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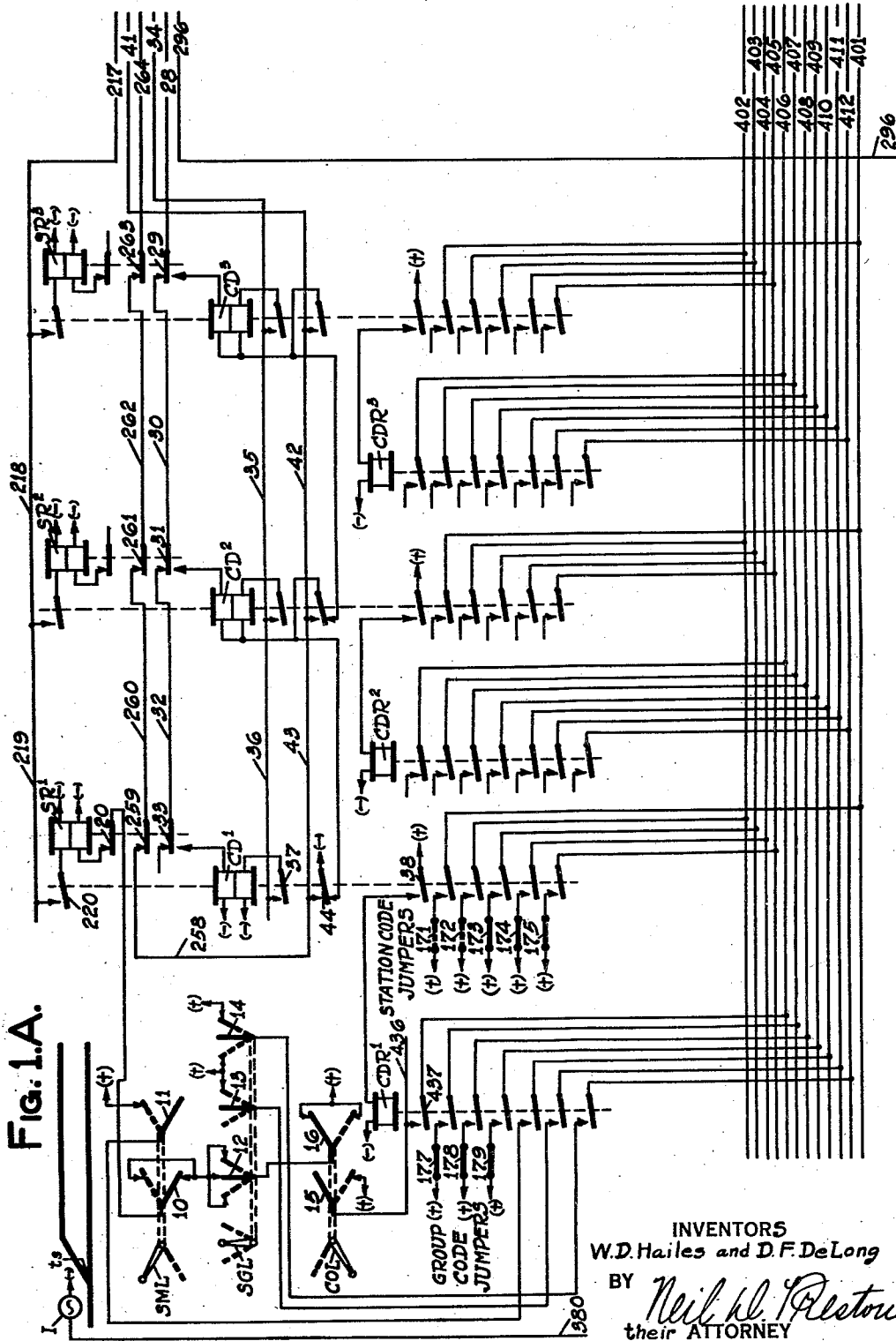
W. D. HAILES ET AL

2,170,141

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed March 31, 1931

8 Sheets-Sheet 1



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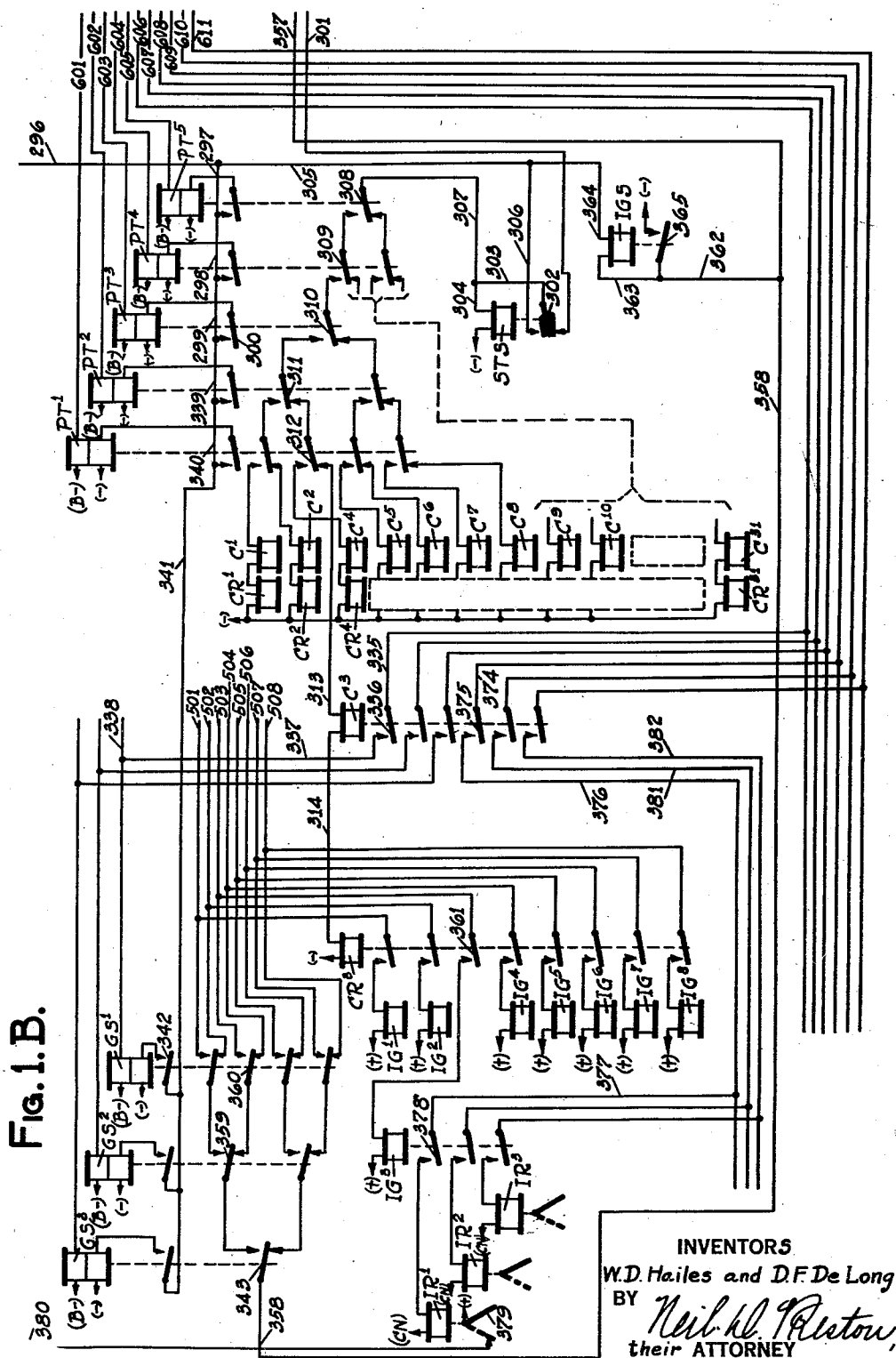
W. D. HAILES ET AL

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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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W. D. HAILES ET AL

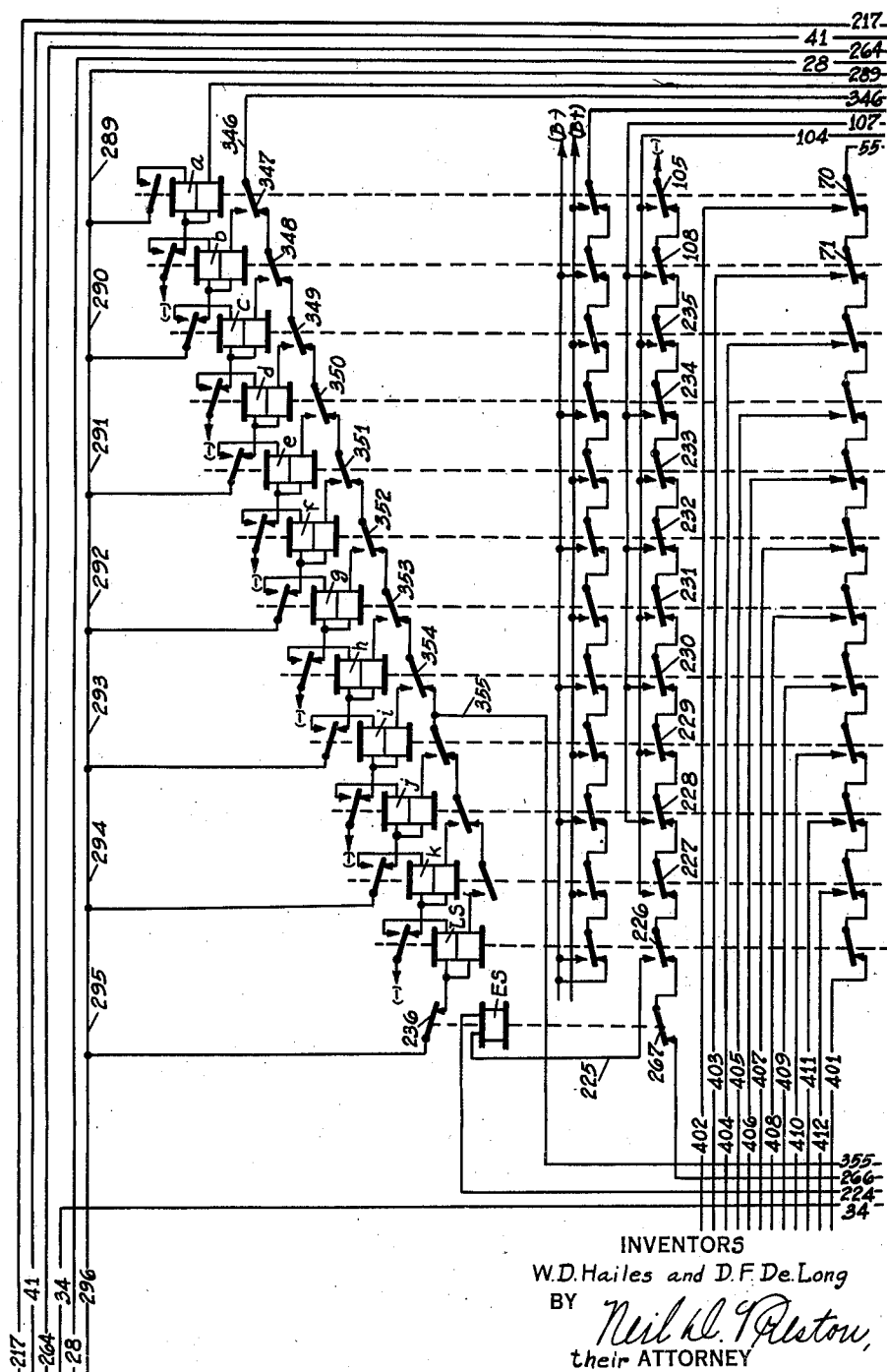
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Fig. 1C.



INVENTORS

W.D. Hailes and D.F. DeLong

BY

Neil H. Preston,
their ATTORNEY

Aug. 22, 1939.

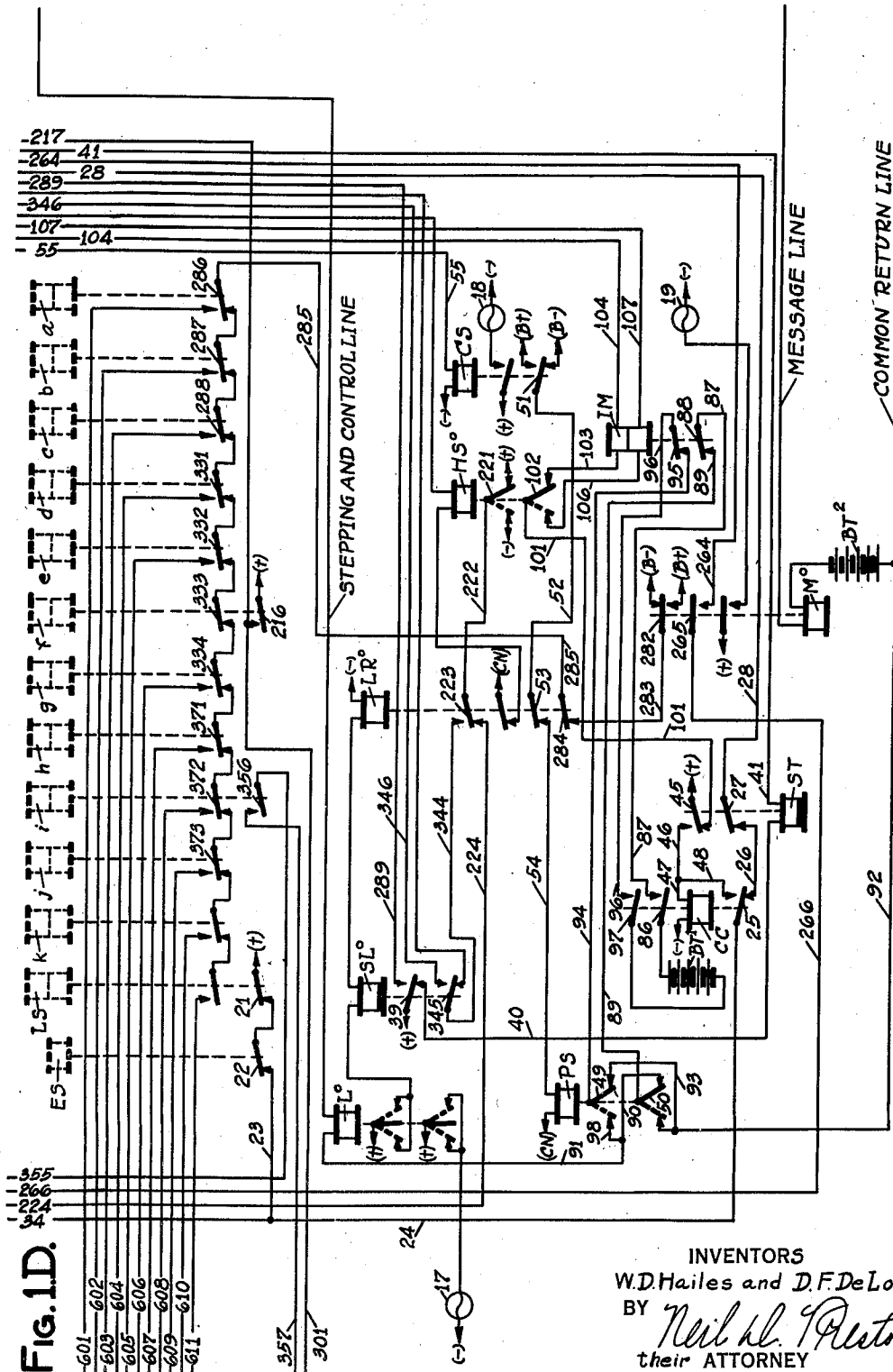
W. D. HAILES ET AL

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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS.

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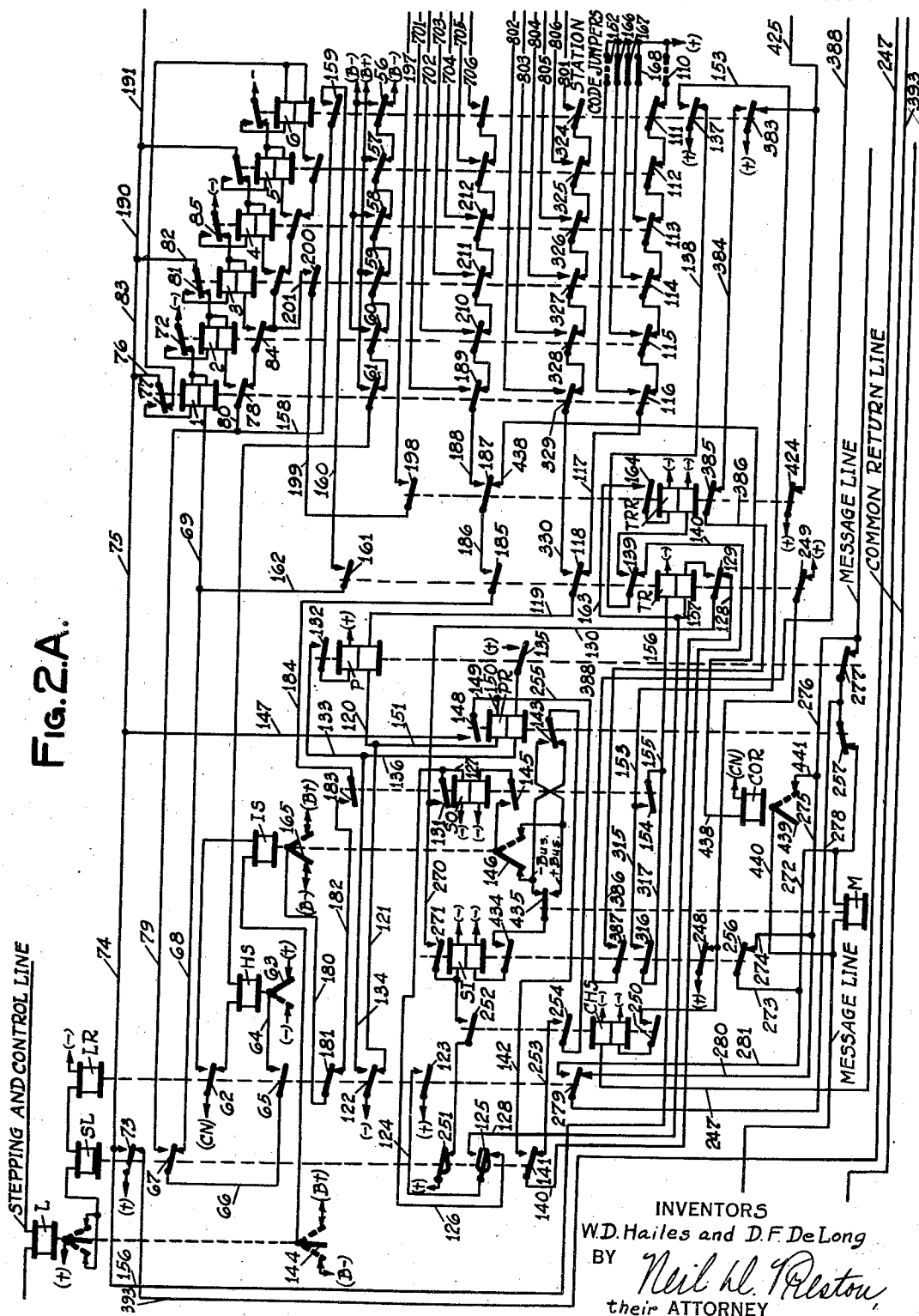
W. D. HAILES ET AL

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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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W. D. HAILES ET AL

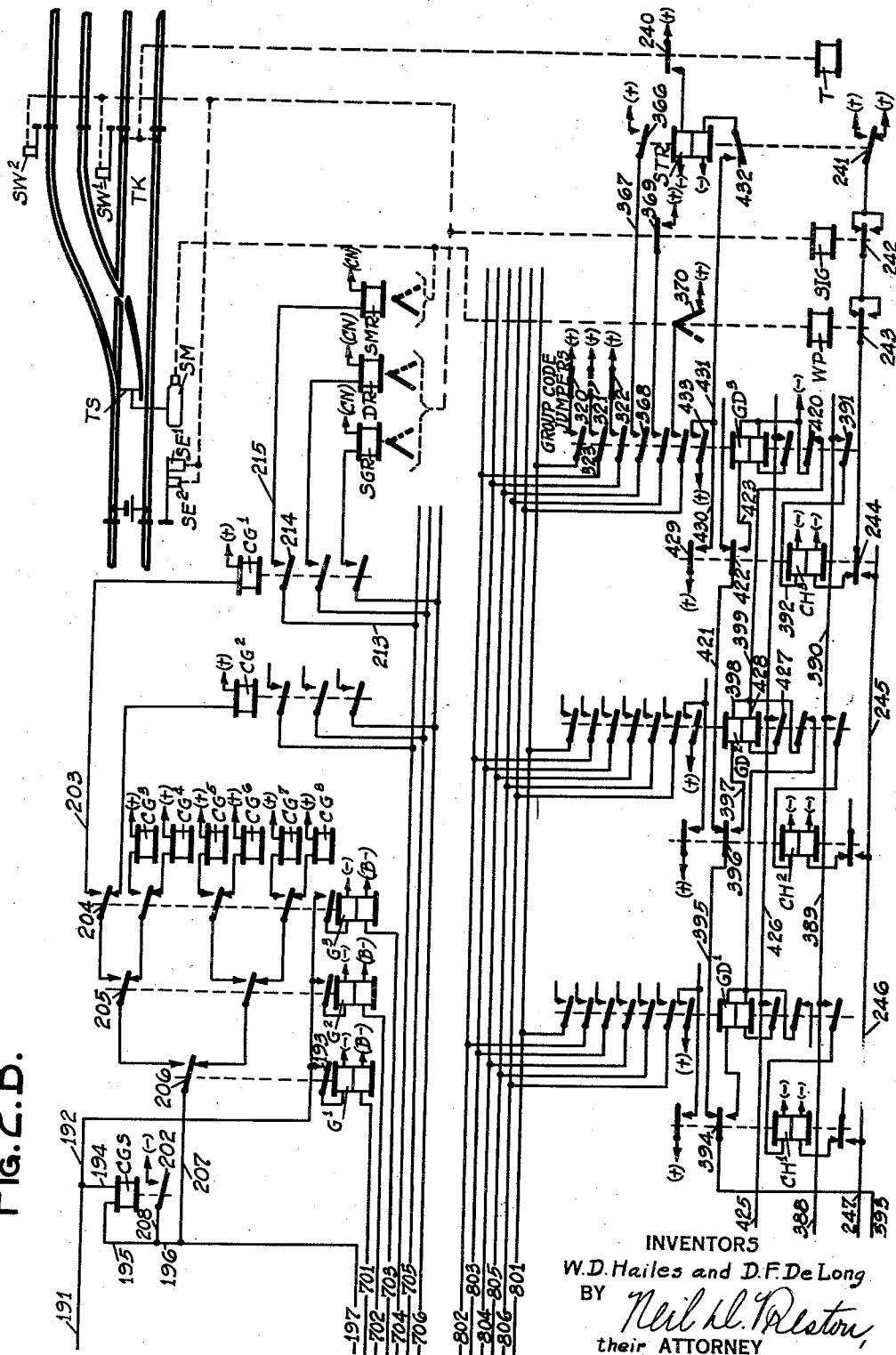
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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Fig. 2.B.



INVENTORS
W.D. Hailes and D.F. De Long
BY
Neil H. Weston,
their ATTORNEY

Aug. 22, 1939.

W. D. HAILES ET AL

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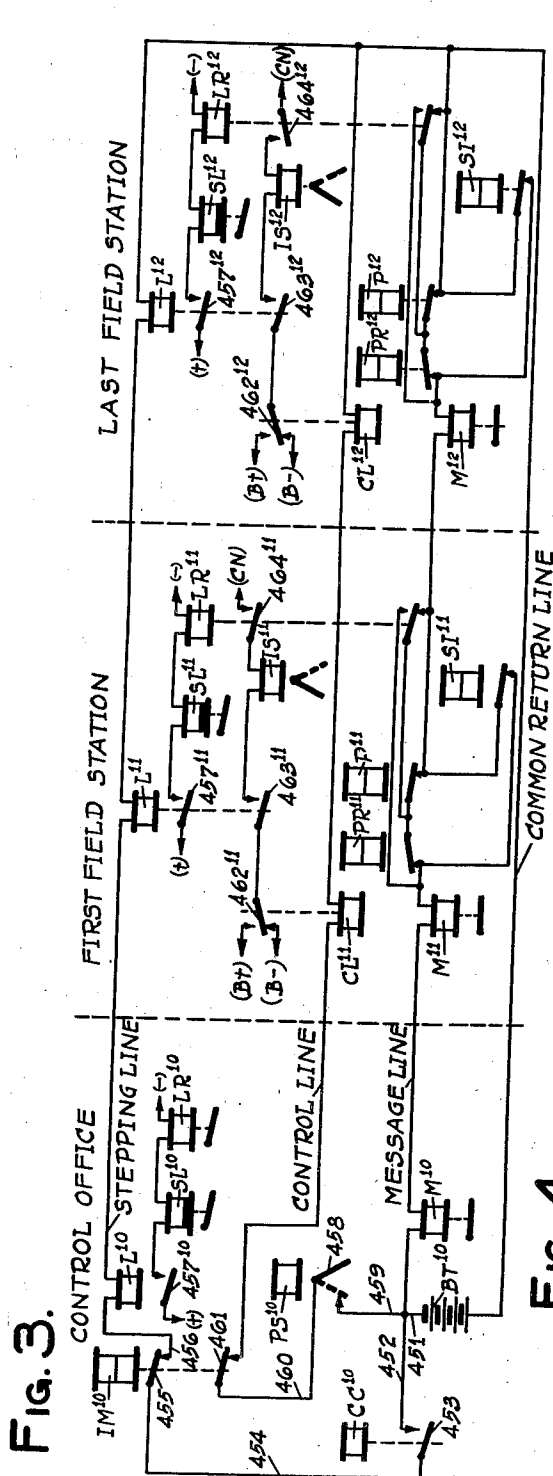
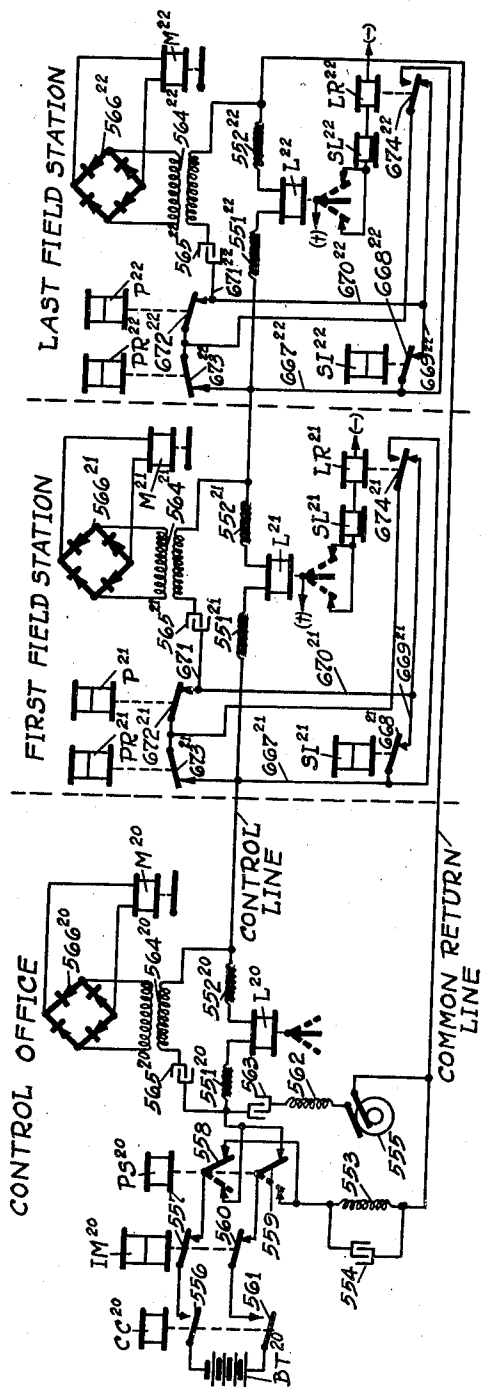


FIG. 4.



INVENTORS
W.D. Hailes and D.F. DeLong
BY
Neil H. Ruston
their ATTORNEY

Aug. 22, 1939.

W. D. HAILES ET AL

2,170,141

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FIG. 5.

TYPICAL OPERATION CHART

No. of Step		First Step		Second Step	
Period	blank	conditioning	execution	conditioning	execution
Stepping Circuit	deenergized	energized(t)or(-)	deenergized	energized(t)or(-)	deenergized
L.R. relay	down	up	down	up	down
Out-going					
P relay	conditioned	held	conditioned	held	conditioned
PR relay	down	conditioned	held	conditioned	held
IS relay	held	conditioned	held	conditioned	held
SO relay	down	up + held	selected or dropped-out	held	selected or dropped-out
In-coming					
P relay	conditioned	held	conditioned	held	conditioned
PR relay	up	conditioned	held	conditioned	held
M relay	down	conditioned	held	conditioned	held
SI relay	up	up and held	selected or dropped-out	held	selected or dropped-out

INVENTORS

W.D. Hailes and D.F. De Long

BY

Neil W. Riston
their ATTORNEY

UNITED STATES PATENT OFFICE

2,170,141

CENTRALIZED TRAFFIC CONTROLLING
SYSTEM FOR RAILROADSWilliam D. Hailes and Darrol F. De Long, Roch-
ester, N. Y., assignors to General Railway Sig-
nal Company, Rochester, N. Y.

Application March 31, 1931, Serial No. 526,674

53 Claims. (Cl. 246—5)

This invention relates to centralized traffic control systems for railroads, and more particularly pertains to the communication part of such a system, by means of which an operator is able to govern traffic controlling devices at various points along a railroad, and is informed of the progress of trains and the operated conditions of the traffic controlling devices.

A centralized traffic control system, generally speaking, is employed to enable the operator to govern train movements, over that portion or territory of a railroad which is under his supervision, by causing operation of the switches and signals at various points in this territory, so as to permit trains to move in any way he may desire. In such a system, the various track switches are usually operated by power, under the control of the operator, with suitable provision for local approach locking and the like, so that the switches may not be improperly and unsafely operated; and the various signals are automatically controlled in accordance with traffic conditions and the positions of the switches, as is usual with automatic block signalling practice, subject to the control of the operator, who may hold any signal at stop, regardless of the automatic control, or may allow any signal to clear, provided the location of trains makes it safe for such signal to be clear.

In other words, the centralized traffic control system contemplated by this invention may be said to comprise a communication system, such for example as disclosed in the pending application of N. D. Preston et al., Ser. No. 455,304 filed May 24, 1930, now U. S. Letters Patent 2,129,183 granted Sept. 6, 1938, permitting the operator to exercise his supervisory control over the operation of the switches and signals, together with a suitable signalling system, such for example, as disclosed in the pending application of S. N. Wight, Ser. No. 120,423, filed July 3, 1926, now U. S. Letters Patent 2,082,436, granted June 1, 1937, providing the necessary block signal and interlocking protection, so that the operator can direct the movement of trains by the indication of signals without written train orders.

The present invention relates more particularly to improvements in the communication part of such a system, whereby increased facility is obtained in the operation thereof and in adaptation of such a system to problems of practice.

In practice, it may happen that the track switches and signals located throughout the territory under the supervision of the operator, may be unevenly distributed so as to make it con-

venient for certain of these traffic controlling devices to be grouped together to comprise a field station, which devices are preferably operated or controlled from the same field station equipment. In a communication system of the coded duplex type, communication is established between the control office and the several field stations along the railroad over a comparatively small number of line wires, by utilizing special combinations of current impulses in the form of a code to select the stations one at a time, and/or register the several field stations, one at a time, in the control office. After the selection or registration of a particular field station, communication is then held between that station and the control office.

One function of the system, after the selection of a particular station, is to enable the operator to condition at will a relay or similar control device for each switch or signal at such selected station, in such a way that each switch may be shifted to either position, and each signal caused to indicate clear or stop, as may be desired by the operator, subject to the control of the signalling system, which prevents the switches and signals being unsafely operated. This function of the system may be referred to as the transmission of controls.

One function of the system, after registration of a particular station, is to transmit indications of the existing operated positions or conditions of the switches and signals, and the presence or absence of trains on various track circuits, together with indications of such other conditions as may be of value to the operator. This function of the system may be referred to as the transmission of indications.

Although a coded duplex type communication system is preferably provided to transmit a particular number of controls and/or indications for each cycle of operation, it may happen that a greater number of track switches and other traffic controlling devices are located at certain field stations, than can be adequately handled by a single field station equipment during the same cycle of operation.

In view of this, it is proposed, in accordance with the present invention, that the traffic controlling devices at such stations be divided into groups with the system so organized as to be able to transmit the number of controls or indications associated with any particular group during a single cycle of operation. In other words, a field station may be said to be comprised of a single group of controls and/or a single group of

indications, or a plurality of such groups. With the communication system of the duplex coded type, either the groups of controls are transmitted, one group at a time for each cycle, and simultaneously therewith the groups of indications are transmitted, one group at a time for each cycle, or the control and indication groups are transmitted separately, one group at a time for each cycle. This function of the system to distinguish between the groups of controls and indications of a field station may be conveniently termed group selection, and is accomplished after the selection of the field station by the transmission of a code characteristic of the particular group of the station with which communication is to be held.

In a selective type communication system where the step-by-step mechanisms are synchronously operated from a control office by impulses transmitted over a stepping circuit, and a message or indication circuit is employed to transmit indication impulses from any particular field station to the control office on each step, such for example as in the coded duplex system disclosed in the above mentioned application of N. D. Preston et al., Ser. No. 455,304, now U. S. Letters Patent 2,129,183 granted Sept. 6, 1938, the step-by-step mechanism must respond to a particular impulse on the stepping circuit before the message circuit can be conditioned to transmit the indication for the corresponding step.

The present invention provides means, so that the condition to be transmitted for each step is set up on the preceding step, with this condition made effective to condition the message circuit immediately upon the application of an impulse to the stepping circuit and simultaneously with the operation of the step-by-step mechanisms. This feature of the present invention serves to decrease the time period required for each step.

A further object of the invention is to provide a communication system of the selective type, which is normally at rest, but which may be initiated into operation by a change in indication conditions at any one or all of the several field stations, with provisions made so that the operator may suppress or prevent certain field stations from thus initiating the system for registration in the control office, whenever he may desire.

A further object of the invention is to provide a communication system of the selective type having four neutral lines for accomplishing the selective control, whereby the system is made more immune to inductive surges due either from operation of the system or from external causes.

A still further object of the invention is to provide a communication system of the selective type having two lines for accomplishing the selective control. This feature of the invention is accomplished by having a direct current polarized control circuit with an alternating current message or indication circuit superimposed thereon.

Other objects, purposes and characteristic features of the present invention will be in part obvious from the accompanying drawings, and in part pointed out as the description of the invention progresses.

In describing the invention in detail, reference will be made to the accompanying drawings, in which similar parts throughout the several views are designated by like reference characters provided with distinctive exponents, and in which—

Figs. 1A, 1B, 1C and 1D, when arranged with

Fig. 1B beneath Fig. 1A, with Fig. 1D beneath Fig. 1C, with Figs. 1A and 1C placed end to end, and with Figs. 1B and 1D placed end to end, illustrate the apparatus and circuits for the control office of a communication system constructed and arranged according to the present invention;

Figs. 2A and 2B when placed end to end illustrate the equipment of a typical field station having a distinctive code call, with its controls and indications divided into several groups, each group of which is provided with a distinctive code call for its selection;

Fig. 3 shows the arrangement of line circuits as modified according to the present invention to provide a system having four neutral lines;

Fig. 4 shows the arrangement of line circuits as modified according to the present invention to provide a system having two line wires; and,

Fig. 5 shows a Typical Operation Chart which gives in a graphic form the sequence of operation of certain relays in the system.

For the purpose of explaining the nature of the present invention, there has been shown in the accompanying drawings one typical embodiment of the invention illustrated as controlling a single track switch and its associated signals; but the same principles and functions of the invention, and the same apparatus and circuits may be employed, or may be readily adapted by obvious modifications, for the control of the switches, signals, or other traffic controlling devices for all kinds of track layouts, and for receiving such indications of the positions or conditions of these traffic controlling devices, track circuit occupancy and the like, as may be desired.

For the purpose of simplifying the illustration and facilitating in the explanation, the various parts and circuits constituting the system of the present invention have been shown diagrammatically and certain conventional illustrations have been employed, the drawings having been made more with the purpose of making it easy to understand the principles and mode of operation of the system, than with the idea of illustrating the specific construction and arrangement of parts that would be employed in practice. Thus, the various relays and their contacts are illustrated in a conventional manner and symbols are used to indicate connections to the terminals of batteries or other sources of electric current, instead of showing all the wiring connections to these terminals.

The communication system of the present invention may be said to comprise a control office conveniently located with respect to the territory under supervision, and a plurality of field or way stations distributed along the railroad at convenient points. Each of the several field stations is connected to the control office by three line wires (in the form shown in Figs. 1A, 1B, 1C, 1D, 2A and 2B), namely, a stepping and control line, a message or indication line, and a common return line. These line wires are connected together so as to complete two separate circuits with a common return connection which circuits include each of the field stations and control office. These circuits are conveniently termed a stepping circuit and a message circuit.

In the form shown in Figs. 1A, 1B, 1C, 1D, 2A and 2B, the stepping circuit accomplishes two functions, namely, that of operating the step-by-step mechanisms, and that of controlling the switches and signals. These two functions do not need to be combined or executed over the

same circuit, but may be provided with individual circuits in a similar manner as shown in Fig. 3 of the accompanying drawings, later to be explained.

The stepping and control line circuit includes at each field station, and at the control office, a polar line relay L which is of the three position biased to neutral type; and the message line circuit includes at each field station and at the control office, a message relay M of the neutral type. At each field station two neutral contacts respectively operated by a neutral pulsing relay P and a neutral pulsing repeater relay PR are also included in the message line circuit.

The stepping and message circuits are supplied with direct current from suitable sources located in the control office, and represented by batteries BT¹ and BT² respectively. The field stations do not supply current to any of the line circuits of the system. This supply of direct current for the line circuits may be storage batteries with suitable trickle charge or periodic charging means, motor generators, or any other suitable source of electrical potential. It is to be understood, that the voltage required from these sources will vary with the length of line wire, the size of the line wire, and the resistance of the relays included in the circuits, with the particular values ascertained in accordance with the usual engineering practices.

Sources of direct current are required at the control office and at each of the field stations for supplying energy to the circuits local thereto, such as for the operation of the switches, signals and other devices at the particular location. Storage batteries, maintained charged through rectifiers from a suitable power line, are preferably employed for this purpose, in accordance with common practice.

Although the line circuits have been shown as supplied with energy from suitable battery sources, local circuits have been designated as supplied with energy from battery sources indicated by symbols. The symbols (+) and (—) are employed to indicate the positive and negative terminals respectively of a suitable battery or other source of direct current; and the circuits with which these symbols are used, always have current flowing in the same direction. The symbols (B+) and (B—) indicate connections to the opposite terminals of a suitable battery or other direct current source which has a central or intermediate tap designated (CN); and the circuits with which these symbols are used, may have current flowing in one direction or the other depending upon the particular terminal used in combination with the intermediate tap (CN).

All of the operations of this communication system (as shown) are performed by relays, preferably of the tractive armature type. Certain of these relays, such as the line relays L, are of the three position biased to neutral polarized type. When such a polar relay is energized, its armature is shifted from its biased-to-neutral deenergized position to an operated position, in one direction or the other, according to the polarity of the current supplied to the windings of the relay. The contacts of these three position polar relays are shown conventionally, and for convenience it is assumed that the contact fingers of these relays are moved to the right by the application of positive current, and to the left by application of negative current, when the left hand terminals of these relays are taken as the points of application.

Certain other of the relays, employed throughout the system, are of the two position polar magnetic stick type, the armature of each relay being held by the magnetic attraction of the permanent magnet incorporated within the relay, in the position to which the armature was actuated upon the last energization of the windings of the relay. The contact fingers of these two position polar relays are similarly conventionally shown, and are also assumed to be moved to the right by an application of positive current and to the left by an application of negative current, when the left hand terminals of these relays are taken as the points of application.

The various other relays employed throughout the system and shown conventionally, are preferably of the neutral armature type commonly used in telephone practice. Some of these relays require two independent windings; and some need slow releasing characteristics, which is obtained in the usual manner by the provision of short circuit windings. It is to be understood that all of the relays are of course constructed in accordance with recognized practice to have the necessary operating characteristics, quick operation of all the relays except the slow releasing relays being desirable to increase the speed of operation of the system. The slow releasing relays have been conventionally designated by heavy base lines, although such designation merely indicates a relative degree of speed of operation with respect to the other relays employed in the system.

Both at the control office and at the field stations certain code jumpers have been illustrated as full line connections between two terminals, when they are connected in active positions placing positive potential (+) on the associated buses; while certain others of these code jumpers have been illustrated as dotted line connections between two terminals, when they are connected or located in inactive positions, so as to leave the associated buses deenergized.

The control office equipment.—The equipment for the control office comprises a suitable control machine which is provided with manually operable levers, indicating lamps, indicating bells, track diagrams, automatic recorders, and various other devices which may be employed to advantage, so as to enable the operator by simple manipulation to control the switches, signals, or other traffic controlling devices of the system at the various field stations, and also have before him such information of the response of these traffic controlling devices, and of the occupied or unoccupied condition of the various track sections, as will make possible the most efficient movement of traffic.

Neither all of the parts, nor a specific arrangement of the parts of the control machine have been shown; but certain control levers, relays, indicating lamps, and various electrical connections therefor, have been shown diagrammatically as typical or representative of what can be suitably employed in a control machine in accordance with the communication system of the present invention.

In the diagrammatic arrangement shown (see Fig. 1A), a control lever SML, movable to either of two positions, and operating contacts 10 and 11, is illustrated for the control of a single track switch. Similarly, a signal control lever SGL, movable to any one of three different positions, and operating contacts 12, 13 and 14, is illustrated for controlling the clearing of the signals and the direction of traffic over a single track switch.

These two control levers SML and SGL are representative or typical of those used for other switches and signals, or other similar traffic controlling devices.

For each field station, a cut-out control lever COL, movable to either of two positions, and operating contacts 15 and 16, is illustrated for governing the corresponding field station to prevent or allow that station to initiate the system and transmit indications, as may be desired. Such station cut-out control levers COL may be located on the control panel adjacent the switch and signal control levers (as shown), so as to be easily manipulated by the operator; or may be located on a separate panel adjacent certain associated relay cabinets, so as to be operated only by a maintainer in the event that a station for one reason or another falsely monopolizes the message circuit.

Although levers have been shown for the control of their respective contacts, other similar mechanical means, such for example, as knobs, dials, push buttons or the like, may be employed for the control of contacts for accomplishing similar purposes as those illustrated.

A miniature track diagram, corresponding with the actual track lay-out in the territory under the supervision of the operator, is preferably made a part of the control machine, and positioned directly over the control levers. As representative of such a track diagram, there is indicated in Fig. 1A, a single miniature track switch TS which is intended to represent the actual track switch TS in the field. It is desirable that the control levers associated with each of the switches may be so positioned with respect to the miniature switches on the track diagram, as to make it easily understood to which switch they belong.

Small indicator lamps of the telephone switch board type, suitably disposed on this track diagram, are lighted to indicate the presence of a train on a corresponding portion of the track. As illustrative of such indication means, the indicator lamp I is shown controlled in accordance with the occupancy of a detector track section located adjacent the track switch TS shown in Fig. 2B. This indicator I is controlled by an indicating relay IR¹ which is in turn controlled through the medium of the communication system, as hereinafter described.

The positions of the switches in the field, whether the signals associated with such switches indicate clear or stop, and various other annunciator indications (not illustrated), are also preferably provided for the purpose of informing the operator as to the conditions existing in the territory under his control. Such additional indications may be controlled by indicating relays IR² and IR³, and such other similar indicating relays as may be necessary to be provided for the number and nature of the indications desired.

As heretofore pointed out, the communication system of the present invention is of the duplex coded type where a given number of controls and/or indications are transmitted during each operating cycle. Due to the uneven distribution of switches, signals and the like, in the supervised territory, one field station may have a greater number of controls and/or indications than can be conveniently transmitted during one cycle. The controls and indications at such a field station are divided into groups, each such group including the number of controls or indications which the system can transmit during

any one cycle. Thus, any particular field station may include a single group of controls and/or a single group of indications, or a plurality of such groups, any one of which may be transmitted during a single operating cycle.

Those control levers, which determine the controls of a particular group, together with a storing relay SR, a code determining relay CD and a code determining repeater relay CDR, may be said to comprise the code and control determining means for that group. In other words, there is a bank of relays SR, relays CD and relays CDR; shown as relays SR¹, SR², SR³; CD¹, CD², CD³; and CDR¹, CDR², CDR³; with the relays having corresponding exponents comprising the relays for each group of controls irrespective of whether such group is one of a plurality of similar groups, or the only group associated with a particular field station.

Each storing relay SR has a stick circuit normally energized through contacts on the control levers of the corresponding group. The movement of any control lever of a particular group momentarily opens the stick circuit of its corresponding storing relay, thereby causing it to be deenergized, in which condition it remains until the code call for the corresponding group has been transmitted.

The code selecting or code determining relays CD are arranged in a bank with interlocked circuits connecting them to their respective storing relay SR, so that only one of these code determining relays CD may be energized at a time, irrespective of the number of storing relays which may be deenergized as the result of the operation of several control levers of different groups. These code determining relays CD with their corresponding repeating relays CDR, when energized one at a time, connect a plurality of control buses 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411 and 412 respectively to the code jumpers and control lever contacts of the corresponding groups, to thereby condition the system for the transmission of code calls and controls, in a manner more fully explained herein-after.

The system is arranged so that each cut-out control lever COL may be employed to suppress the associated field station as a whole rather than a particular group of that station, although such individual group suppression might be employed by slight modification of the circuits. The movement of a particular cut-out control lever COL must result in the selection of the corresponding field station in order to transmit the cut-out control to that station. Although the embodiment of the present invention illustrates the manner in which a particular cut-out control lever is associated with a particular group of a field station in order to obtain the necessary initiation of the system and selection of that station, such cut-out control lever could be provided with its own distinctive group code call. In Fig. 1A, the lever COL is shown as having a contact 16 in the normally closed stick circuit of the storing relay SR¹, thereby associating that cut-out control lever with the first group for the station shown in Figs. 2A and 2B insofar as the initiation of the system and the first transmission of the cut-out control is concerned; while the contact corresponding to contact 437 of the code determining relay CDR¹ for this and each other group of that station connects the control bus 406 to the contact 15, so the proper cut-out control is maintained for each selection of that station.

The control office equipment also includes a bank of station registering or decoding relays (see Fig. 1B), which are responsive to the code calls, communicated to the control office over the message circuit, of stations having new indications to transmit, such stations being registered or identified one at a time on this bank of station registering relays. In the particular arrangement shown, this station registering bank of relays comprises a bank of pilot relays PT¹, PT², PT³, PT⁴ and PT⁵, and a bank of station relays C¹, C², C³, etc., one for each station, the arrangement of relays shown being applicable for thirty-one stations, but being capable of expansion to provide for any desired number of stations. The particular arrangement shown provides for thirty-two code calls, but the thirty-second is not assigned to any station for reasons pointed out in the pending application of N. D. Preston et al, Ser. No. 455,304, filed May 24, 1930, now U. S. Letters Patent 2,129,183 granted Sept. 6, 1938.

Although only the station relays C¹, C², C³, etc., to C⁸ have been shown having circuits selected through contacts on the pilot relays PT, it is to be understood that the succeeding relays C⁹, C¹⁰, C¹¹, etc., to C³¹ are similarly connected, such connections being merely indicated for the sake of simplicity. Also, each of the relays C is provided with a repeater relay CR, shown as relays CR¹, CR², etc., to CR³¹. A station stick relay STS is provided to maintain energized the particular selected station relay C for each cycle of operation in which the corresponding station is registered in the control office.

A bank of group selecting pilot relays GS is employed to register the code call of the particular group transmitting from the particular station which is registered for that cycle of operation by the station registering relays C. The embodiment of the present invention utilizes three steps for group registration, upon which the group selecting relays GS¹, GS² and GS³ are respectively controlled. This arrangement is applicable for a maximum number of eight groups of indications for each station, but the same principles of arrangement may be extended for as many steps as necessary to provide the desired number of groups.

Associated with each station registering relay C is a bank of indication group relays IG, one for each group of the corresponding station, shown as the relays IG¹, IG², etc., to IG⁸ for the stations relay C³. These relays IG are connected to their respective indication group selecting buses 501, 502, 503, 504, 505, 506, 507 and 508 through front contacts of their corresponding station repeating relays CR when the corresponding field station has been registered. Thus, one indication group relay IG for the station registered is energized in accordance with the group code call registered by the relay GS. This selected indication group relay IG is maintained energized for that cycle by an indication group stick relay IGS.

Each indication group relay IG has associated therewith a bank of indication storing relays IR of the polar magnetic stick type. Each such bank of relays includes a number of relays equal to the number of indications to be transmitted by the corresponding group of field indications. The indication storing relays IR of each such bank are connected to the indication buses 609, 610 and 611, one bank for each cycle, through front contacts of the corresponding indication group relays IG and front contacts of the correspond-

ing station relay C. Illustrative of such a bank, indication relays IR¹, IR² and IR³ are shown associated with the relay IG³, which relays are respectively controlled in accordance with track circuit conditions, signals clear or stop, and switch position of the corresponding traffic controlling devices shown in Fig. 2B.

These relays PT, GS and IR are energized or left deenergized on each step during a cycle of operation in which they are to be controlled, in accordance with the particular polarity applied to each over their respective indication buses 601, 602, 603, 604, 605, 606, 607, 608, 609, 610 and 611.

The control office equipment also includes a suitable number of counting or stepping relays, arranged in a bank and energized sequentially one at a time by the impulses applied to the stepping circuit. These stepping relays count off the steps during each operating cycle of the system. Although relays have been shown employed for this purpose, any other suitable step-by-step mechanism could be used. In the particular arrangement shown, providing for five station selecting steps, one transfer step, three group selecting steps and three control and indication steps, there are twelve relays a, b, c, d, etc., including a last step relay LS. It is to be understood that this is only one arrangement, and that the number of stepping relays would be chosen in practice to fit the number of steps required for selection of the stations, and the number of control and indication steps required for the various individual station, as well as the number of steps required for selection of the groups of controls and indications for each station.

An extra step relay ES is associated with the last step relay LS in a manner to cause the relay LS to be deenergized on the last step prior to the advent of the system into the period of blank.

The control office equipment also includes suitable means for applying impulses of a selected positive or negative polarity at the proper time spaced intervals, to the stepping circuit. Although some other suitable means might be employed for this purpose, an impulsing relay IM is provided to operate in conjunction with the stepping relays in the control office, the line relay L⁰ and the half step relay HS⁰ in a manner to provide impulses time spaced in accordance with the actual response of the system.

The polarity of each impulse applied to the stepping circuit is determined by a polarity selecting relay PS, which is in turn controlled by a code sending relay CS. This code sending relay CS is energized or deenergized on the successive steps by the code jumpers associated with the particular code selecting relay CD (with its repeater CDR) then energized, and by the positions of the associated control levers SML, SGL and COL, in a manner more fully explained hereinafter.

The control office equipment further includes relays ST and CC for stopping and starting the system, a quick acting line repeater relay LR⁰, a slow acting line repeater relay SL⁰, a half step relay HS⁰, and various bus wires and connections discussed more fully in connection with the operation of the system.

Included within the control office equipment are three indicator lamps 17, 18 and 19, which are associated with the relays L⁰, CS and M⁰ respectively, in a manner that the operator may ascertain whether or not the system is in operation causing steps to be taken, whether the system is

responsive to controls, and whether the system is transmitting indications.

Field station equipment.—A field station comprises a number of traffic controlling devices together with the equipment necessary to establish communication between that field station and the control office. The number and type of traffic controlling devices at the various field stations of the system may vary, so that any particular station may include a single group of controls and/or a single group of indications, or a plurality of such groups arranged in various combinations.

A field station having a plurality of control groups and a plurality of indication groups has been chosen as representative of every other combination, and is illustrated in Figs. 2A and 2B of the accompanying drawings. The equipment, for such a field station, necessary to establish communication between that station and the control office comprises, station selecting apparatus, control group selecting apparatus, indication group selecting apparatus and the traffic controlling devices associated with each group.

The station selecting apparatus for each station includes the same arrangement of relays, the several stations differing from each other merely in certain station code jumpers or connections which are set to fit the code call assigned to the particular field station location. This station selecting apparatus is preferably arranged in a unit cabinet, so as to be quickly replaced by another unit in the event that a particular unit fails to properly respond.

This station selecting apparatus (see Fig. 2A) includes for each field station, in addition to the line relay L and message relay M already pointed out, a quick-acting line repeating relay LR, and a slow-acting line repeating relay SL, these relays being energized whenever the line relay L is energized with current of either polarity.

An impulse storing relay IS, of the polar magnetic stick type, is arranged to be energized with positive or negative polarity depending upon the polarity with which the line relay L is energized, to thereby store the impulses placed upon the stepping circuit subsequent to the deenergization thereof.

Each field station selecting apparatus includes a bank of stepping or counting relays, energized sequentially one at a time, upon the successive energizations of the stepping circuit irrespective of the polarity of such energizations, and operated in synchronism with the stepping relays at the control office and at each of the other stations. The arrangement shown provides six such stepping relays 1, 2, 3, 4, 5 and 6, the number of these relays depending upon the number of steps required for the particular embodiment of the present invention. The particular embodiment illustrated, employs only six stepping relays at each station, although twelve steps are necessary for each cycle, by reason of the fact that each such bank of stepping relays is caused to operate through the second time for each cycle of operation in which the corresponding station equipment is selected. Each bank of stepping relays is caused to be responsive to energizations of the stepping line, irrespective of the polarity, by reason of its control through the neutral line repeating relay LR together with a half step relay HS which is of the two position polar magnetic stick type.

The repeat operation of the stepping relay bank at each station is accomplished by a trans-

fer relay TR and a transfer repeater relay TRR which relays are energized whenever the station is selected to receive controls and/or transmit indications.

The station selecting apparatus for each station further includes two station selecting relays, one relay SO for selecting the station for the transmission of outgoing controls from the control office, and the other relay SI for selecting the station when it is registered or identified in the control office for transmitting its indications. These selecting relays SO and SI are either selected or dropped out by the code calls transmitted over the stepping and message circuits respectively by comparison of these transmitted code calls with the code call arbitrarily assigned to the station.

The pulsing relay P and a pulsing repeater relay PR are suitably governed on each step in accordance with code jumpers of the corresponding selecting steps and in accordance with the indications of the station upon the corresponding indication transmitting steps.

The station selecting apparatus also includes a change storing relay CHS, which is suitably energized whenever new indications are present at the corresponding field station ready to be transmitted to the control office, and a station cut-out relay COR controlled by the operator for preventing that station from transmitting indications to the control office.

The control group selecting apparatus is also preferably arranged in a unit cabinet suitably connected with the station selecting unit and the associated traffic controlling devices, so as to be readily detached.

The control group selecting apparatus (see Fig. 2B) includes a number of group selecting pilot relays G governed on the corresponding group selecting steps in a manner to select the proper control group relay CG after the completion of the transmission of the corresponding group code call. For the field station illustrated, the control group selecting equipment includes group selecting pilot relays G¹, G² and G³, control group relays CG¹, CG², CG³, CG⁴, CG⁵, CG⁶ and CG⁷, which arrangement is merely illustrative of that organization which might be used, and is made to correspond with the arrangement of group registering relays in the control office. The control group relays CG have associated therewith, a control group stick relay CGS which is energized after the completion of each group code call to maintain the selected control group relay CG energized for the remainder of the operating cycle.

Each control group relay CG has associated therewith a number of function relays which are connected through front contacts of that control group relay to the respective control buses, but for the sake of simplicity, the function relays have been shown only for the first control group of the field station illustrated. Although these relays have been specifically shown as a switch machine function relay SMR, a signal relay SGR and a direction relay DR associated with the control group relay CG¹ and employed for controlling the track switch TS and its associated signals, it is to be understood that other similar relays in the same or other groups may be employed for the same or other purposes.

The indication group selecting apparatus is also preferably arranged in a unit cabinet suitably connected with the station selecting unit and the associated traffic controlling devices, so as to be

readily detached. This indication group selecting equipment includes a change relay CH for each group, shown as relays CH¹, CH² and CH³, and a group determining relay GD for each group, shown as relays GD¹, GD² and GD³. These relays CH and GD are arranged in a bank with interlocked circuits so organized, that only one of the group determining relays GD may be energized at a time, irrespective of the number of change relays CH which may be deenergized. In other words, each change relay CH is associated with the traffic controlling devices of its corresponding group in a manner that when a new indication is present in such group, this change relay CH is deenergized, which in turn energizes the corresponding group determining relay GD if no other group determining relay GD is energized, and the system is in the period of blank.

Illustrative of the indications which may be arranged to comprise a single group, the devices, associated with the track switch TS which are indicated in the control office, have been shown as including, a track relay T associated with a detector track section TK adjacent the track switch TS, a signal relay SIG associated with the signals adjacent the track switch TS in a manner to be energized whenever all of the associated signals are at stop, and a switch position repeating relay WP of the polar-neutral type, which is energized with one polarity or the other in accordance with the extreme locked position of the track switch TS. Associated with each track relay T is a corresponding track storing relay STR employed for purposes hereinafter pointed out.

The track switch TS is shown as associated with the first group of this field station, and is provided with a suitable switch machine SM, such as disclosed for example, in the patent to W. K. Howe, No. 1,466,903, dated September 4, 1923. Such a switch machine SM is supplied with operating current from a local battery and is preferably equipped with a dual control selector permitting hand operation of the switch points as disclosed in the application of W. K. Howe, Ser. No. 354,039, filed April 10, 1929, now U. S. Letters Patent 1,852,573 granted April 5, 1932. The operation of each such switch machine SM is controlled by its corresponding function control relay SMR which relay is of the two position polar magnetic stick type, its energization being under the control of the operator through the medium of the communication system of this invention.

Each track switch is provided with suitable signals, such for example, as those shown for the track switch TS. The signals SE¹ and SW¹ are provided to govern east and west main line movements respectively, and signals SE² and SW² are provided to govern diverging route movements in east and west directions, respectively. These signals are governed by their associated track circuits, the position of the associated switch points, subject to the supervisory control of the operator, through the medium of their corresponding function control relays SGR and DR. The control circuits for the signals have not been shown, but it is to be understood that they may be of any suitable type employed in practice, such for example as in the above referred to application of S. N. Wight, Ser. No. 120,423 filed July 3, 1926, now U. S. Letters Patent 2,082,436 granted June 1, 1937.

Although the first control group and the third indication group are the only groups of this station which have been illustrated in detail, it is to

be understood that each of the other groups of this station is similar and has associated therewith track switches controlled through suitable function relays in a manner which may be understood by analogy to the particular groups illustrated. It is also to be understood, that the track switches thus controlled, may be arranged in various track lay-outs, and that the controls and indications associated therewith may be grouped in any desired manner to most expediently meet the requirements of practice.

Besides the various relays and devices, each station includes a plurality of control buses 701, 702, 703, 704, 705 and 706, a plurality of indication buses 801, 802, 803, 804, 805 and 806, and various other wiring connections. Also, the various relays, devices, buses, connections and the like, are either suitably arranged in unit cabinets as described or are housed in any other suitable manner to best meet practical needs, and are provided with terminal boards, lightning protection and such other means as may be necessary to meet standard signal engineering requirements.

It is believed that other characteristic features and functions of the system of the present invention will be best made apparent by considering the operation of the system under various conditions.

Operation of the system

The general scheme of operation of the system taken as a whole, will be briefly outlined before discussing in detail the various steps which may occur in the operation thereof.

Although the system could be operating continuously, it is preferably arranged (as shown), so as to be normally at rest when no controls are to be transmitted from the control office and no indications are ready for transmission from any of the several field stations. The relays and circuits are shown in the drawings in the positions assumed, when the system is in its normal at-rest condition, the stepping circuit being deenergized, and the message circuit being steadily energized.

When the system is at rest, or in a period of blank, it may be set into operation from the control office for the transmission of new controls to any particular field station, or it may be initiated into operation automatically at any field station having new indications to transmit to the control office. When the system is thus set into operation either manually or automatically, the system operates through what is conveniently termed a cycle of operation and then returns to an at-rest condition.

Each operation cycle of the system is divided into two parts, namely, a selecting part and a transmitting or communicating part. The selecting part of the cycle includes the transmission of the station and group code calls to select a particular group of controls or indications within the particular station with which communication is to be held; while the second part of the operating cycle is the part in which the actual communication is held between the control office and the particular group of controls or indications selected during the first part of that cycle.

In describing the operation of the system in detail, it is convenient to discuss the several steps individually under separate heads, first explaining the operation of the system for the transmission of controls from the control office, then

the operation of the system for the transmission of indications.

Although the embodiment of the present invention includes the features of two-way transmission, superiority of code, and various other features of a selective coded duplex type system, as disclosed in the above referred to application Ser. No. 455,304, these features will be explained only in sufficient detail to point out their relation and application to the devices, features and functions included within the present invention.

Manual starting.—With the system at rest, the operator may transmit controls to any group of controls for a particular station, which he may desire, by positioning the control levers corresponding to the particular traffic controlling devices which he desires to control.

For the present, the provisions made for calling the field stations and groups of controls for such stations, one at a time in a predetermined order, in case one or more control levers of different groups of the same or different stations are actuated simultaneously or in rapid succession, will not be explained; but rather the movement of control levers for only one group of controls for a particular station will be considered.

In the control machine illustrated (see Fig. 1A), the control levers SML, SGL and COL are associated with the first group of controls for the particular field station shown in Figs. 2A and 2B, by reason of their association with the relays SR¹, CD¹ and CDR¹, which, in combination with certain code jumpers, determine the proper code calls for the selection of that station and that particular group of controls of the station.

The actuation of any control lever of a particular group of levers from one position to another, momentarily opens the stick circuit of the corresponding storing relay SR. The relays SR are made sufficiently quick acting so that their contacts will assume deenergized positions, if their stick circuits are opened for an interval of time equal to the shortest time in which the contacts of the associated levers may be moved from one position to another.

For example, the stick circuit for the relay SR¹ is traced from (+), through contact 16 of lever COL in either extreme position, contact 12 of lever SGL in any one of its three positions, contact 10 of lever SML in either extreme position, front contact 20 of relay SR¹, lower winding of relay SR¹, to (—).

If the operator moves any one or all of the levers SML, SGL and COL to new positions, the stick circuit for the relay SR¹ is momentarily opened until the levers have assumed their new positions, which is sufficient to cause the contacts of this storing relay to assume deenergized positions.

With a storing relay, such as SR¹, deenergized, the corresponding code determining relay, such as CD¹, is energized through a circuit which is closed only with the system in an at rest normal condition. This pick-up circuit for the relay CD¹ is traced from (+), through back contact 21 of the last stepping relay LS, back contact 22 of the relay ES, wires 23 and 24, back contact 25 of cycle controlling relay CC, wire 26, back contact 27 of relay ST, wire 28, front contact 29 of storing relay SR³, wire 30, front contact 31 of storing relay SR², wire 32, back contact 33 of storing relay SR¹, upper winding of relay CD¹, to (—).

The relay CD¹ is maintained energized through a stick circuit from (+), through back contact 21 of stepping relay LS, back contact 22 of relay

ES, wires 23, 34, 35 and 36, front contact 37 of relay CD¹, lower winding of relay CD¹, to (—). The relay CD¹ is maintained energized by this stick circuit until the end of the operating cycle upon which it effectively causes the code calls and controls associated therewith to be transmitted.

When the relay CD¹ is energized, it picks up its repeating relay CDR¹ through front contact 38 included in a circuit obvious from the drawings. Also, with the code determining relay CD¹ energized, a circuit for energizing the starting relay ST is closed from (+), back contact 39 of relay SL⁰, wire 40, winding of relay ST, wires 41, 42 and 43, front contact 44 of relay CD¹, to (—).

The starting relay ST closes a pick-up circuit for the cycle controlling relay CC from (+), through front contact 45 of relay ST, wires 46 and 47, winding of relay CC, to (—). The cycle controlling relay CC is maintained energized throughout the cycle of operation, thus initiated, by a stick circuit closed from (+), through back contact 21 of stepping relay LS, back contact 22 of relay ES, wires 23 and 24, front contact 25 of cycle controlling relay CC, wires 48 and 47, windings of relay CC, to (—).

The energization of the cycle controlling relay CC immediately starts the system into operation by placing the first impulse upon the stepping circuit. However, before considering the manner in which the stepping circuit receives its successive impulses, it is convenient to consider how the polarity of these impulses is determined or selected in accordance with the code of the station to be selected, the code of the group to be selected and the controls to be transmitted.

Polarity selection of stepping impulses.—The communication system of this invention is provided with suitable means for energizing the stepping circuit with direct current impulses of either positive or negative polarity, the particular polarity applied being predetermined in accordance with the code calls and controls to be transmitted during the respective parts of the operating cycle.

The polarity selecting relay PS pole changes the impulses applied to the stepping circuit as supplied by the impinging means from battery BT¹. This relay PS is of the two position polar magnetic stick type, having its contacts actuated to right or left hand positions by reason of the polarity of potential applied to its windings with the relay CS deenergized or energized respectively. Negative impulses are applied to the stepping circuit with contacts 49 and 50 of this relay PS in right hand positions; while positive impulses are applied to the stepping circuit with contacts 49 and 50 in left hand positions.

With the relay CS deenergized or energized, (B—) or (B+) are respectively placed upon the relay PS during the deenergized condition of the stepping circuit (message or execution period of each step) through a circuit including back or front contact 51 of relay CS respectively, wire 52, back contact 53 of relay LR⁰, wire 54, winding of relay PS, to (CN).

The code sending relay CS is energized or left deenergized upon each step, to select the desired polarity of the impulse for the next step, in accordance with the energized or deenergized condition of the respective control buses 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411 and 412. When the system is at rest, for example, the relay CS is connected from (—), through winding

of relay CS, wire 55, to the control bus 401 through the back contacts of all of the stepping relays *a*, *b*, *c*, etc., and LS, so that the relay CS may be energized or left deenergized during the period of blank in accordance with the energized or deenergized condition of this code bus. Thus, the polarity of the first stepping impulse may be determined by the energization or deenergization of this control bus 401 prior to the actual response of the system to initiation.

When the first impulse is applied to the stepping circuit, the stepping relay *a* is picked up, irrespective of the polarity of this first impulse, in a manner later to be explained, and this connects the relay CS through front contact 70 of stepping relay *a* to the control bus 402. If this bus is energized, the next or second impulse applied to the stepping circuit will be positive; while, if the control bus 402 is left deenergized, the second stepping impulse will be negative.

When the second impulse is applied to the stepping circuit, the stepping relay *b* is picked up and the stepping relay *a* drops, irrespective of the polarity of the second impulse, which connects the relay CS to the control bus 403 through back contact 70 of relay *a* and front contact 71 of relay *b*.

In the same manner as explained for the control buses 401 and 402, the code sending relay CS is connected to the remaining control buses upon the successive steps, and depending upon whether these buses are energized or deenergized, the code sending relay CS is energized or left deenergized thereby determining whether the stepping impulses shall be positive or negative.

The control buses are selectively energized or deenergized, to provide the desired code calls and controls. In the embodiment of the present invention, the control buses 401, 402, 403, 404 and 405 are controlled in accordance with the code call jumpers of a particular station for each cycle through front contacts of the code determining relay CD corresponding to that station; the control bus 406 is controlled in accordance with the cut-out lever of a particular station for each cycle through front contacts of the corresponding code determining repeater relays CDR of the corresponding station; the control buses 407, 408 and 409 are controlled in accordance with the code call of the particular group of controls for the station through front contacts of the corresponding code determining repeating relay CDR; and the control buses 410, 411 and 412 are controlled in accordance with the control levers of the corresponding group of controls through front contacts of the corresponding code determining repeater relay CDR.

In the arrangement shown, providing for five station selecting steps, one transfer step, three group selecting steps and three control steps, twelve control buses are necessary; but it should be understood that arrangements of code buses, similarly controlled by contacts of similar stepping relays could be provided for various other arrangements of code calls and controls.

As the impinging means, for applying a series of time spaced impulses of selected polarity to the stepping circuit, includes the operation of the stepping relay bank in the control office to thereby regulate the time spacing of the impulses in accordance with the actual response of the system, an understanding of the operation of the stepping relay banks is necessary before considering how the series of impulses is actually applied to the stepping circuit.

Operation of stepping relay bank.—The step-by-step means at the control office and at each field station comprises, a number of neutral relays forming a stepping relay bank, together with a half step polar magnetic stick type relay. The application of a series of impulses to the stepping circuit causes the stepping relays of each bank to sequentially operate in synchronism with the stepping relays of every other such bank, irrespective of the polarity of the impulses.

Assuming for the present that a series of time spaced impulses of selected polarity can be suitably applied to the stepping circuit with the first impulse of relatively long duration to mark the beginning of the series or cycle, in a manner later to be explained, we will consider the operation of the stepping relay bank with more specific reference to the relay bank of Fig. 2A, as the operation of this bank is typical of all others.

With the system normally at rest, or in the period of blank, the half step relay HS is energized with positive potential from (B—), through back contacts 56, 57, 58, 59, 60 and 61 on the stepping relays 6, 5, 4, 3, 2 and 1 respectively, winding of relay HS, back contact 62 of relay LR, to (CN). Thus, whenever the system is at rest, the relay HS is always returned to its normal position in readiness for initiation of the system into a cycle of operation.

The line relay L, included in the stepping circuit, is of the three position biased-to-neutral polar type relay, which actuates its contacts to one extreme position or the other in accordance with the polarity of the impulse applied to the stepping circuit, but irrespective of the position to which the contacts of the relay L are operated, the relays SL and LR are energized in series, as obvious from the drawings (see Fig. 2A).

The application of the first impulse to the stepping circuit results in the energization of the quick acting line repeating relay LR with the slow acting line repeating relay SL responding to this impulse a short time thereafter. This closes a pick-up circuit for the stepping relay 1 from (+), through polar contact 63 of relay HS in a right hand position, wire 64, front contact 65 of relay LR, wire 66, back contact 67 of relay SL, wires 68 and 69, lower winding of stepping relay 1, back contact 72 of stepping relay 2, to (—).

Upon the energization of the relay SL, this pick-up circuit of the stepping relay 1 is opened at back contact 67, but its stick circuit is completed from (+), through front contact 73 of relay SL, wires 74, 75 and 76, front contact 77 of stepping relay 1, upper winding of stepping relay 1, back contact 72 of stepping relay 2, to (—). This arrangement requires that the contact 73 of relay SL preferably be made before back contact 67 is opened.

The energization of the stepping relay 1 closes a pick-up circuit for the stepping relay 2 through front contact 78, but as the same polarity is applied to both terminals of the lower winding of the stepping relay 2, it remains deenergized.

Upon the deenergization of the stepping circuit, the relay LR is deenergized, closing a circuit from (B+), through front contact 61 of stepping relay 1, winding of relay HS, back contact 62 of relay LR, to (CN). This reversal of polarity upon the relay HS, causes it to actuate its contact 63 to the left hand dotted line position, in readiness for applying suitable polarity to the lower winding of the stepping relay 2 to accomplish its

energization as soon as the relay LR is again energized closing front contact 65.

Upon the application of the next impulse to the stepping circuit, the relay LR is again energized, the slow acting relay SL of course remaining energized between the successive impulses, the pick-up circuit for the stepping relay 2 is closed from (—), through polar contact 63 of relay HS in a left hand position, wire 64, front contact 65 of relay LR, wire 66, front contact 67 of relay SL, wires 79 and 80, front contact 78 of stepping relay 1, lower winding of stepping relay 2, back contact 81 of stepping relay 3, wires 82, 83, 75 and 74, front contact 73 of relay SL, to (+).

This energization of the stepping relay 2, opens the stick circuit of stepping relay 1, at back contact 72, and closes its own stick circuit from (—), through front contact 72, upper winding of relay 2, back contact 81 of stepping relay 3, wires 82, 83, 75 and 74, front contact 73 of relay SL, to (+).

The energization of the stepping relay 2 also closes the pick-up circuit of the stepping relay 3, but as explained for the stepping relay 2, the same potential is applied to both terminals of the lower winding of stepping relay 3.

Upon the next deenergization of the stepping circuit, the relay LR is deenergized closing the energizing circuit for relay HS from (B—), through front contact 69 of stepping relay 2, back contact 61 of stepping relay 1, winding of relay HS, back contact 62 of relay LR, to (CN). This actuates the polar contact 63 of relay HS to a right hand position.

Upon the application of the next impulse to the stepping circuit, the relay LR is energized, the slow-acting relay SL of course remaining energized between successive impulses, and the pick-up circuit of the stepping relay 3 is closed from (+), through polar contact 63 of relay HS in a right hand position, wire 64, front contact 65 of relay LR, wire 66, front contact 67 of relay SL, wires 79 and 80, back contact 78 of stepping relay 1, front contact 84 of stepping relay 2, lower winding of stepping relay 3, back contact 85 of stepping relay 4, to (—).

The energization of the stepping relay 3 opens the stick circuit of the stepping relay 2 at back contact 81 and closes its own stick circuit which may be understood by analogy to the stick circuits of stepping relays 1 and 2.

Upon the next deenergization of the stepping circuit, the relay LR is deenergized closing the energizing circuit of the relay HS, from (B+), front contact 59 of stepping relay 3, back contacts 60 and 61 of stepping relays 2 and 1 respectively, winding of relay HS, back contact 62 of relay LR, to (CN).

This operation of the stepping relays is continued from step to step for as many steps as may be required, causing the stepping relay banks to operate sequentially and in synchronism at the control office and at each field station irrespective of the polarity of the impulses applied to the stepping circuit.

Impulsing of the stepping circuit.—It has been explained, how the polarity of the impulses applied to the stepping circuit is determined or selected in accordance with the code calls and the controls desired to be transmitted by suitable control of a polarity selecting relay PS provided with pole changing contacts. Also, the operation of the stepping relays has been described. Therefore, consideration may now be given to

the operation of the impulsing means for applying these impulses to the stepping circuit at the proper time spaced intervals in accordance with the actual response of the system.

The impulsing means is arranged to apply current of the selected polarity to the stepping circuit for a predetermined time interval, conveniently termed an operating or conditioning period, and then deenergized the stepping circuit for another predetermined time interval, conveniently termed the execution or message period. In other words, a step may be said to comprise the energization and deenergization of the stepping circuit. When the system is initiated from an at rest condition, the first impulse is made a long impulse with respect to the succeeding impulses to mark the beginning of the operating cycle; while the end of each operating cycle is made distinctive by the relatively long interval of time between the last impulse of one cycle and the first impulse of the next cycle. This interval of time between cycles of operation is conveniently termed the period of blank, or at rest period.

The energization of the cycle controlling relay CC (see Fig. 1D), in a manner above explained, causes the first impulse of that cycle to be placed upon the stepping circuit, with the polarity of this impulse determined by the position of the contacts of relay PS. The stepping circuit is traced, depending upon the position of relay PS, either from the negative terminal of the battery BT¹ in the control office (see Fig. 1D), through front contact 85 of relay CC, wire 87, back contact 88 of impulsing relay IM, wire 89, polar contact 50 of relay PS in a right position, wires 90 and 91, winding of line relay L⁰, through the stepping and control line to the first field station, through the line relay L at that station (see Fig. 2A), and similarly through the stepping line and the relays at the remaining stations to the common return line at the last station, and thence back to the control office, wires 92 and 93, polar contact 49 of relay PS in a right hand position, wire 94, back contact 95 of impulsing relay IM, wire 96, front contact 97 of relay CC, to the positive terminal of the battery BT¹; or from the positive terminal of the battery BT¹, through front contact 97 of relay CC, wire 96, back contact 95 of impulsing relay IM, wire 94, polar contact 49 of relay PS in a left hand position, wires 90 and 91, winding of line relay L⁰, thence through the stepping and control circuit including the line relay L at each station to the common return line at the last station, and thence back to the control office, wire 92, polar contact 50 of relay PS in a left hand position, wire 89, back contact 88 of relay IM, wire 87, front contact 85 of relay CC, to the negative terminal of battery BT¹.

This application of potential to the stepping circuit causes the polar contacts of the line relays L to be energized either to right or left hand positions, depending upon the polarity, which in turn causes the energization of the line repeating relays SL and LR irrespective of the polarity applied to the stepping circuit, as heretofore explained. The stepping relays at the control office and at each of the field stations are thus caused to take the first step, as previously explained.

The energization of the slow-acting line repeating relay SL⁰ (see Fig. 1D), causes the deenergization of the starting relay ST at back contact 39 which then drops away according to its slow-acting characteristics. With the stepping relay *a* energized and the starting relay ST

deenergized, the impulsing relay IM receives energy through a circuit from (+), through back contact 45 of relay ST, wire 101, polar contact 102 of relay HS⁰ in a right hand position, wire 103, upper winding of impulsing relay IM, wire 104, front contact 105 of stepping relay a, to (-).

This energization of the impulsing relay IM opens the stepping circuit at back contact 88 and 95, which of course causes the deenergization of the quick acting line repeating relays LR.

The deenergization of the relay LR⁰ in the control office causes the half step relay HS⁰ to assume a new position, for reasons previously pointed out, thereby opening the energizing circuit of the impulsing relay IM at polar contact 102 of relay HS⁰. The deenergization of the impulsing relay IM causes the stepping circuit to be again energized with a polarity in accordance with the position of the relay PS which relay is also controlled while the relay LR⁰ is deenergized, as previously explained.

The energization of the stepping circuit causes the next step to be taken at the control office and at each of the field stations. As soon as the second stepping relay b has responded in the control office, an energizing circuit for the impulsing relay IM is completed from (+), through back contact 45 of relay ST, wire 101, polar contact 102 of relay HS⁰ in a left hand position, wire 106, lower winding of impulsing relay IM, wire 107, front contact 108 of stepping relay b, back contact 105 of stepping relay a, to (-). This energization of the impulsing relay IM again opens or deenergizes the stepping circuit thereby dropping relay LR⁰ etc., and thus actuating the half step relay HS⁰.

This alternate energization and deenergization of the stepping circuit continues until the end of the operating cycle, at which time it is deenergized for a relatively long period of time to mark the end of the cycle. This period of blank may be more conveniently explained in describing the end of the operating cycle which will be taken up under a separate heading.

In summary, the conditioning period of the first step (interval of time during which the stepping circuit is energized) includes the pick-up times of the relays L⁰, SL⁰ and IM, together with the drop-away time of the relay ST, as compared with the conditioning period of every other step which includes the pick-up times of relays L⁰, LR⁰, a stepping relay and the relay IM. Thus, the conditioning period of the first step (energization of the stepping circuit) is longer than the remaining conditioning periods by the difference in the pick-up time of relays SL⁰ and LR⁰ together with the difference between the drop-away time of the relay ST and the pick-up time of any stepping relay.

The execution period of each step (interval of time between successive impulses of a cycle during which the stepping circuit is deenergized) includes the drop-away time of relays L⁰, LR⁰, IM and the operating time of relay HS⁰.

Thus, a series of time-spaced impulses, with polarities selected in accordance with the code calls and controls to be transmitted, is placed upon the stepping circuit causing a series of steps to comprise a cycle of operation. As the impulsing means includes the step-by-step means, the impulses of each series or cycle are therefore time spaced in accordance with the actual response of the system.

Sequence of station selection.—It is apparent that only one combination of positive or nega-

tive impulses, constituting a code call for selection of a particular group of a particular station, can be applied to the stepping circuit during any one operating cycle. If it were possible for more than one code call to be applied to the same circuit at the same time, the resultant code call would be false or mutilated in such a manner as to select either the wrong station or the wrong group of a station.

The operator might be relied upon to actuate the control levers for the several stations and groups of such stations for controlling one group of a particular station at a time, so as to avoid such mutilation or interference of the code calls; but the system of this invention provides that the code calls shall be automatically sent out, one at a time on each operating cycle, regardless of the sequence or rapidity with which the operator may manipulate the control levers on the control machine. With such an arrangement, the operator can devote his attention to the making of plans for the handling of traffic and keeping such records and account of the trains and other details as may be required for the proper operation of a railroad.

This feature of automatic determination of which code call shall be transmitted during a particular operating cycle, is provided by the storing relays SR and the code determining relays CD through means of interlocked circuits allowing the energization of but one code determining relay CD regardless of the number of storing relays SR which may be deenergized as the result of the manipulation of several control levers to new positions simultaneously or in rapid succession.

For each group of levers, corresponding to a particular group of controls for a particular field station, there is a storing relay SR, a code determining relay CD, and a code determining repeating relay CDR. The actuation of any lever, in such a group of levers, to a new position momentarily opens the stick circuit of the corresponding storing relay which remains deenergized, until the code calls and controls associated therewith have been insured of transmission.

While the system is at rest, or in the period of blank, the deenergization of any storing relay SR will pick up its corresponding code determining relay CD providing there are no other storing relays deenergized or code determining relays energized. The pick-up circuit for any relay CD in the bank includes a back contact of its corresponding storing relay SR, and front contacts of each storing relay to the right of it, which prevents its energization if any of the storing relays to the right are deenergized. With a particular relay CD energized, the relays CD to the right thereof are prevented from picking up by reason of their pick-up circuits including a back contact on each of the relays CD to the left. For example, assuming the deenergization of the storing relay SR² subsequent to the deenergization and energization of the relays SR¹ and CD¹ respectively, the pick-up circuit for the relay CD² would be opened at back contact 44 of relay CD¹.

In other words, the pick-up circuit of each code determining relay CD in the bank includes a back contact of its corresponding storing relay, a front contact of each storing relay SR to the right of it, and a back contact of each code determining relay CD to the left of it, besides the back contacts upon the relays LS, ES, CC

and ST which serve to prevent the energization of a code determining relay CD except during the period of blank.

If several of the storing relays SR are deenergized in rapid succession by operation of their corresponding levers, the relay SR first to be deenergized will pick up its corresponding relay CD, but thereafter the other relays CD will pick up in a sequence from right to left, as will be evident from the study of the circuits illustrated in Fig. 1A. As heretofore pointed out, each control and code determining means may be associated either with a station as a whole or with a group of controls for a station. This means that, if the operator actuates several levers simultaneously or in rapid succession, regardless of whether such levers are in the same group of levers for a particular group of controls of a particular station or in some other group for the same or a different station, the stations and groups within such stations are called in an order or sequence determined by the location of the corresponding code determining relay CD in this bank of interlocked relays.

Although these relays CD, as above explained, will be energized in a sequence from right to left, the several groups of levers may be connected to the relays SR in any desired order, thereby predetermining the order in which the stations and groups of such stations will be selected. This feature makes it unnecessary for the operator to take count of the operating cycles of the system in order to properly move his levers, but rather he may move the levers in any manner he desires and the system automatically calls the stations and groups within the stations, one at a time in a predetermined sequence, in accordance with the importance of the station as originally determined in making the connections in the interlocked bank of relays.

With only one code determining relay CD and repeater relay CDR energized at a time, the control buses 401, 402 and 403 and so forth, will be respectively connected to one group of station code jumpers, one group of group code jumpers, and one group of control levers for any one cycle of operation. As the code sending relay CS is connected to the control buses 401, 402, 403 and so forth, upon successive steps, each impulse of the series of impulses placed upon the stepping circuit will be of positive or negative polarity in accordance with those station code jumpers, group code jumpers and control levers associated with the particular code determining relay CD then energized for that cycle of operation.

For example, the energization of the code determining relay CD¹ causes the transmission of a series of impulses comprising a cycle of operation as follows:—(—), (—), (+), (+), (+), for the station code call; (—) for the transfer step; (—), (—), (—) for the group code call; and (—), (—), (—) for the controls. This of course assumes that the levers and code jumpers are in the positions as shown, it being understood that one or more control levers must be moved to new positions to initiate the system and cause the transmission of controls, thereby changing the polarity of the corresponding control impulses. The movement of the switch machine lever SML from a normal position to a reverse position, for example, energizes the relay CD¹, initiates the system, and causes the transmission of station and group code call impulses together with a transfer step impulse as above

pointed out, and a series of control impulses now having the polarities (—), (—), (+).

Station selection.—When controls are to be transmitted from the control office, the field stations are selected one at a time in accordance with the combination of positive and negative impulses applied to the stepping circuit for a certain number of steps; while the groups of controls within such stations are selected one at a time in accordance with the combination of positive and negative impulses applied to the stepping circuit for a certain number of succeeding steps.

As above pointed out, each impulse applied to the stepping circuit causes the step-by-step means at the control office and at each of the field stations to take one step, irrespective of the polarity of these impulses. Since the polarity of the impulse causing each step may be made either positive or negative, a number of different combinations of impulses may be obtained depending upon the number of steps.

In other words, during the first or selecting part of the operating cycle, combinations of positive and negative impulses are transmitted, which combinations may be conveniently termed code calls. Each one of these code calls, transmitted during the selecting part of the operating cycle, may be termed a total code call and must be transmitted to select a particular group of controls of a particular field station, before such controls may be transmitted from the control office. For convenience in discussing the selecting part of the operating cycle, those impulses of the total code call, transmitted to select the particular station, may be termed the station code call; while the remaining number of impulses of the total code call, transmitted to select the particular group within the station, may be termed the group code call.

In this type of code, a choice of positive and negative impulses on each of two steps gives four different combinations of impulses or code calls, three steps gives eight different code calls, four steps gives sixteen different code calls, five steps gives thirty-two different code calls, and so on, each additional step doubling the number of possible distinctive code calls. Such an arrangement of positive and negative impulses to obtain eight combinations or code calls for three steps is shown below in a Typical code table, which table may be extended for any number of steps.

Typical code table

Code call	Step one	Step two	Step three
1.-----	+	+	+
2.-----	+	+	—
3.-----	+	—	+
4.-----	+	—	—
5.-----	—	+	+
6.-----	—	+	—
7.-----	—	—	+
8.-----	—	—	—

With a code call assigned to each field station, selection is made between half of the total number of stations on the first station selecting step, depending upon whether it is a positive or a negative impulse. Similarly, on the second station selecting step, a selection is made between half of the stations remaining after the first selection, depending upon the polarity of the second impulse, leaving only one quarter of the total number of stations. This elimination of stations is carried on for as many steps as may

be required until only one station remains on the last station selecting step.

In a similar manner, selection is made between half of the groups within the selected station upon the first group selecting step; between half of the remaining groups upon the second group selecting step, and so on, for as many group selecting steps as may be required.

The embodiment of the present invention, provides five station selecting steps and three group selecting steps, which give thirty-two station code calls and eight group code calls (for each station) respectively, or two hundred and fifty-six total code calls for a system having thirty-two stations of eight groups each. It is to be understood, however, that all stations do not need to be divided into the same number of groups, but rather are arranged to meet the particular requirements of the particular station in each case. A code table for this number of station selecting and group selecting steps may be arranged by reference to the Typical code table shown, which table illustrates the code combinations or code calls for three steps only for the sake of simplicity.

The field stations are arranged, so that the transmission of any particular total code call during a particular cycle, results in the selection of a certain group of a particular station, all other groups of the same station and all other stations being prevented from selection by suitable means hereinafter described.

The circuits for each field station selecting equipment or apparatus are similar, the only difference being in the positions of a number of station code jumpers, which serve to condition or energize one or the other of two station selecting buses in accordance with the code call assigned to that station. The transmission of a code call, connects a selecting stick circuit of a station selecting relay SO to one or the other of these station selecting code buses. If the code call transmitted, corresponds to the code call assigned to the station, then the selecting stick circuit will be connected to an energized bus for each step; but if the transmitted code call does not correspond to the station code call, then this selecting stick circuit will be connected to a deenergized bus for one step, thereby causing the corresponding station selecting relay SO to be deenergized. The station with which communication is held, is the one at which the station selecting relay SO remains energized, all other stations except this one having been dropped out during the station selecting part of the operating cycle.

More specifically considering the operation, station selection will be explained with reference to Fig. 2A of the accompanying drawings, which illustrates a typical station selecting equipment.

During the period of blank, with the stepping circuit deenergized, the quick acting line repeating relay LR is deenergized with its contacts down (see Fig. 2A). During this period of blank, the relay P is conditioned in accordance with the code jumper 110. If the code jumper 110 is connected in an inactive position, the relay P is deenergized; but, if the code jumper 110 is connected in an active position, the relay P is energized through a circuit from (+), through code jumper 110, back contacts 111, 112, 113, 114, 115 and 116 of the stepping relay bank, wire 117, back contact 118 of transfer relay TR, wire 119, lower winding of relay P, wires 120 and 121, back contact 122 of relay LR, to (-).

Upon the application of the first impulse to the stepping circuit of either positive or negative polarity, depending upon the particular code call to be transmitted, the quick-acting line repeating relay LR is energized causing the first stepping relay 1 to be energized through its pick-up circuit as heretofore pointed out. At the same time, a pick-up circuit for the relay SO is completed from (+), through front contact 123 of relay LR, wire 124, back contact 125 of relay SL, wires 126 and 127, upper winding of relay SO, to (-).

The contacts of the relay SO are now in an up or energized position and are maintained or held in such position by the completion of a stick circuit as soon as the relay SL is energized. This stick circuit may be termed the holding stick circuit, which is completed during the conditioning period of each step if the relay SO is up at the beginning of the corresponding step. In this case, during the conditioning period of the first step, the relay SO has just been energized and the relay SL closes this holding stick circuit before opening its pick-up circuit by reason of contact 125 of relay SL being a make-before-break contact. This holding stick circuit is completed from (+), through front contact 123 of relay LR, wire 124, front contact 125 of relay SL, wire 126, back contact 129 of relay TR, wire 130, front contact 131 of relay SO, wire 127, upper winding of relay SO, to (-).

During this conditioning period (first) with the relay LR energized and its contacts up, the relay P is held in the same condition existing during the period of blank. If the relay P remained deenergized during the period of blank, then such condition is maintained or held during the conditioning period of the first step; but if the relay P was energized during the period of blank, then it is maintained or held energized during the conditioning period of the first step, by reason of a stick circuit from (+), through upper winding of relay P, front contact 132 of relay P, wires 133 and 134, front contact 122 of relay LR, to (-).

Also, during this conditioning period of the first step, the relay PR is conditioned (energized or left deenergized) in accordance with the condition of the relay P. If the relay P is deenergized, the relay PR is deenergized, but; if the relay P is energized, the relay PR is energized from (+), through front contact 135 of relay P, lower winding of relay PR, wires 136 and 134, front contact 122 of relay LR, to (-).

Either the "+" or "-" bus is energized, depending upon the position of relay PR, from (+), through back contact 137 of stepping relay 6, wire 138, back contact 139 of relay TR, wire 140, front contact 141 of relay SL, wire 142, to either the "+" bus or the "-" bus through front or back points respectively of contact 143 of relay PR depending upon whether the relay PR is energized or deenergized.

The relay IS is also conditioned, during the conditioning period of this first step, in accordance with the position to which the contacts of the relay L are actuated as determined by the polarity of this first impulse. If the first impulse is negative, (B-) is applied through contact 144 of relay L in a left hand position, winding of relay IS, front contact 62 of relay LR, to (CN); but if the impulse is positive, (B+) will be applied through polar contact 144 of relay L in a right hand position, winding of relay IS, front contact 62 of relay LR, to (CN).

Depending upon the polarity of the impulse, the relay IS connects the selecting stick circuit of the relay SO to either the "+ bus" or the "- bus." For example, if the impulse is positive, the selecting stick circuit is connected to the "+ bus" from (-), through lower winding of relay SO, front contact 145 of relay SO, polar contact 146 of relay IS in a right hand position, to the "+ bus"; but, if the impulse is negative, the selecting stick circuit is connected to the "- bus" from (-), through lower winding of relay SO, front contact 145 of relay SO, polar contact 146 of relay IS in a left hand position, to the "- bus."

Thus, the selecting stick circuit of the relay SO is energized or deenergized depending upon whether the polarity of the impulse connects its selecting stick circuit to the particular "+" or "-" bus which is energized in accordance with the code jumper 110.

During the execution period of the first step with the stepping circuit deenergized and the contacts of the relay LR down, the position of the relay PR is maintained or held. If the relay PR is deenergized during the conditioning period, it is maintained deenergized; but if it is energized during the conditioning period, it is maintained energized during the execution period by reason of a stick circuit from (+), through front contact 73 of relay SL, wires 74 and 147, front contact 148 of relay PR, wires 149 and 150, upper winding of relay PR, wires 151 and 121, back contact 122 of relay LR, to (-).

The deenergization of the relay LR opens the holding stick circuit of the relay SO at front contact 123, thereby making the relay SO dependent upon the energization or deenergization of its selecting stick circuit. In other words, the relay SO is selected or dropped out in accordance with whether the preceding impulse was positive or negative connecting the selecting stick circuit of the relay SO to the particular "+" or "-" bus which is energized by reason of the station code jumper 110. If the code jumper 110 is connected in an inactive position, the relay PR is deenergized, thereby requiring, in order to select the relay SO, that the code impulse shall be a (-) impulse to connect the selecting stick circuit of the relay SO to the "- bus"; but if the code jumper is connected in an active position then the relay PR is held energized, thereby requiring, in order to select the relay SO, that the code impulse shall be a (+) impulse to connect the selecting stick circuit of the relay SO to the "+ bus."

At half of the stations, the code jumper 110 is connected in an inactive position, while at the other half of these stations it is connected in an active position. Thus, if the first impulse is negative, then a certain half of the stations will be selected by maintaining the relays SO energized at those stations; but if the first impulse is positive, the other half of the stations will be selected by maintaining the relays SO energized at those stations.

During the execution period of the first step, the pick-up circuit of the relay PR is opened at front contact 122 of relay LR and its holding stick circuit is connected through back contact 122, so that the relay P can be conditioned in accordance with the next code jumper 152. For example, if the code jumper 152 is connected in an inactive position, the relay P is deenergized during this execution period (first); but, if the code jumper

152 is connected in an active position, the relay P is energized from (+), through code jumper 152, front contact 116 of stepping relay 1, wire 117, back contact 118 of relay TR, wire 119, lower winding of relay P, wires 120 and 121, back contact 122 of relay LR, to (-).

If the relay SO is selected or maintained energized during the execution period of the first step, its holding stick circuit is closed during the next conditioning period (application of the second impulse to the stepping circuit), thereby causing it to be held in such energized condition until the execution period of the second step. On the other hand, if the relay SO is dropped out during the execution period of the first step, it is held in such deenergized position or condition throughout the remainder of the operating cycle.

Upon the application of the next impulse (second) of the code call to the stepping circuit, the relay LR is energized, the relay IS is conditioned, the relay P is maintained or held in its previous condition established during the preceding execution period, the relay PR is conditioned, thus energizing the "+" or "-" bus in accordance with the next code jumper 152 and connecting the selecting stick circuit of the relay SO to one or the other of the selecting buses in accordance with the polarity of the code call impulse.

If the relay SO is held energized during the conditioning period of the second step, it is made dependent upon the energization or deenergization of its selecting stick circuit upon the deenergization of the relay LR with its contact 123 in a down position during this execution period (second). In other words, the relay SO is again selected or dropped out in accordance with whether the preceding impulse (second) was positive or negative connecting the selecting stick circuit of this relay SO to the particular "+" or "-" bus which is energized by reason of the station code jumper 152. If the code jumper is connected in an inactive position, the "- bus" is energized, thereby requiring, in order to select the relay SO, that the code impulse shall be a (-) impulse to connect the selecting stick circuit of the relay SO to the "- bus"; but, if the code jumper 152 is connected in an active position, then the "+ bus" is energized, thereby requiring, in order to select the relay SO, that the code impulse shall be a (+) impulse to connect the selecting stick circuit of the relay SO to the "+ bus".

That half of the stations requiring a (-) impulse upon the first step, is in turn divided in halves with one half requiring the code jumper 152 to be connected in an inactive position, and with the opposite half requiring that the code jumper 152 be connected in an active position. Similarly, that half of the stations requiring a (+) impulse for the first step, is also divided into halves, one half of which requires that the code jumper 152 be connected in an inactive position, while the opposite one requires that the code jumper 152 be connected in an active position. This arrangement and assignment of the code calls to the various stations may be better understood by reference to the Typical code table.

Thus, if the second impulse is negative, then a certain half of those stations, selected upon the execution period of the first step, will be selected upon the execution of the second step by maintaining the relays SO energized at such stations; but if the second impulse is positive, the other half of those stations, selected upon the first step, will be selected by maintaining the relays SO

energized at such stations during the execution period of the second step.

This selection continues throughout the station selecting steps for as many steps as may be required, depending upon the number of stations, until the station selecting relay SO is energized at only one station, which is the station that will receive a group code call to select a particular group of controls therein.

The station code jumpers 110, 152, 166, 167 and 168, for the station selecting equipment illustrated in Fig. 2A of the accompanying drawings, are arranged to cause its associated apparatus to be responsive to the code call (—), (—), (+), (+), (+), which is the station code call transmitted over the stepping circuit during a cycle of operation with the code determining relay CD¹ energized in the control office (see Fig. 1A) in accordance with the station code jumpers 171, 172, 173, 174 and 175. In other words, the operation of the system, when initiated by the movement of any one or all of the control levers SML, SGL and COL, will operate to select the field station equipment illustrated in Figs. 2A and 2B.

The operation of the system for station selection may be briefly summarized with reference to Fig. 5 of the accompanying drawings, which illustrates in a graphic manner the sequence of operation of certain relays in what may be termed a Typical Operation Chart.

The first column in the chart (reading from left to right) designates the relays, or the like, which are to be described, while the remaining columns designate in order the operations of these relays as they occur during a cycle of operation. The operations are described in the chart by the use of certain key words taken from the description, as will be readily apparent.

The stepping circuit is deenergized during the period of blank (see Fig. 5 column 2 opposite "Stepping circuit" in column 1) and during the execution period of each step (see Fig. 5 columns 4 and 6); while it is energized with positive or negative impulses during the conditioning period of each step (see Fig. 5 columns 3 and 5) in accordance with the code calls or controls being transmitted. Whenever the stepping circuit is deenergized, the relay LR is deenergized and its contacts are down; but, whenever the stepping circuit is energized, irrespective of the polarity, the relay LR is energized and its contacts are up.

For the transmission of controls (see Fig. 5 under "outgoing"), the relay P is conditioned during the period of blank and during the execution period of each step in accordance with the code jumpers or indications to be transmitted; while the condition of the relay P established during the period of blank and the execution period of each step is maintained or held during the conditioning period of each step, irrespective of whether the relay P was in an energized or deenergized condition.

During the period of blank, the contacts of the relay PR are down, except when the system is initiated from the field in a manner to be hereinafter pointed out. During the conditioning period of each step, the relay PR is conditioned in accordance with the energized or deenergized condition of the relay P; while the condition of the relay PR established during each conditioning period is maintained or held during the following execution period.

The impulse storing relay IS is of the magnetic stick type, so as to maintain its contacts in their last operated positions. Thus, the contacts of

the relay IS may be said to be held during the period of blank and during the execution period of each step, while they are conditioned or actuated only during the conditioning period of each step.

The contacts of the relay SO are always down during the period of blank and are always picked up at the beginning of a cycle of operation, during the conditioning period of the first step, being held in such positions until the execution period of the first step. If the conditions of the relays PR and IS correspond, the relay SO is selected or maintained energized during the execution period of each step, but if the conditions of these relays do not correspond during the execution period of a particular step, then the relay SO is dropped out or deenergized upon such execution period. Upon the conditioning period following each execution period, the relay SO is held or maintained energized through a stick circuit if it was selected or maintained energized upon the preceding execution period; while, if it was dropped out or deenergized upon the preceding execution period, it remains in such a condition throughout the remainder of that cycle of operation. This selection of the relay SO, or in other words, the comparison between the code call transmitted and the code call of the station by comparing the conditions of the relays PR and IS, occurs during the execution period of each of the station selecting steps of the cycle, for as many steps as may be desired.

This scheme of selection may be said to be upon the subdivision or elimination basis, as all of the station selecting relays SO are energized at the beginning of a cycle, and one-half of those relays are deenergized upon the first step, one-half of the remaining relays deenergized upon the second step, and so on, until the SO relay at only one station remains energized.

Transfer and repeat operations.—At each field station where the code call impulses transmitted over the stepping circuit do not correspond to the code call combination assigned to that station, the station selecting relay SO at such station is dropped out before the end of the last station selecting step, so that the step taken upon the application of the next or transfer impulse (sixth in this case) to the stepping circuit, is the last step in that cycle of operation for such a station. In other words, when a station is not selected, its stepping bank of relays locks up on the sixth step, and remains in that condition until the period of blank at the end of that particular operating cycle, when the stick circuit of the stepping relay provided for the transfer step, is opened by the deenergization of the slow acting line repeating relay SL.

On the other hand, at that field station of the system where the code call transmitted corresponds to the code call assigned to that station, the relay SO is selected or maintained energized throughout the station selecting steps, so that upon the next step after the last station code call step (sixth step), the transfer relay TR is energized through a circuit from (+), through front contact 137 of stepping relay 6, wire 153, front contact 154 of relay SO, wire 155, upper winding of transfer relay TR, to (—). The energization of the transfer relay TR completes its own stick circuit in series with the holding stick circuit of the relay SO from (+), through front contact 73 of relay SL, wires 156 and 157, lower winding of relay TR, front contact 129 of relay TR, wire 130, 75

front contact 131 of relay SO, wire 127, upper winding of relay SO, to (—).

The energization of the transfer relay TR together with the energization of the relay SO indicates the selection of that station for outgoing controls and conditions the stepping relay bank at such a station for a repeat operation.

It is noted that the sixth step (transfer step) is taken irrespective of the polarity of the stepping impulse (sixth) in a similar manner as the preceding steps, and the transfer relay TR is energized dependent upon the condition of the relays SO and SI (the operation of the relay SI being explained hereinafter). However, the polarity of the transfer step (sixth) is employed for the cut-out control later to be explained.

With the transfer relay TR energized upon the transfer step, the application of the next impulse (seventh) to the stepping circuit causes the energization of the first stepping relay 1 through a circuit from (+), through polar contact 63 of relay HS in a right hand position, wire 64, front contact 65 of relay LR, wire 66, front contact 67 of relay SL, wires 79 and 153, front contact 159 of stepping relay 6, wire 160, front contact 161 of transfer relay TR, wires 162 and 69, lower winding of stepping relay 1, back contact 72 of stepping relay 2, to (—).

The energization of the stepping relay 1 opens the stick circuit for the stepping relay 6 at back contact 77. This deenergization of the stepping relay 6 closes a pick-up circuit for the transfer repeating relay TRR from (+), through back contact 137 of stepping relay 6, wire 138, front contact 139 of transfer relay TR, lower winding of transfer repeating relay TRR, to (—). The energization of the transfer repeating relay TRR completes its own stick circuit from (+), through front contact 73 of relay SL, wires 156 and 153, front contact 164 of relay TRR, upper winding of relay TRR, to (—).

With the transfer relays TR and TRR together with the relay SO energized, the stepping relay bank repeats its operation, thereby closing a series of circuits, one for each step, to the control buses 701, 702, 703, 704, 705 and 706 which then receive energy in accordance with the position of the impulse storing relay IS for the respective steps.

This repeat operation is employed only for the stepping relay banks of the field stations for the purpose of economizing in the number of stepping relays required for each such bank, and need not be employed if an additional number of stepping relays is provided to sequentially step after the selection of the station. In the control office, all of the stepping relays must operate through for each cycle of operation, and do not need to be locked up upon the transfer step under any conditions. Also, the repeat operation is not employed in the control office by reason of the additional circuits which are required to be completed by each of the stepping relays, thereby making it more desirable to use each relay only once for each cycle of operation.

Control group selection.—After the selection of the station and the transfer step has been taken, as above explained, the stepping relays at such selected field station are operated through the second time to complete the cycle of operation. During this continued operation a plurality of circuits are closed which receive energy in accordance with the polarity of the impulses applied to the stepping circuit. According to the present invention, a part of these circuits are em-

ployed to divide the controls of the station into groups, while the remainder of these circuits are employed for the actual transmission of the controls of a particular group.

In the field station equipment illustrated in Figs. 2A and 2B, six steps are taken after the transfer step, so as to complete six distinctive circuits one for each step. Although these circuits may be employed in any combination desired so as to divide the controls into a certain number of groups with each group including a certain number of controls governed after the selection of the corresponding group, the specific illustration provides that three steps be employed for group selection and three steps for the reception of controls.

When the field station shown in Figs. 2A and 2B is selected, for example, with the relays SO, TR and TRR energized, the contact 165 of relay IS applies either positive or negative potential to the buses 701, 702, 703, 704, 705 and 706 upon the respective steps in accordance with the polarity of the impulses applied to the stepping circuit. The first three of these buses 701, 702 and 703 are connected to group selecting pilot relays G, so that upon each of the first three steps after the transfer step, the respective relay G is energized or left deenergized in accordance with the polarity of the impulse applied to the stepping circuit for that step. If the impulse is negative (—), the particular relay G for that step is left deenergized, but if the impulse is positive (+), that particular G relay is energized.

The particular combination of impulses transmitted forms the group code call and is employed to select the particular group to which controls are to be transmitted for that cycle of operation. Two such G relays provide four groups, three G relays provide eight groups, and so on, for as many group selecting steps as may be needed for the requirements of each station. It is obvious that these code call combinations for the groups are arranged in a similar manner as explained for the code calls employed for selecting the station, the Typical Code Table given being similarly applicable thereto.

If, for example, the group to be selected is the first group, due to the movement of one of the control levers associated with that group in the control office, then the group code applied to the stepping circuit is (+), (+), (+) in accordance with the code jumpers 177, 178 and 179 placing energy upon the relay CS for each of the three group selecting steps. Thus, for each of these steps, the contact 165 of relay IS is actuated to a right hand position thereby placing (B+) upon the control buses 701, 702 and 703. The energizing circuit of the relay G¹ is traced from (B+), through contact 165 of relay IS in a right hand position, wire 180, back contact 181 of relay LR, wire 182, front contact 183 of relay SO, wire 184, front contact 185 of relay TR, wire 186, front contact 187 of relay TRR, wire 188, front contact 189 of stepping relay 1, bus 701, lower winding of relay G¹, to (B—). The relays G² and G³ are energized on their respective steps through similar circuits. These group relays G¹, G² and G³ are maintained energized throughout the remainder of the operating cycle through stick circuits in multiple, as for example, the stick circuit for relay G¹ is closed from (+), through front contact 73 of relay SL, wires 74, 75, 83, 190, 191 and 192, through front contact 193 of relay G¹, 75

through the upper winding of the relay G^1 , to (-).

However, if some other group code call is transmitted including a (-) impulse, then the corresponding one of the group selecting relays G will remain deenergized.

During the execution period of the last group selecting step (ninth step in this case), the control group stick relay CGS is caused to be energized through a pick-up circuit from (+), through front contact 73 of relay SL, wires 74, 75, 83, 190, 191 and 194, winding of relay CGS, wires 195, 196 and 197, front contact 198 of relay TRR, wire 199, front contact 200 of stepping relay 3, wire 201, back contacts 84 and 78 of stepping relays 2 and 1 respectively, wires 80 and 79, front contact 67 of relay SL, wire 66, front contact 65 of relay LR, wire 64, polar contact 63 of relay HS in a left hand position, to (-). This circuit has positive potential (+) applied to both terminals of the relay CGS until the half step relay HS has responded after the deenergization of the relay LR at the beginning of the execution period of this ninth step, at which time this polar contact 63 of relay HS is actuated to a left hand position thereby placing negative potential (-) to the circuit as pointed out.

The energization of the relay CGS closes a stick circuit placing negative potential (-) to the left hand terminal of the relay CGS through front contact 202, and wires 203 and 195, which maintains the relay energized until the relay SL is deenergized at the end of the cycle.

The energization of the relay CGS places negative potential on the left hand terminal on the particular control group relay CG selected in accordance with the positions of the group selecting pilot relays G , until the end of the operating cycle. For example, with the relays G^1 , G^2 and G^3 energized as pointed out to select the first group of this station in correspondence with the group code call transmitted from the control office with the relay CD^1 energized, the relay CG^1 is energized from (+), through winding of relay CG^1 , wire 203, front contact 204 of relay G^3 , front contact 205 of relay G^2 , front contact 206 of relay G^1 , wires 207, 195 and 208, front contact 202 of relay CGS, to (-).

The relay CG^1 is thus selectively energized in accordance with its group code call, thereby closing through its front contacts, circuits from its corresponding group of function relays to the buses 704, 705 and 706. In a similar manner, any particular one of the remaining relays CG may be selected by the transmission of its corresponding group code call, to thereby connect its associated group of function relays to the control buses 704, 705 and 706. It is obvious that only one such group of function relays are connected to these buses during a particular cycle of operation.

Transmission of controls.—The particular group of function relays, which are connected to the control buses, are controlled upon the succeeding steps in accordance with the polarity of the impulses applied to the stepping line circuit. For example, with the lever SML in the position as shown, with the first group of this field station selected, then a negative (-) control impulse is placed upon the stepping circuit for the tenth step; but if the lever SML is in the opposite position, this stepping impulse is positive (+) in character. The polarity of this control impulse positions the impulse storing relay IS during the conditioning period of the tenth step,

during the conditioning period of the tenth step, in a manner heretofore explained, which then places either positive or negative potential upon the energizing circuit for the relay SMR during the execution period of this tenth step, from either (B+) or (B-), through polar contact 165 of relay IS either in a right or left hand position respectively, wire 180, back contact 181 of relay LR, wire 182, front contact 183 of relay SO, wire 184, front contact 185 of relay TR, wire 186, front contact 187 of relay TRR, wire 188, back contacts 189, 210 and 211 of stepping relays 1, 2 and 3 respectively, front contact 212 of stepping relay 4, bus 704, wire 213, front contact 214 of relay CG^1 , wire 215, winding of relay SMR, to (CN). The application of one potential or the other to the relay SMR, depending upon the position of contact 11 of the lever SML, actuates the polar contacts of the relay SMR to corresponding extreme positions, thereby causing the switch machine SM to operate the track switch TS to corresponding extreme positions.

Similarly, the relays DR and SGR are controlled in accordance with the polarity applied thereto, as determined by the polarity of the impulse applied to the stepping circuit on the eleventh and twelfth steps respectively in accordance with the positions of contacts 13 and 14 of the signal lever SGL to thereby control the associated signals.

End of operating cycle.—During the operation of the system, after the proper code call has been transmitted, the particular storing relay SR, then conditioned for causing the code calls to be transmitted, is energized so as to be in readiness for storing subsequent changes in position of its associated control levers. For example, the pick-up circuit for the relay SR^1 is closed upon the transfer step (sixth step) with the stepping relay f energized and with the corresponding code determining relay CD^1 energized, from (+), through front contact 216 of stepping relay f , wires 217, 218 and 219, front contact 220 of relay CD^1 , upper winding of relay SR^1 , to (-).

Should some other storing relay SR be deenergized, the code determining relay CD corresponding to such storing relay SR could not be energized while relay SR^1 is energized. Also, energy is not applied to the pick-up circuits of the relays CD until the cycle controlling relay CC is deenergized closing back contact 25 during the period of blank.

Upon the twelfth step with the stepping relay LS energized, the stick circuits for the relays CD^1 and CC are opened at back contact 21. The deenergization of the cycle controlling relay CC causes the cessation of impulses upon the stepping circuit and closes the pick-up circuit for the code determining relay CD next to be energized, as soon as the slow acting relay SL^0 is deenergized and the relays ES and LS become deenergized.

The energization of the stepping relay LS completes a pick-up circuit for the extra step relay ES without the application of a corresponding stepping impulse to the stepping circuit, from (+), through polar contact 221 of relay HS^0 in a right hand position, wire 222, back contact 223 of relay LR⁰, wire 224, winding of relay ES, wire 225, front contact 226 of stepping relay LS, back contacts 227, 228, 229, 230, 231, 232, 233, 234, 235, 108 and 105 of stepping relays $k, j, i, h, g, f, e, d, c, b$ and a respectively, to (-).

The energization of the extra step relay ES breaks the stick circuit for the last stepping relay LS at back contact 236 thereby causing the step-

ping relay LS to be immediately deenergized. The deenergization of the last stepping relay LS immediately opens the energizing circuit of the extra step relay ES at front contact 226. Thus, the application of the twelfth impulse to the stepping circuit causes the energization of the last stepping relay LS, the energization of the extra step relay ES, resulting in the deenergization of the stepping relay LS followed by the deenergization of the extra step relay ES, all of which occurs prior to the deenergization of the slow acting relay SL⁰ in the control office.

As there are no impulses placed upon the stepping circuit with the cycle controlling relay CC deenergized, the relay SL at each of the field stations becomes deenergized opening the stick circuit of the stepping relay 6, the stick circuit of the relay SO, the stick circuit of the transfer relays TR and TRR, the stick circuit of the control group selecting relay CGS, as well as opening various other circuits for other relays, which returns each of the field stations to their normal at rest condition. After sufficient time has elapsed, the slow acting relay SL⁰ in the control office becomes deenergized, it being slightly more slow acting than the relays SL at the field stations. This conditions the pick-up circuit of the starting relay ST, so that it may be energized in accordance with the energized condition of any code determining relay which may be now energized to again initiate the system into operation.

It is noted, that the deenergization of the relays LS and ES prior to the deenergization of the relay SL⁰ allows the next code determining relay CD to be energized, so as to be in readiness for the energization of the starting relay ST as soon as the relay SL⁰ has become deenergized. The deenergization of these relays LS and ES also conditions the stick circuit of the cycle controlling relay CC, so that it may be again stuck up as soon as the starting relay has picked it up, as well as conditioning the stick circuits of the code determining relays CD.

The time interval between the last impulse on the stepping circuit for one cycle and the first impulse for the next cycle includes the drop away time for relays L⁰ and SL⁰ and the pick-up time of relays ST and CC. This time interval when the system is at rest or in a period of blank is relatively long compared to the time interval between the impulses during the cycle which includes the drop away time of relays L⁰, LR⁰ and IM together with the operating time of relay HS⁰. The reason for the additional time, although there are four relay operations in each case, is the fact that the relays SL⁰ and ST are of the slow acting type.

Thus, at the end of an operating cycle for outgoing controls, there is a period of relatively long deenergization of the stepping circuit which causes the equipments at each of the field stations to assume their normal conditions ready for another operation; and in the control office those relays SR, CD and CDR effective for that cycle are returned to normal, and the relays CD and CDR for the next station to be called, if any, are picked up in turn causing energization of the starting relay ST. These operations occur simultaneously or in rapid succession, so that after a brief interval marked by the end of an operating cycle, another operating cycle can start, if there are any new controls to be transmitted to any other stations. The order in which the stations will be controlled, if new controls have been set up for several stations,

will be determined by the interlocked bank of relays SR and CD previously explained.

The end of an operating cycle, as just explained, is the same, when the system is automatically set into operation from a field station, in a manner presently to be explained, for the purpose of communicating new indications to the control office; and these operating cycles occur one after the other, as long as there are new controls to be transmitted from the control office to some field station and/or new indications are to be transmitted from some field station to the control office.

Indications.—Each field station includes a plurality of traffic controlling devices having indications to transmit to the control office. If the number of indications for these traffic controlling devices is not greater than the system can transmit or register in the control office during one cycle, then these indications comprise a single group and are transmitted after the registration of the station. On the other hand, when the number of these indications exceeds the number which can conveniently be transmitted to the control office during one cycle, these indications are then divided into several groups. For convenience, those indications associated with a single track switch have been selected as comprising each group, but any other suitable arrangement may be employed.

In accordance with the present invention, the message circuit is utilized for the transmission of indications to the control office from the various field stations, one station at a time during each operating cycle, and from the various groups of indications within such field stations, one group at a time during each operating cycle. In other words, a single group of indications may be transmitted during each operating cycle.

Although indications may be transmitted from any group of a field station simultaneously during the same operating cycle with the transmission of controls to any group of controls of that field station or any other field station, it is convenient to explain the communication of a single group of indications alone on an operating cycle before considering the features of simultaneous two-way transmission.

In the operation of a railroad, trains are located at various points along the railroad or territory under the supervision of the centrally located operator, and these trains may enter or leave various track circuits at the same time, also various devices for controlling these trains may be operated simultaneously or in rapid succession, which causes several groups of the same or different field stations to have indications standing ready for transmission at the same time.

If several groups within the same field station have indications standing ready for transmission at the beginning of a cycle of operation, only one group may be registered in the control office and transmit its indications during that cycle, the remaining groups being registered in an order or sequence determined by a bank of interlocked group determining relays. This feature of the present invention will be considered separately under the heading "Sequence of group registration".

If several groups within different stations have indications standing ready for transmission at the beginning of a cycle of operation, only one group from one particular station can be registered in the control office and transmit its indications during that cycle, with the particular

group within the station being determined by the group determining interlocked bank of relays and with the particular station being determined by the relative superiority of the code call characteristic of that station with respect to the code calls characteristic of the other stations. The remaining stations register their respective groups in accordance with their respective code call characteristics during succeeding cycles of operation. This feature of the present invention will be considered separately under the heading "Sequence of station registration".

The operation of the communication system to transmit indications to the control office, involves automatic starting, the registration of a particular field station, the registration of a particular group of indications within that station, and finally the transmission of the indications of this group.

Automatic starting.—The field station illustrated in Figs. 2A and 2B is indicated as having three groups of indications, but the system, providing three group registering steps, is capable of handling eight such groups. Also, the third group is the only one shown in detail. This group has been associated with the track switch TS by way of illustration, but may be associated with any other indicating devices as desired.

Each group of indicating devices has associated therewith a change relay CH which is normally energized through a stick circuit. Whenever a change in condition of any device within a particular group occurs, the stick circuit of the change relay CH for that group is deenergized. The deenergization of one or more of these change relays CH results in the initiation or automatic starting of the system.

For example, (see Fig. 2B) the entrance of a train into the track section TK, causes the deenergization of the track relay T, in turn causing the energization of the track storing relay STR through back contact 240 included within a circuit obvious from the drawings. The energization of the track storing relay STR momentarily opens the stick circuit of the relay CH³ by movement of contact 241 from a back to a front contacting position, thereby causing the contacts of relay CH³ to assume deenergized positions. Likewise, the change in condition of any of the other devices in this group, such as relays SIG and WP, will cause the deenergization of relay CH³. The stick circuit for the relay CH³ is closed from (+), through front or back points of contact 241, front or back points of contact 242, front or back points of contact 243, front contact 244, lower winding of relay CH³, to (—).

In this connection, it is noted that the change relays CH are of the quick acting type and become deenergized if their stick circuits are momentarily opened by the movement of the contacts of relatively slow acting relays from front to back, or back to front positions. This use of a quick acting relay having a stick circuit passing through front and back contacts of a series of relatively slow relays, to provide that a change in any number of these relatively slow relays will be insured of registration, has been set forth more fully in the pending application of Darrol F. DeLong et al. Ser. No. 477,364 filed August 23, 1930, now U. S. Letters Patent 1,852,402, granted March 5, 1932, and need not be herein considered in detail.

The deenergization of the change relay CH³ closes a pick-up circuit for a change storing relay CHS from (+), through front contact 241 of

relay STR (in this case, but back contact 241 if relay STR had been deenergized), front or back contact 242 of relay SIG, front or back contact 243 of relay WP, back contact 244 of relay CH³, wires 245, 246 and 247, upper winding of relay CHS, to (—). The energization of this change storing relay CHS closes its own stick circuit from (+), through back contacts 248 and 249 of the relays SI and TR respectively in multiple, through front contact 250 of relay CHS, lower winding of relay CHS, to (—).

With the system in the period of blank, the energization of the change storing relay CHS completes a pick-up circuit for the relay SI from (+), through back contact 251 of relay SL, front contact 252 of relay CHS, upper winding of relay SI, to (—).

Also, a pick-up circuit for the relay PR is completed from (+), through back contact 137 of stepping relay 6, wire 138, back contact 141 of relay SL, relay TR, wire 140, back contact 141 of relay SL, wire 253, front contact 254 of relay CHS, wires 255 and 150, upper winding of relay PR, wires 151 and 121, back contact 122 of relay LR, to (—).

The energization of the relays SI and PR opens the message circuit at contacts 256 and 257, thereby deenergizing the message circuit including the relay M⁰ at the control office and a relay M at each field station. At the control office the deenergization of the relay M⁰ causes the energization of the starting relay ST, which in turn energizes the cycle controlling relay CC initiating the system into operation in the manner described for the transmission of controls.

This energizing circuit for the starting relay ST is traced from (+), through back contact 39 of relay SL⁰, wire 40, winding of relay ST, wires 41, 42, 43 and 258, front contact 259 of relay SR¹, wire 260, front contact 261 of relay SR², wire 262, front contact 263 of relay SR³, and through similar front contacts on the remaining SR relays, wire 264, back contact 265 of relay M⁰, wire 266, back contacts 267, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 108 and 105 of the relays ES, LS, k, j, i, h, g, f, e, d, c, b and a respectively, to (—).

The energization of the starting relay ST causes the energization of the cycle controlling relay CC as above pointed out, placing an impulse upon the stepping circuit to cause the first step.

During such a cycle of operation, when no controls are being transmitted, all of the code determining relays CD deenergized, the control buses 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411 and 412 are deenergized, the code sending relay CS is deenergized, all of which causes the polarity selecting relay PS to remain in its normal position for placing negative impulses (—) upon the stepping circuit throughout the cycle. In other words, for a cycle of operation for the transmission of indications only, each impulse, placed upon the stepping circuit to cause the operation of the step-by-step means at the control office and at each field station, is of negative polarity.

Although the particular polarity of these stepping impulses makes no difference in the operation insofar as communication of indications to the control office is concerned, it is necessary that one particular combination of code impulses, which is not employed for selection purposes, be applied to the stepping circuit, when no controls are being transmitted, to thereby prevent the transmission of false controls.

Station registration for indications.—The operation of the system will now be considered when only one group of one field station has indications standing ready for transmission and when no controls are being transmitted from the control office. In this case, the system is initiated into operation from that field station during the period of blank, in a manner above described, energizing the stepping circuit with a series of impulses which has not been assigned as a code call.

With reference to Fig. 2A of the accompanying drawings, the first stepping relay is energized upon the application of the first impulse to the stepping circuit during the time period between the successive energizations of the relays LR and SL, as heretofore pointed out.

Upon the energization of the relay SL, a holding stick circuit is completed for the relay SI from (+), through front contact 123 of relay LR, wire 124, front contact 125 of relay SL, wire 128, back contact 129 of relay TR, wires 130 and 276, front contact 271 of relay SI, upper winding of relay SI, to (−). Inasmuch as the pick-up circuit for the relay SI includes back contact 251 of relay SL, it is necessary that front contact 125 of relay SL be closed prior to the opening of back contact 251 of this relay.

In the event that more than one field station is transmitting indications, the relay SI is selectively energized or deenergized in accordance with the position of the relay M during the execution period of each of the station selecting steps, which functioning of the system is more conveniently explained under the heading "Sequence of station registration", but for the present, where only one station has indications standing ready for transmission, it may be assumed that the relay SI remains selectively energized throughout the entire cycle of operation.

When the system is not transmitting indications, the relay SI at each station is deenergized, so that the message circuit is completed and normally energized. For example, at the field station illustrated (see Fig. 2A) the message circuit is completed from the right hand terminal of the relay M, through wires 272 and 273, back contact 256 of the relay SI (when it is deenergized), wires 274, 275 and 276, to the message line extending to the next field station.

However, with this field station having indications standing ready for transmission, the relay SI is energized before the system is initiated, causing the completion of the message circuit at this field station to be dependent upon the contacts 277 and 257 of the relays P and PR respectively. But with the system at rest, the relay LR is deenergized completing a shunt circuit around the contact 277 of relay P from the heel of contact 277, through wire 278, back contact 279 of relay LR, wires 280, 275 and 276, to the back point of contact 277 of relay P. Thus, to initiate the system, the relay PR is energized which opens the message circuit at back contact 257.

The application of the first impulse to the stepping circuit for this cycle of operation, energizes the relay LR closing a shunt circuit around the contact 257 of relay PR from back point of contact 257 and the right hand terminal of relay M, through wires 272 and 281, front contact 279 of relay LR, wire 278, to the heel of contact 257 of relay PR. In other words, the condition of contact 257 may be said to be shunted or covered.

The energization of the relay LR opens the

shunt circuit around contact 277 of relay P a back contact 279 of relay LR, or in other words, the condition of contact 277 may be said to be uncovered. Thus, the energization of the message circuit is now dependent upon back contact 277 of relay P.

As previously explained, the relay P is conditioned in accordance with the station code jumper 110 during the period of blank, such condition being maintained or held during the following conditioning period. If the code jumper 110 is connected in an inactive position, the relay P is deenergized during this conditioning period of the first step causing the message circuit to be completed immediately upon the application of the first impulse to the stepping circuit, and simultaneously with the operation of the stepping relay 1; while, if the code jumper 110 is connected in an active position, the relay P is energized and the message circuit is maintained open during the conditioning period of the first step by reason of open back contact 277.

During the execution period of the first step, the relay LR is deenergized and the contact 277 of relay P is shunted or covered through a circuit previously traced, but the relay PR has been conditioned in accordance with the relay P during the preceding conditioning period, in a manner previously explained, so that the deenergization of the relay LR opens the shunt circuit around this contact 257 of relay PR, thereby causing the condition of the message circuit established by the relay P to be continued during the execution period of the first step.

Thus, if the code jumper 110 is connected in an inactive position corresponding to a (−) code impulse, the message circuit remains energized during the first step, but if it is connected in an active position corresponding to a (+) code impulse, the message circuit remains open or deenergized for that step (first).

The opening of front contact 123 of relay LR does not drop the relay SI at the calling station, although its holding stick circuit is open, as the relay SI is maintained energized during this execution period (first) through its selecting stick circuit, hereinafter discussed.

As the back contact 277 of relay P is shunted during the execution period of this step (first), the condition of the relay P does not effect the message circuit, although it is now being conditioned in accordance with the position of the code jumper 152, as previously explained.

Upon the application of the next impulse to the stepping circuit (second), the relay LR is energized covering the condition or position of contact 257 of the relay PR and uncovering the condition or position of the contact 277 of relay P, so as to condition the message circuit in accordance with the position of the code jumper 152, immediately upon the energization of the stepping circuit. If the code jumper 152 is connected in an inactive position, the relay P is deenergized during the conditioning period of this step (second) causing the message circuit to be closed or energized; but if the code jumper 152 is connected in an active position, the message circuit is opened.

During the execution period of the second step, the relay LR is deenergized and the contact 277 of relay P is shunted through a circuit previously traced, but the relay PR has been conditioned in accordance with the relay P during the preceding conditioning period, so that the deenergization of the relay LR opens the

shunt circuit around contact 257 of relay PR, and causes the condition of the message circuit established by the relay P to be continued during the execution period of this step (second).

Thus, if the code jumper 152 is connected in an inactive position corresponding to a (—) code impulse, the message circuit is energized during the second step, but if it is connected in an active position corresponding to a (+) code impulse, the message circuit is opened or deenergized for the second step.

In a similar manner, these relays P and PR are effective to open or close the message circuit during each of the remaining steps in accordance with the condition of relay P established during the execution period of the preceding step. This control of the message circuit through the medium of the relays P and PR with the relay SI energized is in accordance with the station code jumpers for the first five selecting or registering steps, and is in accordance with the group code jumpers, in a manner presently to be explained, upon the remaining selecting steps.

Thus, if the station code jumpers are arranged in such positions as to correspond to a station code call (—), (—), (+), (+) and (+) as illustrated in Fig. 2A, then the message circuit will be closed, closed, opened, opened and opened upon the respective station selecting or registering steps, so as to energize or deenergize the relay M at the control office and at each field station.

The manner, in which a field station controls the message circuit on certain steps in accordance with the station code call for that station, has been explained, so that the functioning of the system to register the condition of the message circuit on those steps in the control office may now be considered with reference to Figs. 1A, 1B, 1C and 1D.

In the control office, the deenergization of the relay M⁰ during the period of blank causes the initiation of the system, as previously explained. This results in the sequential and synchronous operation of the step-by-step means at the control office and at each field station.

During the execution period of the first step with the relay a energized, the control bus 601 is energized from (B—) or (B+), depending upon the energized or deenergized position respectively of contact 282 of relay M⁰, through wire 283, back contact 284 of relay LR⁰, wire 285, front contact 286 of stepping relay a, to indication bus 601.

Upon the application of the next impulse to the stepping circuit, the second stepping relay b is energized, so that upon the deenergization of the stepping circuit during the execution period of the second step, the indication bus 602 is energized from (B—) or (B+) through a similar circuit as above traced for indication bus 601, but including front contact 287 and back contact 286 of relays b and a respectively.

In other words, upon the successive steps, as closed by this step-by-step means in the control office, the indication buses 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611 are respectively energized with positive or negative potential during the execution period of the respective steps in accordance with the deenergized or energized condition of the relay M⁰.

The right hand terminals of the respective upper windings of the pilot relays PT¹, PT², PT³, PT⁴ and PT⁵ are directly connected to the indication buses 601, 602, 603, 604 and 605 respectively,

and the left hand terminals of these windings are connected to (B—). Thus, if a particular indication bus is energized with negative potential (B—) by the front contact 282 of relay M⁰, then the corresponding pilot relay PT remains deenergized as the same potential is applied to its opposite terminal, while if positive potential (B+) is applied to a particular indication bus by back contact 282 of relay M⁰, then the corresponding pilot relay PT is energized.

In other words, a pilot relay PT is energized or left deenergized on each of the station selecting or registering steps depending upon whether the message circuit is deenergized or energized respectively during the execution period of each of those steps. If a pilot relay PT is energized on its respective step, it is maintained energized throughout the remainder of the operating cycle by means of a stick circuit; but if it is not energized on its respective step, it remains deenergized throughout the remainder of the cycle.

In the case where only one station is ready to transmit indications, the message circuit is governed by the station code jumpers of that station only, so that the pilot relays PT assume energized or deenergized positions in accordance with the active or inactive positions of the respective station code jumpers.

For example, if the station transmitting is the one illustrated in Figs. 2A and 2B, the code call is (—), (—), (+), (+), (+), which closes the message circuit on the first two steps and opens the message circuit on the last three steps, so as to leave the relays PT¹ and PT² deenergized and to energize the relays PT³, PT⁴ and PT⁵. The relay PT³, for example, is energized during the execution period of the third step from (B+), through back contact 282 of relay M⁰, wire 283, back contact 284 of relay LR⁰, wire 285, back contacts 286 and 287 of stepping relays a and b respectively, front contact 288 of stepping relay c, indication bus 603, upper winding of relay PT³, to (B—). This relay PT³, for example, is maintained energized throughout the remainder of the operating cycle through a stick circuit from (+), through front contact 39 of relay SL⁰, wires 289, 290, 291, 292, 293, 294, 295, 296, 297, 298 and 299, front contact 300 of relay PT³, lower winding of relay PT³, to (—).

With the pilot relays PT assuming positions in accordance with the code call of the station having new indications standing ready for transmission, the station registering relays C and CR, corresponding to the code call registered, are energized upon the transfer step (sixth in this case) and are maintained energized during the rest of the cycle by the use of a station stick relay STS.

The pick-up circuit for the station stick relay STS is completed from (+), through front contact 216 of relay f, wire 301, back contact 302 of relay STS, wires 303 and 304, winding of relay STS, to (—). The contact 302 of this relay STS is of the make-before-break type so that upon closing its front contact, it is maintained energized through a circuit from (+), through front contact 39 of relay SL⁰, wires 289, 290, 291, 292, 293, 294, 295, 296, 305 and 306, front contact 302 of relay STS, wires 303 and 304, winding of relay STS, to (—).

The energization of the station stick relay STS completes a circuit for energizing the selected station relays, such for example as relays C³ and CR³ with the corresponding code call registered as pointed out, from (+), through the pick-up

and stick circuits of the relay STS to the heel of contact 302 of relay STS, through wires 303 and 307, front contacts 308, 309, and 310 of the relays PT⁵, PT⁴ and PT³ respectively, back contacts 311 and 312 of relays PT² and PT¹ respectively, wire 313, winding of relay C³, wire 314, winding of relay CR³, to (—).

As the relays PT are maintained in their positions registering the code call of the station, and the relay STS is maintained energized through a stick circuit including front contact 39 of the relay SL⁰, the station relays C and CR of the station registered are maintained energized throughout the remainder of the operating cycle.

It is noted, that in some cases where the number of selecting or registering steps is comparatively large, a large number of contacts will be required for some of the pilot relays PT. In such cases repeater relays are preferably provided. The present invention also provides that the pilot relays having the largest number of contacts or repeater relays shall be controlled first, or in what may be termed a reverse order, so that all repeater relays shall have had time to assume their proper positions prior to the energization of the station stick relay STS. Although this particular arrangement of pilot relays has been illustrated and described for the pilot relays PT in the control office, it is to be understood, that such an arrangement may be applied to any other bank of selecting pilot relays either at the control office or at the field stations, in such cases where it appears desirable to do so.

Group registration.—On the next step after the last station selecting step, the transfer step is taken (sixth in this case) thereby energizing the transfer relay TR at the station calling from (+), through front contact 137 of stepping relay 6, wires 153 and 315, front contact 316 of relay SI, wires 317 and 155, upper winding of relay TR, to (—).

The transfer relay TR is not picked up at any of the other stations, because the relay SI is not up at any of these stations, due to the fact that no indications were standing ready for transmission with the change storing relay CHS energized at the time of the first impulse on the stepping circuit. Although the change storing relay CHS might be picked up shortly after this first impulse, the station selecting relay SI at that station cannot be energized, as its pick-up circuit includes back contact 251 of relay SL which is open subsequent to the first impulse.

When the transfer relay TR is energized at the station calling, it completes a stick circuit for itself and for the relay SI in series from (+), through front contact 73 of relay SL, wires 156 and 157, lower winding of relay TR, front contact 129 of relay TR, wires 130 and 270, front contact 271 of relay SI, upper winding of relay SI, to (—).

The energization of the transfer relay TR opens back contact 118 disconnecting the lower winding of the relay P from the control of the station code jumpers and connects it through front contact 118, so as to be controlled by the indication buses 801, 802, 803, 804, 805, 806 upon the succeeding steps in accordance with the group code jumpers and indication contacts.

As the transfer relay TR is energized during the conditioning period of this step (sixth), the relay P is controlled in accordance with the energized or deenergized condition of the indication bus 801 during the execution period of this step.

In the specific illustration employed as the em-

bodiment of the present invention, the first three steps following the transfer step are employed for the transmission of group code calls. Thus, the indication buses 801, 802 and 803 are connected to the group code jumpers corresponding to the group determining relay GD then energized, only one of which may be energized during any particular cycle of operation.

The provisions made for registering the groups of a particular field station in the control office, one at a time, in a predetermined order, in the event that several groups within the same station have new indications standing ready for transmission at the same time, will be considered hereinafter under the heading "Sequence of group registration".

For the present assuming that only one group of the station illustrated has new indications standing ready, then the deenergization of the corresponding change relay CH picks up the corresponding group determining relay GD, which is then held energized for that operating cycle, as more conveniently discussed in connection with the sequence of group registration.

For example, with the relay CH³ deenergized, as previously explained, the relay GD³ is energized (later to be explained) which causes the buses 801, 802 and 803 to be connected to the group code jumpers 320, 321 and 322. Thus, during the execution period of the transfer step (sixth), the relay P is energized or is left deenergized depending upon whether the group code jumper 320 is connected in an active or inactive position respectively. If the code jumper 320 is connected in an inactive position, the relay P remains deenergized; but if it is connected in an active position, it is energized from (+), through group code jumper 320, front contact 323 of relay GD³, indication bus 801, front contact 324 of stepping relay 6, back contacts 325, 326, 327, 328 and 329 of stepping relays 5, 4, 3, 2 and 1 respectively, wire 330, front contact 118 of transfer relay TR, wire 119, lower winding of relay P, wires 120 and 121, back contact 122 of relay LR, to (—).

During the conditioning period of the next step (seventh), the relay P is held in its prior condition in a manner heretofore pointed out, and conditions the relay PR in accordance therewith. The energization of the relay LR uncovers the condition of contact 277 of relay P, thereby conditioning the message circuit in accordance with the code jumper 320. This condition of the message circuit is maintained through the execution period of this step (seventh) by the contact 257 of relay PR, which is held in its prior condition, as heretofore pointed out.

Thus, if the group code jumper 320 is connected in an active position corresponding to a (+) code call, the message circuit is open during the seventh step. If on the other hand the code jumper 320 is connected in an inactive position, the message circuit remains energized during the seventh step corresponding to a (—) code call.

In a similar manner, this control of the message circuit for the transmission of group code calls may be carried on for as many steps as desired, but in the illustration only three steps (seventh, eighth and ninth steps) are employed for this purpose. The group code jumpers corresponding to the group determining relay GD³ are arranged to transmit a code call of (+), (—), (+) for registering the corresponding group in the control office.

In the control office, irrespective of the particular station which is registered therein, the

group selecting relays GS are connected through the corresponding station registering relay C to the indication buses 606, 607 and 608, if the indications of the corresponding station are divided into more than one group.

During the conditioning period of the seventh step, the stepping relay *g* is energized. Thus, upon the deenergization of the stepping circuit for the execution period of this step, the indication bus 606 is energized with positive or negative potential in accordance with the position of contact 282 of the relay M^0 which either energizes or leaves deenergized the group selecting relay GS^1 respectively. If, for example, the relay M^0 is energized, (B—) is connected through front contact 282 of relay M^0 , wire 283, back contact 284 of relay LR^0 , wire 285, back contacts 286, 287, 288, 331, 332 and 333 of relays *a*, *b*, *c*, *d*, *e* and *f* respectively, front contact 334 of stepping relay *g*, indication bus 606, wire 335, front contact 336 of station relay C^3 wire 337, group selecting bus 338, upper winding of relay GS^1 to (B—). In this case, the relay GS^1 remains deenergized as like potentials are applied to both terminals of its upper winding. If on the other hand, the relay M^0 is deenergized, (B+) is applied through the circuit just traced including back contact 282 so as to energize this relay GS^1 .

Similarly, during the execution period of the remaining group selecting steps, the relays GS^2 and GS^3 are respectively controlled in accordance with the energized or deenergized condition of the relay M^0 .

When a group selecting relay GS is energized it is maintained energized for that cycle of operation through a stick circuit. For example, when the relay GS^1 is energized, a stick circuit is closed from (+), through front contact 39 of relay SL^0 , wires 289, 290, 291, 292, 293, 294, 295, 296, 297, 278, 299, 339, 340 and 341, front contact 342 of relay GS^1 , lower winding of relay GS^1 , to (—).

With the relay GD^3 energized for this cycle of operation, the code call transmitted is (+), (—), (+), as heretofore pointed out, so that the relays GS^1 and GS^3 will be energized, while the relay GS^2 will remain deenergized. The contacts of these group selecting relays GS are arranged in a fan fashion in a similar manner as the contacts on the station selecting pilot relays PT so that the application of positive potential to the heel of contact 343 of relay GS^3 , applies energy to a particular one of the group registering buses 501, 502, 503, 504, 505, 506, 507 and 508 corresponding to the group code call transmitted by the field station.

The relay GS^3 , the last to be operated, is energized or left deenergized during the conditioning period of the last group registering step (ninth), so that energy is applied to the particular group selecting bus to be energized during the execution period of this same step (ninth).

The station registering relay CR connects, through front contacts the bank of indication group registering relays IG corresponding to the station selected, to the group selecting buses 501, 502, 503, 504, 505, 506, 507 and 508, so that one of these relays is energized in accordance with the group code call transmitted, as registered on the group selecting relays GS.

For example, with a field station registered by the energization of the relays C^3 and CR^3 , then the relay IG^3 is energized during the conditioning period of the tenth step through a circuit closed from (—), through polar contact 221 of

relay HS^0 in a left hand position, wire 222, front contact 223 of relay LR^0 , wire 344, front contact 345 of relay SL^0 , wire 346, back contacts 347, 348, 349, 350, 351, 352, 353 and 354 of relays *a*, *b*, *c*, *d*, *e*, *f*, *g* and *h* respectively, wire 355, front contact 356 of relay *i*, wires 357 and 358, front contact 343 of relay GS^3 , back contact 359 of relay GS^2 , front contact 360 of relay GS^1 , group selecting bus 503, front contact 361 of relay CR^3 , winding of relay IG^3 , to (+).

This energized relay IG^3 is maintained energized by the use of an indication group stick relay IGS which is energized in multiple therewith, from wire 357, through wires 362 and 363, winding of relay IGS, wires 364, 305, 296, 295, 294, 293, 292, 291, 290 and 289, front contact 39 of relay SL^0 , to (+). The momentary energization of the relay IGS closes front contact 365 connecting negative potential (—) through front contact 365, wire 363, winding of relay IGS, thence through the circuit heretofore traced including front contact of relay SL^0 , to (+). The relay IG^3 receives energy until the end of the cycle when relay IGS is deenergized, through a circuit from (—), through front contact 365 of relay IGS, wires 362 and 358, front contact 343 of relay GS^3 , back contact 359 of relay GS^2 , front contact 360 of relay GS^1 , group selecting bus 503, front contact 361 of relay GR^3 , winding of relay IG^3 , to (+).

The registration in the control office of a particular group of a field station having new indications to communicate to the control office has been explained, and by way of example the third indication group for the station illustrated, is explained as registered by the energization of station registering relays C^3 and CR^3 and the indication group relay IG^3 .

Transmission of indications.—As the relay P is conditioned by a particular code jumper during the execution period of each step preceding the step upon which the message circuit is conditioned in accordance with that code jumper, the relay P is conditioned during the execution period of the ninth step in accordance with the indication contact of the first indication to be transmitted on step ten.

For example, with the relay GD^3 energized, the indication contact 366 of relay STR is connected to the indication bus 804, so as to condition the relay P in accordance therewith. If front contact 366 is closed, then the relay P is energized during the execution period of the ninth step; but if the front contact 366 is open, then the relay P remains deenergized, thus causing the message circuit to be open or closed during the tenth step in accordance with the closed or open condition of contact 366 of relay STR.

If, for example, the relay STR is energized due to a train having passed over the detector track section TK, then the relay P is energized during the execution period of the ninth step through a circuit from (+), through front contact 366 of relay STR, wire 367, front contact 368 of relay GD^3 , indication bus 804, front contact 327 of stepping relay 3, back contacts 328 and 329 of stepping relays 2 and 1 respectively, wire 330, front contact 118 of relay TR, wire 119, lower winding of relay P, wires 120 and 121, back contact 122 of relay LR, to (—).

Likewise, the contact 369 of signal relay SIG and the contact 370 of relay WP similarly energize or leave deenergized the relay P in accordance with the positions during the execution period of their respective steps ten and

eleven, so as to control the message circuit in accordance therewith on steps eleven and twelve respectively.

In the control office during the execution period of the tenth step, positive or negative potential is applied to the relay IR^1 in accordance with the energized or deenergized condition of the relay M^0 through a circuit from either (B-) or (B+), through either front or back contact 282 of relay M^0 respectively, wire 283, back contact 284 of relay LR^0 , wire 285, back contacts 286, 287, 288, 331, 332, 333, 334, 371 and 372, front contact 373 of relay j , indication bus 602, wire 374, front contact 375 of relay C^3 , indication bus 376, wire 377, contact 378 of relay IG^3 , winding of relay IR^1 , to (CN). If the message circuit is open, in accordance with the closed condition of front contact 366 of relay STR at the field station, then (B+) is placed upon the relay IR^1 causing contact 379 to be actuated to a left hand position; while if the message circuit is energized in accordance with the opened position of front contact 366 of relay STR, then (B-) is placed upon the relay IR^1 causing the contact 379 of relay IR^1 to be actuated to a right hand position. With the contact 379 of relay IR^1 in a left hand position, a circuit is closed for indicator lamp I from (+), through polar contact 379 of relay IR^1 in a left hand position, wire 380, indicator lamp I, to (-). In other words, if the contact 366 of relay STR is closed, then the indicator lamp I is illuminated, but if the contact 366 of relay STR is open, then the indicator lamp I is not illuminated, indicating the occupied or unoccupied condition respectively of the track circuit TK.

In a similar manner, the relays IR^2 and IR^3 are controlled upon their respective steps in accordance with the energized or deenergized condition of the message circuit on those steps governed by their respective indication contacts 369 and 370 of the relays SIG and WP respectively. The contacts of the relays IR^2 and IR^3 may respectively be employed in any suitable manner to indicate the condition of the signals SE^1 , SE^2 , SW^1 , SW^2 and the position of the track switch TS.

The indication storing relays IR associated with each of the other relays IG^1 , IG^2 , etc., to IG^3 are also connected to the buses 376, 381 and 382 when the corresponding relay IG is energized, but only one of which may be energized at one time.

At the end of the last step (twelfth) the cycle controlling relay CC is energized with the last step relay LS (see Fig. 1C) energized, causing the system to enter the period of blank in readiness for another cycle of operation, as previously explained.

During such a cycle of operation, where only one group of a particular station has indications to transmit, the change relay CH for that group is energized or resensitized, so to speak, during the transfer step (sixth).

For example, assuming the relay GD^3 to be energized, a pick-up circuit is completed for the relay CH^3 from (+), through front contact 333 of stepping relay 6, wire 384, back contact 385 of relay TRR, wire 386, front contact 387 of relay SI, wires 388, 389 and 390, front contact 391 of relay GD^3 , wire 392, upper winding of relay CH^3 , to (-).

Also, during such a cycle of operation, with the relays SI and TR both energized, the stick circuit for the relay CHS is opened at back contacts 248 and 249 of relays SI and TR respectively,

so that the system is not again initiated until another change in indication condition occurs.

However, if other groups in the same station have new indications to transmit, the change storing relay CHS is not deenergized during the cycle, and the system is again automatically initiated into operation for the transmission of such remaining new indications, in a manner presently to be explained.

Sequence of group registration.—It may happen, as previously pointed out, that among the large number of devices having indications to be transmitted from a particular field station, several such devices associated with different groups may change conditions simultaneously or in rapid succession, so as to condition several groups at the same station to have new indications standing ready for transmission at the same time. These groups are registered in the control office for transmitting their indications during separate cycles, one group for each cycle, in an order or sequence determined by their relation to the group determining relays at that field station.

Each group of devices, having indications to be transmitted, has associated therewith a change relay CH and a group determining relay GD (see Fig. 2B). Each change relay CH is controlled through a normally closed stick circuit, as above pointed out, so that a change in condition of any device within a particular group of devices causes the deenergization of the corresponding change relay. The deenergization of one or more of the change relays CH causes the energization of the change storing relay CHS, to thereby initiate a cycle of operation.

If several change relays CH are deenergized in rapid succession, the relay CH first deenergized will pick up its corresponding GD relay during the period of blank, but thereafter the other GD relays will pick up in a sequence from left to right, one for each operating cycle, providing of course that the indications, associated with the particular relay GD energized for the preceding cycle, have been transmitted. In other words, the relays CH and GD for each group are so interlocked, that irrespective of the number of change relays CH which are deenergized at any one time, only one group determining relay GD may be energized at that time.

This is in part accomplished by including in the pick-up circuit of each group determining relay GD, the back contact of its corresponding change relay CH, and a front contact of each change relay CH to the left of it, as well as a back contact of each group determining relay GD to the right of it.

For example, the pick-up circuit for the relay GD^2 , assuming only the relay CH^2 to be deenergized and the system to be at rest, is closed from (+), through back contact 73 of relay SL, wire 393, front contact 394 of relay CH^1 , wire 395, back contact 396 of relay CH^2 , wire 397, upper winding of relay GD^2 , wires 398 and 399, back contact 420 of relay GD^2 , to (-).

This pick-up circuit for the relay GD^2 is closed only while the system is in the period of blank, as it includes back contact 73 of relay SL. It can also be seen, that this relay GD^2 cannot be energized through its pick-up circuit if either the relay CH^1 is deenergized or the relay GD^3 is energized by reason of front contact 394 and back contact 420 respectively included in this pick-up circuit.

Similarly, the pick-up circuit for the relay GD^3 ,

assuming only the relay CH³ to be deenergized, is closed from (+), through back contact 73 of relay SL, wire 393, front contact 394 of relay CH¹, wire 395, front contact 396 of relay CH², wire 421, back contact 422 of relay CH³, wire 423, upper winding of relay GD³, to (-).

This pick-up circuit for the relay GD³ does not include a back contact of any other GD relay, as it is illustrated as being the last in the order or sequence. It cannot be picked up, however, with some other relay GD energized, as the change relay CH corresponding to such energized relay GD, would be deenergized, thereby opening the pick-up circuit of the relay GD³.

When several change relays CH are deenergized at the same time, the group determining relays GD are energized in an order or sequence from left to right by reason of the fact that the pick-up circuit of each group determining relay GD includes a front contact of the preceding change relay CH to the left thereof. For example, assuming the relays CH¹, CH² and CH³ have been deenergized, the pick-up circuit for the relay GD¹ is the first to be completed, as back contact 394 of relay CH¹ is closed; while front contact 394 is opened thereby preventing the closure of the pick-up circuit for the relays GD² and GD³ at this time. After a cycle of operation for transmitting the indications associated with GD¹, the relay CH¹ is energized, thereby closing front contact 394, so that the relay GD² is the next group determining relay to be energized; but the group determining relay GD³ is prevented from being picked up by open front contact 396. However, on this second cycle the relay CH² is energized, so the relay GD³ is picked up for the third cycle. This sequence is the same irrespective of the number of groups provided.

When any group determining relay GD (except the last) is energized, it is maintained energized for that cycle through a stick circuit including a back contact of each group determining relay to the right thereof. For example, the relay GD² is maintained through a stick circuit from (+), through back contacts 424 and 383 of relays TRR and 6 respectively, wires 425 and 426, front contact 427 of relays GD², lower winding of relay GD², wires 428 and 399, back contact 420 of relay GD³, to (-).

The last group determining relay to the right, illustrated by relay GD³, is maintained through a similar stick circuit, but does not include a back contact of any relay GD.

The energization of a group determining relay GD, only one of which may be energized at a time, causes the indication buses 801, 802 and 803 to be connected to the respective group code jumpers for the corresponding group. Thus, after the system is initiated into operation and the station code call of the corresponding station has been registered in the control office, the code call of the group associated with the particular group determining relay GD, then energized, is transmitted so as to register that group in the control office.

Also, the energization of the group determining relay GD connects the indication contacts of that group to the indication buses 804, 805 and 806, so that after the registration of the station and the group, the indications are transmitted.

In some cases, the indications to be transmitted are of a temporary character, that is, they do not always continue to exist until they have been transmitted. This may be best illustrated by a track circuit which is particularly short. For

example, a train passing over a short track circuit may deenergize the associated track relay, pass beyond that track circuit and again energize the track relay, before a system of this type shall have transmitted the occupied condition of that track circuit. Such indications require that some storing means be employed in connection therewith.

A storing relay STR is provided in connection with the track relay T associated with the track section TK (see Fig. 2B), but it is to be understood that a similar storing relay may be associated with such other indicating devices as may be desired. This storing relay STR is energized by the deenergization of the track relay T through a circuit obvious from the drawings. The energization of the storing relay opens momentarily the stick circuit of the corresponding change relay CH³, thereby initiating the system and energizing the corresponding group determining relay GD³.

The deenergization of the change relay CH³ closes a stick circuit for the relay STR from (+), through back contact 429 of relay CH³, wires 430 and 431, front contact 432 of relay STR, lower winding of relay STR, to (-). This stick circuit then causes the storing relay STR to be maintained energized in the event that the track relay T is energized prior to the transmission of the associated indication. The energization of the relay GD³ closes, in multiple with the contact 429 of relay CH³, a stick circuit from (+), through front contact 433 of relay GD³, wire 431, front contact 432 of relay STR, lower winding of relay STR, to (-). Thus, the relay STR is insured of being maintained energized until the corresponding indication determined by front contact 366, is transmitted.

When the station is selected with a change relay CH deenergized and its corresponding group determining relay GD energized, a pick-up circuit for that change relay CH is completed during the transfer step (sixth in this case), as heretofore pointed out.

Inasmuch as only one group determining relay GD may be energized or picked up at the beginning of a particular operating cycle, only the corresponding change relay CH may be energized on the transfer step, (providing the station is selected) irrespective of the number of change relays which may be deenergized.

Also, the selection or registration of the station opens the stick circuit of the change storing relay CHS with the relays SI and TR both energized on the sixth step, as above explained, and thus deenergizes the relay CHS. This is true however, only when a single change relay CH has been deenergized, or in other words, any time a change relay CH is deenergized, the change relay CHS is caused to be energized through its pick-up circuit. Thus, if at the end of a cycle of operation a change relay CH is still deenergized, the relay SI is maintained energized through its pick-up circuit if that station was selected for the preceding cycle, and the relay PR is energized after the deenergization of the stepping relay 6 and the relay SL, so as to immediately initiate the system into another cycle of operation.

At the end of a cycle in which the station has been registered, the particular group determining relay GD energized for that cycle drops out by reason of the opening of back contact 383 of stepping relay 6 on the twelfth step. This stick circuit for the relay GD is not opened upon the sixth step with the stepping relay 6 energized, as

the transfer repeating relay TRR is not energized in response to the station selection or registration, until the stepping relay 6 has been deenergized after the energization of the stepping relay 1 for the seventh step.

The deenergization of a group determining relay GD, such as relay GD³ for example, at the end of a cycle, opens the stick circuit of the associated storing relay, such as storing relay STR, at open front contact 433, as the corresponding change relay, such as relay CH³, has been energized on the transfer step (sixth) opening back contact 429. The deenergization of any particular group determining relay GD at the end of a cycle of operation allows the next group determining relay GD to be picked up, if any change relay CH remains energized, as soon as the relay SL assumes a deenergized position.

In brief, each change relay CH is deenergized by a change in condition of one of its associated devices, and the group determining relays GD corresponding to these change relays CH which are deenergized, are respectively energized in a sequence from left to right, one at a time for each operating cycle. The change storing relay CHS is energized by the deenergization of any one or several of the change relays CH and is maintained energized until all of the change relays CH have been energized or resensitized. If only one change relay CH is deenergized, then the change storing relay CHS is maintained energized only until the station has been conditioned for the transmission of the new indications for the group corresponding to that change relay.

The contacts controlling the indication buses for the transmission of the associated indications may be connected directly to the devices to be indicated or may be connected to a suitable storing device or relay as illustrated by relay STR, so as to maintain the indication condition until the system has transmitted such condition regardless of the change of the actual device prior to the transmission of the indication of such changed condition.

Sequence of station registration.—With the movement of trains and the control of various devices occurring either simultaneously or in rapid succession at various times, it may happen that one or more groups of indications at each of several field stations are standing ready for transmission at the same time. In such a case, the change storing relays CHS are energized at each of these field stations having new indications to transmit. This results in the opening of the series message circuit at each of several points which causes it to be deenergized the same as opening it at one point in the case where only one field station has indications standing ready for transmission.

In other words, the energization of the change storing relay CHS at each of several field stations energizes the selecting relay SI at each of these stations and also energizes the relay PR at each of these stations. This deenergizes the message circuit in a manner heretofore pointed out, deenergizing the relays M at the control office and at each of the field stations.

The deenergization of the relay M⁰ in the control office initiates the system, as previously explained, by the energization of the starting relay ST and the cycle controlling relay CC. If no controls are to be transmitted on the same cycle, a series of negative impulses (—) is placed on the stepping circuit to cause the operation of the stepping relay banks at the control office and at

each field station. On the other hand, if controls are to be simultaneously transmitted, impulses are applied of selected polarities, later to be explained. Thus, the stepping relay banks are caused to operate sequentially and in synchronism in either case.

Upon the application of the first impulse to the stepping circuit, the quick acting line repeating relay LR at each field station is energized shunting the contact 257 of relay PR and uncovering the contact 277 of relay P at each station. At those stations where the change storing relay CHS is energized, the relay PR and the relay SI are energized during the period of blank. During the conditioning period of the first step after the relay SL has become energized, the relay SI at each of these stations is held energized through a holding stick circuit (see Fig. 2A for example) from (+), through front contact 123 of relay LR, wire 124, front contact 125 of relay SL, wire 128, back contact 129 of relay TR, wires 130 and 270, front contact 271 of relay SI, upper winding of relay SI, to (—); while the relay PR at each of these stations assumes its position in accordance with the relay P during this conditioning period (first), inasmuch as its pick-up circuit, due to the energization of the change storing relay CHS, is open at back contact 141 of relay SL. Thus, during the conditioning period of the first step, the relay SI is energized at each of the stations having new indications to transmit, so that the energization of the message circuit is dependent upon the condition of the contact 277 of the relay P at each of these stations.

The relay P at each field station (see Fig. 2A) is controlled in accordance with the station code jumper 110 during the period of blank and the relay PR is controlled in accordance with the condition of the relay P during the conditioning period of the first step, as previously pointed out. This energizes either the "+" or "—" bus at each station in accordance with the code call assigned to that station, which always happens irrespective of the function to be accomplished by the particular cycle of operation.

The selecting stick circuit for the relay SI at each of these stations (see Fig. 2A for example) is connected from (—), through lower winding of relay SI, front contact 434 of relay SI, front or back contact 435 of the relay M at each of these stations to either the "—" bus or the "+" bus respectively depending upon whether the relay M at each station is energized or deenergized.

If the station code call begins with a (—) at each of the stations having indications standing ready for transmission, then the relay P at each of these stations is deenergized, so that the message circuit is completed; but if any one or all of these stations has a code call beginning with a (+), the relay P at such a station is energized opening the message circuit at back contact 277. This deenergizes the message circuit and causes the relays M at the control office and at each field station to be deenergized. In other words, those stations having a (+) code call are superior to those having a (—) code call.

If the message circuit remains energized, then the selecting stick circuit for the relay SI is connected to the "—" bus at each of the stations calling; but if the message circuit is deenergized, then the selecting stick circuit for the relay SI is connected to the "+" bus at each of the stations calling. This means, that, if there is no station calling which has a (+) code call, the relays SI have their selecting stick circuits con-

nected to the "— bus" corresponding to the bus which is energized at such calling stations; but, if one or more stations among those calling have a (+) code call, then the selecting stick circuits of each of the relays SI at each of the stations calling is connected to the "+ bus", corresponding to the bus which is energized at only those calling stations having a code call beginning with a (+) impulse.

During the execution period of the first step, the relay PR at each station, having been conditioned in accordance with the code call of the station through the relay P, causes the message circuit to continue in the condition established by the relay P by uncovering the contact 257 of relay PR and shunting or covering the contact 277 of relay P.

The holding stick circuit, completed during the conditioning period (first), is opened at front contact 123 of relay LR during the execution period (first), so that the relays SI at the stations calling are dependent for energization upon their selecting stick circuits. If the selecting stick circuit of the relay SI at a station is connected to the particular "+" or "—" bus which is energized in accordance with the code call of that station, then the relay SI is maintained energized during this execution period; but if the selecting stick circuit of the relay SI is connected to the bus which is deenergized, then the relay SI at such station is dropped out shunting the contacts 277 and 257 of relays P and PR respectively by closing back contact 255. This causes such stations to be silent, so to speak, preventing them from further controlling the message circuit. However, at those stations where the selecting stick circuit for the relay SI is connected to the particular "+" or "—" bus which is energized, then the relay SI is maintained energized during such execution period and are maintained or held during the conditioning period of the succeeding step (second) through their holding stick circuits including front contact 123 of relay LR.

Thus, it can be seen that a station having a code call beginning with a (+) is capable of controlling the message circuit and connecting the selecting stick circuit of its SI relay to the "+ bus" which is the one energized at that station, thereby maintaining or selecting the SI relay for that step and dropping out the relays SI at those stations having code calls beginning with a (—).

During the execution period of the first step, the relay P at each field station is controlled in accordance with its respective station code jumper 152, so that upon the application of the next impulse (second) to the stepping circuit, the message circuit is immediately controlled in accordance with the position of contact 277 of the relay P, by reason of open back contact 279 of relay LR. During this conditioning period (second), the message circuit is conditioned in accordance with the position of the relay P at those stations where the relay SI is still energized, and the selecting stick circuits of these relays SI are connected to the "+" or "—" bus at the corresponding stations in accordance with the nature of the code calls of those stations still calling. These relays SI are selected or dropped out in accordance with the superiority of the particular code impressed on the message circuit, in a similar manner as described for the first step.

This station selection may be carried on for as many steps as desired, depending upon the total

number of stations between which selection is to be made. The relay SI remains energized or selected at only one field station when the total number of station selecting or registering steps have been taken.

The resulting condition of the message circuit on each step, regardless of the number of stations calling, is registered in the control office by the relay M⁰ suitably controlling the registering relay banks the same as when only one station is calling.

The particular station which is registered in the control office and selected in the field when several are ready to transmit indications at the same time, is the one which has the most superior code call, that is, the station which opens or deenergizes the message circuit upon the earliest step, or the greatest number of steps, among the station selecting steps of the cycle.

The feature of selecting one of several stations according to the superiority of their respective code calls, has been explained and set forth in great detail in the above mentioned pending application of N. D. Preston et al., Ser. No. 455,304, filed May 24, 1930, now U. S. Letters Patent 2,129,183 granted Sept. 6, 1938, and need not be herein set forth in detail.

One feature of the present invention more particularly pertains to the manner in which the message circuit is controlled or governed in accordance with the code calls immediately upon the energization of the stepping circuit and simultaneously with the operation of the step-by-step mechanisms at the field stations. This feature may be best understood by briefly summarizing the above described operation with reference to Fig. 5 of the accompanying drawings, which illustrates in a graphic manner the sequence of operation of certain relays in what may be termed a typical operation chart.

As previously explained, the first column in the chart (reading from left to right) designates the relays or the like, which are to be described, while the remaining columns designate in order the operations of these relays as they occur during a cycle of operation. The operations are described in the chart by the use of certain key words which are taken from the description, as will be readily apparent.

The stepping circuit is deenergized during the period of blank and during the execution period of each step; while it is energized with positive or negative impulses during the conditioning period of each step in accordance with the code calls or controls being transmitted. In the case where only indications are being transmitted, then the stepping circuit is energized with a series of negative impulses forming a code call which has not been employed for the selection of any station or the selection of any group of any station. Whenever the stepping circuit is deenergized, the relay LR is deenergized and its contacts are down; but whenever the stepping circuit is energized, irrespective of the polarity, the relay LR is energized and its contacts are up.

For the transmission of indications (see Fig. 5 under "incoming"), the relay P at each field station is conditioned during the period of blank in accordance with the first code jumper of the corresponding station and thereafter during the execution period of each step in accordance with the respective code jumpers or indications to be transmitted; while the condition of the relay P established during such period of blank and the execution period of each step is maintained or

held during the conditioning period of each succeeding step, irrespective of whether the relay P was in an energized or deenergized condition.

During the period of blank the contacts of the relay PR are normally down, but when a field station initiates the system into operation, the relay PR at that station is energized so that its contacts are up (see Fig 5 under "incoming"). However, irrespective of whether the relay PR is energized or deenergized during the period of blank, it is conditioned in accordance with the relay P during the conditioning period of each step, such condition being held or maintained during the corresponding execution period of each step.

If the station code call requires a (—) impulse for a step, the relay PR is deenergized for that step; while, if the station code call requires a (+) impulse for a step, the relay PR is energized for that step.

The contact 279 of relay LR shunts the message circuit controlling contact 277 of relay P, when contact 279 is down, and uncovers contact 257 of relay PR. On the other hand, this contact 279 of relay LR shunts the message circuit controlling contact 257 of relay PR, when contact 279 is up, and uncovers the contact 277 of relay P. With reference to Fig. 5, it can be seen that the relays P and PR are conditioned on alternate periods of each step, when the contact 279 of relay LR is in such a position as to cover or shunt their respective message circuit controlling contacts. In other words, these relays can control the message circuit only when they are in stable or held conditions. As the relay P is conditioned during the execution period of the step preceding the step upon which it is effective (except in the case of the first step for which it is conditioned during the period of blank), its message circuit controlling contact 277 is in a stable or held condition immediately upon the application of an impulse to the stepping circuit. This condition is immediately uncovered by the relay LR, simultaneously with the operation of the stepping relays.

The relay SI is normally deenergized, but when a station initiates the system from the field, the corresponding SI relay is energized during the period of blank, so that its contacts are up to allow the contacts 277 and 257 of relays P and PR to control the message circuit. If the relay SI is not energized upon the application of the first impulse to the stepping circuit (conditioning period of the first step), it may not then be energized until the period of blank following that cycle of operation; but if the relay SI is energized, then it is maintained or held energized upon the conditioning period of the first step.

The energization of the relays SI and PR, due to a change in condition of the indications at a particular station, causes the system to be initiated by the deenergization of the message circuit during the period of blank.

The message circuit is energized or deenergized on each step in accordance with code calls of the stations calling by reason of the relays P and PR at those stations. The relays M at the control office and at each field station assume positions in accordance with the resulting condition of the message circuit, which, if deenergized, corresponds to a (+) code call impulse, but if energized, corresponds to a (—) code call impulse.

Upon the conditioning period of the first step, the relays SI, which are energized at those sta-

tions calling, are held or maintained energized while the relays and message circuit are assuming stable conditions.

Upon the execution period of the first step, the relay SI, which are energized at those stations calling, are selected or maintained energized if the resulting code call on the message circuit corresponds to the code call of the respective stations; while at those stations where the code calls do not correspond the relays SI are dropped out. In other words, if the relays PR at certain of the calling stations are deenergized corresponding to a (—) code call impulse, and the message circuit is deenergized corresponding to a (+) code call impulse, then the relays SI at those stations are dropped out; while at certain of the stations the relays PR are energized corresponding to a (+) code call impulse which causes the relays SI to be selected or maintained at such stations. This means that a (+) code call impulse assigned to a station gives that station a superiority with respect to the stations requiring a (—) code impulse. If all the stations calling require either a (—) or a (+) code call impulse, then the message circuit is of course either energized or deenergized respectively in correspondence therewith which causes the relays SI to remain energized at such stations.

Upon the conditioning period of the second step, those relays SI of the stations calling which remained energized through the execution period of the first step, are held or maintained energized until the execution period of the second step when they are selected or dropped out in accordance with the resulting code call impulse on the message circuit, in a similar manner as explained for the first step.

This selection of a relay SI, or in other words, the comparison between the code call resulting upon the message circuit and the code call of the stations occurs during the execution period of each of the station selecting or registering steps of the cycle, until the total number of selecting steps have been taken and only one station is registered in the control office and the corresponding station is selected in the field.

This scheme of selection may be said to be upon the sub-division or elimination basis, as all of the station selecting relays SI are energized at the beginning of a cycle, if all of the stations have new indications to transmit, and one half of those relays are deenergized upon the first step, one half of the remaining relays deenergized upon the second step, and so on, until the SI relay at only one station remains energized.

When a station is selected by maintaining its relay SI energized, which results in the energization of the transfer relay TR upon the transfer step (sixth), then the change storing relay CHS is dropped out as the contacts 248 and 249 of the relays SI and TR respectively are energized opening the stick circuit of this change storing relay. However, if the relay SI at a station is dropped out during such a registering cycle, as some more superior station dominates the message circuit, then the change storing relay CHS is maintained energized until the corresponding station becomes the most superior station and dominates the message circuit so as to register its code call in the control office and maintain energized or select its relay SI for that cycle of operation.

Two-way transmission.—The preceding description points out the operation of the system in response to the actuation of a control lever for the transmission of controls to a selected field

station during an operating cycle, and also the operation of the system occurring by reason of one or several field stations having new indications to transmit, for the registration of a particular station in the control office and the control of suitable indication storing relays associated with that particular station. From such description, it will be readily observed that the transmission of controls to a selected station takes place over the stepping circuit, while the transmission of indications takes place over the message circuit independently of the polarity of the stepping impulses.

Thus, the system of this invention functions for the transmission of controls to any selected station and the transmission of indications from that station or any other station during the same operating cycle, which feature of the present invention may be conveniently termed two-way or duplex transmission.

More specifically, the "+" or "-" bus at each field station is energized in accordance with the code call of that station irrespective of the type of operating cycle which occurs. The relay SO at each station is energized at the beginning of every operating cycle, irrespective of whether controls are to be transmitted or not, and is dropped out in accordance with the code call transmitted. If the code call transmitted is one which is not assigned to any station, such for example as a (-) impulse for each selecting step, employed when only indications are being transmitted, then every SO relay is deenergized at the end of the station selecting part of the cycle, so that false controls are not transmitted; but, if the code call transmitted is one which is assigned to a particular station, the relay SO is dropped out at each station except at the station having that code call.

The SI relay at each station is energized at the beginning of each cycle, if its corresponding change storing relay CHS is energized, and is selected or dropped out in accordance with the code call impressed upon the message circuit, independently of the SO relay and hence independently of the polarity or nature of the code call transmitted over the stepping circuit.

When the relay SO is energized together with the transfer relay TR, the control buses 701, 702, 703, 704, 705 and 706 receive positive or negative impulses upon their respective steps in accordance with the group code calls and controls transmitted. When the relay SI is energized together with the transfer relay TR, the indication buses 801, 802, 803, 804, 805 and 806 are employed to control the relays P and PR upon the respective steps, in accordance with the group code calls and indications transmitted. In other words, the energization of the relay TR at the end of the station selecting part of the cycle determines the selection of the station, while the energization of the relay SO or the relay SI determines the particular type of cycle of operation.

This independent selection of the relays SO and SI in accordance with code calls on their respective governing circuits, causes each field station to be responsive on each operating cycle to those controls and/or indications existing at the beginning of the cycle and which may occur at regular or irregular time intervals, successively or simultaneously at the control office and at the various field stations respectively. Such a system, provided with two-way transmission has been set forth in great detail in the above mentioned pending application of N. D. Preston et al., Ser. No. 455,304, filed May 24, 1930, and need not be further explained.

Station suppression.—The communication system embodying the present invention provides that each field station may initiate the system into operation, so as to register its code call in the control office in accordance with its superiority with respect to the code calls of the other stations which are also endeavoring to register themselves in the control office for that cycle of operation, after which the particular station having registered itself in the control office, transmits its indications.

However, it may happen for one reason or another, that some field station may monopolize the message circuit for a large number of operating cycles, that is, some station might cause the system to be initiated during each succeeding period of blank and register itself in the control office, thereby preventing some important indication from some other station, which has been assigned an inferior code call with respect to the code call of such station, from being transmitted to the control office. This condition, where a particular field station may monopolize the message circuit, may arise from several conditions or combination of circumstances, such as for example, the failure of some part of the field station equipment, or a train crew might contemplate making a large number of local train movements within a given territory, which movements would be unrelated to the major train movements then under the consideration of the centrally located operator.

In accordance with the present invention, a cut-out lever COL is provided in the control office for each field station, so that the operator, by simple manipulation of this cut-out lever, may operate the contacts of a polar magnetic stick type cut-out relay COR to either of two extreme positions. When the contacts of this cut-out relay are in one extreme position, that field station operates in the usual manner to initiate the system and register itself in the control office when a change in the condition of the devices at that station occurs; while with the contacts of this relay COR in the opposite position, that field station is prevented from initiating the system. In other words, the present invention provides that the operator may at will suppress a particular station, that is, prevent it from controlling the message circuit.

More specifically, a cut-out lever COL (see Fig. 1A) is provided with contacts 15 and 16. The contact 16 is included in the normally closed stick circuit of the storing relay SR¹, so that any time the cut-out lever COL is moved to a new position, the relay SR¹ is deenergized and the code determining relay CD¹ is energized in accordance with its location in the code determining bank, so that the station code call of the corresponding station is transmitted upon the resulting cycle of operation.

When the cut-out lever COL is in a normal position, the cut-out bus 436 is deenergized; but when the cut-out lever COL is in a reverse dotted line position, the cut-out bus 436 is energized from (+), through contact 15 in a dotted line position. The energization of the code determining repeating relay CDR¹ connects the control bus 406 to the cut-out bus 436 through front contact 437 thereby causing this control bus 406 to be energized or deenergized in accordance with the normal or reverse positions respectively of the cut-out lever COL. The energized or deenergized condition of the control bus 406 causes the sixth stepping impulse to be either a (+) or a (-) impulse by suitably controlling the polarity 75

selecting relay PS in a manner previously described.

In other words, the movement of the cut-out lever COL to a new position, causes the transmission of the code call of the associated field station and causes the transfer step for that cycle to be taken by either a (—) or a (+) impulse on the stepping circuit in accordance with the position of the cut-out lever COL. The transmission of the station code call selects the corresponding field station, which, in this case with relay CDR¹ energized, is the station illustrated in Figs. 2A and 2B, by causing the relay SO at that station to still be energized at the end of the station selecting steps. With the relay SO energized upon the conditioning period of the sixth step, the transfer relay TR is energized as previously pointed out. Irrespective of the particular polarity of the impulse upon the stepping circuit, the sixth step is taken, while the polarity of the impulse suitably positions the impulse storing relay IS, as previously pointed out.

Thus, during the execution period of this sixth step with the relays SO and TR energized, a circuit is completed for the cut-out relay COR from either (B—) or (B+), through contact 165 of relay IS in a left hand or right hand position respectively, wire 180, back contact 181 of relay LR, wire 182, front contact 183 of relay SO, wire 184, front contact 185 of relay TR, wire 186, back contact 187 of relay TRR, wire 438, winding of relay COR, to (CN). Thus, if the stepping impulse for the transfer step (sixth) is a (—) impulse, (B—) is applied to the windings of the relay COR and contact 439 is actuated to a left hand position; while if the impulse for the transfer step is a (+) impulse, (B+) is applied to the windings of this relay COR and contact 439 is actuated to a right hand position. This energizing circuit for the cut-out relay COR is opened by the energization of the transfer repeating relay TRR during the conditioning period of the seventh step with the stepping relay 1 energized and with the stepping relay 6 deenergized.

In a system where it is more particularly desired to prevent a field station from automatically initiating the system in the case of trouble, such for example as contact failure, or the like, the cut-out relay COR is employed to complete the message circuit through that station by shunting the message relay M and the message circuit controlling contacts of the relays P, PR, LR and SI at that station.

For example, with reference to Fig. 2A, the cut-out relay COR is arranged to suppress or prevent that field station from initiating the system by completing a shunt circuit, when the polar contact 439 is in a right hand dotted line position corresponding to a reverse position of the corresponding cut-out control lever COL in the control office. This shunt circuit is traced from the message line extending to this field station, through wire 440, polar contact 439 of relay COR in a right hand position, wires 441 and 276, to the message circuit extending to the next field station.

This control of the message circuit by the cut-out relay COR is particularly useful in the event of the failure of the message circuit controlling contacts 257, 277, 279 and 256, although the cut-out relay is operated during a cycle of operation thereby interrupting the transmission of indications for that cycle. But this arrangement is preferably used only in the event of failure at a field station, when such interruption of a cycle is immaterial, as those indications being trans-

mitted for that cycle would probably be erroneous, even if they were transmitted.

On the other hand, where it is more particularly desired to provide means so that the operator can at will prevent a field station from transmitting certain indications until a later time, so as to allow some other station with which he more particularly desires to communicate to control the message circuit, then the cut-out relay COR is preferably employed to control the pick-up circuit of the relay SI instead of shunting the message circuit as above explained. In this case, the potential applied to the heel of contact 251 of relay SL from (+), would be normally applied through contact 439 of relay COR in a left hand position, and removed in the event that the contact 439 is operated to a right hand position when the operator desires to temporarily suppress the transmission of indications from this station.

This method of suppressing a field station does not become effective except during the period of blank, as that is the only time the pick-up circuit for the relay SI can be closed for initiating the system. Thus, this arrangement does not interrupt the transmission of indications during an operating cycle and may be employed by the operator any time he may desire.

Although these two arrangements of cut-out control have been explained separately, they may be employed together by providing two cut-out relays suitably controlled.

It is noted, that, in the control office, the cut-out lever COL is associated with the storing relay SR¹ and the code determining repeating relay CDR¹, but the contact, corresponding to contact 437 of relay CDR¹, of each code determining repeating relay CDR associated with each of the remaining groups of the corresponding field station, also connects the control bus 406 to the contact 15 of the cut-out lever COL through cut-out bus 436. This provides, that, although control impulses are transmitted to some other group, besides the first group, after the initial transmission of the cut-out control, the same condition of the cut-out relay COR is maintained. In other words, if this provision was not made, the control bus 406 would be energized with the cut-out lever COL in a reverse position only when the first group of that station is selected, and would be deenergized when other groups were selected although the cut-out lever COL remained in the same position, thereby resulting in the transmission of a (—) impulse for the sixth or transfer step which would actuate the cut-out relay COR to a position out of correspondence with its lever COL.

Briefly, the present invention provides a cut-out control lever COL for each field station, similar to other control levers, which, by simple manipulation, the operator can control a cut-out relay COR at the corresponding field station in a similar manner as other control levers control their respective function relays. This cut-out control may be accomplished on any control step desired and within any group of control steps associated with a particular field station, although for the purpose of illustration in connection with this specific embodiment of the present invention, the transfer step is employed, as this step would not otherwise be employed for control purposes.

Four neutral line wire system.—When a communication system, as above described, is provided with a polarized direct current stepping and control circuit together with a neutral direct

current message circuit, as explained for Figs. 1A, 1B, 1C, 1D, 2A and 2B, difficulty is sometimes had, in regions where electrical storms are frequent, due to discharges over the polarized stepping line which cause erroneous steps to be taken. This is in part due to the inherent quick response of a polar relay to low current values. The same undesirable effect is sometimes present due to the inductive effect of opening or closing an adjacent line where the system is employed over an extensive territory.

In view of the above, the present invention proposes to employ, when desirable, two neutral line circuits in place of the polarized stepping and control circuit. One of these neutral circuits is employed for transmitting the stepping impulses, and the other neutral circuit is employed for transmitting the control impulses. The usual neutral message circuit is employed therewith for the transmission of indications. This arrangement of line circuits permits the use of neutral relays in place of the polar relays. As neutral relays can be made to respond more slowly to the application of current, an induced current in the line usually has time to die out before appreciably affecting such relays.

With reference to Fig. 3 of the accompanying drawings, typical line circuits of such a system having four neutral lines is illustrated. The same control office and field station equipments, as previously described in connection with Figs. 1A, 1B, 1C, 1D, 2A and 2B, may be employed with this line circuit arrangement; and the same general mode of operation and features apply to a system thus modified with only those exceptions and adaptations as hereinafter pointed out. Those relays which serve to connect the line circuits to the control office and field station equipments the same as previously described, have been shown having the same reference characters with the distinctive exponents "10" for the control office, "11" for the first field station and "12" for the last field station. The only additional relays employed are the neutral relays CL included in the control line, one at each field station, suitably distinguished by the exponent distinctive of that field station. The line relay L included in the stepping line is in this case of the neutral type.

The stepping circuit is suitably energized, when the cycle controlling relay CC¹⁰ is picked up, with impulses suitably time spaced in accordance with the operation of the system, as previously explained, by the operation of the impulsing relay IM¹⁰ which is suitably controlled in conjunction with the half step relay in the control office and the associated stepping relay bank. For example, assuming the cycle controlling relay CC¹⁰ to be energized, the stepping circuit is energized from the positive terminal of the battery BT¹⁰, through wires 451 and 452, front contact 453 of relay CC¹⁰, wire 454, back contact 455 of relay IM¹⁰, wire 456, winding of line relay L¹⁰, through the stepping line to the first field station, through the winding of the line relay L¹¹, and similarly over the stepping line and through the stepping line relays at the remaining stations, to the common return line, thence to the negative terminal of the battery BT¹⁰ in the control office.

The stepping circuit thus closed initially by the cycle controlling relay CC¹⁰ is opened by the impulsing relay IM¹⁰ at definite predetermined time intervals in accordance with the response of the system. The application of time spaced

impulses causes the operation of the step-by-step means at the control office and at each field station in the usual way, by control of the line repeating relays LR¹⁰, LR¹¹ and LR¹², through front contacts 457¹⁰, 457¹¹ and 457¹² of the corresponding line relays L¹⁰, L¹¹ and L¹².

The polarity selecting relay PS¹⁰ is suitably controlled, as previously explained in connection with relay PS of Fig. 1D, during the execution period of each step in accordance with the controls to be transmitted so that during the conditioning period of each succeeding step, that is, with the stepping circuit energized for the next step, the control line is either energized or deenergized depending upon the character of the code or control impulse to be transmitted. Thus, if the contact 458 of relay PS¹⁰ is actuated to a left hand position corresponding to a (+) code call, then the control circuit is energized from the positive terminal of the battery BT¹⁰, through wires 451 and 459, polar contact 458 of relay PS¹⁰ in a left hand position, wire 460, back contact 461 of relay IM¹⁰, through the control line to the first field station, through the winding of the control line relay CL¹¹, and similarly over the control line and through control line relays at the remaining stations to the common return wire, and thence to the negative terminal of the battery BT¹⁰ in the control office. If on the other hand, the particular impulse to be transmitted corresponds to a (-) impulse, the relay PS is suitably actuated during the execution period of the preceding step so that the polar contact 458 is in a right hand position for the conditioning period of the next step. This leaves the control line deenergized during such conditioning period.

Depending upon whether the control line relay CL at each station is energized or deenergized during the conditioning period of each step, the impulse storing relay IS at each of the corresponding stations is energized either from (B+) or (B-) through front or back contact 462¹¹ respectively of relay CL¹¹, at the first field station for example, front contact 463¹¹ of relay L¹¹, winding of relay IS¹¹, front contact 464¹¹ of relay LR¹¹, to (CN). The relay IS, thus controlled during the conditioning period of each step, stores such control during the following execution period, as it is a polar magnetic stick type relay with its circuit open at back contacts 463 and 464 of relays L and LR respectively, and functions to suitably establish the controls, as previously pointed out in connection with Figs. 2A and 2B.

The message circuit of this four wire system is the same as that employed for the three wire system explained in connection with Figs. 1A, 1B, 1C, 1D, 2A and 2B, in which the message circuit is closed or opened upon each step in accordance with the character of the code or indication impulse to be transmitted, and need not be further explained in detail.

Two-wire system.—In Fig. 4 of the accompanying drawings, a modified form of the line circuits is illustrated, in which a polarized direct current stepping and control circuit is completed over two line wires together with an alternating current message or indication circuit superimposed thereon.

The same control office and field station equipments, as previously described in connection with Figs. 1A, 1B, 1C, 1D, 2A and 2B, may be employed with this line circuit arrangement; and the same general mode of operation and features apply to a system thus modified with

only those exceptions and adaptations as hereinafter pointed out.

The relays associated with the line circuits which have been previously described have been designated by the same reference characters with the distinctive exponents "20" for the control office, "21" for the first station and "22" for the last field station, each of these relays having the same functions and features as previously described.

The direct current polarized stepping and control circuit is of the same general arrangement as previously described but with alternating current impedances 551 and 552 of low ohmic resistance preferably connected on each side of the line relays L as illustrated. Also, an alternating current impedance 553 of low ohmic resistance is provided in series in the common return wire having connected in multiple therewith a condenser 554 of such capacity as to tune the inductance and condenser combination to anti-resonance with respect to the frequency of alternating current supplied for the message or indication circuit by an alternator 555.

The stepping circuit thus modified, is traced, for example, assuming the cycle controlling relay CC²⁰ to be energized and the impulsing relay IM²⁰ to be deenergized, from the positive terminal of the battery BT²⁰ through front contact 556 of cycle controlling relay CC²⁰, back contact 557 of relay IM²⁰, through polar contact 558 of relay PS²⁰ in a right hand position, impedance 553, through common return line to the last field station, impedance 552²², winding of the relay L²², impedance 551²², over the control line to the remaining stations and through the windings of polar relays L and alternating current impedances 552 and 551 at those stations to the control office, impedance 552²⁰, winding of relay L²⁰, impedance 551²⁰, polar contact 559 of relay PS²⁰ in a right hand position, back contact 560 of relay IM²⁰, front contact 561 of relay CC²⁰, to the negative terminal of the battery BT²⁰. It is to be understood of course that with the polar contacts 558 and 559 of the relay PS²⁰ in left hand dotted line positions, the direction of current flow is reversed so as to energize the relays L²⁰, L²¹ and L²² with the opposite polarity, all of which may be best understood with reference to the description of relay PS in connection with Figs. 1A, 1B, 1C, 1D, 2A and 2B.

Each polar relay L operates a slow acting line repeating relay SL, quick acting line repeating relay LR and an impulse storing relay IS, in a similar manner as previously explained.

The message or indication circuit is normally supplied with alternating current energy of a frequency suitably selected with respect to the frequency of the stepping impulses applied to the stepping circuit, so as to make it easy to segregate the alternating current from the direct current according to the usual engineering practices. This alternating current is supplied by a suitable alternator 555 having in series therewith a condenser 562 and an impedance 563 tuned to resonance with respect to the frequency of the alternator, so as to allow the alternating current to readily flow, but to prevent a short circuit to the stepping circuit upon which direct current impulses are applied.

In multiple with the line relays L and the impedances 551 and 552, at the control office and at each field station, the primary winding of suitable transformer 564 is connected in series with a condenser 565. The condenser preferably tunes

the transformer to resonance with respect to the frequency of the alternator 555, so as to allow the alternating current to flow in the indication circuit and prevent the flow of direct current impulses. The secondary of this transformer 564 is connected to a suitable rectifier 566 of any suitable type, such for example as a copper oxide bridge connected rectifying unit, although any other type rectifying unit may be employed. A direct current neutral type message relay M is connected across the direct current out-put terminals of this rectifying unit 566.

The message circuit normally receives current from the alternator 555 through a circuit from its upper terminal through impedance 562, condenser 563, condenser 565²⁰, secondary of transformer 564²⁰, control line to the first field station, wire 667²¹, back contact 668²¹ of relay SI²¹, wires 669²¹, 670²¹ and 671²¹, condenser 565²¹, secondary winding of transformer 564²¹, over the control line wire and similarly through the remaining stations, to the common return line and thence to the control office to the lower terminal of the alternator.

This message or indication circuit normally includes the back contacts 668²¹ and 668²² of the relays SI²¹ and SI²² respectively, but when the stations are transmitting indications these contacts are open, as previously described in connection with contact 274 of relay SI of Fig. 2A, so as to allow the indication circuit to be controlled in accordance with contacts 672²¹ and 672²², also contacts 673²¹ and 673²² of relays P²¹ and P²², also relays PR²¹ and PR²² respectively together with the covering and uncovering contacts 674²¹ and 674²² of relays LR²¹ and LR²² respectively at each station.

The operation of a system, thus modified, will be well understood with reference to the preceding description in connection with the three wire system shown in Figs. 1A, 1B, 1C, 1D, 2A and 2B, and need not be pointed out in detail.

General summary.—The above description points out the various individual steps in the operation of the communication system contemplated by this invention, as well as the characteristic features, the mode of operation, and the advantages of the system as a whole; and it is believed that a brief general statement will be sufficient to make clear the nature of the invention, both broadly and specifically.

The communication system of the present invention may be provided with various line circuit arrangements, three of which have been disclosed by the embodiment chosen for the present invention. In Figs. 1A, 1B, 1C, 1D, 2A and 2B the system is provided with three line wires to form a polarized direct current stepping and control circuit, and a neutral direct current message or indication circuit, with both circuits extending from the control office through all of the field stations. In Fig. 3, a modified form of line circuits is illustrated in which four line wires form a neutral direct current stepping circuit, a neutral direct current control circuit, and a neutral direct current message or indication circuit, with these three circuits extending from the control office through all of the field stations. In Fig. 4, a modified form of line circuits is illustrated in which two line wires form a polarized direct current stepping and control circuit upon which an alternating current message or indication circuit is superimposed.

Irrespective of the particular combination of line circuits employed, a bank of stepping relays

in the control office and at each field station operate sequentially, one at a time and in synchronism, in response to impulses applied to the stepping circuit. In the case of the polarized stepping circuit, the stepping relay banks take one step for each impulse irrespective of the polarity of the impulse.

The system is set into operation whenever the operator actuates a control lever to a new position, or when a change relay CH is deenergized at any field station as a result of a change in the condition of the various devices at that station which are to be indicated in the control office.

The operating cycle of the system is divided into a selecting part and a control and/or indication part. During the selecting part of the cycle, the impulses applied to the control circuit form a station selecting code and a group selecting code. The station selecting code either belongs to a particular station, or to what may be termed a phantom station, if no new controls are to be transmitted upon the second part of the cycle.

During the selecting part of the cycle, the station selecting impulses are effective to select between the station selecting relays SO at the several stations (which are all energized upon the first impulse of each cycle) so as to drop out or deenergize these selecting relays SO in groups during the execution period of each impulse until there remains only one relay SO energized at the particular station being called. The group selecting impulses cause group selecting pilot relays to be positioned in accordance with the impulses transmitted to the field station, so as to select a particular group within the particular station having its SO relay energized.

After the selection of a station and the selection of a particular group within that station, the second part of the cycle is employed to transmit controls in accordance with the positions of the corresponding control levers in the control office.

Also, during the selecting part of any cycle, a field station may register its station code call in the control office by suitably controlling the message circuit to position station registering pilot relays in the control office after which the particular group having indications to transmit from that station may register its code call by suitably controlling the message circuit to position group registering pilot relays in the control office. When one or more field stations are ready at the beginning of an operating cycle to transmit indications, the station selecting relays SI at these stations are all energized on the first impulse, and are automatically deenergized in groups, one group at a time, during the execution period of each step, in accordance with the relative superiority of the code calls of these stations, until only one selecting relay SI remains energized at the end of the station selecting or registering steps of the cycle. After the necessary number of selecting steps have been taken for the registration in the control office of a particular group, the indications of that group are then transmitted and suitably stored by positioning polar magnetic stick type relays in the control office.

The system is so arranged that controls and/or indications may be transmitted over the system during each operating cycle. An operating cycle occurs whenever the system (which is normally at rest) is set into operation from either the

control office or from one or more field stations; and these operating cycles follow one another with an intervening period of deenergization of the stepping circuit to mark off the cycles, so long as there are new controls stored up in the control office, or new indications stored up in the field stations. The order or sequence in which the controls are transmitted to the stations, where there are a plurality of controls for each of several stations, is predetermined by an interlocked bank of code determining relays in the control office independently of the geographic locations of the stations. The order or sequence in which a plurality of stations all having indications to transmit at the same time act to transmit their indications, one station at a time for each cycle, is determined by the relative superiority of the code calls assigned to these stations and independently of the geographic locations of the stations; while the groups within these stations are allowed to transmit their indications in a predetermined order or sequence determined by an interlocked bank of group determining relays.

The system may be extended for any desired number of stations, for any desired number of groups within the stations, or for any desired number of controls and/or indications within any particular group, all in accordance with the requirements of practice, by providing the necessary number of selecting and transmitting steps. The embodiment of the present invention shows only one arrangement of selecting and transmitting steps, it being understood that other arrangements may be used or decided upon in any arbitrary manner best suited to the situation at hand.

The system of the present invention is of the type where the step-by-step means at the control office and at each field station are operated sequentially and in synchronism by impulses applied to a series stepping circuit from the control office, irrespective of whether controls are being transmitted from the control office or indications are being transmitted from one of the field stations. The present invention provides means whereby the indication or message circuit, employed for the transmission of indications, may be controlled upon each step immediately after the application of the corresponding stepping impulse and simultaneous with the operation of the step-by-step means, which feature of the present invention provides for increased efficiency of the system by increasing its speed of operation.

Although the system of the present invention is arranged so that the field stations may automatically initiate the system into operation when new indications are present for transmission, means is provided, manually controllable by the operator, for suppressing or preventing such automatic initiation at such stations as the operator may desire, so as to allow some other station with which he more particularly desires to communicate to assume the superior code call relationship with respect to the remaining stations which are calling.

Various other characteristic features and advantages of the present invention will be apparent. The specific organization of the relays and circuits being shown and described is merely one illustrative specific embodiment of the invention and it is to be understood that various modifications, adaptations and additions may be made to this specific embodiment, without de-

parting from the spirit or scope of the invention, with the appended claims being intended to define the several features and limitations in the scope of the invention, rather than the foregoing description.

5 What we claim is—

1. In a centralized traffic controlling system for railroads, the combination with a plurality of field stations, of control office equipment comprising a plurality of control levers for each field station, a storing relay for each field station, each of said relays having a normally closed stick circuit, means opening the stick circuit of each storing relay upon movement of one or more of the corresponding control levers to new positions, a code determining relay for each field station, means energizing those of said code determining relays corresponding to those of said storing relays which are deenergized, said means being effective to energize only one of said code determining relays at a time, means governed by each of said code determining relays for rendering effective the corresponding control levers, and means for reenergizing said storing relays when said control levers have been rendered effective.
2. In a centralized traffic controlling system for railroads, the combination with a plurality of field stations, of control office equipment comprising control levers for each field station, a storing relay for each field station, each of said relays having a normally closed stick circuit, means for momentarily deenergizing the stick circuit of a particular storing relay upon the movement of an associated control lever, code determining means governed by each of said storing relays for rendering the control levers associated with each of said storing relays effective, and means allowing only those control levers associated with one of said storing relays to be effective during any one time interval.
3. In a centralized traffic controlling system for railroads, a plurality of control levers divided into groups, a normally energized storing relay associated with each group of said control levers, means deenergizing a particular storing relay upon the movement of any one or several of said levers in the corresponding group of levers, a code determining relay associated with each storing relay, means energizing those of said code determining relays corresponding to the deenergized storing relays, one at a time in a predetermined sequence, and means reenergizing each deenergized storing relay during the time interval in which its corresponding code determining relay is energized.
4. In a centralized traffic controlling system for railroads, the combination with a control office and a plurality of field stations, of a selector type communication system capable of operating through cycles of operation and comprising, a plurality of control levers divided into groups, a storing relay for each group, a stick circuit for each storing relay, means momentarily opening said stick circuit of a particular storing relay when any one or several of said control levers of the corresponding group have been moved to new positions, whereby said storing relay is deenergized, a code determining relay associated with each storing relay, a pick-up circuit for each code determining relay conditioned with its corresponding storing relay deenergized, a stick circuit for each code determining relay, a pick-up circuit for each storing relay conditioned with its corresponding code determining relay energized, means energizing said conditioned pick-up

circuit of one of said code determining relays preceding each cycle of operation of said system, means energizing said stick circuit of said energized code determining relay during each cycle of operation, means energizing said conditioned pick-up circuit of the corresponding storing relay during each cycle of operation, and means deenergizing said stick circuit of said one code determining relay at the end of that cycle of operation, whereby those of said code determining relays corresponding to the groups in which control levers have been moved to new positions, are energized in a predetermined order, one for each cycle of operation, thereby rendering the control levers of the corresponding groups effective to govern said communication system.

5. In a centralized traffic controlling system, a control office, a plurality of field stations, a bank of stepping relays at said control office and at each of said field stations, a stepping circuit extending from the control office to the several field stations, means at the control office and at each of said field stations responsive to each impulse of a series of impulses placed upon said stepping circuit, means at the control office for placing a series of impulses upon said stepping circuit, whereby said stepping relay banks are caused to take a series of steps, cycle marking means at the control office and at each field station responsive to each series of impulses as a whole, step holding means at the control office and at each field station for maintaining the stepping relay for each step energized until the stepping relay for the next step is energized, said means being effective only when said cycle marking means is responding to a series of impulses, and means rendering said step holding means at the control office ineffective when the stepping relay for the last step is energized.

6. In a centralized traffic controlling system, a control office, a plurality of field stations, a stepping circuit extending from the control office through the several field stations, a bank of stepping relays at the control office and at each field station operated synchronously and one step for each time the stepping circuit is energized by an impulse, impulsing means at the control office for energizing said stepping circuit with a series of impulses time-spaced in accordance with the response of said bank of stepping relays at the control office, step holding means at the control office and at each field station for maintaining the stepping relay for each step energized after it has responded to an impulse until the stepping relay for the next step has responded to the next impulse, and means at the control office rendering said step holding means ineffective for the stepping relay for the last step in the control office.

7. In a centralized traffic controlling system for railroads, step-by-step means at the control office and at each field station operated synchronously, a control circuit connecting the control office and each of the several field stations, a message circuit connecting the control office and each of the several field stations, means governed by the message circuit for registering the stations one at a time at the control office in accordance with the code call allotted to the several field stations, means at each field station for pulsing the message circuit in accordance with the code call allotted to it, and suppressing means to prevent effective operation of said pulsing means, said suppressing means being manually controlled from said control office over said control circuit.

8. In a centralized traffic controlling system

for railroads, step-by-step means at the control office and at each field station operated synchronously, a control circuit connecting the control office and each of the several field stations, a message circuit connecting the control office and each of the several field stations, means at the control office governed in accordance with the condition of said message circuit for initiating said step-by-step means into operation, means at each field station for conditioning said message circuit to control said initiating means, suppressing means at each field station for preventing operation of said message circuit conditioning means, said means being governed in accordance with said control circuit, and suppressing means at the control office for conditioning said control circuit for governing said suppressing means.

9. In a centralized traffic control system for railroads, a control office, a plurality of field stations, a step-by-step mechanism at the control office and at each field station operable through cycles of operation each step being taken in synchronism, a control circuit extending from said control office through each of said field stations, a plurality of traffic governing devices at each field station divided into groups, control means at each field station for operating the respective traffic governing devices of each group in accordance with the condition of said control circuit for the respective steps of a cycle when selectively governed, means determining what particular field station shall have a control means selectively governed for a particular cycle of operation, and means determining which group of said devices at that particular field station shall be operated with the control means at that field station selectively governed.

10. In a centralized traffic control system for railroads, a control office, a plurality of field stations, a step-by-step mechanism at the control office and at each field station operable through cycles of operation each step being taken in synchronism, a message circuit extending from said control office through each of said field stations, a plurality of traffic governing devices at each field station divided into groups, indication storing relays in said control office divided into groups for storing the condition of corresponding devices in corresponding groups of said traffic governing devices, the respective indication storing relays of a particular group being controlled on the respective steps in accordance with the condition of said message circuit for the corresponding steps during a particular cycle of operation, means governed by the traffic governing devices of each group for selectively determining the condition of said message circuit for each step of a particular cycle of operation, and means determining which particular group of said traffic governing devices will be in communication with its corresponding group of said indication storing relays for a particular cycle of operation.

11. In a centralized traffic control system for railroads, a field station having a bank of stepping relays sequentially operated through a cycle of operation, a message circuit extending from said field station, a plurality of traffic governing devices divided into groups, means governed by the respective devices of each group for controlling the condition of said message circuit on the respective steps of each cycle of operation, and means selectively determining which group of said devices shall be effective for controlling the

condition of the message circuit for any particular cycle of operation.

12. In a centralized traffic control system for railroads having a control office and a plurality of field stations, a selective type communication system comprising step-by-step means at the control office and at each field station operable through cycles of operation in synchronism, means for the transmission of controls to a particular field station, means for the transmission of indications to the control office, and means at each field station governed by the transmission of suitable controls from the control office to a particular field station for preventing that field station from transmitting indications, said last mentioned means being initially effective at the end of the cycle of operation upon which it is effectively governed.

13. In a centralized traffic control system for railroads having a control office and a plurality of field stations, a stepping relay bank at the control office and at each field station, a stepping circuit extending from said control office through each field station, a line relay at said control office and at each of said field stations included in series in said stepping circuit, circuit means at the control office and at each field station governed by its respective line relay to cause each of said stepping relay banks to take one step for each impulse applied to said stepping circuit, a half-step relay at said control office and at each of said field stations responsive to each deenergization of said line circuit as repeated by its respective line relay, impulsing means at the control office for applying series of time-spaced impulses to said stepping circuit, said impulsing means being operable to cause the application of the next impulse or time space dependent upon the actual response of said stepping relay bank or said half-step relay at said control office to the then present time space or impulse on said stepping circuit.

14. In a centralized traffic control system for railroads having a control office and a field station, a stepping relay bank at the control office and at said field station, a stepping circuit extending from said control office to said field station, means for applying a series of spaced impulses upon said stepping circuit, a line relay for each of said stepping relay banks, a half step relay for each of said stepping relay banks operated to a new position for each space between successive impulses on said stepping circuit, whereby each of said stepping relay banks is caused to take one step for each impulse of a series applied to said stepping circuit and each of said half-step relays is operated to a new position for each space between successive impulses, a cycle controlling relay in said control office for initially energizing said stepping circuit, an impulsing relay for deenergizing said stepping circuit when picked up, pick-up circuits for said impulsing relay closed upon the response of a stepping relay to its corresponding impulse, and means opening said pick-up circuits upon the response of said half step relay to the deenergization of said stepping circuit.

15. In combination, a plurality of step-by-step mechanisms, a stepping circuit and a message circuit interconnecting said mechanisms, means applying time-spaced impulses to said stepping circuit, whereby said mechanisms are caused to take one step for each of said time-spaced impulses, and means associated with each of said mechanisms for conditioning said message cir-

cuit for each step during the application of the corresponding time-space and impulse on said stepping circuit for that step, said means being effective prior to the actual response of said mechanisms to said time-spaced impulse for each step.

16. In a centralized traffic control system for railroads having a control office and a plurality of field stations, a step-by-step mechanism at the control office and at each field station, a stepping circuit extending from said control office through each of said field stations, a message circuit extending from said control office through each of said field stations, means applying impulses to said stepping circuit, whereby said mechanisms are operated in synchronism one step for each impulse, a plurality of code determining means at each field station, and means for conditioning said message circuit for each step in accordance with the condition of the respective code determining means for that step, said means being effective upon the application of one impulse and until the application of the next impulse.

17. In a centralized traffic control system for railroads having a control office and a plurality of field stations, a step-by-step mechanism at the control office and at each field station, a stepping circuit extending from said control office through each of said field stations, a message circuit extending from said control office through each of said field stations, means applying time-spaced impulses to said stepping circuit, whereby said mechanisms are operated in synchronism one step for each impulse, a plurality of code determining means at each field station, said code determining means being rendered successively active one at a time by the step-by-step means, and means for conditioning said message circuit throughout each of said impulses and its following time space in accordance with the respective code determining means rendered active on the preceding step of said step-by-step mechanism.

18. In combination, a plurality of step-by-step mechanisms, a stepping circuit and a message circuit interconnecting said mechanisms, means applying time-spaced impulses to said stepping circuit, whereby said mechanisms are caused to take one step for each of said time-spaced impulses, and means associated with each of said mechanisms for distinctively conditioning said message circuit for each step subsequent to the application of the next successive time-spaced impulse and up to the application of the next following impulse with such conditioning being independent of the response of said step-by-step mechanisms during that time.

19. In combination, a stepping circuit, a message circuit, a step-by-step mechanism operated through a series of steps by impulses applied to said stepping circuit, means distinctively conditioning said message circuit for each impulse applied to said stepping circuit, said means being initially effective prior to the response of said step-by-step mechanism and throughout such impulse irrespective of the operation of said step-by-step mechanism during such impulse.

20. In a centralized traffic control system for railroads having a control office and a plurality of field stations comprising a plurality of traffic governing devices, a neutral control circuit extending from the control office through the several field stations, a neutral stepping circuit extending from the control office through the sev-

eral field stations, a neutral message circuit extending from the control office through the several field stations, a plurality of stepping relay banks, one at the control office and at each field station, operated synchronously by impulses applied to said stepping circuit, means at the control office manually operable for distinctively governing the operation of said control circuit for each step, means at each field station governed by the condition of said control circuit for each step to operate said traffic governing devices, means at each field station distinctively conditioning said message circuit for each step in accordance with the condition of said traffic governing devices, means at the control office for storing the condition of said message circuit for each step, means selectively determining which field station shall have its traffic governing devices operated for a particular cycle, and means selectively determining which field station shall govern the message circuit for a particular cycle.

21. In a centralized traffic control system for railroads having a control office and a plurality of field stations comprising a plurality of traffic governing devices, a direct current polarized stepping and control circuit extending from the control office through the several field stations, an alternating current message circuit superimposed upon said stepping and control circuit, a plurality of stepping relay banks operated synchronously by impulses applied to said stepping circuit irrespective of their polarity, means at the control office manually operable for determining the polarity of each impulse applied to said stepping circuit, means at each field station governed in accordance with the polarity of each impulse on said stepping and control circuit to operate said traffic governing devices, means at each field station for determining the energized or deenergized condition of said alternating current message circuit for each step in accordance with the condition of said traffic governing devices, means in the control office for storing the energized or deenergized condition of said message circuit for each step, means for selectively determining which field station shall have its traffic governing devices operated for a particular cycle, and means selectively determining which field station shall govern the message circuit for a particular cycle.

22. In a centralized traffic control system, in combination, with a control office and a plurality of field stations, a cyclic operating communication system, a plurality of groups of control levers, a storing relay and a code determining relay for each group, a circuit for each storing relay controlled by any of its levers, a pick-up circuit for each code determining relay including a back point of its storing relay, a front point of each storing relay to one side thereof and a back point of each code determining relay to the other side thereof, and means to retain an energized code determining relay in energized condition during a cycle of operation.

23. In a centralized traffic controlling system for railroads, step-by-step means at the control office and at each field station operated synchronously, a control circuit connecting the control office and each of the several field stations a message circuit connecting the control office and each of the several field stations, means governed by the message circuit for registering the stations one at a time at the control office in accordance with the code call allotted to the several field stations, pulsing means at each field station for puls-

ing the message circuit in accordance with the code call of the station, and cut-out means controllable over the control circuit for shunting the message line around said pulsing means.

24. In a centralized traffic controlling system for railroads, step-by-step means at the control office and at each field station operated synchronously, a message circuit connecting the control office and each of the several field stations, means governed by the message circuit for registering the stations one at a time at the control office in accordance with the code call allotted to the several field stations, pulsing means at each field station, means, dependent for its effectiveness, upon the code call for the station, for causing the pulsing means to pulse the message circuit in accordance with the station code call, and cut-out means, for preventing the dependent means from being effective.

25. In a centralized traffic controlling system for railroads; step-by-step means at the control office and at each field station operated synchronously; a control circuit connecting the control office and each of the several field stations; a message circuit connecting the control office and each of the several field stations; means governed by the message circuit for registering the stations one at a time at the control office in accordance with the code call allotted to the several field stations; pulsing means at each field station; means, dependent for its effectiveness upon the code call for the station, for causing the pulsing means to pulse the message circuit in accordance with the station code call; and cut-out means, controllable over the control circuit, for preventing the dependent means from being effective.

26. In a centralized traffic controlling system for railroads, step-by-step means at the control office and at each field station operated synchronously, a control circuit connecting the control office and each of the several field stations, a message circuit connecting the control office and each of the several field stations, means governed by the message circuit for registering the stations one at a time at the control office in accordance with the code call allotted to the several field stations, pulsing means at each station for pulsing the message circuit in accordance with its particular code call, and cut-out means at each station, controllable over the control circuit at the beginning of a cycle of operation, for making the pulsing means ineffective to pulse the message circuit.

27. In a centralized traffic controlling system for railroads, step-by-step means at the control office and at each field station operated synchronously, a control circuit connecting the control office and each of the several field stations, a message circuit connecting the control office and each of the several field stations, means governed by the message circuit for registering the stations one at a time at the control office in accordance with the code call allotted to the several field stations, pulsing means at each station for pulsing the message circuit in accordance with its particular code call, and cut-out means at each station, controllable over the control circuit at an intermediate portion of a cycle of operation, for making the pulsing means ineffective to pulse the message circuit.

28. In a centralized traffic control system for railroads, a control office, a plurality of field stations, a step-by-step mechanism at the control office and at each field station, said mechanism being operated synchronously, a control circuit

extending from said control office through each of said field stations, a plurality of traffic governing devices at each field station divided into exclusive groups, means at each field station responsive to a particular combination of impulses on said control circuit to select that field station, means at each field station responsive to a particular combination of impulses, when the corresponding field station is selected, to select a particular group of traffic governing devices at that station.

29. In combination, a plurality of step-by-step mechanisms, a stepping circuit and a message circuit interconnecting said mechanisms, means applying time-spaced impulses to said stepping circuit, whereby said mechanisms are caused to take one step for each of said time-spaced impulses, and means associated with each of said mechanisms for conditioning said message circuit for each step upon the application of the corresponding time-spaced impulse to said stepping circuit for that step, said means being effective prior to, and independent of, the actual response of said mechanisms to said time-spaced impulse for each step.

30. In a communication system, in combination, a control office and a plurality of way stations, a bank of stepping relays at each station, a neutral stepping line connecting each station to the control office for causing the relays of each stepping bank to operate in sequence by spaced current impulses placed on the neutral stepping line, a neutral control line connecting the control office and the way stations for selectively controlling devices thereover by current on and off of the control line, and a neutral message line connecting the office and way stations for sending indications into the office from the way stations.

31. In a communication system, in combination with a control office and a plurality of way stations, a single line circuit connecting the office and way stations, a bank of stepping relays at each station, means for placing spaced current impulses of at times differing polarity, on the line circuit, means for causing the relays of each stepping bank to operate in sequence in response to the spaced current impulses, to thereby prepare channel circuits, means for selectively completing prepared channel circuits in accordance with polarity of said impulses, and means for sending indications from stations to office, over the line circuit, by means of current differing in character from that of the stepping impulses.

32. In a communication system, in combination with a control office and a plurality of way stations, a single line circuit connecting the office and way stations, a bank of stepping relays of each station, means for placing spaced current impulses of at times differing polarity, on the line circuit, means for causing the relays of each stepping bank to operate in sequence in response to the spaced current impulses, to thereby prepare channel circuits, means for selectively completing prepared channel circuits in accordance with polarity of said impulses, and means for sending indications from stations to office, over the line circuit, by means of alternating current.

33. In combination; a bank of stepping relays; means for operating said relays of said bank sequentially; a plurality of channel circuits prepared by said bank of stepping relays, one for each operation of one of said stepping relays; means for dividing each of said channel circuits into a plurality of branches with the corresponding branches of said plurality of channel circuits

- separated into groups; a group of devices for each of said groups of branched channel circuits; means for connecting the devices of any group to its corresponding group of channel circuits
- 5 whenever a change in the condition of one of the devices in that group occurs; and means for interlocking said groups of channel circuits so that only one group of branched channel circuits can be connected to its devices for any particular
- 10 operation of said bank of stepping relays.
34. In combination; a bank of stepping relays; means for operating said relays of said bank sequentially; a plurality of channel circuits prepared by said bank of stepping relays, one for
- 15 each operation of one of said stepping relays, means for dividing each of said channel circuits into a plurality of branches with the corresponding branches of said plurality of channel circuits separated into groups; a plurality of groups of
- 20 electro-responsive devices, each of said groups corresponding to one of said groups of branched channel circuits and each of said devices corresponding to one of said branched channel circuits for that group; means for at times selecting
- 25 a particular group of electro-responsive devices to be connected to its corresponding group of branched channel circuits, whereby said branched channel circuit may be closed; and means for selectively energizing said branched channel circuits of the group selected in accordance with
- 30 a control code upon their sequential closure during the sequential operation of said bank of stepping relays.
35. In combination; a station code responsive means; a group code responsive means; a plurality of groups of control devices, a bank of stepping relays; means for operating said relays of said bank sequentially; a plurality of channel
- 35 circuits prepared by said bank of stepping relays, one for each operation of one of said stepping relays; means for selectively applying potentials of different polarities in accordance with a code to one end of said channel circuits; circuit means
- 40 for routing the other end of a first part of said channel circuits to said station code responsive means; means for routing the other end of a second part of said channel circuits to said group
- 45 code responsive means dependent upon said station code responsive means; means for dividing the other end of each of said channel circuits of a third part of said channel circuits into a plurality of branches with the corresponding branches
- 50 of each channel circuit of said third part separated into groups; and means including said group code responsive means for at times connecting each particular group of branched channel circuits to a particular one of said groups of control devices.
36. In combination; a control office; a field station; two line wires connecting said control office and said field station, means at said control
- 60 office for applying both direct current and alternating current to said line wire, means at said control office and field station for segregating said direct current and said alternating current, means at said control office for transmitting codes by
- 65 breaking said direct current up into impulses of distinctive polarities, means at said field station for decoding said direct current codes, means at said field station transmitting codes by breaking
- 70 said alternating current up into impulses coincident with said direct current impulses, and means at said control office for decoding said alternating current codes, whereby codes are transmitted from said field station to said control office simultaneously with the transmission of codes from said control office to said field station by means of distinctive kinds of current on the same two line wires.
37. In combination; two line circuits connecting a control office with a field station; means at the control office for applying time spaced impulses to one of said line circuits, each impulse and its following time space comprising a step
- 75 period; means at said field station for repeating each of said impulses; means at the control office for normally energizing the other of said line circuits; means at said field station prepared on each step period, as marked off by said repeating means, for effectively opening or closing in accordance with a predetermined code said other of said line circuits during the succeeding step period; and code responsive means in said control office controlled by the open and closed condition of said other of said line circuits during each of said step periods.
38. In combination; two line circuits connecting a control office with a field station, means at the control office for applying time spaced impulses to one of said line circuits, each impulse and its following time space comprising a step
- 80 period; means at said field station for repeating each of said impulses; means at the control office for normally energizing the other of said line circuits; means at said field station prepared during the time space of each step period, as marked off by said repeating means, for actually opening or closing in accordance with a prearranged code said other of said line circuits throughout the succeeding step period; and code responsive
- 85 means in said control office controlled by the open and closed condition of said other of said line circuits during each of said step periods.
39. In combination; two line circuits connecting a control office with a field station; means at the control office for applying time spaced impulses to one of said line circuits, each impulse and its following time space comprising a
- 90 step period; means at said field station for repeating each of said impulses; means at the control office for normally energizing the other of said line circuits; pulsing means at said field station prepared during each step period for, when rendered effective, opening or closing in accordance with a predetermined code said other of said line circuits; means at said field station for rendering effective said pulsing means for each step period, said means being initially effective for impressing the prepared condition
- 95 only upon the repeating of the impulse on said one of said line circuits by said repeating means; and code responsive means in said control office controlled by the open and closed condition of said other of said line circuits during each of said step periods.
40. In combination; a line circuit having a series of distinctive impulses applied thereto; a bank of stepping relays; means for operating all of said stepping relays in said bank sequentially one for each impulse of said series of impulses; a
- 100 channel circuit prepared by each of said stepping relays; and means controlled over said channel circuits of a first part for branching each of said channel circuits of a second part into any one of a plurality of branches, said plurality being greater than two.
41. In a centralized traffic controlling system for railroads, a control office, a plurality of field stations, a stepping relay bank at said control office and at each of said field stations, a step-
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ping circuit extending from said control office through said field stations, operating means at said control office and at each of said field stations for causing said stepping relay banks at the respective locations to take one step for each impulse applied to said stepping circuit, impulsing means at said control office dependent on the actual response of said stepping bank at said control office in order to be effective to impress a series of impulses on said stepping line circuit, a message line circuit connecting said control office and said field station, transmitting means at each field station for conditioning said message circuit on each step in accordance with its code call and indications at that station, means at said control office responsive on each step to the condition of said message circuit to register the station code call and indications transmitted, and means effective to allow only one station code call to be registered at any one time and to allow only the corresponding registered station to transmit indications at that time.

42. In a centralized traffic controlling system for railroads; a control office; a field station; two line wires connecting said control office and said field station; a stepping relay bank at said control office and at said field station; impulsing means at said control office, said impulsing means including said stepping bank at said control office, for impressing a series of impulses on said two line wires; means at said control office and at said field station for causing said stepping relay banks at the respective locations to operate step-by-step in response to said impulses on said two line wires as applied by said impulsing means at said control office; and means at said field station for transmitting a code impulse to said control office over said two line wires on each step taken by said stepping relay banks.

43. In combination; a stepping circuit having a series of time-spaced impulses applied thereto; a message circuit; a step-by-step mechanism responsive to take one step for each of said time-spaced impulses; two pulsing relays, each provided with a contact for distinctively conditioning said message circuit; means effective for each step of said step-by-step mechanism to control said two pulsing relays; and means rendering said contact of one of said pulsing relays effective only when said stepping circuit is energized, and rendering said contact of the other of said pulsing relays effective only when said stepping circuit is deenergized.

44. In combination with a plurality of field stations; a plurality of control levers for each field station; a storing relay for each field station, each of said storing relays having a normally energized stick circuit; manually operable means for each field station associated with said storing relay for that station, said manually operable means being effective to momentarily open said stick circuit for such storing relay when manually operated; and code determining means governed by each of said storing relays for rendering effective said control levers for the corresponding stations, only one station at a time.

45. In a centralized traffic controlling system for railroads, the combination with a plurality of field stations, of control office equipment comprising a plurality of control levers for each field station, a storing relay for each field station, each of said relays having a normally energized stick circuit, manually operable means opening the stick circuit of each storing relay, a code determining relay for each field station, means

energizing those of said code determining relays corresponding to those of said storing relays which are deenergized, said means being effective to energize only one of said code determining relays at a time, means governed by each of said code determining relays for rendering effective the corresponding control levers, and means for reenergizing said storing relays when said control levers have been rendered effective.

46. In a centralized traffic controlling system of the station selective code type, a control office and a plurality of field stations connected by a line circuit, relays in said control office corresponding to said stations and each of said relays provided with a normally energized stick circuit, a manually operated lever in said office associated with each of said relays, a traffic controlling device at each of said field stations, manually operable means associated with each of said relays effective when manually operated to momentarily open said stick circuit for the associated relay, means responsive to the deenergization of any one of said relays for applying a characteristic series of distinctive impulses to said line circuit, means responsive to each of said characteristic series of impulses for effecting selection of a corresponding station, means controlled by the position of the lever for the selected station for actuating the traffic controlling device at that station, means for effecting only the application of a preferred characteristic series of impulses when more than one of said relays is deenergized at the same time, and means for reenergizing each of said relays after it has effected the application of its characteristic series of impulses.

47. In a centralized traffic control system for railroads; a first station; a second station; two line wires only connecting said two stations; a stepping relay bank at each of said stations; impulsing means at one of said stations, said impulsing means including said stepping bank at said one station for impressing a series of impulses on said two line wires; means separate from said impulsing means for characterizing the polarity of the current flowing in said line wires on each step to constitute a distinctive control impulse for that step to transmit a message over said two line wires on each step from said first to said second station; means at each of said stations for causing the stepping relay bank at that station to operate step-by-step in response to said impulses on said line wires as applied by said impulsing means at said one station and irrespective of the polarity of the impulses; and means including said impulsing means for distinctively conditioning a circuit including said two line wires on each step taken by said stepping relay banks to transmit a message from said second station to said first station over said two line wires on each step.

48. Code-transmitting apparatus comprising a normally closed line circuit connecting a plurality of stations, a line relay and a transmitting relay at each station, the winding of each line relay and a contact of each transmitting relay being included in said line circuit, a stick relay at each station effective when energized to cause the associated transmitting relay to deliver a code comprising a series of time-spaced impulses characteristic of the station to said line circuit, means associated with each stick relay for energizing it to initiate such code, a holding circuit for each stick relay, means including cooperating contacts of the associated line relay and transmitting re-

lay for opening such circuit to release the stick relay during the code provided the line relay fails to pick up when the transmitting relay closes its line contact or if it releases while its line contact is closed, and other means for releasing said stick relay at the end of the code.

49. In a remote control system, an office and a plurality of stations connected by a line circuit, a transmitter relay at each station for determining the continuity of the line circuit, means at each station for operating such transmitter relay repeatedly to transmit a code characteristic of the station to said office, and means effective in the event a plurality of transmitter relays are set into operation at the same time to render ineffective all but one of such relays comprising a line relay at each station responsive to the codes delivered to said line circuit, and a circuit governing the effective operation of each transmitter relay including cooperating contacts of such relay and of the associated line relay.

50. In a remote control system, an office and a plurality of stations connected by a line circuit, a transmitter relay at each station for determining the continuity of the line circuit, means at each station for operating such transmitter relay repeatedly to transmit a code characteristic of the station to said office, and means effective in the event a plurality of transmitter relays are set into operation at the same time to render ineffective all but one of such relays comprising a line relay at each station responsive to the codes delivered to said line circuit, a circuit governing the effective operation of each transmitter relay including cooperating contacts of the transmitter relay and of the associated line relay, said circuit being arranged to be opened on any step of the code to render ineffective the operation of such transmitter relay unless the transmitter relay and the line relay are operated in accordance with the same code.

51. In a remote control system, an office and a plurality of stations connected by a line circuit, a transmitter relay at each station for determining the continuity of the line circuit, means at each station for operating such transmitter relay repeatedly to transmit a code characteristic of the station to said office, means effective in the

event a plurality of transmitter relays are set into operation at the same time to render ineffective all but one of such relays comprising a line relay at each station responsive to the codes delivered to said line circuit, a circuit associated with each transmitter relay including contacts of that relay and of the associated line relay, and means opening such circuit to render ineffective the transmitter relay in the event that the response of the associated line relay on any step of the code is not in accordance with the code operation of such transmitter relay.

52. In a remote control system, a control office and a field station connected by a line circuit, means at said office for applying time spaced direct current impulses to said line circuit, means at said office for transmitting control codes to said station by marking said impulses with distinctive polarities, a source of alternating current included in said line circuit, means at said field station for transmitting indication codes to said office by preventing or permitting said alternating current to flow over said line circuit to said office concomitantly with the flow of said direct current impulses, and means at said field station and at said office for simultaneously decoding said control and said indication codes respectively.

53. In a remote control system, a control office and a plurality of field stations connected by a line circuit, means at said office for applying time spaced direct current impulses to said line circuit, step-by-step means including a series of neutral stepping relays at said office and at each of said stations, the neutral stepping relays of each means being energized one at a time one for each direct current impulse, a source of alternating current included in said line circuit, means including the step-by-step means at said office and at one of said field stations for transmitting indication codes to said office by preventing or permitting said alternating current to flow over said line circuit to said office concomitantly with the flow of said direct current impulses, and means at said office for decoding said indication code.

WILLIAM D. HAILES.
DARROL F. DE LONG.

DISCLAIMER

2,170,141.—*William D. Hailes and Darrol F. De Long*, Rochester, N. Y. CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS. Patent dated August 22, 1939. Disclaimer filed December 14, 1939, by the assignee, *General Railway Signal Company*.

Hereby enters this disclaimer by disclaiming from claim 9 any system for centralized traffic control, except wherein "the condition of said control circuit for the respective steps of a cycle" depends on the character of the current flowing in a single "circuit extending from said control office through each of said field stations";

By disclaiming from claim 10 any system of centralized traffic control, except wherein the "step-by-step mechanism at the control office and at each field station" are controlled in synchronism by apparatus located at said control office and wherein the "condition of said message circuit" is determined by apparatus at a "field station";

By disclaiming from claim 11 any system of centralized traffic control, except wherein the "stepping relays" at the "field station" are controlled by apparatus at a distant control office and "the condition of said message circuit" is determined by apparatus at the "field station";

By disclaiming from claim 28 any system of centralized traffic control, except wherein the "impulses" of the "combination of impulses on said control circuit" comprise successive impulses transmitted over a single "control circuit";

By disclaiming from claim 40 any system of centralized traffic control, except wherein the "distinctive impulses" are individual current impulses which are by themselves distinctive in character and are transmitted over a single "line circuit";

By disclaiming claim 33 in said patent.

[*Official Gazette January 9, 1940.*]