has been proved in public service.

It has been mentioned above that impulses are transmitted over the line wires to position selectors at all stations. As the accuracy of calling depends upon the accuracy of the transmission and reception of these impulses special measures are taken to ensure satisfactory impulsing over the exceptionally long lines peculiar to train control systems. In automatic telephony signalling is accomplished by means of interruptions in the line current. This method is simple and efficient if the line resistances and capacities are of reasonably low values, but is unsuitable where high resistances and capacities are encountered. The principle of reverse current impulsing is therefore employed.

A simplified diagram to show the method of selection is given in Fig. 1 In the normal condition the lines at the control office are connected directly to the operator's telephone and also to a local lamp indicator circuit which enables the way stations to signal the controller when he is not listening on the line. When the dial finger plate is rotated in a clockwise direction (preparatory to release on reaching the finger stop), contacts A are operated and automatically locked so that the line battery is placed across the line. Through its impulse springs the dial also controls a relay having contacts B which connect the line battery in a direction depending on whether this relay is operated or released. Thus when the dial finger plate is released the direct current flowing in the line is interrupted and reversed a number of times according to the digit dialled.

At each way station there is bridged across the lines a polarised relay which operates to the current received before impulsing commences and releases at each reversal, i.e., when the dial impulse springs open. The contacts of this relay therefore reproduce the functioning of the operator's dial.

The impulses are received at all way stations and control the stepping of a rotary selector of the type illustrated in Fig. 2. This selector is capable of being set in any one of ten positions, but as the number of stations on a line greatly exceeds this figure, it becomes necessary to transmit two trains of impulses to obtain selection over the desired range. The stations are accordingly considered in groups, the first or "tens" digit selecting the particular group required, and the second or "units" digit the particular station in that group. Actually there may be ten groups of nine stations each, the system having a capacity of ninety stations on one line.

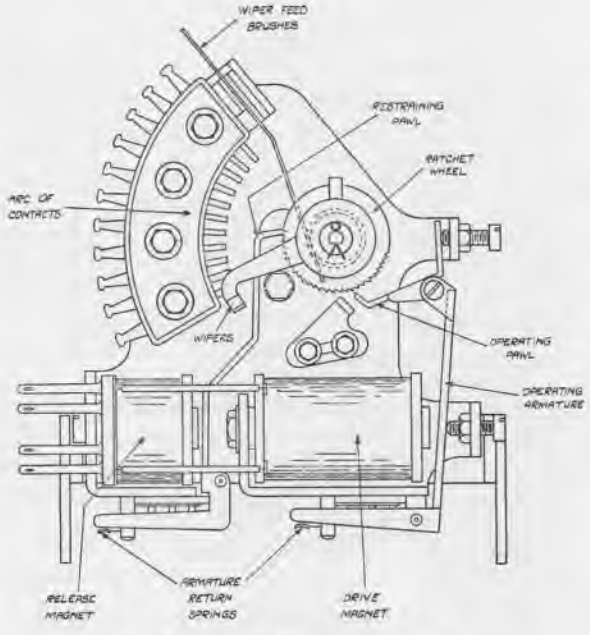

Fig. 2.—Rotary step-by-step selector.

In calling the station numbered 73, for example, the controller will first dial the digit 7 and the selectors at all stations will be stepped up to their seventh position. At all stations having 7 as the first digit of their characteristic number the reception of this digit prepares the local circuit for further discrimination on the second digit. All other stations remain unprepared for this discrimination.

The controller now dials the second digit ; in this case 3. This is again received at all stations but is only effective to cause further discrimination at those which were prepared by the first digit 7 The number of such stations is limited to nine and thus the second digit is able to select the particular one required in that group. In this case the station having 3 as its second digit will be selected. At this station only will the circuit conditions

be such that the call bell rings. The bell will continue to ring until either the telephone receiver is lifted or the controller disconnects the battery from the line. The latter operation involves the release of contacts A, which have remained locked, and is effected by the depression of a key fitted to the controller's telephone.

It should be noted here that if the receiver is inadvertently left off its hook the station can still be called. The circuit is so arranged that the call bell will ring in the usual manner and may then be silenced by the momentary replacement of the receiver Thus a safeguard is given against any station being cut off from the controller in such circumstances.

During the whole of the time that the call bell is ringing a tone is superimposed on the line and reaches the controller's telephone receiver through a transformer which forms part of an auxiliary circuit connected to the line at the control office during the calling period. As this tone is actually generated by the vibrations of the armature of the bell, its reception is a positive indication that the bell is ringing.

When ringing tone ceases the wanted station has answered, and the controller thereupon disconnects battery from the line in the manner already stated. This restores to normal the selectors at all stations, and conversation can proceed.

In addition to the selection of any one of a large number of stations, a further facility given by this system is that known as the "Common Call." This allows the controller, by the dialling of a special number consisting of one digit only, to call simultaneously all the stations on one control line. When this digit is dialled, the selectors at all stations are advanced to a position in which the call bells are rung immediately Ringing tone is fed to the line from each station, where the circuit conditions are now such that on lifting the receiver the call bell is not silenced. This indicates to the attendant that a common call is being made and prevents the confusion caused by a number of stations coming on to the line together and simultaneously announcing their identity Although the call bells continue to ring the ringing tone is cut off at each station as the receiver is lifted, until finally when the last station answers, the tone ceases entirely The controller is therefore given a definite indication that all station attendants are listening on the line, and then disconnects the line battery to silence the bells. This service is commonly required for the communication of general instructions, time signals, etc., its value depending largely on the time taken to verify that every station has answered. When compared with the usual roll call the method employed in the system under review is infinitely more rapid and accurate.

If the controller is provided with a receiver of the headset type he can listen continuously on the line and a distant party desiring to communicate with him need only lift the way station receiver and speak. Such head receivers are, however, rather irksome to wear and since they also restrict the movements of the user, a handcombination type of telephone is often preferred. The controller does not then listen continuously and it becomes necessary to provide a means of calling him. Each way station instrument is therefore equipped with a key which, when depressed, connects a small local battery across the line, operating at the control office a sensitive relay which lights a calling lamp on the control desk. This signalling circuit is so arranged that the relay remains operated and the calling

lamp glows until the controller answers, although the key at the way station is only momentarily depressed.

In many instances it is found that there are occasions when connection is desired between the control office and points which are not normally of sufficient importance to justify their being served by the main control telephone system. They may, for example, be signal boxes on a branch line of the railway carrying only light traffic. Such points are usually served by a local code ringing system employing the more well known type of railway telephone equipped with a relay to close the call bell circuit, and a calling key by means of which a code of short and long rings may be sent out to all stations.

With the dial calling system under consideration a unique device is introduced for the automatic connection of local code ringing lines so that they may be worked when required from the controller's desk. At that station on the control line which forms the junction point with the branch line an auxiliary equipment called a Code Ringing Repeater is provided, which, when a particular number is dialled by the controller, functions to couple the two lines together Further impulsing by the controller results in the local battery at this station being applied to the code ringing line continuously during the reception of each train of impulses. The dialling speed being ten impulses per second, the reception of digit "0" will cause the battery to be connected to the line for a period of one second, and digit "3" for approximately one-third of a second. The relays at all stations will respond accordingly and the duration of the ringing of the bells will thus depend on the digit dialled.

To call any station on a local line where this facility of interconnection is provided, the controller first dials the particular two digits allocated to the code ringing repeater and so automatically couples up the main control line. The digits 0 and 3 are then dialled according to the code of the wanted station. For example, if the code is "long-short-long," the digits will be 030. The bells at all stations on the local line will give out this selected code which may then be repeated by the dialling of the same three digits until the wanted station replies. After the conversation has ended, the uncoupling of the lines is effected by the dialling of one digit allocated for this purpose. At the control office the calling codes of all local line stations will therefore consist of three parts such as 59-030-5, 59 being the coupling code, 030 the station ringing code, and 5 the uncoupling digit.

By means of the code ringing repeater it is also possible for stations on local lines to call the control office. As an addition to the local telephone instrument a key may be provided which, when operated, causes the code ringing line to be coupled to the main control system as before. Without any further action by the attendant, conversation can then be carried on if the controller is listening continuously on the line. If, however, no reply is received from the controller, the attendant will operate the ordinary calling key once, causing the code ringing repeater to apply the calling battery to the control line, and so light the lamp on the control desk. At the same time depression of the calling key will ring the bells once at all local stations, but this signal will be ignored since it will not constitute a station code call. On completion of the conversation the lines are uncoupled by the attendant at the local station again operating the coupling key.

Where several control lines are worked from one office, each requiring an operator's

undivided attention during normal traffic periods only, it is the usual practice at other times to concentrate two or more lines on one position of the control desk. To provide for this the lines are not definitely terminated on any one position, but are connected to coupling keys which appear on all positions. A controller coming on duty is therefore required to operate the coupling key associated with the line which he works and so connect his telephone and calling equipment to that line. Incoming signals will then be received on his position until the coupling key is restored when they will appear on the master position.

Such methods of distribution and concentration of lines in the control office are naturally dependent on the routine adopted and vary considerably with different transport undertakings. In the following more detailed description of the apparatus employed it is therefore proposed to deal with the various units without reference to the variety of internal switching arrangements which may be introduced to meet specific requirements.

Control Office Equipment.

The equipment provided at a control office may be divided into four groups, namely :—

(*a*) A dial, with coupling key and lamp cabinet, per position.

(*b*) A transmitting unit per line circuit.

(*c*) An operator's telephone set per position.

(*d*) Signalling and speaking batteries.

(*a*) *The Dial, Coupling Key and Lamp Cabinet.*

The location of the equipment on the control positions is a matter of choice and there are several popular methods of assembling the apparatus for the convenience of the user It may, for example, be contained in a small, compact cabinet complete with local wiring and terminals ready for cabling to the external parts of the circuit. The key and lamp panel is hinged in the face of the cabinet to provide ready access to the wiring, the dial being connected by means of a jack-in type mounting which permits instant replacement of the calling device without disturbing the permanent wiring.

As an alternative the dial, keys and lamps may be mounted on a panel framework arranged for insertion in the flat writing top of the control desk.

A third method, which has recently been adopted by a leading British Railway Company, includes the provision of a special panel with both horizontal and vertical faces, the former being equipped with the coupling keys which line up with the writing top of the desk, and the latter forming the lamp panel which is mounted flush with the back rail. In this case the dial is fitted in a separate jack-in type mounting at the front of the desk.

Fig. 3.—Control office transmitting unit.

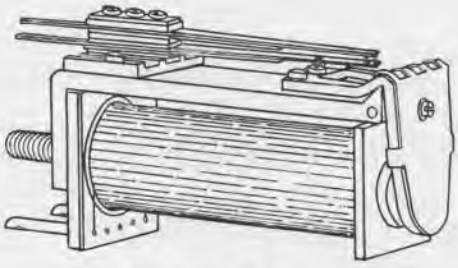

Fig. 4.—Typical relay.

(*b*) *The Transmitting Unit.*

This is illustrated in Fig. 3 and consists of a group of relays, impulse smoothing equipment, line protectors, line cut-off switches, battery fuses and a battery cut-off switch, all mounted on a teak backboard with a hinged cover for those parts not having individual protection. The relays are of the types used in automatic telephone exchanges and are fitted with springs having double platinum contacts (Fig. 4).

The impulse smoothing equipment comprises two retardation coils with condensers and resistances forming a filter in the dialling circuit. This serves to smoothen the line impulses, to reduce sparking at the contacts of the impulsing relay, and also to reduce interference with adjacent lines during dialling.

Two line protectors are provided, each consisting of two fuses of the glass tube type, two heat coils and two lightning arresters, assembled on a porcelain base with common cover This duplication is to allow the connection of two lines serving different sections of the railway system but which may be operated together as one circuit with a common numbering scheme, thus requiring only one transmitting unit.

(*c*) *The Operator's Telephone Set.*

Where the controller listens continuously on the line his telephone comprises a standard head receiver and a transmitter which may be either of the breastplate or pedestal type. A footswitch is also provided for disconnecting battery from the line after calling a way station, and for completing the transmitter circuit. The alternative instrument, for use when way stations are required to signal the controller, is the ordinary handcombination set in which the press key takes the place of the footswitch.

(*d*) *Signalling and Speaking Batteries.*

As shown in Fig. 5 the voltage of the main battery for the supply of line current for signalling depends on the number of way stations served by a line and the resistance of the line loop. From this battery a 50-volt tapping is taken for the relay circuits in the control office, the transmitter current being obtained from a separate source.

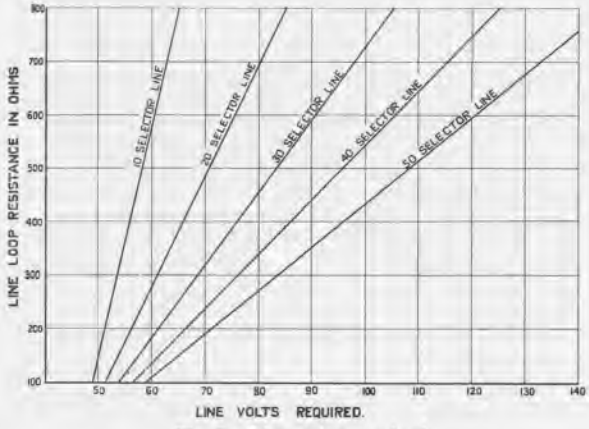

Fig. 5.—Line volts required.

Way Station Equipment.

The equipment at each way station consists of :—

(*a*) A selector unit.
(*b*) A telephone instrument.
(*c*) A line protector
(*d*) Two batteries.

Fig. 6.—Way station selector unit.

(*a*) *The Selector Unit.*

This is illustrated in Fig. 6 and will be seen to include the rotary step-by-step selector, a group of four relays, a cross-connecting panel and a variable resistance mounted on a teak backboard with cover

The selector (shown in Fig. 2) is of a type extensively used in automatic telephony and is unaffected by gravity, vibration or dust. It consists of an arc of contacts swept by a set of "wipers" or brushes clamped to a shaft carrying a ratchet wheel which is engaged by the operating pawl. This pawl is pivoted on the extremity of the operating armature which is pulled forward under the control of the drive magnet against the tension of the return spring. The restraining pawl is kept in engagement with the ratchet wheel by a spring, and is pulled out of engagement when the release magnet is energised. The return spring is housed within the hollow ratchet wheel and having one extremity clamped to the ratchet and the other to the frame is wound up as the wipers are advanced over the arc of contacts. When the restraining pawl is withdrawn from the ratchet this spring returns the wipers to a normal position.

The polarised line relay by which the dialled impulses are received is shown in Fig. 7 When its coil is energised to have a similar polarity to the permanent magnet the armature is attracted and the contacts operated. With each reversal of the line battery during impulsing, the coil is energised so that its polarity is reversed, and as the flux across the armature gap is decreased owing to the shunt path provided by the permanent magnet, the armature is released.

By means of the links on the cross-connecting panel the selector may readily be arranged to respond to a particular code. If, for example, the number of the station at which the selector unit is installed is 53, the corres-

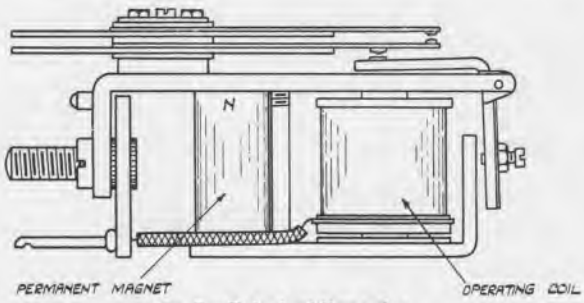

Fig. 7.—Polarised line relay.

Fig. 8.—Way station telephone (wall pattern).

ponding "tens" and "units" terminals are linked to their respective points. The advantage of this device is in the consequent standardisation of all way station equipment and the simplicity with which numbering schemes may be revised or altered in the event of extensions being made to the system.

The variable compensating resistance group is placed in series with the line relay and is provided so that suitable settings may be made at each station to give approximately equal currents in all line relays.

(*b*) *The Telephone Instrument.*

A typical wall pattern telephone is shown in Fig. 8. In general design this instrument follows standard practice and is equipped with a ringing key for calling the control office. A second key may also be fitted for connecting the transmitter circuit and simultaneously placing a shunt across the receiver in order to increase the transmission efficiency over long and heavily loaded lines.

(*c*) *The Line Protector*

This unit contains the usual fuses, heat coils and lightning arresters and is identical with that fitted on the control office transmitting unit. At the way station it forms a separate item for installation with similar devices serving telegraph and other circuits entering the station together.

Fig. 9.—Code ringing repeater.

(*d*) *Batteries.*

For the selector, relay, signalling and bell circuits at each way station one 12-volt battery is required, which may consist of high capacity primary cells. A separate three cell battery is employed for the local transmitter circuit.

Code Ringing Repeater

The additional equipment for the way station which forms the point of junction between the main system and a local code ringing line consists only of a group of nine relays suitably mounted and wired for connection to appropriate points on the selector unit. An illustration of the complete code ringing repeater is given in Fig. 9.