

April 16, 1946.

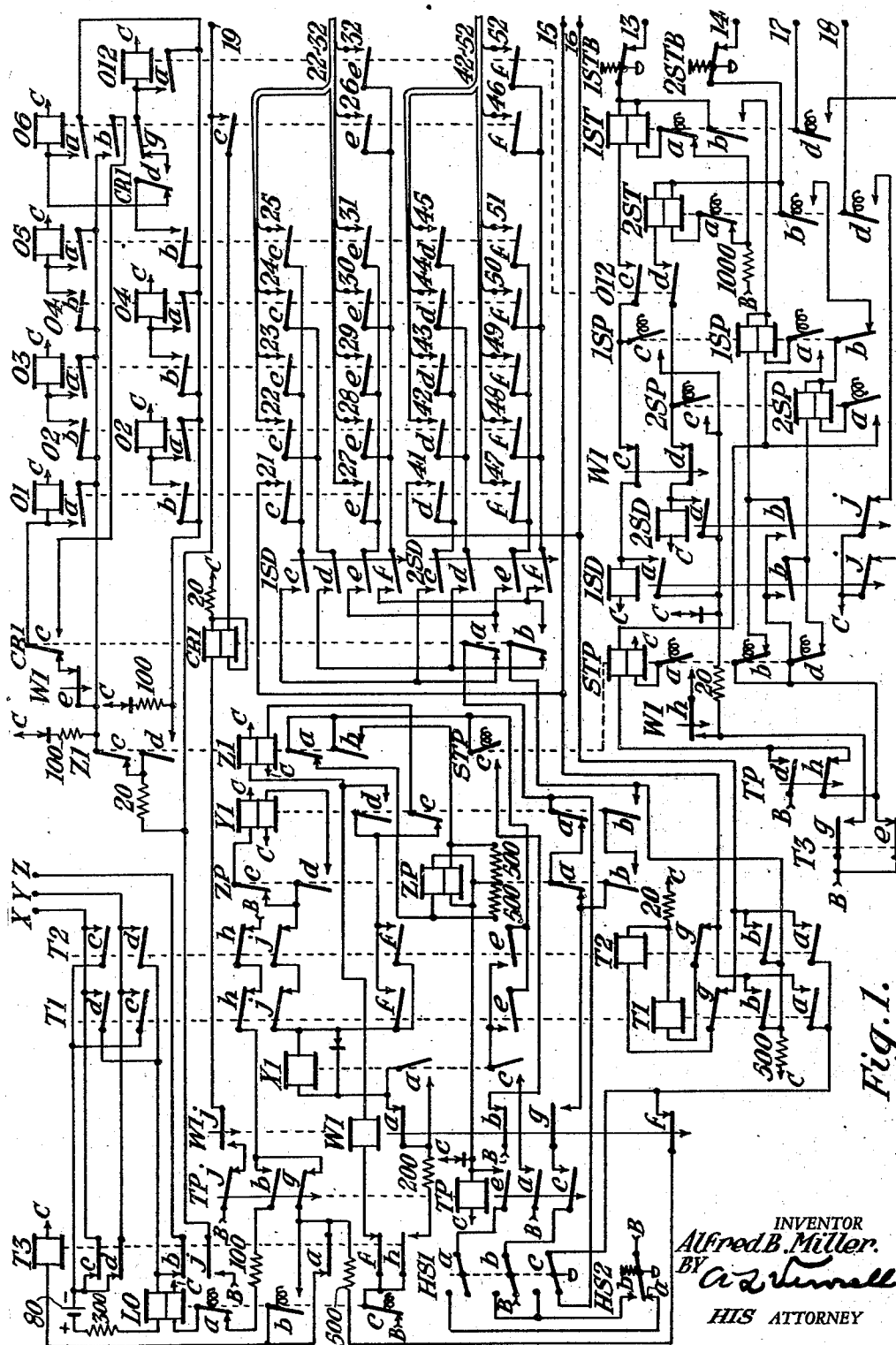
A. B. MILLER

2,398,588

REMOTE CONTROL SYSTEM

Filed Nov. 25, 1943

7 Sheets-Sheet 1



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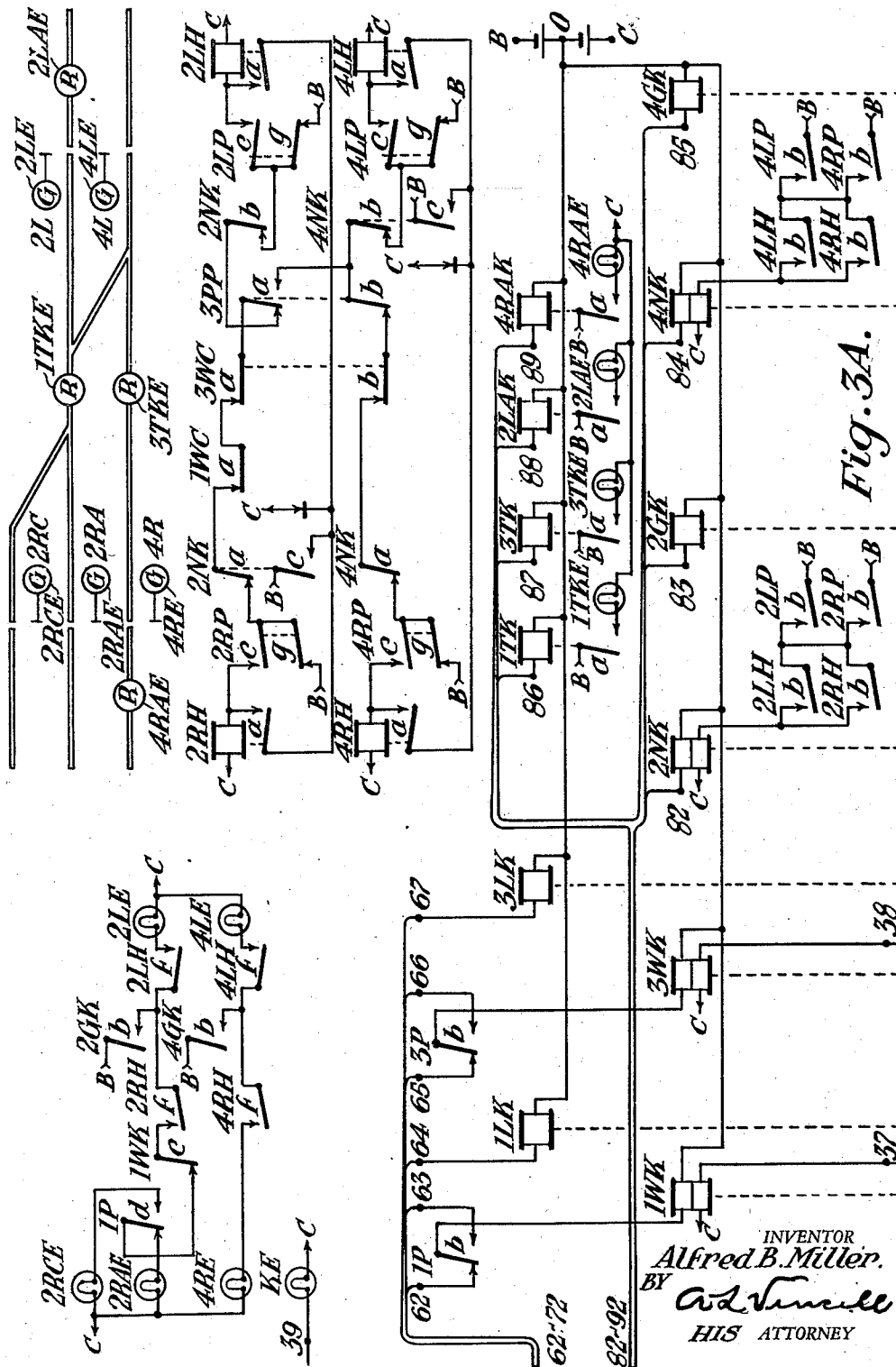
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REMOTE CONTROL SYSTEM

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7 Sheets-Sheet 3



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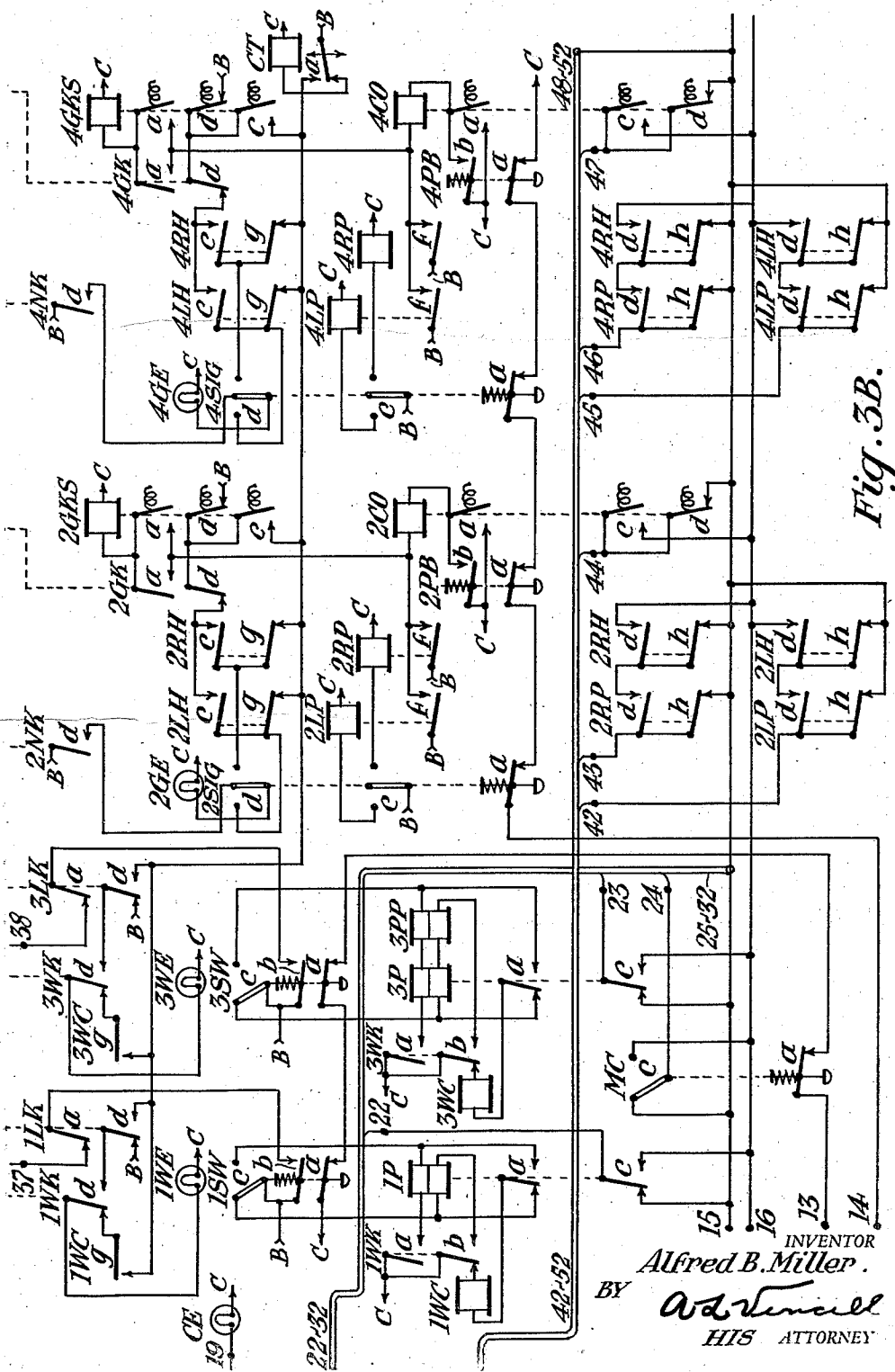
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REMOTE CONTROL SYSTEM

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7 Sheets-Sheet 4



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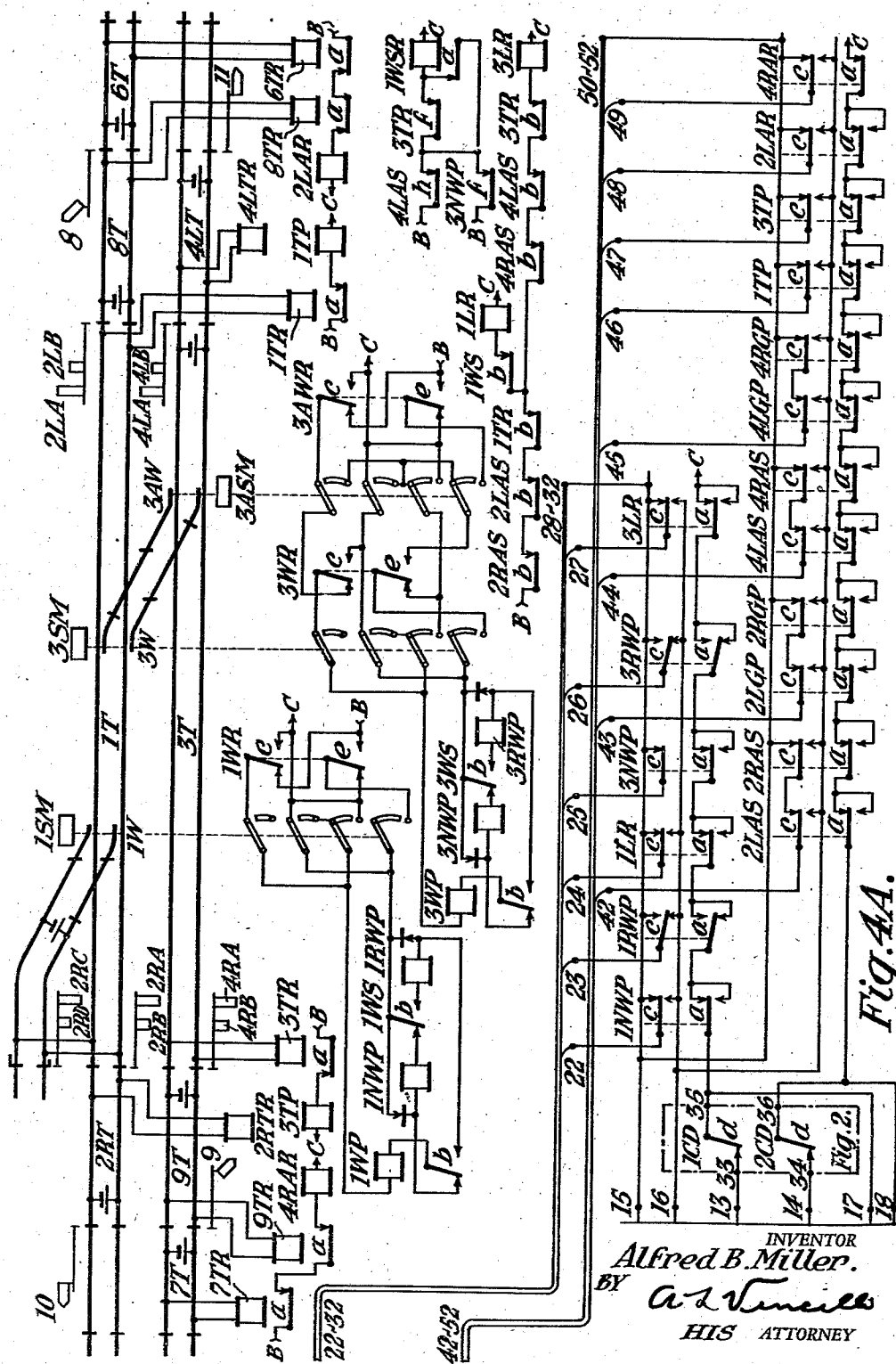
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REMOTE CONTROL SYSTEM

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7 Sheets-Sheet 5



April 16, 1946.

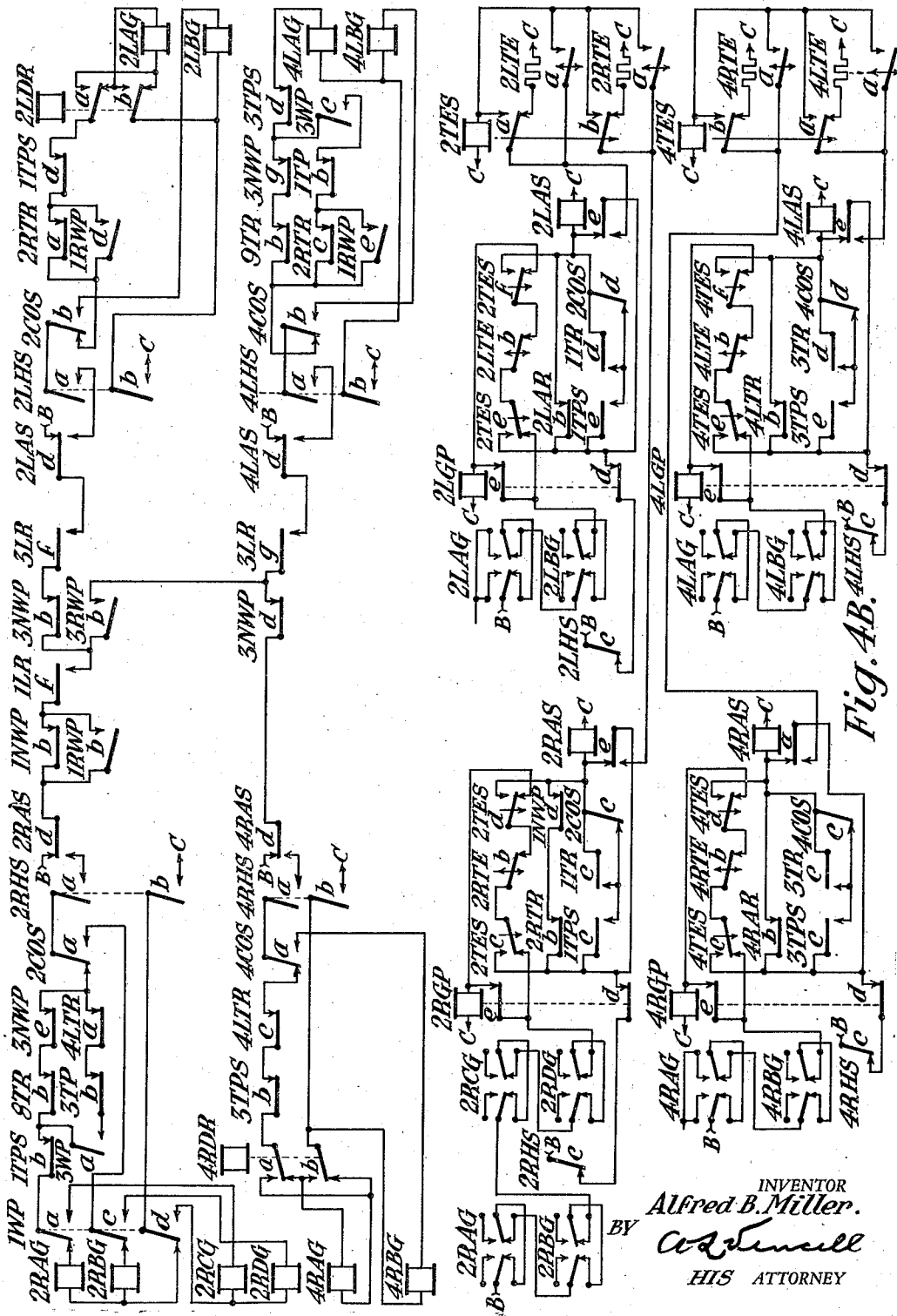
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2,398,588

REMOTE CONTROL SYSTEM

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April 16, 1946.

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REMOTE CONTROL SYSTEM

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7 Sheets-Sheet 7

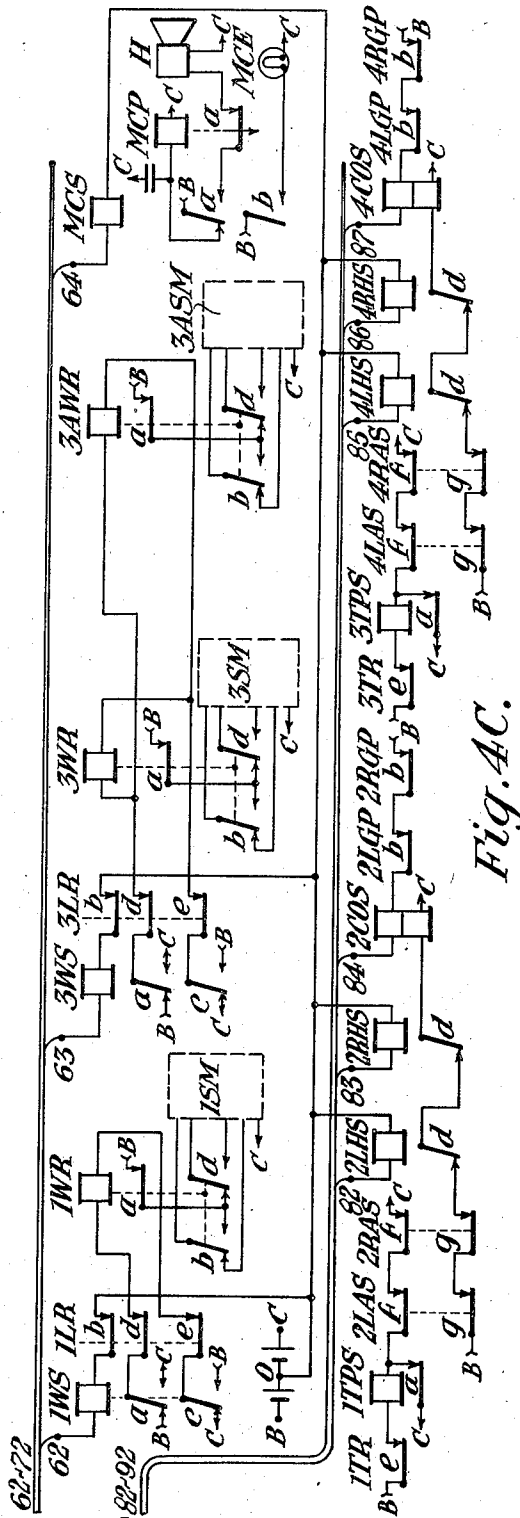


Fig. 4C.

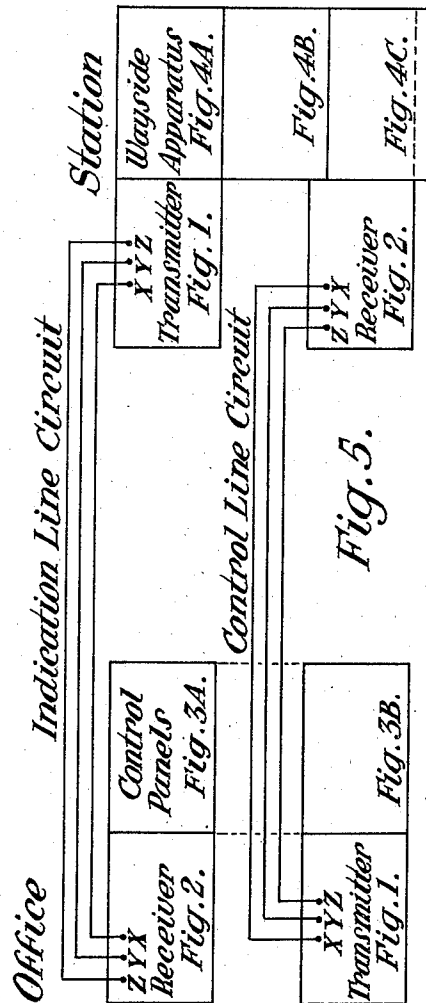


Fig. 5.

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UNITED STATES PATENT OFFICE

2,398,588

REMOTE-CONTROL SYSTEM

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Application November 25, 1943, Serial No. 511,687

14 Claims. (Cl. 246—134)

My invention relates to remote control systems for the control from a central office of selected devices located at distant stations, and for also indicating at the office the condition of such devices and of other devices located at such stations, by means of impulse codes transmitted intermittently over line wires.

In its specific embodiment my invention relates to centralized traffic control systems for railroads, and has for its principal object the provision of a system for the remote control of interlocked track switches and signals from a central office or control tower and for indicating their condition and for reporting train movements at the tower by means of which routes may be set up with substantially no more delay than when direct wire control is used. The system of my invention is adapted particularly for use in the vicinity of large railway terminals where the controlled functions are scattered over such a wide area and their number is so large as to make direct wire control as employed heretofore uneconomical. In the practice of my invention, the terminal area is divided into zones of suitable size and a separate set of equipment such as is disclosed herein is provided for the control and indication of the interlocked switches and signals in each zone. A three wire line circuit extending from a code transmitter at the control office or tower to a receiver at a centrally located station within the zone provides a channel for the transmission of control codes to the station. A second three wire line circuit extends from a code transmitter at the station to an individual receiver at the office and provides an independent channel for the transmission of indication codes to the office.

Normally all three wires of the three wire line circuit are energized to hold a station line relay energized which relay when released conditions the receiver to respond to a code. The codes consist of a series of short impulses of positive or negative current transmitted over two of the line wires, the third line wire remaining deenergized. The energization of the line relay referred to over the third line wire restores the receiver to its normal inactive condition at the end of the code, the successive impulses of which are adapted to operate polar stick relays for governing the various railway traffic governing devices in the zone or for indicating their condition at the office. The coding apparatus is adapted to control two groups of such relays, the relative polarity of the first impulse of each code selecting the relays of one group or the other for operation, one at a time

in order, each in accordance with a different one of the remaining impulses of the code.

In setting up a traffic route it is the practice to operate the levers controlling the track switches first, and to defer the operation of the signal lever for clearing the signal for the desired route until the establishment of that route is verified by the display of the proper switch indications. Accordingly the switch controls are placed in one group and the signal controls in the other. In the case of indication codes, the various indications are divided arbitrarily into two groups and a change in condition of any indicating device initiates a code for successively indicating all of the devices of its group. If the changes occur so frequently as to operate the transmitter continuously, the two groups of indications are transmitted alternately thereby limiting the delay in receiving an indication of a change in either group to the time required to transmit one code.

A further feature of my invention resides in the provision of coding circuits using relays having unusually fast operating characteristics, the normal speed of the system being at the rate of 35 impulses per second. The time consumed in transmitting a code being hardly more than that required to move a control lever therefore introduces no delay in the operation of the plant even when controlling trains running under close headway.

A feature of my invention is the provision of improved arrangements for interlocking the code control circuits at the office to enforce the carrying out of a sequence of operations in the desired order and under proper traffic conditions. Another feature resides in the provision of means in the field for preventing operation of the controlled devices by repeated codes, each code impulse being effective only if the corresponding control lever has been operated to a new position. For illustration, if a signal has been cleared and then put to stop by a passing train, it cannot be cleared again by a repetition of the code by which it was originally cleared unless a code for restoring it to stop is interposed.

The system herein disclosed is an improvement upon that shown in my prior application for Letters Patent of the United States, Serial No. 403,494, filed July 22, 1941, for Remote control systems, now Patent No. 2,339,872, granted January 25, 1944.

I shall describe one form of apparatus embodying my invention, and shall then point out the novel features thereof in claims.

In the accompanying drawings, Figs. 1, 2, 3A

and 3B, and Figs. 4A, 4B and 4C illustrate different component parts of the system of my invention, and Fig. 5 shows how these views may be assembled to form a centralized traffic control system illustrating one form of apparatus embodying my invention. More particularly, Fig. 1 shows the transmitter by means of which the impulse codes are generated and delivered to the three wire line circuit formed by the line wires X, Y and Z by means of which each transmitter is connected to the associated receiver. Fig. 2 shows the receiver which responds to the codes received over the line wires X, Y and Z. As shown in the lower portion of Fig. 5, a transmitter such as is shown in Fig. 1 is located at the office and connected by the three line wires to a receiver of Fig. 2 located at the station to effect the transmission of control codes from the office to the station. The transmission of indication codes is effected independently by similar apparatus over a second three wire line circuit, and therefore may be illustrated by the same views, by locating Fig. 1 at the station and Fig. 2 at the office, as illustrated in the upper portion of Fig. 5.

Figs. 3A and 3B, taken together as in Fig. 5, show a portion of the operator's control panel arranged for the control of a particular zone or section of the interlocking plant corresponding to the miniature track diagram at the top of Fig. 3A. Fig. 3A also shows a group of polar stick indication relays K controlled by the office receiver of Fig. 2, and a circuit network including a group of route relays RH and LH for governing the transmission of control codes for clearing the signals. Fig. 3B shows the switch levers SW, signal levers SIG and call on push buttons PB together with certain lever repeating relays P, for governing the transmission of control codes by the office transmitter of Fig. 1.

Figs. 4A, 4B and 4C taken together show the trackway circuits and apparatus at the station. More particularly, Fig. 4A shows in the upper portion the track plan for the controlled zone together with the circuits for the track relays TR and their repeating relays TP, the switch indication relays WP and their repeating relays NWP and RWP, the switch locking relays LR and a section locking relay WSR, and in the lower portion the circuits for controlling the transmission of indication codes by the station transmitter of Fig. 1, located at the left of Fig. 4A as shown in Fig. 5. Fig. 4B shows in the upper portion a signal circuit network of circuits for the signal mechanisms G. It is to be understood that the signals are of the well-known search-light type, located as shown in the track plan and each having an operating mechanism G such as that shown in the Blake Reissue Patent No. 14,940, reissued August 31, 1920. Fig. 4B shows in the lower portion, circuits for signal indication relays RGP and LGP repeating the stop indications of the signals, and circuits controlled thereby for governing the approach locking stick relays RAS and LAS, and the time element relays TE and stick relays TES associated therewith.

Fig. 4C shows the circuits for the stick polar control relays governed by the station receiver of Fig. 2, these including the switch control relays WS, the signal control relays LHS and RHS, the call-on signal control relays COS, and a relay MCS for controlling a maintainer's call signal device comprising a horn H and a lamp MCE. The relays WS control switch operating relays WR, also shown in Fig. 4C, which govern the power switch machines SM for operating the

track switches W. Fig. 4C also shows circuits for the signal slotting relays TPS.

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

As will be clear from the drawings, each track switch is identified by an odd number, switch 1W, 3W or 3AW, for example, and each signal by an even number, as illustrated by the signals 4RA, 2LB, etc., the corresponding number being prefixed to the designation of each relay associated with such switch or signal, for ready identification and in order to enable the operation of the system to be more readily traced. Local batteries are provided at the office and the station for energizing the relays as shown in Fig. 3A, having a positive terminal B, a negative terminal C, and a center tap or intermediate connection O.

Those relays shown in Figs. 4A, 4B and 4C are to be understood to be railway signaling relays of the types commonly employed in relay interlocking systems, with the exception of the stick polar control relays WS, LHS, etc. These stick polar relays and also the indication relays K of Fig. 3A, the lever repeating relays P of Fig. 3B, relay CR1 of Fig. 1, and relays 1CD, 2CD, CRP and CR2 of Fig. 2 are preferably of the type shown in Letters Patent of the United States No. 2,256,653, granted September 23, 1941, to Clarence S. Snively. Each such relay has four normal and reverse contacts *a*, *b*, *c* and *d*, and is adapted to hold its contacts in their last operated position when deenergized, operating its contacts to the normal or left-hand position when positive current is supplied to the left-hand terminal of its winding, and to reverse when supplied with current flowing in the opposite direction. The relays Y1, Z1 and ZP of Fig. 1, and relays Y2 and Z2 of Fig. 2 are of the same type but have only two normal contacts *a* and *c* and two reverse contacts *b* and *d*. The remaining polar relays shown in Figs. 1, 2, 3A and 3B are biased as indicated conventionally by biasing springs on their contacts. The biased polar relays each have two contacts *a* and *c* which close when positive current is supplied to the left-hand terminal of its winding, and two contacts *b* and *d* which close when the relay is deenergized or is supplied with current flowing in the reverse direction.

The neutral relays shown in Figs. 1, 2, 3A and 3B are quick acting relays, preferably of the type shown in Letters Patent of the United States No. 2,259,183, granted October 14, 1941, to Clarence S. Snively. Each of these neutral relays is equipped with six front contacts *a* to *f*, inclusive, and three back contacts *g*, *h* and *i*.

The relay circuits as shown include various electronic rectifiers and resistors for governing the time of operation of the relays and to eliminate sparking at the contacts, the resistors bearing numerical designations such as 20, 100, etc., corresponding to the values in ohms, commonly used in practice, in order to enable their effect upon the relay operations to be more readily understood.

The switch and signal levers SW and SIG of Fig. 3B, and also the lever MC, which lever controls a maintainer's call signal relay MCS shown in Fig. 4C, are to be understood to be of a type combining the functions of a spring return starting push button and a rotatable control lever in a single device, such as is shown in Letters Patent of the United States No. 2,289,736, issued July 14, 1942, to Clarence S. Snively and Regis H. Zetwo. Each such lever is normally locked in its last operated position by a spring actuated detent and

the lever must first be pushed to open its contact *a*, also closing a contact *b*, if required, to disengage the detent, and may then be rotated to move its control contacts *c* and *d* to the desired position. The release of the lever handle allows the spring to lock the control contacts closed, and also closes its contact *a*, the latter completing a circuit for initiating the transmission of the code.

Each switch lever SW has associated therewith a correspondence relay WC, a switch indication relay WK, a lock indication relay LK, a lever repeating relay P, and an indication lamp WE, all arranged as shown in the Remote control system of Letters Patent of the United States No. 2,292,245, issued August 4, 1942, to Clarence S. Snavely et al. Each three position signal lever SIG has associated therewith a normal indication relay NK, a signal indication relay GK, an indication stick relay GKS, two lever repeating relays LP and RP and two route relays LH and RH. Each call-on push button PB has a repeating stick relay CO associated therewith.

The three wire control and indication line circuits over which the codes are transmitted between the office and station each includes at the transmitting end, Fig. 1, a line battery 80, the winding of a line check relay L0 and contacts of three transmitter relays T1, T2 and T3 by means of which the positive terminal of battery 80 may be connected to line wires X, Y and Z, respectively, and at the receiving end, Fig. 2, the line circuits include the windings of three line relays L1, L2 and L3 which repeat the operation of the corresponding relays T.

Relay T3 is energized when the system is in its normal at rest condition over a stick circuit extending from terminal B over back contacts *h* of relays T2 and T1, back contact *g* of a transmitter check relay TP and the front contact *a* and winding of relay T3 to terminal C. Consequently the line circuit is normally closed from the positive terminal of battery 80 through the upper winding of relay L0, contact *b* of relay T3 to line wire Z, and thence through relay L3, thereby energizing relays L0 and L3 in series, the circuit then extending differentially through the windings of relays L1 and L2 to line wires X and Y and over contacts *c* and *d* of relay T3 to the negative terminal of battery 80, so that relays L1 and L2 normally stand released.

In Fig. 1, relay T3 is released for the duration of each code, and either relay T1 or T2 is picked up on each step. When relay T1 picks up, the positive terminal of battery 80 is connected through relay L0 and over contact *d* of relay T1 to line wire X, thence from left to right through relay L1, and in the reverse direction through relay L2 to line wire Y and contact *c* of relay T1 to the negative terminal C of battery 80, thereby energizing relays L0 and L1 in series, relays L2 and L3 remaining released. When relay T2 picks up, its contacts *d* and *c* connect the positive terminal of battery 80 to the line wire Y, and the negative terminal to line wire X, thereby energizing relays L0 and L2 in series, relays L1 and L3 remaining released. The codes thus comprise a series of impulses, each comprising an X or Y impulse with a single Z impulse between each two successive codes.

To initiate the two different series of code impulses, two code storage relays 1ST and 2ST are provided. Each storage relay ST is normally energized over a stick circuit extending from terminal B over its own front contact *a* and lower winding, and a contact of a push button 1STB

or 2STB, provided for test purposes, to terminal C over wire 13 or 14. At the office, Fig. 3B, wire 13 is connected to terminal C over contacts *a* of the switch levers SW and of the lever MC, and wire 14 is connected to terminal C over contacts *a* of the signal lever SIG and the associated call-on push buttons PB, while at the station, Fig. 4A, wires 13 and 14 extend to terminal C over contacts of the indicating relays, which may be arranged in two groups in any desired manner.

Each relay 1ST or 2ST controls a storage repeating relay 1SP or 2SP, governing a selector relay 1SD or 2SD, and a starting relay STP. Relays 1SD and 2SD select the X or Y character, respectively, for the first step of the transmitted code, and also prepare circuits by means of which the character of the succeeding steps is determined, comprising circuits for relays T1 and T2 extending over wires 22—32 or wires 42—52, respectively, to Fig. 3B or Fig. 4A. Relay STP initiates the code transmission by energizing the transmitter check relay TP to release relay T3 by opening its stick circuit already traced, and to also release a reset check relay W1 which is normally energized over a circuit extending from terminal B at the front contact *c* of relay L0 over front contact *f* of relay T3, through relays W1 and Z1 in series, to terminal C.

The release of relay W1 completes the first of the circuits prepared for relays T1 and T2 by relay 1SD or 2SD. Relay T1 or T2 picks up and releases on each step, energizing a pair of half-step relays Y1 and Z1 alternately to reverse and to normal, in series with a half-step check relay X1. Relay Z1 controls a repeating relay ZP, and a chain of counting relays O1 to O6 which pick up one at a time in order to count the successive impulses of the code. A chain repeat relay CR1 provides connections for energizing relay O1 as the next in order after relay O6, to operate the relay chain through a second cycle, on the last step of which relay O12 operates in place of relay O6, to terminate the code.

As shown, the transmitter is arranged to deliver a code of twelve impulses. This number in practice is varied by providing different numbers of counting relays at different locations in accordance with the number of devices to be controlled or indicated in the different zones.

The transmitter of Fig. 1 also includes two hand stepping switches HS1 and HS2 by means of which a code may be transmitted manually, pausing on each step, for purposes of test or observation.

In the receiver, Fig. 2, it will be understood that the line relays L1, L2 and L3 repeat the code operation of the corresponding relays T1, T2 and T3, that is, relay L3 releases for the duration of the code and relays L1 and L2 respond to the X and Y impulses to control the relays W2, X2, Y2, Z2, CR2 and the counting relays 1 to 6, inclusive, and 12, each of which operates substantially in unison with the corresponding relay of Fig. 1. The receiver also includes two delivery relays 1CD and 2CD which respond to the X or Y character, respectively, of the first impulse and prepare circuits including wires 62—72 or 82—92, over which the corresponding group of polar stick relays of Fig. 3A or Fig. 4C are controlled. Relay W2 is normally held energized and relays 1CD, 2CD, CR2 and Z2 are held normal by relay L3 over the circuit extending to terminal B at contact *a* of relay L3, and a repeating relay CRP is held energized in the normal direction over contact *c* of relay CR2. Relay W2 prepares a circuit for

the first counting relay I, and is released in response to the operation of the line relay L1 or L2 by the first impulse of a code.

The operator's control panel of Figs. 3A and B includes two code indicator lamps CE and KE. Lamp CE is energized over wire 19 and back contact j of relay T3, and is lighted for the duration of each control code. Lamp KE is energized over wire 39 and back contact d of relay L3, for the duration of each indication code.

Having thus pointed out the general features of the system of my invention, I shall now describe its operation under different assumed conditions by tracing the circuits in detail, starting with the apparatus in its normal at rest condition as shown, with all track switches normal and all signals at stop.

I shall first assume that the operator reverses the switch lever ISW, Fig. 3B, to set up a route to enable signal 2RC to be cleared. When lever ISW is pressed to release the lever latch, the opening of its contact a disconnects terminal C from wire 13, releasing relay IST, and the closing of its contact b connects terminal B over contact a of relay ILK to wire 37 to complete a circuit through relay IWK to terminal C to operate relay IWK to its reverse position. Relay IWC, normally energized over the left-hand or normal contact c of lever ISW, the left-hand contact a of relay IP and the left-hand contact b of relay IWK, is thereby released, and lamp IWE becomes lighted over the circuit from terminal B at the left-hand contact d of relay ILK, the right-hand contact d of relay IWK, lamp IWE to terminal C. The opening of contacts a of relay IWC in the route circuit network of Fig. 3A prevents the transmission of code elements for clearing the signal for any route over switch IW. The closing of the reverse contact c of lever ISW completes a circuit from terminal B through the upper winding of relay IP and contact a of relay IWK to terminal C, causing relay IP to reverse. The release of lever ISW in the reverse position reconnects terminal C to wire 13, completing a circuit from terminal B at contact e of relay T3 over contact b of relay STP through the upper winding of relay ISP and over contact b of relay IST to wire 13 and thence to terminal C, so that relay ISP picks up. The closing of contact a of relay ISP completes a circuit from terminal B at contact e of relay T3 over contact h of relay TP through the upper winding of relay STP, contact a and the lower winding of relay ISP and thence over contact b of relay IST and wire 13 to terminal C, over which relay STP picks up and relay ISP is held energized, the circuit over which relay ISP picked up being opened at contact b of relay STP, while contact d of relay STP opens the pick-up circuit for relay 2SP.

The closing of contact c of relay STP completes a circuit from terminal B at contact b of relay W1 over contact c of relay STP, contact a of relay Z1, through the upper winding of relay ZP and the winding of relay TP to terminal C over which relay TP is picked up, and relay ZP is held normal. The closing of contact b of relay TP completes a stick circuit for relay L0 extending from terminal B over contacts h of relays T2 and T1, contact b of relay TP, contact a and the lower winding of relay L0 to terminal C, over which relay L0 is held energized during the intervals between code impulses when its upper winding is deenergized, so that relay L0 remains picked up for the duration of the code. The opening of contact g of

relay TP opens the stick circuit for relay T3 already traced, so that relay T3 releases to open the line circuit.

The opening of contact e of relay T3 disconnects terminal B from the pick-up circuits for the SP relays, but relays STP and ISP are held energized over the stick circuit for relay ISP extending to terminal B at contact d of relay TP. Contact f of relay T3 opens the circuit for relay W1, which is slow to release and remains picked up until relays X1, ISD and O1 become energized over circuits closed by the release of relay T3, which will now be traced.

Relay X1 picks up over the circuit from terminal B at contact c of relay L0, contact h of relay T3, contact a of relay W1, relay X1, contacts j of relays T1 and T2, contact c of relay ZP, through the upper winding of relay Y1 to terminal C, checking relay Y1 normal, and relay X1 completes a stick circuit over its own contact a. Relay ISD picks up over the circuit from terminal B at contact g of relay T3, contacts c of relays ISP and W1 through relay ISD to terminal C, and relay ISD completes a stick circuit over its own contact a. The closing of contact j of relay T3 completes a circuit over wire 19 to light lamp CE, and over contact c of relay Z1, contact e of relay W1 and contact c of relay CR1 through relay O1 to terminal C. Relay O1 picks up and completes a stick circuit at its contact a.

Relay W1 now releases, relays X1, ISD and O1 remaining energized over their respective stick circuits. Contact b of relay W1 opens the pick-up circuit for relay TP, but relay TP is slow to release and remains picked up.

The release of relay W1 completes a stick circuit for relay STP from terminal B at contact g of relay T3, over contact h of relay W1, contact a and the lower winding of relay STP to terminal C. Relay STP is thus held energized to complete the code in the event terminal C is disconnected from wire 13 by lever operation and relay ISP is released during the code transmission. The release of relay W1 also completes a circuit for selecting the character of the first impulse of the code which extends from terminal B at contact b of the hand stepping switch HS1 over contact c of relay TP, contact g of relay W1, contacts a of relays ZP, Y1 and CR1, contacts c of relays ISD and O1, wires 21 and 15, contact g of relay T2 through the winding of relay T1 to terminal C.

Relay T1 picks up and supplies an X impulse to the line circuit, and completes a stick circuit from wire 15 over its own contact a, contact c of switch HS1 to contact a of relay Y1, over a path already traced to terminal B at contact b of switch HS1. Contacts j and f of relay T1 pick up and shift the circuit through relay X1 from the branch including the upper winding of relay Y1 to the one including contact c of relay Y1 and the lower winding of relay Z1, thereby reversing relay Z1. The closing of contact e of relay T1 completes a stick circuit for relay TP extending from terminal B at its contact a over contact c of relay X1, contact e of relay T1, contact a or b of relay Z1 through relays ZP and TP to terminal C, whereby relay TP is held energized and relay ZP reverses in response to the reversal of relay Z1. The reversal of relay Z1 also picks up relay O2 over the circuit extending from terminal B at contact j of relay T3, contact d of relay Z1, contact b of relay O1 through relay O2 to terminal C. Relay O2 sticks up over its contact a, and relay O1 releases, due to the opening of con-

tact *c* of relay *ZI*. The opening of contact *a* of relay *ZP* releases relay *T1*, opening the line circuit to terminate the first impulse.

Relay *T1* upon releasing opens the circuit for relay *TP* at contact *e* of relay *T1*, but relay *TP* remains picked up. The dropping of contacts *f* and *j* of relay *T1* shifts the circuit for relay *X1* from the branch including the lower winding of relay *Z1* to the one including contact *d* of relay *ZP* and the lower winding of relay *Y1*, thereby reversing relay *Y1*. Relay *Y1* then completes a circuit for selecting the character of the second impulse. This circuit extends from terminal *B* at contact *b* of switch *HS1*, over contact *c* of relay *TP*, contact *g* of relay *W1*, contacts *b* of relays *ZP*, *Y1* and *CR1*, contact *d* of relay *ISD*, contact *c* of relay *O2*, wire 22, contact *c* of relay *1P*, which contact, as assumed, now stands reversed, thence to wire 16, contact *g* of relay *T1* through relay *T2* to terminal *C*.

Relay *T2* picks up and supplies a *Y* impulse to the line circuit, and completes a stick circuit from wire 16 over its own contact *b* contact *b* of relay *Y1*, and thence to terminal *B* at contact *b* of switch *HS1*. Contacts *f* and *j* of relay *T2* pick up and shift the circuit through relay *X1* from the branch including the lower winding of relay *Y1* to the one including contact *d* of relay *Y1* and the upper winding of relay *Z1* thereby operating relay *Z1* to normal. The closing of contact *c* of relay *T2* completes the stick circuit for relay *TP* through relay *ZP*, and relay *ZP* is restored to normal by relay *Z1*. The closing of the normal contact *c* of relay *Z1* completes a pick-up circuit for relay *O3* over contact *b* of relay *O2*. Relay *O3* sticks up over its contact *a*, and relay *O2* releases, due to the opening of contact *d* of relay *Z1*. The opening of contact *b* of relay *ZP* releases relay *T2*, opening the line circuit to terminate the second impulse.

Relay *T2* upon releasing completes a circuit at its contact *j* over contact *c* of relay *ZP* to hold relay *X1* energized and to operate relay *Y1* to normal. The closing of the normal contact *a* of relay *Y1* then completes a circuit for selecting the character of the third impulse. This circuit extends from terminal *B* at contact *b* of switch *HS1*, as already traced, to contact *c* of relay *O3*, thence over wire 23 to contact *c* of relay *3P* to wire 15, and thence through relay *T1* to terminal *C*.

Reviewing these operations, it will be seen that the selector relay *ISD* and the first counting relay *O1* pick up during the interval preceding the first impulse and complete a circuit over wire 21 to pick up relay *T1*. When relay *T1* or *T2* picks up over wire 21, 23, 25, etc., to transmit an odd-numbered impulse, relay *Z1* is operated to reverse to pick up an even-numbered counting relay *O2*, *O4*, *O6*, etc., and to operate relay *ZP* to reverse to relay *T1* or *T2* whereupon relay *Y1* is operated to reverse to complete a new circuit for relay *T1* or *T2* over wire 22, 24, 26, etc. Relay *T1* or *T2* then picks up to transmit an even-numbered impulse, and relay *Z1* is operated to normal to pick up the next odd-numbered counting relay *O3*, *O5*, etc., and to operate relay *ZP* to normal, which releases relay *T1* or *T2*, whereupon relay *Y1* is operated to normal to complete the next circuit over wire 23, 25, etc., this process continuing step by step until the code is completed. When relay *O6* picks up on the fifth step, relay *CR1* reverses in response to the closing of the circuit from terminal *B* at back contact *j* of relay *T3*, wire 19, contact *c* of relay *O6* through the lower winding of relay

CR1 to terminal *C*. Relay *CR1* closes its right-hand contacts *a* and *b* to prepare circuits extending over contacts *e* and *f* of relay *ISD* and wires 26—32 for selecting the character of the sixth to twelfth impulses, inclusive. The reversal of contact *c* of relay *CR1* prepares a circuit over contact *b* of relay *O6* for operating relay *O1* on the sixth step, and contact *d* of relay *CR1* prepares a circuit over contact *g* of relay *O6* for operating relay *O12* in place of relay *O6* on the eleventh step. It may be that some of the steps are not needed for control purposes, in which case the corresponding wires as shown for wires 25—32 in Fig. 3B are connected directly to wire 15 so as to provide the *X* character for each of these steps.

On the eleventh step, relay *T1* or *T2* picks up over wire 31, and relay *O12* over contact *b* of relay *O5*, and when relay *O12* picks up relay *IST* is picked up over a circuit extending from terminal *B* at contact *g* of relay *T3*, contacts *c* of relays *ISP* and *O12* through the upper winding of relay *IST* and thence to terminal *C* over wire 13. Relay *IST* closes its contact *a* and thereby reestablishes its normally closed stick circuit, and opens its contact *b* to release relay *ISP*. Relay *T1* or *T2* reverses relay *Z1*, relay *Z1* reverses relay *ZP*, and then relay *T1* or *T2* releases to operate relay *Y1* to re-reverse. Relay *T1* or *T2* then picks up over wire 32 to transmit the twelfth impulse, restoring relays *Z1* and *ZP* to normal, thereby releasing relay *O12* and relay *T1* or *T2*, which then restores relay *Y1* to normal.

Relays *T1* and *T2* now remain released, consequently relay *TP* releases, closing a circuit from terminal *B* over contacts *j* of relays *TP* and *W1* through the upper winding of relay *CR1* to terminal *C*, restoring relay *CR1* to normal. The opening of contact *b* of relay *TP* releases relay *L0*, and relay *L0* in turn releases relay *X1*. The closing of contact *b* of relay *L0* completes a pick-up circuit for relay *T3*, which now becomes energized to supply a *Z* impulse to the line, that is to say, to restore the line circuit to its normal closed condition, whereupon relay *L0* becomes reenergized over its upper winding. Relay *T3* completes a stick circuit at its contact *a* and so remains picked up after relay *L0* is reenergized. The opening of contact *j* of relay *T3* extinguishes lamp *CE* and the opening of contact *g* of relay *T3* releases relays *ISD* and *STP*. When relay *L0* becomes reenergized, the closing of its contact *c* completes the circuit for energizing relay *W1* and for holding relay *Z1* which completes the restoration of the transmitter to its normal at rest condition.

In the foregoing it has been pointed out that a switch control code is initiated by momentarily interrupting the normally closed starting circuit extending from wire 13 over certain lever contacts *a* to terminal *C*, to release relay *IST* and to pick up relays *ISP* and *ISD*. The transmission of a signal control code is effected in a similar manner by momentarily interrupting the starting circuit extending from wire 14 over the contacts *a* of the signal levers *SIG* and of the call-on push buttons *PB*, to terminal *C*. To clear signal *2RC*, for example, lever *2SIG* is pressed to release the lever latch thereby opening its contact *a* to release relay *2ST*, and is then turned to the right and released, the closing of its contact *a* completing a circuit over wire 14, contacts *b* of relays *2ST* and *ISP*, to pick up relay *2SP* by energizing its upper winding over contact *d* of relay *STP*. The closing of contact *a* of relay *2SP* then energizes the upper winding of relay *STP*

in series with the lower winding of relay 2SP, and relay STP picks up, closing its contact *c* to pick up relay TP, which releases relay T3 to pick up relay 2SD. Relay 2SD completes a connection from wire 41 to wire 16 to energize relay T2 causing the first impulse to be a Y impulse and completes connections over wires 42—52 and contacts *d* and *f* of the counting relays for controlling the character of the remaining steps, the signal control code being in other respects similar to the switch code as described above in detail.

It may happen that the starting circuits over wires 13 and 14 are both opened at the same time while the system is at rest so as to release relays 1ST and 2ST simultaneously. In this case relay 1SP picks up and relay 2SP remains released due to the opening of its circuit by contact *b* of relay 1SP, so that relay 1SD becomes energized and a switch control code is transmitted. Relay 1ST is reenergized on the eleventh step of the code releasing relay 1SP as already described. When relay T3 picks up at the end of the code, relay 2SP picks up over the circuit from terminal B at contact *e* of relay T3 over contact *b* of relay 1SD through the upper winding of relay 2SP and over contacts *b* of relays 1SP and 2ST and wire 14 to terminal C. The stick circuit for relay STP is opened at contact *g* of relay T3 at the same time, but relay 2ST picks up quickly closing its contact *a* to energize relay STP in series with its lower winding so that relay STP remains picked up. Relay 1SD releases due to the opening of contact *g* of relay T3; relay L0 picks up and reenergizes relay W1, whereupon relay TP picks up to release relay T3, which picks up relay 2SD to initiate a signal control code.

It will be seen therefore that a code started by opening wire 13 takes precedence over one started by opening wire 14, if both starting circuits are opened at the same time while the system is at rest.

Assuming that a switch lever is operated during the transmission of a switch control code but that no signal lever is operated so that relay 2ST remains energized, it will be seen that relay 1SP will be released by the momentary opening of the starting circuit over wire 13 while the switch control code is in progress so that relay 1ST will not become reenergized on the eleventh step, due to the opening of contact *c* of relay 1SP. In this case, when relay T3 picks up at the end of the code, the opening of its contact *g* releases relays STP and 1SD, and relay 1SP picks up over contact *b* of relay STP, and is then held energized and relay STP is reenergized over contact *a* of relay 1SP. Relay T3 energizes relay L0 which picks up relay W1 and then relay TP picks up over contact *c* of relay STP releasing relay T3 to pick up relay 1SD to initiate a second switch control code.

Two codes stored by the release of relay 1ST will thus be transmitted successively only if relay 2ST is not released, and similarly, two codes stored by the release of relay 2ST will be transmitted successively only if relay 1ST is not released. If the starting circuits over wires 13 and 14 are interrupted repeatedly to effect the transmission of a series of codes, the two codes will alternate, due to the operation of contacts *b* of relays 1SD and 2SD. In this case relay STP remains picked up, relay 2SP picks up over wire 14 at the end of a code governed by relay 1SD, and relay 1SP picks up over wire 13 at the end of a code governed by relay 2SD, thereby limiting the delay in transmitting a code including a par-

ticular element in either group to the time required to transmit one code.

The switch control code just described may be repeated at a slow rate for test or observation by reversing the manually operable switch HS1 and then operating the push button 1STB momentarily to release relay 1ST. Relays 1SP, STP and TP then pick up as already described, relay TP completing a stick circuit at its contact *e* extending to terminal B over contacts *a* of switches HS1 and HS2, and then relay T3 releases and relays X1, O1 and 1SD pick up and relay W1 releases in the normal manner, the closing of contact *g* of relay W1 preparing a circuit for relay T1, extending to terminal B over contacts *b* of switches HS1 and HS2. The line circuit therefore is opened by the release of relay T3, and is closed by operating switch HS2 to pick up relay T1. Relay T1 by closing its contact *e* completes a stick circuit for relay TP and reverses relay ZP. Relay ZP opens the pick-up circuit for relay T1 but relay T1 is now held energized over a stick circuit including its contact *a* and contact *b* of switch HS2 and remains picked up until switch HS2 is manually released, whereupon the stick circuit for relay TP including its contact *e* is re-established. The code therefore may be transmitted step by step by repeatedly operating switch HS2. Relay O12 releases on the twelfth step, and consequently the thirteenth operation of switch HS2 fails to pick up relay T1 or T2, consequently relay TP releases and in turn releases relay L0 to complete the pick-up circuit for relay T3 extending to terminal B at contact *h* of relay T2. Relay T3 closes the normal line circuit, restoring the apparatus to normal in the usual manner, whereupon switch HS2 may be released.

When relay W1 picks up, if a second code is stored for transmission so that contact *c* of relay STP is closed, relay TP will be reenergized opening the normal stick circuit for relay T3, but relay T3 is held energized until switch HS2 is released due to the provision of an auxiliary stick circuit including contact *f* of relay W1.

I shall now explain how the above described switch control code is received by the station receiver of Fig. 2.

When the line circuit is initially opened by the release of relay T3, relay L3 releases, its contact *a* opening the normally closed circuit including the upper windings of relays W2, 1CD, 2CD, CR2 and Z2, and its contact *b* closing a circuit through relay X2 over contacts *b* of relays L1 and L2, contact *a* and the lower winding of relay W2 and the upper winding of relay Y2 to terminal C, whereby relay X2 is picked up, relay W2 held energized and relay Y2 held normal. The closing of contact *c* of relay X2 completes a circuit from terminal B at contact *d* of relay L3 over contacts *c* of relays X2, Z2, W2 and CRP through relay 1 to terminal C. Relay 1 picks up completing a stick circuit at its contact *a*.

The first impulse of the code being of the X character, current flows from the positive terminal of battery 80 over contact *d* of relay T1 and line X through both windings of line relay L1 from left to right and through both windings of line relay L2 from right to left, to line Y and thence over contact *c* of relay T1 to the negative terminal battery 80, consequently relay L1 picks up, closing its contacts *a* and *c* while relay L2 remains released. Relay L1 completes a circuit from terminal B at its contact *c* over contacts *c* of relays Y2 and 1, wire 61, contact *d* of relay CRP, through the lower windings of relays 1CD

and 2CD, reversing relay 1CD and holding relay 2CD normal. The opening of contact *b* of relay L1 releases relay W2. The closing of contact *a* of relay L1 completes a circuit from terminal B at contact *b* of relay L3 including the winding and front contact *a* of relay X2, contacts *a* of relays L1 and Y2 through the lower winding of relay Z2 to terminal C, holding relay X2 energized and reversing relay Z2. Relay Z2 completes a circuit from terminal B at contact *d* of relay L3 over contact *c* of relay X2, contact *d* of relay Z2, contact *b* of relay 1 through relay 2 to terminal C. Relay 2 picks up, completing a stick circuit at its contact *a*, and relay 1 releases in response to the opening of contacts *c* of relays W2 and Z2.

Relay L1 releases upon the termination of the first impulse, its contact *a* opens and its contact *d* closes to shift the stick circuit for relay X2 from the branch including relay Z2 to one extending over contacts *d* of relays L1, L2 and W2, contact *b* of relay Z2 through the lower winding of relay Y2 to terminal C, thereby reversing relay Y2.

The second impulse of the code is of the Y character corresponding with the assumed reverse position of contact *c* of relay 1P of Fig. 3B, current now flows from the positive terminal of battery 80 over contact *d* of relay T2 to line Y, and thence through both windings of relay L1 from right to left, and through both windings of relay L2 from left to right, to line X and over contact *c* of relay T2 to the negative terminal of battery 80, consequently relay L2 becomes energized, relay L1 remaining released. Contact *a* of relay L2 closes and its contact *d* opens to shift the circuit for relay X2 from the branch including relay Z2 to one extending over contact *b* of relay Y2 through the upper winding of relay Z2 to terminal C, thereby operating relay Z2 to normal. The closing of contact *c* of relay L2 completes a circuit from the middle terminal O of the local battery, Fig. 4C, contact *b* of the switch locking relay 1LR through relay 1WS to terminal 62, thence, in Fig. 2, over contact *c* of relay 2, contact *a* of relay CRP, contact *b* of relay 1CD, contact *d* of relay Y2 to terminal C at contact *c* of relay L2. Relay 1WS is thereby operated to reverse, provided the switch locking relay 1LR is energized, relay 1LR being controlled by the interlocking circuits of Figs. 4A and 4B in such a manner that it is energized only when traffic conditions are proper for the operation of the track switch 1W.

The operation of relay Z2 to normal completes a circuit from terminal B at contact *d* of relay L3 over contacts *c* of relays X2 and Z2, contact *b* of relay 2 through relay 3 to terminal C, so that relay 3 picks up establishing a stick circuit at its contact *a*. The opening of contact *d* of relay Z2 releases relay 2, which relay by opening its contact *c* terminates the impulse delivered to relay 1WS.

Relay L2 releases upon the termination of the second impulse, its contact *a* opens and its contact *d* closes to shift the circuit for relay X2 from the branch including relay Z2 to one extending over contact *a* of relay Z2 through the upper winding of relay Y2 to terminal C, thereby operating relay Y2 to normal.

The third impulse is of the X character, like the first, except that in this case its character corresponds with the normal position of contact *c* of relay 3P of Fig. 3B, and consequently relay L1 becomes energized in the same manner as on

the first step already described, completing a circuit over its contact *a* and contact *a* of relay Y2 as on the first step to reverse relay Z2. The closing of contact *c* of relay L1 on the third step completes a circuit from terminal B over contact *c* of relay Y2, contacts *a* of relays 1CD, CR2, contact *c* of relay 3, wire 63 through relay 3WS, Fig. 4C, thence over contact *b* of relay 3LR to terminal O, thereby checking relay 3W in its normal position, provided relay 3LR is energized.

Reviewing the receiving operations as so far described, it will be seen that the first counting relay 1 picks up in the interval preceding the first impulse of the code and prepares a circuit over wire 61 to reverse the delivery relay 1CD if the first impulse is an X impulse to which relay L1 responds, and relay 1CD prepares circuits over wires 62-72 to operate a group of stick polar relays to normal or reverse in accordance with the X or Y character of the remaining impulses. Similarly, if the first impulse is of the Y character, as in the case of a signal control code initiated by releasing the office storage relay 2ST, relay L2 responds to the first impulse to reverse relay 2CD to prepare circuits over wires 82-92 to operate a second group of stick polar relays such as the signal control relays 2LHS, 2RHS, 2COS, etc., of Fig. 4C, in accordance with the character of the remaining impulses.

When relay L1 or L2 picks up in response to an odd-numbered impulse relay Z2 reverses and picks up an even-numbered counting relay 2, 4, 6, etc., relay Y1 reversing when relay L1 or L2 releases. On each even-numbered impulse relay L1 or L2 restores relay Z2 to normal to pick up an odd-numbered counting relay 3, 5, etc., and relay Y1 is restored to normal when relay L1 or L2 releases. Relays CR2 and CRP are reversed by the closing of contact *c* of relay 6 on the fifth step, contact *c* of relay CRP preparing a circuit for operating relay 1 on the sixth step, and contact *d* of relay CR2 preparing one for operating relay 12 on the eleventh step, the counting relays operating through two cycles like the corresponding relays of Fig. 1 as already described. On the twelfth step, an impulse is supplied to wire 72 or 92 and relay Z2 is operated to normal, releasing relay 12, and when relay L1 or L2 releases, relay Y2 is operated to normal.

A reset impulse of the Z character follows the final code impulse, energizing relay L3. The opening of contact *b* of relay L3 releases relay X2, and the closing of contact *a* of relay L3 picks up relay W2 and operates relays 1CD and CR2 to normal and holds relays 2CD and Z2 normal. Relay CR2 restores relay CRP to normal, the receiving apparatus then being in the condition shown in the drawings.

In the foregoing I have explained how the various polar stick control relays are controlled by the code apparatus of Figs. 1 and 2 over sequentially established communication channels all including the same line wires X and Y, and since the indication system employs similar apparatus it will be understood that the polar stick indication relays of Fig. 3A are similarly controlled by the operation of the indicating relay contacts of Fig. 4A. For an understanding of the operation of these polar stick control and indication relays in the system it is often convenient to note that the sequentially established code channels may be replaced by separate direct wire connections, this being the usual practice for the control of a zone in the immediate vicinity of the control office in conjunction with code control of

the more distant zones. For direct wire control, Figs. 1 and 2 are omitted; terminals 15 and 16 are connected to terminals B and C, respectively, in Figs. 3B and 4A, instead of to the code transmitters; while the control wires 62—64 and 82—87 of Fig. 4C are connected respectively to wires 22—24 and 42—47 of Fig. 3B, and the indication wires 62—67 and 82—89 of Fig. 3A are connected respectively to wires 22—27 and 42—49 of Fig. 4A instead of to the code receivers.

The code transmitter and receiver at the station are so arranged that each control code is followed by the transmission of an indication code by the station transmitter. The reversal of relay 1CD by the first impulse of the control code just described opens its contact *d*, which is included in the starting circuit for the station transmitter as shown in Fig. 4A. Consequently the station relay 1ST, Fig. 1, releases on the first step of the control code, and the closing of contact *d* of relay 1CD during the reset impulse following the control code picks up relay 1SP to initiate the indication code.

The reversal of relay 1WS by the control code reverses the switch operating relay 1WR, Fig. 4C, for the switch machine 1SM, thereby operating switch 1W to reverse, contact *b* of relay 1WS opening the normal switch indication circuit including relay 1WP and 1NWP, Fig. 4A, and preparing a circuit for energizing relay 1RWP when the switch machine 1SM completes its operation and locks switch 1W in its reverse position. These indication circuits are of the type disclosed in a pending application for Letters Patent of the United States, Serial No. 465,183, filed November 12, 1942, by Arthur E. Dodd, for Electrical control apparatus. It will be evident that the control code will be followed by two indication codes. The first is initiated by the operation of contact *d* of relay 1CD when relays 1NWP and 1RWP are both released to connect wires 22 and 23 over back contacts *c* of these relays to wire 16, as shown in Fig. 4A, so that the second and third impulses of the first indication code are Y impulses. The office receiver is consequently conditioned to supply impulses of reverse polarity over wires 62 and 63, Fig. 3A. The circuit for the second impulse including wire 62 is open at the left-hand contact *b* of relay 1P, which stands open under the conditions assumed. The circuit for the third impulse is completed from terminal O, Fig. 3A, through relay 1WK and the reverse contact *b* of relay 1P to wire 63 and thence to terminal C at contact *c* of relay L2 of the office receiver tending to operate relay 1WK to reverse, but as assumed, relay 1WK has already been reversed by the closing of the circuit over wire 37. The second indication code is initiated by the momentary opening of contact *a* of relay 1RWP as that relay picks up when switch 1W becomes locked reverse, and since contact *c* of relay 1RWP is connected to wires 15 and 23, relay 1WK is operated to normal over wire 63 to complete a circuit at its contact *b* to reenergize relay 1WC, thereby extinguishing lamp 1WE, and preparing a pick-up circuit for relay 2RH.

I shall now describe the operations involved in the transmission of a control code for clearing signal 2RC. Noting that the switch lever lamps 1WE and 3WE are both dark, indicating that a route corresponding to the positions of levers 1SW and 3SW is established, the operator moves lever 2SIG to its right-hand position to initiate a control code for clearing signal 2RC. The opening of contact *a* of lever 2SIG releases relay

2ST, and the subsequent closing of this contact when the lever is released effects the energization of relays 2SP, STP and TP, and relay TP releases relay T3 to pick up relay 2SD, as hereinbefore described. The closing of contact *c* of lever 2SIG energizes the lever repeating relay 2RP, which relay completes a route circuit extending in Fig. 3A from terminal B at contact *g* of relay 2LP over contact *b* of relay 2NK, contacts *a* of relays 3PP, 3WC, 1WC and 2NK, contact *c* of relay 2RP through the route relay 2RH to terminal C. Relay 2RH picks up and completes a circuit for lighting the red lamp 2GE associated with lever 2SIG, extending from terminal B at contact *d* of relay 2GKS over contact *d* of relay 2GK, contact *c* of relay 2RH and the right-hand contact *d* of lever 2SIG through lamp 2GE to terminal C. Relay 2NK, Fig. 3A, is now operated to reverse over the circuit including contacts *b* of relays 2RP and 2RH and by the operation of its contacts *a* and *c* disconnects relay 2RH from the route circuit network and holds relay 2RH energized over a stick circuit including its own front contact *a* and contact *c* of relay 2NK. Relay 2RH also prepares a circuit in Fig. 3B from wire 16 over front contacts *d* of relays 2RH and 2RP to wire 43 so that the third impulse of the resulting signal control code operates relay 2RHS, Fig. 4C, to reverse over wire 83.

The reversal of the signal control relay 2RHS opens its contact *c* in the circuit for relay 2RAS, Fig. 4B. These approach locking stick relays RAS and LAS are controlled in the manner disclosed in Letters Patent of the United States No. 2,198,712, granted April 30, 1940, to Harry C. Vantassel, for Railway traffic controlling apparatus. Relay 2RAS therefore releases, opening its contact *b* in the circuits for the switch locking relays 1LR and 3LR to lock the switches for routes over which traffic movements are governed by the signals which relay 2RHS controls. Relays 1LR and 3LR therefore release, closing their back contacts *f* in the signal network comprising the upper portion of Fig. 4B, to complete a circuit for mechanism 2RCG which extends from terminal B at front contact *d* of relay 2LAS over contact *f* of relay 3LR, contact *b* of relay 3NWP, contact *f* of relay 1LR, contact *b* of relay 1RWP, back contact *d* of relay 2RAS, reverse contact *a* of relay 2RHS, normal contact *a* of relay 2COS, contact *e* of relay 3NWP, contacts *b* of the track relay 3TR and the track stick relay 1TPS, the reverse contact *a* of relay 1WP through mechanism 2RCG and over the reverse contacts *d* of relay 1WP and *b* of relay 2RHS to terminal C. Mechanism 2RCG thus becomes energized to clear signal 2RC and to release the signal indicating relay 2RGP shown in the lower portion of Fig. 4B.

By reference to Fig. 4A it will be seen that the operation of relay 2CD and the release of relays 2LAS, 1LR, 3LR and 2RGP will interrupt the circuits over wires 13 and 14 to initiate two and possibly three indication codes in response to which the lock indication relays 1LK and 3LK, Fig. 3A, are operated to reverse over wires 64 and 67, relays 1WK and 3WK are checked normal over wires 63 and 65, relay 2NK is checked reverse over wire 82, relays 4NK and 4GK are checked normal over wires 84 and 85, and relay 2GK is operated to reverse over wire 83. The opening of contacts *a* of relays 1LK and 3LK locks relays 1WK and 3WK normal, and thereby locks relay 1P reverse and relays 3P and 3PP normal, rendering these relays non-responsive

to the operation of levers 1SW and 3SW. If now lever 1SW is inadvertently operated or if the track switch should become displaced or unlocked mechanically by the switch machine 1SM so as to release relay 1RWP and thereby operate relay 1WK to reverse, relay 1WC will release due to the opening of the reverse contact *c* of lever 1SW or of the normal contact *b* of relay 1WK to complete a circuit for flashing lamp 1WE, which extends from contact *a* of a flasher relay CT over contact *g* of relay 1WC and the normal contact *d* of relay 1WK, or over the reverse contacts *d* of relays 1LK and 1WK through lamp 1WE to terminal C.

It will be seen therefore that if a switch lever is moved or a track switch becomes displaced when it is not locked electrically, its relay LR being energized, a steady light will be displayed by the lamp WE associated with the lever, but if its relay LR stands released at the time a flashing light will appear to inform the operator that the switch cannot be operated and if this is due to a lever movement that the lever should be returned to its original position.

It will also be seen that when the track switches are locked electrically their control relays WS are rendered non-responsive to control code impulses, due to the opening of contacts *b* of the relays LR. The switch control circuits thus include a "non-storage" feature whereby the switch control relays are rendered responsive to the operation of their respective levers only if the levers are operated at a time when the track switches are free to respond. Switch control codes however may be freely transmitted including the elements assigned to the control of the electrically locked switches for the purpose of operating other track switches or for other purposes to control relay MCS, for example.

The reversal of the signal indication relay 2GK completes a pick-up circuit for relay 2GKS, Fig. 3B, extending from terminal B at contact *f* of relay 2RP over contact *a* of relay 2GK through relay 2GKS to terminal C, relay 2GKS picking up and completing a stick circuit at its contact *a*. Relay 2GK also extinguishes the red lamp 2GE by opening its contact *c* and completes a circuit for lighting a green lamp 2RCE, Fig. 3A, for illuminating the representation of signal 2RC on the track diagram, this circuit extending from terminal B at contact *b* of relay 2GK over contact *f* of relay 2RH, contact *c* of relay 1WK, reverse contact *b* of relay 1P through lamp 2RCE to terminal C.

The circuits including wires 13 and 14 by which the above described indication codes are initiated differ in one respect from those at the office as described in connection with Fig. 1, as will now be pointed out. Since the initiation of the codes is dependent upon the integrity of these circuits, which are more susceptible to failure because of the number of contacts in series, emergency connections to terminal C over wires 17 and 18 are provided. If, for example, one of the indicating relays such as relay 2RGP opens its front contact *a* to release relay 2ST, Fig. 1, and if due to a fault the closing of its back contact *a* fails to re-establish the connection to terminal C to pick up relay 2SP, the transmitter which otherwise would be unable to function, is set into operation by picking up relay 2SP over the connection from wire 14 to wire 18, contact *d* of relay 2ST to terminal C at contact *f* of relay 2SD. Since this connection includes back contact *d* of relay 2ST it does not provide a circuit for holding re-

lay 2ST energized, consequently it causes the code initiated by relay 2ST to be transmitted repeatedly, with codes initiated by relay 1ST interposed at intervals whenever the circuit over wire 13 is momentarily opened, until the fault is corrected, thereby enabling the system to be kept in operation.

I shall next assume that the approaching train governed by signal 2RC enters section 1T. This releases the track relay 1TR, which in turn releases relays 1TP and 1TPS. The opening of contact *b* of relay 1TPS opens the circuit for mechanism 2RCG, restoring signal 2RC to stop, and reenergizing relay 2RGP, and an indication code is initiated in response to which relay 1TK is operated to reverse over wire 86 to light the red lamp 2TKE in the track diagram and relay 2GK is operated to normal over wire 83. Relay 2GK extinguishes the green lamp 2RCE, and completes a circuit for flashing the red lamp 2GE, extending from contact *a* of the flasher relay CT over contacts *c* and *d* of relay 2GKS and 2GK, contact *c* of relay 2RH, contact *d* of lever 2SIG through lamp 2GE to terminal C. Lamp 2GE is thereby supplied with interrupted current and continues to flash until lever 2SIG is restored to normal.

If the train now vacates section 1T, the energization of relays TR and TP initiates an indication code to extinguish lamp 1TKE, but conditions otherwise remain the same. The signal is held at stop by relay 2TPS, which remains released because contact *f* of relay 2RAS in its pick-up circuit is open, and relay 2RAS remains released because its circuits include the normal contact *c* of relay 2RHS which relay remains reversed.

The operator now restores lever 2SIG to normal, releasing relays 2RP and 2GKS, thereby lighting lamp 2GE steadily over the circuit extending from terminal B at contact *d* of relay 2NK over the middle contact *d* of lever 2SIG to terminal C, and initiating a signal control code in which wire 43 is connected over contact *h* of relay 2RP to wire 15 to operate relay 2RHS, Fig. 4C, to normal over wire 83. Relay 2RAS then picks up over the circuit extending from terminal B at contact *c* of relay 2RHS, contact *d* of relay 2RGP, contacts *c* of relays 1TPS and 2COS through relay 2RAS to terminal C, relay 2RAS completing a stick circuit at its contact *e*. Relay 1TPS now picks up over contact *f* of relay 2RAS, and relays 1LR and 3LR pick up over contact *b* of relay 2RAS, provided section 1T has been vacated so that contact *e* of relay 1TR is closed. Relay 2RAS initiates an indication code in which wire 42 is connected to wire 15, causing relay 2NK, Fig. 3A, to be restored to normal over wire 82, and relay 2NK by opening its contacts *c* and *d* releases relay 2RH and extinguishes lamp 2GE.

The energization of relays 1LR and 3LR initiates an indication code restoring relays 1LK and 3LK to normal. If lever 2SIG is restored to normal while section 1T is occupied, this code will be transmitted when the section becomes vacated and will include the impulse for extinguishing lamp 1TE, indicating that levers 1SW and 3SW are again free to be operated.

It will be seen that if a signal lever is moved from normal to right or left when the switches in the route correspond in position with their switch levers and no conflicting route is set up, a steady red light will be displayed by the lamp GE associated with the lever, which will become dark and

a green light will be displayed at the signal location in the track diagram when the signal clears. If the lever is reversed when these conditions are not met, or if the signal is put to stop by train movement, a flashing light is displayed by lamp GE until the signal lever is restored to normal.

I shall now assume that signal 2RC has been cleared as above described and that the operator desires to restore it manually to stop to set up a different route, such for example, as the one governed by signal 2RC which extends over switches 3W and 3AW reversed. The operator will first restore lever 2SIG to its normal center position, releasing relays 2RP and 2GKS. The green lamp 2RCE remains lighted, and the red lamp 2GE becomes lighted over the normal contact d of lever 2SIG, and a signal control code is transmitted as before, to restore relay 2RHS to normal. Mechanism 2RCG is thereby deenergized to put signal 2RC to stop, and relay 2RGP becomes reenergized to initiate a code to restore relay 2GK to normal, thereby extinguishing lamp 2RCE.

The reenergization of relay 2RAS is delayed by the operation of the time locking, the closing of contact c of relay 2RHS and contact d of relay 2RGP completing a circuit for a thermal relay 2RTE, which after a suitable time picks up a stick relay 2TES, deenergizing relay 2RTE, which then returns to its normal condition after a further time interval to complete a pick-up circuit for relay 2RAS including contact b of relay 2RTE and contacts c and d of relay 2TES. Relay 2RAS then picks up, reenergizing relays 1LR and 3LR, and initiating a code to restore relay 2NK to normal, thereby releasing relay 2RH and extinguishing lamp 2GE. Relays 1LR and 3LR initiate a second indication code to restore relays 1LK and 3LK to normal.

The operator now reverses lever 3SW, initiating a switch control code in the manner hereinbefore described to reverse switches 3W and 3AW, lamp 3WE becoming lighted in response to the lever operation and extinguished upon the receipt of an indication code indicating that switches 3W and 3AW are mechanically locked reverse.

The operator then operates lever 2SIG to the right, the operations differing from those already described only in that relay 2RH is now picked up over the route circuit which extends to terminal B over the reverse contact a of relay 3PP, contact b of relay 4NK and contact g of relay 4LP, and mechanism 2RCG is energized over the corresponding circuit in Fig. 4B extending to terminal B at front contact d of relay 4LAS and including contact g of relay 3LR, contacts b of relays 3RWP and 3TP and contacts a of relays 4LTR and 3WP.

It will be seen from Fig. 3A that relays 4RH and 4LH are now rendered non-responsive to the operation of lever 4SIG, even though lever 2SIG is restored to normal, for the reason that contact b of relay 3PP and contact a of relay 2NK are open, and if lever 4SIG is now moved to the left or right, lamp 4GE will be caused to flash due to the closing of its circuit over back contact g of relay 4LH or 4RH, in Fig. 3B, indicating that none of the routes governed by lever 4SIG are available.

If one or more of the track sections 1T, 3T or 4LT of the route just described are occupied by a train, the call-on signal 2RD may be cleared to permit a second train to enter the route. To clear signal 2RD, the operator leaves or places lever 2SIG in its right-hand position so that relays

2RP and 2RH will be energized to operate relay 2RHS to reverse, and then presses button 2PB momentarily to pick up relay 2CO over the circuit from terminal B at contact f of relay 2RP through relay 2CO and over contact b of button 2PB to terminal C, relay 2CO completing a stick circuit at its contact a. Wire 44 is thereby connected to wire 16 over contact c of relay 2CO so that the resulting control code will cause relay 2COS, Fig. 4C, to be operated to reverse over the connection from terminal B over contacts b of relays 2LGP and 2RGP through relay 2COS to wire 84 and thence in Fig. 2 to terminal C at contact c of relay L2. The closing of the right-hand contact a of relay 2COS in the signal circuit network, Fig. 4B, completes a circuit for energizing mechanism 2RDG, which circuit is similar to the one for mechanism 2RCG already traced, except that it does not include contacts of the track relays for the route. Signal 2RD is thereby cleared and relay 2RGP releases to initiate an indication code, thereby reversing relay 2GK to extinguish lamp 2GE and to light lamp 2RCE, the same as when the proceed signal 2RC is cleared.

To put the call-on signal to stop, the operator restores lever 2SIG to normal, thereby releasing relays 2RP and 2CO, and initiating a control code which restores relay 2RHS to normal. Wire 44 is now connected to wire 15 over contact d of relay 2CO so that an X impulse is transmitted over the channel assigned to relay 2COS, the circuit for which is open at contact b of relay 2RGP. Signal 2RD is put to stop by the operation of relay 2RHS to normal, thereby reenergizing relay 2RGP. It is to be noted that with relay 2CO released, control codes transmitted after relay 2RGP picks up are not effective to restore relay 2COS to normal because relay L1 picks up on the assigned step and connects terminal B to wire 84, which merely establishes the same potential at both terminals of relay 2COS. The closing of the normal contact c of relay 2RHS completes a pick-up circuit for relay 2RAS, provided section 1T of the route is still occupied, over contacts c of relays 1TPS and 1TR, reenergizing relay 2RAS, which relay restores relay 2COS to normal by completing a circuit from terminal B over contacts g of relays 2RAS and 2LAS, Fig. 4C, through the lower winding of relay 2COS to terminal C. If the call-on signal 2RD is restored manually to stop while section 1T is unoccupied, relay 2RAS can be picked up only at the end of the time locking period, due to the provision of contacts c of relays 2COS and 1TR in the release circuit for relay 2RAS which includes contact c of relay 1TPS. Without this provision it would be possible to put signal 2RD to stop while a train was approaching and to then operate switch 1W under conditions such that the train might be unable to stop without overrunning the switch in transit, since signal 4RD may be cleared while relay 1TPS is released.

It will be noted that when a signal has been cleared, it cannot be put to stop inadvertently by the operation of any lever other than its control lever, nor by the operation of a call-on push-button, although the clearing of the signal as effected through the route circuits of Fig. 3A is dependent upon the position of the switch lever for each switch of the route and of the signal lever for the opposing signal for the route. Furthermore, the time and approach locking which governs the transmission of codes

for operating the track switches also governs the transmission of signal control codes for reversing the direction of traffic movements over a route. It will also be noted that a repetition of a code for clearing a signal which has been put to stop by a train is effective only if it is the result of a second operation of the signal lever.

In the foregoing I have described but a few typical operations of the control system, but as the remainder are carried out in a manner similar to those described, it is believed that they will be understood without further explanation.

Although I have herein shown and described only one form of remote control system embodying 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, a code transmitter and a receiver, each including a chain of counting relays, three line wires connecting said code transmitter and receiver, three line relays for controlling the receiver each selectively responsive to current of a given polarity only transmitted over the corresponding one of said line wires from a source adjacent said transmitter and returning to said source through the winding of another of said line relays and the line wire corresponding thereto, one of said line relays being normally energized by current from said source, a fourth line relay for controlling the transmitter normally energized in series with said source and said one line relay, a starting circuit effective only when said fourth line relay is energized for initiating the operation of the transmitter, means controlled by the transmitter when initiated for energizing the transmitter counting relays one at a time in order, and for disconnecting said source from one line wire to maintain said one line relay and said fourth line relay deenergized while supplying a series of impulses of current from said source of either polarity to the other two line wires in series to selectively operate the other receiver line relays in accordance with the relative polarity of said impulses, means controlled by said one line relay when deenergized for rendering the receiver counting relays responsive to the impulses received by said other line relays, a plurality of control relays, and means controlled by the receiver counting relays for rendering each control relay responsive to the relative polarity of a different one of said impulses.

2. In a remote control system, a three wire line circuit normally energized by current of a given polarity transmitted over one of the line wires and returning over the other two line wires in parallel, a chain of counting relays adapted to be operated one at a time in sequence in response to a series of current impulses, a line relay responsive only to current of said given polarity transmitted over said one line wire, a circuit closed in response to the release of said line relay for operating the first relay of said chain, and means responsive to a series of impulses transmitted over a two wire circuit comprising said other two line wires only and effective only so long as said line relay remains released for operating each succeeding relay of said chain.

3. In a remote control system, a source of current, a line circuit comprising three line wires

two of which are normally energized by current from said source of the same polarity, said current having a return path including the third line wire, a transmitter effective when initiated to disconnect said third line wire from said source and to then transmit a series of impulses of current of normal or reverse polarity from said source over a circuit formed by said two line wires, a receiver including a chain of counting relays and a line relay selectively responsive to the current in said third line wire, means responsive to the release of said line relay for energizing the first relay of said chain, means responsive to impulses transmitted over said two line wires for energizing each succeeding relay of the chain, means including a back contact of said line relay for holding each counting relay energized only until the next succeeding relay of the chain is energized, a series of control relays of the stick polar type, and means controlled by said counting relays for operating said polar stick relays successively to normal or reverse each in accordance with the relative polarity of a different impulse of said series.

4. In a remote control system, a source of current, two line wires normally energized by current of the same polarity supplied from said source over a third line wire, a receiver including a line relay responsive to said current, a code transmitter effective when initiated to temporarily disconnect said source from said third line wire and to then connect said source reversibly to said two line wires to thereby transmit a series of impulses of the opposite polarity over one or the other of said two line wires while the third wire is deenergized, a chain of counting relays controlled by said receiver, means controlled by said line relay in its released position for operating the first relay of the chain effective only when the operation of said code transmitter is initiated, pick-up circuits controlled by said receiver for operating the remaining relays of the chain one at a time in order to count the received impulses, a stick circuit for each counting relay, said pick-up and stick circuits including contacts closed by the line relay in its released position, and means controlled by said transmitter for energizing both line wires by said current of the same polarity to reenergize said line relay following the transmission of a predetermined number of impulses.

5. In a remote control system a line circuit comprising three line wires two of which are normally energized by current of the same polarity, said current having a return path including the third line wire, a transmitter effective when initiated to transmit a series of impulses of normal or reverse polarity over a circuit formed by said two line wires, a chain of counting relays for controlling the transmission of said impulses, a line check relay responsive to said impulses and also to current in said third line wire, means for locally energizing said line check relay during the intervals between successive impulses, means for energizing said counting relays one at a time in order to count the transmitted impulses and for releasing said line check relay after the last counting relay of the chain has been operated, a receiver including a line relay selectively responsive to the current in said third line wire, means responsive to the release of said line relay for rendering the receiver responsive to said impulses, and means responsive to the release of said line check relay for again supplying current of the same polarity to said two line wires.

6. In a remote control system, a code transmitter including three transmitter relays and a line check relay, a code receiver including three line relays, a line circuit comprising three line wires two of which are normally energized by current of the same polarity over front contacts of the first of said transmitter relays, said current having a return path including the first of said line relays and said line check relay, means dependent upon the continued energization of said line check relay and comprising the second and third transmitter relays for transmitting impulses of normal or reverse polarity over a circuit including said two line wires, said second and third line relays and said line check relay, a local circuit including back contacts of said second and third transmitting relays for maintaining the line check relay energized during the intervals between successive impulses, a receiver conditioned by the release of said first line relay to respond to the impulses received by said second and third line relays, and means for reenergizing said first transmitter relay after the transmission of a predetermined number of impulses.

7. In a remote control system, a line circuit, a code transmitter including three transmitter relays for controlling said line circuit, a slow release transmitter check relay for controlling said transmitter relays, an energizing circuit for the first transmitter relay including a back contact of said transmitter check relay, starting means for at times momentarily energizing said transmitter check relay, circuits including a front contact of said transmitter check relay for selectively and repeatedly energizing said second and third transmitter relays to deliver a series of impulses of selected character to said line circuit, and a stick circuit for said transmitter check relay completed upon the energization of either said second or third transmitter relay for intermittently energizing said transmitter check relay to maintain it picked up during the transmission of said series of impulses.

8. In a remote control system, a line circuit, a transmitter for delivering impulse codes to said line circuit, two groups of indicating relays, a storage relay, a repeating relay and a selector relay for each group, a normally closed stick circuit for each storage relay including contacts of each indication relay of its group, arranged to open the circuit momentarily in response to a change in position of such relay, pick-up and stick circuits for each repeating relay including a back contact of its storage relay and said contacts of the indication relays of its group, said pick-up circuits also including a contact closed only when the transmitter is in a normal at rest condition, and the circuits for one repeating relay including a back contact of the other, circuits closed by each repeating relay when energized for energizing the associated selector relay and for initiating the delivery of a code by said transmitter including impulses for indicating the positions of the indication relays of the corresponding group, a code receiver controlled over said line circuit and responsive to such code, means including said indication relay contacts for releasing the energized repeating relay without interrupting the code if a change occurs in the position of any of such indication relays during its transmission, and means for returning said transmitter to its normal at rest condition at the end of the code comprising a pick-up circuit for each storage relay including a front contact of the associated repeating relay.

9. In a remote control system, a line circuit, a transmitter for delivering impulse codes to said line circuit, two groups of indicating relays, a storage relay, a repeating relay and a selector relay for each group, a normally closed stick circuit for each storage relay including contacts of each indication relay of its group, arranged to open the circuit momentarily in response to a change in position of such relay, pick-up and stick circuits for each repeating relay including a back contact of its storage relay and said contacts of the indication relays of its group, said pick-up circuits also including a contact closed only when the transmitter is in a normal at rest condition, and the circuits for one repeating relay including a back contact of the other, circuits closed by each repeating relay when energized for energizing the associated selector relay and for initiating the delivery of a code by said transmitter including impulses for indicating the positions of the indication relays of the corresponding group, a code receiver controlled over said line circuit and responsive to such code, means including said indication relay contacts for releasing the energized repeating relay without interrupting the code if a change occurs in the position of any of such indication relays during its transmission, a pick-up circuit for each storage relay including a front contact of the associated repeating relay, and a pick-up circuit for each repeating relay including a back contact of the associated storage relay and a front contact of the selector relay associated with the other storage relay, rendering said repeating relays effective to initiate codes for indicating the condition of said two groups of indicating relays alternately in the event of repeated changes in the condition of such relays.

10. In a remote control system, a line circuit, a transmitter for delivering impulse codes to said line circuit, two groups of indicating relays, a storage relay, a repeating relay and a selector relay for each group, a normally closed stick circuit for each storage relay including contacts of each indication relay of its group, arranged to open the circuit momentarily in response to a change in position of such relay, pick-up and stick circuits for each repeating relay including a back contact of its storage relay and said contacts of the indication relays of its group, said pick-up circuits also including a contact closed only when the transmitter is in a normal at rest condition, and the circuits for one repeating relay including a back contact of the other, circuits closed by each repeating relay when energized for energizing the associated selector relay and for initiating the delivery of a code by said transmitter including impulses for indicating the positions of the indication relays of the corresponding group, a code receiver controlled over said line circuit and responsive to such code, means including said indication relay contacts for releasing the energized repeating relay without interrupting the code if a change occurs in the position of any of such indication relays during its transmission, a pick-up circuit for each storage relay including a front contact of the associated repeating relay and said contacts of the associated indicating relays, and an auxiliary energizing circuit for each repeating relay including back contacts of the associated storage and selector relays for effecting its energization in the event of a failure of its normal energizing circuit including said indicating relay contacts.

11. In a remote control system, an office and a

station connected by a line circuit, a group of indicating relays, a storage relay, a repeating relay and a selector relay at the station, a transmitter at the station for delivering an impulse code to said line circuit for indicating the positions of said selector and indication relays, receiving means at the office responsive to said code, a starting circuit which normally provides a stick circuit for the storage relay and when such relay is released provides an energizing circuit for the repeating relay, said circuit including contacts of each indication relay arranged to open the circuit momentarily in response to a change in position of such relay, circuits closed by the repeating relay when energized for energizing the selector relay and for initiating the delivery of a code by said transmitter, and an auxiliary circuit for energizing said repeating relay in the event said starting circuit remains open, including back contacts of the storage relay and of the selector relay.

12. In combination with a section of railway track having a track relay, a signal for governing the movement of traffic into said section, a signal control relay of the stick polar type, a normally energized approach locking relay associated with said signal, energizing circuits for said approach locking relay including a normal contact of said signal control relay and an indication contact closed only when the signal indicates stop, a track stick relay having a pick-up circuit including a front contact of said approach locking relay and a stick circuit including a front contact of said track relay, and an energizing circuit for said signal including a reverse contact of said signal control relay, a back contact of said approach locking relay and a front contact of said track stick relay.

13. In a system for controlling traffic movements over a railway track layout provided with track switches for forming different traffic routes and interlocked with signals controlled by traffic conditions for governing traffic movements over such routes; switch levers, signal levers, and a normally inactive code transmitter controlled by said levers for controlling said switches and signals; a switch storage relay and selector relay, a signal storage relay and selector relay, means responsive to a change in position of any switch lever or of any signal lever for actuating the switch storage relay or the signal storage relay, respectively, means controlled by the switch stor-

age relay when actuated for energizing the switch selector relay and for initiating the transmission of a series of impulses selected thereby each adapted to operate a different track switch to a position corresponding to that of its switch lever, means controlled by traffic conditions for preventing the reception of each such impulse except when the corresponding switch is free to be operated, means controlled by the signal storage relay when actuated for energizing the signal selector relay and for initiating the transmission of a series of impulses selected thereby each adapted to operate a different signal to a position corresponding to that of its signal lever, and means for preventing the response of each signal to its code impulse in the event such signal has responded to a similar impulse in a preceding code and its condition has then been changed due to a change in traffic conditions in said layout.

14. In a system for controlling traffic movements over a railway track layout provided with track switches for forming different traffic routes and interlocking with signals for governing traffic movements over such routes, switch levers and signal levers for manually controlling said switches and signals, an indication relay of the stick polar type controlled by each signal, a route relay for each signal having a stick circuit including a reverse contact of the associated indication relay, a route circuit network including a circuit for each route through the track layout extending between normally closed contacts of the indication relays for the opposite ends of the route and including contacts controlled by each switch of its route which are closed only when the switch is in the position required for such route and in correspondence with its switch lever, each such indication relay contact connecting the route circuit to a source of current when the signal lever for the corresponding signal is normal and through the route relay for such signal to the other terminal of the source when such signal lever is reversed, means controlled by each route relay when energized over a selected route circuit in response to the reversal of its signal lever for reversing the associated indication relay to isolate such relay from the route circuit network and to complete its stick circuit, and means controlled by each route relay when energized for clearing the corresponding signal.

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