July 30, 1935. W. T. POWELL 2,009,946

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed March 22, 1933 5 Sheets-Sheet 1

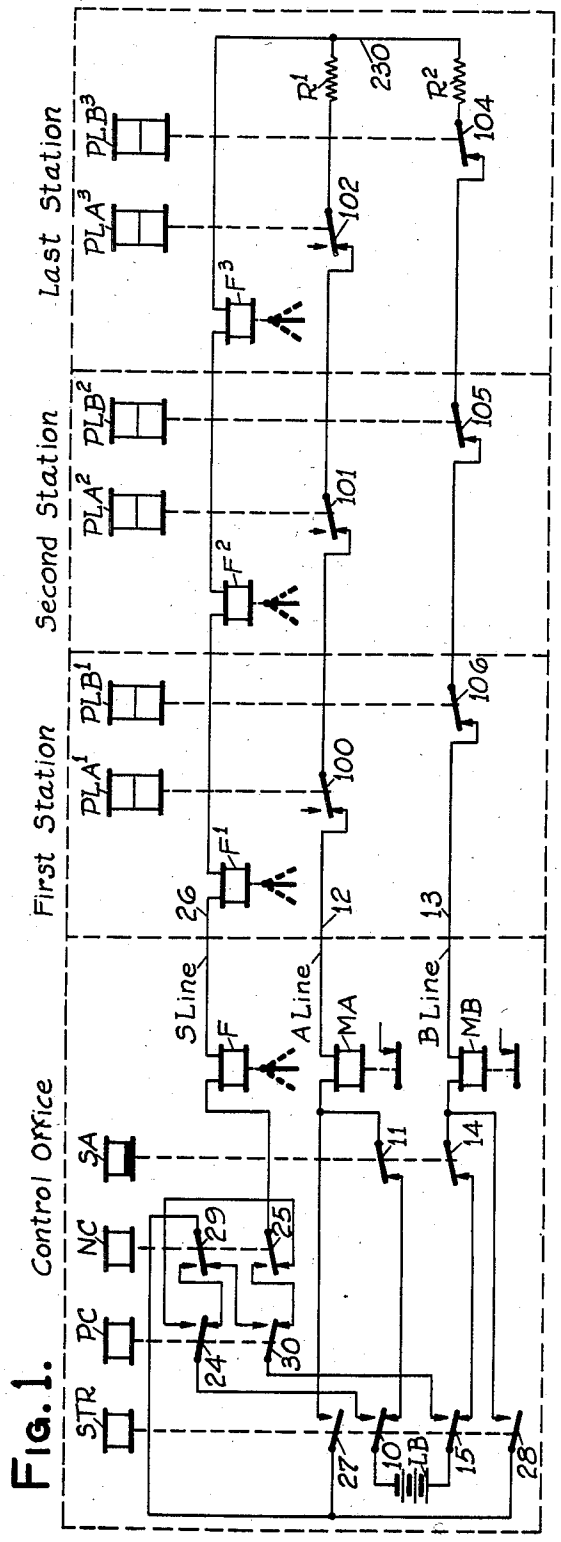



FIG. 1.

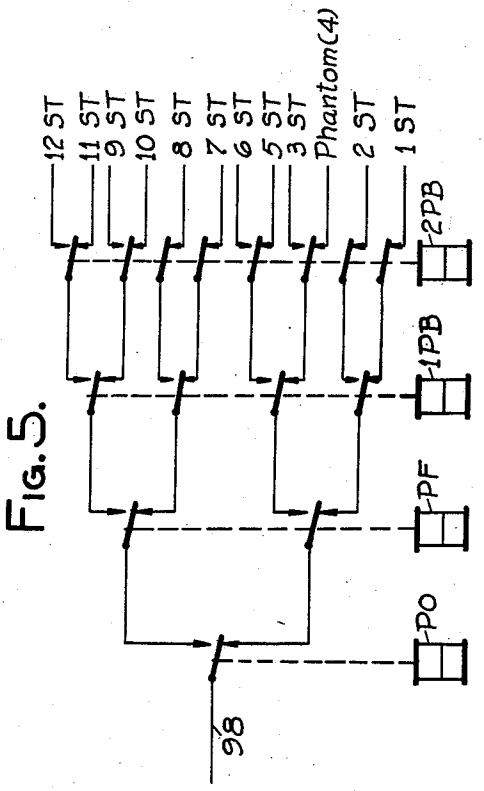



FIG. 5.

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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed March 22, 1933 5 Sheets-Sheet 2

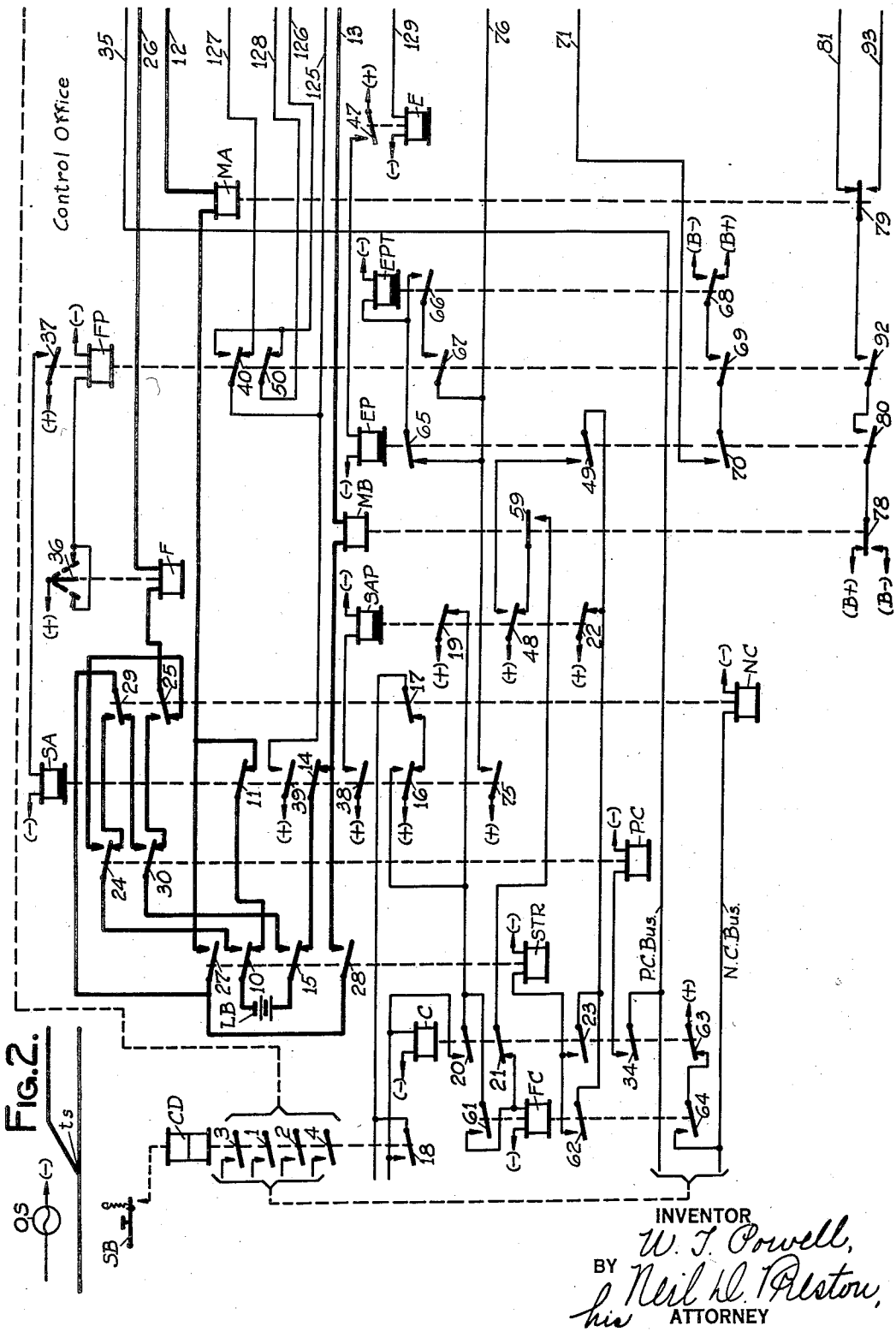



FIG. 2.

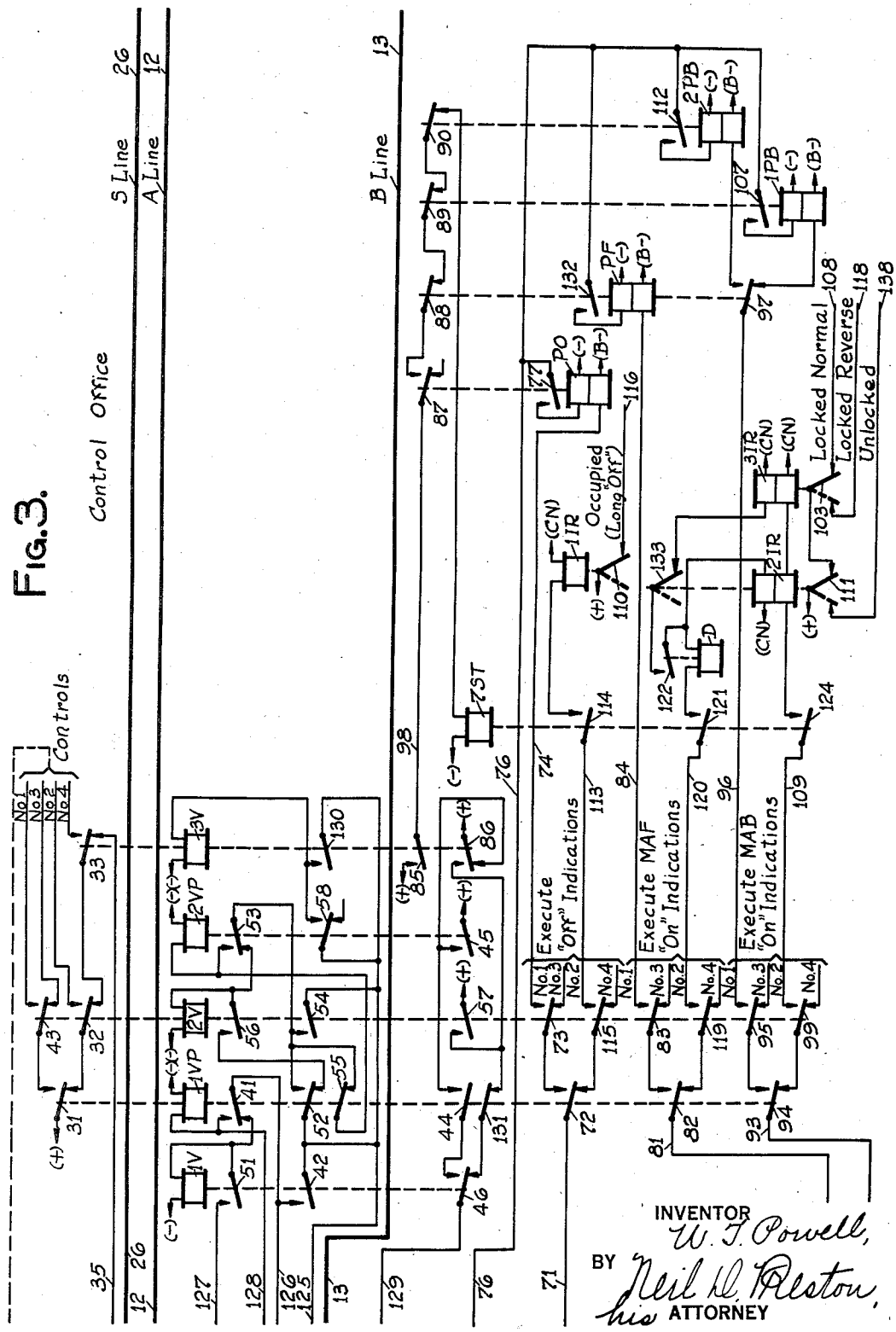
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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FIG. 3.



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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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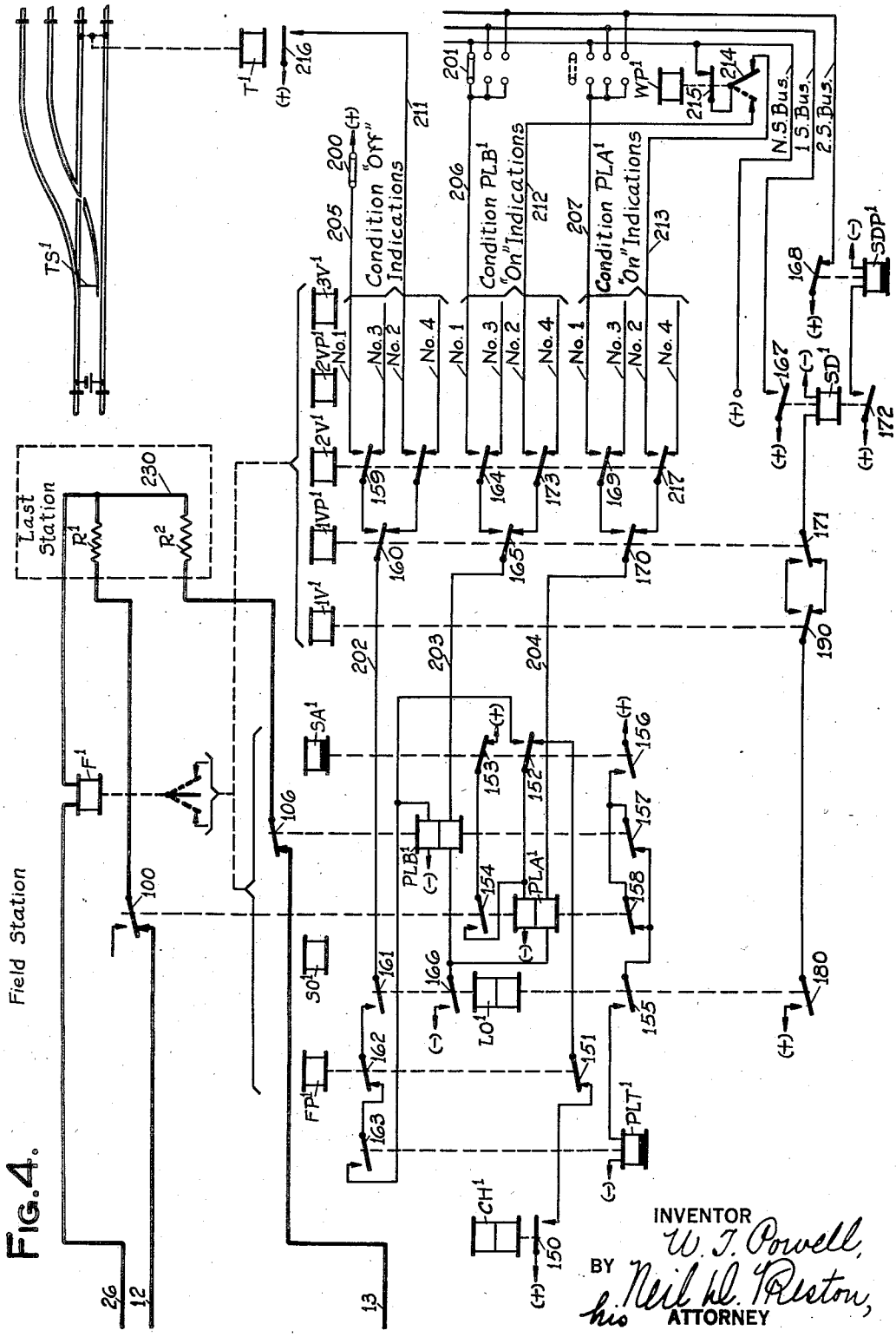



FIG. 4.

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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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FIG. 6.

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Patented July 30, 1935 2,009,946

# UNITED STATES PATENT OFFICE

2,009,946

## CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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Application March 22, 1933, Serial No. 662,116

20 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.

The present invention contemplates a centralized traffic controlling system in which communication is established between a control office and a number of outlying field stations by means of a communication system of the selective coded duplex type. The switches and signals at the outlying stations located along the railroad track are connected to the control office by means of a three-wire line circuit.

These switches and signals are under the supervision and control of an operator at the control office, so that he may at will change the position of the switches subject to automatic approach and detector locking circuits which prevent unsafe operation of any switch. The operator may also at will hold at-stop any of the signals or allow them to clear, dependent upon the position of the associated switches and provided the location of trains makes it safe for such signals to indicate proceed.

This system further provides means whereby indications are displayed in the control office to provide the operator with the necessary information for governing train movements, such as the indication of the presence or absence of trains on the various track sections and the positions and conditions of the various switches, signals and the like.

In this system a series of impulses forming a distinctive code combination is transmitted over the line circuit for the selection of a particular field station and for the transmission of controls to the selected station. Similarly, a series of impulses forming a distinctive code combination is transmitted over the line circuit for the registration of a particular field station in the control office and the transmission of new indications from the registered station. The control and indication circuits are so interrelated with the selector type apparatus employed that controls and/or indications are transmitted during the same cycle of operations.

In the present invention, it is proposed to provide a line battery at the control office for energizing the line conductors to transmit control and indication impulses. The control impulses are made distinctive by reason of their polarity for the purpose of transmitting the code combinations for selecting field stations and for transmitting the desired controls to the selected station. The indication combinations are formed, first by varying the time intervals or spaces between successive impulses applied to the line and second by arranging the return path for the impulses by way of two of the three line conductors in particular sequence combinations, all of which will be more specifically pointed out in the detailed description.

As the system 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 station selecting code is first transmitted to select that station with which communication is desired, then this code is followed by the control impulses for transmitting controls to the selected station. Similarly, when indications are transmitted, that particular field station which is transmitting, first transmits its station registering code and thereafter code combinations are transmitted corresponding to the indications which are to be transmitted from the registered station.

Irrespective of whether the control office or a field station is impulsing the line circuit, the length of each impulse is determined in the control office. The polarity of each impulse is likewise determined in the control office when either controls or indications are transmitted, by selectively connecting the control office battery to the communication line.

The field station transmitting indications determines the length of each time space between the impulses of a series during an operating cycle, that is, the field station determines whether the interval between impulses will be comparatively short (normal) or comparatively long (abnormal).

The three line wire conductors connecting the control office with the various field stations are conveniently referred to as the S line (stepping line) and the A and B lines. In addition to varying the length of the time spaces between impulses for providing a portion of the code combinations, the field station transmitting may provide the return path for the polar impulses which are applied to line S at each step by way of the A line conductor alone, the B line conductor alone or these two return line conductors in sequence combinations for obtaining a choice of six code combinations per step. This choice of six combinations together with the choice of two combinations obtained by means of the short and long "off" periods between impulses, makes it possible to obtain a choice of twelve combinations per step.

Certain of the characteristic features of this invention are disclosed in the prior application of Neil D. Preston Ser. No. 644,481 filed November 26, 1932, and no claim is made herein to these features.

These characteristic features of the present invention will be explained more in detail in the following description of one embodiment of the invention and various other characteristic features, advantages and functions will be in part pointed out and in part apparent as the description progresses.

In describing the invention in detail, reference will be made to the accompanying drawings which illustrate one method of carrying out the invention by way of example. The drawings illustrate in a diagrammatic manner the apparatus and circuits employed and for convenience, those parts having similar features and functions are designated in the several views by like letter reference characters that are generally made distinctive either by reason of distinctive exponents representative of their location or by reason of preceding numerals which represent the order of their operation and in which:—

Fig. 1 diagrammatically illustrates the three-wire line circuit extending from the control office through two intermediate field stations to the end field station.

Figs. 2 and 3, when placed end to end in the order named, illustrate the apparatus and circuits employed at a typical control office.

Fig. 4 illustrates the apparatus and circuits employed at a typical field station.

Fig. 5 illustrates the wiring of the contacts of the four pilot relays shown in Fig. 3.

Fig. 6 illustrates a typical indication code table which will be conveniently referred to when describing the method of obtaining the indication combinations.

For the purpose of simplifying the illustrations and facilitating in the explanation, various parts and circuits have been shown diagrammatically with certain conventional illustrations employed and the drawings have been made more with the purpose of making it easy to understand the principles and mode of operation of the invention, rather than illustrating the specific construction and arrangement of parts that would be preferably employed in practice.

The arrangement of those parts of the system which are not illustrated in the drawings and their cooperation and connection with the illustrated portions will be set forth in the following general description. After the general description, a more detailed description will be given of the operation of the invention.

*General description*

The symbols (+) and (—) are employed to indicate the positive and negative terminals respectively of suitable batteries or other sources of direct current and the circuits with which these symbols are used always have current flowing in the same direction. The symbols (B+) and (B—) indicate connections to the opposite terminals of a suitable battery or other direct current source which has a central or intermediate tap designated (CN) and the circuits with which these symbols are used may have current flowing in one direction or the other depending upon the particular terminal used in combination with the tap (CN).

For convenience in describing the operation of the system, the three line wires connecting the control office with the field stations are identified by referring to them as the stepping line (S) and the return lines (A and B). At the control office, a line battery LB is arranged to be selectively connected in series with the stepping line conductor and the return line conductors for applying polar impulses to the line during outbound and duplex cycles. During an inbound cycle, line battery LB is connected to the stepping line in the same manner for all impulses, that is, a series of (—) impulses is applied to line S.

The field station circuits illustrated in Fig. 4 have not been shown in detail. Only that portion of the field station circuits used during the transmission of indications is shown in detail. The circuit organization for operating the stepping relays is the same as used in the control office, therefore, it is believed unnecessary to show the circuit wiring which controls these relays. The series of dashes connecting the contacts of the line relay to the bracket associated with the stepping relay bank indicates that these relays are controlled by the line relay at the station which operates in synchronism with the line relay in the control office.

Similarly, the line repeating relay, the station relay and the slow acting relay at the field station are connected by means of the series of dashes to the contacts of the line relay which indicates that these relays are also controlled over the line circuit. This control of these various relays is completely disclosed in N. D. Preston application, Ser. No. 644,481, filed November 26, 1932.

In Fig. 4, the three code jumper connections which determine the code combination for the transmission of indications are shown in detail for the first and second steps. It is believed that a complete explanation of the operation of this feature during the first two steps will be sufficient to indicate how these indication code combinations are obtained for as many steps as the size of the system requires.

In the upper portion of Fig. 6, the jumper wire connections and the resulting relay positions are indicated for the two distinctive indications which are obtained during the first "off" period between impulses in the line circuit. This portion of the code table indicates that the connection of a code jumper from wire **205** of Fig. 4 to (+) results in a long "off" period and this in turn causes relays PLA[1] and PLB[1] to be picked up, leaving relays PLT[1] and EPT down. Relay EPT down results in the first pilot relay PO (off) picking up. The alternate arrangement of wire **205** of Fig. 4, that is disconnected from (+) results in these various relays being in their alternate positions as indicated in this table. Therefore, the result of this selective jumper connection of wire **205** at the station determines whether relay PO in the office will be up or down during a particular step.

In the lower portion of Fig. 6, the six conditions are illustrated whereby a choice of six indication code combinations per step is obtained. The pilot relays PF, 1PB and 2PB which are to be conditioned as determined by the connections of the code jumpers to wires **206** and **207** at the field station, are shown in the right hand portion of this illustration and it will be observed that these pilot relays are up and down in six different combinations, as indicated by reference characters U and D respectively.

For convenience in describing the operation which results from the various connections of the sequence determining circuits, an "on" period

(line circuit energized) has been divided into first, second and third portions and the positions of the PLA[1], PLB[1], MA and MB relays during these different portions of an "on" period are indicated by reference characters D and U which indicate that an associated relay is down or up respectively.

As will be clearly pointed out in the following description, the picking up of relay PLA[1] during an "on" period opens the A line conductor, which results in relay MA remaining down and the picking up of relay PLB[1] results in opening line B so that relay MB remains down. In the table it will be noticed that the reference character U occurs in association with the MA and MB relays during a particular portion of the "on" period when the reference character D is associated with the corresponding PLA[1] and PLB[1] relays.

In order to pick up any of the three pilot relays, PF, 1PB or 2PB, relay MB must be up. Pilot relay PF is picked up when relays MA and MB are up at the same time. Relay 1PB is picked up when relay MA is down and relay MB is up before relay PF has been picked up. Relay 2PB is picked up when relay MA is down and relay MB is up after relay PF has been picked up. It will be noted that relay PF is up for the third, fourth, fifth and sixth combinations. This is because relays MA and MB are both up at the same time only for these four combinations and this occurs in the second portion of the "on" period.

The first combination results in all three pilot relays remaining down because relay MB is not picked up during any of the three portions of the "on" period. For the second combination relay 1PB is picked up because relay MB is picked up while relay MA remains down (first portion) before relay PF has been picked up.

Relay 2PB is picked up for the third combination because relay MB is up with relay MA down (third portion) after relay PF has been picked up. For the fourth combination relay MB is not up with relay MA down either before or after relay PF has been picked up. For the fifth combination relay 1PB is picked up because relay MB is up while relay MA is down (first portion) before relay PF has been picked up. For the sixth combination relays 1PB and 2PB are both up because relay MB is up while relay MA is down both before and after (first and third portions) relay PF has been picked up.

In considering the organization of the line circuit illustrated in Fig. 1, it will be understood that additional field stations may be connected between the control office and the first station or between any two of the stations illustrated.

*Control office equipment.*—The control office includes, besides the apparatus above mentioned, a quick acting line relay F of the polar biased-to-neutral type which has its contacts positioned to the right when a (+) impulse is connected to the stepping line and to the left when a (—) impulse is applied to the stepping line from battery B. Relay F is of the polar type for obtaining speed of operation only and it will be obvious that a neutral type relay can be used if desired.

A quick acting line repeating relay FP of the neutral type repeats each energization of the line relay F, this relay being picked up each time the line circuit is energized during a cycle of operations and dropped between successive impulses.

Slow acting line repeating relay SA of the neutral type is energized at the beginning of a cycle and because of its slow acting characteristics, it remains picked up between successive impulses throughout the cycle and is dropped after a predetermined time interval elapses following the last impulse. An additional slow acting relay SAP is provided for repeating the condition of the SA relay in such a manner that relay SAP is picked up at the beginning of a cycle and dropped after a predetermined time interval elapses following the dropping of relay SA at the end of the cycle.

The impulses of a cycle cause the step-by-step operation of a stepping relay bank including relays 1V, 1VP, 2V, 2VP and 3V. This stepping relay bank is arranged so that there will be a shift in position of some one of these relays for each de-energized condition of the stepping line circuit as well as for each energized condition of the stepping line circuit. More specifically, relay 1VP is picked up during each odd "off" period and is dropped during each even "off" period. Relay 1V is picked up during the conditioning and each even "on" period and is dropped during each odd "on" period.

Relay 2V is picked up during every second odd "off" period (first, fifth, ninth, etc.) and is dropped during alternate odd (third, seventh, eleventh, etc.) "off" periods. Relay 2VP is picked up during every second even (second, sixth, tenth, etc.) "off" period and is dropped on alternate even (fourth, eighth, twelfth, etc.) "on" periods. Relay 3V follows the operation of relay 2VP in the same manner that relay 2V follows relay 1VP. In other words, relays 1V and 1VP in combination are picked up and dropped once for each two impulses in the line circuit and relays 2V and 2VP in combination are picked up and dropped once for each two complete operations of relay 1VP.

In this particular embodiment (because only four steps are illustrated) relay 3V is stuck up, when picked up, until the end of the cycle. This operation of the stepping relay bank results in an exponential selection of channel circuits, this feature being disclosed and claimed in the prior application of W. T. Powell, Ser. No. 648,095 filed December 20, 1932.

Slow acting relays E and EP are for the purpose of timing the duration of the "on" periods. A starting relay STR is arranged to be picked up at the start of each cycle and also to be dropped and picked up in accordance with the position of relay EP to impulse the line. In other words, relay STR is a combined starting and line impulsing relay.

Office control relay C is picked up at the start of a control cycle and remains up during such a cycle until the "change to normal" period at the end of the cycle. Relay C remains down during an indication cycle. Field control relay FC is picked up at the start of an indication cycle, remains up throughout such a cycle and is dropped during the "change to normal" period at the end of a cycle. Relay FC is not picked up during a control cycle. Positive polarity control relay PC and negative polarity control relay NC are used to selectively connect battery LB to the line circuit during the "off" periods, in preparation for energizing the line with the proper polarity during the succeeding "on" periods.

Relay MA is connected in series with the A line return conductor and relay MB is in series with the B line conductor. These two relays are for the purpose of executing in the control office the conditions of the A and B lines during certain portions of the "on" period. While these relays are indicated as being of the neutral type it is obvious that they may be of the polar type for

speed of operation. Relay MB is also used to start a cycle of operations from a field station. Slow acting relay EPT records in the control office whether a particular "off" period is normal (short) or abnormal (long).

As typical of the equipment located in the control office, a miniature track switch *ts* which corresponds to a particular track switch at the field station is illustrated. A starting button SB is provided to be actuated subsequent to the proper positioning of the control levers (not shown) for initiating the system for the transmission of controls as set up by the levers.

A number of storing relays (not shown) for storing simultaneous office start conditions interconnected with corresponding code determining relays such as relay CD, are so arranged that several storing relays may be up at the same time but corresponding CD relays can only be picked up one at a time during successive operating cycles. The order in which the code determining relays are picked up is predetermined by their relative locations in the 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 24, 1930, corresponding to Australian Patent 1501 of 1931. This prior application likewise discloses the connections of the switch machine and signal control levers, as well as the jumper connections which connect the contacts of relay CD to the PC and NC buses as illustrated by the dashed line of Fig. 2.

For the purpose of illustrating station registration, a typical pilot relay arrangement is shown in Figs. 3 and 5. The pilot relays PO, PF, 1PB and 2PB are connected to the indication buses so that they may be positioned on the first step of a cycle when indications are transmitted. Relay PO (off) is connected to "off" indication bus No. 1. Relay PF (operated by front contact of relay MA) is shown connected to the No. 1 MAF "on" indication bus. Relays 1PB and 2PB (operated by back contact of relay MA) are connected through contacts of relay PF to the No. 1 MAB "on" indication bus. It will be understood that the additional pilot relays may be provided and connected to additional steps of the stepping relay bank, up to the point where sufficient codes for station registration are obtained.

Station relay 1ST is provided in Fig. 3 for the purpose of registering in the control office the station indicated in Fig. 4 which it is assumed is transmitting indications. This station relay is merely typical of a number of such relays which would ordinarily be provided, one for registering each individual station. Additional relays similar to relay 1ST would be connected to conductors indicated by reference characters 1ST, 2ST, 3ST, 5ST, 6ST, 8ST, 9ST, 10ST, 11ST and 12ST which are connected to the contacts of relay 2PB as shown in Fig. 5.

Suitable indication storing relays, such as relays 1IR, 2IR and 3IR are provided for storing the various indications transmitted from the field stations, after a station has been registered in the control office by the selection of a station relay. It will be understood that these relays are merely typical of additional indication storing relays which may be provided for storing additional indications repeated by conditions at the field station and executed by means of the additional indication buses shown in the lower left hand portion of Fig. 3 and that the contacts of these indication storing relays may be connected to indicating devices, such as lamp OS shown in the upper left hand portion of Fig. 2. Relay D is for the purpose of delaying the connection to the upper winding of relay 3IR.

*Field station equipment.*—The field station illustrated in Fig. 4 includes a quick acting relay $F^1$ of the polar biased-to-neutral type, which relay is actuated to the right by positive current coming over the S line from the control office and to the left by negative current applied to the S line in the control office. Relay $FP^1$ repeats the impulses in the control line irrespective of their polarities.

Slow acting relay $SA^1$ functions similarly to the corresponding relay SA in the control office, that is, it defines the bounds of each operating cycle. It is picked up at the start of each cycle and dropped during the "change to normal" period at the end of the cycle. Each field station includes a station relay $SO^1$ which is picked up at all stations at the start of each operating cycle and after station selection only the SO relay associated with the selected station remains picked up. Lock-out relay $LO^1$ is picked up at the station which is sending indications over the communication line, the circuits of this relay being so organized that when several field stations have new indications to transmit at substantially the same time, the station nearest the end of the line obtains connection with the communication system and other stations are locked out.

Relay $CH^1$ at the field station registers a change in the traffic controlling devices so that the sytem will be automatically started through a cycle of operations for the transmission of new indications whenever relay $CH^1$ is down. Although the circuit of relay $CH^1$ is not shown in detail, it will be understood that it is normally stuck up and is released to close its back contact 150 by the interruption of its holding stick circuit, when a change in position of indication repeating relays takes place. Relay $CH^1$ will register a change in one or more of a large number of devices and will initiate indication cycles as long as there are new indications to be transmitted.

As above mentioned, the detailed circuits of these various relays have not been included in the drawings of Fig. 4, since they are the same as have been disclosed in other prior applications such as the above mentioned application of N. D. Preston, Ser. No. 644,481.

Relay $PLA^1$ conditions the A line conductor and relay $PLB^1$ conditions the B line conductor during the "on" periods and these two relays in combination form the six indication codes which are selectable during each "on" period. Relay $PLT^1$, in cooperation with relays $PLA^1$ and $PLB^1$, controls the time space between each pair of impulses for selectively conditioning the indication circuits to record a choice of two indications (long or short "off") for each step taken by the stepping relay bank.

Sequence determining relay $SD^1$ and sequence determining repeating relay $SDP^1$ function to deenergize the No. 1 sequence bus 1S and to energize the No. 2 sequence bus 2S in the order named. Relay $SD^1$ energizes the 1S bus at the start of each "on" period and deenergizes this bus about the middle of each "on" period. Relay $SDP^1$ deenergizes the 2S bus at the start of each "on" period and again energizes this bus a predetermined time after relay $SD^1$ deenergizes the 1S bus during each "on" period. The operation of these two sequence determining re-

lays in energizing these two buses in sequence, makes it possible to obtain the four indication combinations numbered 3, 4, 5 and 6 of Fig. 6. The "no sequence" bus NS, is supplied with permanent (+) potential so that the connection of an indication wire to this bus results in relay PLB[1] or relay PLA[1] being up through all three portions of a corresponding "on" period.

Suitable switch machine and signal relays (not shown) are provided at each field station. The relays which repeat the condition of the switch machine (WP[1]) and the detector track section (T[1]) are indicated but for the sake of simplicity, the energizing circuits of these relays are not shown in the drawings.

It is believed that the nature of the invention, its advantages and characteristic features may be best understood by continuing the description in a manner relating to the detailed operation of the system.

*Operation*

While the system is in its at-rest or period of blank condition, line S is deenergized. Lines A and B are energized by means of a circuit which extends from the (+) terminal of battery LB, back contact 10 of relay STR, back contact 11 of relay SA, winding of relay MA, A line conductor 12, back contact 100 of relay PLA[1], back contacts 101 and 102 of relays PLA[2] and PLA[3] respectively at other field stations (see Fig. 1), resistance unit R[1], conductor 230 (at last station), resistance unit R[2], back contacts 104, 105 and 106 of the PLB relays (with suitable exponents) at all stations, B line conductor 13, winding of relay MB, back contact 14 of relay SA and back contact 15 of relay STR to the (—) terminal of battery LB. The current in this circuit is effective to maintain relays MA and MB picked up when the system is in its normal condition.

*Manual start.*—The operator initiates a cycle of operations for the selection of a particular field station and the transmission of controls to the selected station by positioning the necessary control levers (not shown) and then actuating starting button SB. The actuation of button SB while the system is normal causes the code determining relay CD to be picked up. A circuit is now closed for picking up relay C which extends from (+), back contact 16 of relay SA, back contact 17 of relay NC, front contact 18 of relay CD and winding of relay C, to (—). Relay C closes a stick circuit for itself extending from (+), back contact 19 of relay SAP, front contact 20 and winding of relay C, to (—). Relay C opens its back contact 21 included in the circuit of relay FC, which prevents the picking up of relay FC during this cycle.

A circuit is closed for picking up relay PC which extends from (+), back contact 31 of relay 1VP, back contact 32 of relay 2V, back contact 33 of relay 3V, conductor 35, front contact 34 of relay C and winding of relay PC, to (—). A circuit is now closed for picking up relay STR which extends from (+), back contact 22 of relay SAP, front contact 23 of relay C and winding of relay STR, to (—).

The actuation of contacts 10 and 15 of relay STR opens the above described energizing circuit of the A and B line conductors and closes a circuit for energizing the S line conductor to mark the beginning of the conditioning "on" period. This circuit extends from the (+) terminal of battery LB, front contact 10 of relay STR, front contact 24 of relay PC, back contact 25 of relay NC, winding of relay F, S line conductor 26, winding of relay F[1] and over the above described circuit including the A and B line conductors to front contacts 27 and 28 of relay STR. The circuit now continues through back contact 29 of relay NC, front contact 30 of relay PC and front contact 15 of relay STR, to the (—) terminal of battery LB.

Current flowing in line S from the (+) terminal of battery LB is effective to position the line relays in the control office and at the field stations to the right. Relay F closes a circuit for picking up relay FP which extends from (+), contact 36 of relay F in its right hand dotted position and the winding of relay FP, to (—). Relay FP closes a circuit for picking up relay SA which extends from (+), front contact 37 of relay FP and winding of relay SA, to (—). Relay SA maintains its back contacts 11 and 14 open throughout the cycle so that the dropping of relay STR will not be effective to connect battery LB to the A and B line conductors.

It will be understood that relays FP[1] and SA[1] at the field station of Fig. 4 (as well as similar relays at other field stations) are picked up at substantially the same time as the corresponding relays in the control office. Relay SA closes a circuit for picking up relay SAP which extends from (+), front contact 38 of relay SA and winding of relay SAP, to (—). Relay SAP opens its back contact 22 which causes the release of relay STR. The dropping of relay STR deenergizes the line conductors to mark the end of the conditioning "on" period and the beginning of the first "off" period.

The picking up of relay SAP opens the above described stick circuit of relay C but this latter relay is not dropped, due to a substitute stick circuit being closed at front contact 16 of relay SA before relay SAP is picked up.

Relay SO[1] at the station is picked up during the conditioning period. Relay LO[1] is not picked up during this cycle and since its front contact 155 is not closed, relay PLT[1] cannot be energized. Since relay LO[1] maintains its front contact 166 open, the indication conditioning circuits including conductors 202, 203 and 204 are not energized so that relays PLA[1] and PLB[1] remain down.

*Line impulsing and stepping relay operation.*—The impulsing and stepping operations will be directed to Figs. 2 and 3. Since relays F[1] and FP[1] at the field station operate in synchronism with relays F and FP in the control office, it will be obvious that the stepping relays 1V[1], 1VP[1], 2V[1], 2VP[1] and 3V[1] will operate in synchronism with corresponding stepping relays in the control office when the circuits are connected as shown in Figs. 2 and 3.

During the conditioning period, relay FP is picked up as above described and closes a circuit for picking up relay 1V extending from (+), front contact 39 of relay SA, front contact 40 of relay FP, conductor 126, back contact 41 of relay 1VP and winding of relay 1V, to (—). Relay 1V establishes a stick circuit for itself extending from (+), front contact 39 of relay SA, conductor 125, front contact 42 of relay 1V, back contact 41 of relay 1VP and winding of relay 1V, to (—). This stick circuit is effective until relay 1VP is picked up to open its back contact 41.

At the start of the first "off" period (above described) the deenergization of line S drops relays F and FP. Relay FP closes a circuit for picking up relay 1VP which extends from (+), front contact 39 of relay SA, conductor 125, front contact 42 of relay 1V, conductor 126, back con-

tact 50 of relay FP, conductor 128 and winding of relays 1VP, to (—). Relay 1V is stuck up after relay 1VP picks up over a circuit extending from (+), front contact 39 of relay SA, back contact 40 of relay FP, conductor 127, front contact 51 and winding of relay 1V, to (—). Relay 2V is picked up at this time over a circuit extending from (+), front contact 39 of relay SA, conductor 125, front contact 52 of relay 1VP, back contact 53 of relay 2VP, and winding of relay 2V, to (—).

The picking up of relay 1VP opens the above described pick-up circuit for relay PC at back contact 31. Relay PC is immediately reenergized or relay NC is energized, depending upon the connection of the No. 1 control wire by way of front contact 31 of relay 1VP and front contact 43 of relay 2V to the PC or NC bus as determined by the code jumper arrangement (not shown).

Relay E is now picked up over a circuit extending from (+), back contact 86 of relay 3V, front contact 44 of relay 1VP, front contact 46 of relay 1V, conductor 129 and winding of relay E, to (—). Relay E closes a circuit at its front contact 47 for picking up relay EP. Relay STR is now picked up by means of a circuit extending from (+), front contact 48 of relay SAP, front contact 49 of relay EP, front contact 23 of relay C and winding of relay STR, to (—). The picking up of relay STR marks the end of the first "off" period and the beginning of the first "on" period by again energizing the line conductors.

The energization of line S results in relay FP picking up. Relay 1V is now dropped because one energizing circuit is open at back contact 41 of relay 1VP and the other energizing circuit (through its front contact 51) is open at back contact 40 of relay FP. Relay 1VP remains up during the "on" period over a stick circuit extending from (+), front contact 39 of relay SA, front contact 40 of relay FP, conductor 126, front contact 41 and winding of relay 1VP, to (—).

The dropping of relay 1V opens the circuit of relay E at front contact 46 and after a predetermined time interval relay E drops, which is effective to open the energizing circuit of relay EP at contact 47 and relay EP drops after a predetermined time interval. The dropping of relay EP opens the above described circuit of relay STR at back contact 49, so that relay STR drops to mark the end of the first "on" period and the beginning of the second "off" period by deenergizing the line.

Relay FP is now dropped and relay 1VP drops because both conductors 126 and 128 are deenergized at front contact 42 of relay 1V and front contact 40 of relay FP, now in their deenergized positions. Relay 2V remains energized over a circuit extending from (+) on conductor 125, front contact 54 of relay 2V, back contact 53 of relay 2VP and winding of relay 2V, to (—).

Relay 2VP is now picked up by means of a circuit extending from (+) on conductor 125, front contact 54 of relay 2V, back contact 55 of relay 1VP and winding of relay 2VP, to (—). Relay 3V is now picked up over a circuit extending from (+) on conductor 125, front contact 58 of relay 2VP and winding of relay 3V, to (—). Relay 3V closes a stick circuit for itself which is effective until the end of the cycle and which extends from (+) on conductor 125, front contact 130 and winding of relay 3V, to (—).

A circuit is now closed for picking up relay E which extends from (+), front contact 86 of relay 3V, back contact 131 of relay 1VP, back contact 46 of relay 1V, conductor 129 and winding of relay E, to (—). Relay E again closes the above described pick-up circuit for relay EP after which relay STR is picked up over its previously described pick-up circuit. This marks the end of the second "off" period and the beginning of the second "on" period by energizing line S.

Relay FP now picks up and closes a circuit for picking up relay 1V which circuit was previously described. Relay 2V remains stuck up after the picking up of relay 1V because relay 1VP is down and a circuit is completed from (+) on conductor 125, through back contact 52 of relay 1VP and front contact 56 of relay 2V to the winding of relay 2V.

The picking up of relay 1V during the second "on" period as above described, results in relay E dropping because its circuit is open at back contact 46 and because the circuit through front contact 46 is open at front contact 44 of relay 1VP. Relays EP and STR now drop in turn to deenergize the line, which marks the end of the second "on" period and the beginning of the third "off" period.

Relay FP again drops and by means of the previously described circuit when relay FP was dropped during the first "off" period, relay 1VP is picked up. Relays E, EP and STR now pick up in rotation, to mark the end of the third "off" period and the beginning of the third "on" period by energizing line S.

During the third "off" period, relay 2V is dropped when relay 1VP picks up because its circuit is open at back contact 53 of relay 2VP and at back contact 52 of relay 1VP.

Relay FP again picks up and by means of the circuit described during the first "on" period, effects the release of relay 1V. Relay E is now dropped since its circuit is open at front contact 46 of relay 1V and at back contact 131 of relay 1VP. Relays EP and STR now drop in rotation to mark the end of the third "on" period and the beginning of the fourth "off" period.

Relay FP now drops and causes the release of relay 1VP in the same manner as this relay was released during the second "off" period. Relay 2VP is now dropped because its stick circuit through its own front contact 53 is open at front contact 54 of relay 2V and at front contact 52 of relay 1VP. The pick-up circuit for relay 2VP through back contact 55 of relay 1VP is now open at front contact 54 of relay 2V.

Relay E is now picked up by means of a circuit extending from (+), front contact 86 of relay 3V, back contact 131 of relay 1VP, back contact 46 of relay 1V, conductor 129 and winding of relay E, to (—). Relays EP and STR now pick up in turn and the line circuit is energized to mark the end of the fourth "off" period and the beginning of the fourth "on" period.

Relay FP picks up and causes relay 1V to be picked up by means of the circuit described during the second "on" period. Relay E is now dropped since the above described circuit through back contact 46 of relay 1V is open and the circuit through front contact 46 is open at front contact 44 of relay 1VP which is now down. Relays EP and STR now drop and the line is deenergized to mark the end of the fourth "on" period and the beginning of the "change to normal" period.

Relay FP is dropped and relay 1VP is picked up by means of the circuit described during the first "off" period. Relay E cannot be picked up at this time because the circuit through front

contacts 46 and 44 of relays 1V and 1VP respectively is not completed to (+), since relay 2VP is down which opens its front contact 45 and since relay 3V is up which opens its back contact 86. Since relay E cannot pick up, the circuits are not closed for picking up relays EP and STR, which results in line S remaining deenergized for a time interval which is sufficiently long to allow relay SA to drop, because its energizing circuit is open at front contact 37 of relay FP. Relay SA opens the circuit of relay SAP at front contact 38 and relay SAP is dropped.

The dropping of relay SA opens the stick circuit of relay C at front contact 16 before relay SAP drops and again closes this stick circuit at back contact 19, with the result that relay C is dropped. Relays 1V, 1VP and 3V drop when relay SA releases and opens its front contact 39.

From the above it will be seen that relay 1VP is picked up during the first, third and "change to normal" "off" periods and dropped during the second, fourth and "change to normal" "off" periods. Likewise, relay 1V is picked up during the conditioning, second and fourth "on" periods and is dropped during the first and third "on" periods and the "change to normal" period.

It will be observed from a consideration of the above description and an examination of the stepping relay circuits, that when relays 1V and 1VP are used in a larger system, they will be picked up and dropped in the same order as shown in the present embodiment. In other words, relay 1VP will be picked up during each odd "off" period and dropped during each even "off" period, while relay 1V will be picked up during the conditioning and each even "on" period and dropped during each odd "on" period.

It will also be observed that relays 2V and 2VP are controlled by two contact sets (52 and 55) on relay 1VP in the same manner that contact sets 40 and 50 of relay FP control relays 1V and 1VP. When the system is extended in size, additional relays such as relay 3V and relay 3VP (not shown) will be controlled by contact sets on relay 2VP which are similar to contact sets 52 and 55 of relay 1VP.

This results in relays 2V and 2VP counting each pair of complete operations of relay 1VP and since relay 1VP, in cooperation with relay 1V, counts each pair of relay operations of relay FP, it is apparent that relay 2VP will count every four operations of relay FP or in other words, four complete "off" and "on" periods. Therefore, four channel circuits are selectable during four steps by the use of four stepping relays. Relay 3V is only needed because of the additional channel (conditioning) shown in the present embodiment. By the addition of each pair of stepping relays operating in the order above described, the number of channels selectable is doubled. This feature has been disclosed in more detail in the above mentioned Powell application, Ser. No. 648,095.

*Polarity selection of impulses.*—As above pointed out, when a cycle of operations is initiated manually from the control office, line S is energized with a (+) potential as determined by relay PC picking up by means of a circuit extending through back contacts 33, 32 and 31 of relays 3V, 2V and 1VP respectively.

During the first "off" period after the conditioning period, the No. 1 control is conditioned (+) or (−) by connecting (+) through front contact 31 of relay 1VP and front contact 43 of relay 2V to the No. 1 control wire, which leads through a front contact of the particular CD relay which is picked up and the particular jumper connection to either the PC or NC bus. During the second "off" period this circuit is switched from the No. 1 to the No. 2 control wire for actuating the PC or NC relay as determined by the bus or lever connection. During the third and fourth "off" periods, the No. 3 and No. 4 wires respectively are similarly selected for determining the polarity with which line S is to be energized following these "off" periods. It will be noted that these control wires are selected by way of contacts of the stepping relays during the "off" periods, which do not shift during the succeeding "on" period so that the proper polarity is maintained during an "on" period as selected during the preceding "off" period.

These control conditioning circuits which lead from contacts of relays 2V and 3V through contacts of relay CD and the jumper and lever connections to the PC and NC buses are not shown in detail, since they may be similar to those disclosed in the prior application of N. D. Preston, Ser. No. 644,481.

The control executing circuits at the field station are likewise not shown, since these circuits may be controlled on the different steps of the stepping relay bank by the (+) (right hand dotted position) and the (−) (left hand dotted position) actuations of relay $F^1$, in a manner similar to that disclosed in the above mentioned application, 644,481.

During a control cycle, line S is energized during each "on" period in series with the A and B lines in multiple, which results in picking up relays MA and MB during these periods and dropping them during the "off" periods. This is effective to pick up relay PF of Fig. 3 but as will be later pointed out, this condition in combination with a series of normally short "off" periods forms a phantom code, which results in no station being registered in the control office.

*Automatic start.*—The system may be initiated into a cycle of operations from its normal position by an automatic change in condition at a field station. Such initiation may be the result of a change in traffic conditions or it may be due to the operation of a traffic controlling device to a new position, as a result of controls transmitted from the control office.

The stick circuit for change relay $CH^1$ of Fig. 4 is interrupted when such a change in conditions takes place, so that this relay drops and closes a circuit for picking up relay $PLA^1$ which extends from (+), back contact 150 of relay $CH^1$, back contact 151 of relay $FP^1$, back contact 152 of relay $SA^1$ and upper winding of relay $PLA^1$, to (−). Relay $PLA^1$ closes a stick circuit for itself extending from (+), back contact 153 of relay $SA^1$, front contact 154 and upper winding of relay $PLA^1$, to (−).

Relay $PLA^1$ opens the normally energized A and B line circuit at its back contact 100, resulting in dropping relays MA and MB in the control office. A circuit is now closed for picking up relay FC extending from (+), back contact 48 of relay SAP, back contact 59 of relay MB, back contact 21 of relay C and winding of relay FC, to (−). Relay FC closes a stick circuit for itself by way of its front contact 61, which is the same as the above described stick circuit for relay C.

A circuit is now closed for picking up relay STR which is the same as formerly traced, except that it now extends through front contact

62 of relay FC instead of front contact 23 of relay C. Relay STR energizes the S line circuit for marking the end of the normal period and the beginning of the conditioning period. Relays F, FP, SA and SAP now pick up in turn and the system is stepped through the cycle in the same manner as previously described, except in this case relays NC and PC are not selectively actuated to determine the polarity applied to line S. Relay NC is maintained actuated by a circuit extending from (+), back contact 63 of relay C and front contact 64 of relay FC to the winding of relay NC. Relay PC is not picked up during this cycle because front contact 34 of relay C is not closed. This circuit is effective to make all of the impulses applied to line S during this cycle (—) in character.

In the event that there are several stations with indications to transmit at the same time at the beginning of a cycle, the lock-out circuit arrangement is effective to permit the picking up of only one lock-out relay, for example, relay LO¹ of Fig. 4. Since this feature forms no part of the present invention and since it has been disclosed and explained in detail in the above mentioned prior application, Ser. No. 644,481, it will not be shown or described in the present embodiment. It is sufficient for a clear understanding of the present invention to know that relay LO¹ at only one field station can be up at any one time.

*Transmission of indications.*—It will be assumed that the field station illustrated in Fig. 4 is station No. 7 and that relay 7ST of Fig. 3 is the station relay which is to be picked up to register station No. 7 in the control office, when this station is transmitting. This necessitates the connection of wire 205 at the field station by means of jumper 200 to (+), the connection of wire 206 by jumper 201 to the NS bus and the disconnection of wire 207, all of which is indicated in Fig. 4.

Wire 205 connected to (+) by means of jumper 200 determines that the first "off" period will be long. When lock-out relay LO¹ is picked up during the conditioning period, a circuit is closed for picking up relay PLT¹ which extends from (+), front contact 156 of relay SA¹, back contact 157 of relay PLB¹ in multiple with back contact 158 of relay PLA¹, front contact 155 of relay LO¹ and the winding of relay PLT¹, to (—). When relays 1VP¹ and 2V¹ are picked up during the first "off" period, a circuit is closed for picking up relays PLA¹ and PLB¹ which extends from (+), jumper 200, wire 205, front contact 159 of relay 2V¹, front contact 160 of relay 1VP¹, conductor 202, front contact 161 of relay LO¹, back contact 162 of relay FP¹, front contact 163 of relay PLT¹ and the upper winding of relay PLB¹, to (—). This circuit also extends through front contact 152 of relay SA¹ and the upper winding of relay PLA¹, to (—).

With relays PLA¹ and PLB¹ picked up, both back contacts 157 and 158 are opened, which results in relay PLT¹ dropping after a predetermined time interval. The drop-away time interval of relay PLT¹ is considerably longer than the pick-up time intervals of relays E, EP and STR and the drop-away time of relay EPT in the control office. This results in the failure of relay STR to energize line S for picking up relay FP to close the stick circuit of relay EPT, (at front contact 67) before relay EPT drops after its pick-up circuit is opened at back contact 65 of relay EP. In other words, relay STR attempts to energize the S line but fails, because both return conductors 12 and 13 are open at back contacts 100 and 106 of relays PLA¹ and PLB¹ respectively. Since both the pick-up and stick circuits of relay EPT are open this relay is dropped.

During the succeeding (first) "on" period, (started by the dropping of relays PLT¹, PLA¹ and PLB¹) relays F and FP are picked up, and the No. 1 "off" indication executing circuit is completed from (B+), back contact 68 of relay EPT, front contact 69 of relay FP, front contact 70 of relay EP, conductor 71, front contact 72 of relay 1VP, front contact 73 of relay 2V, No. 1 "off" indication wire 74 and lower winding of relay PO, to (B—). Relay PO is picked up and stuck up by means of a circuit extending from (+), front contact 75 of relay SA, conductor 76, front contact 77 and upper winding of relay PO, to (—).

Referring to the upper portion of the code table illustrated in Fig. 6, it will be noted that relay PO is picked up when wire 205 is connected by jumper 200 to (+). In the event that wire 205 is not connected to (+) (as illustrated for the No. 1 choice "off" indication), then relay PO remains down. This is brought about because the absence of an energizing circuit for wire 205 results in relays PLA¹ and PLB¹ being down during the first "off" period, so that relay STR in picking up is effective to energize line S to make this "off" interval short. This results in relay FP picking up and closing the stick circuit of relay EPT at front contact 67 before relay EPT has time to release. In this case the No. 1 "off" indication executing circuit, as above described, extends from (B—) at front contact 68 of relay EPT to the lower winding of relay PO and since this relay has (B—) potential connected to the other terminal of the lower winding, it is not picked up.

By referring to Fig. 5, it will be observed that relay PO is picked up to register stations 7 to 12 inclusive and this relay remains down to register stations 1 to 6 inclusive (excluding phantom No. 4).

When the system advances from the first "off" into the first "on" period, line conductor S is energized, the return circuit being by way of the A line conductor alone because relay PLB¹ is picked up during the first "off" period to open line conductor B at back contact 106. The circuit for picking up relay PLB¹ extends from (+), NS bus, jumper 201, wire 206, front contact 164 of relay 2V¹, front contact 165 of relay 1VP¹, conductor 203, lower winding of relay PLB¹ and front contact 166 of relay LO¹, to (—).

With the A line conductor energized and the B line conductor de-energized, relay MA is picked up and relay MB remains down. This condition continues throughout the first "on" period because the above described circuit for picking up relay PLB¹ is not interrupted and because there is no circuit established for picking up relay PLA¹ during this period. With relay MB down there is no circuit completed for energizing either wire 81 or wire 93 (with B+) so that the jumper 201 being connected as shown in Fig. 6 for the No. 1 "on" choice results in relays PF, 1PB and 2PB remaining down.

Station registering relay 7ST is picked up when the system is advanced into the second "off" period by means of a circuit extending from (+), front contact 85 of relay 3V, conductor 98, front contact 87 of relay PO, back contact 88 of relay PF, back contact 89 of relay 1PB, back contact

90 of relay 2PB and winding of relay 7ST, to (—). Since relay 3V does not drop until the end of the cycle, this circuit remains intact for holding relay 7ST up.

The above example indicates how the particular station illustrated in Fig. 4 is registered in the control office. It will now be explained how additional combinations are obtained so that five other choices during the first step are effective to condition pilot relays PF, 1PB and 2PB in their up and down positions as indicated in the last column of Fig. 6.

The No. 2 choice is obtained when wire 207 is connected to (+) on the NS bus by means of jumper 208 (see Fig. 6). This results in relay PLA[1] being up and relay PLB[1] being down throughout the first "on" period, so that the B line conductor is energized and the A line conductor is de-energized. This causes relay MB to be picked up and relay MA to remain down throughout this period, as indicated by reference letters U and D associated with these relays in Fig. 6.

With relay MB up and relay MA down, a circuit is closed for picking up relay 1PB which extends from (B+), front contact 78 of relay MB, front contact 80 of relay EP, front contact 92 of relay FP, back contact 79 of relay MA, conductor 93, front contact 94 of relay 1VP, front contact 95 of relay 2V, No. 1MAB "on" conductor 36, back contact 97 of relay PF and lower winding of relay 1PB, to (B—). Relay 1PB picks up and sticks by means of a circuit through its front contact 107 to (+) on conductor 76. There are no circuits during this choice for picking up relays PF and 2PB.

The No. 3 choice is obtained when jumper 209 is connected to the 1S bus and jumper 210 is connected to the 2S bus as indicated in Fig. 6. This results in relay PLA[1] being down and relay PLB[1] being up during the first portion of the "on" period, relay PLA[1] being down and relay PLB[1] being down during the second portion of the "on" period and relay PLA[1] being up and relay PLB[1] being down during the third portion of the "on" period. This is brought about by the sequence connection of (+) potential to the 1S and 2S buses. During the first "off" period, relay SD[1] is picked up by means of a circuit extending from (+), front contact 180 of relay LO[1], front contact 190 of relay 1V[1], front contact 171 of relay 1VP[1] and winding of relay SD[1], to (—). Relay SD[1] closes a circuit by way of its front contact 172 for picking up relay SDP[1].

Relay PLB[1] is picked up during the first portion of the first "on" period by a circuit extending from (+), front contact 167 of relay SD[1], 1S bus, jumper 209 (No. 3 choice, see Fig. 6), wire 206, front contact 164 of relay 2V[1], front contact 165 of relay 1VP[1], conductor 203, lower winding of relay PLB[1] and front contact 166 of relay LO[1], to (—). Relay PLA[1] remains down during this first portion of the first "on" period because the 2S bus is de-energized at back contact 168 of relay SDP[1], now picked up.

When relay 1V[1] drops during the first "on" period, the above described circuit of relay SD[1] is opened at front contact 190. Relay SD[1] drops to mark the end of the first portion of the first "on" period and de-energizes the 1S bus, so that relay PLB[1] is dropped during the second portion of the first "on" period. The 2S bus is de-energized during this second portion because of the time interval before relay SDP[1] drops to energize this bus.

The dropping of relay SDP[1] marks the end of the second portion of the "on" period and energizes the 2S bus, so that a circuit is closed for picking up relay PLA[1] in the third portion, extending from (+), back contact 168 of relay SDP[1], 2S bus, jumper 210 (see Fig. 6), wire 207, front contact 169 of relay 2V[1], front contact 170 of relay 1VP[1], conductor 204, lower winding of relay PLA[1] and front contact 166 of relay LO[1], to (—). Relay PLB[1] remains down during the third portion of the "on" period because relay SD[1] is down which de-energizes the 1S bus. The de-energization of the line to mark the end of the "on" period also ends the third portion of this period.

This explains the up and down positions of relays PLA[1] and PLB[1] during the three "on" portions, as indicated by reference letters U and D associated with the No. 3 choice in the table of Fig. 6. It will be obvious that relays MA and MB will assume opposite positions from relays PLA[1] and PLB[1] because they drop when relays PLA[1] and PLB[1] pick up to de-energize the associated lines and they pick up when these relays at the station drop to energize the lines.

When the No. 3 choice is executed, relays PF and 2PB are picked up and relay 1PB remains down. Relay PF is picked up because relays MA and MB are up during the second portion of the "on" period for closing a circuit from (B+), front contact 78 of relay MB, front contact 80 of relay EP, front contact 92 of relay FP, front contact 79 of relay MA, conductor 81, front contact 82 of relay 1VP, front contact 83 of relay 2V, conductor 84 and lower winding of relay PF to (—).

Relay 1PB can not be picked up because this requires that relay MB be up and that relay MA be down before they are both up together and by referring to the table of Fig. 6 it will be noted that this condition does not exist. Relay MB is picked up, however, while relay MA is down during the third portion of the "on" period which is after relay PF has picked up. Therefore, a circuit is completed for picking up relay 2PB extending from (B+), front contact 78 of relay MB, front contact 80 of relay EP, front contact 92 of relay FP, back contact 79 of relay MA, conductor 93, front contact 94 of relay 1VP, front contact 95 of relay 2V, conductor 96, front contact 97 of relay PF and lower winding of relay 2PB, to (B—). Relay 2PB sticks by way of its front contact 112 and its upper winding to (+) on conductor 76.

The No. 4 choice is obtained when jumpers 209 and 210 connect wire 206 to both the 1S and 2S buses as indicated in Fig. 6. This results in relay SD[1] connecting (+) by way of the 1S bus and wire 206 to the lower winding of relay PLB[1] for picking up this relay during the first portion of the "on" period. Relay PLA[1] remains down during this portion of the "on" period because wire 207 is not connected to either bus. When relay SD[1] drops to mark the end of the first portion of the "on" period, relay PLB[1] drops because the 1S bus is de-energized and relay PLA[1] remains down because wire 207 is open. Relay PLB[1] is picked up when relay SDP[1] drops to mark the end of the second portion of the "on" period, energizing the 2S bus by closing its back contact 168. Relay PLA[1] remains down during this portion of the "on" period because wire 207 is open.

The MA and MB relays will be in the positions indicated opposite the No. 4 choice, which positions are as above explained opposite to the posi-

tions of relays PLA[1] and PLB[1]. Recalling that relays MB and MA must be up at the same time to pick up relay PF, it will be noted that these two relays are up together during the second portion of the "on" period and relay PF is picked up as indicated. Relay PF sticks by energizing its upper winding through its front contact 132 to (+) on conductor 76. Since relay MB must be up with relay MA down before relay PF picks up for relay 1PB to be picked up, it will be observed that this condition does not exist so that relay 1PB remains down as indicated. Since relay MB must be up and relay MA down after relay PF is picked up to energize relay 2PB and since this condition does not exist for this choice, there is no circuit for picking up relay 2PB and it remains down as indicated.

The No. 5 choice is effected by connecting wires 207 and 206 to the 1S and 2S buses respectively by jumpers 209 and 210. This results in relay PLA[1] being picked up during the first portion of the "on" period because relay SD[1] connects (+) to the 1S bus at this time. Relay PLB[1] remains down during the first portion of the "on" period because the 2S bus is de-energized at back contact 163 of relay SDP[1]. When relay SD[1] drops to advance the system into the second portion of the "on" period, both the 1S and 2S buses are de-energized so that relays PLA[1] and PLB[1] are both down. When relay SDP[1] drops to advance the system into the third portion of the "on" period, the 2S bus alone is energized for energizing wire 206 and picking up relay PLB[1]. Relay PLA[1] is down at this time because wire 207 connected to the 1S bus is de-energized.

The MA and MB relays take opposite positions to the PLA[1] and PLB[1] relays respectively as indicated in the columns associated with these relays. Relay PF is picked up for this choice because relays MA and MB are up together (second portion). Relay 1PB is picked up because relay MB is up while relay MA is down before relay PF picks up (first portion). Relay 2PB is down because relay MB is not up with relay MA down after relay PF is picked up (third portion).

The No. 6 choice is effected by connecting jumpers 209 and 210 from wire 207 to both the 1S and 2S buses. This results in energizing wire 207 to pick up relay PLA[1] during the first portion of the "on" period when relay SD[1] is picked up. Relay PLB[1] is down during all three portions of the "on" period because wire 206 is left open. Relay PLA[1] is down during the second portion of the "on" period because both the 1S and 2S buses are de-energized after relay SD[1] drops and before relay SDP[1] drops. Relay PLA[1] is picked up during the third portion of the "on" period because the 2S bus is energized for energizing wire 207 when relay SDP[1] drops.

As indicated in Fig. 6, relays MA and MB take positions opposite the PLA[1] and PLB[1] relays. This combination requires that relays PF, 1PB and 2PB all pick up. Relay 1PB is picked up because relay MB is up with relay MA down before relay PF is picked up (first portion). Relay PF is up because both the MA and MB relays are up at the same time (second portion). Relay 2PB is up because relay MB is up and relay MA is down after relay PF is picked up (third portion).

From the above explanation and by referring to Fig. 6 it is seen that the first two choices of the six "on" indication combinations per step are obtained by selectively providing the return circuit for line S by way of line A and line B respectively. Further, the additional four choices are obtained by the sequential order in which lines A and B are connected up to selectively provide the return circuit for line S.

More specifically, the third combination is obtained by first energizing line A, next energizing line B, next de-energizing line A and then de-energizing line B. The fourth combination is obtained by first energizing line A, next energizing line B, then de-energizing line B and thereafter de-energizing line A. The fifth combination is obtained by first energizing line B, next energizing line A, then de-energizing line B and thereafter de-energizing line A. The sixth combination is obtained by energizing line B first next energizing line A, then de-energizing line A and thereafter de-energizing line B.

Another way of considering this feature of the invention is that lines A and B are energized with combinations of three different lengths of impulses (long, medium and short) during a single impulse period of line S. For example, choice No. 4 is a long impulse in line A, since relay MA is up during all three portions of the "on" period. No. 6 is a long impulse in line B, since relay MB is up during all three portions of the "on" period. No. 5 is a medium impulse in both the A and B lines, since relays MA and MB are each up during only two portions of the "on" period. No. 6 is a short impulse in line A because relay MA is only up during one portion of the "on" period.

By referring to Fig. 5 and considering the different combinations in which the four pilot relays are positioned, it will be seen that a selection of any one of twelve different code combinations is obtained for each step taken by the stepping relay bank. The No. 4 combination is not associated with a station since this is the phantom code and cannot be used for registering a station in the control office in the present embodiment, due to the fact that this is the combination inherently selected during a cycle of operations for the transmission of controls alone. This results during such a cycle because the "off" period between impulses is normally short which causes relay PO to remain down. Relay PF is picked up and relays 1PB and 2PB remain down during a cycle of this class, because relays PLA[1] and PLB[1] at the station are down (because the lockout relay is down) resulting in relays MA and MB being up in all three portions of the "on" period, which picks up relay PF because relays MA and MB are up together. Neither relay 1PB nor relay 2PB can pick up since there is no condition during the "on" period when relay MB is up with relay MA down before or after relay PF is picked up.

In the event that the number of stations required is more than 11, an additional group of pilot relays similar to those shown in Fig. 5 is provided, which results in obtaining 144 combinations for two steps of the stepping relay bank. Since one of these combinations is a phantom code, the actual number of stations that can be registered in a system using two steps for station selection is 143. It will thus be seen that the number of combinations obtained equals twelve raised to the power of the number of steps used for station registration.

*Indications from registered stations.*—After a station is registered in the control office by the actuation of its corresponding station relay such as relay 1ST of Fig. 3, the particular indications which are to be transmitted from the registered

station may be on a basis of a choice of two plus an additional choice of three per step.

As an illustration of the manner in which this combination of choices is transmitted, the No. 2 indication wires 211, 212 and 213 of Fig. 4 are shown connected to contacts of relays T¹ and WP¹. Relay T¹ is the usual track relay which repeats the occupied or unoccupied condition of the track section by being down and up respectively for these two conditions. Relay WP¹ is the customary relay which repeats the condition of the track switch. For convenience, it is assumed that this relay actuates its polar contact 214 to the right and its neutral contact 215 to its picked up position when the associated track switch is in its normal locked position. When the track switch is in its reverse locked position, relay WP¹ actuates its contact 215 to its energized position and its polar contact 214 to the left hand dotted position. When the track switch is unlocked, contact 215 is dropped and contact 214 remains in its last actuated position.

Assuming that the track switch TS¹ is unoccupied, relay T¹ will be picked up which removes (+) potential from wire 211 at the open contact 216. Due to the absence of (+) potential on wire 211, the No. 2 "off" indication is conditioned short in a manner which has already been explained in connection with the de-energized condition of wire 205 during the first step. This short "off" condition results in relay EPT remaining up for positioning indication receiving relay 1IR to the left over a circuit extending from (B—), front contact 68 of relay EPT, front contact 69 of relay FP, front contact 70 of relay EP, conductors 71, back contact 72 of relay 1VP, front contact 115 of relay 2V, No. 2 "off" indication executing wire 113, front contact 114 of relay 7ST and winding of relay 1IR, to (CN). Contact 110 of relay 1IR in its left hand dotted position de-energizes the occupied conductor 116, which may connect to an indicating device such as lamp OS for displaying the indication that the track section is unoccupied, by the dark condition of this lamp.

With relay T¹ down due to the track section being occupied, wire 211 is energized resulting in a long "off" for dropping relay EPT, in the specific manner already described in detail in connection with wire 205 during the first step. With relay EPT down, (B+) is connected through back contact 68 of this relay and over the remainder of the circuit above described to relay 1IR, which is effective to position this relay to the right for energizing the occupied wire 116 for displaying the occupied condition of the track section by lighting lamp OS.

The above discussion relates to the choice of two distinctive indications conditioned during the second "off" period for execution during the second "on" period. It will now be explained how an additional choice of three indication conditions during the second "on" period may be obtained for execution during the same "on" period. This choice of three may be conveniently used for registering the three repeating positions of relay WP¹, that is, normally locked, reverse locked and unlocked.

First assuming that relay WP¹ is in its normally locked repeating position as indicated in Fig. 4, it is necessary to position indication receiving relays 2IR and 3IR to their right hand positions for energizing the locked normal wire 108 by the connection of (+) potential through the right hand contacts 111 and 103 of these two relays respectively.

During the second "off" period, a circuit is closed for picking up relay PLA¹ which extends from (+) on the NS bus, front contact 215 of relay WP¹, contact 214 of relay WP¹ in its right hand position, conductor 213, front contact 217 of relay 2V¹, back contact 170 of relay 1VP¹, conductor 204, lower winding of relay PLA¹ and front contact 166 of relay LO¹, to (—). Relay PLB¹ is not picked up under this condition because wire 212 is not energized. Since neither relay 1VP¹ or relay 2V¹ shift during the second "on" period, this circuit is effective throughout this "on" period to de-energize line A and energize line B, resulting in relay MA remaining down and relay MB picking up.

With relay MB up and relay MA down, a circuit is closed for positioning relays 2IR and 3IR to the right, extending from (B+), front contact 78 of relay MB, front contact 80 of relay EP, front contact 92 of relay FP, back contact 79 of relay MA, conductor 93, back contact 94 of relay 1VP, front contact 99 of relay 2V, No. 2 MAB "on" indication executing wire 109, front contact 124 of relay 7ST and the lower windings of relays 2IR and 3IR in series to (CN).

In the event that relay WP¹ has its contact 215 in its energized position and its contact 214 in its left hand dotted position, it is then necessary to position relay 2IR to the right and relay 3IR to the left for energizing the locked reverse wire 118 by means of an obvious circuit.

With relay WP¹ in this assumed position, (+) on the NS bus is extended through front contact 215 of relay WP¹, contact 214 of relay WP¹ in its left hand dotted position, conductor 212, front contact 173 of relay 2V¹, back contact 165 of relay 1VP¹, conductor 203, lower winding of relay PLB¹ and front contact 166 of relay LO¹, to (—). This results in relay PLB¹ picking up to de-energize the B line conductor and since there is no circuit for picking up relay PLA¹ under this condition, the A line conductor is energized. This results in relay MA being picked up and relay MB being down.

A circuit is now closed from (B—), back contact 78 of relay MB, front contact 80 of relay EP, front contact 92 of relay FP, front contact 79 of relay MA, conductor 81, back contact 82 of relay 1VP, front contact 119 of relay 2V, conductor 120, front contact 121 of relay 7ST, winding of delay relay D and upper winding of relay 2IR, to (CN). The current flowing in this circuit is in such a direction that relay 2IR is positioned to the right. Relay D is picked up and by means of its front contact 122 connects the upper winding of relay 3IR in multiple with the upper winding of relay 2IR through contact 133 of relay 2IR in its right hand position. Since the connection to this winding of relay 3IR is opposite from that of relay 2IR, it is apparent that relay 3IR will be positioned to the left for completing the above mentioned circuit for energizing conductor 118.

In the event that relay WP¹ has its contact 215 open due to the unlocked condition of the associated switch machine, then neither conductors 212 or 213 are energized for picking up the PLA¹ or PLB¹ relays. This results in both the A and B line conductors being energized throughout the second "on" period for picking up relays MA and MB. A circuit is now completed for positioning relay 2IR to the left without disturbing the condition of relay 3IR. This circuit extends from (B+), front contact 78 of relay MB, front contact

80 of relay EP, front contact 92 of relay FP, front contact 79 of relay MA, conductor 81, back contact 82 of relay 1VP, front contact 119 of relay 2V, conductor 120, front contact 121 of relay 7ST, winding of relay D and upper winding of relay 2IR, to (CN). Since relay 2IR takes its left-hand position in considerably less time than it takes relay D to pick up, the upper winding of relay 3IR will be opened at contact 133 of relay 2IR before it is closed at contact 122 of relay D.

With relay 2IR positioned to the left the circuit through contact 111 in its right hand position is interrupted so that neither wire 108 nor wire 113 will be energized. With contact 111 in its left hand dotted position the unlocked wire 138 will be energized. It is obvious that these wires 108, 113 and 138 may connect to lamps or other indicating devices for displaying the proper indication. Or wires 108 and 113 may connect to indicating devices while wire 138 may not be used, which arrangement will display an indication for either locked condition and an absence of an indication for the unlocked condition.

From the above examples, it is believed obvious how the connections of the No. 3 and No. 4 indication wires of Fig. 4 in different combinations can be used to execute circuits comprising the No. 3 and No. 6 executing wires of Fig. 3. These conditioning and executing circuits may be used for positioning additional indication receiving relays associated with the registered station, or they may of course be used for registering a station in the control office in the same manner as described in connection with the No. 1 conditioning and executing circuits if the system is of sufficient size.

*End of indication cycle.*—The step-by-step operations and the impulsing of the S line circuit during an indication cycle are similar to those during a control cycle, except for the length of the "off" periods which has been explained. After relays E and EP in the control office drop during the last "on" period, they cannot be picked up during the next "off" period (for the reason previously explained), so that relays F and FP in the control office and the corresponding relays at the field station remain down for a time interval which is sufficiently long to drop relays SA and SAP in the control office and the SA relay at the field station. The stepping relays are released in the same manner as described in connection with a control cycle. Relay FC of Fig. 2 drops when relay SA opens its front contact 16, which removes (+) potential from the stick circuit of relay FC before relay SAP drops to apply (+) potential to this stick circuit. Relay NC is dropped when relay FC drops and opens its front contact 64.

Lock-out relay $LO^1$ at the field station is deenergized in a manner which is not shown but which is completely disclosed in the above mentioned prior application, Ser. No. 644,481. The reason for connecting the pick-up circuit of relays $PLT^1$ and $SD^1$ through front contacts 155 and 180 respectively of relay $LO^1$, is to prevent the unnecessary operation of relays $PLT^1$, $SD^1$ and $SDP^1$ during a control cycle when relay $LO^1$ is down and the operation of these relays is not required.

*Lock-out between field stations.*—It may happen that changes take place at the several field stations simultaneously or in rapid succession so that more than one station may have indications to transmit at the beginning of a cycle. In order to prevent more than one station obtaining access to the line during a cycle of operations, lock-out means are provided at each field station which are effective to give control of the line to the station nearest the end of the line and farthest from the control office. Since this feature forms no portion of the present invention and since an example of the manner of accomplishing it is disclosed in the above mentioned Preston application, Ser. No. 644,481, further discussion will be omitted.

*Two-way transmission.*—It has been mentioned that control and indication cycles may occur separately or simultaneously. The operation for each of these cycles alone has been described and it will now be explained how the system operates when controls and indications are transmitted during the same cycle. Such a cycle is conveniently referred to as a duplex cycle. It will be recalled that relay C is up and relay FC is down during a cycle for the transmission of controls alone. Relay C is down and relay FC is up during a cycle for the transmission of indications alone.

The actuation of a starting button in the control office and the picking up of relay CD which follows, results in picking up relay STR which marks the beginning of the conditioning period. Relay FC cannot be picked up after relay C picks up and opens its back contact 21, but relay FC can be picked up if there is a field station waiting to transmit indications at the beginning of a cycle so that relay MB is down before relay C picks up. Relay C can be picked up at the start of a cycle before relay NC is picked up during the conditioning period. Therefore, it is possible for both the C and FC relays to be up at the start of a particular cycle of operations.

In this case, the continuous energizing circuit for relay NC is disconnected at back contact 63 of relay C and the PC and NC buses are selectively conditioned in accordance with the jumper and lever positions selected by the CD relay. This selective conditioning of the PC and NC relays is effective to provide the polar impulses for energizing line S, to select the required field station and to transmit controls to the selected station.

During a duplex cycle, a (+) impulse is applied to line S during the conditioning period because relay PC is picked up over the previously described circuit through back contacts 33, 32 and 31 of relays 3V, 2V and 1VP respectively. The following impulses applied to line S are (+) or (−) as determined by the selective conditioning of the PC and NC buses. The return circuit for line S is preconditioned by way of the A and B lines and the lengths of the "off" periods are preconditioned, in the same manner as has been described in connection with the transmission of indications alone.

It is therefore evident that, since only one CD relay in the control office and one lock-out relay $LO^1$ at a field station can be up at one time during a cycle of operations and since transmission of controls and transmission of indications are determined by separate and distinct conditions of the line, these transmissions are independent of each other and can be incorporated in the same operating cycle for obtaining the duplex feature.

The present embodiment has been described more particularly with reference to the character of the devices employed in a centralized traffic controlling system and their respective functions together with typical operating conditions.

It will be understood that all possible combinations of circumstances cannot be considered in detail and that the drawings and description have been limited as much as possible in order to avoid complicating the disclosure. Although one specific embodiment of the present invention has been shown, it is to be understood that various rearrangements of the circuits may be made without departing from the spirit of the invention.

Having thus described one preferred embodiment of a centralized traffic controlling system, it is desired to be understood that the particular arrangements illustrated are only typical and are not intended to illustrate the exact circuit design necessary to carry out the features of the invention, but have been selected to facilitate in the disclosure rather than to limit its scope and it is further desired to be understood that various modifications, adaptations and alterations may be applied to the specific form disclosed in order to meet the problems encountered in practice and that the system may be varied in the number of field stations to which the invention is applied and the amount of apparatus included in a particular field station, all 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 stepping line circuit having a plurality of series of time spaced impulses impressed thereon, a step-by-step mechanism operable through a separate cycle for each of said series of impulses, means controlled by said mechanism for selecting three local channel circuits for each step, means for causing said mechanism to take one step for each time space between successive impulses of a series, a first return line and a second return line for said stepping line circuit, means for distinctively energizing two of said channel circuits in accordance with the energized or deenergized condition of said return lines for that step, and means for distinctively energizing the third of said channel circuits in accordance with the length of the time space for that step.

2. In a remote control system, a stepping line circuit having a plurality of series of time spaced impulses impressed thereon, a step-by-step mechanism operable through a separate cycle for each of said series of impulses, means controlled by said mechanism for selecting three local channel circuits for each step, means for causing said mechanism to take one step for each time space between successive impulses of a series, electro-responsive devices for each of said channel circuits, a first return line and a second return line for said stepping line circuit, means for distinctively energizing two of said channel circuits in accordance with the energized or deenergized condition of said return lines for that step, means for distinctively energizing the third of said channel circuits in accordance with the length of the time space for that step, and means responsive to said distinct energization of the three channel circuits of each step for positioning said electro-responsive devices in any one of six distinctive combinations.

3. In a remote control system, a stepping line circuit having a plurality of series of time spaced impulses impressed thereon, a step-by-step mechanism operable through a separate cycle for each of said series of impulses, means controlled by said mechanism for selecting three local channel circuits for each step, means for causing said mechanism to take one step for each time space between successive impulses of a series, electro-responsive devices for said channel circuits comprising a plurality of electro-responsive devices for at least one of said channel circuits, a first return line and a second return line for said stepping line circuit, means for distinctively energizing two of said channel circuits in accordance with the sequential order of energization or de-energization of said return lines for that step, means for distinctively energizing the third of said channel circuits in accordance with the length of the time space for that step, and means responsive to said distinct energization of the three channel circuits of each step for positioning said electro-responsive devices in any one of eight distinctive combinations.

4. In a remote control system, a stepping line circuit having a plurality of series of time spaced impulses impressed thereon, a step-by-step mechanism operable through a separate cycle for each of said series of impulses, means controlled by said mechanism for selecting three local channel circuits for each step, means for causing said mechanism to take one step for each time space between successive impulses of a series, a first return line and a second return line for said stepping line circuit, means for distinctively energizing two of said channel circuits for each step in accordance with the energized or deenergized condition of said return lines for that step, means for recording the length of each time space between impulses, means for storing the recorded length of a time space during the succeeding impulse, and means for distinctively energizing the third of said channel circuits in accordance with the stored length of said time space.

5. In a remote control system, a stepping line circuit having a plurality of series of time spaced impulses impressed thereon, a step-by-step mechanism operable through a separate cycle for each of said series of impulses, means controlled by said mechanism for selecting three local channel circuits for each step, means for causing said mechanism to take one step for each time space between successive impulses of a series, a first return line and a second return line for said stepping line circuit, means for distinctively energizing two of said channel circuits for each step in accordance with the sequential order of energization of said return lines for that step, means for recording the length of each time space between impulses, means for storing the recorded length of a time space during the succeeding impulse, and means for distinctively energizing the third of said channel circuits in accordance with the stored length of said time space.

6. In a remote control system, a stepping line circuit having a plurality of series of time spaced impulses impressed thereon, a step-by-step mechanism operable through a separate cycle for each of said series of impulses, means controlled by said mechanism for selecting three local channel circuits for each step, means for causing said mechanism to take one step for each time space between successive impulses of a series, a first return line and second return line for said stepping line circuit, means for distinctively energizing two of said channel circuits for each step in accordance with the sequential order of deenergization of said return lines for that step, means for recording the length of each time space between impulses, means for storing the recorded length of a time space during the succeeding im-

pulse, and means for distinctively energizing the third of said channel circuits in accordance with the stored length of said time space.

7. In a remote control system, a stepping line circuit having a plurality of series of time spaced impulses impressed thereon, a step-by-step mechanism operable through a separate cycle for each of said series of impulses, means controlled by said mechanism for selecting three local channel circuits for each step, means for causing said mechanism to take one step for each time space between successive impulses of a series, a first return line and a second return line for said stepping line circuit, means for distinctively energizing two of said channel circuits for each step in accordance with the sequential order of energization and deenergization of said return lines for that step, means for recording the length of each time space between impulses, means for storing the recorded length of a time space during the succeeding impulse, and means for distinctively energizing the third of said channel circuits in accordance with the stored length of said time space.

8. In a remote control system; a stepping line having a series of time spaced impulses impressed thereon; a plurality of return lines for said stepping line; means for selectively energizing said return lines in combination and in sequence for each impulse; means for selectively varying the length of each time space between impulses; step-by-step mechanism operated one step for each of said time spaces for preparing a plurality of channel circuits for each step; and means for energizing said channel circuits for each step in accordance with the return line or lines energized for that step, in accordance with the sequence of energization of the return lines for that step and in accordance with the length of the time space preceding that step.

9. In a remote control system; a stepping line having a series of time spaced impulses impressed thereon; a plurality of return lines for said stepping line; means for selectively energizing said return lines in combination and in sequence for each impulse; means for selectively varying the length of each time space between impulses; step-by-step mechanism operated one step for each of said time spaces for preparing a plurality of channel circuits for each step; and means for energizing said channel circuits for each step in accordance with the return line or lines energized for that step, in accordance with the sequence of deenergization of the return lines for that step and in accordance with the length of the time space preceding that step.

10. In a remote control system, a first line circuit and a second line circuit, means for energizing and deenergizing said line circuits in combinations and in sequential order, a selector mechanism controlled over said first line circuit, means controlled by said mechanism for selecting a plurality of channel circuits, a plurality of branches for a first one of said channel circuits, means for distinctively energizing a second one of said channel circuits in accordance with the energization or deenergization of said line circuits, and means for energizing said branches in accordance with the sequential order of energization and deenergization of said line circuits.

11. In a remote control system, a first line circuit and a second line circuit, means for energizing and deenergizing said line circuits in combinations and in sequential order, a selector mechanism controlled over said first line circuit, means controlled by said mechanism for selecting a plurality of channel circuits, a plurality of branches for a first one of said channel circuits, means for distinctively energizing a second one of said channel circuits in accordance with the energization or deenergization of said line circuits, means responsive to the distinctive energization of said second channel circuit for selecting said branches, and means for energizing said branches in accordance with the sequential order of energization and deenergization of said line circuits.

12. In a centralized traffic controlling system for railroads, a control office, a plurality of field stations, a stepping line connecting said office with said stations, a plurality of return lines connecting said office with said stations, means only in said office for closing and opening said stepping line to impress time spaced impulses thereon, transmitting means at each station for closing and opening said return lines for distinctively conditioning said return lines for each of said impulses, transmitting means at each station for maintaining said plurality of said return lines open after said office closes said stepping line for distinctively conditioning said stepping line and said return lines for each of said impulses, and lockout means at one of said stations for preventing the operation of the associated transmitting means.

13. In a centralized traffic controlling system of the selector type, the combination with a control office and a plurality of field stations, a single stepping line and a plurality of return lines connecting said office with said stations, means for energizing said stepping line with a plurality of impulses separated by normally short time spaces, selective mechanism at said office and at said stations operated during said time spaces in synchronism at said stations for selectively connecting said return lines to said stepping line for energizing said return lines in a plurality of combinations, means at said stations for opening said return lines to provide abnormally long time spaces, a relay in series with each of said lines in the control office, and means responsive to the combinations of selective energization of said return lines and the combinations of short and long time spaces in said stepping line for selectively operating said relays to register any one of said stations in said office during an operating cycle.

14. In a centralized traffic controlling system of the selector type, the combination with a control office and a plurality of field stations, a single stepping line and a plurality of return lines connecting said office with said stations, means for energizing said stepping line with a plurality of impulses separated by normally short time spaces, selective mechanism at said office and at said stations operated during said time spaces in synchronism at said stations for selectively connecting and disconnecting said return lines to said stepping line in sequential order for energizing said return lines in a plurality of combinations, means at said stations for opening said return lines to provide abnormally long time spaces, and means responsive to the combinations of selective energization of said return lines the sequential order of energization and deenergization of said return lines and the combinations of short and long time spaces in said stepping line for selectively operating said relays to register any one of said stations in said office during an operating cycle.

15. In a selective type communication system; a central office; a field station; a stepping line having in series therewith two return lines in

multiple connecting said office and said station; means at said office for applying to said stepping line a series of time spaced impulses; step-by-step means at said office and at said station caused to take one step during each time space in said series; means at said station effective on each step to form a code in accordance with the energization of only one, only the other or both of said return lines and in accordance with the order of energization when both are energized; and means at said office distinctively controlled at each step in accordance with said code.

16. In a selective type communication system; a central office; a field station; a stepping line having in series therewith two return lines in multiple connecting said office and said station; means at said office for applying to said stepping line a series of time spaced impulses; step-by-step means at said office and at said station caused to take one step during each time space in said series; means at said station effective on each step to cause only one, only the other or both of said return lines to be energized; means at said station effective on each step to cause said return lines to be sequentially energized in one order or the other when both are energized for that step and thereafter to cause one or the other of said return lines to be deenergized for the remainder of that step in accordance with a code; and means in said office distinctively responsive to the particular return line energized, the particular sequential order of energization of said return lines and the particular sequential order of deenergization of said return lines provided on that step.

17. In a selective type communicating system, a central office, a field station, a stepping line having in series therewith two return lines in multiple connecting said office and said station, an impulse relay at said office, means including said impulse relay for applying to said stepping line a series of time spaced impulses, step-by-step means at said station caused to take one step during each time space in said series, a first and a second stepping relay in said office, means for positioning said first stepping relay to alternate positions during consecutive time spaces, means for positioning said second stepping relay to alternate positions during consecutive impulse periods, means controlled by said stepping relays in combination for positioning said impulse relay to alternate positions during consecutive impulse periods and spaces, means at said station effective on each step to form a code in accordance with the sequential order of energization of said return lines, and means at said office selected by said first stepping relay and distinctively controlled in accordance with said code.

18. In a selective type communication system; a central office; a field station; a stepping line having in series therewith two return lines in multiple connecting said office and said station; means at said office for applying to said stepping line a series of time spaced impulses; step-by-step means at said office and at said station caused to take one step during each time space in said series; code forming means at said station effective on each step to form a code in accordance with the order of energization of said return lines, comprising a first bus permanently energized and second and third buses intermittently energized in a predetermined order; and means at said office distinctively controlled on each step in accordance with said code.

19. In a selective type communication system; a central office; a field station; a stepping line having in series therewith two return lines in multiple connecting said office and said station; means at said office for applying to said stepping line a series of time spaced impulses; step-by-step means at said office and at said station caused to take one step during each time space in said series; code forming means at said station effective on each step to form a code in accordance with the order of energization of said return lines, comprising a first bus permanently energized and second and third buses intermittently energized in a predetermined order; and decoding means at said office comprising a first relay responsive to the simultaneous energization of said return lines, a second relay responsive only when one of said return lines is energized in advance of the other of said return lines and a third relay responsive only when said one of said return lines is deenergized in advance of said other of said return lines.

20. In a centralized traffic controlling system for railroads, a control office, a plurality of field stations, a stepping line connecting said office with said stations, a plurality of return lines connecting said office with said stations, means only in said office for closing and opening said stepping line to impress time spaced impulses thereon, code forming means at each station for energizing said return lines with combinations of short and long impulses for each of said time spaced impulses and code forming means at each station for maintaining said plurality of return lines open after said office closes said stepping line for distinctively conditioning said stepping line and said return lines for each of said impulses to thereby form codes, and means responsive to said codes for registering any one of said stations in said office.

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