

March 2, 1937.

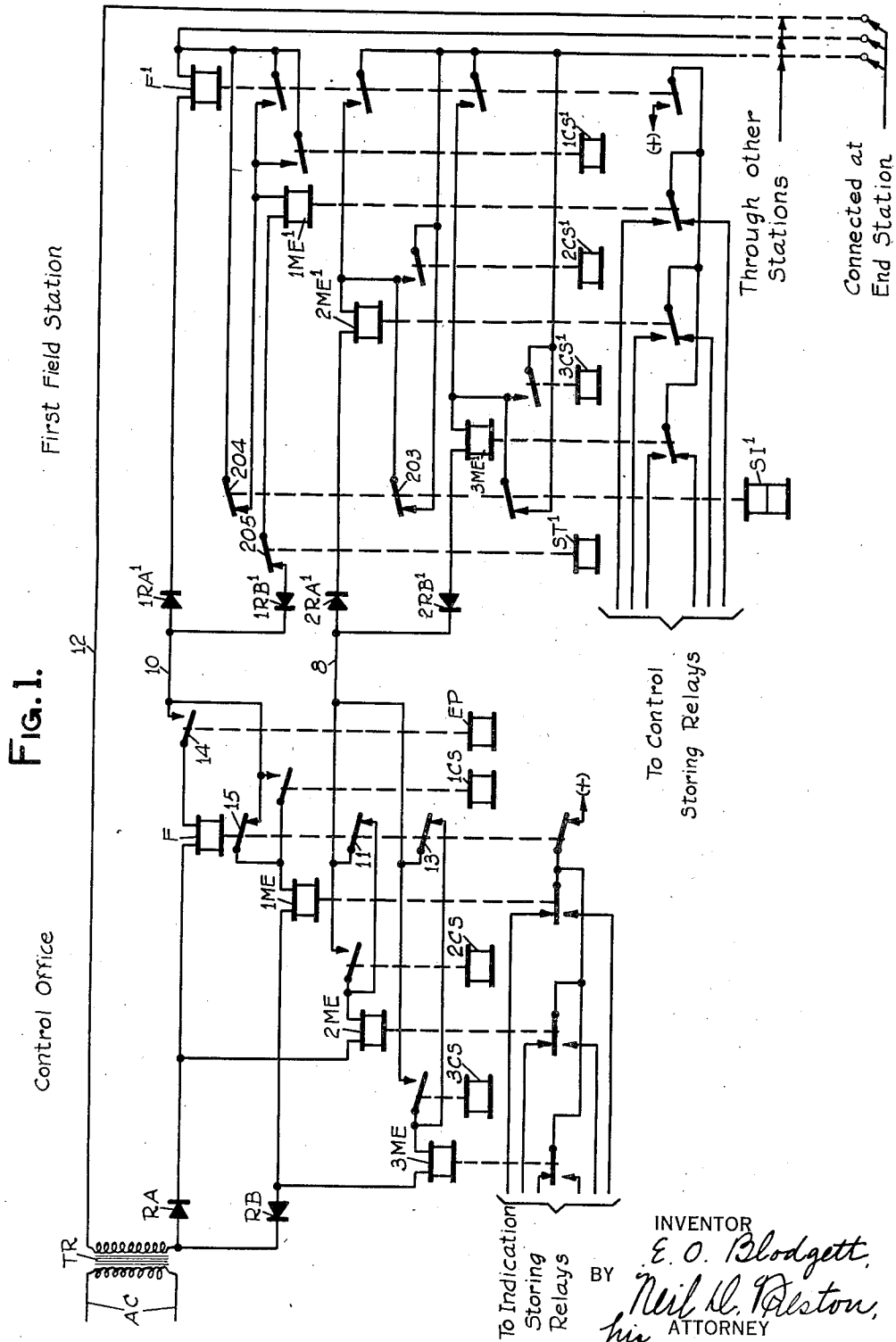
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed Oct. 13, 1933

5 Sheets-Sheet 1



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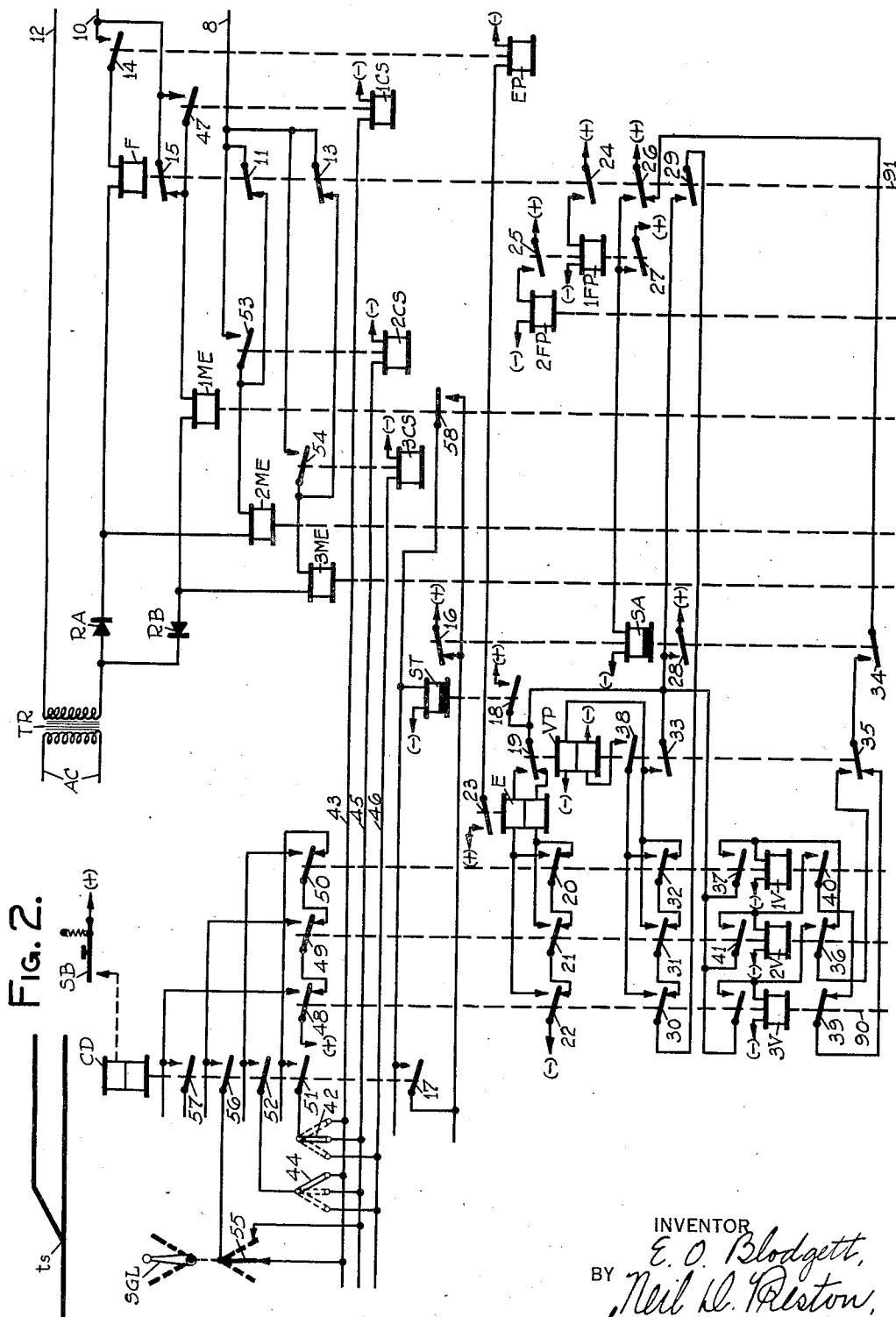
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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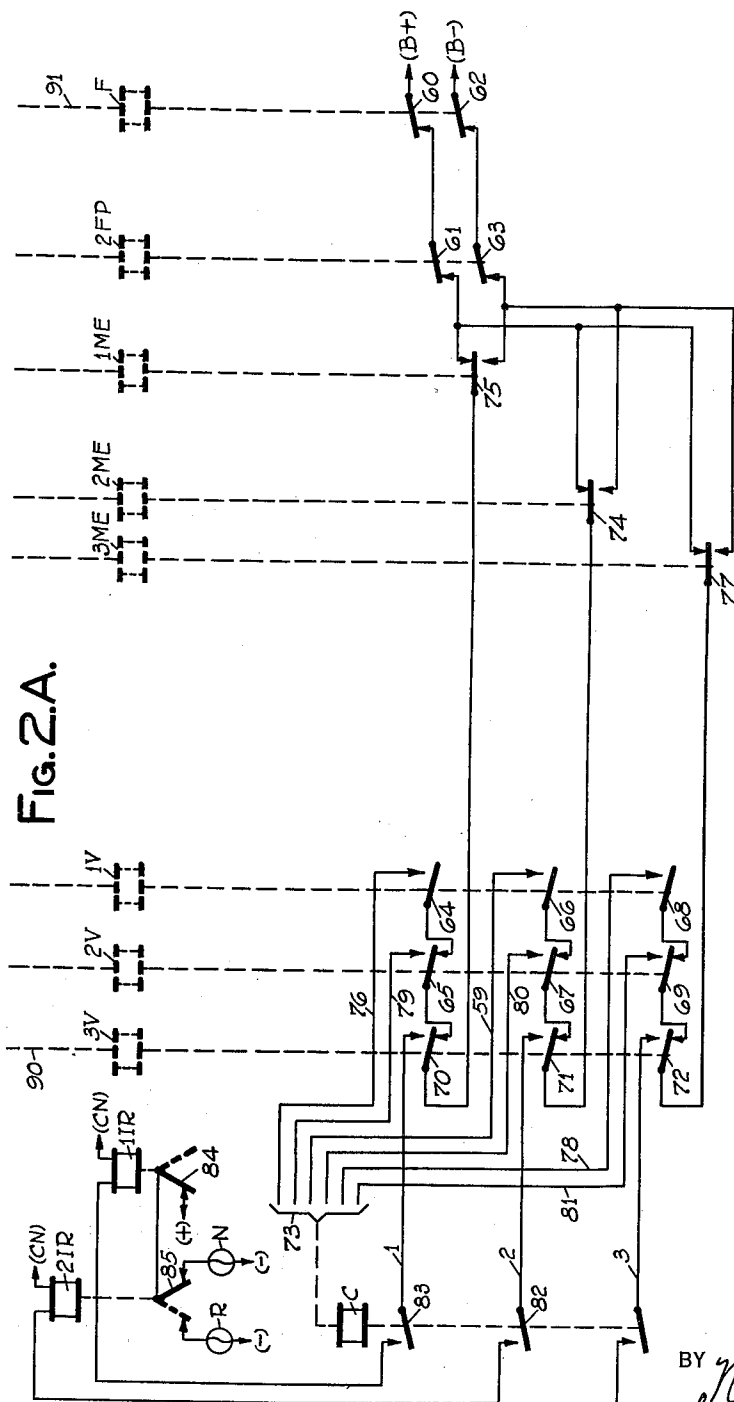
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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Fig. 2.A.



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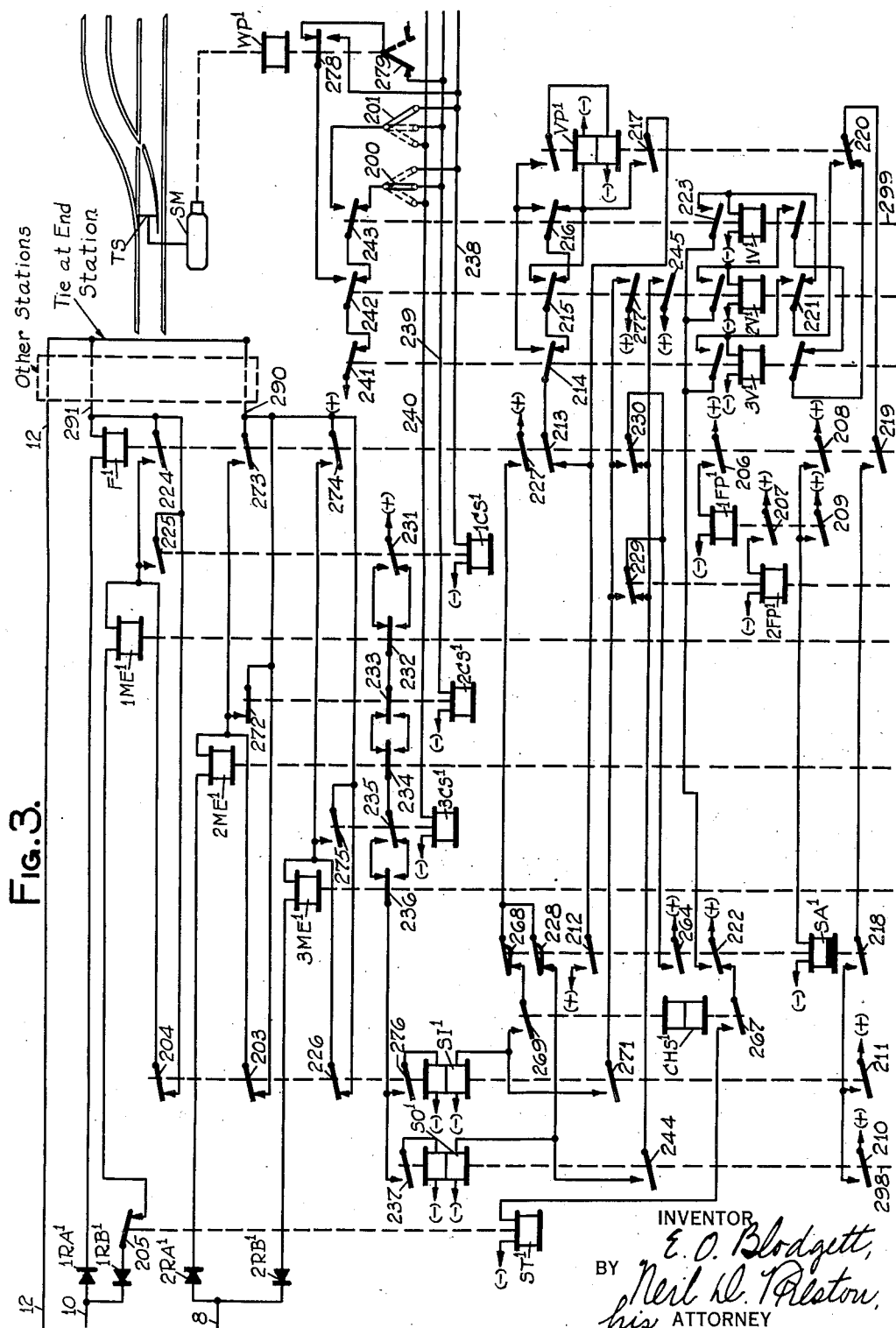
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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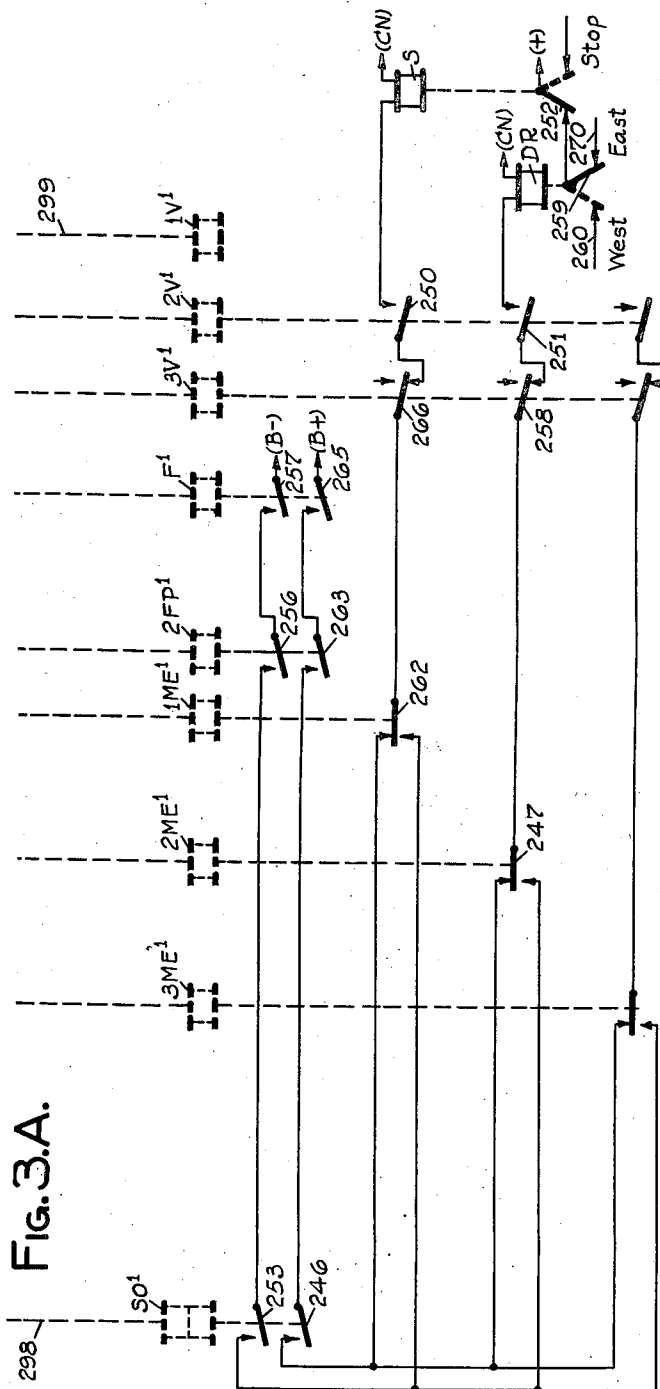
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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5 Sheets-Sheet 5



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2,072,079

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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Application October 13, 1933, Serial No. 693,484

9 Claims. (Cl. 177—353)

This invention relates to centralized traffic controlling systems for railroads and it more particularly pertains to the communication part of such systems.

5 The present invention contemplates a centralized traffic controlling system of the type in which the switches and signals at various points along a railroad system are placed under the control of an operator in a central control office, in such
10 a way that the operator may at will change the positions of the switches, subject to automatic approach and detector locking circuits which prevent unsafe operation of any switch and in such a way that the operator may at will hold
15 at stop any of the signals or allow them to clear dependent upon the position of the associated switches and also provided the location of trains makes it safe for such signals to indicate proceed.

In that type of centralized traffic controlling
20 system where a communication system of the station selective type is employed, control impulses are transmitted from the control office to the several field stations during separate operating cycles. Similarly, indication impulses are
25 transmitted to the control office in accordance with the positions of the various traffic controlling devices at the several field stations and these indication impulses are transmitted to the control office, one station for each operating cycle.

30 Since the system of the present invention is of the coded duplex type, it is operable through cycles of operation for the transmission of controls and/or for the transmission of indications. When controls are transmitted, a particular field
35 station selecting code is first transmitted to select the desired station and this code is then followed by the controls to be transmitted to the selected station. Similarly, when indications are transmitted, that particular field station which is
40 transmitting first transmits its station registering code followed by the transmission of the indications at that station.

The system chosen as one embodiment of the present invention provides that the control office
45 and the field stations are connected in series by a stepping line circuit and a message line circuit comprising three line wires. These three line wires are supplied with energy from an alternating current source, preferably located in the control office, although such source might be located
50 anywhere else along the communication system. The alternating current energy supplied to each line circuit is divided into two branches conveniently referred to as the A branch and the B
55 branch. This division of circuits is accomplished

by the use of suitable one-way devices, such for example, as the common copper oxide rectifier so that the A branch may have current flowing in one direction only when it is closed and so that the B branch may have current flowing in the
5 opposite direction only when it is closed.

In the present embodiment, the A branch of the source of energy is connected to the stepping line circuit for governing the step-by-step operation required in a selector type system at the
10 control office and at the several field stations. This A branch is also selectively connected to the message line circuit and serves to make up a portion of the code combination formed during the transmission of controls. The B branch is selectively
15 connected to the stepping line and to the message line for completing the code combination used in transmitting controls. In the present invention this selective connection of the A and B branch circuits of the source of energy to the stepping and message lines for the transmission of controls is applied during the impulse
20 periods which will be conveniently referred to as the "on" periods. The B branch is selectively connected to the stepping and message lines during the time spaces between impulse periods, which will be conveniently referred to as the "off" periods. The A branch is selectively connected to the message line during the "off" periods. This connection of the A and B branches to the stepping and message lines during the "off" periods is for the transmission of indications.

For example, when the A branch is connected to the stepping line circuit, an impulse is applied to this circuit for energizing the line relays in the control office and at all field stations in series. During the time that the stepping line is energized by way of the A branch the stepping line may be energized or deenergized by way of the B branch as determined by the control code to be
40 transmitted. Similarly, during the time that the stepping line circuit is energized by way of the A branch, the message line circuit may be selectively energized or deenergized by way of either or both the A and B branches, thus combining
45 with this selective energization of the stepping line by way of the B branch to form the control code.

Likewise, since indications are transmitted during the "off" periods, the B branch is selectively
50 connected to the stepping and message lines and the A branch is selectively connected to the message line during the "off" periods for energizing or not energizing these lines in combination for providing the indication code.
55

Although it is to be understood that the system of the present invention may be readily adapted for use in a system of selective lock-out between field stations such as disclosed, for example, in the pending application of T. J. Judge, Ser. No. 613,353, filed May 25, 1932, the present embodiment has been shown as employing the so-called superiority of code principle between the field stations. This arrangement provides that all field stations having new indications to transmit at the beginning of an operating cycle attempt to transmit their station registering code calls, but only that station having the most superior code call is successful in transmitting its complete code, while all of the other stations drop out for the remainder of that cycle and again endeavor to transmit their codes during the next cycle. In this way, the field stations are allowed to transmit their indications one station at a time in a sequence or order determined by the relative characteristics of the station registering code calls.

These characteristic features of the present invention thus briefly stated will be explained more in detail in the following description of one embodiment of the invention and various other features, functions and advantages of a system embodying this invention will be in part pointed out and in part apparent as the description thereof progresses.

In describing the invention in detail, reference will be made to the accompanying drawings in which those parts having similar features and functions are designated in the several views by like letter reference characters which are generally made distinctive either by reason of distinctive exponents representative of their location or by reason of preceding numerals representative of the order of their operation and in which:

Fig. 1 illustrates the line circuit arrangement for a control office and one field station in a system embodying the present invention, together with the apparatus most closely associated with these circuits.

Figs. 2 and 2A illustrate the apparatus and circuit arrangements employed at the control office for providing means whereby an operator may govern the switches and signals throughout the territory served by the communication system and for providing means whereby indications may be received from the various field stations throughout such territory.

Figs. 3 and 3A illustrate the apparatus and circuit arrangements employed at a typical field station for providing control of a single railway track switch and for transmitting indications to the control office, all in accordance with the present invention.

In considering the circuits illustrated in these figures in connection with the following description, Fig. 2 should be placed above Fig. 2A and Fig. 3 should be placed above Fig. 3A, with Fig. 3 to the right of Fig. 2 and with correspondingly numbered lines in alignment.

For the purpose of simplifying the illustrations and facilitating in the explanation, various parts and circuits constituting the embodiment of the invention have been shown diagrammatically and certain conventional illustrations have been employed. The drawings have been made more with the purpose of making it easy to understand the principles and mode of operation rather 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 the connections to the terminals of batteries or other sources of current instead of showing all of the wiring connections to these terminals.

The symbols (+) and (−) are employed to indicate the positive and negative terminals respectively of suitable batteries or other sources of electrical energy and the circuits with which these symbols are used always have current flowing in the same direction. It should be noted that the present embodiment employs direct current at the control office and at the field stations for energizing the local circuits while alternating current is employed for energizing the line circuits. However, it might be expedient to employ alternating current for the local circuits and in such event, the usual engineering expedients may be employed in adapting the operation of the system to an alternating source of energy. When alternating current is used in place of direct current, the particular symbols employed as representing local sources of energy should be considered as indicating the relative instantaneous polarities of the alternating current source substituted for the direct current source. The symbols (B+) and (B−) are employed to indicate the positive and negative terminals respectively of suitable batteries or other sources of current having mid-taps designated (CN). The circuits with which these symbols are used may have current flowing in one direction or the other depending upon whether terminal (B+) or (B−) is used in combination with the center tap (CN).

Communication system.—The general plan of organization of the system may be best understood by referring to Fig. 1 of the drawings which discloses the line circuits with the most closely associated apparatus. It is to be understood that the system may be extended to include as many field stations as necessary for the proper supervision of the territory allotted to a particular control office but for convenience in disclosing the present invention only a first field station has been illustrated.

The line wires 8, 10 and 12 connect the control office with the first field station and similarly, these line conductors extend from the first to the second field station and so on to the end of the system where they are connected together to provide closed circuits for conductors 8, 10 and 12. Although the control office has been shown located at one end of the system, it is to be understood that it may be located at any intermediate point or at the opposite end of the system since the present system is of the coded type employing a superiority of code between field stations.

The line circuit is energized in the control office from a suitable source of alternating current indicated as being connected to the primary of transformer TR with one terminal of the secondary of this transformer permanently connected to common conductor 12, while the other terminal is selectively connected to conductor 10 and message conductor 8. The alternating current may have the usual sine wave form and may have a frequency distinctive from the usual power lines in order to avoid interference.

The stepping line circuit including conductor 10 includes a line relay F at the control office in series with a rectifier unit RA and a line relay F¹ at the field station in series with a rectifier unit

IRA¹. These line relays are of the neutral type and it will be understood that similar relays and rectifiers are connected in the stepping line conductor at the other stations. Line 10 also includes a front contact 14 of a pulsing relay EP in the control office. Branch B of line 10 at the field station includes a rectifier unit 1RB¹ in series with a message relay 1ME¹ and certain contacts, the purpose of which will be described later in the specification. Branch B of line 10 in the control office includes a message relay 1ME in series with a rectifier unit RB and contacts of certain relays, the purpose of which will be later explained.

Branch A and branch B in the control office are each connected through message relays 2ME and 3ME respectively to message line conductor 8 by the operation of certain relay contacts which will be thoroughly discussed. At the field station, the message line conductor is connected in series with message relay 2ME¹ and rectifier unit 2RA¹. The message line conductor is likewise connected to message relay 3ME¹ in series with rectifier unit 2RB¹. This connection of relays 2ME¹ and 3ME¹ in series with message line conductor 8 is controlled by certain relay contacts as will be later explained.

It will be understood that the F and ME relays at the control office and at the various field stations are controlled over the line circuits by half cycles of alternating current or in other words pulsating current. For greatest efficiency, these relays may be designed with such characteristics that they will operate without undue chattering or vibration of the armature, although the conventional direct current telephone type relay will operate satisfactorily. An expedient employed to provide proper operation of these relays may include shunting the relay windings with suitable resistors, rectifier units or by a resistor and a condenser in series. Likewise, a special design of the magnetic circuits of these relays may be provided to hold over the relay armature between successive energizations of its windings on successive half waves of the alternating current.

Control office equipment.—The control office (see Figs. 2 and 2A) includes a control machine having a group of control levers for each of the field stations, a miniature track layout corresponding in every way to the actual track layout in the field and various indicating lamps or equivalent devices, together with the apparatus and circuits to accomplish the functioning of the system.

That part of the control office illustrated shows more particularly those devices of a control machine which are typical of the apparatus associated with a single field station having a track switch, a cross-over or the like, together with the general transmitting apparatus used in common by all such field stations.

The apparatus for one track switch includes a signal control lever SGL, a starting button SB, a miniature track switch point ts and track switch position indicating lamps N and R. Similarly a switch control lever or levers (not shown) would also be associated with the apparatus of the same field station, but these devices have been omitted for convenience in the description since the control of the signals by lever SGL may be considered as typical of the control of other traffic controlling devices.

The movement of the signal lever to one extreme position or the other, or when this lever is left in its neutral position, followed by the actua-

tion of the starting button results in clearing the corresponding signals at the field station associated with the starting button, or putting the signals to stop in accordance with the position of the signal control lever, through the medium of the communication system of the present invention. The momentary actuation of the starting button SB is preferably stored by a suitable storing relay (not shown) which in turn picks up the corresponding code determining relay CD for the associated station. Such control has merely been indicated in order to simplify the present disclosure.

The storing relays for each starting button and their respective code determining relays are so interlocked that irrespective of the number of storing relays that are energized simultaneously or in rapid succession for the transmission of controls to their respective field stations, only one code determining relay for a particular station may be picked up during any one particular cycle of operations. This interlocked bank of relays is so arranged that if several storing relays are up at the same time their corresponding code determining relays will be picked up successively during successive operating cycles in a predetermined order as determined by their location in the code determining relay bank, all of which has been completely disclosed in the prior application of N. D. Preston et al., Ser. No. 455,304 filed May 20, 1930, corresponding to Australian Patent 1,501 of 1931.

The control office includes a neutral line relay F and its associated line repeating relays 1FP and 2FP which repeat each energization and de-energization of relay F. The line repeating relay 2FP is for the purpose of obtaining suitable time margins. Slow acting relay SA is picked up at the beginning of each cycle and is dropped at the end of each cycle. This relay has such slow acting characteristics that its pick-up time is relatively slow compared to the pick-up time of the neutral relays such as 1FP and 2FP for example, but the drop-away period of relay SA is comparatively longer than its pick-up period.

Associated with the line relay and its repeating relays is a bank of relays including stepping relays 1V, 2V, 3V and half step relay VP. This bank of relays marks off the successive steps of each cycle of operations. An impulsing relay E is jointly controlled by the stepping relays and the half step relay. This impulsing relay, together with its repeating relay EP, governs the opening and closing of the A branch of the circuit connection to the stepping line.

The B branch of the A. C. supply is selectively connected to the stepping line during each "on" period by reason of the deenergized or energized condition of the code sending relay 1CS. The A branch of the A. C. supply is selectively connected to the message line during each "on" period by reason of the deenergized or energized condition of the code sending relay 2CS. The B branch of the A. C. supply is selectively connected to the message line during each "on" period by reason of the deenergized or energized condition of the code sending relay 3CS. These code sending relays are of the neutral type and are energized or left deenergized on each step in accordance with the station code call and the particular controls to be transmitted during a particular cycle of operations following the selection of a station.

Message receiving relays 1ME, 2ME and 3ME are effective during each "off" period to position

on the corresponding step suitable pilot relays in accordance with their conditions (energized or deenergized). This conditioning of the message receiving relays is determined at the field station by the particular code transmitted.

For the purpose of illustrating the registration of a field station, only one station relay C has been shown, which relay is indicated as being selected in accordance with the character of the code impulses for the first two steps. In other words, any suitable pilot relay bank such as disclosed for example in the above mentioned prior application of N. D. Preston et al., Ser. No. 455,304 may be employed for registering the station code call and for selecting the particular station relay C associated with the calling station. The remaining steps of the cycle are thereafter effective to register the condition of the message receiving relays 1ME, 2ME and 3ME for positioning indication storing relays such as relays 1IR and 2IR in accordance with the indications being transmitted from the registered field station.

A starting relay ST is provided for causing the system to initiate a cycle of operations whenever this relay is picked up with the system at rest. This relay may be energized by reason of the presence of any controls to be transmitted from the control office or by reason of the presence of any indications to be transmitted from one or more field stations.

The control office also includes various sources of current supply, bus wires and circuit connections, indicator lamps, terminal boards, overload protection and such other devices as may be required for the proper functioning of such a system.

Field station equipment.—The field station illustrated in Figs. 3 and 3A is typical of all field stations of this system and may be adapted for use at the first, second or any other location by merely altering certain code jumpers and connections to arrange for the desired codes assigned to the various locations. For convenience in describing the present invention the apparatus illustrated in Figs. 3 and 3A has been designated as associated with the first field station by reason of the distinctive exponent (1) employed with each of the letter reference characters.

With reference to Fig. 3, a turn-out track is illustrated as connected to a main track by means of a track switch TS which may be operated from one extreme locked position to the other by a suitable switch machine SM. This switch machine is governed by a switch control relay (not shown) which is controlled from the control office through the medium of the communication system herein disclosed.

Suitable signals (not shown) are associated with the track switch TS for governing traffic thereover and are provided with automatic signaling means interrelating the traffic over this track switch with such other track switches and track sections as may be associated therewith. These signals are contemplated as being governed from the control office through the medium of the communication system by control relays such as direction relay DR and stop relay S of Fig. 3A.

Certain other devices such as the usual track relay, the track battery, as well as the usual lock relays have been omitted from the present disclosure for the sake of simplifying the drawings and description.

The communication part of the system in-

cludes at the field station a line relay F¹ and its associated repeating relays 1FP¹ and 2FP¹ all of the neutral type. These relays, like the corresponding relays in the control office, follow each energization and each deenergization of the stepping line from the A branch of the source of current supply. Slow acting relay SA¹ corresponds to relay SA in the control office and has similar characteristics and functions.

The field station includes a bank of stepping relays including relays 1V¹, 2V¹, 3V¹ together with a half step relay VP¹ arranged and controlled in a similar manner as the stepping relay bank in the control office, with certain exceptions which will be later explained in detail.

The field station includes a selecting relay SO¹ which is responsive to the station selecting code calls transmitted from the control office, so as to select the corresponding field station and render this station effective to receive succeeding control impulses whenever the code call corresponds to the one assigned to this field station. Similarly, a selecting relay SI¹ is provided to be responsive to the code calls transmitted from the field stations, so that when the resulting code call corresponds to that assigned to its station this station will be effective to permit transmission of indications to the control office.

A change storing relay CHS¹ is provided to register a change in any of the traffic controlling devices at the field station such as the track relay (not shown), the switch repeating relay WP¹, etc., so that the system will be initiated for the transmission of new indications when this change storing relay is picked up. The specific control for this relay has not been illustrated since it may be of any approved arrangement such as disclosed in detail in the patent to D. F. DeLong et al. Pat. No. 1,852,492 issued April 5, 1932. The change storing relay when once energized can be deenergized only when its field station has been effective in registering its code call in the control office.

For the purpose of applying the code call of the field station by way of the B branch of the A. C. supply to the stepping line in accordance with the positions of station code jumpers 290, 291, a code sending relay 1CS¹ of the neutral type is provided. For the purpose of applying the code call of the field station by way of the A branch of the A. C. supply to the message line conductor in accordance with the positions of the station code jumpers 290, 291, a code sending relay 2CS¹ of the neutral type is provided. For the purpose of applying the code call of the field station by way of the B branch of the A. C. supply to the message line conductor in accordance with the positions of the station code jumpers 290, 291, a code sending relay 3CS¹ of the neutral type is provided.

These code sending relays are subject to the control of the selecting relay SI¹ so that they are rendered ineffective during a cycle of operations in which this field station is endeavoring to transmit, as soon as this station fails to be selected by reason of the differences between the code call actually transmitted to the control office and the code call assigned to this field station. This control of the CS relays by the SI¹ relay is effected by shunting the CS relay contacts by back contacts on the SI¹ relay, closed when this latter relay is dropped.

Relays 1ME¹, 2ME¹ and 3ME¹ are effective in similar branches of the circuits and over similar line conductors as corresponding relays in the

control office for selectively energizing the selecting relay SO¹ and the selecting relay SI¹, as well as controlling the conditioning of the controlled relays at the selected station in accordance with the code combinations received over the communication system, all in a manner which will be explained in detail.

Two rectifiers 1RA¹ and 1RB¹ (or a single rectifier device with a center tap) are connected in the stepping line circuit at each field station for selecting the A and B branches of the A. C. supply which is connected to the stepping line. Two rectifiers 2RA¹ and 2RB¹ (or a single rectifier with a center tap) are connected in the message line conductor for providing two separate circuit paths for the A and B branches of the A. C. supply in connection with the message line conductor at each field station.

For illustrating the manner in which indications are transmitted from a registered field station in groups of three for each step of the stepping relay bank, a switch repeating relay WP¹ is provided. The three conditions repeated by this relay are, first the corresponding switch unlocked, second the corresponding switch locked in its normal position and third the corresponding switch locked in its reverse position. The first condition is indicated by the neutral contact 278 of relay WP¹ being dropped and the second and third conditions are indicated by the neutral contact 278 up and polar contact 279 of relay WP¹ in its left and right hand positions respectively. For illustrating the manner in which controls are transmitted to a selected station in groups of three for each step, a stop relay S and a direction relay DR are provided. The three conditions received and recorded by these relays are, first putting all signals to stop, second clearing signals east and third clearing signals west.

The field station also includes suitable bus wires, circuit connections, code jumpers and such other devices as are necessary for a centralized traffic controlling system as contemplated in accordance with the present invention.

It is believed that the nature of the invention, its advantages and characteristic features, can be best understood with further description being set forth from the standpoint of operation.

Operation

The communication system of the present invention is normally in a condition of rest from which it may be initiated into a cycle of operations either from the control office or from any of the field stations when there are new controls or new indications ready to be transmitted. If new controls are ready for transmission to several different field stations at substantially the same time, they are transmitted on separate cycles of operation, one station for each cycle. Similarly, if several field stations have indications ready for transmission at substantially the same time, they are transmitted from such field stations, one station at a time on separate operating cycles.

Whenever there are new controls and new indications ready for transmission at the same time, controls are transmitted to a particular field station on the same operating cycle that indications are transmitted from the same station or from some other selected station, depending upon the particular station having new indications to transmit.

Irrespective of whether a cycle of operations is for the transmission of controls and/or indications, a predetermined number of time spaced

impulses are applied to the stepping line circuit by way of the A branch of the source of current to accomplish the step-by-step operation of the stepping relay banks at the control office and at each field station. Each series of impulses includes a relatively long conditioning impulse at the beginning of the cycle, while the remaining impulses of the series are of substantially equal duration. Also, the time spaces between the impulses of each series are of substantially equal duration.

The stepping relay bank in the control office is arranged to take one step for each of the time spaces of any series of impulses applied to the stepping line circuit. The stepping relay banks at the field stations are arranged to take one step for each of the impulse periods of such series of impulses. Thus, the stepping relays in the office are picked up during the "off" periods and the stepping relays at the stations are picked up during the "on" periods. The half step relay VP in the control office is shifted during the "on" periods, that is, it is picked up and dropped during alternate "on" periods. The half step relay VP¹ at the field station is shifted during the "off" periods, that is, it is picked up and dropped during alternate "off" periods. This also refers of course, to the stepping relays and the half step relays at other stations since they operate in synchronism with those at the typical station illustrated in the drawings.

Whenever a cycle of operations is initiated for the transmission of controls, the characters of the impulses placed upon the stepping line circuit by way of the B branch of the A. C. supply and the characters of the impulses placed upon the message line circuit by way of both the A and B branches of the A. C. supply during the "on" periods are determined in accordance with the station to be selected and the controls to be transmitted to the selected station, as set up by the code jumpers and control levers associated with the corresponding station in the control office.

On the other hand, during a cycle initiated for the transmission of indications, the characters of the impulses placed upon the message line circuit by way of the A and B branches of the A. C. supply and the characters of the impulses placed upon the stepping line circuit by way of the B branch of the A. C. supply during the "off" periods are determined in accordance with the positions of the code jumpers at the station to be registered in the control office and the indication contacts on the various indication devices at that station.

If controls are being transmitted alone, then a non-registering or phantom code is applied to the stepping and message line circuits during the indication transmitting periods. If indications are being transmitted alone, then a non-selecting or phantom code is applied to the stepping and message line circuits during the control transmitting periods. When both controls and indications are being transmitted, the characters of the impulses during the respective transmitting periods are determined in accordance with their respective code transmitting means.

Normal condition.—Although the system is illustrated as being in a condition of rest, the message line circuit is normally energized by way of the B branch in order to permit any field station to initiate the system into a cycle of operations. This energizing circuit extends from the upper terminal of transformer TR of Fig. 2, com-

mon line conductor 12 through all of the field stations in series, returning by way of message line conductor 290 through all of the field stations in series, back contact 293 of relay SI¹, winding of relay 2ME¹, rectifier 2RA¹, message line conductor 8, back contact 11 of relay F¹, winding of relay 2ME and rectifier RA to the other side of the transformer. It will be assumed that only the positive half cycles of the A. C. current from transformer TR flow through the above described circuit and this circuit is effective to energize relay 2ME.

A branch circuit may be traced from message line conductor 8 in Fig. 2 which extends through back contact 13 of relay F¹, winding of relay 3ME and through rectifier RB to the lower side of transformer TR. The opposite half cycles of the A. C. current (for example (-)) flow through this circuit and this current is effective to energize relay 3ME. An additional branch from the return line conductor at the end field station extends by way of stepping line conductor 291 through all of the field stations in series, back contact 204 of relay SI¹, winding of relay 1ME¹, back contact 205 of relay ST¹, rectifier 1RB¹, stepping line conductor 10, back contact 15 of relay F¹, winding of relay 1ME and rectifier RB to the lower terminal of the transformer TR. Current during the negative half cycles flowing over this circuit is effective to energize relay 1ME.

Since the above described circuits including relays 1ME, 2ME and 3ME also include corresponding relays 1ME¹, 2ME¹ and 3ME¹ at the field station, these latter relays are likewise normally energized. The remaining circuits of the system are normally deenergized with but a few exceptions. For example, track switch repeating relay WP¹ associated with track switch TS is preferably of the closed circuit type. Also, the detector track circuit including the usual track relay, as well as the usual signals-at-stop relay and the change relay are normally energized but in order to eliminate undue complications, these circuits have not been shown in detail. Relay 2CS¹ is normally energized over a circuit extending from (+), back contacts 241, 242 and 243 of relays 3V¹, 2V¹ and 1V¹ respectively, jumper 200, bus 239 and winding of relay 2CS¹, to (-).

Manual starting.—With the system in a condition of rest, it may be manually initiated into a cycle of operations for the transmission of controls. To initiate such a cycle, the operator first positions the control levers for the field station or stations to which controls are to be transmitted and he then actuates the starting button or buttons associated with this station or stations.

For the purpose of considering the operation of the present invention, it is sufficient to know that the actuation of starting button SB of Fig. 2, for example, causes the actuation of code determining relay CD in its proper turn while the system is at rest. The response of relay CD, or any other code determining relay (not shown), closes a pick-up circuit for starting relay ST extending from (+), back contact 16 of relay SA, front contact 17 of relay CD and winding of relay ST, to (-). It will be understood that the bus wires to which front contact 17 is connected extend to the remaining code determining relays in the bank.

The response of relay ST closes a pick-up circuit for relay E extending from (+), front contact 18 of relay ST, back contact 19 of relay VP,

lower winding of relay E, back contact 23 of relay IV, back contact 21 of relay 2V and back contact 22 of relay 3V, to (-). The energization of relay E is repeated by relay EP upon the closure of front contact 23 of relay E.

The closure of front contact 14 of relay EP energizes the stepping line conductor 10 over the A branch of the A. C. portion of the circuit. This energizing circuit for the stepping line conductor extends from the lower terminal of transformer TR through rectifier RA, relay F¹, front contact 14 of relay EP, stepping line conductor 10, rectifier 1RA¹, relay F¹, conductor 291 extending through the A branches including the line relays at other field stations and thence through the tie at the end field station and by way of common return conductor 12 to the upper terminal of transformer TR. This energization of the stepping line conductor is repeated at the control office and at each field station by the response of the line relays.

The response of the line relays is repeated by their respective repeating relays 1FP and 2FP in the control office and relays 1FP¹ and 2FP¹ at the illustrated field station. For example, relay 1FP is energized upon the closure of front contact 24 of relay F¹ and relay 2FP is energized upon the closure of front contact 25 of relay 1FP. Relay 1FP¹ is energized upon the closure of front contact 206 of relay F¹ and relay 2FP¹ is energized upon the closure of front contact 207 of relay 1FP¹.

The picking up of the F and FP relays in the control office and at each field station is repeated by their respective slow acting relays. For example, the picking up of front contact 26 of relay F¹ and front contact 27 of relay 1FP in the control office closes an obvious energizing circuit for relay SA. The picking up of front contact 208 of relay F¹ and front contact 209 of relay 1FP¹ closes an obvious energizing circuit for relay SA¹ at the field station.

The response of relay SA in the control office closes a pick-up circuit for relay VP extending from (+), front contact 28 of relay SA, front contact 29 of relay F¹, back contacts 30, 31 and 32 of relays 3V, 2V and 1V respectively and the upper winding of relay VP, to (-). The picking up of front contact 33 of relay VP closes a stick circuit for this relay which is independent of contacts 30, 31 and 32 of the stepping relays. The response of relay SA¹ at the field station is not followed by the response of relay VP¹ until the following deenergized period of the stepping line circuit.

Although the station selecting relays SO¹ and SI¹ at the field station are initially conditioned for selection during the pick-up periods of their respective slow acting relays together with the conditioning of various other devices, such operations will be considered separately. Attention is more particularly directed at this time to the manner in which the stepping line circuit is impulsed with time spaced impulses over the A branch of the source of supply for marking off the "off" and "on" periods of the cycle.

Impulsing operation.—As above mentioned, the first energized period of the stepping line circuit is provided by the actuation of relay EP as a result of starting relay ST being picked up. Likewise, the successive energizations of relays F, 1FP and 2FP are effected. Assuming for the moment that relay VP responds as above pointed out, the opening of its back contact 19 deenergizes relay E. The dropping of front contact 23 of re-

lay E deenergizes relay EP which in turn deenergizes the stepping line by opening front contact 14.

It will be pointed out at this time that the picking up of back contact 16 of relay SA deenergizes relay ST but the dropping of front contact 13 of relay ST is not effective to remove the control of relay E from the VP and stepping relays. This is because the closure of front contact 23 of relay SA places (+) potential upon the control circuits of relay E and maintains this potential throughout the cycle of operations.

The deenergization of relay F during the first "off" period is repeated by relays 1FP and 2FP in succession. Since relay SA is sufficiently slow acting, its contacts are maintained in their picked up positions between successive "on" periods of a cycle although the energizing circuit of relay SA is opened during the "off" periods. The response of relay F to the first "off" period causes relay 1V to be picked up over a circuit which will be later pointed out.

The response of relay 1V with relay VP picked up closes an energizing circuit for relay E which extends from (+), front contact 23 of relay SA, front contact 19 of relay VP, upper winding of relay E, front contact 20 of relay 1V and back contacts 21 and 22 of relays 2V and 3V respectively, to (-). The picking up of relay E is repeated by relay EP which again energizes the stepping line circuit over the A branch of the source of supply for marking the beginning of the second "on" period.

The second energization of the stepping line circuit is repeated by relays F, 1FP and 2FP as before. The response of relay F causes relay VP to be deenergized as will be later explained. The dropping of front contact 19 of relay VP opens the energizing circuit of relay E which drops, followed by the dropping of relay EP which in turn deenergizes the stepping line circuit to mark the end of the second "on" period and the beginning of the third "off" period.

In the embodiment of the present invention, this impulsing of the stepping line circuit continues in the above described manner for four "on" periods separated by "off" periods to comprise a cycle of operations. It will be apparent that the impulses are time spaced as determined by the response of the stepping relay bank in the control office. Briefly, each "on" period causes the actuation of the contacts of relay VP to opposite positions while each "off" period causes the picking up of the next succeeding stepping relay. The response of relay VP causes the dropping of relays E and EP for deenergizing the stepping line, while the response of the stepping relays during each "off" period causes relays E and EP to be picked up for energizing the stepping line with the next impulse. The stopping of the impulsing at the end of a cycle by prolonging the "off" period will be explained in detail when considering the operations effected at the end of the cycle.

Having pointed out in detail how a series of time spaced impulses are applied to the stepping line circuit through the A branch of the source of supply, the response of the stepping relay banks at the control office and at the field stations may now be considered.

Step-by-step operations.—The stepping operations will be considered with particular reference to the stepping relay bank illustrated in the control office (see Fig. 2), while those exceptions with regard to the operation of the corresponding

stepping relay banks at the field stations will be pointed out more particularly with reference to the typical field station (see Fig. 3).

The application of the first impulse to the stepping line circuit by way of the A branch of the source of current supply as repeated by line relay F causes relay VP to be picked up over a circuit which has been previously described. The stick circuit closed by front contact 33 of relay VP has likewise been described.

With the contacts of relay VP picked up, the pick-up circuit for stepping relay 1V is prepared so that when the first "off" period is repeated by the dropping of relay F, a pick-up circuit for relay 1V is completed which extends from (+), back contact 26 of relay F, front contact 34 of relay SA, front contact 35 of relay VP, back contact 36 of relay 2V and winding of relay 1V, to (-). Relay 1V closes a stick circuit for itself extending from (+), front contact 23 of relay SA, front contact 37 and winding of relay 1V, to (-).

The response of relay 1V prepares the circuit for the differential winding of relay VP so that when the second "on" period is repeated by the picking up of relay F, relay VP is deenergized and its contacts are dropped. This differential energizing circuit for relay VP extends from (+), front contact 23 of relay SA, front contact 29 of relay F, back contacts 30 and 31 of relays 3V and 2V respectively, front contact 32 of relay 1V, front contact 38 and lower winding of relay VP, to (-). Since the two windings of relay VP are energized in opposite directions, the magnetic flux in the core of relay VP is reduced substantially to zero causing it to release its armature. The dropping of front contacts 33 and 38 deenergize both windings of this relay, therefore it remains in its deenergized position until its pick-up circuit is again closed.

With relay VP deenergized, the pick-up circuit for relay 2V is prepared so that when the next "off" period (second) is repeated by the dropping of relay F, stepping relay 2V is picked up over a circuit which extends from (+), back contact 26 of relay F, front contact 34 of relay SA, back contact 35 of relay VP, back contact 39 of relay 3V, front contact 40 of relay 1V and winding of relay 2V, to (-). Relay 2V closes a stick circuit for itself extending from (+), front contact 23 of relay SA, front contact 41 and winding of relay 2V, to (-).

This step-by-step operation continues throughout the cycle until the last step has been taken. It will be apparent that for each "on" period of the stepping line circuit by way of the A branch of the source of supply relay VP is actuated to a new position, while during each "off" period of this same circuit the next stepping relay is picked up. Those stepping relays which pick up at each step are stuck up until the end of the cycle under the control of relay SA.

The step-by-step operations of the stepping relay banks at the several field stations are identical, so that an explanation of this operation in connection with Fig. 3 may be considered as typical of all field stations. At each station, the operation of the stepping relay is made dependent upon station selection as rendered effective by the selecting relays SO¹ and SI¹, for example. For the purpose of considering the stepping operation before the station selection function has been described, it may be assumed that at least one of the selecting relays SO¹ or SI¹ is picked up so that at least one of the front contacts 210 or 211 will be closed.

The response of relay SA^1 at the beginning of the cycle does not close a pick-up circuit for the VP relay or for any stepping relay. During the first "off" period relay F^1 is dropped for closing
 5 a pick-up circuit for relay VP^1 which extends from (+), front contact 212 of relay SA^1 , back contact 213 of relay F^1 , back contacts 214, 215 and 216 of relays $3V^1$, $2V^1$ and $1V^1$ respectively and upper winding of relay VP^1 , to (-). Relay
 10 VP^1 closes a stick circuit for itself extending from (+), front contact 212 of relay SA^1 , front contact 217 and upper winding of relay VP^1 , to (-).

During the next "on" period (second) as repeated by the picking up of relay F^1 , a circuit is
 15 closed for picking up relay $1V^1$ which extends from (+), front contact 210 or front contact 211 of one or the other of the station selecting relays, front contact 218 of relay SA^1 , front contact 219 of relay F^1 , front contact 229 of relay VP^1 , back
 20 contact 221 of relay $2V^1$ and winding of relay $1V^1$, to (-). Relay $1V^1$ closes a stick circuit for itself extending from (+), front contact 222 of relay SA^1 , front contact 223 and winding of relay $1V^1$, to (-).

25 The stepping bank takes one step for each "on" period and relay VP^1 is actuated to opposite positions for each "off" period throughout the cycle as long as the pick-up circuits for the stepping relays are closed by one of the station selecting
 30 relay contacts 210 or 211.

It is considered unnecessary to point out the detailed operation of the stepping and half step relays since they are substantially identical with similar circuits already explained in connection
 35 with the control office, with the obvious exception that these relays at the stations operate during opposite periods from corresponding relays in the control office.

Station selection for controls.—The application of impulses to the stepping line circuit has been explained in detail. In brief, a series of impulses is applied to the stepping line from the source of current through the A branch and each of these impulses includes a series of half
 45 cycles of alternating current. This current flows in a direction permitted by the rectifying units RA and $1RA^1$ at the control office and at the field station. For convenience, the half cycles of A. C. current which flow through the RA rectifiers will be referred to as (+) impulses. This
 50 application of a series of (+) impulses to the stepping line circuit causes the step-by-step operations.

The half cycles of A. C. current which flow through the RB rectifiers will be referred to as (-) impulses. Therefore, the stepping line circuit may be conditioned during the "on" periods by the (-) impulses for the purpose of the transmission of control codes. Likewise, the
 60 message line circuit may be conditioned during the "on" periods by (+) impulses and (-) impulses for transmitting additional control codes.

The energy selectively applied to the stepping and message line circuits includes a series of
 65 (+) and (-) impulses by reason of the opposite arrangement of the RA and RB rectifying units at the control office and at the illustrated field station. It will of course be understood that the additional field stations are supplied
 70 with rectifier units connected in the line circuits in the same manner as illustrated in Fig. 3, but it is believed unnecessary to complicate the drawings and description by showing these additional stations.

75 The energized and deenergized conditions of

the stepping line circuit by (-) impulses during "on" periods are employed for the transmission of controls as above mentioned while the "off" periods of the stepping line circuit are conditioned by (-) impulses for the transmission of indications. The conditioning of the stepping and the message lines for the transmission of indications will be explained later. It is considered sufficient to know that so far as the field stations are concerned during a cycle
 10 of operations for the transmission of controls alone, the stepping and message line circuits are continuously closed as will be explained more in detail hereinafter.

As soon as the operator has actuated starting button SB which results in the response of relay CD, the code sending relays 2CS and 3CS are conditioned in accordance with the first code jumper 42 associated with relay CD. When the first impulse is applied to the stepping line circuit causing relay F to open its back contact 15, the stepping line circuit is conditioned by applying or not applying (-) impulses to the stepping line circuit as determined by front contact 47 of relay 1CS. More specifically, in the arrangement illustrated in Fig. 2 with jumper 42 disconnected from bus 43 relay 1CS does not close its front contact 47 and the stepping line circuit is not energized with (-) impulses.

In the event that jumper 42 is connected in its right hand dotted position to bus 43, then a circuit is effective to pick up relay 1CS which extends from (+), back contact 48 of relay 3V, back contact 49 of relay 2V, back contact 50 of relay 1V, front contact 51 of relay CD, jumper 42, bus 43 and winding of relay 1CS, to (-). The picking up of front contact 47 of relay 1CS allows the (-) half cycles of current to flow over the stepping line circuit. This current flows over a circuit extending from the upper terminal of transformer TR, conductor 12, conductor 291, back contact 204, of relay SI^1 , winding of relay $1ME^1$, back contact 205 of relay ST^1 , rectifier $1RB^1$, conductor 19, front contact 47 of relay 1CS, winding of relay $1ME$ and rectifier RB, to the lower terminal of transformer TR. Current flowing over this circuit is effective to pick up relay $1ME^1$ at the field station and relay $1ME$ in the control office.

In the alternate condition, that is, jumper 42 not connected to bus 43, relay 1CS is not picked up to close its front contact 47 so that the above described circuit through relays $1ME^1$ and $1ME$ is not completed, with the result that these two relays are not picked up during the first "on" period after relay F drops.

It should be noted at this point that when relay F is energized, the control of the coding impulses applied to the stepping and the message line circuits during the "on" periods is with relays 1CS, 2CS and 3CS. For example, with relay F energized, back contact 15 removes the shunt from front contact 47 of relay 1CS, back contact 11 removes the shunt from front contact 53 of relay 2CS and back contact 13 removes the shunt from front contact 54 of relay 3CS. Therefore, the (-) impulses are applied or not applied to the stepping line circuit as determined by whether relay 1CS is picked up or not. The (+) impulses are applied or not applied to the message line circuit as determined by whether or not relay 2CS is picked up. The (-) impulses are applied or not applied to the message line circuit as determined by whether or not relay 3CS is picked up.

On the other hand, with relay F deenergized, contacts 15, 11 and 13 shunt front contacts 47, 53 and 54 of relays 1CS, 2CS and 3CS respectively so that the stepping and message line circuits may be energized with (—) impulses and the message line circuit may be energized with (+) impulses during the "off" periods as determined by the indication code transmitted.

The condition of relay 1CS as selected by front contact 51 of relay CD is maintained until relay IV is picked up during the first "off" period. Shortly after the picking up of relay IV, relay F is picked up (during the second "on" period) and (—) impulses are applied or not applied to the stepping line circuit by relay 1CS being picked up or not picked up as determined by the connection of jumper 44 which is selected through front contact 50 of relay IV and front contact 52 of relay CD.

Relay 2V is picked up during the second "off" period and relay 1CS is conditioned to impulse or not impulse the stepping line circuit with (—) impulses when relay F picks up its back contact 15 at the beginning of the third "on" period, as determined by the connection of signal lever contact 55. This contact is selected by way of front contact 49 of relay 2V and front contact 56 of relay CD. If contact 55 is in its neutral position, relay 1CS will be picked up to apply (—) impulses to the stepping line during the third "on" period, after the picking up of contact 15 of relay F, but if contact 55 is not in its neutral position, relay 1CS will be down so that (—) impulses are not applied to the stepping line after relay F picks up its back contact 15 in the third "on" period.

Similarly, for each of the remaining steps the control of relay 1CS is shifted from one contact of relay CD to the other so that relay 1CS is picked up or not as determined by control lever contacts or jumper connections, all in accordance with the arrangement of these contacts and connections in the system.

Relay 2CS is connected to bus 45 and this bus is energized or not energized as determined by the jumper and control lever contact connections during separate steps of the operating cycle. Likewise, relay 3CS is connected to bus 46 which is selectively conditioned in a like manner as determined by the jumper and lever contact connections at different steps of the cycle.

If relay 2CS is picked up during an "off" period by the energization of bus 45 when the stepping relay picks up during this "off" period, then the message line circuit is impulsed during the succeeding "on" period with (+) impulses over a circuit extending from the lower terminal of transformer TR, rectifier RA, winding of relay 2ME, front contact 53 of relay 2CS, conductor 8, rectifier 2RA¹, winding of relay 2ME¹, back contact 203 of relay SI¹, conductor 290 and conductor 12 to the upper terminal of transformer TR. If relay 2CS is not picked up during a particular "off" period, then when relay F picks up its back contact 11 during the succeeding "on" period, the message line circuit is not impulsed with (+) impulses.

If relay 3CS is picked up during a particular "off" period, the message line circuit is impulsed with (—) impulses during the succeeding "on" period over a circuit extending from the upper terminal of transformer TR, conductor 12, conductor 290, back contact 226 of relay SI¹, winding of relay 3ME¹, rectifier 2RB¹, conductor 8, front contact 54 of relay 3CS, winding of relay

3ME and rectifier RB to the lower terminal of transformer TR. In the event that relay 3CS is not energized when the step is taken during a particular "off" period, then since its front contact 54 is not closed, the message line circuit is not impulsed with (—) impulses during the succeeding "on" period when relay F picks up its back contact 13.

It is believed that the above discussion indicates how the line circuits are impulsed by combinations of (+) and (—) impulses during the "on" periods for obtaining a choice of eight different combinations per step. It will be recalled that the stepping line circuit is impulsed with (+) impulses for controlling the stepping in the office and at the stations. Therefore, (+) impulses applied to the stepping line cannot be used for control code combinations. The eight different control code combinations obtainable during each "on" period are as listed in the following typical code table:

First typical code table—For first step

Code	Stepping Line B Branch	Message Line A Branch	Message Line B Branch
1-----	—	0	0
2-----	0	+	0
3-----	0	0	—
4-----	—	+	0
5-----	—	0	—
6-----	0	+	—
7-----	—	+	—
8-----	0	0	0

In the above table "0" represents an open jumper which is effective to deenergize the associated line circuit. "—" and "+" each represent a closed jumper which is effective to energize the associated line circuit with "—" and "+" impulses respectively. The first combination energizes the 1ME relays. The second combination energizes the 2ME relays. The third combination energizes the 3ME relays. The fourth combination energizes the 1ME and 2ME relays. The fifth combination energizes the 1ME and 3ME relays. The sixth combination energizes the 2ME and 3ME relays. The seventh combination energizes the 1ME, 2ME and 3ME relays. The eighth combination does not energize any of the ME relays.

The code jumpers and the signal control lever connected in the combination shown in Fig. 2 of the present embodiment are effective to condition the stepping and message line circuits during the three "on" periods in accordance with the following typical code table.

Second typical code table

Line	First step	Second step	Third step
Stepping B branch-----	0	—	—
Message A branch-----	+	0	0
Message B branch-----	0	0	0

For the purpose of illustration, the code jumpers 42 and 44 and the signal lever contact 55 are arranged to transmit the above combinations indicated for the first, second and third steps. Front contact 57 of relay CD is not shown connected to a jumper or control lever but it is obvious that this contact can connect to any one of the buses 43, 45 and 46 so that additional code combinations may be applied to the stepping and message line circuits as required. It will also be

apparent that more than one ME relay can be simultaneously energized, for example, relays 1ME, 2ME and 3ME (and the corresponding relays at the stations) to provide the seventh choice by connecting three jumpers such as jumper 42 to all three buses 43, 45 and 46 for a particular step.

It is thus seen how the stepping and message line circuits are conditioned in accordance with the positions of the three code sending relays during the "on" periods of the cycle. The eight combinations listed in the first typical code table above, which are obtainable on each step of the stepping relay bank, may be expanded so that the total number of combinations equals eight raised to the power of the number of steps. For example, sixty-four different combinations may be obtained with two steps. This will be evident by noting that any of the eight combinations listed in the above first typical code table can be used on the second step in connection with each one of the eight combinations obtainable on the first step.

These conditions of the two line circuits are rendered effective at the several field stations so as to select a particular station in accordance with the code transmitted and to actuate suitable control code storing relays in accordance with the controls transmitted. Before considering how these conditions of the two line circuits are effective to select a field station, such as the typical field station illustrated in Fig. 3, in accordance with the positions of the code jumpers in the control office illustrated in Fig. 2, it is necessary to know that the station selecting relays are picked up at all of the stations during the first "on" period of the stepping line circuit at the beginning of the cycle. For example, relay SO¹ at the first field station is picked up, as soon as relay F¹ is picked up, over a circuit extending from (+), front contact 227 of relay F¹, back contact 228 of relay SA¹ and lower winding of relay SO¹, to (-). Similar circuits are effective to pick up the SO relays at all other stations.

With all of the SO relays picked up, all of the field stations are then in readiness to be selected or dropped out. The system of the present invention employs the familiar Baudot code wherein the number of selections with a given number of code impulses, when a choice of eight characters may be had for each impulse, is equal to eight raised to the power of the number of impulses. It may be well to note that one eighth of the stations are selected on the first code impulse and the other seven eighths are dropped out. One eighth of those selected on the first impulse are selected on the second impulse and the other seven eighths are dropped out. This process of elimination continues until only one field station remains. The code jumpers in the control office cause the code sending relays 1CS, 2CS and 3CS to transmit the code combinations above noted, to which all SO relays are subjected at the beginning of the code but at the end of the code only one SO relay remains picked up.

It will now be explained how the station illustrated in Figs. 3 and 3A is selected in accordance with the arrangement of code jumpers 42 and 44 selected by relay CD of Fig. 2. Recalling that relay SO¹ was picked up at the beginning of the first "on" period, it will be noted that both the pick-up and holding circuits of relay SO¹ are open after relay SA¹ is picked up. The pick-up circuit is open at back contact 228 of relay SA¹ and the holding circuit is open at back contact

229 of relay 2FP¹ and at back contact 230 of relay F¹. Therefore, relay SO¹ is dependent upon its selecting stick circuit for energization.

At the time the stepping line is energized with (+) current for providing the first "on" period, the stepping and message line circuits are coded as indicated in the "first step" column of the above second typical code table. The stepping line is not energized with (-) impulses over the B branch as indicated by the "0" symbol associated with this branch at the first step. Therefore, relay 1ME¹ of Fig. 3 is dropped. The message line is impulsed with (+) impulses over the A branch during the first "on" period as indicated by the "+" symbol which is effective to maintain relay 2ME¹ picked up. The message line is not impulsed with (-) impulses over the B branch as indicated by the "0" symbol which is effective to drop relay 3ME¹. In this discussion it will be understood that relays similar to 1ME¹, 2ME¹ and 3ME¹ located at all other field stations are conditioned in the same manner as those at the illustrated field station.

It will be pointed out at this time that the field station code jumpers such as 200 and 201 connect to the buses which lead to relays 1CS¹, 2CS¹ and 3CS¹ in the same order that the code jumpers such as 42 and 44 of Fig. 2 connect to the buses which lead to relays 1CS, 2CS and 3CS. In other words, the combination of code jumpers associated with a particular energized CD relay will cause the selection of a field station having its code jumpers connected in the same combination.

With relay 1ME¹ down, relay 2ME¹ up and relay 3ME¹ down during the first "on" period as above described, relay SO¹ is maintained energized by reason of a selecting stick circuit extending from (+), back contact 231 of relay 1CS¹, back contact 232 of relay 1ME¹, front contact 233 of relay 2CS¹, front contact 234 of relay 2ME¹, back contact 235 of relay 3CS¹, back contact 236 of relay 3ME¹, front contact 237 and upper winding of relay SO¹, to (-). It will be noted that relay 1CS¹ is not picked up because there is no jumper connection for energizing bus 238 during the first "on" period. Relay 2CS¹ is picked up over a circuit extending from (+), back contact 241 of relay 3V¹, back contact 242 of relay 2V¹, back contact 243 of relay 1V¹, jumper 200, bus 239 and winding of relay 2CS¹, to (-). Since bus 240 is not energized, relay 3CS¹ is not picked up.

It will be obvious that at all other field stations where the code jumpers corresponding to jumper 200 are connected to buses similar to 239, the selecting stick circuits for the SO relays will be completed. On the other hand, at all other field stations where the code jumpers corresponding to jumper 200 are connected either to the buses corresponding to 238 or 240, the selecting stick circuits for the SO relays at those stations will be opened.

The first "off" period is repeated by the dropping of relays F¹, 1FP¹ and 2FP¹ at the first field station. Similar relays at all other field stations of course are likewise dropped. This completes a holding stick circuit for relay SO¹ extending from (+), front contact 264 of relay SA¹, back contact 230 of relay F¹ in multiple with back contact 229 of relay 2FP¹, front contact 244 and lower winding of relay SO¹, to (-). Therefore, at the beginning of an "off" period, back contact 230 of relay F¹ initially closes the holding stick circuit of relay SO¹ before relay 1V in the control office shifts the control of the CS relays to the second code. During the "on" period, the back contact

229 of relay 2FP¹ finally opens the holding stick circuit of relay SO¹ but this does not occur until the code selecting relays 1CS¹, 2CS¹ and 3CS¹ and the message receiving relays 1ME¹, 2ME¹ and 3ME¹ at the field station have been conditioned in accordance with the code applied to the line during this "on" period.

The application of the second impulse to the stepping line for providing the second "on" period is repeated by the picking up of relays F¹, 1FP¹ and 2FP¹. The code for the second step as indicated in the typical code table results in energizing the stepping line with (—) impulses, in not energizing the message line with (+) impulses and in not energizing the message line with (—) impulses. This results in relay 1ME¹ at the field station being up and relays 2ME¹ and 3ME¹ being down. Relay 1CS¹ is picked up over a circuit extending from (+), back contact 241 of relay 3V¹, back contact 242 of relay 2V¹, front contact 243 of relay 1V¹, jumper 201, bus 238 and winding of relay 1CS¹, to (—). Neither relay 2CS¹ nor relay 3CS¹ is energized during the second "on" period because buses 239 and 240 are deenergized.

The selecting stick circuit for relay SO¹ is now completed from (+), front contact 231 of relay 1CS¹, front contact 232 of relay 1ME¹, back contact 233 of relay 2CS¹, back contact 234 of relay 2ME¹, back contact 235 of relay 3CS¹, back contact 236 of relay 3ME¹, front contact 237 and upper winding of relay SO¹, to (—).

At all of those stations having code jumpers similar to 201 connected to buses similar to 238, the SO relays are maintained energized over their selecting stick circuits which are similar to that described in connection with the illustrated station. At those stations having code jumpers similar to 201 connected to buses similar to 239 and 240, the selecting stick circuits of the SO relays are not completed because there will be a lack of correspondence between one or more of the pairs of relays similar to 2CS¹, 2ME¹, 3CS¹ and 3ME¹.

The end of the second "on" period and the beginning of the second "off" period is marked off by the dropping of relays F¹, 1FP¹ and 2FP¹. The holding stick circuit above described in connection with relay SO¹ is again completed at the illustrated station. In the present embodiment, station selection is illustrated as being accomplished during two steps of the cycle so that at this time only relay SO¹ of Fig. 3 will be in its energized position.

The end of the second "off" period and the beginning of the third "on" period is marked off by the picking up of relays F¹, 1FP¹ and 2FP¹. Before relay 2FP¹ picks up its back contact 229 to open the holding stick circuit of relay SO¹, a permanent stick circuit is established for relay SO¹. Relay 2V¹ is picked up during the third "on" period before relay 2FP¹ is picked up so that the permanent stick circuit is established from (+), front contact 245 of relay 2V¹, front contact 244 and lower winding of relay SO¹, to (—). This permanent stick circuit is of course effective until the end of the cycle when the stepping relays are dropped at which time relay 2V¹ drops its front contact 245.

Transmission of controls.—From the above description, it will be seen how a station may be selected when the code call of that station agrees with the code call transmitted over the stepping and message line circuits during the "on" periods.

Assuming that the field station illustrated in

Fig. 3 has been selected by its relay SO¹ remaining in an energized position until relay 2V¹ is picked up, the application of the third impulse is repeated by relays F¹, 1FP¹ and 2FP¹. The code impulses applied during the third "on" period are in accordance with the position of lever SGL in the control office, for example, and with this lever in the position illustrated in Fig. 2, this code combination is as follows: Stepping line energized with (—) impulses, message line not energized with (+) impulses and message line not energized with (—) impulses. This is due to relays 2CS and 3CS not being picked up on this step because contact 55 is in its neutral position. Relay 1CS is picked up over a circuit extending from (+), back contact 48 of relay 3V, front contact 49 of relay 2V, front contact 56 of relay CD, contact 55 of the signal control lever in its neutral position, bus 43 and winding of relay 1CS, to (—).

This code combination results in relay 1ME¹ being energized, relay 2ME¹ being deenergized and relay 3ME¹ being deenergized. At this step the code selecting relays at the field station have no function because the station has been selected prior to this step.

At the time relay 2V¹ is picked up during the third "on" period, circuits are prepared for executing the control condition by closing front contacts 250 and 251. During the third "on" period the executing circuits are completed when relays F¹ and 2FP¹ pick up. Since lever SGL in the control office is shown in a position for putting signals to stop at the selected station, this particular condition will be executed in the assumed example. More specifically, a circuit is closed which actuates polar contact 252 of the stop relay S to its right hand dotted position which circuit extends from (B+), front contact 265 of relay F¹, front contact 263 of relay 2FP¹, front contact 246 of relay SO¹, front contact 262 of relay 1ME¹, back contact 266 of relay 3V¹, front contact 250 of relay 2V¹ and winding of relay S, to (CN). Although the detailed circuits have not been shown, it will be understood that the actuation of contact 252 to the right completes suitable circuits for putting the signals to stop.

During the third "off" period relay F¹ is dropped so that the above mentioned executing circuit to relay S is deenergized. From the above example it will be seen how a particular control code is transmitted. It is not believed necessary to describe in detail the transmission and reception of other control codes although it will be briefly explained how the two additional code combinations which are possible for a single step may be used for clearing signals east and for clearing signals west.

If, for example, relay 2ME¹ remains picked up throughout the third "on" period (due to relay 2CS in the control office being energized by lever SGL in its right hand dotted position), then a circuit is closed for energizing relay DR which extends from (B+), front contact 265 of relay F¹, front contact 263 of relay 2FP¹, front contact 246 of relay SO¹, front contact 247 of relay 2ME¹, back contact 258 of relay 3V¹, front contact 251 of relay 2V¹ and winding of relay DR, to (CN). Relay DR actuates its polar contact 259 to the right. A circuit is also closed for actuating contact 252 of relay S to the left extending from (B—), front contact 257 of relay F¹, front contact 256 of relay 2FP¹, front contact 253 of relay SO¹, back contact 262 of relay 1ME¹, back contact 266

of relay 3V¹, front contact 250 of relay 2V¹ and winding of relay S, to (CN). This energizes conductor 270 for clearing eastbound signals.

On the other hand, if relays 1ME¹ and 2ME¹ are not picked up during the third "on" period (because relays 1CS and 2CS in the control office are deenergized by lever SGL in its left hand dotted position) then relays S and DR will be positioned to the left because (B—) is applied to both these relays through back contacts 262 and 247 of relays 1ME¹ and 2ME¹ respectively. This obviously clears westbound signals by energizing conductor 260.

End of operating cycle.—The operation of the system during a cycle has been explained in detail and it will now be pointed out how the system is returned to normal. As previously mentioned, the stepping relay bank in the control office takes one step for each "off" period. Thus, the picking up of relay 3V during the third "off" period causes the fourth energization of the stepping line with (+) impulses. This in turn causes relay VP to drop for causing the fourth deenergization of the stepping line. This fourth deenergized or "off" period does not result in again picking up relays E and EP because with relay VP down and relay 3V up there is no circuit for energizing either winding of relay E. This produces a prolonged "off" period which allows relay SA in the control office to drop its contacts. The dropping of front contact 28 of relay SA deenergizes all of the stepping relays and prevents the picking up of relay E. The closing of back contact 16 of relay SA permits the starting relay ST to be conditioned in readiness for the initiation of another cycle. The picking up of relay 3V prior to the dropping of relay SA causes relay CD to be deenergized by means of a circuit which is not shown but which may be the same as disclosed, for example, in the prior application of N. D. Preston et al., Ser. No. 455,304 filed May 24, 1930.

At the field station, the system is similarly restored to normal by the prolonged "off" period dropping the stepping relays when relay SA¹ drops its front contact 222. The deenergization of the stepping relays opens the holding stick circuit of relay SO¹ by reason of open front contact 245 of relay 2V¹.

The system is now in condition for the initiation of another cycle either from the control office or from a field station.

Indications.—As previously mentioned, indications may be ready for transmission at a field station at the same time that controls are ready for transmission from the control office. The system is so arranged that simultaneous two-way or duplex transmission of controls and indications may occur during each cycle of operations. However, for convenience, the transmission of controls has been considered separately and the transmission of indications will also be considered separately with the duplex operation considered under a separate heading.

It also may happen that there are several field stations which may have indications ready for transmission at the same time and they are registered in the control office one at a time in an order determined by the relative characteristics of their code calls. This feature of determining the order of station registration by the superiority of code plan will also be considered under a separate heading. The transmission of indications from the single typical station illustrated in Figs. 3 and 3a will be considered at this time.

Automatic starting.—A change in the position of a controlled device or the automatic change of a traffic indicating device, such as the usual track relay, causes the system to be initiated by the energization of change storing relay CHS¹. As soon as relay CHS¹ is picked up, a pick-up circuit is closed for starting relay ST¹ which extends from (+), back contact 222 of relay SA¹, front contact 267 of relay CHS¹ and winding of relay ST¹, to (—). Relay ST¹ thus being picked up causes the normally energized B branch of the stepping line circuit to be opened at back contact 205 so that all of the 1ME relays are deenergized. The dropping of relay 1ME in the control office closes a pick-up circuit for starting relay ST extending from (+), back contact 16 of relay SA, back contact 58 of relay 1ME and winding of relay ST, to (—).

The response of front contact 18 of relay ST causes the system to be initiated and a series of (+) impulses is applied to the stepping line circuit as previously described for marking off the stepping operations of the cycle. During this cycle, it will be assumed that no controls are being transmitted, therefore, none of the code sending relays 1CS, 2CS and 3CS in the control office are picked up so that during the "on" periods the stepping line circuit is not energized with (—) impulses and the message line circuit is not energized with (—) or (+) impulses.

Such a code of no (—) impulses applied to the stepping line and no (+) or (—) impulses applied to the message line during the "on" periods of the cycle results in dropping out all of the SO relays at the field stations. This is because no field station has such a code combination assigned to it, since this code combination corresponds to the phantom code. This occurs irrespective of the fact that all the SO relays are picked up at the beginning of the cycle in the usual manner. The step-by-step operations occur in the manner previously described so that a description of this portion of the cycle need not be repeated. A description of the registration of the particular transmitting station will now be given.

Station registration.—The application of the first (+) impulses to the stepping line circuit is repeated by the F relays at the control office and at the field stations. The closure of the front contacts of the line relay at the station which has initiated the system (assumed to be the station illustrated) causes relay SI¹ to be picked up over a circuit extending from (+), front contact 227 of relay F¹, back contact 268 of relay SA¹, front contact 269 of relay CHS¹ and lower winding of relay SI¹, to (—). A holding stick circuit is closed for relay SI¹ extending from (+), front contact 264 of relay SA¹, front contact 230 of relay F¹, front contact 271 and lower winding of relay SI¹, to (—).

The picking up of relay F¹ is repeated by the sequential energizations of relays FP¹ and 2FP¹. The closure of front contact 229 of relay 2FP¹ bridges front contact 230 of relay F¹ so that the closure of front contact 230 of relay F¹ initially closes the holding stick circuit for relay SI¹ while the front contact 229 of relay 2FP¹ finally opens this holding stick circuit at each step. This operation is analogous to the operation of relay SO¹ except that the holding stick circuit for relay SI¹ is closed during deenergized periods of the line while the holding stick circuit for relay SI¹ is closed during the energized periods of the line.

After the predetermined time measured off by the picking up of relay SA¹, the pick-up circuit of relay SI¹ is opened at back contact 268 of relay SA¹, but since this contact is of the follow-up type the holding circuit through front contact 264 is closed before the pick-up circuit is opened.

It will now be assumed that relay SI¹ is maintained energized by reason of the fact that the code call impressed upon the line circuits during the "off" periods corresponds to the code call of the illustrated station, since it is assumed that this is the only station which is transmitting. As soon as the (+) impulses are removed from the stepping line circuit, relay F¹ drops its contact 230 and shortly thereafter relay 2FP¹ drops its contact 229 for deenergizing the holding stick circuit of relay SI¹. Before contact 229 is dropped, however, the selecting stick circuit of relay SI¹ is completed. Since jumper 200 is connected to bus 239 for picking up relay 2CS¹, the message line circuit is energized with (+) impulses during the first "off" period for picking up relays 2ME¹ and 2ME. This circuit extends from the upper terminal of transformer TR, conductor 12, conductor 290, front contact 272 of relay 2CS¹, winding of relay 2ME¹, rectifier 2RA¹, conductor 8, back contact 11 of relay F, winding of relay 2ME and rectifier RA to the lower terminal of transformer TR.

Since buses 238 and 240 are deenergized at this time, relays 1CS¹ and 3CS¹ are down so that the stepping line circuit is not energized with (—) impulses and the message line circuit is not energized with (—) impulses. This is because during the "off" period front contacts 224 and 274 of relay F¹ are dropped and front contacts 225 and 275 of relays 1CS¹ and 3CS¹ respectively are dropped. Of course, back contacts 204, 203 and 226 of relay SI¹ are open at this time. Front contact 273 of relay F¹ is also open but this contact is bridged by front contact 272 of relay 2CS¹ to energize the 2ME relays as above described.

The selecting stick circuit for relay SI¹ is now completed from (+), back contact 231 of relay 1CS¹, back contact 232 of relay 1ME¹, front contact 233 of relay 2CS¹, front contact 234 of relay 2ME¹, back contact 235 of relay 3CS¹, back contact 236 of relay 3ME¹, front contact 276 and upper winding of relay SI¹, to (—).

When relay F¹ picks up at the beginning of the second "on" period, the holding stick circuit for relay SI¹ is closed at front contact 230 so that relay SI¹ is maintained energized during the "on" period. Relay 1V¹ is picked up during the second "on" period and its contact 243 switches from jumper 200 to 201 for energizing bus 238 and picking up relay 1CS¹.

When relays F¹ and 2FP¹ drop their contacts 230 and 229 during the second "off" period, the selecting stick circuit for relay SI¹ is maintained energized from (+), front contact 231 of relay 1CS¹, front contact 232 of relay 1ME¹, back contact 233 of relay 2CS¹, back contact 234 of relay 2ME¹, back contact 235 of relay 3CS¹, back contact 236 of relay 3ME¹, front contact 276 and upper winding of relay SI¹, to (—). It will be understood that relay 1ME¹ is picked (and relay 1ME in the office is picked up) because relay 1CS¹ has its front contact 225 closed for energizing the stepping line circuit with (—) impulses during the second "off" period.

Relays F¹ and 2FP¹ are picked up during the third "on" period and relay 2V¹ picks up to close the permanent stick circuit for relay SI¹. This permanent stick circuit is effective to maintain

relay SI¹ energized until the end of the cycle and extends from (+), front contact 277 of relay 2V¹, front contact 271 and lower winding of relay SI¹, to (—).

Referring to the control office circuits, it will be recalled that relay 2ME was picked up during the first "off" period and relay 1ME was picked up during the second "off" period, in series with corresponding relays at the transmitting field station. During the first and second "off" periods this code combination is registered in the control office on suitable pilot relays which for convenience have not been illustrated but which may be of any suitable type, such as disclosed in the pending application of N. D. Preston et al., Ser. No. 455,304 filed May 24, 1930. It is sufficient for an understanding of the present invention to know that the conditions of the ME relays in the control office are executed during each "off" period to condition a suitable pilot relay when the F and 2FP relays are deenergized.

During each executing period a circuit is closed either from (B+) or (B—) through back contacts 60 or 62 of relay F, 61 or 63 of relay 2FP, to front and back contacts of the three ME relays. These circuits are then extended by way of the front and back contacts of the ME relays in the positions to which they have been actuated by the code call from the transmitting station, through selecting contacts 64 to 69 inclusive of the stepping relays to the conductors leading to bracket 73 and thence to the particular pilot relays, all of which will be readily understood.

For example, during the first "off" period with relay 2ME picked up and relays 1ME and 3ME down, a first executing circuit is completed which extends from (B+), back contact 60 of relay F, back contact 61 of relay 2FP, front contact 74 of relay 2ME, back contact 71 of relay 3V, back contact 67 of relay 2V and front contact 66 of relay 1V, to conductor 59. Since relay 1ME is down at this time, a second executing circuit is completed which extends from (B—), back contact 62 of relay F, back contact 63 of relay 2FP, back contact 75 of relay 1ME, back contact 70 of relay 3V, back contact 65 of relay 2V and front contact 64 of relay 1V, to conductor 76. Since relay 3ME is down at this time, a third executing circuit extends from (B—) through back contacts 62 and 63 of relays F and 2FP and thence through back contact 77 of relay 3ME, back contact 72 of relay 3V, back contact 69 of relay 2V and front contact 68 of relay 1V, to conductor 78.

During the second "off" period, with relay 1ME picked up and relays 2ME and 3ME dropped, it will be obvious how (B+) is extended by way of front contact 65 of relay 2V to conductor 79 and (B—) is extended by way of front contacts 67 and 69 of relay 2V to conductors 80 and 81.

Following the registration of the code call impressed upon the line circuits, the station relay C is picked up through the contact selection of the pilot relays. Relay C corresponds to the particular station illustrated in Fig. 3 and this relay connects the indication storing relays, such as 1IR and 2IR associated with this station, to buses which are sequentially energized in accordance with the indications received after the station is registered.

More specifically, the pilot relays are positioned on the first two steps in accordance with the polarities applied to the conductors leading to bracket 73. Buses 1, 2 and 3 are energized in accordance with the indications received on the

third step since these buses are selected by front contacts 70, 71 and 72 of relay 3V. Assuming relay C energized, then upon the third "off" period indication buses 1, 2 and 3 are energized with (B+) or (B-) in accordance with the condition of the three message receiving relays.

With relay WP¹ of Fig. 3 in the position illustrated for indicating the track switch in its normal locked position, for example when relay 2V¹ is picked up during the third "on" period, a circuit is closed for energizing relay 2CS¹ which extends from (+), back contact 241 of relay 3V¹, front contact 242 of relay 2V¹, front contact 278 of relay WP¹, contact 279 of relay WP¹ in its left hand position, bus 239 and winding of relay 2CS¹, to (-). During the third "off" period, the dropping of front contacts 224, 273 and 274 of relay F¹ attempts to deenergize the line circuits but since front contact 272 of relay 2CS¹ is closed, the message line circuit is energized by way of the A branch, that is, with (+) impulses. This picks up relay 2ME in the control office and establishes a circuit for energizing relay 2IR which extends from (B+), back contacts 60 and 61 of relays F and 2FP respectively, front contact 74 of relay 2ME, front contact 71 of relay 3V, front contact 82 of relay C, and winding of relay 2IR, to (CN).

Relay 2IR is positioned to the right and since the other ME relays are down (B-) is connected to buses 1 and 3. Bus 1 is extended by way of front contact 83 of relay C to the winding of relay 1IR and this relay is positioned to the left. A circuit is now closed from (+), through contact 84 of relay 1IR in its left hand position and contact 85 of relay 2IR in its right hand position to energize normal lamp N as an indication that the corresponding track switch at the field station is in its normal locked position.

On the other hand, if polar contact 279 of relay WP¹ is in its right hand dotted position, then relays 1CS¹, 2CS¹ and 3CS¹ remain down when relay 2V¹ takes its step. This results in relays 1ME, 2ME and 3ME remaining down. A circuit is closed from (B-), back contacts 62 and 63 of relays F and 2FP, back contact 71 of relay 3ME and front contact 72 of relay 3V to bus 3. This circuit is not shown complete since it may be used for additional indications. (B-) is also applied to buses 1 and 2 because relays 1ME and 2ME are down. This positions relays 1IR and 2IR to the left for lighting reverse lamp R.

In the event that relay WP¹ is in its unlocked position, then relay 1CS¹ is picked up for energizing the stepping line with (-) impulses which picks up relay 1ME in the control office. This extends (B+) by way of bus 1 to relay 1IR for positioning this relay to the right. The (B-) applied to bus 2 will of course position relay 2IR to the left but neither lamp is energized with contact 84 in its right hand dotted position, which is an indication that the track switch is in its unlocked condition.

After the registration of a station and the transmission of its indications, the system returns to normal as previously described.

It is believed that the above example of registering the illustrated station in the control office is sufficient to indicate how other stations having different combinations of code jumpers such as 200 and 201 are effective to register themselves by providing distinctive code calls for each station. It is obvious that the same

code combinations are available for transmitting inbound codes during the "off" periods as are available for transmitting outbound codes during the "on" periods. It will be noted that the same combinations are obtainable with the code selecting relays at the field station as are obtained with the code selecting relays in the control office. Those combinations in the control office are made up during the "on" periods when relay F has its back contacts 15, 11 and 13 picked up, while they are made up at the field station when relay F¹ has its front contacts 224, 273 and 274 dropped. Thus, a choice of eight combinations for station registration is obtained for the first step, a choice of sixty-four is obtained for the second step and so on in the same manner as described in connection with controls.

It is also believed unnecessary to recite other examples relating to the transmission of indications from a registered station, since it is believed obvious how these indications are effective to position indication receiving relays during additional steps in the same manner as in the example cited for the third step of the cycle.

Plurality of stations transmitting.—In accordance with this invention, only one station can register itself in the control office during an operating cycle regardless of the number of stations which may have their SI relays picked up at the beginning of the cycle. The sequence or order in which the stations communicate their indications, one station at a time is determined by the characteristics of the code calls of these stations.

With reference to the second typical code table given above, which is applicable to both station selection and station registration, a "-" and a "+" symbol are assigned to represent the energized condition of the A and B branches of the message line and the B branch of the stepping line, while the "0" symbol is assigned to represent the open or deenergized condition of these branches during the "off" periods. The code call for the first two steps in this table is assigned to the illustrated station both for outbound and inbound transmission. Since the branches indicated in this table are in series circuits, they may be opened at any field station during the "off" periods by the code selecting relay front contacts irrespective of the closed condition of the corresponding contacts at any other field station.

In other words, the open condition represented by the "0" symbol is the most superior condition and any field station having such a code element in its code call is superior to all other stations having a "+" or a "-" symbol in its code call for the corresponding period of the cycle.

This feature may be more readily understood by consideration of the code call of the illustrated station. It will be noted from the second typical code table that the B branch of the stepping line and the B branch of the message line are opened while the A branch of the message line is energized with (+) impulses on the first step. This is due to relay 2CS¹ being picked up. Since the polarity of the impulses which energize these two line circuits is of no consequence during this portion of the operation, it need only be considered that these three branches are energized or not energized as indicated.

Since code jumper 200 is not connected to bus 238, the B branch of the stepping line is deenergized (opened) during the first "off" period.

Those stations with a "-" code element for the B branch of the stepping line (see second column of first typical code table) are inferior and cannot impress their code elements upon this branch while the illustrated station is impressing its "0" code element upon this branch. The SI relays at those inferior stations will be dropped out because those stations can not energize their 1ME relays (with suitable exponents) to effect correspondence between contacts such as 231 and 232 of relays such as 1CS¹ and 1ME¹. The first code selecting relays such as 1CS¹ will be picked up at those stations because jumpers similar to 200 will connect to buses similar to 238, but the first message relay such as 1ME¹ will not be picked up because this branch of the line circuits cannot be energized.

At the superior stations, the condition (de-energized) of the B branch of the stepping line corresponds to the condition of the buses such as 238 (deenergized) so that correspondence exists between the relays such as 1CS¹ and 1ME¹.

Since code jumper 200 is connected to bus 239, the A branch of the message line is energized (closed) during the first "off" period. Those stations with a "+" code element for the A branch of the message line (see third column of first typical code table) on this step are inferior (including the illustrated station) and cannot impress their code call elements upon this branch when a station is impressing its "0" code element upon this branch.

The SI relays at those inferior stations will be dropped out because they cannot energize their 2ME relays (with suitable exponents) to effect correspondence between contacts such as 233 and 234 of relays such as 2CS¹ and 2ME¹. In the assumed example however, the illustrated station will not be dropped out if there is no other station transmitting with a "0" code element associated with the A branch of the stepping line.

Since code jumper 200 is not connected to bus 240, the B branch of the message line is de-energized (opened) during the first "off" period. These stations with a "-" code element for the B branch of the message line (see fourth column of first typical code table) on this step are inferior and cannot impress their code call elements upon this branch while the illustrated station is impressing its "0" code element upon this branch.

The SI relays at those inferior stations will be dropped out because those stations cannot energize their 3ME relays (with suitable exponents) to effect correspondence between contacts such as 235 and 236 of relays such as 3CS¹ and 3ME¹. The third code selecting relays such as 3CS¹ will be picked up at those stations because jumpers similar to 200 will connect to buses similar to 240, but the third message relays will not be picked up because this branch of the line circuits cannot be energized.

At the superior stations, the condition (de-energized) of the B branch of the message line corresponds to the condition of the buses such as 240 (de-energized) so that correspondence exists between the relays such as 3CS¹ and 3ME¹.

Irrespective of the number of stations transmitting at the same time, the most superior station maintains its SI relay picked up and the SI relays at the other stations are dropped out in groups. In the present embodiment, since station registration is accomplished with two steps, it is possible to register any one of 63 stations in

the control office on two steps, that is, eight times eight minus the phantom station. For the first step of the cycle, at one-eighth of the stations, jumpers similar to 200 will be connected as shown for the typical field station of Fig. 3. Therefore, assuming all stations transmitting, eight stations will maintain their SI relays picked up during the first step and the remaining stations will drop out their SI relays. During the second step, only one-eighth of the selected stations (one station) will have a jumper 201 connected as illustrated in Fig. 3 and this will be the station which will be finally selected during this step. The remaining seven stations will be dropped out on the second step.

It is believed unnecessary to explain in further detail the manner in which the stations are given preference over one another in accordance with their code characteristics as the feature of superiority of code has been explained in detail in the above mentioned application Ser. No. 455,304. It will be understood that the use of the superiority of code is adaptable to a system arranged in accordance with the present invention but the invention is not necessarily limited to such a system. It will also be understood that each of the sixty-three possible stations which may be registered during two steps in the present embodiment will have code jumpers corresponding to 200 and 201 connected in sixty-three different combinations, one combination for each station. Of course, some of these stations will have more than one jumper corresponding to 200 connected to more than one bus corresponding to 238, 239 and 240. Likewise, there will be one, two and three jumpers similar to 201 at the stations connecting to buses 238, 239 and 240 in all possible combinations.

Duplex transmission.—From the above description it is apparent that the stepping and message line circuits are employed for the transmission of controls during the "on" periods of the cycle, as marked off by the energization of the stepping line with (+) impulses, while indications are transmitted over the stepping and message line circuits during the "off" periods of the cycle, as marked off by the disconnection of the (+) impulses from the stepping line circuit.

This is accomplished in accordance with the present invention by providing the line relays at the various stations with front contacts which shunt the front contacts of the code sending relays during the "on" periods and remove the shunts from the code sending relay contacts during the "off" periods. The line relay in the control office is provided with back contacts which shunt the front contacts of the code sending relays during the "off" periods and remove these shunts during the "on" periods. In other words, the "on" and "off" conditions of the A branch of the stepping line circuit for each step are employed successively for the transmission of controls and indications for that step. Thus it is apparent that the message line circuit and the B branch of the stepping line circuit accommodates the transmission of both controls and indications during the same cycle of operations.

In brief, the SO relays at the field stations are picked up at the beginning of each cycle of operations but the SI relays at the stations are picked up only at the beginning of such cycles as their stations have indications to transmit. For a cycle of operations for the transmission of controls alone, a code call is applied to the stepping

and message line during the "on" periods of each step for the selection of a station but since the SI relays are not picked up, their code sending relays such as 1CS¹, 2CS¹ and 3CS¹ are rendered ineffective by back contacts similar to 204, 203 and 226 of relay SI¹. Therefore, the code placed upon the line circuits during the "off" periods of each step corresponds to a phantom code which is not assigned to any station and which provides that no field station will be registered in the control office.

On the other hand, if the cycle of operations is for the transmission of both controls and indications, then the stepping and message line circuits are conditioned with a particular station selecting code during the "on" periods and a particular station registering code during the "off" periods of the cycle to provide for both the selection of a field station and the registration of that field station or some other field station having indications to transmit. The particular station registered will be the most superior station among those having simultaneous indications to be transmitted.

If the cycle of operations is for the transmission of indications alone, then the code sending relays 1CS, 2CS and 3CS in the control office are effective to condition the line circuits during the "on" periods with a phantom code which is not assigned to any field station. Therefore, although the cycle of operations continues for the transmission of indications, no station is selected for the reception of controls. It will be obvious that the phantom code which is effective during a cycle of operations is the same code combination for both a control cycle and an indication cycle. The indication phantom code which results in no station being registered in the control office during a cycle for the transmission of controls alone is provided by the B branch of the stepping line and the A and B branches of the message line being de-energized during the "off" periods at all steps, which periods are otherwise used for the transmission of indications. During the transmission of indications alone, then these branches of the stepping and message lines are de-energized during the "on" periods at all of the steps to provide the control phantom code.

As previously mentioned, the stepping relay banks at the field station are dependent for their operation upon the energized condition of at least one of their selecting relays such as SO¹ and SI¹. Thus, if one field station is being selected for controls and another field station is being selected for registering indications, the step-by-step operations occur at both such field stations but at the remaining field stations of the system the step-by-step operations discontinue as soon as a field station fails to be selected.

Thus, duplex transmission is provided by allotting the line circuits to the transmission of controls and indications during separate conditions of each step by the provision of separate station selecting means at each station for both controls and indications and by making the step-by-step operation at each field station dependent upon both of its station selecting means.

It is believed unnecessary to point out in detail the operations involved for the simultaneous two-way transmission of controls and indications since such operations are merely the simultaneous occurrence of the control and indication cycles separately described above.

Having thus described a centralized traffic controlling system for railroads as one specific em-

bodiment of the present invention, it is desired to be understood that this form is selected to facilitate in the disclosure of the invention rather than to limit the number of forms which it may assume and it is further desired to be understood that various modifications, adaptations and alterations may be applied to the specific form shown to meet the requirements of practice without in any manner departing from the spirit or scope of the present invention except as limited by the appended claims.

What I claim is:

1. In a remote control system, a plurality of locations including a control office and a plurality of field stations connected by a plurality of line circuits, a plurality of code sending relays at said office and at each of said stations, a plurality of code receiving relays at each of said stations, means controlled by the code sending relays at any of said locations for positioning the code receiving relays at all of said stations over said line circuits, and means controlled by the correspondence between the contacts of said code sending relays and said code receiving relays at a particular station for selecting said station.

2. In a remote control system, a plurality of locations including a control office and a plurality of field stations connected by a plurality of line circuits, a plurality of code sending relays at said office and at each of said stations, a plurality of code receiving relays at each of said stations, means controlled by the code sending relays at any one of said stations for positioning the code receiving relays at all of said stations over said line circuits, and means controlled by the correspondence between the contacts of said code sending relays and said code receiving relays at a particular station for permitting said station only to be registered in said office.

3. In a remote control system, a plurality of locations including a control office and a plurality of field stations connected by a plurality of line circuits, a plurality of code sending relays at said office and at each of said stations, a plurality of code receiving relays at each of said stations, means controlled by the code sending relays at any one of said locations for positioning the code receiving relays at all of said stations over said line circuits, and means controlled by the correspondence between the contacts of said code sending relays and said code receiving relays at a particular station for selecting said station and for permitting said station only to be registered in said office.

4. In a remote control system, a control office and a plurality of field stations interconnected by a stepping line circuit and a message line circuit, a series of stepping relays at said office and at each of said stations, a source of current, means at said office for applying a series of time-spaced impulses of current of selected character derived from said source to said stepping line circuit, means responsive to said impulses for operating said stepping relays at said office and at said stations in synchronism through a cycle of operations, control transmitting means at said office for transmitting codes over said stepping and said message line circuits to any one of said stations by said impulses, indication transmitting means at each of said stations for transmitting codes over said stepping and said message line circuits to said office by impulses of selected character derived from said source, means responsive to said codes for registering messages at said office and at said stations during the synchro-

hous operation of said stepping relays, and means for preventing more than one of said stations from transmitting its complete code during the same cycle of operations.

5 5. In a signalling system, a plurality of locations connected by a normally closed signal circuit, means for supplying said circuit with current impulses flowing alternately in opposite directions therein, a code signal transmitter at each
10 of said locations, a code signal receiver at one of said locations, means responsive to impulses flowing in a certain direction in said circuit for operating the transmitters at each of said locations to a plurality of distinctive positions, means
15 responsive to impulses flowing in another direction in said circuit for operating the receiver at said one location to a plurality of distinctive positions, and code signal manifesting means at one of said locations operative only in response
20 to the transmitter and the receiver thereat being in corresponding positions.

6. In a remote control system, a plurality of locations including a control office and a plurality of field stations connected by a plurality of line
25 circuits, means for applying a series of time spaced stepping impulses of current to one of said line circuits, stepping mechanisms at said office and at each of said stations operated in synchronism in response to said stepping impulses, a
30 plurality of code sending relays at said office and at each of said stations, a plurality of code receiving relays at each of said stations, means controlled over said line circuits by the code sending relays at any of said locations for positioning
35 the code receiving relays at all of said stations at each step of said mechanisms, and means controlled by a composite code rendered effective by the correspondence between the contacts of said code sending relays and said code receiving
40 relays at a plurality of steps of the stepping mechanism at a particular station for selecting that station.

7. In a remote control system, a plurality of locations including a control office and a plurality
45 of field stations connected by a plurality of line circuits, means for applying a series of time spaced stepping impulses of current to one of said line circuits, stepping mechanisms at said office and at each of said stations operated in synchronism
50 in response to said stepping impulses, a plurality of code sending relays at said office and at each of said stations, a plurality of code receiving relays at each of said stations, means controlled over said line circuits by the code sending relays
55 at any of said stations for positioning the code

receiving relays at all of said stations at each step of said mechanisms, and means controlled by a composite code rendered effective by the correspondence between the contacts of said code sending relays and said code receiving relays at
5 a plurality of steps of the stepping mechanism at a particular station for permitting said station only to be registered in said office.

8. In a remote control system, a plurality of locations including a control office and a plurality
10 of field stations connected by a plurality of line circuits, means for applying a series of time spaced stepping impulses of current to one of said line circuits, stepping mechanisms at said office and at each of said stations operated in synchronism in response to said stepping impulses, a
15 plurality of code sending relays at said office and at each of said stations, a plurality of code receiving relays at each of said stations, means controlled over said line circuits by the code sending relays at any of said locations for positioning
20 the code receiving relays at all of said stations at each step of said mechanisms, and means controlled by a composite code rendered effective by the correspondence between the contacts of
25 said code sending relays and said code receiving relays at a plurality of steps of the stepping mechanism at a particular station for selecting said station and for permitting said station only to be registered in said office.
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9. In a signalling system, a plurality of locations connected by a signal circuit, means for supplying said signal circuit with current impulses flowing alternately in opposite directions therein, step-by-step mechanisms at each of said
35 locations, a code signal transmitter at each of said locations, a code signal receiver at each of said locations, means responsive to impulses flowing in a certain direction in said signal circuit for operating the transmitter at each of said locations
40 at a particular step of said mechanisms, means responsive to impulses flowing in another direction in said signal circuit for operating the receiver at each of said locations at said particular step of said mechanisms, and code signal manifesting means at each location for maintaining
45 the signal transmitter for that location in operation for the next step only if said transmitter and said receiver assume corresponding positions on a particular step.
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