Jan. 25, 1944. A. B. MILLER 2,339,872

REMOTE CONTROL SYSTEM

Filed July 22, 1941 4 Sheets-Sheet 1

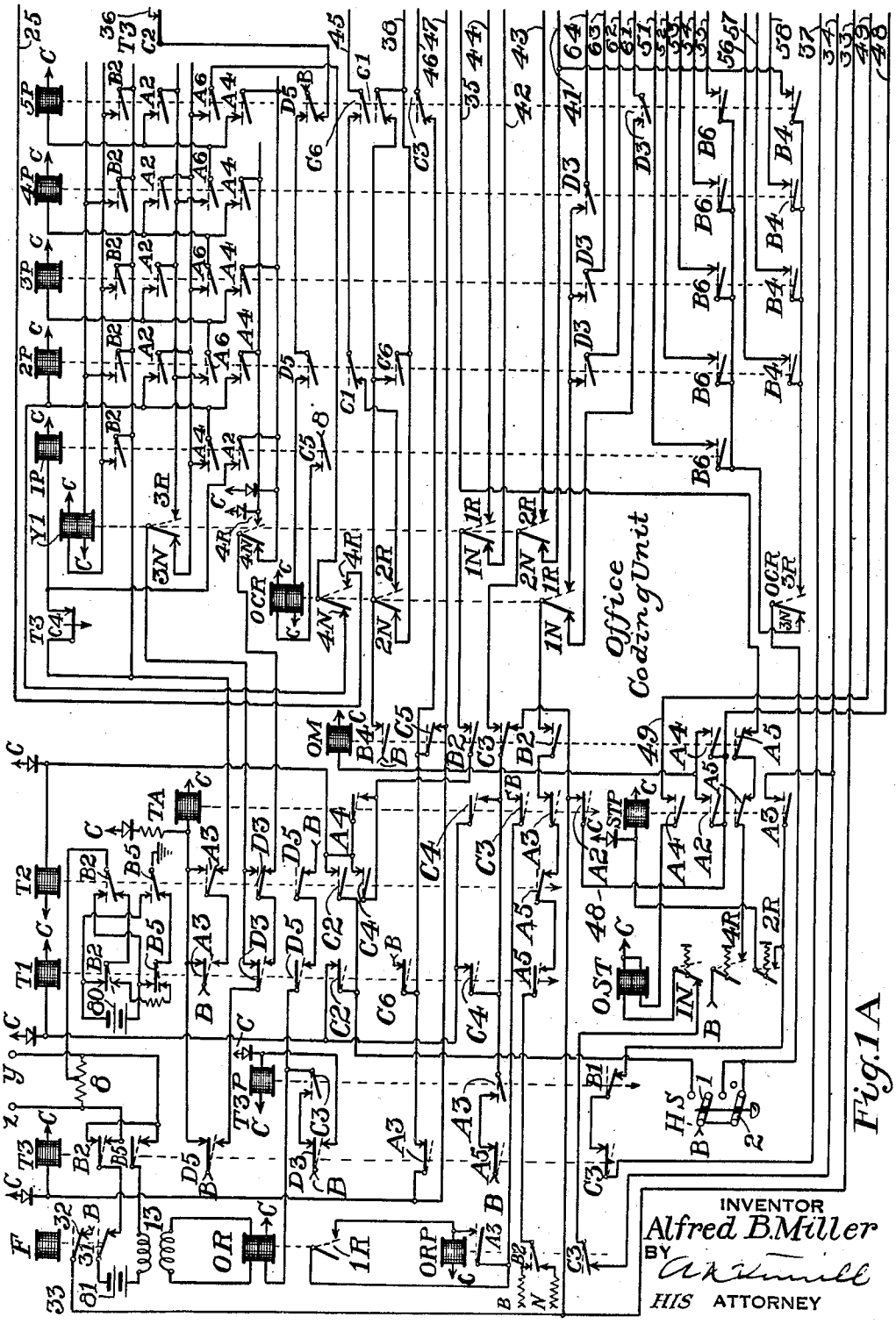

Fig. 1A

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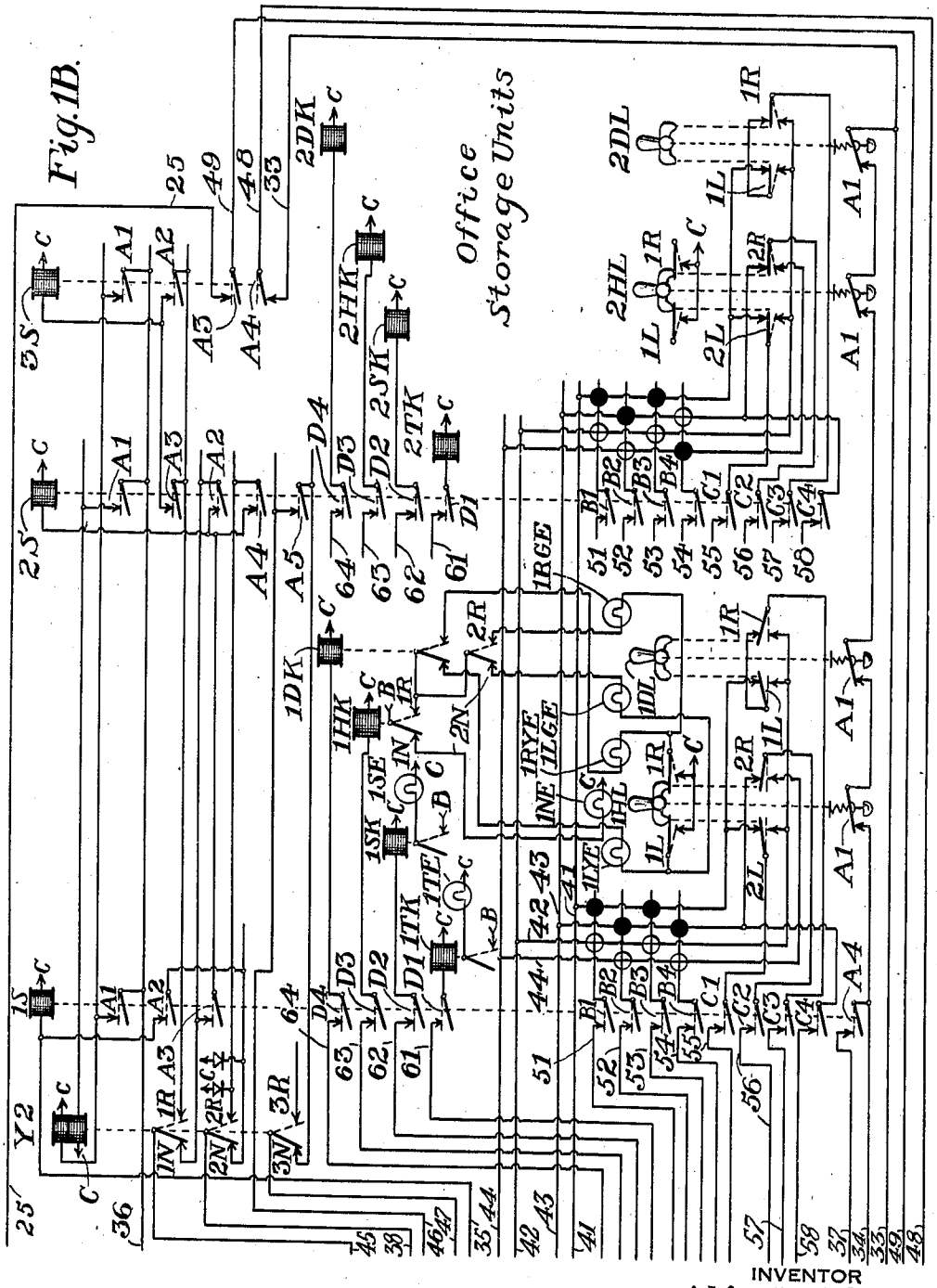
REMOTE CONTROL SYSTEM

Filed July 22, 1941 4 Sheets-Sheet 2



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Jan. 25, 1944. A. B. MILLER 2,339,872

REMOTE CONTROL SYSTEM

Filed July 22, 1941 4 Sheets-Sheet 3

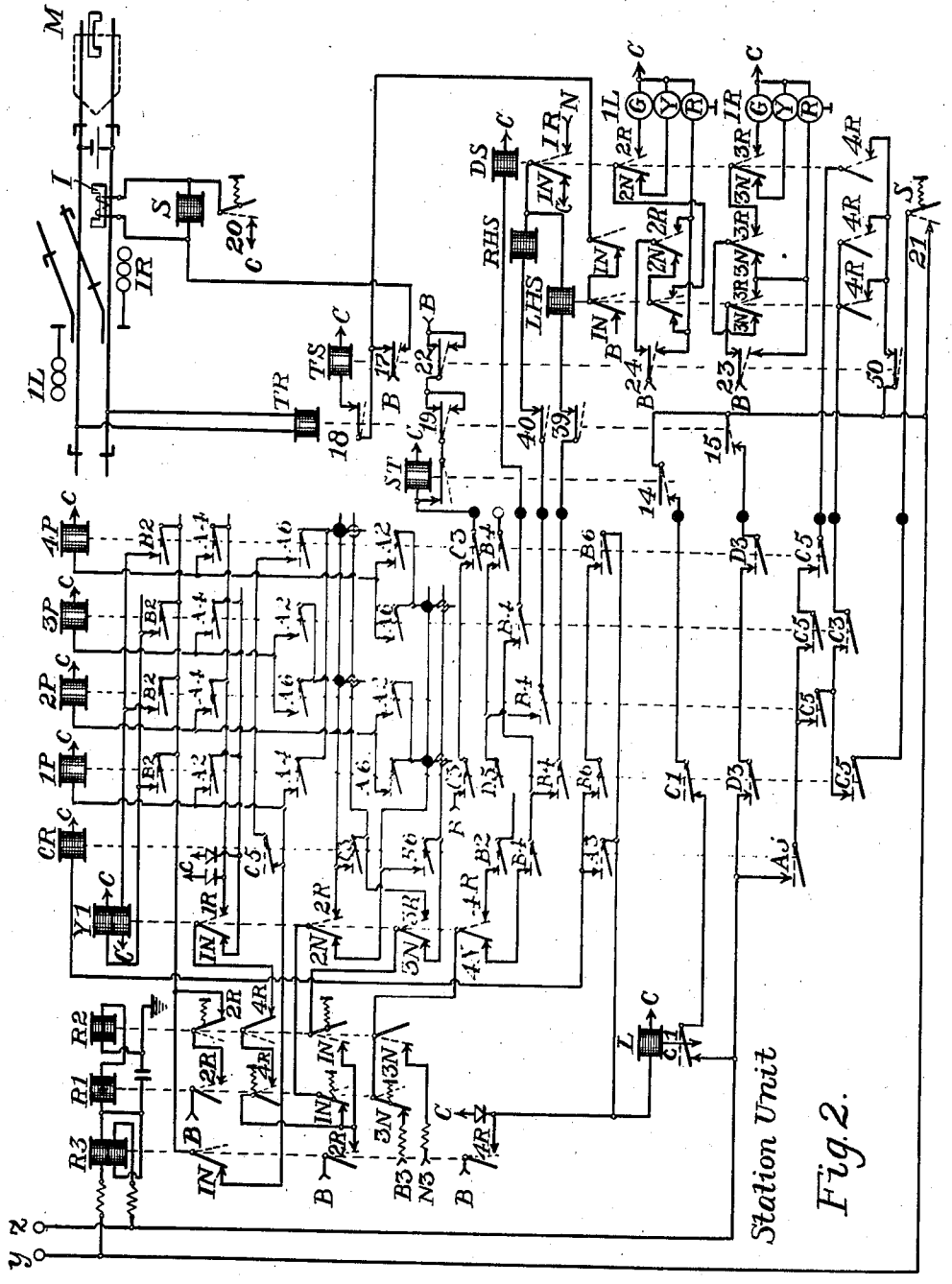

Fig. 2.

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REMOTE CONTROL SYSTEM

Filed July 22, 1941 4 Sheets-Sheet 4

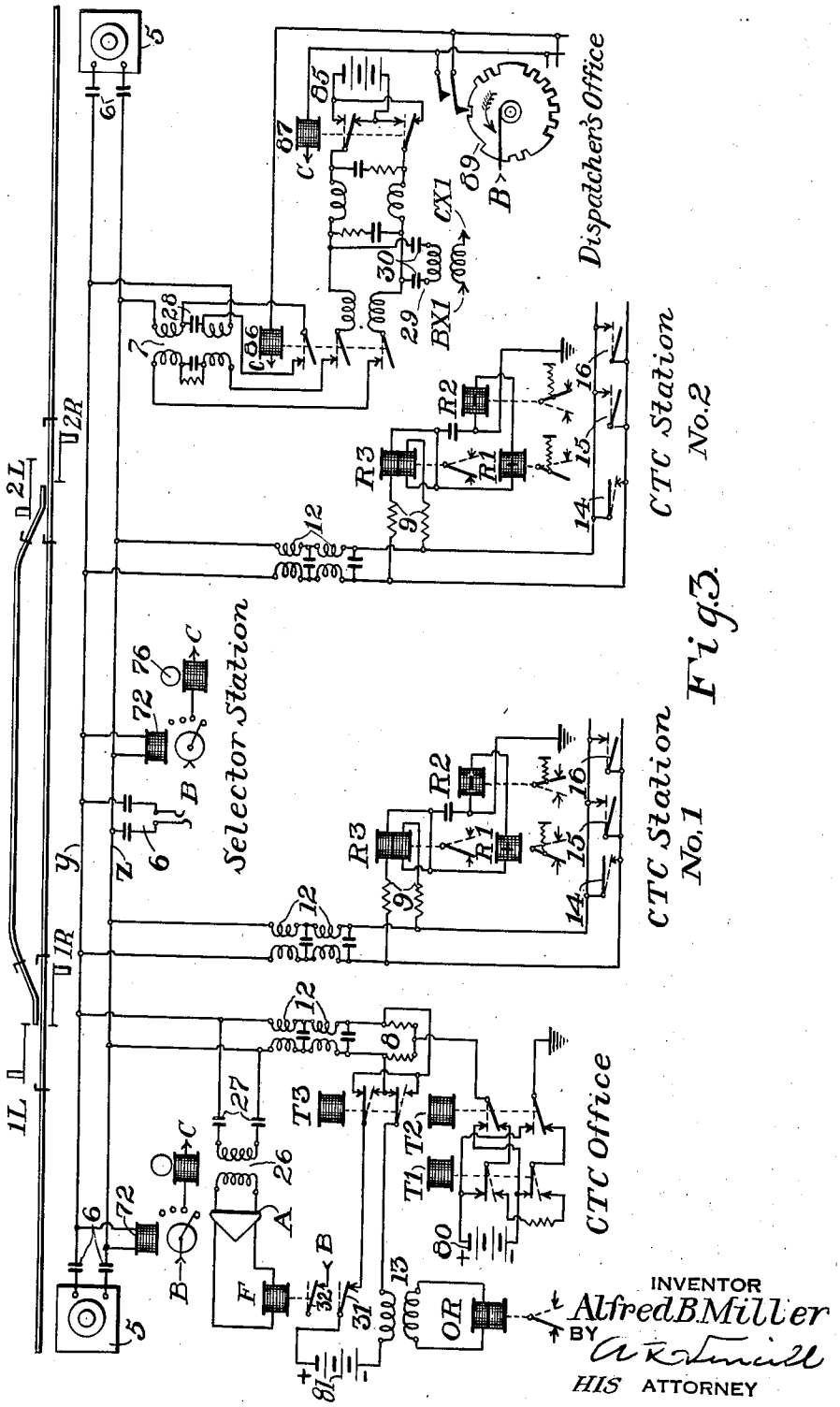

Fig.3.

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Patented Jan. 25, 1944 2,339,872

UNITED STATES PATENT OFFICE

2,339,872

REMOTE CONTROL SYSTEM

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Application July 22, 1941, Serial No. 403,494

9 Claims. (Cl. 177—353)

My invention relates to remote control systems, and more particularly to centralized traffic control systems for railroads of the type in which railway traffic controlling devices are governed from a central office and the condition of such devices is indicated at the office by means of impulse codes transmitted over line wires extending from the office through each station at which such devices are located.

One object of my invention is to provide a system of this character which is relatively low in cost, by the use of novel circuits requiring fewer relays than are usually required in systems of this character, and by arranging the apparatus so that only two line wires are required, which may be used jointly by other communication facilities, such as a dispatcher's telephone line equipped with a call selector system, without interference.

My invention is an improvement upon those disclosed in the Baughman and Agnew application, Serial No. 326,440, filed March 28, 1940, now Patent No. 2,303,875, issued December 1, 1942, for Remote control systems, and in the Snavely, Miller and Jackel application, Serial No. 366,874, filed November 23, 1940, now Patent No. 2,292,245, issued August 4, 1942, for Remote control systems.

I shall describe one form of apparatus embodying my invention by first explaining the functions of the various parts and by then tracing the circuits in detail, and shall then point out the novel features thereof in claims.

In the accompanying drawings, Figs. 1A, 1B, 2 and 3, inclusive, form a diagrammatic view illustrating in condensed form a centralized traffic control system comprising a specific embodiment of my invention, in which Figs. 1A and 1B comprise the central office equipment, Fig. 2 shows the apparatus at a typical field station, and Fig. 3 shows typical line circuits.

Similar reference characters refer to similar parts in each of the several views.

The system of my invention is of the coded duplex type employing two line channels, comprising a main stepping and control line channel and a subordinate message or indication line channel, but these are arranged in a manner analogous to the well-known "simplex" telegraph circuit that only two line wires are required. The stepping line channel employs the two line wires in parallel as one side of a grounded line circuit, while the message line channel is a metallic circuit employing the two line wires in series and is superimposed upon the telephone circuit by interposing a suitable low pass filter at each point of connection of the C. T. C. apparatus to the line wires, the telephone apparatus being connected to the line wires through condensers or high pass filters.

Referring to Fig. 3, the line wires employed by my system as shown herein are designated *y* and *z*, respectively, and provide a telephone channel extending from a set of telephone apparatus **5** located at the point designated "Dispatcher's office" to a similar set of apparatus **5** located at the opposite end of the line, as shown, or to one of a plurality of intermediate points such as the one designated "Selector station" on the drawings, a suitable high pass filter as indicated by the condenser **6** being interposed between each set of telephone apparatus and the line wires.

The dispatcher's office is also provided with a selector system for selectively calling the telephone stations, which is to be understood to be of the type shown in the Field Patent No. 1,343,256, granted June 15, 1920, having a plurality of code wheels such as the wheel **89**, by means of which the operator at the dispatcher's office may transmit impulse codes to selectively call the way stations to establish telephone communication therewith. The selector system includes the selectors **72** for operating call bells **76** at the station, and at the dispatcher's office includes a selector battery **85**, a connector relay **86** and a pole changer relay **87**. All of these devices are similar to the correspondingly designated devices of the Field patent and their detailed operation may be understood by reference to the patent, with one exception, which is that in Fig. 3 the battery **85** is not connected directly to the line by the operation of relay **86**, but a transformer **7** is interposed, an arrangement which is well-known and widely used.

It has been assumed that the dispatcher's office and the C. T. C. control office are at different locations, as shown. The stepping line channel of the C. T. C. system extends from a connection to ground at the C. T. C. office, over contacts of a pair of transmitter relays T1 and T2 through a line battery **80** to one terminal of each of two balancing resistors **8**, the remaining terminals of which are connected through a filter **12** across the line wires *y* and *z*. When relay T1 or T2 is picked up, positive or negative current, respectively, flows from battery **80** over line wires *y* and *z* in parallel and returns to ground and thence back to battery **80** over a plurality of multiple paths, including one at each station, each such path comprising a balanced

connection from line wires *y* and *z* through a filter 12, resistors 9, and the windings of the line relays R3, R1 and R2 to ground.

Relay R3 is of relatively high resistance as compared with the resistance of the line wires, and the stick polar type, such for example, as that shown in the Snavely Patent No. 2,140,604, granted December 20, 1938, and its armature normally occupies its left-hand position, as shown, but as relay R3 is connected across line wires *y* and *z* it is non-responsive to current from battery 80 in the stepping line channel since this flows in opposite directions in the two windings of relay R3. Relays R1 and R2 are also high resistance polar relays of the same general type, but these relays are biased as indicated conventionally by a spring, as shown, so that their armatures occupy the right-hand position when the relay is deenergized, or when energized by positive current flowing from right to left through the winding, as indicated by the position of relay R2, and the armatures assume the left-hand position only when positive current flows from left to right through the winding, as indicated by the position of relay R1. In other words, relay R1 responds only to positive current and relay R2 to negative current, as indicated conventionally by the signs + and — on these relays in the drawings.

The stepping line channel is used for the transmission of impulse codes from the C. T. C. office to the stations. To transmit a code, relays T1 and T2 are energized alternately or repeatedly one at a time to transmit impulse codes comprising a series of short impulses of selected polarity to operate the line relays R1 and R2 at each C. T. C. station. Each code includes a first group of impulses constituting a station code call for selecting the desired station, and a second group of impulses for operating movable devices at the selected station to one position or another according to the relative polarity of the impulses.

The message line channel is a metallic circuit which may be traced in Fig. 3 from the positive terminal of a line battery 81 over a back contact 31 of a line relay F, the contacts of a line pole-changer relay T3, the right-hand side of the associated filter 12 to line wire *y*, and thence through a plurality of paths, in multiple, to line wire *z*, each of which paths includes in series the windings of a line relay R3 and the associated resistors 9 and filter 12, the circuit being completed from line wire *z* through the left-hand side of the office filter 12 and the primary of a transformer 13 to the negative terminal of battery 81.

Relay T3 is normally picked up, and the relays R3 are normally energized by positive current in line wire *y* to hold their left-hand contacts closed as shown.

The relays R3 are used as cycle marking relays to mark the beginning and end of a series of impulses constituting a code, and are controlled over the message line channel by the transmission of a single long impulse of reverse polarity corresponding to the series of impulses transmitted over the stepping line and constituting a code. That is, relay T3 is released and consequently each relay R3 is reversed for the duration of each C. T. C. code, and the apparatus at each C. T. C. field station is conditioned to initiate its response to a code transmitted over the stepping line channel only when the associated line relay R3 is normal and to respond to the successive steps of the code only when relay R3 is reversed, and is restored to normal by that relay at the end of each code.

When the system is at rest, the message line channel is employed for the transmission of starting impulses from the C. T. C. stations to the C. T. C. office for initiating the operation of the system in response to a change in conditions at a station, and when the system is in operation, it is employed for transmitting indication impulses for indicating station conditions at the office. Such impulses are transmitted by temporarily connecting the line wires *y* and *z* together through a shunt circuit path as indicated diagrammatically by the contacts 14, 15 and 16 in Fig. 3. The closing of contact 14, for example, is without effect upon the telephone channel because filter 12 is interposed, and it is also without effect upon relay R3 because that relay is of the stick polar type and remains in its last operated position when deenergized. The current flowing through the shunting contact 14 results in an increase in the current drawn from battery 81 and flowing in the primary of transformer 13 at the office. Relay OR is a stick polar relay having a line winding connected to the secondary of transformer 13, and is arranged like the relay OR of the Baughman and Agnew application hereinbefore referred to, to operate its contacts to the right in response to each increase in the current supplied to transformer 13 as described. As hereinafter explained in detail, relay OR is restored locally after each operation; its response to the operation of a starting contact such as 14 is employed to initiate the transmission of codes over the stepping line channel, and the position of relay OR on certain steps of a code, which depends upon whether or not contacts such as 15 and 16 are closed at the time, is employed to indicate at the office, the position of these contacts.

In its specific embodiment as herein illustrated, the C. T. C. system of my invention is applied to the control of manual block signals for governing train movements in territory of relatively light traffic not equipped with continuous track circuits, such as that illustrated by the track diagram in Fig. 3, and also for reporting to the control office the movements of trains in such territory. My system is peculiarly suited to such an application because of its relatively low cost due to the comparatively small number of relays required at each field station.

Referring now to Fig. 2, the track diagram thereon represents a typical field location and shows a pair of opposing manual block signals 1L and 1R located in a short isolated detector track section having a track relay TR. The signals are illustrated as of the color light type, having lamps R, Y and G for indicating stop, permissive, and clear, respectively, and they are manually governed by signal control relays LHS, RHS and DS of the stick polar type. A track stick relay TS is also provided, having a pick-up circuit closed over contacts 1N of relays LHS and RHS when these relays occupy their normal or stop positions as shown, with relay TR energized. Relay TS also has a stick circuit including its own front contact 17 and the front contact 18 of relay TR, as shown. Each signal indicates stop either when its control relay LHS or RHS is normal or when relay TS is released, and indicates permissive or clear, according to the position of relay DS, when its control relay is reversed with relay TS picked up. The signals are restored automatically to stop when a train

enters the detector track section and remain at stop after it is vacated, and the subsequent clearing of either signal can be effected only if the operator first restores the previously operated signal control relay to normal to pick up relay TS.

The signal control relays are controlled by means of impulse codes transmitted from the office over the stepping line channel. In its specific embodiment as shown herein, the apparatus is arranged so that each code includes a group of four station selecting impulses which may be arranged in different combinations of positive and negative polarity to provide station code calls for sixteen stations like that of Fig. 2, and each code call is followed by four function impulses received at the selected station only. Three of the latter control the stick polar relays LHS, RHS and DS, respectively, according to their relative polarity, the fourth being available for any desired purpose such as for operating a maintainer's call signal.

Each code may also include the transmission of impulses over the message line channel for operating a group of four indication relays such as the relays ITK, ISK, IHK and IDK of Fig. 1B, for indicating the condition of four devices at the selected station. The shunting of the message line channel by contacts such as 15 and 16 to transmit these indications occurs during the 4th to 7th steps, respectively, of the code transmitted over the stepping line channel, and takes place only at the called station.

It is to be understood that suitable local sources of current are provided for energizing all of the relays shown herein except those controlled over the line. Each local source is indicated by reference characters B designating the positive or supply terminal and C the negative or common return terminal of the source. As to the polar relays, it is to be understood that each is operated to the left when terminal B is connected to its left-hand terminal. Certain of these have double windings, and are operated to the right when terminal B is connected to the right-hand terminal of a second winding. Those having single windings, such as relays IHK and ILHS, are operated to the right by connecting the negative terminal N of a second source of current to the left-hand terminal of its winding, terminal C constituting the positive terminal of this second source. Certain of the neutral relays are made slow release in a well-known manner by the provision of electronic rectifiers connected across their windings, as will be apparent from the drawings.

The station apparatus of Fig. 2 includes a starting relay ST, normally held energized over a stick circuit including contact 19 of relay TR and contact 22 of relay TS, which circuit opens to release relay ST in response to any change in the position of relay TR or TS. Relay ST upon releasing closes the contact 14 hereinbefore referred to in connection with Fig. 3, to transmit a starting impulse to the office, becoming reenergized upon receipt of the corresponding code call.

With the apparatus arranged as shown in Fig. 2, the first indication step, that is, the one transmitted on the fourth code step, is controlled by relay TR, the corresponding indication relay ITK at the office being reversed by the code if contact 15 is closed, and being restored locally to normal if contact 15 is open during this step, to thereby indicate at the office whether or not the detector track section is occupied.

The indication impulse transmitted on the fifth code step controls relay ISK at the office according to the position of relay S, to report whether or not a train which has just vacated the detector section is complete and intact, relay S being controlled by devices disclosed in the copending applications, Serial No. 396,731, filed June 5, 1941, by H. A. Wallace, and Serial No. 396,745, filed on the same day by G. W. Baughman, for Train detecting and reporting apparatus. For an understanding of the relation of these devices to the present invention, it will suffice to point out that each train moving over the controlled territory is required to be provided with a rear-end marker in addition to those required by the usual operating rules, comprising a magnet M, mounted at the rear of the train in such a position that it will come into inductive relation with a trackway inductor I as the rear of the train passes through the detector track section. Accordingly, if the train is complete and intact with magnet M in the proper position, an electromotive force is induced in inductor I to pick up a relay S which relay is of a sensitive biased polar type, relay S then being held energized over a stick circuit including its own contact 20 and back contact 17 of relay TS. Contact 21 of relay S provides a means (corresponding to contact 16 referred to in connection with Fig. 3) for indicating the condition of that relay on the assigned step of each code.

The operator at the office after receiving a report that a complete train has passed out of the track section at a station, may restore relay LHS or RHS to normal to pick up relay TS, whereupon relay S is released by the opening of back contact 17 of relay TS, and the starting relay ST is again released by the operation of contact 22 of relay TS to initiate a new cycle of operation to cancel the train report, contact 21 of relay S being open.

The indication transmitted on the sixth code step is controlled by contact 4R of relay LHS or RHS to indicate when one of these relays is reversed, while that transmitted on the seventh step is controlled by contact 4R of relay DS. Since these relays are operated at the beginning of the fifth, sixth and seventh steps, respectively, indications of their response to their respective control impulses are returned in the same code by which these relays are operated.

The remaining relays of Fig. 2 include a chain of four stepping relays 1P to 4P, a stick polar relay Y1, a "chain repeat" relay CR and a slow release relay L. The stepping relays are energized one at a time successively, and each is sufficiently slow in releasing so that it remains picked up until the next stepping relay is fully picked up. Relay 1P is operated over back contacts 2R of line relays R1 and R2 provided relay R3 is normal, when the stepping line channel is first opened to begin a code. Relays 2P, 3P, 4P and 1P are energized over front contacts 1N of relay R1 or R2 in response to the first four impulses of a code but only if these are arranged in accordance with the code call for the station, as determined by adjustable jumper connections, as shown in Fig. 2. Relay Y1 is a "half-step" relay operated to the left and to the right alternately over contacts B2 of the stepping relays during the intervals between impulses and provides stick circuit connections for the proper operation of these relays. Relay CR is a stick relay picked up at the beginning of the fourth step at

the selected station only, rendering relays 2P, 3P and 4P at that station responsive to the 5th to 7th impulses irrespective of their polarity, and also cooperates with the stepping relays to prepare the circuits for receiving controls and transmitting indications.

Relay L is a slow release relay required only when the line wires *y* and *z* are used for the transmission of selector codes. Such codes, comprising impulses of alternately opposite polarity, operate relay R3 which in turn energizes relays 1P and L alternately. The latter relays have back contacts C1 in the message line shunt including contact 14 of relay ST, and prevent the release of relay ST from causing interference with the response of the selectors 72 to their codes.

Referring now to Fig. 1B, I have assumed that there are but two stations to be controlled, and have illustrated but two office storage units, although it will be apparent that as many may be provided as there are available code calls. Each storage unit, as shown, includes a connector relay such as 1S, and a group of apparatus controlled thereby. The circuits over contacts B1 to B4, inclusive, of relay 1S include adjustable jumper connections and are for controlling the transmitter relays T1 and T2 of Fig. 1A to determine the station code call, and those over contacts C1 to C4 of relay 1S control relays T1 and T2 to determine the polarity of the function steps according to the positions of control levers such as 1HL and 1DL. Contacts D1 to D4 of relay 1S prepare circuits for the indication relays 1TK, etc., which are energized by current of normal or reverse polarity according to the position of a repeating relay ORP controlled by the message line relay OR.

It is to be understood that the contacts 2L and 2R of lever 1HL in its center or normal position as shown control the character of code elements for operating relays LHS and RHS of Fig. 2 to normal, and that LHS or RHS is reversed by the code element transmitted when the lever occupies its left-hand or right-hand position, respectively. Relays LHS and RHS in their normal position control the indication relay 1HK to normal to light lamp 1NE. Relay 1HK is operated to reverse when either relay LHS or RHS is reversed, but lamp 1LYE or 1RYE is lighted only when lever 1HL is in a corresponding left-hand or right-hand position with relay 1HK reversed and relay 1DK normal. Relay DS of Fig. 2 is controlled to normal with lever 1DL in its center position and is reversed with lever 1DL in either its left-hand or right-hand position, while relay 1DK repeats the position of DS, lighting lamp 1LGE or 1RGE, according to the position of lever 1HL when relays 1HK and 1DK are both reversed. The control levers are preferably of a type diclosed in an application Serial No. 381,062, filed February 28, 1941, by Snavely and Zetwo, for Circuit controllers, now Patent No. 2,289,736, granted July 14, 1942, and the movable element is not only rotatable to left or right to operate control contacts as described, but is also operable in an axial direction to serve as a push button for opening a starting contact A1. The push contacts A1 of the control levers are all connected in series in the stick circuit for a normally energized office starting relay OST, shown in Fig. 1A, and an operating cycle of the system is initiated by opening this circuit in response to the operation of any control lever. This circuit also includes a back contact C3 of relay ORP controlled by the line relay OR, whereby the system is initiated by the operation of relay OR in response to the release of the starting relay ST at any station.

The system as shown is so arranged that in response to each initiation it operates through a cycle which includes the transmission of a complete code as above described to each station in turn, including the transmission of indications from each station during the transmission of the corresponding code. That is, whenever relay OST is released, provided the system is not already in operation, the connector relay 1S becomes energized, so that the first code transmitted will be the one for station No. 1. Relay OST energizes a storing relay STP, which energizes a master relay OM, releasing relay T3 to reverse the polarity of the current supplied to the message line, and placing the stepping line transmitters T1 and T2 under the control of relay 1S. An auxiliary relay TA controlled by relays T1 and T2 causes these relays to operate repeatedly at the proper rate to transmit the code.

The office apparatus, as shown in Fig. 1A, also includes a chain of stepping relays 1P to 5P, and stick polar relays Y1 and OCR which function in a manner corresponding generally to that of the similarly designated relays of Fig. 2 already described.

The office stepping relays 1P to 5P are controlled directly by the transmitter relays T1 and T2, relay 1P operating when the stepping line is first opened and relays 2P to 5P responding successively as relays T1 and T2 pick up to transmit steps 1 to 4 of the code, constituting the station code call, in unison with the relays 2P, 3P, 4P and 1P at station No. 1, under the control of relay Y1. Then the office relays 2P, 3P and 4P operate on steps 5, 6 and 7 of the code in unison with the corresponding station relays, relay OCR being reversed at the beginning of the fifth step, and finally, relay 5P is operated by relay T1 on the eighth step. The relays 1S, 2S, etc., form a chain of relays similar to the relays 1P, 2P, etc., but controlled by a stick relay Y2 so that they are operated one at a time in order, one for each code. That is, the operation of relay 5P on step 8 causes relay 2S to pick up and relay 1S to release. Relay 5P then causes the energization of relay 1T to initiate a 9th step, reenergizing relay T3 and releasing relay T3P to restore the transmitting and receiving apparatus to normal. Relay OST, however, remains released, and relays STP, OM and 2S remain picked up; a new code is therefore initiated in response to the release of relay T3P, comprising eight steps of which the character is controlled by circuits over contacts of relay 2S and which therefore governs the apparatus at station No. 2. On the last step of this code, that is, on the 17th step of the cycle, assuming there are but two stations, the final relay 3S of the connector relay chain is operated, relay OST is reenergized and relays STP and OM released and all apparatus is restored to normal to complete the cycle.

The office apparatus also includes a relay F which remains deenergized in normal operation but which is provided for the purpose of preventing interference between the C. T. C. and selector systems.

Relay F is controlled as indicated in Fig. 3 by apparatus similar to that shown in a copending application, Serial No. 401,092, filed July 5, 1941, by G. W. Baughman and N. F. Agnew, for Remote-control systems. As will be apparent from Fig. 3, relay F is connected through an amplifier

A and a transformer 26 having its primary connected through condensers 27 across the line wires Y and Z.

Whenever the operator at the dispatcher's office releases a code wheel such as 89, the connector relay 86 is energized to connect battery 85 to the primary of transformer 9 and to short circuit the condenser 28 in the secondary circuit of transformer 9, for the duration of a code delivered by the pole-changer relay 87 according to the arrangement of the code wheel teeth. As long as relay 86 is energized, alternating current supplied from terminals BX and CX of a suitable source to the primary of transformer 29 is delivered through a tuned circuit comprising its secondary and the condensers 30 over the lower contacts of relay 86 through transformer 9 to line wires *y* and *z*, and thus to the primary of transformer 26, which is tuned to the frequency of this current by condensers 27, with the result that relay F repeats the position of relay 86 and is picked up for the duration of each selector code. It has been found in practice that satisfactory operation of this arrangement may be secured by connecting terminals BX and CX to a 60 cycle source, the line current required for operation of relay F being of low value and practically inaudible in the telephones 5, and the selectors 72 are wholly non-responsive to the current from transformer 29.

It will be seen that when relay F is picked up its back contact 31 disconnects battery 81 from line wires *y* and *z* and thereby prevents interference with the operation of the selectors 72. Contact 32 of relay F also opens, disconnecting terminal B of the local source of current from the stick circuits for relays OST and STP. If a C. T. C. code is being transmitted and relay STP is picked up at the time, it will be released, deenergizing the circuits for the relays 1S, 2S, etc., to stop further transmission. In any case the release of relay OST causes the initiation of an operating cycle of the C. T. C. system following each selector code. It will be seen that the selector system is operable at all times regardless of the condition of the C. T. C. system, without interference, and result of the operation of a code wheel being to cause the operation of both systems.

Having thus explained the mode of operation of my apparatus, I shall now trace the circuits in detail, starting with the apparatus in its normal condition and assuming that levers 1HL and 1DL are operated to the right to change the indication of signal 1R from "stop" to "clear."

Normally relays T1, TA, T3 and OST at the office, Fig. 1A, are energized, and likewise relays R1, R3 and ST of Fig. 2 at each station. Relay T1 is energized over its stick circuit extending from terminal B at back contact 32 of relay F, back contact C3 of relay OM, front contact C4 and winding of relay T1 to terminal C. Relay TA is energized over a circuit having a multiple connection to terminal B at front contacts A3 and D5 of relays T1 and T3. Relay T3 is picked up over a circuit from terminal B, contact C6 of relay T1, back contact C5 of relay OM, relay T3 to terminal C and is held energized over a stick circuit including its own contact A3. Relay OST is energized over a stick circuit from terminal B over contact 32 of relay F, wire 33, contacts A1 of all the contact levers of Fig. 1B, in series, wire 34, contact C3 of relay ORP, contact 1N and the upper winding of relay OST to terminal C.

When the operator opens one of the lever contacts A1, relay OST releases, completing a pick-up circuit for relay 1S from terminal B at contact 4R of relay OST, contacts A5 of relays STP and OM, wire 35, relay 1S to terminal C. Relay 1S picks up and completes a circuit for relay Y2 from terminal B at back contact D5 of relay 5P, contact C2 of relay T3, wire 36, contact A1 of relay 1S and the upper winding of relay Y2 to terminal C, operating relay Y2 to the left.

When the operator completes the movement of levers 1HL and 1DL to the right and releases these levers, terminal B at contact 32 of relay F becomes connected over wires 33 and 34 to contact A4 of relay 1S and thence to wire 37 to complete a pick-up circuit for relay STP over contact C3 of relay T3, contact B1 of relay T3P, contact 2R of relay OST, relay STP to terminal C. Relay STP picks up, its contact A3 completing its stick circuit extending to terminal B over wires 34 and 33, and its contact A2 completing a pick-up circuit for relay OM from terminal B at wire 33 over contacts A2 of relays TA and A4 of relay 3S (Fig. 1B) in multiple, to wire 48, thence over contact A2 of relay STP through relay OM to terminal C.

Relay OM picks up and completes its stick circuit to wire 48 over its contact A4 and also completes a stick circuit for relay 1S from terminal B at contact B4 of relay OM, contacts C1 of relay 5P, C6 of relay 2P and 2N of relay OCR in multiple to wire 38, thence over contact 2N of relay Y2, contact A2 and winding of relay 1S to terminal C.

Relay T1 is released by the opening of back contact C3 of relay OM, and opens the stepping line circuit at its contacts B2 and B5, releasing relay R1 at each station, and circuits are closed over back contacts D5 of relays T1 and T2 to maintain relay OR normal, and over back contacts A3 of relays T1 and T2 and front contact C4 of relay T3 to pick up the office relay 1P which then completes a circuit at its contact C5 to operate relay OCR to the left.

The release of relay R1 at each station completes a pick-up circuit for the associated relay 1P over contacts 2R of relays R1 and R2 and contact 1N of relay R3, so that the relays 1P pick up at the office and at each station substantially in unison. Each relay 1P at its contact B2 completes a circuit for operating the associated relay Y1 to the left.

The circuit for relay T3 is opened at contact C6 of relay T1 and after a short period relay T3 releases. Its contacts B2 and B5 reverse the polarity supplied to the message line, thereby reversing relay R3 at each station and each relay R3 energizes the associated slow release relay L. The pick-up circuits for all 1P relays are now open, but the office relay 1P is held energized over a stick circuit from terminal B at back contact D5 of relay T3 over back contacts D3 of relays T1 and T2, contact 4N of relay Y1, contact A2 and winding of relay 1P to terminal C, while relay 1P at each station is held energized over a stick circuit from terminal B at contact 2R of relay R3, contacts 4R of relays R1 and R2, contact 1N of relay Y1, contact A2 and winding of relay 1P to terminal C. Relay T3 at its back contact A5 completes a circuit to pick up relay T3P, which relay remains picked up for the duration of the code, and at its contact C2 opens the circuit over wire 36 for relay Y2, but relay Y2 being of the stick polar type

remains to the left to maintain the stick circuit for relay 1S closed. Relay T3 at its front contact D5 opens the circuit for relay TA which releases after a brief period.

First step

Either relay T1 or T2 may be energized to make the first impulse positive or negative according to the code call desired, by connecting contact B1 of relay 1S either to wire 41, as shown, or to wire 42. A similar connection over contact B3 of relay 1S controls the character of the third step, while the second and fourth steps are made positive by connecting contacts B2 and B4 of relay 1S to wire 43, and made negative by connecting these contacts to wire 44. With the jumper connections as shown, the code call for station No. 1 comprises four positive impulses while that for station No. 2 comprises three positive impulses and one negative impulse.

When relay TA releases to begin the first step, it completes at its contact C4 a pick-up circuit for relay T1 extending from terminal B at contact 2 of a hand stepping switch HS, contact 3N of relay OCR, contact B6 of relay 1P, wire 51, contact B1 of relay 1S, wire 41, contact 2N of relay Y1, front contact C3 of relay OM, back contact C4 of relay TA, relay T1 to terminal C. Relay T1 picks up, applying positive current to the stepping line channel to pick up relay R1 at each station. Relay T1 reenergizes relay TA but remains picked up over a stick circuit comprising a branch of the circuit just traced which includes its own front contact C4, and energizes the office relay 2P over a circuit from terminal B at back contact D5 of relay T3, front contact D3 of relay T1, contact 3N of relay Y1, contact A4 of relay 1P, relay 2P to terminal C, and relay 2P at its contact A2 completes a stick circuit over contact 3N of relay Y1. Relay Y1 is deenergized by the opening of back contact A3 of relay T1 but remains in its last operated or left-hand position.

At each station the energization of relay R1 deenergizes Y1 which remains in its left-hand position, and if the station is arranged to receive a first positive impulse, relay R1 completes a circuit for the station stepping relay 2P from terminal B at contact 2R of relay R3, contact 1N of relay R1, contact 2N of relay Y1, contact A6 of relay 1P, relay 2P to terminal C, and each station relay 2P having the proper jumper connection picks up to complete its stick circuit at its contact A2. Each station relay 1P is deenergized by the opening of contact 4R of relay R1 and releases after a short period.

The office relay 1P is similarly released by the opening of back contact D3 of relay T1, opening the circuit for relay OCR, which however remains in its left-hand position. Relay 1P also opens the circuit for relay T1 at its contact B6. Relay T1 then releases, opening the stepping line to release the relays R1, and closing a circuit from terminal B at its back contact A3 over contact B2 of relay 2P to operate relay Y1 to the right, while at each station at which relay 2P is picked up, relay Y1 is operated to the right by relay R1 over a similar circuit extending to terminal B at contact 2R of relay R1. The release of relays T1 and R1 opens the stick circuits for the relays 2P extending over their own contacts A2 and the left-hand contacts of Y1, but as soon as the relays Y1 reverse, new stick circuits for the relays 2P are completed over their contacts A4 and the right-hand contacts of relays Y1. The relays Y1 also prepare pick-up circuits for relays 3P by closing their right-hand contacts.

Relay T1 upon releasing deenergizes relay TA which also releases after a short period and terminates the interval following the first step by completing a new pick-up circuit for relay T1 or T2.

Second step

Relay T1 picks up over a circuit from terminal B at switch HS over contact 3N of relay OCR, contact B6 of relay 2P, wire 52, contact B2 of relay 1S, wire 43, contact 2R of relay Y1, front contact C3 of relay OM, back contact C4 of relay TA, relay T1 to terminal C, and completes its stick circuit at its own contact C4. Relay T1 reenergizes relay TA, applies positive current to the stepping line channel, energizing relay R1 at each station, and also picks up the office stepping relay 3P over a circuit including contact 3R of relay Y1 and contact A6 of relay 2P, and relay 3P completes its stick circuit at its contact A2. At each station for which the first two impulses of the code call are positive, relay 3P is picked up by relay R1 over a similar circuit, and completes a stick circuit at its contact A2. The relays 2P are deenergized due to the opening of the stick circuits including their contact A4, by relays T1 and R1, respectively, and release after a short period, the office relay 2P opening the circuit for relay T1 which releases to terminate the impulse thereby releasing the line relays R1. Each relay Y1 is then operated to the left over contact B2 of relay 3P, and a new stick circuit for each energized relay 3P is completed over its contact A4 and a left-hand contact of relay Y1.

Relay T1 upon releasing deenergizes relay TA, which also releases after a short period and terminates the interval following the second step, thereby completing a new pick-up circuit for relay T1 or T2.

Third step

Relay T1 picks up over a circuit extending from terminal B at switch HS over contact 3N of relay OCR, contact B6 of relay 3P, wire 53, contact B3 of relay S1, wire 41 and thence as for the first step, through relay T1 to terminal C. Relay T1 reenergizes relay TA, applies positive current to the stepping line channel, energizing relay R1 at each station, and also picks up the office stepping relay 4P over a circuit including contact A6 of relay 3P and relay 4P completes a stick circuit at its contact A2. At each station for which the first three impulses of the code call are positive, relay 4P is picked up by relay R1 over a similar circuit and completes a stick circuit at its contact A2. The relays 3P are deenergized and release after a short period, the office relay 3P opening the circuit for relay T1 which releases to terminate the impulse thereby releasing the line relays R1. Each energized relay 4P prepares a circuit for the associated relay Y1, over its contact B2, so that these relays Y1 are now operated to the right, and a new stick circuit for each energized relay 4P is completed over its contact A4 and a right-hand contact of relay Y1.

Relay T1 upon releasing deenergizes relay TA which releases and terminates the interval following the third step by completing a new pick-up circuit for relay T1 or T2.

Fourth step

Relay T1 picks up over a circuit extending from terminal B at switch HS over contact 3N of relay OCR, contact B6 of relay 4P, wire 54, contact B4

of relay 1S, wire 43 and thence as for the second step through relay T1 to terminal C. Relay T1 reenergizes relay TA, applies positive current to the stepping line channel, energizing relay R1 at each station, and also picks up the office stepping relay 5P over a circuit including contact A6 of relay 4P, and relay 5P completes a stick circuit at its contact A2. At station No. 1 only, since this is the only station arranged to receive a code call of four positive impulses, relay 1P is picked up by relay R1 over a circuit including contact 2R of relay Y1, contact A6 of relay 4P and back contact C5 of relay CR, relay 1P completing its stick circuit at its own contact A4.

The relays 4P are now deenergized and release after a short period, but before the station relay 4P releases, that is, while relays 4P and 1P are both picked up, a pick-up circuit for relay CR is closed momentarily from terminal B at contact 4R of relay R3, contacts B6 of relays 4P and 1P, relay CR to terminal C. Relay CR picks up completing its stick circuit at its own contact A3.

At the same time, a circuit path is prepared for shunting the message line at station No. 1 to transmit the first indication impulse in case relay TR is released. This shunt path may be traced in Fig. 2 from line wire *y* over contact 15 of relay TR, contacts D3 of relays 4P and 1P to line wire *z*. A circuit is closed at this time over contacts C3 of relays 4P and 1P to pick up the station starting relay ST if this relay has been released.

The front contacts B6 and C3 of relay CR now short circuit the jumper connections in the pick-up circuits for the station stepping relays at station No. 1, thereby conditioning these relays to respond to the remaining impulses of the code regardless of their polarity.

The office relay 4P upon releasing opens the circuit for relay T1, which releases to terminate the impulse thereby releasing the line relays R1.

At the office, relay Y1 is operated to the left over contact B2 of relay 5P, completing a new stick circuit for relay 5P at its own contact A4.

At station No. 1, relay Y1 is operated to the left over contact B2 of relay 1P completing a new stick circuit for relay 1P at its own contact A2.

Each time relay T1 or T2 releases during the code, relay OR is operated to the left over its local circuit including contacts D5 of relays T1 and T2, consequently relay ORP is now deenergized.

Relay T1 upon releasing deenergizes relay TA but before relay TA releases to terminate the interval following the fourth impulse a circuit is closed momentarily to operate the indication relay 1TK. This circuit extends from terminal B at back contact B2 of relay ORP, contacts A5 of relays T1 and T2, contact A3 of relay TA, contact B2 of relay OM, contact 1N of relay OCR, contact D3 of relay 5P, wire 61, contact D1 of relay 1S, relay 1TK to terminal C, energizing relay 1TK in the normal direction as shown.

Relay TA upon releasing completes a new pick-up circuit for relay T1 or T2.

Fifth step

The character of this step is determined by the position of contact 2L of lever 1HL, this contact being in its upper position when lever 1HL is in its right-hand position, as assumed. Relay T1 picks up over a circuit including contact B6 of relay 5P, wire 55, contact C1 of relay 1S, contact 2L of lever 1HL and wire 41. Relay T1 reenergizes relay TA, applies positive current to the stepping line channel, energizing relay R1 at each station, and also picks up the office stepping relay 2P over a circuit including contact A6 of relay 5P, and contact 4N of relay OCR, relay 2P completing its stick circuit at its own contact A2.

At station No. 1, relay 2P picks up over a circuit which is the same as for the first step, and at the same time relay LHS is energized momentarily in the normal direction over a circuit from terminal B at contact 3N of relay R1, contact 4N of relay Y1, contacts B4 of relays CR and 1P, contact 39 of relay TR, relay LHS, contact 1N of relay DS to terminal C.

The office relay 5P and the station relay 1P are now deenergized and release after a short period, relay 1P opening the circuit for relay LHS just traced, but while the office relays 5P and 2P are both picked up a circuit is closed momentarily from terminal B over contact D5 of these relays to operate relay OCR to the right.

At the same time, that is while relays 1P and 2P are both picked up at station No. 1, a shunt circuit path is prepared for transmitting the second indication impulse in case relay S is released, which extends from line wire *y* over contact 21 of relay S, contacts C5 of relays 1P and 2P, contact A5 of relay CR to line wire *z*.

The reversal of relay OCR opens its contact 3N in the circuit for relay T1, and relay T1 releases to terminate the impulse thereby releasing the line relays R1, relays Y1 being operated to the right at the office and at station No. 1 as on the first step to complete new stick circuits for relays 2P.

Relay T1 upon releasing deenergizes relay TA, but before relay TA releases to terminate the interval following the fifth impulse, relay ORP being deenergized, a circuit is closed momentarily to operate the indication relay 1SK. This circuit extends from terminal B at back contact B2 of relay ORP over a path already traced to contact 1R of relay OCR, thence over contact D3 of relay 2P, wire 62, contact D2 of relay 1S, relay 1SK to terminal C, energizing relay 1SK in the normal direction as shown.

Relay TA upon releasing completes a new pick-up circuit for relay T1 or T2.

Sixth step

Since lever 1HL is in its right-hand position, its lower contact 2R is closed and relay T2 picks up over a circuit from terminal B at contact 2 of switch HS, contact 3R of relay OCR, contact B4 of relay 2P, wire 56, contact C2 of relay 1S, contact 2R of lever 1HL, wire 44, contact 1R of relay Y1, contact B2 of relay OM, contact A4 of relay TA, relay T2 to terminal C. Relay T2 completes its stick circuit at its own contact C4, reenergizes relay TA by closing its contact A3, applies negative current to the stepping line channel to energize relay R2 at each station and also picks up the office stepping relay 3P by closing its front contact D3.

At station No. 1, relay 3P is picked up over a circuit from terminal B at contact 2R of relay R3, contact 1N of relay R2, contact 3R of relay Y1, contact C3 of relay CR, contact A6 of relay 2P, relay 3P to terminal C, and relay 3P completes its stick circuit over its own contact A2. At the same time, relay RHS is operated to the right over a circuit closed momentarily from terminal C at contact 1N of relay DS through relay RHS, contact 40 of relay TR, contact B4 of relay 2P, back contact D5 of relay 1P, contact B2 of relay CR, contact 4R of relay Y1, and contact 3N

of relay R2 to the negative terminal N of the second local source hereinbefore referred to.

Relays 2P are now deenergized due to the opening of their stick circuits by relays T2 and R2 and release after a short period, the station relay 2P opening the circuit for relay RHS just traced. Relay RHS being quick acting operates to the right slightly before relay 3P is fully picked up, and during the period when relays 2P and 3P are both picked up the message line channel is shunted by the closing of the circuit path extending from line wire *y*, contact 50 of relay TS, contact 4R of relay RHS, contact C3 of relay 3P, contact C5 of relay 2P, contact A5 of relay CR to line wire *z*.

At the office, relay OR is operated to close its contact 1R by an impulse delivered by transformer 13 corresponding to the increment in the current from battery 81 which flows through the shunt path at station No. 1. Relay ORP therefore picks up over the circuit extending to terminal B at contact C3 of relay TA and is held energized over the stick circuit including its own contact A3.

The release of the office relay 2P opens the circuit for relay T2, which releases to terminate the sixth impulse, releasing the line relays R2. Relays Y1 are operated to the left in response to the closing of back contact A3 of relay T2 and contact 2R of relay R2, and relays 3P complete new stick circuits at their contacts A4.

Relay T2 upon releasing deenergizes relay TA but before relay TA releases to terminate the interval following the sixth impulse, a circuit is closed momentarily to operate the indication relay 1HK. This circuit extends from terminal C through relay 1HK, contact D3 of relay 1S, wire 63, contact D3 of relay 3P, contact 1R of relay OCR and thence over contact B2 of relay OM, contact A3 of relay TA, contacts A5 of relays T2 and T1 to terminal N at front contact B2 of relay ORP.

Relay 1HK is thus operated to the right, and at the same time relay OR is restored to the left by the closing of back contact D5 of relay T2.

Relay TA upon releasing completes a new pick-up circuit for relay T1 or T2 and by opening its contact C3 releases relay ORP.

Seventh step

Since lever 1DL is in its right-hand position relay T2 picks up over a circuit from terminal B over contact B4 of relay 3P, wire 57, contact C3 of relay 1S, lower contact 1R of lever 1DL, wire 42 and contact 1N of relay Y1. Relay T2 reenergizes relay TA, applies negative current to the stepping line channel to energize relay R2 at each station and also picks up the office relay 4P by closing its front contact D3.

At station No. 1, relay 4P is picked up over a circuit including contact 1N of relay R2, contact 3N of relay Y1, contact B6 of relay CR and contact A6 of relay 3P, and completes the usual stick circuit and at the same time relay DS is operated to the right over a circuit closed momentarily from terminal C through relay DS, contacts B4 of relays 3P and CR, contact 4N of relay Y1, contact 3N of relay R2 to terminal N.

Relay 3P are now deenergized and release after a short period, the station relay 3P opening the circuit for relay DS just traced. Relay DS being quick acting operates to the right slightly before relay 4P is fully picked up, and during the period when relays 3P and 4P are both picked up the message line channel is shunted by the closing of the circuit path extending from line wire *y*, contact 50 of relay TS, contact 4R of relay DS, contacts C5 of relays 4P and 3P and contact A5 of relay CR to line wire *z*.

At the office, relay OR which was restored to its left-hand position during the preceding interval, is now operated to the right and relay ORP picks up, as on the sixth step.

The release of the office relay 3P opens the circuit for relay T2, which releases to terminate the seventh impulse, releasing the line relays R2. Relays Y1 are operated to the right to complete new stick circuits for relays 4P in response to the closing of back contact A3 of relay T2 and contact 2R of relay R2.

Relay T2 upon releasing deenergizes relay TA but before relay TA releases to terminate the interval following the seventh impulse a circuit is closed momentarily to operate the indication relay 1DK. This circuit extends from terminal C through relay 1DK, contact D4 of relay 1S, wire 64, contact D3 of relay 3P, and thence to terminal N at front contact B2 of relay ORP.

Relay 1DK is thus operated to the right, completing a circuit for lighting lamp 1RGE which extends from terminal B at contact 1R of relay 1HK over contact 2R of relay 1DK through lamp 1RGE to terminal C at the lower contact 1R of lever 1HL.

At station No. 1, lamp G of signal 1R is lighted to cause signal 1R to display a clear indication, over the circuit from terminal B at front contact 23 of relay TS, contact 3N of relay LHS, contacts 3R of relays RHS and DS, lamp G to terminal C, while the opposing signal 1L is caused to display a stop indication because its lamp L is lighted over a circuit including front contact 24 of relay TS and contact 2R of relay RHS.

As in the case of the preceding steps, step 7 is completed when relay TA releases to prepare a new pick-up circuit for relay T1 or T2, and to release relay ORP.

Eighth step

Relay T1 picks up over a circuit from terminal B, contact 2 of switch HS, contact 3R of relay OCR, contact B4 of relay 4P, wire 58, contact C4 of relay 1S to wire 43, thence over contact 2R of relay Y1, contact C3 of relay OM, contact C4 of relay TA, relay T1 to terminal C. Relay T1 reenergizes relay TA, applies positive current to the stepping line channel to energize relay R1 at each station and also deenergizes the office relay 4P and picks up the office relay 5P as on the fourth step.

At station No. 1, relay R1 opens the stick circuit for relay 4P, but the pick-up circuit for relay 1P over contact A6 of relay 4P is now open at back contact C5 of relay CR and relay 1P is not operated. A control circuit is now prepared momentarily over contact 3N of relay R1 and contact B4 of relay 4P, but this is not used in the present instance. Relay 4P releases after a short period, terminating the effective operations at station No. 1, while at the other stations the operations were terminated on one or another of the steps of the station code call.

When the office relay 5P picks up on this step it closes a pick-up circuit for relay 2S from terminal B at contact B4 of relay OM, contact 2R of relay OCR, back contact C1 of relay 2P, contact C3 of relay 5P, wire 45, contact 1N of relay Y2, contact A3 of relay 1S through relay 2S to terminal C. Relay 2S picks up and com-

pletes its stick circuit at its own contact A2, comprising a branch of the pick-up circuit just traced. The stick circuit for relay 1S extending over wire 38 is opened at back contact C1 of relay 5P, since the contacts 2N of relay OCR and C6 of relay 2P which shunt this contact are now open, so that relay 1S releases after a short period.

The release of the office relay 4P opens the circuit for relay T1 which releases to terminate the eighth impulse, releasing the line relays R1. The office relay Y1 is operated to the left to complete a new stick circuit for relay 5P as on step 4. Relay T1 also deenergizes relay TA which releases to terminate the interval following the eighth impulse and completes a new pick-up circuit for relay T1.

Ninth step

Relay T1 picks up over a circuit comprising a connection from terminal B over contact B4 of relay 5P extending directly to wire 41. Relay T1 reenergizes relay TA, applies positive current to the stepping line channel to energize the line relays R1 and deenergizes relay 5P. The pick-up circuit for the office relay 2P completed on step 5 over contact A6 of relay 5P is now open at contact 4N of relay OCR and relay 2P is not operated.

Relay 5P releases after a short period, completing a pick-up circuit for relay T3 from terminal B at contact C6 of relay T1, back contact C3 of relay 5P, wire 46, contact A5 of relay 2S, contact 3N of relay Y2, wire 47, relay T3 to terminal C.

Relay T3 picks up, restoring the polarity of the message line channel to normal, thereby causing the line relays R3 to close their left-hand contacts, and at its contact D3 completes a circuit over contact C3 of relay T3P to maintain relay OR normal. Each relay R3 prepares a pick-up circuit for the associated relay 1P, and at station No. 1 relay R3 releases relays CR and L. Relay T3 also closes a circuit from terminal B at back contact D5 of relay 5P, contact C2 of relay T3, wire 36, contact A1 of relay 2S through relay Y2 to terminal C operating relay Y2 to the right, thereby completing a new stick circuit for relay 2S over its own contact A4, contact 2R of relay Y2, wire 38 and contact C1 of relay 5P to terminal B at contact B4 of relay OM. Relay Y2 opens the pick-up circuit for relay T3, but relay T3 remains picked up over its stick circuit including its own contact A3 and contact C6 of relay T1. The release of relay 5P opens the original energizing circuit for relay T1, but relay T1 is now held energized over a new stick circuit from terminal B at front contact A5 of relay T3, contact A3 of relay T3P and contact C4 of relay T1, and relay TA is held energized over front contact D5 of relay T3. Relay T3P is deenergized by the opening of back contact D3 of relay T3 and releases after a short period, opening the circuit for relay T1 at its contact A3. Relay T1 then releases, terminating the ninth impulse of the cycle, deenergizing relay T3 and the line relays R1 and energizing the relays 1P precisely as occurred when relay T1 was released prior to the transmission of the first step of the code, as already described. The upper winding of each relay Y1 is now energized over contact B2 of the associated relay 1P, so that any relay Y1 which happens to have been left in its reverse position is restored to normal. Relay OCR is restored to normal by the energization of its upper winding over contact C5 of the office relay 1P.

Relay T3 releases after a short period and deenergizes relay TA, which then releases to terminate the interval following the ninth step of the cycle, and to prepare a new pick-up circuit for relay T1 or T2.

Steps 10 to 17, inclusive

The condition of the apparatus at the beginning of the tenth step is the same as at the beginning of the first step except that relay Y2 is now reversed and relays T1 and T2 are now under the control of relay 2S in place of relay 1S. Steps 10 to 17 constitute an an eight step code including four steps constituting the code call for station No. 2 and four function steps controllable by levers such as 2HL and 2DL, in a manner similar to that already described, and a detailed description appears unnecessary. It will be assumed, therefore, that these steps have been transmitted.

At the beginning of the 17th step of the cycle, comprising the eighth step of the second code, relay T1 is picked up over a circuit from terminal B, contact 2 of switch HS, contact 3R of relay OCR, contact B4 of relay 4P, wire 58, contact C4 of relay 2S and wire 43, thence as previously traced through relay T1 to terminal C. Relay T1 reenergizes relay TA, applies positive current to the stepping line channel to energize relay R1 at each station, and also deenergizes the office relay 4P and picks up relay 5P as on the eighth step. At station No. 2, relay R1 opens the stick circuit for relay 4P which releases terminating the operations at that station.

When the office relay 5P picks up on this step, it closes a pick-up circuit for relay 3S from terminal B at contact B4 of relay OM, contact 2R of relay OCR, contact C1 of relay 2P, contact C3 of relay 5P, wire 45, contact 1R of relay Y2, contact A3 of relay 2S through relay 3S to terminal C. Relay 3S picks up and completes a stick circuit extending to terminal B over wire 45, at its own contact A2. Back contact C1 of relay 5P opens the stick circuit for relay 2S over wire 38, and relay 2S releases after a short period.

Relay 4P upon releasing deenergizes relay T1 which releases to terminate the 17th impulse, releasing the line relays and operating the office relay Y1 to the left to complete a new stick circuit for relay 5P. Relay T1 also deenergizes relay TA which releases to prepare a new pick-up circuit for relay T1. Since relay 3S is now picked up, its contact A4 bridging contact A2 of relay TA in the stick circuit for relay OM is open, consequently the opening of contact A2 of relay TA disconnects terminal B from wire 48, deenergizing relay OM.

Return to normal

Relay T1 is energized over contact B4 of relay 5P and front contact C3 of relay OM at the same time that relay OM is deenergized. When relay OM releases its back contact C3 establishes a connection directly to wire 33 for energizing relay T1. Relay T1 therefore picks up regardless of the release of relay OM and establishes its normal stick circuit over its own contact C4 extending over wire 33 to terminal B at back contact 32 of relay F. Relay T1 reenergizes relay TA, applies positive current to the stepping line channel to reenergize the line relays R1, deenergizes relay 5P, which releases after a short peri-

od. Relay T1 also completes a pick-up circuit momentarily for relay OST, extending from terminal B at back contact D5 of relay T3 over front contact D3 of relay T1, contact 3N of relay, Y1, contact A6 of relay 5P, contact 4R of relay OCR, wire 25, contact A3 of relay 3S, wire 49, contact A4 of relay STP through the lower winding of relay OST to terminal C.

Relay OST picks up, completing its stick circuit at its contact 1N, and opening the stick circuit for relay STP, which releases.

When relay OM releases, it completes a pick-up circuit for relay T3 at back contact C5 of relay OM, extending to terminal B at contact C3 of relay T1, and relay T3 picks up, restoring the message line polarity to normal, and causing the relays R3 to close their left-hand contacts, thereby releasing relay CR at station No. 2 and deenergizing relay L at each station. The release of relay OM also disconnects terminal B from wire 45, deenergizing relay 3S which releases. Relay T3 upon picking up deenergizes relay T3P which releases after a short period completing the restoration of the apparatus to normal.

It will next be assumed that a train enters the track section as station No. 1, releasing relays TR, TS and ST and restoring signal 1R to stop. If the line circuits are in their normal closed condition, contact 14 of relay ST will apply a shunt to the message line channel reversing the office line relay OR and picking up relay ORP, which by opening its contact C3 will release relay OST to initiate an operating cycle.

During this cycle relay ST at station No. 1 will be reenergized on the fourth step as above described, and relay 1TK will be reversed to light lamp 1TE at the end of that step.

It may happen that relay ST is released during the transmission of a cycle but after the fourth step of the corresponding station code call has been transmitted. In this case relay ST will be in its released position when the line circuits are restored to normal at the end of the cycle. At that time relay OR is in its normal position, having been operated to that position when relay T3 picked up to restore relays R3 to normal at the end of the cycle. At that time, relay T3 deenergizes relay T3A, and each relay R3 deenergizes the associated relay L. Relay L has a longer release period than relay T3A and its back contact C1 therefore applies a shunt to the message line in case contact 14 of relay ST is closed, to reverse relay OR shortly after relay OR has been positioned to normal, and its local circuit opened by the release of relay T3A. It will be seen therefore that relay OR will be operated to reverse to initiate a new cycle in the event relay ST at any stations is in its deenergized condition at the end of a cycle.

It may also happen that one of the lever contacts A1 is opened during the transmission of a cycle. This will open the connection from terminal B to wire 34, deenergizing relay STP, and thereby preventing relay OST from picking up at the end of the cycle. Relay OM however will remain picked up and the apparatus will complete the cycle, which will be terminated as above described except that relay OST will remain released and will complete the pick-up circut already traced for relay 1S when relay OM releases. Relay 1S will therefore pick up, and upon the closing of back contact B1 of contact T3P at the end of the cycle, assuming the lever contacts A1 to be also closed, relay STP will be reenergized to initiate a new cycle of operation.

As already mentioned, the selector system of Fig. 3 is free to be operated at any time, and relay F of Fig. 1A is picked up for the duration of each selector code, disconnecting the message line battery 81 from line wires *y* and *z* and also disconnecting terminal B of the local source from wire 33. If relay F is picked up when the C. T. C. system is idle, relay OST is released, but without starting a cycle of operation, while if relay F is picked up when the C. T. C. system is in operation, relays STP and OM are also released to suspend further operation of the system as long as relay F is energized. In either case, relay T1 is released, disconnecting battery 80 from the stepping line channel, and a new cycle of operation is initiated when relay F releases.

My apparatus also includes a hand stepping switch HS by means of which the stepping operations may be manually controlled for observation or test purposes. Normally switch HS occupies a lower position as shown but if switch HS is moved to its center position and a cycle of operation is there initiated, it will be stopped with the stepping line open and with the apparatus in a condition ready to begin the first step, but with the circuit for relay T1 or T2 held open at contact 2. The first line closed period may now be initiated by moving HS to its upper position, in which contact 2 completes the pick-up circuit for T1 or T2 and contact 1 completes a holding circuit for relay T1 or T2 over its contact C2, and the operation will be stopped with the apparatus on the line closed portion of the first step. If relay HS is then restored to its center position, relay T1 or T2 releases and the operation stops with the stepping line open and the apparatus in condition to transmit the second step. It will be seen that a different pick-up circuit for relay T1 or T2 is closed by contact 2 over the contacts B6 and B4 of the stepping relays each time switch HS is moved to the upper position, and the energized relay T1 or T2 is released each time switch HS is returned to the center position, while if switch HS is restored to the lower position after the transmission of any number of steps in this manner, the remaining steps of the cycle will be transmitted automatically in the manner hereinbefore described.

Although I have herein shown and described but one form of my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In a remote control system, an office and a plurality of stations connected by two line wires, a polar relay at each station bridged across said line wires, a first line channel including said relays, said line wires in series, and a source of current bridged across said line wires at said office, stepping line relays connected between said line wires and ground at each station, a second line channel including said stepping line relays, said line wires in multiple, and a second source of current connected between said line wires and ground at said office, transmitting means at said office for controlling the connection of said second source of current to the line wires to deliver multiple impulse codes to said line wires to operate said stepping line relays, means at the office for reversing the polarity of the current supplied to said first line channel to cause said polar

relays to assume a reversed position during the delivery of each code, and code responsive means at each station controlled over said second line channel by the stepping line relays and selectively responsive to said codes provided the polar relay at such station is reversed but requiring such polar relay to be in its normal position to initiate its response to a code.

2. In a remote control system, an office and a station connected by two line wires, a message line channel including said line wires and a source of current bridged across said line wires at said office, a message line relay at said office responsive to variations in the current delivered to said message line channel from said source, a stepping line relay connected between said line wires and ground at said station, a stepping line channel including said stepping line relay, said line wires and a second source of current connected between said line wires and ground at said office, a transmitter relay at said office for controlling the connection of said second source of current to the line wires to transmit impulses from the office to the station over said stepping line channel to repeatedly operate said stepping line relay, step-by-step means at the office and station operable respectively by said transmitter relay and by said stepping line relay one step for each operation of said transmitter relay, means controlled by the step-by-step means at the station for connecting said line wires together on selected steps to transmit current variations from the station to the office over said message line channel to operate said message line-relay, and indication means controlled by the step-by-step means at the office in accordance with the condition of said message line relay on said selected steps.

3. In a remote control system, an office and a station connected by two line wires, a message line channel including said line wires and a source of current bridged across said line wires at the office, a line relay at the office of the stick polar type operable to a reverse position in response to an increase in the current delivered to said message line channel from said source, a stepping line channel including said two line wires, step-by-step means at the office operable through a series of steps, means including a second source of current for delivering a series of impulses to said stepping line channel one for each operation of the office step-by-step means, step-by-step means at said station controlled over said stepping line channel and operable by said impulses in unison with said office step-by-step means, means for locally operating said line relay to normal just prior to each operation of said office step-by-step means, means controlled by the station step-by-step means for connecting said line wires together on selected steps of said series to increase the current delivered to said message line channel to reverse said line relay, and indication means at the office controlled in accordance with the condition of said line relay on each of a plurality of steps of said series.

4. In a remote control system, an office and a station connected by two line wires, a series of movable devices at the station, an indication relay at the office for each said device, means for controlling each indication relay in accordance with the condition of the corresponding device, comprising a message line channel including said line wires and source of current bridged across said line wires at the office, a line relay of the stick polar type operable to a reverse position in response to an increase in the current delivered to said message line channel from said source, step-by-step means at the office and station operable through a series of steps, including one step for each said device, a stepping line channel including said two line wires, means including a second source of current for delivering a series of impulses to said stepping line channel, one for each operation of the office step-by-step means, step-by-step means at said station controlled over said stepping line channel and operable by said impulses in unison with said office step-by-step means, means for locally operating said office line relay to normal just prior to each operation of said office step-by-step means, means controlled by said station step-by-step means on each step of said series of impulses delivered over said stepping line channel for preparing a shunt path adapted to connect said line wires together to momentarily increase the current delivered to said message line channel to reverse said line relay, each such path prepared by the step-by-step means being closed or left open dependent upon the condition of the movable device associated with the corresponding step, and means controlled by the office step-by-step means for operating each indication relay to normal or reverse according to the position of the line relay on the corresponding step.

5. In a remote control system, an office and a plurality of stations connected by line wires, means at said office for transmitting different codes of impulses of selected relative polarity over said line wires, each including a combination of impulses constituting a station code call, a series of stepping relays at said station, a circuit for at times energizing the first stepping relay of each series, circuits for energizing a plurality of said stepping relays at a particular station one at a time in order, each in response to a different impulse but only if the relative polarity of such impulse is in accordance with the code call for that station, the energization of each relay of said plurality being also dependent upon the energization of the next preceding relay of the same series, circuits effective only if the last relay of said plurality becomes energized for again energizing the relays at said particular station one at a time in order through a second cycle in response to the succeeding impulses of the code but regardless of the polarity, a plurality of movable devices and circuits controlled by said stepping relays during their second cycle of operation for successively controlling said movable devices one at a time in order in accordance with the relative polarity of the corresponding impulses.

6. In a remote control system, an office and a plurality of stations connected by line wires, means at said office for transmitting different codes of impulses of selected relative polarity over said line wires, each including a combination of impulses constituting a station code call, a series of stepping relays at said station, a circuit for at times energizing the first stepping relay of each series, circuits for energizing a plurality of said stepping relays at a particular station one at a time in order, each in response to a different impulse but only if the relative polarity of such impulse is in accordance with the code call for that station, the energization of each relay of said plurality being also dependent upon the energization of the next preceeding relay of the same series, a circuit controlled by the last relay of said plurality when energized for rendering the first stepping relay responsive to the next

impulse in order, thereby preparing the plurality of stepping relays at said particular station for operation through a second cycle in response to succeeding impulses of the code, a chain repeat relay, a circuit for operating said chain repeat relay closed momentarily at the beginning of said second cycle of operation, means for maintaining said chain repeat relay energized during the transmission of the succeeding impulses of the code, and means controlled by said chain repeat relay for rendering the stepping relays responsive to said succeeding impulses regardless of the relative polarity of such impulses.

7. In a remote control system, an office and a plurality of stations connected by line wires, a first source of current bridged across said line wires at the office, a cycle marking relay of the stick polar type bridged across the line wires at each station, step-by-step means at the office operable through a series of steps, means including a second source of current for delivering a series of impulses to said line wires, one for each operation of the office step-by-step means, and for reversing the connections of said first source of current whereby the cycle marking relay at each station is reversed for the duration of said series of impulses, and step-by-step means at each station adapted to respond to said series of impulses but only if the cycle marking relay at such station is initially in its normal position and is then reversed for the duration of said series of impulses.

8. In a remote control system, an office and a plurality of stations connected by line wires, a series of stepping relays, a series of connector relays, including one for each station, and a starting relay, all at the office, a series of stepping relays at each station, means effective when said starting relay is operated for energizing said connector relays only one at a time in a fixed order and for operating said office stepping relays one at a time in order during the period of energization of each connector relay, means controlled by said office stepping relays for delivering a series of impulses to said line wires including one impulse for each stepping relay, means controlled by the connector relay then energized for controlling the relative polarity of certain of said impulses to form a distinctive code call characteristic of the corresponding station, means controlled over said line wires for operating the stepping relays at each station in response to such impulses but only if the relative polarity of said certain impulses is in accordance with the code call for that station, and means for operating said starting relay.

9. In a remote control system, an office and a plurality of stations connected by line wires, a series of stepping relays, a series of connector relays, including one for each station, and a series of starting relays, all at the office, a plurality of movable devices at each station, means effective when said starting relay is operated for energizing said connector relays only one at a time in a fixed order and for operating said stepping relays one at a time in order during the period of energization of each connector relay, means controlled by said stepping relays for delivering to said line wires a series of impulses one for each stepping relay having a relative polarity determined by the connector relay then energized, each series including a combination of impulses constituting a code call for the station with which such connector relay is associated, means at each station controlled over said line wires and selectively responsive to the corresponding code call, indication means controlled by each connector relay for indicating the condition of the movable devices at the corresponding station, means at each station responsive to the received impulses and rendered effective upon receipt of the corresponding code call for controlling the condition of said line wires to operate such indication means in accordance with the condition of the corresponding movable devices, and means at each station for controlling the condition of said line wires to operate said starting relay.

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