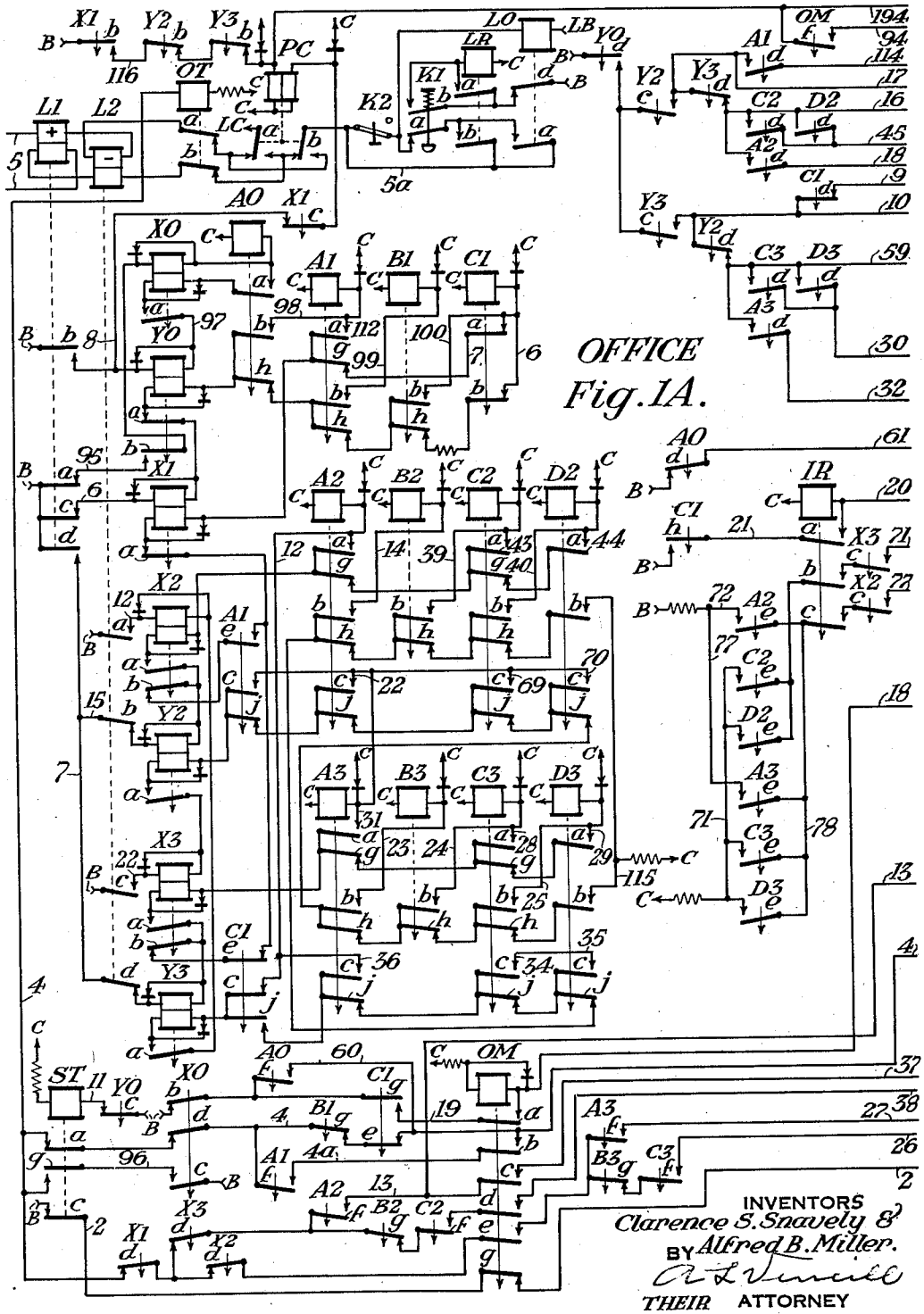
Feb. 17, 1942. C. S. SNAVELY ET AL 2,273,383

REMOTE CONTROL SYSTEM

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OFFICE

Fig. 1A.

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REMOTE CONTROL SYSTEM

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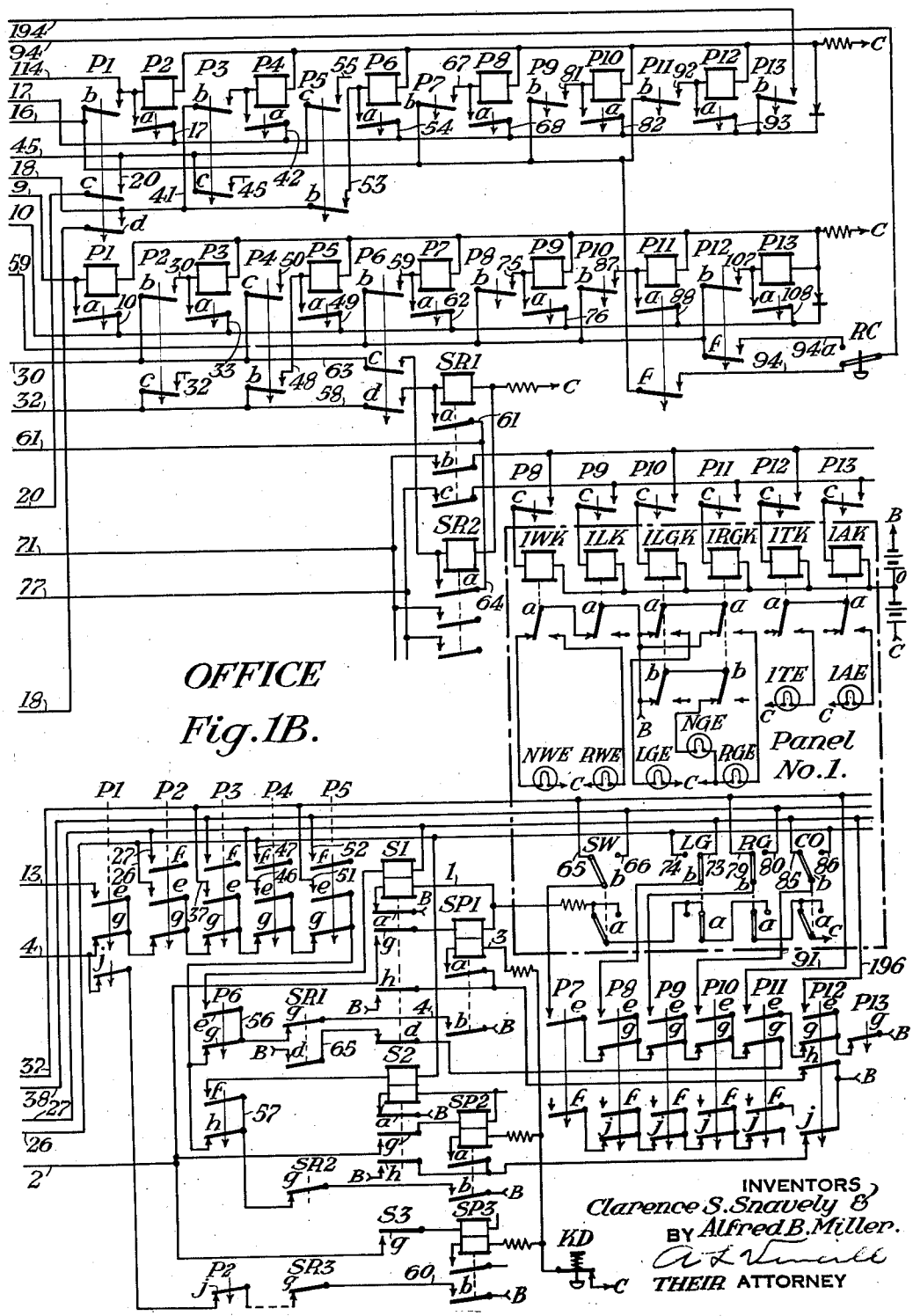


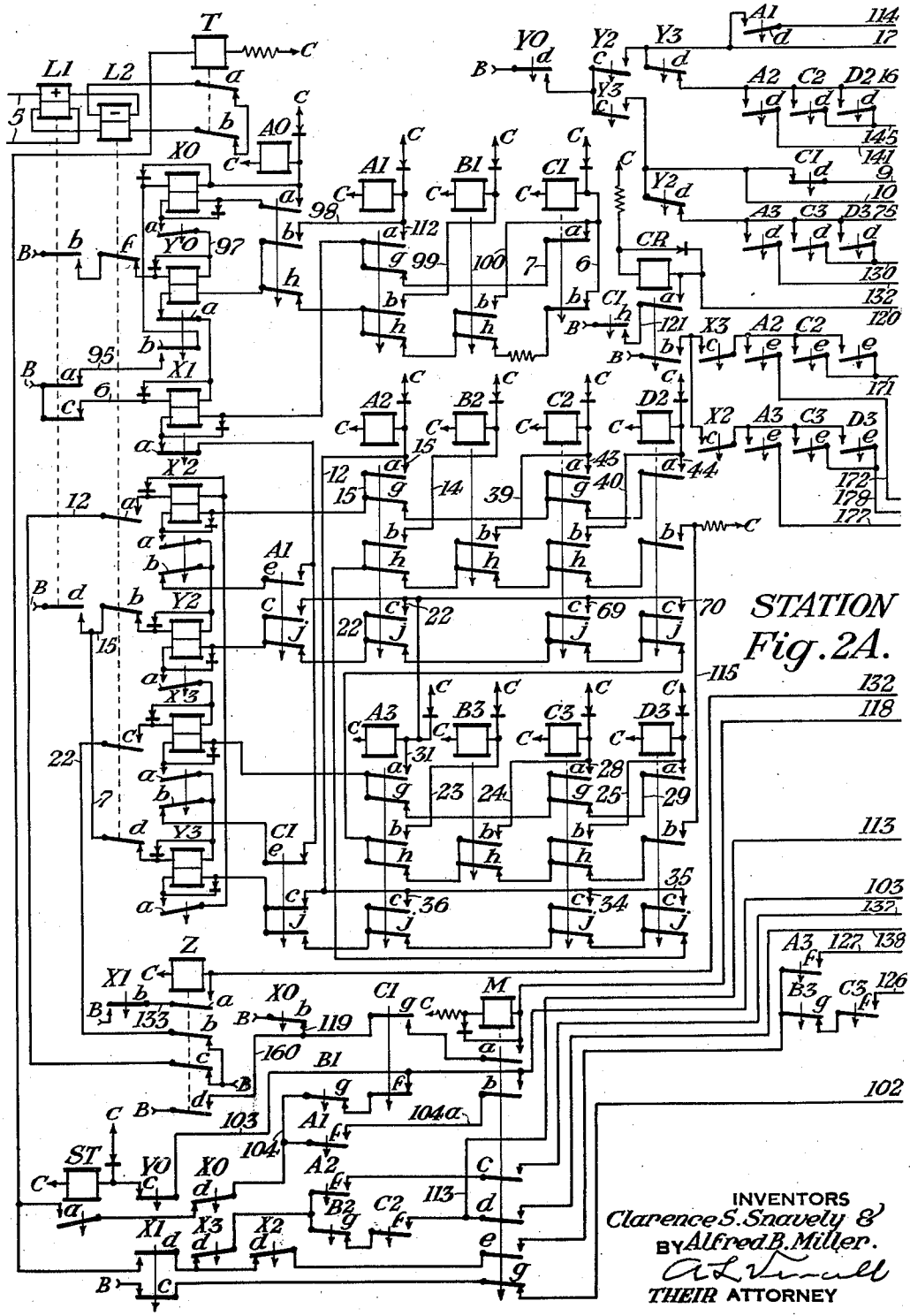
Fig. 1B.

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REMOTE CONTROL SYSTEM

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STATION

Fig. 2A.

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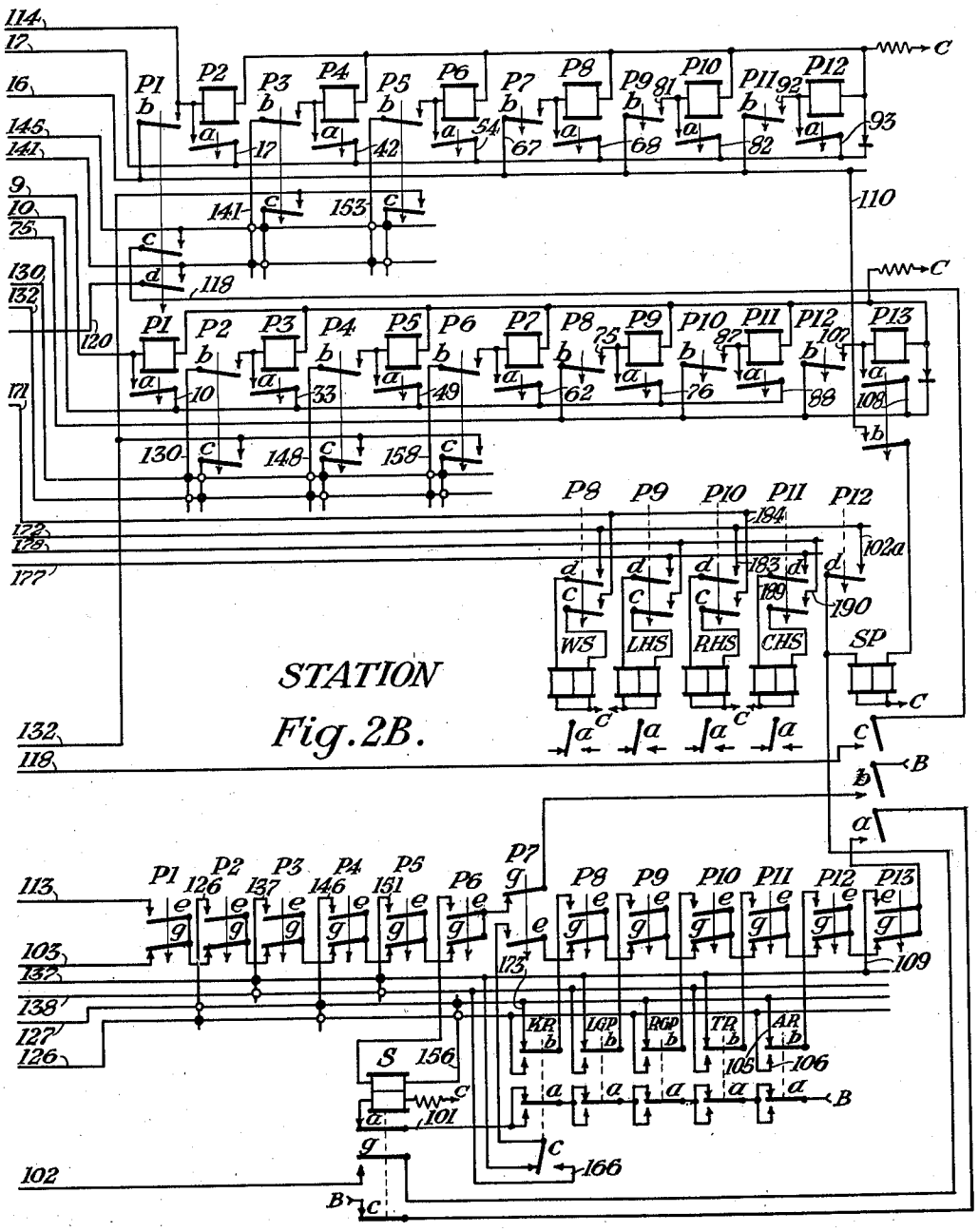


Fig. 2B.

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REMOTE CONTROL SYSTEM

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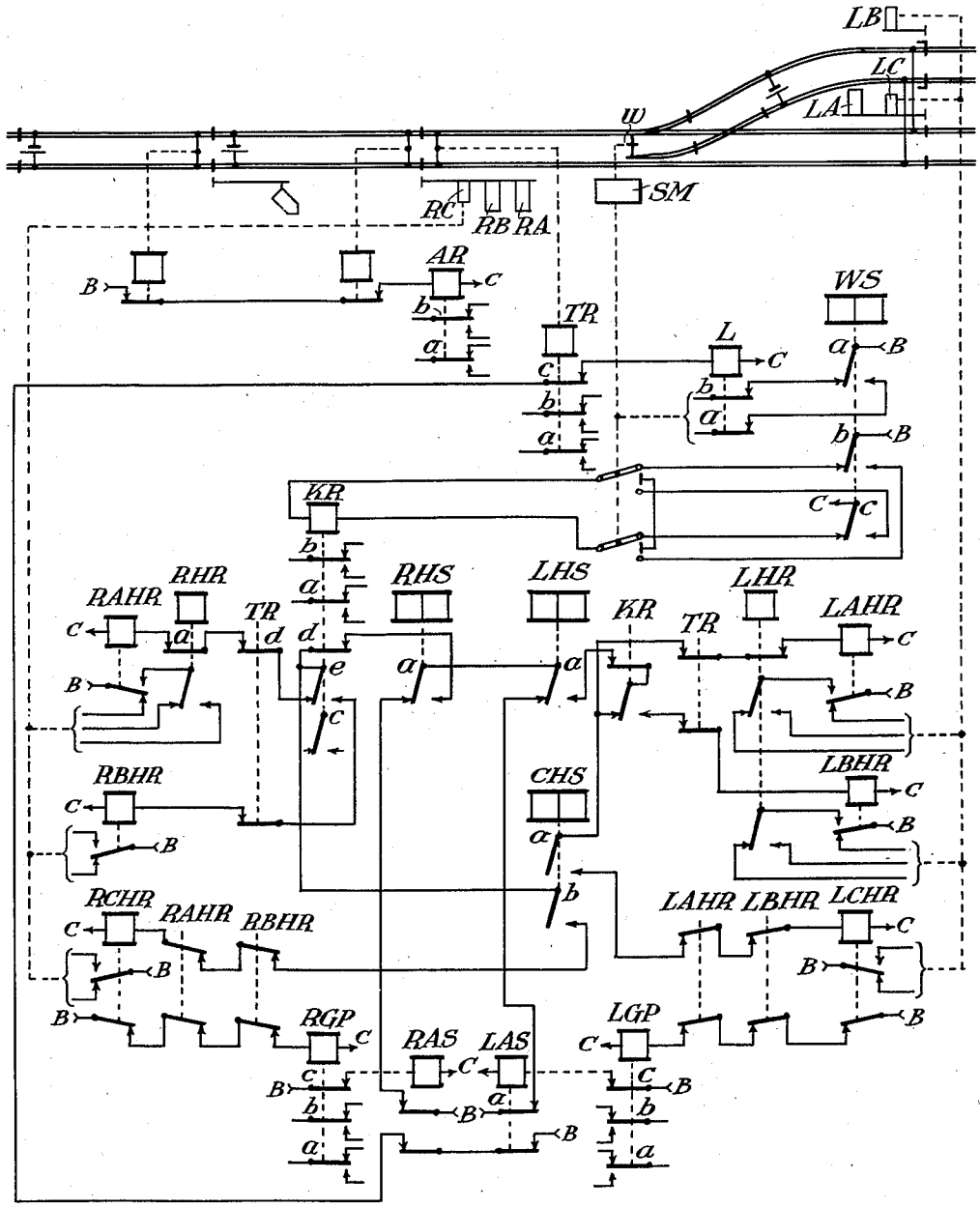


Fig. 3.

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Patented Feb. 17, 1942 2,273,383

UNITED STATES PATENT OFFICE

2,273,383

REMOTE CONTROL SYSTEM

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Application August 5, 1938, Serial No. 223,287

25 Claims. (Cl. 177—353)

Our invention relates to remote control systems for the control from a central point of selected devices located at remote points, and for also indicating at the control point the condition of such devices and other devices at remote points. In its specific embodiment, our invention relates to centralized traffic control systems for railroads of the type in which a large number of railway signals and track switches at different stations along the track are controlled from time to time from a dispatcher's office over a single line circuit, and in which the same line circuit is also employed at other times to indicate the positions assumed by the switches and signals and also to indicate the presence of trains at the same or at other field stations.

Our invention comprises a code signalling system employing a single line circuit normally energized by current of a given relative polarity in which the line is first opened and then a code of short and long impulses of the reverse polarity is transmitted so that in a series of codes the code impulses are all of the reverse polarity but the codes are spaced definitely by impulses of normal polarity.

One object of our invention relates to the provision of a relatively simple and reliable code signalling system in which all the operations of generating and receiving codes are performed by relays, and which functions in such a manner that the control office may be located at either end or at an intermediate point in the line circuit and the different control and indication codes will be transmitted one at a time in a predetermined order even though two stations or the office and a station start to transmit at the same time. In respect to the means by which this object is attained, our invention is an improvement over those disclosed in the copending applications, Serial No. 31,592, filed July 16, 1935, by Snavely, Miller and Jackel, now Patent No. 2,183,155, granted December 12, 1939, and Serial No. 222,860, filed August 3, 1938, by Snavely and Miller, for Remote control systems.

The invention of the present application relates particularly to a communication system providing two-way communication over a line circuit in which the initiation of a multiple element impulse code establishes a given direction of transmission in accordance with the character of its first element, and in which the codes are normally delivered to the line circuit in the order in which they are initiated, successive codes being spaced by time intervals during which the line is idle. An object of our invention is the provision of means for storing codes for subsequent transmission as long as the line is in use, and for maintaining an established direction of transmission as long as there are codes stored for transmission in that direction, the stored codes being transmitted in a group, in a given order of code superiority. A direction determining code element is transmitted only in the first code of a group, and the successive codes of a group are spaced by relatively short time intervals so that the average speed of transmission is thereby materially increased.

Another feature of our invention resides in the provision of means for preventing the transmission of any code which becomes stored after the transmission of a group of codes has been initiated until all of the group have been delivered. In this manner the line is rendered available for communication with the different stations for substantially equal time intervals, irrespective of the relative superiority of the stations which govern the order of delivery when a plurality of codes are initiated at the same time.

Other objects and features of our invention will become apparent as the description proceeds.

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

In the accompanying drawings, Figs. 1A, 1B, 2A, 2B and 3, inclusive, form a diagrammatic view illustrating in condensed form one arrangement of apparatus employed in a centralized traffic control system embodying our invention. More particularly, Figs. 1A and 1B, taken together, comprise the dispatcher's office equipment for generating and delivering codes to the line circuit for transmission to one station, and for receiving codes from that station and operating the appropriate indication devices of the corresponding office panel. As hereinafter explained in detail, this apparatus may be readily expanded by duplicating certain portions so that it may be used to control and indicate apparatus at thirty-two different stations, corresponding to the maximum capacity of the system as herein illustrated, in which case the office equipment will include thirty-two individual panels each similar to the one shown at the right in Fig. 1B. Figs. 2A and 2B, taken together, comprise the equipment at one field station. The equipment at all the stations is alike, the different stations being distinguished by an appropriate arrangement of jumper connections, so that each is adapted to send and receive a particular code call characteristic of the station. Fig. 3 illustrates a

typical arrangement of apparatus controlled by the apparatus of Figs. 2A and 2B for directly controlling the railway signals and track switches at a station and for initiating and determining the character of the indication codes.

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

Before proceeding with a detailed description of the circuits, we shall briefly explain the general plan and organization of our apparatus.

In the specific embodiment of our invention herein illustrated, each control code consists of a series of twelve impulses, while each indication code has fourteen impulses. The first step of a code initiated while the line is free is employed to select the direction of transmission. The first step of a control code initiated when the line is free is a short negative impulse, while the first step of an indication code initiated when the line is free is a long negative impulse. When the direction of transmission is once established, it is maintained as long as there are codes stored for transmission in the same direction, and in each of the succeeding codes of a series the first step is a short positive impulse, irrespective of whether these are control codes or indication codes. All of the remaining steps of each code are negative except the last step, which comprises a short positive impulse.

The five impulses immediately following the first impulse may be arranged to provide thirty-two different combinations of short and long impulses for station selection in case of control codes, or for the selection of the office panel corresponding to the transmitting station in the case of indication codes. The remaining impulses are described as "function" elements, and in the case of a control code the lengths of the seventh, eighth, ninth and tenth impulses are determined each in accordance with the position of a different control lever of the corresponding panel. The seventh step is controlled by the switch lever SW, Fig. 1B; the eighth and ninth steps by the signal levers LG and RG, respectively; while the tenth step is controlled by an auxiliary or "call-on" signal lever CO. Each of these steps is short when the lever is in the position shown and long when the lever is reversed, and at the selected station each of these impulses is "stored," and when the next succeeding impulse is received a polar stick relay WS, LHS, RHS, or CHS, Fig. 2B, is operated to a position corresponding to that of the associated lever. That is, these relays are operated during the eighth, ninth, tenth and eleventh steps of the code, and they control the track switch and railway signals of Fig. 3 in a manner hereinafter pointed out.

The seventh and eighth steps of an indication code are controlled by a switch indication relay KR, and are both short when the track switch is locked normal; the seventh is long and the eighth short when the switch is locked reverse; and the seventh is short and the eighth long when the switch is unlocked or when relay KR and the associated switch control relay WS are not in corresponding positions. At the office, the indication relays 1WK and 1LK governing the switch indication lamps NWE and RWE are operated in accordance with the character of the seventh and eighth steps during the eighth and ninth steps, respectively, lamp NWE or RWE being lighted when the track switch is locked in the corresponding normal or reverse position in agreement with the position of the switch control relay WS.

The ninth and tenth steps of an indication code are controlled by two signal indication relays LGP and RGP, respectively, so that both these steps are short when the signals LG and RG are at stop, and the ninth or tenth step is long when the corresponding signal is clear. At the office, these steps control the polar stick signal indication relays 1LGK and 1RGK during the tenth and eleventh steps, respectively. The signal indication relays cause a lamp NGE to be lighted to display a stop indication when the ninth and tenth steps are short, or cause the corresponding lamp LGE or RGE to be lighted to display a clear signal indication when the corresponding step is long.

The eleventh and twelfth steps are controlled respectively by the track relay 1TR for the switch section *t*, Fig. 3, and by an approach relay 1AR, which releases when a train occupies the approach zone comprising sections *u* and *v*. These relays when released cause the transmission of long impulses to reverse the respective indication relays 1TK and 1AK during the twelfth and thirteenth steps, respectively, thereby causing lamp 1TE or 1AE to indicate that the corresponding track section is occupied.

The apparatus at the office and stations is generally similar and with a few exceptions, which will be pointed out as the description proceeds, corresponding relays at the office and stations operate in unison on each step. Each code is initiated by releasing a normally energized starting relay such as relay S1, Fig. 1B, or relay S, Fig. 2B, which when released "stores" the code for transmission, and when the line becomes available operates the corresponding code sending relay SP to start transmission.

The line circuit, identified on the drawings by the reference 5, includes in series a positively biased polar line relay L1, a negatively biased polar line relay L2, and back contacts *a* and *b* of a transmitter relay T or OT at the office and at each station, and at the office, as shown in Fig. 1A, also includes a line battery, identified by the terminals LB and LC, respectively, which is connected to the line through the winding of an auxiliary relay LO, key K2, and contacts *a* and *b* of a pole changer relay PC.

It will be understood that the portion of line 5 shown in Fig. 1A, and a plurality of portions of line 5, one for each station, each similar to the portion shown in Fig. 2A, are connected by line wires to form a single closed circuit which is normally energized by current supplied by the office line battery. This current is normally of the proper polarity to cause the relays L1 to be picked up, while the relays L2 which operate on current of the opposite polarity normally occupy their released positions, as shown. During code transmission, the polarity is reversed so that each relay L1 remains released and the relays L2 are operated in unison in accordance with the code generated by the repeated opening and closing of the line circuit by relay OT, in case of a control code, or by one of the relays T, in case of an indication code.

The pole-changer PC is restored to its normal position during the line-open interval preceding the last impulse, which therefore is positive and operates the line relays L1, relays L2 remaining released. Relays L1 are again energized and

pick up when the line is restored to normal at the end of a code.

Each line relay L2 controls a group of intermediate stepping relays X2, Y2, X3 and Y3 which are operated repeatedly one at a time in that order as relay L2 alternately picks up and releases, to count the steps of the code, and also controls two groups of cascade-connected timing relays A2, B2, C2, D2, and A3, B3, C3, D3, which are operated alternately in series with different ones of the stepping relays, and serve to measure and register the short or long character of the successive steps, and to operate a main series of stepping relays P1 to P13, inclusive.

On each station selecting step the corresponding relay P is operated only if the step is a particular character, the successive operation of a particular series of relays P2 to P6, inclusive, constituting the station or panel selection. On the function steps, relays P prepare circuits for the polar stick control or indication relays successively so that each such relay will be positioned on a different step in accordance with the relative length of the next preceding step. Each relay P is operated during the line-open period which precedes the correspondingly numbered impulse of the code.

Each line relay L1 controls a group of similar stepping relays XO, YO or X1 in series with the timing relays AO or the relays A1, B1, C1, the operation of which governs the restoration of the apparatus to normal at the end of a code.

At the transmitting station, after relay T or OT has been initially energized by the operation of relay SP to open line 5 it is released by relay P1 and is then placed under the control of the remaining relays P by the operation of a master relay M or OM which is energized in accordance with the character of the first step. Each relay P prepares a different circuit for relay T or OT which is so controlled by the intermediate stepping and timing relays as to give the desired character to the next impulse, the action being such that when once initiated relay T or OT is operated repeatedly by the P relays which it controls until the code is completed.

A number of the relays employed in our apparatus are rendered slow release by the connection of asymmetric units of the copper oxide rectifier type in multiple with the relays, as shown conventionally for relay AO, Fig. 1A, for example. These units present a high resistance to the flow of current from the power source while providing a low resistance discharge path to permit the gradual discharge of the stored inductive energy of the relay when the power source becomes disconnected. The stepping relays X, Y and P are in this manner arranged to have sufficient retardation to hold them picked up in each case until other relays have picked up, while the timing relays A, B, C, D, etc. are arranged to have a definite constant time period so chosen as to provide the proper rate of operation and to so measure the relative lengths of the different impulses as to insure a wide margin against incorrect operation.

While any suitable relays may be used, the code relays shown herein are preferably of the types shown in the Snavely applications Serial No. 139,535, filed April 28, 1937, now Patent No. 2,140,604, granted December 20, 1938, and Serial No. 141,311, filed May 7, 1937, now Patent No. 2,178,289, granted October 31, 1939, for Electrical relays.

Referring now to Fig. 3, the track diagram at the top represents a stretch of railway track including a track switch *w* and a group of signals LA, LB, LC, RA, RB and RC for governing traffic movements over the switch, corresponding to one end of a passing siding on a single track railway. The circuits of Fig. 3 represent one arrangement of interlocked switch and signal control apparatus which the polar stick relays WS, LHS, RHS and CHS of our station equipment as shown in Figs. 2A and 2B are adapted to control. As indicated conventionally in Fig. 3, the code-responsive switch control relay WS of Fig. 2B controls the switch machine SM so as to operate the track switch *w* to a position to correspond with that of its contact *a*, and its contact *b* permits the energization of the switch indication relay KR in a direction corresponding to the position of switch *w* and relay WS. Contacts *a*, *b* and *c* of relay KR govern the transmission of switch indication codes as hereinafter described in connection with Figs. 2A and 2B.

The signals shown in Fig. 3 are assumed to be of the light signal type and each is controlled by a signal relay HR. When all the signals for one direction are at stop, the corresponding signal indication relay RGP or LGP is energized, which at its contacts *a* and *b* governs the transmission of signal indication codes as hereinafter described, and at its contact *c* controls an approach locking stick relay LAS or RAS. The detailed circuits for relays LAS and RAS have been omitted, to simplify the drawings, but these may be arranged, for example, as shown for relays M5 and M6 of the Wallace Patent No. 1,959,072, granted May 15, 1934. The approach locking relays together with the track relay TR for the switch section *t* control a switch locking relay L which opens the circuits for switch machine SM when a signal has been cleared or the switch is approach locked.

Contacts *a* and *b* of the track relay TR and the approach relay AR govern the transmission of track indication codes by the apparatus of Figs. 2A and 2B, and the manner in which these relays are controlled to effect the transmission of indications of track conditions will be apparent from the drawings.

The main signal relays HR having the prefixes A and B for governing train movements over the main track and siding, respectively, are controlled in accordance with the position of relay KR by the code-responsive signal control relays RHS and LHS. The circuit for relay RAHR, for example, which is typical, may be traced from one terminal B of a suitable local battery, contact *a* of relay LAS, normal contact *a* of relay LHS, reverse contact *a* of relay RHS, neutral contact *d* and normal polar contact *e* of relay KR, contact *d* of relay TR, contact *a* of a polarized line relay RHR, relay RAHR to the other terminal C of the local battery. The circuit for relay RBHR is generally similar, and it will be apparent that to clear signal RA or RB the operator will initiate a code to operate relay WS to normal or reverse as required and will then reverse relay RHS by code, or he may put signal RA or RB to stop manually by operating relay RHS to normal by code. Similarly, signal LA or LB may be cleared by the reversal of relay LHS by code.

It is to be understood that relay RHR is controlled in accordance with traffic conditions at the right of section *t*, and that signal RA is arranged in the usual manner to indicate clear, caution or stop in accordance with the conditions of relays RHR and RAHR. Signals LA

and LB are similarly controlled by conditions relating to the opposite direction, while signal RB governing traffic movements into the siding is a two-position signal.

The circuits for the slow speed signal relays RCHR and LCHR are arranged in the usual manner so that the signals which these relays control can be cleared only when traffic conditions are such as to prevent the clearing of the corresponding main signal. It will be apparent from the drawings that the clearing of signal RC or LC requires the call-on relay CHS to be reversed, by code, to close its contacts *a* and *b* in addition to the reversal of the corresponding signal control relay LHS or RHS.

The transmission of a typical control code will now be described in detail. It will be assumed that the apparatus is in the condition shown in the drawings, and that the code is initiated by a movement of the switch lever SW, Fig. 1B, which controls the track switch at station No. 1, from normal to reverse, and that the corresponding station code call is represented by one long impulse followed by four short impulses.

The movement of lever SW at the office opens a normally closed starting circuit 1 which may be traced in Fig. 1B from one terminal B of a suitable local battery over contact *a* and the lower winding of the starting relay S1, contacts *a* of levers SW, LG, RG and CO of panel No. 1 to the other terminal C of the local battery. Relay S1 releases whenever one of the levers is moved, and at its contact *g* completes a circuit 2 from terminal B at contact *c* of relay ST, Fig. 1A, contacts g of relays OM and S1, through the upper winding of the code sending relay SP1 and over the above-mentioned lever contacts *a* to terminal C. Relay SP1 picks up and completes a stick circuit 3 which extends from terminal B over contacts *h* of relays S1 and P12, in multiple, contact *a* and the lower winding of relay SP1, thence over the normally closed contact of the knock-down key KD to terminal C.

Relay SP1 upon picking up closes an initial energizing circuit 4 for the transmitter relay OT which extends from terminal B over contact *b* of relay SP1, the back contacts *g* of relays SR1, P6, P5, P4, P3, P2, P1, contact *e* of relay C1, contact *g* of relay B1, contact *d* of relay XO, contact *a* of relay ST, relay OT, to terminal C. Relay OT therefore picks up and at its contacts *a* and *b* opens the line circuit 5, releasing the plus line relays L1 at the office and at all stations.

When each line relay L1 releases, its contact *c* opens a normally closed circuit 6 which may be traced in Fig. 1A and also in Fig. 2A, from terminal B, contact *c* of relay L1, the upper winding of relay X1, contact *a* and the lower winding of relay YO, contacts *h* of relays AO, A1 and B1, contact *b* and winding of relay C1 to terminal C. At the same time, circuits 7 are closed from terminal B over back contact *d* of each line relay L1, contact *d* of relay L2, the upper winding of relay Y3, contact *b* of relay X3, contact *e* of relay C1, contact *a* and the lower winding of relay X1, contact *g* of relay A1, contact *a* and winding of relay C1 to terminal C. It follows that relay Y3 picks up, relays X1 and C1 are held energized and relay YO releases at the office and at each station.

At the office the closing of back contact *b* of relay L1 completes a circuit 8 from terminal B over contact *c* of relay X1, the right-hand winding of the pole changer relay PC to terminal C. Relay PC therefore operates its contacts *a* and *b* to the right so that when relay OT releases the polarity of the current supplied to the line circuit 5 will be reversed.

When each relay YO releases, a pick-up circuit 9 is closed for the associated relay P1 from terminal B, back contact *d* of relay YO, shown at the upper right in Figs. 1A and 2A, over contact *c* of relay Y3, contact *d* of relay C1, relay P1 to terminal C. Relay YO at the office also opens circuit 11, releasing relay ST. When each relay P1 picks up, it completes at its contact *a* a stick circuit 10 which is a branch of circuit 9 bridging contact *d* of relay C1.

When relay P1 at the office picks up, its back contact *g* opens circuit 4 to release relay OT to terminate the first line-open period of the code.

First step—Short

Since relay PC is now reversed, the closing of line 5 by relay OT causes the minus line relay L2 to pick up at the office and at each station, relays L1 remaining released until the next to the last step of the code is completed.

Each relay L2 at its front contact *a* completes a circuit 12 from terminal B, the upper winding of relay X2, contact *a* and the lower winding of relay Y3, contact *c* of relay C1, relay A2 to terminal C, so that X2 and A2 pick up. At the same time, relay L2 opens circuit 7 to release relays X1 and C1 while relay Y3, being included also in circuit 12, is held energized.

It will be noted from Fig. 2A that circuit 12 at the station and also circuit 22 differ slightly from the corresponding office circuits in that they extend to terminal B over contacts *c* and *b*, respectively, of a relay Z for a purpose hereinafter described.

When relay X1 at the office releases a pick-up circuit 13 for relay OT is closed which is the same as circuit 4 from terminal B to contact *g* of relay P2 and then extends over contact *e* of relay P1, contact *f* of relay A2, contacts *d* of relays X3 and X1, relay OT, to terminal C. Relay OT therefore picks up over circuit 13 to open line 5. The release of relay X1 opens circuit 8, but relay PC is of the polar stick type and holds its contacts closed in the reverse position.

It will be noted that relay C1 is deenergized at the same time as X1. Relay C1 has a release period greater than that of X1, but if the period of any relay C1 is less than normal so that it releases before the end of the step, circuit 12 will be opened at contact *c* of relay C1 and a branch 14 of that circuit will be closed to maintain relays X2 and Y3 energized in series with relay B2. Circuit 14 may be traced from terminal B, contact *a* of relay L2, relays X2 and Y3, contacts *j* of relays C1, A3, C3 and D3, contact *b* of relay A2, relay B2 to terminal C, so that relay B2 will pick up in series with relays X2 and Y3.

When line 5 opens the line relays L2 release and each closes a circuit 15 from terminal B, back contact *d* of relay L1, back contact *b* of relay L2, through the upper winding of relay Y2, contact *a* and the lower winding of relay X2, contact *a* and the winding of relay A2 to terminal C, and at the same time relay L2 opens contact *a* in circuits 12 and 14. Therefore, relay Y2 picks up, relays X2 and A2 are held energized, and relay Y3 releases. Relay B2, if picked up, becomes deenergized and releases.

When each relay Y3 releases, it completes a pick-up circuit 16 for relay P2 from terminal B over contact *d* of relay YO, contact *c* of relay

Y2, contact *d* of relay Y3, contact *b* of relay P1, relay P2, to terminal C, and at the same time, each relay Y3 at its contact *c* opens the stick circuit 16 for relay P1 so that P1 releases. When each relay P2 picks up, it completes a stick circuit 17 extending to terminal B over its own contact *a*, contact *c* of relay Y2, and contact *d* of relay YO.

When relay Y3 at the office releases, it closes at its back contact *d* a circuit 18 for the office master relay OM from terminal B, back contact *d* of relay YO, Fig. 1A, contact *c* of relay Y2, contacts *d* of relays Y3, A2 and P1, relay OM to terminal C. Relay OM picks up and completes its stick circuit 19 which extends to terminal B over contact *a* of relay OM, contact *g* of relay C1 and contact *b* of relay XO. Relays XO and C1 remain deenergized, and therefore relay OM remains picked up until the code transmission is completed.

When relay Y3 at each field station releases, it closes at its back contact *d* a circuit 120 for the control code register relay CR from terminal B, contact *d* of relay YO, Fig. 2A, contact *c* of relay Y2, contacts *d* of relays Y3, A2, and P1, relay CR to terminal C. Relay CR picks up and completes a stick circuit 121 which extends to terminal B over its contact *a* and contact *h* of relay C1. Relay CR remains energized until the code transmission is completed.

When the office relay P2 picks up it opens the energizing circuit 13 for relay OT at its back contact *g*, so that relay OT releases to close the line circuit 5.

Second step—Long

When each line relay L2 picks up, it closes a circuit 22 from terminal B over its contact *c*, relays X3 and Y2, back contact *j* of relay A1, contact *c* of relay A2, relay A3 to terminal C. Each relay L2 at its contact *b* opens circuit 15. Relay X3 picks up and relays Y2 and A3 are held energized over circuit 22, while relays X2 and A2 release.

Relay A2, upon releasing, opens circuit 22 at its contact *c*, deenergizing relay A3, but maintaining relays Y2 and X3 energized and picking up relay B3 over a branch 23 of circuit 22 including back contacts *j* of relays A2, C2 and D2 and front contact *b* of relay A2. When relay A3 releases, its contact *b* opens circuit 23, deenergizing relay B3. Relays Y2 and X3 are now maintained energized and relay C3 picks up over a branch circuit 24 which includes back contact *h* of relay A3 and front contact *b* of relay C3.

When relay B3 releases, its contact *b* opens circuit 24, deenergizing relay C3. Relays Y2 and X3 are now held energized and relay D3 picks up over a branch circuit 25 which includes back contact *h* of relay B3 and front contact *b* of relay C3.

When relay B3 at the office releases, a branch 26 of circuit 4 for relay OT becomes closed, which extends from terminal B over front contact *e* of relay P2, contact *f* of relay C3, contact *g* of relay B3, contact *e* of relay OM, contacts *d* of relays X2 and X1, relay OT to terminal C. Relay OT now picks up to open line 5.

It is to be understood that the code sending relays SP for the office panels for the sixteen stations for which the second step, comprising the first element of the station call, is a long impulse, are arranged, as shown for relay SP1, to effect the energization of circuit 26. The code sending relays SP for the remaining sixteen stations, for which this step is a short step, are arranged with a connection from their contacts *b* to contact *f* instead of to contact *e* of relay P2 to effect the energization of a branch circuit 27 on the second step. Circuit 27 extends from terminal B at contact *b* of the respective relay SP, not shown, over contact *f* of relay P2, contact *f* of relay A3 and joins circuit 26 at contact *e* of relay OM. When circuit 27 has been prepared, it closes as soon as relay X2 releases at the beginning of the second step. It will be apparent that the second step will be short when circuit 27 is used and will be long when circuit 26 is used.

At the end of the line-closed portion of the long second step, it will be found that relays Y2, X3 and D3 are energized and relay C3 deenergized. If relay C3 is still in its energized position, the release of each line relay L2 will close a circuit 28 at its contact *d* through relay Y3, contact *a* and winding of relay X3, contact *g* of relay A3, contact *a* and winding of relay C3, while if relay C3 has released, the branch 29 will be closed over contact *g* of relay C3, contact *a* and winding of relay D3. At the same time circuit 22 is opened at contact *c* of relay L2 so that relay Y2 will release. It follows that relay Y2 will release, Y3 will pick up, and X3 and C3 or D3 will be held energized.

When the office relay Y2 releases it closes the pick-up circuit 30 for relay P3 from terminal B over contact *d* of relay YO, contact *c* of relay Y3, contacts *d* of relays Y2 and C3 or D3, contact *b* of relay P2, relay P3, to terminal C, and relay P3 picks up to close its stick circuit 33 comprising a branch of circuit 18.

If the second step were short instead of long relay A3 would be held energized over a stick circuit comprising a branch 31 of circuit 28 in place of relay C3 or D3, and a branch circuit 32 would be closed when the office relay Y2 releases, over contact *c* of relay P2 to energize another relay corresponding to P3 but not shown.

It is to be understood that the office relays P are connected in pyramid formation, and when the apparatus is arranged for the control of the full complement of thirty-two stations, it includes two relays like P3, each of which controls two relays like P4. Each of the latter controls two relays like P5, each of which in turn controls two relays like P6. Each of the P6 relays controls a different series of relays P7 to P13. That is, there are sixteen sets of relays like the relays P7 to P13 of which but one set, namely the one associated with stations Nos. 1 and 2, is shown. It will be clear that only one series of relays P will be operated by any one code, but that any two codes which differ only in the character of the sixth element will operate the same series of P relays.

At each field station, when relay Y2 releases it closes a circuit 130 or 132 similar to circuit 30 or 32. At sixteen of the stations circuit 130 is arranged as shown in Fig. 2B to include the station relay P3 and circuit 132 includes the winding of a lock-out relay Z, while at the remainder relay Z is included in circuit 130 and relay P3 in circuit 132 by an interchange of jumper connections in a manner which will be apparent from the drawing. The circuit 132 for relay Z, as shown, extends from terminal B at contact *d* of relay YO, contact *c* of relay Y3, contacts *d* of relays Y2 and A3, contact *c* of relay P2, relay Z to terminal C. As shown, the station apparatus is arranged to receive a code

in which the second step is long, in which case the station relay P3 picks up and by closing its contact *a* completes its stick circuit 33. If a code is received in which the second step is short relay Z picks up and is held energized over a stick circuit 133 extending to terminal B over its own contact *a* and contact *b* of relay X1 until relay X1 picks up at the end of the code. In either case relay Y2 opens circuit 17 to release relay P2. As will be apparent from the drawing, similar circuits for relay Z are provided over contacts *c* of relays P3, P4, P5 and P6. It follows that relay Z picks up on any station selecting step of a character to which the station apparatus is not intended to respond and by opening its contacts *b* and *c* prevents further operation of the stepping apparatus at that station during that particular code.

When the office relay P3 picks up, it opens the energizing circuit 26 or 27 for relay OT at its back contact *g* so that relay OT releases to close line 5.

Third step—Short

When each line relay L2 picks up, it closes at contact *a* a branch 34, 35 or 36 of circuit 12 to pick up relays X2 and A2 and to hold Y3 energized, the particular branch closed depending upon which of the relays C3, D3 or A3 are picked up at the time. These circuits differ from circuit 12 already traced in that they include a contact *c* of relay C3, D3 or A3, respectively, in place of contact *c* of relay C1. Relay L2 at its contact *d* opens circuit 28, 29, or 31, deenergizing relay X3 and relay C3, D3 or A3, as the case may be.

When relay X3 at the office releases, a pick-up circuit 37 for relay OT is closed which is the same as circuit 4 from terminal B to contact *g* of relay P4 and then extends over contact *e* of relay P3, contact *c* of relay OM, contact *f* of relay A2, contacts *d* of relays X3 and X1, relay OT, to terminal C. Relay OT picks up over circuit 37 to open line 5.

It is to be understood that the code sending relays SP for all stations for which the station call includes a short third impulse are arranged as shown for relay SP1 to effect the energization of circuit 37 on the third step. The code sending relays for all stations for which this step is a long impulse are arranged to provide a connection from terminal B to contact *f* of relay P3 to effect the energization of a branch 38 of circuit 4 which extends from contact *b* of the respective relay SP over contact *f* of relay P3, contact *d* of relay OM, contact *f* of relay C2, contact *g* of relay B2, contacts *d* of relays X3 and X1, relay OT, to terminal C.

In the event circuit 38 is prepared in place of circuit 37, the energization of relay OT is delayed until relays A2 and B2 release consecutively at the office and stations. One of the relays C3, D3 or A3, it will be remembered, becomes deenergized at the beginning of the third step, and upon releasing opens circuit 34, 35 or 36 at its contact *c*, deenergizing relay A2, and at the same time by closing its contact *j* completes circuit 14 to pick up relay B2 in series with relays X2 and Y3. Relay A2 upon releasing opens circuit 14 at its contact *b*, closing a branch circuit 39 at its contact *h* to pick up relay C2 in series with relays X2 and Y3 over front contact *b* of relay B2. Relay B2 upon releasing opens circuit 39, closing a branch circuit 40 at its contact *h* to pick up relay D2 in series with relays X2 and Y3 over front contact *b* of relay C2, and at the same time relay B2 at the office by closing contact *g* completes the above-mentioned circuit 38 for relay OT to terminate the long third step by opening line 5.

It follows that at the end of the line-closed portion of the third step, relays X2 and Y3 will be energized in series with relay A2 if the step is short, and in series with relay C2 or D2 if the step is long. If the step is short, the release of each line relay L2 will close circuit 15, as on the first step, to pick up relay Y2 and to hold relays X2 and A2 energized, and at the same time circuit 34, 35 or 36 will be opened at contact *a* of relay L2 to release relay Y3.

The office relay Y3 at its back contact *d* then completes a branch 41 of circuit 18 from terminal B at contact *d* of relay Y0 to pick up relay P4. At eight of the sixteen stations at which relay P3 is energized, the station relay P4 similarly picks up over a corresponding circuit 141, while at the other eight stations of the group the jumper connections are interchanged so that relay Z picks up when circuit 141 is energized. At all sixteen stations, relay Y3 opens circuit 33 to release the associated relay P3. Each energized relay P4 upon picking up completes a stick circuit 42 similar to circuit 17 already traced.

If the third step of a code is long, relay C2 or D2 is picked up when relay L2 releases, and a branch 43 or 44 of circuit 15 is closed to pick up relay Y2 and to hold relays X2 and C2 or D2 energized, and relay Y3 upon releasing completes a pick-up circuit 45 and 145 for the corresponding relays P4, these circuits being similar to circuit 41 except that they include front contacts *d* of relays C2 and D2 in place of contact *d* of relay A2.

When the office relay P4 picks up, it opens at its contact *g* circuit 37 or 38 to release relay OT to close line 5.

Fourth step—Short

When each line relay L2 picks up, it closes circuit 22 to pick up X3 and A3 and to hold Y2 energized, and opens circuit 15, 43 or 44 to release X2 and A2, C2 or D2, as the case may be. When the office relay X2 releases, a branch 46 of circuit 27 is closed over contact *e* of relay P4 to pick up relay OT when relay X2 releases, to open line 5. In transmitting codes in which the fourth step is long, a branch 47 of circuit 26 is closed over contact *f* of relay P4 to pick up relay OT when relay B3 releases, to open line 5.

When each line relay L2 releases, it closes circuit 31 to pick up Y3 and to hold X3 and A3 energized, and opens circuit 22, releasing Y2. Relays Y2 at their back contacts *d* complete branches 48 and 148 of circuits 32 and 132 to pick up relay P5 at the office and at four of the eight stations at which relay P4 is energized, relay Z picking up over circuit 148 at the remaining four of these stations. Relays Y3 at contacts *c* open circuits 42 to release all the energized relays P4. Each relay P5 that picks up completes its stick circuit 49. In the case of codes in which the fourth step is long the corresponding office relay P5 is picked up over a branch 50 of circuit 30, while at the stations responsive to such codes relay P5 is picked up over a branch of circuit 130, as will be apparent from the drawing. The office relay P5 upon picking up opens its contact *g* in circuits 46 and 47 so that relay OT releases to close line 5.

Fifth step—Short

When each line relay L2 picks up, it closes circuit 36 to pick up relays X2 and A2 and to hold Y3 energized, and opens circuit 31, releasing relays X3 and A3. When the office relay X3 releases a branch 51 of circuit 37 is closed over contact *e* of relay P5 to pick up relay OT to open line 5. In transmitting codes in which the fifth step is long, a branch 52 of circuit 38 is closed at this time over contact *f* of relay P5 to pick up relay OT when relay B2 releases, to open line 5.

When each line relay L2 releases, it closes circuit 15 to pick up Y2 and to hold X2 and A2 energized and opens circuit 36, releasing Y3. Relays Y3 at their back contacts *d* complete branches 53 and 153 of circuits 41 and 141, respectively, to pick up relays P6 at the office and at two of the four stations at which P5 is energized, relay Z picking up over circuit 153 at the other two stations of this group. Relays Y3 at their contacts *c* open circuits 49 to release all energized relays P5. Relays P6 at the office and at the two selected stations pick up and complete their stick circuits 54. In the case of codes in which the fifth step is long, the corresponding relays P5 are picked up over branches of circuits 45 and 145, such as the circuit 55 of Fig. 1B. The office relay P6, upon picking up, opens its contact *g* in circuits 51 and 52 so that relay OT releases to close line 5.

Sixth step—Short

When relays L2 pick up, circuits 22 close and circuits 15 open so that relays X3 and A3 pick up. Y2 is held energized, and X2 and A2 release. When the office relay X2 releases a circuit 56 is closed from terminal B at contact *b* of relay SP1, contact *g* of relay SR1, contact *d* of relay P6, the upper winding of relay S1, and thence over the same path as for circuit 27 through relay OT to terminal C. Relays S1 and OT pick up in series, relay S1 completing its normally closed stick circuit 1 at contact *a*, and relay OT opening line 5.

A code in which the sixth step is long is initiated by the release of a different starting relay such as S2, in which case a circuit 57 is closed from terminal B at contact *b* of relay SP2, contact *g* of relay SR2, contact *f* of relay P6, the upper winding of relay S2 and thence over the same path as for circuit 26 through relay OT to terminal C; circuit 57, when effective, being completed when relay B3 releases.

When line relay L2 releases it closes circuit 31 to pick up Y3 and to hold X3 and A3 energized, and opens circuit 22, releasing Y2. The office relay Y2 at its back contacts *d* completes a branch 58 of circuit 32 to pick up relay SR1, and also completes a circuit 59 to pick up relay P7. Relay Y2 at one of the two stations only, at which P6 is energized, completes a circuit 158 similar to circuit 58 to pick up relay P7 at that station, while at the other station at which P6 is energized relay Z picks up. Relay SR1 picks up and completes its stick circuit 61 from terminal B, back contact *d* of relay AO, front contact *a* and winding of relay SR1 to terminal C. Relays P7 at the office and selected station upon picking up complete their stick circuits 62, similar to circuit 10. This completes the station selection and further progression takes place at the office and at the selected station only, because relay Z is picked up at all other stations. Relays Y2 at contacts *c* open the stick circuits 54, releasing the energized relays P6.

In the case of codes in which the sixth step is long, relay SR2 is picked up over a branch 63 of circuit 30, and establishes a stick circuit 64 similar to circuit 61.

When relay SR1 or SR2 picks up, its back contact *g* opens circuit 56 or 57 so that relay OT releases to close line 5.

It is to be understood that the relays referred to in the description of the remaining steps of the code, except as otherwise noted, are those at the office and at the selected station only.

Seventh step—Long

When each relay L2 picks up, circuit 36 closes and 31 opens so that relays X2 and A2 pick up, Y3 is held energized and X3 and A3 become deenergized. The character of this step is determined by the position of the switch lever SW, and if this lever is normal, as shown, a circuit 65 is closed to pick up relay OT when relay X3 releases, which extends from terminal B, contacts *d* of relays SR1 and S1, contacts *g* of relays P11, P10, P9, and P8, contact *e* of relay P7, left-hand contact *b* of lever SW, and thence over the same path as circuit 37 through relay T to terminal C.

However, it will be remembered that the code being described was initiated by reversing lever SW, and therefore circuit 65 is not effective and relay OT remains deenergized. Consequently, relay A3 releases, opening circuit 36 to deenergize relay A2, and closing circuit 14 to pick up relay B2. Relay A2 then releases, opening circuit 14 to deenergize relay B2 and closing circuit 39 to pick up relay C2, and finally, relay B2 releases opening circuit 39 to deenergize relay C2 and closing circuit 40 to pick up relay D2. When the office relay B2 releases, it completes, at its back contact *g*, a circuit 66 which extends from terminal B to contact *e* of relay P7 over the same path as circuit 65 to lever SW, thence over the right-hand contact *b* of lever W and over the same path as circuit 38 through relay OT to terminal C, so that relay OT picks up to open line 5.

When each line relay L2 releases, relay C2 or D2 will be in its energized position so that circuit 43 or 44 will close and circuit 39 or 40 will open, picking up relay Y2 and holding relays X2 and C2 or D2 energized, and releasing relay Y3. Relays Y3 at the office and selected station at their back contacts *d* complete branches 67 of circuit 16 to pick up the corresponding relays P8, and relays P8 complete their stick circuits 68. Relays Y3 at contacts *c* open the stick circuits 62, releasing relays P7.

The office relay P8 upon picking up at contact *g* opens circuit 65 or 66 so that relay OT releases to close line 5.

Eighth step—Short

When each line relay L2 picks up, a circuit 69 or 70, which is similar to circuit 22 but includes contact *c* of relay C2 or D2, becomes closed, in case the preceding step is long, or circuit 22 closes, in case the preceding step is short, to pick up X3 and A3 and to hold Y2 energized. Circuit 43 or 44 opens to deenergize relays X2 and C2 or D2 if the preceding step is long, or circuit 15 opens, to deenergize relays X2 and A2 in case the preceding step is short.

Since in the code described the preceding step was long, lever SW being reversed, it follows that when X3 picks up, a circuit 171 is closed momen-

tarily from terminal B, contact *b* of relay CR at the selected station, contact *c* of relay X3, contact *e* of relay C2 or D2, contact *c* of relay P8, the right-hand winding of the polar-stick switch control relay WS to terminal C. If the preceding step were short (lever SW normal) a similar circuit 172 would be closed at this time over contact *e* of relay A2, contact *d* of relay P8 through the left-hand winding of relay WS. Relay WS will be operated to the right or left over circuit 171 or 172 in acordance with the position of lever SW, and remains in its last-operated position until it is again energized.

The character of the eighth step is determined by the position of the signal lever LG, and with this lever in its normal or stop position, as shown, the eighth step is short because a circuit 73 is completed from terminal B at front contact *d* of relay SR1, over contact *d* of relay S1, contacts *g* of relays P11, P10 and P9, contact *e* of relay P8, contact *b* of lever LG and thence over the same path as circuit 27 over contact *f* of relay A3 through relay OT to terminal C. Relay OT picks up over circuit 73 to open line 5 when the office relay X2 releases and closes its contact *d*.

If lever LG had been in its left-hand or clear position circuit 73 would be ineffective, so that relay OT would remain deenergized and circuit 69, 70 or 22 would open and circuit 23 close to pick up relay B3 in series with relays X3 and Y2 upon the release of relay C2, D2 or A2. Relay A3 upon releasing due to the opening of circuit 22 would close circuit 24 and open circuit 23 to pick up relay C3 and deenergize relay B3, and relay B3 upon releasing would complete a branch 74 of circuit 26 over the left-hand contact *b* of lever LG and contact *f* of relay C2 to pick up relay OT.

In either case, when relay OT picks up to open line 5 each relay L2 releases and closes circuit 31, 28 or 29 to pick up relay Y3 and to hold relay X3 energized in series with relay A3, C3 or D3, and opens circuit 69, 70 or 22 to release relay Y2. Relays Y2, upon releasing, complete circuits 75 to pick up relays P9 and open circuits 68 to release relays P8, and relays P9 complete their stick circuits 76 at the office and selected station. The office relay P9 upon picking up opens circuit 73 or 74 so that relay OT releases to close line 5.

Ninth step—Short

When each line relay L2 picks up circuit 36, 34 or 35 closes to pick up relays X2 and A2 and to hold relay Y3 energized, and circuit 31, 28 or 29 opens to deenergize relays X3 and A3, C3 or D3.

Since the preceding step was short (lever LG normal) relay A3 is now picked up but deenergized and when relay X2 picks up a circuit 177 is closed momentarily at the selected station from terminal B, contact *b* of relay CR, contact *c* of relay X2, contact *e* of relay A3, contact *d* of relay P9, the left-hand winding of relay LHS to terminal C. If the preceding step were long (lever LG at the left) relay C3 or D3 would be picked up and a similar circuit 178 would be closed over contact *e* of relay C3 and D3, contact *c* of relay P9, the right-hand winding of relay LHS to terminal C. In either case relay LHS will be energized momentarily in a direction to operate it to a position to correspond with that of lever LG.

The ninth step is short when signal lever RG is in its normal position, as shown, and is long when lever RG occupies its right-hand position, and its length is determined by circuits 79 and 80 for relay OT similar to circuits 65 and 66 already described. When relay X3 releases relay OT picks up over circuit 79 or 80 and opens line 5. Each line relay L2 releases to close circuit 15, 43 or 44 to pick up relay Y2 and to hold relay X2 energized in series with relay A2, C2 or D2 and to open circuit 36, 34 or 35 to release relay Y3.

Relays Y3, upon releasing, complete circuits 91 to pick up the relays P10 and open circuits 76 to release relays P9, and relays P10 complete their stick circuits 82 at the office and selected station. The office relay P10 upon picking up opens circuit 79 or 80 so that relay OT releases to close line 5.

Tenth step—Short

When each line relay L2 picks up, circuit 22, 69 or 70 closes to pick up relays X3 and A3 and to hold relay Y2 energized, and circuit 15, 43 or 44 opens to deenergize relays X2 and A2, C2 or D2.

Relay RHS is now operated to the left or right over a circuit 183 or 184 in accordance with the position of lever RG, the circuits being similar to circuits 171 and 172 for relay WS already described.

The length of the tenth step is determined in accordance with the position of the call-on signal lever CO by means of circuits 85 and 86 for relay OT which are similar to circuits 73 and 74 controlled by lever LG already described. When relay OT picks up over circuit 85 or 86 each line relay L2 releases and closes circuit 31, 28 or 29 to pick up relay Y3 and to hold relay X3 energized in series with relay A3, C3 or D3, and opens circuit 22, 69 or 70 to release relay Y2. Relays Y2 upon releasing complete circuits 87 to pick up relays P11 and open circuits 82 to release relays P10, and relays P11 complete their stick circuits 88. The office relay P11 upon picking up opens circuit 85 or 86 so that relay OT releases to close line 5.

Eleventh step—Short

When each line relay L2 picks up circuit 36, 34 or 35 closes to pick up relays X2 and A2 and to hold Y3 energized, and circuit 31, 28 or 29 opens to deenergize X3 and A3, C3 or D3.

Relay CHS is now operated to the left or right over a circuit 189 or 190 in accordance with the position of lever CO, these circuits being similar to those for relay LHS already described. The eleventh step is short in all control codes, and relay OT is picked up over a branch 91 of circuit 37 over contact *e* of relay P11, which closes when relay X3 releases. When relay OT picks up over circuit 91 and opens line 5 each line relay L2 releases to close circuit 15 to pick up relay Y2 and to hold relays X2 and A2 energized and to open circuit 36, 34 or 35 to release relay Y3.

Relays Y3 upon releasing complete circuits 92 to pick up relays P12 and open circuits 88 to release relays P11, and relays P12 complete their stick circuits 93.

The office relay Y3 now completes at its back contact *d* a circuit 94 for relay PC comprising a branch of circuit 16 extending from terminal B over contact *f* of relay P11, the normal contact of the recall key RC, contact *f* of relay OM, the left-hand winding of relay PC to terminal C. Relay PC therefore operates its contacts *a* and *b* to the left, so that when relay OT releases cur-

rent of normal polarity will be delivered to line 5.

When the office relay P12 picks up it opens the stick circuit 3 for relay SP1 at its contact *h*, since contact *h* of relay S1 is now open, and relay SP1 releases. At contact *g*, the office relay P12 opens circuit 91 to release relay OT to close line 5.

Twelfth step

Since the line circuit now becomes energized by current of normal polarity relays L1 at the office and at all stations pick up, and each at contacts *a* closes a circuit 95 from terminal B over contact *b* of relay YO, the upper winding of relay XO, relay AO to terminal C, so that relays XO and AO pick up. At the same time circuit 15 is opened at contact *d* of relay L1 so that relays Y2, X2 and A2 release. Relays Y2 open circuits 93 releasing relays P12. Relays P13 are not operated during a control code unless the recall key RC is operated, as hereinafter described.

When the office relay AO picks up it opens circuit 61, releasing relay SR1.

When the office relay XO picks up it opens the stick circuit 19 for relay OM at its contact *b* and relay OM releases. The office relay XO, at contact *c*, closes a circuit 96 from terminal B over contact *g* of relay ST, relay OT to terminal C so that relay OT picks up and opens line 5 to terminate the line-closed portion of the twelfth step.

Relays L1 therefore release, and each closes a circuit 97 to pick up relay YO and to hold relays XO and AO energized, which at the office extends from terminal B, contact *b* of relay L1, upper winding of relay YO, contact *a* and winding of relay XO, contact *a* and winding of relay AO to terminal C. Circuits 97 at the field stations are similar, but each includes, in addition, a back contact *f* of relay L2. The office relay YO at contact *c* closes circuit 11 to reenergize relay ST. When relay ST picks up its contact *g* opens circuit 96, releasing relay OT to close line 5.

Restoration to normal

All relays L1 now pick up and remain steadily energized and each closes a circuit 98 from terminal B over its contact *c*, upper winding of relay X1, contact *a* and lower winding of relay YO, contact *b* of relay AO, relay A1 to terminal C, so that relays X1 and A1 pick up and YO is held energized. At the same time circuit 97 is opened and relays XO and AO are deenergized. At each station at which the lock-out relay Z has been picked up, that relay now releases due to the opening of circuit 133 at back contact *b* of relay X1. When each relay AO releases it opens circuit 98 at its contact *b* to deenergize relay A1 and closes a circuit 99 at its contact *h* to pick up relay B1 in series with relays X1 and YO. When each relay A1 releases, it similarly opens circuit 99 and closes a circuit 100 to deenergize B1 and to pick up relay C1 in series with relays X1 and YO. When each relay B1 releases, it opens circuit 100 and at its contact *h* completes the normally closed holding circuit 6 for relays X1, YO and C1. When the station relays C1 pick up, each at its contact *h* opens circuit 121 releasing relay CR. All of the apparatus, with the exception of lever SW and relay WS, which have been reversed, has now been restored to its normal condition.

If a starting relay such as S2 has been released during the transmission of the code just described, the corresponding sending relay SP2 will pick up over circuit 2 when relay ST picks up during the line open period at the end of the twelfth step. Then when the line becomes steadily energized, relays AO, A1 and B1 release successively as described, circuit 4 becoming closed at contact *g* of relay B1 to pick up relay OT and thereby initiate the new code, when relay B1 releases. The two codes are thus separated by a long positive impulse following the short positive twelfth step of the first code.

The transmission of a typical indication code will now be described. As shown in Fig. 2B, the station starting relay S has a normally closed holding circuit 101, similar to the office circuit 1 already described, which is opened to release relay S upon a change in position of any of the indication transmitting relays at the station. It will be assumed that the coding apparatus is in its normal condition, as shown, but that the track switch at station No. 1 has been operated to reverse as a result of the reversal of relay WS by the control code already described. When the movement of the track switch is completed, the switch indication relay KR becomes energized in the reverse direction, opening circuit 101 at its contact *a*. This initiates the code and it is to be understood that the station code call will be represented by one long and four short impulses, as in the control code to which the apparatus at station No. 1 is responsive, and that all the function elements of the code are short steps except the seventh step controlled by contact *c* of relay KR which is long to indicate that the track switch is reversed.

Relay S, at station No. 1, at its contact *g* completes a circuit 102 from terminal B, contact *c* of relay X1, Fig. 2A, contact *g* of relay M, contact *g* of relay S through the left-hand winding of the polar stick relay SP to terminal C. Relay SP operates its contacts to the left, closing a circuit 103 from terminal B over its contact *b* and the contacts *g* of the P relays, contact *c* of relay YO, relay ST, Fig. 2A, to terminal C.

The station relay ST picks up and completes a circuit 104 which extends from terminal B over the same path as circuit 103 in Fig. 2B, but which is completed in Fig. 2A over contact *f* of relay C1, contact *g* of relay B1, contact *d* of relay XO, contact *a* of relay ST, relay T to terminal C. Relay T therefore picks up and at its contacts *a* and *b* opens the line circuit 5 deenergizing the plus line relays L1 at the office and at all stations.

The release of the line relays L1 has the same result as in the case of the control code already described; that is, circuit 6 is opened and 7 closed, picking up the relays Y3, holding relays X1 and C1 energized and releasing relay YO; circuit 8 closes, reversing PC; and circuits 9 and 10 close picking up and sticking relays P1.

When the station relay P1 picks up, it opens circuit 104 at its contact *g*, releasing relay T to close line 5. Relay YO upon releasing opens circuit 103 to release relay ST.

The character of the first step of the code determines the direction of transmission, being short in a control code and long in an indication code.

Since relay PC is now reversed, the closing of line 5 by relay T causes the minus line relays L2 to pick up, each closing circuit 12 and opening circuit 7 to pick up relays X2 and A2 to hold relay Y3 energized and to release relays X1 and C1. The station relay X1 upon releasing opens

circuit 102. Each relay C1 upon releasing opens circuit 12 and closes circuit 14, deenergizing relay A2 and energizing relay B2 in series with relays X2 and Y3. Each relay A2, upon releasing, opens circuit 14 and closes circuit 39, deenergizing relay B2 and energizing relay C2 in series with relays X2 and Y3. The station relay B2, upon releasing, closes a circuit 113 for relay T which extends over the same path as circuit 103 from terminal B to contact *g* of relay P2 and then extends over contact *e* of relay P1, contacts *f* of relay C2, contact *g* of relay B2, contacts *d* of relays X3 and X1, relay T to terminal C. Relay T therefore picks up over circuit 113 to open line 5.

When line 5 opens, relays L2 release and close circuits 43 to pick up relays Y2 and to hold relays X2 and C2 energized, and open circuits 39 to release relays Y3. Each relay Y3 upon releasing, closes circuit 16 to pick up relay P2 and opens circuit 18 to release P1, and each relay P2 closes its stick circuit 17. The relay Y3 at the transmitting station closes a circuit 118 from terminal B at contact *d* of relay YO over the same path as for circuit 145 to contact *c* of relay P1, thence over that contact and contact *c* of relay SP, relay M to terminal C. Relay M upon picking up closes its stick circuit 119 which extends to terminal B over contact *g* of relay C1 and contact *b* of relay XO.

Relay Y3, at the office, upon releasing, closes a branch 20 of circuit 45 over contact *e* of relay P1 to pick up the indication register relay IR, which upon picking up completes its stick circuit 21 which extends to terminal B over its contact *a* and contact *h* of relay C1. Relay IR remains energized until the code transmission is completed.

When relay P2 at the transmitting station picks up, it opens the energizing circuit 113 for relay T at its back contact *g* so that relay T releases to close the line circuit 5.

The operations on second to sixth steps, inclusive, of the indication code are identical with those effected during the corresponding steps of the control code already described, except that the transmission is governed by the station relay T, which is energized successively over branch circuits 126, 137, 146, 151 and 156 similar, respectively, to the circuits 26, 37, 46, 51 and 56 for the office relay OT already described.

At each other field station, relay Z will be picked up on one or another of these steps, over circuit 132 as in the case of a control code, so that the relay progression continues beyond the fifth step at the office and transmitting station only. On the sixth step, relay S picks up over a circuit 156 similar to circuit 56 already described, and closes its stick circuit 101, and at its contact *c* prepares circuits for controlling relay T on succeeding steps.

The indication code has six function steps, two more than the control code described. On the seventh and eighth steps, relay T is controlled, respectively, over the polar contact *c* and the neutral contact *b* of the switch indication relay KR, and since it has been assumed that this relay is energized in the reverse direction, relay T will be energized over circuits 166 and 173, respectively, corresponding to the office circuits 66 and 73 already described, to produce a long seventh step and a short eighth step, each of which is registered at the office on the next succeeding step by the momentary energization of a polar stick indication relay. Since the seventh step is long, it will be found that relays X3 and C2 or D2 are in their energized positions at the beginning of the eighth step, and a circuit 71 is closed from the middle terminal O of the local battery, Fig. 1B, through the winding of the switch indication relay 1WK, contact *c* of relay P8, contact *b* of relay SR1, contact *c* of relay X3, contact *b* of relay IR, contact *e* of relay C2 or D2 to terminal C, energizing relay 1WK in the reverse direction to close its right-hand contact *a*. If the seventh step were short, relays X3 and A2 would be in their energized positions at the beginning of the eighth step, and a circuit 72 would be closed at the beginning of the eighth step which extends from terminal B, contact *e* of relay A2 and thence over the same path as for circuit 71 through relay 1WK to the middle terminal O of the local battery, to cause relay 1WK to move contact *a* to the left, as shown.

The eighth step being short, at the beginning of the ninth step, relays X2 and A3 are in their energized positions and a circuit 77 is closed from terminal B, contact *e* of relay A3, contacts *c* of relays IR, X2, SR1 and P8, relay 1LK to terminal O to operate relay 1LK to the left. When the eighth step is long, a circuit 78 similar to 77 but including contact *e* of relay C2 or D2 closes at this time and relay 1LK is operated to the right.

It is to be noted that when the movement of the track switch from normal to reverse is initiated, relay KR releases, transmitting a code to energize relay 1WK in the normal direction and relay 1LK in the reverse direction, and the normal switch indication lamp NWE is extinguished by the opening of contact *a* of relay 1LK. When the switch completes its movement to reverse an indication code is transmitted to energize relay 1WK in the reverse direction and relay 1LK in the normal direction, as described, to light the reverse switch indication lamp RWE, as will be apparent from the drawings.

In a similar manner, the signal repeating relays LGP and RGP and the track relays TR and AR control the character of the ninth, tenth, eleventh and twelfth steps. When the signals indicate stop, LGP and RGP are both energized, the ninth and tenth steps are short, relays 1LGK and 1RGK are both operated to the left and lamp NGE is lighted. When signal LG or RG is clear, relay LGP or GRP is released and the corresponding code step is long so that 1LGK and 1RGK are operated to the right to light lamps LGE and RGE, as the case may be.

Similarly, the eleventh and twelfth steps are short or long depending upon whether the relays 1TR and 1AR, respectively, are energized or released, relays 1TK and 1AK being operated to the right to light lamps 1TE and 1AE by long impulses on the 12th and 13th steps, respectively, to indicate the occupancy of the respective track sections.

At station No. 2, the jumper connection for relay S will be arranged to connect circuits 156 and 126, so that when an indication code is initiated at station No. 2, the sixth step will be long to effect the energization of relay SR2 over circuit 63, in place of relay SR1, and another set of indication relays K, not shown, but similar to those associated with the control panel for station No. 1, will be operated over circuits such as 71 and 77, as will be apparent from the drawings.

The stepping operations on the seventh to eleventh steps, inclusive, of an indication code are the same as for the control code already de-

scribed, but since the indication code includes two additional steps the succeeding operations are different. Circuit 94 is open at contact *f* of relay OM, and consequently it does not become closed to restore relay PC to normal during the line-open period of the 11th step. It follows that in an indication code, the 12th step is of negative polarity, and relays L2 pick up when relay T releases and closes line 5 at the beginning of the twelfth step, as on preceding even numbered steps, closing circuits 22 and opening circuits 15 to pick up relays X3 and A3, to hold relay Y2 energized, and to deenergize relays X2 and A2.

Relay ITK is energized momentarily on this step, as already pointed out, and when relay X2 releases, relay T is energized selectively to determine the length of the step over a circuit 105 or 106 including contact *e* of relay P12. When relay T picks up, relays L2 release and each closes circuit 21, 28 or 29 to pick up relay Y3 and to hold relay X3 energized in series with relay A3, C3 or D3, and opens circuit 22, 69 or 70 to release relay Y2. Relays Y2 upon releasing complete circuits 107 to pick up relays P13, and open circuits 93 to release relays P12, and relays P13 complete their stick circuits 103. The station relay P13 upon picking up opens circuit 105 or 106 so that relay T releases to close line 5.

At the beginning of the thirteenth step, line relays L2 pick up, closing circuits 36 and opening circuits 31 to pick up relays X2 and A2 and hold Y3 energized, and to deenergize X3 and A3.

Relay IAK is energized momentarily on this step, as already described, and when relay X3 releases, relay T is energized over a circuit 109 including front contact *e* of the station relay P13. The thirteenth step therefore is a short impulse, and relays L2 release, closing circuits 15 to pick up relay Y2 and to hold X2 and A2 energized, and opening circuits 36 to release Y3.

The office relay Y2 upon picking up closes a branch 194 of circuit 17 from terminal B at contact *d* of relay YO over contact *b* of the office relay P13, through the left-hand winding of relay PC to terminal C. Relay PC therefore operates its contacts *a* and *b* to the left during the line-open period of the thirteenth step.

When the station relay Y3 releases, it opens circuit 108 to deenergize relay P13 and at the same time closes a branch 110 of circuit 16 from terminal B over contact *b* of relay P13 through the right-hand winding of relay SP, energizing relay SP momentarily to restore it to its reverse position, as shown. Relay SP at contact *a* opens circuit 109 to deenergize relay T.

When relay T releases, line 5 becomes energized by current of normal polarity to begin the fourteenth step, and relays L1 at the office and all stations pick up, closing circuits 95 to pick up relays XO and AO, and opening circuit 15 to release Y2, X2 and A2, as already described in connection with the twelfth step of the control code.

The office relay AO upon picking up opens circuit 61, releasing relay SR1. The station relay XO upon picking up opens circuit 119, releasing relay M. At the same time the office relay XO closes circuit 96 to pick up relay OT to open line 5.

Relays L1 release, and, as already described, close circuits 97 to pick up relay YO and to hold XO and AO energized. The office relay YO closes circuit 11, picking up the office relay ST, which opens circuit 96 releasing OT to close line 5.

All relays L1 now pick up and remain steadily energized and close circuits 98 and open circuits 97 to pick up relays X1 and A1, to hold YO energized and to release relays XO and AO. Relays X1 open circuits 133 to release relays Z at the stations at which these relays have been energized, and as the end of a control code, circuits 99, 100 and 6 close to energize relays B1 and C1 successively and to complete the stick circuit for energizing relay C1 in series with relays X1 and YO, as shown. When the office relay C1 picks up circuit 21 opens to release relay IR. All of the apparatus with the exception of lever SW and relays KR and IWK which are reversed, is now in its normal condition, as shown.

If a starting relay such as relay S has been released at any station during the transmission of the code just described, the corresponding relay SP will be reversed by the closing of circuit 102 when relay X1 picks up upon the restoration of the line to normal. Relays AO, A1 and B1 then release successively, circuit 104 closing at back contact *g* of relay B1 to initiate the new code when relay B1 releases. The two codes are thus separated by a long positive impulse following the short positive 14th step of the first code.

Our apparatus includes a novel "recall" feature by means of which the operator may cause an indication code to be initiated without causing a change in the condition of any of the station devices. This is accomplished by reversing the recall key RC, Fig. 1B, and by then opening circuit 1 by momentarily reversing one of the control levers. This results in the transmission of a control code which differs from that hereinbefore described in that it includes one additional step. Circuit 94 is not closed to restore relay PC to normal on the 11th step, and consequently, line 5 is energized by current of reverse polarity on the 12th step, as in the case of an indication code. The 12th step is short, because relay OT is energized over the branch 196 of circuit 27 which extends to terminal B over contact *e* of relay P12 and contact *g* of relay P13. Relay PC is restored to normal when relay Y2 releases on the 12th step by energization over a circuit 94*a* which extends from terminal B at contact *d* of relay YO over the same path as circuit 59 to contact *f* of relay P12, thence over that contact and the reverse contact of the recall key RC, contact *f* of relay OM through the left-hand winding of relay PC to terminal C. Relay P13 picks up over circuit 107 and opens circuit 196, deenergizing relay OT, and when relay OT closes line 5 to begin the 13th step, line relays L1 will pick up, the remaining operations involved in restoring the apparatus to normal being similar to those previously described. The recall code, however, will produce a different result at the selected station. Since the 11th step of the code is short, relay A2 will be in its energized position at the beginning of the 12th step and since the 12th step is negative relay X3 will pick up to close a circuit 102*a* momentarily from terminal B at contact *b* of relay CR over the same path as circuit 172, front contact *d* of relay P12, the left-hand winding of relay SP to terminal C. Consequently, relay SP will be operated to the left by the control code and will connect terminal B to circuit 103, so that circuit 104 will become closed when relay B1 releases following the restoration to normal at the end of the code, thereby initiating the transmission of an indication code, the two codes being

separated by a long positive impulse as in the cases previously described.

Our apparatus is so arranged that after a code has been initiated by any transmitter it can not be interfered with by the operation of other transmitters, and also so that if two or more codes are initiated simultaneously, no interference will occur, but the codes will be transmitted one at a time in a predetermined order of code superiority.

No station relay SP can be operated to the left by the release of the associated relay S during transmission because circuit 102 is opened by relay XI which releases when the line circuit is opened at the beginning of a code. Similarly, no office relay such as SP1 can pick up during transmission because its pick-up circuit 2 is similarly controlled by the office relay ST. It may happen, however, that two or more relays such as SP1 and SP are operated at the same time.

Since all circuits for the station transmitter relay T, except the initiating circuit 104 and circuit 113 for producing a long first step, include front contacts of relay M, relay M must pick up in order to permit a station to continue transmission beyond the first step. The pick up circuit 118 for relay M is a branch of circuit 145 and closes only when the first step of the code is a long impulse. If the office and one or more stations start simultaneously, the station apparatus will be unable to prevent the office relay OT from opening line 5 to produce a short first step, consequently, none of the station relays M can pick up; relay OT will remain in control of the line, and relay OM at the office will pick up over circuit 18, which closes only when the first step of the code is a short impulse, and the office transmitter will remain in operation.

Relays CR at the stations will pick up in response to the short first impulse to condition the stations to register the control code while the office relay IR will remain deenergized.

If two or more stations start simultaneously, their transmitting relays T will be held in step by the line relays only as long as the code steps are of identical character. As soon, however, as a station attempts to transmit a long impulse while another station is transmitting a short impulse, its operation will be discontinued. Assume that station No. 1 starts to transmit the indication code hereinbefore described, and that at the same time another station starts a code having a short second step. At station No. 1, the line relay L2 will release at the end of the line-closed portion of the second step while relay A3 is picked up, that is, before relay C3 has picked up to prepare circuit 130 for relay P3, consequently, relay Z will pick up over circuit 132, and relay P2 will release without energizing relay P3, circuit 137 will remain open, and consequently relay T at station No. 1 will remain deenergized and the code being transmitted by the other station will continue without interference. The operation of the timing relays at station No. 1 is discontinued due to the opening of contacts *b* and *c* of relay Z.

It will be apparent that a similar result may occur on any station selecting step of the code, and that the selection as to which station will retain control of the line is on the basis of code superiority, the transmission of a short impulse on any step taking precedence over a long impulse.

Since the office control levers may be operated individually or in any combination at any time, it may happen that a plurality of code sending relays such as SP1 and SP2 are picked up at the same time and provide a multiple energization of circuit 4 to initiate different control codes. On any station selecting step, it is obvious that the circuit such as 27 or 56 for picking up relay OT to produce a short code element will be closed before the corresponding circuit 26 or 57 for producing a long element can be closed and will effect the energization of the proper relay P to render the latter circuit ineffective. Consequently, but one relay, SP2 for example, will remain in control of relay OT, and no interference between the stored codes will occur. Each code sending relay SP at the office will be released at the end of the last negative step of the code provided the associated starting relay is reenergized during the tranmission of the 6th step of the corresponding code, and the stored codes will be transmitted one at a time in order.

As explained more fully in the Snavely, Miller and Jackel Patent No. 2,183,155 hereinbefore referred to, the station apparatus may be provided with a plurality of series of relays P such as are provided for the office apparatus described herein, when there are a plurality of storage units, or groups of controlled devices at a station to be controlled and indicated by the station coding apparatus. When the station apparatus is so arranged, there will be a plurality of relays SP at a station, one for each storage unit, and these relays SP may have their contacts *b* closed at the same time to initiate different indication codes. It is evident that, as in the case of the office apparatus, the station apparatus may be so arranged that but one relay SP will remain in control of relay T and no interference will occur.

If two or more control levers of a group such as levers SW and LG associated with station No. 1 are operated, it is evident that the code will contain the proper function steps corresponding to the new positions of all the levers that have been operated provided these operations are completed in time to permit the starting relay such as S1 to pick up over circuit 56, which circuit closes prior to the transmission of the first function step of the code. A lever movement occurring during the transmission of the function steps will open circuits 1 and 2 at the lever contact *a* and cause relay S1 to release and open the circuits for relay OT. This causes the apparatus to subsequently transmit a new code, thereby insuring that the function steps of a completed control code correspond to the final positions of the levers.

Since the station circuits are similarly arranged, it will be evident that similar considerations apply, in the event one or more of the indication controlling devices change their positions during the transmission of an indication code from the corresponding station.

In accordance with another feature of our invention, our apparatus is so arranged that stored codes are usually transmitted in the order in which they are stored, and only in accordance with the relative code superiority when the codes are stored at the same time, or prior to the initiation of a series of codes. When a plurality of control codes are stored while the line is in use, the office will transmit all the stored control codes in the order of code superiority when the line becomes free, before it transmits

any control codes that become stored while these stored codes are being transmitted. Similarly, when the stations obtain control of the line, one indication code will be transmitted from each station storage unit which has at that time a code stored for transmission, before any station storage unit can transmit a second code, and also before the office can transmit a code which becomes stored while the stored indication codes are being transmitted.

To explain this feature of our invention it will first be assumed that levers for controlling devices at station No. 1 and at some inferior station No. 3 are operated, either at the same time or while indication codes are being received. In either case, pick-up circuits 2 for the two relays SP1 and SP3 will be closed so that both will pick up and will jointly energize circuit 4 to initiate a control code when the line becomes available, which by reason of code superiority will be the code for station No. 1.

It will also be assumed that one or more levers for controlling devices at other stations, including the superior station No. 2, are operated after the code transmission has started. The pick-up circuit 2 for relay SP2 and other similar relays for which the corresponding starting relays S have been released is held open at contact *c* of relay ST, and the first code transmitted will be the one for station No. 1, but there are now two or more control codes stored for subsequent transmission. Because the code for the inferior station No. 3 was stored first, it will be transmitted first, as will now be explained.

The first control code will progress as hereinbefore described up to the final, or 12th step, at which time the line relays L1 pick up to open circuit 15 and close circuit 95 to energize relays XO and AO and release relays X2, Y2 and A2, as already described. The office relay XO upon picking up opens the normal stick circuit 19 for relay OM, at its contact *b*, but relay OM does not release If there are other control codes stored for transmission, but remains energized over an auxiliary stick circuit 60 which is closed at this time by relay AO, comprising a branch of circuit 4 which extends from terminal B at front contact *b* of any relay SP which is already picked up, such as relay SP3 over back contacts *g* of relay SR3 and back contacts of the corresponding series of relays P6 to P1, contact *f* of relay AO, contact *g* of relay C1, contact *a* and winding of relay OM to terminal C.

It may be noted that relay SP3 now controls circuit 60 because relay SP1 was released when relay P12 picked up at the end of the 11th step, and relay SP2 has not been picked up.

As in the case of the control code previously described, the office relay XO at its contact *c* closes circuit 96, causing relay OT to open line 5, to terminate the line-closed position of the twelfth step, thereby releasing relays L1, whereupon circuits 97 close to pick up relay YO and to hold realys XO and AO energized, the office relay YO closing circuit 11 to pick up relay ST. Relay ST connects terminal B to circuit 2, but this circuit is now held open at back contact *g* of relay OM. It follows that although relay S2 has been released, relay SP2 does not pick up at this time. Relay ST opens circuit 96, releasing relay OT and closing line 5.

In the cases previously described, this initiated the return to normal at the end of the code, or the beginning of the long positive impulse interposed between successive codes, but in the present case, it represents the beginning of the first step of the second code of the series, which is a short positive step. Since relay PC is still normal, relays L1 pick up, closing circuits 98 and opening circuits 97 so that relays X1 and A1 pick up, relays YO and ST are held energized, and XO and AO are deenergized.

The office relay AO now opens the auxiliary stick circuit 60 and at the same time relay XO reestablishes the normal stick circuit 19 for relay OM and also closes a circuit 4*a* for relay OT from terminal B at front contact *b* of relay SP3 over the same path as for circuit 60 just traced to contact *g* of relay P1, thence over contact *b* of relay OM, contact *f* of relay A1, contact *d* of relay XO, contact *a* of relay ST, relay OT, to terminal C. Relay OT, upon becoming energized over circuit 4*a*, opens line 5, releasing relays L1. Each relay L1 upon releasing closes a circuit 112 from terminal B, contact *d* of relay L1, contact *b* of relay L2, relay Y2, contact *b* of relay X2, contact *e* of relay A1, contact *a* and winding of relay X1, contact *a* and winding of relay A1 to terminal C. Relays Y2 pick up and relays X1 and A1 are held energized over circuits 112, and circuits 98 are opened, releasing relays YO. Since relay X1 has been picked up, the release of the office relay L1 closes circuit 8 to position relay PC to the right at this time. Relays P1, it will be noted, have not been operated.

When relays YO release, each relay P2 picks up over circuit 114 extending from terminal B, contact *d* of relay YO, contact *c* of relay Y2, contact *d* of relay A1, relay P2, to terminal C, and each relay P2 then closes its stick circuit 17. The office relay P2 at contact *g* opens circuit 4*a*, releasing OT and thereby closing line 5. Since the relays C1 have not been operated, the control register relays CR at each station remain energized.

This completes the first step of the second control code of the series, which, it will be seen, is a short positive step as distinguished from the short negative first step of the first control code of a series as hereinbefore described. The apparatus is now in the same condition as at the corresponding point of the control code first described. The apparatus continues to operate as hereinbefore described until the code for the inferior station No. 3 is completed. If other code sending relays in addition to relay SR3 were picked up when the series of codes was initiated, branches of circuit 60 will be completed to terminal B over contact *b* of such relays at the end of this code, and relay OM will not release until the corresponding codes have been transmitted. Relay OM will release at the end of the last of such codes, closing its contact *g* to prepare circuit 2 to pick up relay SP2, and any other relay SP for which the corresponding relay S is released, but will open circuit 4*a* at its contact *b* so that the first code will be followed by a long positive impulse, terminated when relay OT picks up over circuit 4 following the release of relay B1, as already explained in the description of the restoration of the apparatus to normal at the end of a code. Since relay X1 picks up at the beginning of this long impulse, circuit 8 closes to reverse relay PC during the succeeding line-open period, so that the next impulse, comprising the first step of the code for the superior station No. 2, will be of negative polarity.

The apparatus is now in the same condition as at the corresponding point of the control code

first described, and will therefore continue to operate until the office panels for each of the stations No. 2, etc. transmit their codes in order.

It will be seen that our apparatus functions as described because we have provided two sets of relays for storing the codes in two groups, one of which has priority over the other.

As already explained, the apparatus at a field station may also be arranged to have a plurality of storage units each comprising a relay S and a relay SP, as illustrated by the office apparatus of Fig. 1B, and when so arranged these relays will also function in the manner described to give priority to codes stored prior to the beginning of a series. This is also true when the codes are stored in storage units at different stations.

To make this clear, I will assume that the apparatus is arranged to have but one storage unit per station, as shown in Fig. 2B, and that devices at station No. 1 and at some inferior station No. 3 change positions at the same time, or while the line is not available, so that relays SP at the two stations are operated to the left over circuits 102 at the same time, to jointly initiate an indication code when the line becomes available by the simultaneous operation of their relays T, and that after the code transmission has started a device at the superior station No. 2 changes its position.

The relays T at stations Nos. 1 and 3 will be held in synchronism by the line relays L2 only as long as the code elements are alike. It will be assumed that the first, second and third steps of the code for station No. 3 are long, while in the code for station No. 1, as already described, the first and second steps are long and the third step is short. Consequently, relays M at both stations will pick up over circuit 118 on the long first step, and relays P3 will pick up at both stations over circuit 130 on the long second step. Relay T at station No. 1 will be energized over circuit 137 to produce a short third step. Consequently, relay P4 will pick up at station No. 1 over circuit 145, while at station No. 3 the jumper connections in the circuits over contacts *b* and *c* of relay P3 are interchanged so that relay Z will pick up, relays P2 releasing at both stations. Further progression at station No. 3 is stopped, as already explained, and although relay M at that station remains energized over its stick circuit 119, the energizing circuits for relay T which it controls are not closed because no relay P is energized. The transmission by station No. 1 will continue as hereinbefore described up to the final, or 14th step, when the plus line relays L1 pick up. At station No. 1, which transmitted the code, relay M is released by the opening of circuit 119 on this step, while at the inferior station No. 3, having a code stored for transmission, relay M is held energized over an auxiliary stick circuit 160 extending to terminal B over contact *d* of relay Z, which relay is now energized over its stick circuit 133. Relays L1 are released on this step by the energization of relay OT over circuit 96, as on the final step of a control code, and the code delivered by station No. 1 is completed when line 5 is closed as the result of opening circuit 96.

This, as already described, results in again picking up relays L1, X1 and A1 to begin the return to normal when there are no codes stored for transmission but in the present case, although circuit 133 is opened at this time, releasing relay Z to open the auxiliary stick circuit 160 for the energized relay M at station No. 3, the normal stick circuit 119 for that relay is reestablished by the release of relay XO before circuit 160 opens. Consequently, relay M at station No. 3 remains energized and as soon as relay A1 picks up a branch 104*a* of circuit 104 is closed. Circuit 104*a* includes contact *b* of relay M and corresponds to the office circuit 4*a* already described, so that relay T picks up at station No. 3 to open line 5. This constitutes the first step of the second indication code, which like the corresponding step of the second control code of a series is a short positive step as distinguished from the long negative first step of the first indication code of a series, and this step follows immediately after the last step of the preceding code.

At the office, relays YO and ST pick up, as already described, on the line-open period of the last step, and since relay OM has not been energized, circuit 2 becomes closed to pick up any relays SP for which the corresponding office relays S have been released as the result of lever movement occurring during the code just described.

Relays P2 pick up during the line-open portion of the first positive step of the second code over circuits 114 and since the office relays P1 and C1 are not operated, circuits 4, 13 and 18 are held open and the office relays OT and OM do not pick up even though there are codes stored at the office, and circuit 21 remains closed so that the indication register relay IR remains energized.

When the station relays X1 pick up during the line-closed portion of the first positive step, circuit 102 becomes closed at each station at which relay M is deenergized, that is, at each station except station No. 3, to actuate relays SP if the relays S at such stations are released, but since the station relays P1 and C1 are not operated, circuits 104, 112 and 118 are held open and relays T and M at such stations do not pick up even though the stations have codes stored for transmission. Since relay M at station No. 1 releases before relay SP is actuated in response to a change in the position of a device at such station occurring during the transmission of the code by that station, it follows that station No. 1 will transmit but one code, and at the end of that code the inferior station No. 3 will assume control of the line even though the code sending relays at superior stations become actuated after the initiation of the code for station No. 1.

The apparatus is now ready to begin the second step of the second indication code of the series, and is in the same condition as at the corresponding point of the indication code first described, and therefore continues to operate as described until station No. 3 completes its code. If no other relays M have been energized, the apparatus will restore to normal at the end of this code. After the transmission of a long positive impulse following the last impulse of the code from station No. 3, relays C1 will pick up to close circuit 104 at each station at which relay SP has been operated to initiate the transmission of a new series of indication codes.

It will be seen therefore, that any two groups of codes are separated by a long positive impulse, while any two codes of a group are separated only by a brief line-open period similar to the interval between any two steps of a code. Furthermore, the first step of each except the first code of a group is a short positive step, while the first step of the first code of a group is a long or short

negative step, depending upon the direction of transmission. It will also be apparent that the direction of transmission is established by the first code of the group, and that all the stored codes for that direction will be transmitted before any codes for the opposite directions are transmitted.

It will be seen that under conditions of heavy traffic, codes will be transmitted from each office panel or station in turn until all the stored codes are transmitted and that new code storages established subsequently cannot delay the transmission of those codes previously stored, even though the new codes have superior code calls. In the absence of this feature, it is apparent that the transmission of certain code messages might be delayed to an extent greater than could be well tolerated.

Another result of this feature of our invention is that communication with the more superior stations is held up for longer time intervals than otherwise due to the more equal division of line time between the stations. Several successive changes in the positions of the levers for controlling the devices at such stations or in the positions of the indicating relays at such stations may be stored for transmission in a single code while otherwise each would require a separate code, so that the total number of codes is decreased and the traffic capacity of the system correspondingly increased.

Another feature of our invention resides in the arrangement of the apparatus so as to minimize the effect of a failure of any relay circuit upon the system as a whole. Assume, for example, that on the third step of an indication code, the station relay T is energized over circuit **137** and is holding line **5** open as already described, but relay **P4** fails to pick up to break circuit **137**. Relay T will not remain energized to prevent further use of the line because relay **Y3** will release due to the opening of the circuit through its lower winding when relay **L2** releases, and **P3** will release due to the opening of circuit **33** by relay Y3. Relay **P3** will then open circuit **137** to release relay T, closing line **5**, which will now remain closed with the L2 relays picked up. Each relay **L2** closes circuit **22** and opens circuit **15**, energizing relay **A3** in series with relays **X3** and **Y2** and deenergizing relays **X2** and **A2**. Relay **A2** upon releasing, closes circuit **23** and opens circuit **22**, energizing relay **B3** in series with relays **X3** and **Y2** and deenergizing relay **A3**. Relay **A3** then releases, closing circuit **24** and opening circuit **23**, energizing relay **C3** in series with relays **X3** and **Y2** and deenergizing **B3**, and when relay **B3** releases, circuit **25** closes and circuit **24** opens so that relay **D3** picks up in series with relays **X3** and **Y2** and **C3** is deenergized. Relay **C3** upon releasing, deenergizes relay **D3** but maintains relays **X3** and **Y2** energized over circuit **115** until relay D3 releases. It follows that relays **A2**, **A3**, **B3**, **C3**, **D3** and **Y2** release successively in that order and when the office relay **Y2** releases, a circuit **116** is closed from terminal B over contacts *b* of relays **X1**, **Y2** and **Y3**, the left-hand winding of relay PC to terminal C to restore relay PC to normal. This releases the relays **L2** and energizes relays **L1** and the apparatus is then restored to normal in the same manner as when relays **L1** pick up at the end of a complete code. A similar result occurs if there is a failure on any other odd-numbered step of a code, while on the even-numbered steps, a similar reset is obtained by the successive release of relays **A3**, **B2**, **C2**, **D2** and **Y3**. Since relay **Z** at the transmitting station has not been energized, relay M at that station will be released in response to the energization of relay **X0** by relay **L1**. It follows that other stations having codes stored for transmission, at which relays M and Z are energized, will take precedence and will transmit their codes before the station which failed can again initiate a code. This arrangement permits a station to "repeat," as is desirable, in the event a code is not completed, but in such a manner as to not interfere with the use of the line by other stations.

If the office apparatus for any reason is unable to complete a code, a similar reset action will occur, and the operations will be repeated until a complete code is transmitted, or until they are stopped manually by cancelling the code storages by the operations of the knock-down key KD to release the energized relays such as **S1** and **SP1**.

If a failure occurs during a line-closed period, it will also prevent further progression, and the apparatus will similarly reset to normal.

This is because the circuits are so arranged that a failure of any of the relay circuits to close as intended will merely stop operation, and will not cause a false selection. Thus for example, when relay **L2** picks up at the beginning of the first step, relays **X2** and **A2** are picked up in series over a circuit **12**, and if **L2** remains energized, relays **B2**, **C2** and **D2** are picked up successively in series with relay **X2**, over circuits **14**, **39** and **40**. The failure of any of these circuits to close at the proper time will cause relay **X2** to release and prevent the closing of circuit **15** when relay **L2** releases, so that the progression is stopped. The selection as to whether an impulse is registered as short or long depends upon the release periods of the A and B timing relays provided by the associated rectifier units. If the circuit for the unit associated with relay **A2** is open, relay **A2** will release quickly when relay **C1** releases and open the circuit **12** before relay **B2** picks up over circuit **14**, so that neither relay **A2** nor **C2** will be energized when relay **L2** releases.

It will be apparent from the drawings that insurance against improper operation such as is provided in the few instances just described is provided in each of those circuits disclosed herein, and that the apparatus is not able to hold the line open for an extended period to prevent the use of the line by other stations.

Since the various relay operations are checked on each step and the end of the code is marked by a positive impulse, the number of steps in a code may be varied as required without sacrifice in the reliability of the apparatus.

One manner by which a step may be added to a control code to provide an additional function has already been explained in connection with the "recall" feature of the apparatus. Obviously a control element for any function of which the use is relatively infrequent may be added in this manner, so that it will be included in the control codes only when required. In practice the codes for the different stations do not necessarily have the same number of steps, but each may have as many function steps as there are devices to be controlled or indicated, since in each code the transmission of negative impulses continues until relay PC is actuated over a circuit **94**, **94*a*** or **194**, and these circuits may be arranged to include contacts *f* of different P relays as re-

quired. Each code is definitely terminated and the apparatus conditioned to initiate a new code when a circuit such as 94 becomes closed, or in case a code is not completed when circuit 116 becomes closed.

Another feature of our invention is the provision of manual stepping equipment at the office by which the code progression may be stopped on each step so that the operation of the various relays may be more readily observed. In normal operation, when relays of the types disclosed in the hereinbefore mentioned Snavely applications are used, the speed of transmission is much higher than that usually attained in apparatus of this character, the time of transmission of a complete code being of the order of one second. This is because these relays are unusually efficient and rapid in operation and the time constants of the circuits have been minimized in many circuits by including non-inductive resistors in series with the relays, as shown on the drawings. It follows that the sequence of operation of the various relays takes place normally at a too rapid rate to be conveniently observed, and for this reason it is desirable to operate the apparatus at a slower rate for purposes of testing and adjustment.

When the progression of the relays is to be controlled manually, a key K2 at the office is operated. This inserts a branch 5*a* into the line circuit 5, which branch includes the front contact *a* of the neutral line relay LO and the normally closed contact *a* of a push button K1. If line 5 then opens due to the initiation of a code by any transmitter, relay LO will release and hold the line open at its contact *a* after the transmitter contact which opened the line has again closed. The code apparatus will be held inactive with the apparatus in the condition hereinbefore described, on the line-open period preceding the first impulse of a code. That is, relays Y3, X1 and C1 will be held energized over the stick circuit 7, and relays Y3 will hold relays P1 energized over the stick circuit 10, as long as the line is held open.

If the push button K1 is now operated, its contact *b* closes to complete a circuit from terminal B at contact *d* of relay LO through relay LR to terminal C. Relay LR picks up and completes its stick circuit at its contact *a* and closes contact *b* which bridges contact *a* of relay LO. When push button K1 is released, its contact *b* closes, completing the line circuit 5 through branch 5*a* and causing relays LO and L1 to pick up. Relay LO closes its contact *a* in the line circuit and releases relay LR, while relays L1 operate the stepping relays and continue the progression automatically to the point where the transmitter relay opens the line to terminate the first impulse. Then relays LO and L1 release, relays Y2, X2 and A2 are held energized over stick circuit 15 and relays Y2 hold relays P2 energized over the stick circuit 17, and it follows that the apparatus will remain inactive until K1 is again operated. It will be apparent that the transmission of a complete code may be carried out in this manner and that it permits the various relay operations to be readily observed and any irregularity in operation to be more readily detected and corrected.

Although we have herein shown and described only one form of remote control apparatus embodying our 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 our invention.

Having thus described our invention, what we claim is:

1. In a remote control system, a plurality of stations connected by a normally closed line circuit, a source of current at one station for energizing said line circuit, a code transmitter at each station effective when initiated to transmit an impulse code of timed impulses of current from said source over said line circuit, a pole changer at said one station for controlling the polarity of the current in said line circuit, means for reversing said pole changer in response to the opening of said line circuit at the beginning of a code, to cause all the impulses of such code to be of the reverse polarity, lock-out means effective when a plurality of code transmitters are initiated simultaneously to cause the different codes to be transmitted one at a time in a predetermined order, a line relay at each station responsive only to current of reverse polarity in said line circuit, two timing devices at each station, circuits controlled by each timing device for operating the other in response to successive operations of said line relay, including means for selectively operating one timing device at each station in accordance with the lengths of the alternate impulses of a code, said circuits also including means for selectively operating the other timing device at each station in accordance with the intervening impulses of said code; a main series of stepping relays at each station, means controlled by said timing devices for selectively operating a plurality of said stepping relays one for each of a plurality of impulses of a code, each stepping relay of said plurality being operated in accordance with the relative length of a particular impulse of a code but only if said plurality of impulses are arranged in a particular code pattern, a plurality of movable devices at each station, means for causing the operation of additional stepping relays of said main series at a selected station only at which said plurality of stepping relays have been fully operated, in response to additional impulses of a code, means controlled by the timing device at the selected station and by said additional stepping relays for selectively controlling the movable devices at such station in accordance with the lengths of the impulses each when a particular one of said additional impulses is being received, means controlled by the last additional stepping relay of the series located at said one station for restoring said pole changer to normal, thereby energizing said line circuit by current of normal polarity to indicate the completion of said code, and means dependent upon the energization of said line circuit at least briefly by current of normal polarity for initiating the operation of each code transmitter and for effecting the energization of the first stepping relay of each said series.

2. In a remote control system, a line circuit normally energized by current of a given polarity, a code transmitter effective when initiated to reverse the polarity of the current supplied to said line circuit and to then deliver a code of timed impulses all of the opposite polarity followed by an additional impulse of said given polarity to said line circuit, means for restoring said line circuit to normal in response to the transmission of said additional impulse, and means effective only when the line circuit is normally energized by current of said given

polarity for initiating the operation of said code transmitter.

3. In a remote control system, an office and a plurality of stations connected by a single line circuit, means at said office for normally energizing said line circuit by current of a given polarity, a pole changer effective when operated to reverse the polarity of the line current, means effective if said line circuit is opened momentarily for operating said pole changer, a code transmitter at each station, each effective when initiated to momentarily open said line circuit and to then deliver a code of time spaced impulses over said line circuit to said office provided the polarity of the line current has been reversed, means controlled by the last impulse of said code for restoring said pole changer to normal and for then delivering an additional impulse of normal polarity to said line circuit, and means for initiating the operation of said code transmitter effective only when the line circuit is steadily energized by current of said given polarity.

4. Apparatus for the selective control of movable devices comprising a two-position relay, means for operating said relay repeatedly to one position and for retaining the relay in said position for different time intervals, two groups of relays each including two stepping relays and a series of cascade-connected timing relays, means energizing the first stepping relays of each group alternately, each in response to a different operation of said two-position relay to its one position, and for successively energizing the timing relays of the corresponding group in accordance with the length of time said two-position relay remains in said one position, means controlled by the first stepping relay of each group for energizing the second stepping relay of the same group when said two-position relay assumes its other position, means for maintaining energized that timing relay which is energized when the two-position relay assumes its other position until said relay again assumes its one position, means controlled by the second stepping relay of each group for selecting the first stepping relay of the other group for energization when the two-position relay next assumes said one position, means controlled by said stepping relays for selecting different ones of said movable devices for operation, and means controlled by that timing relay which remains energized while said two-position relay is in said other position for selectively operating that movable device selected by said stepping relays.

5. In a remote control system, a line circuit, a movable device, a line relay responsive only to current of a given polarity in said line circuit, means for energizing said line relay repeatedly for selected time intervals, two series of timing relays, means for operating the timing relays of said two series alternately in response to repeated operations of said line relay, the relays of each series being operated one at a time in sequence when said line relay is energized, a series of stepping relays, means responsive only to line current of the opposite polarity for operating the first stepping relay of said series, means governed in accordance with the condition of said timing relays for selectively operating a different stepping relay in response to each of a plurality of operations of said line relay, means for operating an additional stepping relay of said series in response to an additional operation of said line relay, and means governed by said additional stepping relay in accordance with the condition of said timing relays for selectively operating said movable device.

6. Apparatus for the selective control of movable devices comprising a two-position relay, means operating said relay repeatedly to one position and for retaining the relay in said one position for different time intervals, a series of cascade-connected slow-release timing relays, a circuit for momentarily energizing the first timing relay of the series including a contact which closes when said two-position relay is operated to its one position, and a contact which opens shortly thereafter, a circuit for momentarily energizing the second timing relay of the series including a contact which closes when the circuit for said first timing relay is opened and a contact which opens when said first timing relay releases, a circuit for energizing the third timing relay of the series including a contact which closes when the first timing relay releases, stick circuit means for holding the first or third timing relay energized if such relay is in its energized position when the two-position relay assumes its other position, and means for selectively controlling a particular one of said movable devices depending upon which timing relay is held energized by said stick circuit means.

7. Apparatus for the selective control of movable devices comprising a two-position relay, means operating said relay repeatedly to one position and for retaining the relay in said one position for different time intervals, two series of cascade-connected timing relays, means for energizing the first timing relay of each series alternately, one such relay or the other becoming energized each time the two-position relay is operated to its one position, means momentarily energizing the second relay of the same series when such first relay becomes deenergized, means energizing the third relay of the same series when such first relay releases, stick circuit means for holding the first or third relay energized, if such relay is in its energized position when the two-position relay assumes its other position, until the two-position relay is again operated to said one position, and means for selectively controlling a particular one of said movable devices depending upon which timing relay is held energized by said stick circuit means.

8. Apparatus for the selective control of movable devices comprising a two-position relay, means operating said relay repeatedly to one position and for retaining the relay in said one position for different time intervals, two series of cascade-connected timing relays, means for energizing the first timing relay of each series alternately, one such relay or the other becoming energized each time the two-position relay is operated to its one position, means momentarily energizing the second relay of the same series when such first relay becomes deenergized, means energizing the third relay of the same series when such first relay releases, stick circuit means for holding the first or third relay energized, if such relay is in its energized position when the two-position relay assumes its other position, until the two-position relay is again operated to said one position, and means effective when said two-position relay is next operated to said one position for selectively controlling a particular one of said movable devices depending upon which timing relay has been held energized by said stick circuit means.

9. Apparatus for the selective control of mov-

able devices comprising a two-position relay, means operating said relay repeatedly to one position and for retaining the relay in said one position for different time intervals, two series of cascade-connected timing relays, means energizing the first timing relay of each series, provided a relay of the other series is picked up, when the two-position relay is operated to its one position, means deenergizing said first relay and energizing the second relay of the same series when said relay of the other series releases, means deenergizing the second relay and energizing the third relay of the same series when said first relay releases, means for holding the first or third relay energized comprising a stick circuit which closes if such relay is in its energized position when the two-position relay assumes its other position, and which opens to deenergize such first or third relay when the two-position relay again assumes said one position, and means for selectively controlling a particular one of said movable devices dependent upon which timing relay is held energized until said two-position relay is operated to said one position.

10. In combination, a line circuit connecting a control office and a plurality of stations, a code transmitter at said office operating when initiated to transmit different impulse codes to said stations over said line circuit, a plurality of code sending relays at said office, one for each station, means effective when a code sending relay is actuated and the line circuit has been free for at least a brief time interval to initiate the code transmitter, means controlled by the actuated code sending relay for causing the transmitted code to have a distinctive character for selecting the corresponding staiton, means restoring each actuated code sending relay to normal when the code for the corresponding station has been transmitted, and means for actuating each code sending relay effective only when the line circuit has been free for a time interval greater than said brief interval.

11. In combination, a line circuit connecting a control office and a plurality of stations, a code transmitter at said office operating when initiated to transmit different impulse codes to said stations over said line circuit, a plurality of starting relays at said office, one for each station, a code sending relay for each starting relay, independent means for actuating said starting relays, means controlled by each starting relay for actuating the corresponding code sending relay, means effective when a code sending relay is actuated and the line circuit has been free for at least a brief time interval to initiate said code transmitter, means controlled by each actuated code sending relay for causing the transmitted code to have a distinctive character for selecting the corresponding station, said means being effective when a plurality of code sending relays are actuated to cause the corresponding codes to be transmitted one at a time in order, means restoring each actuated starting relay and code sending relay to normal when the corresponding impulse code is transmitted, and means preventing the actuation of each code sending relay by the corresponding starting relay except when the line circuit has been free for a time interval greater than said brief interval.

12. In combination, a line circuit, a plurality of movable levers, a starting relay and a code sending relay for each lever, a code transmitter operating when initiated to deliver different impulse codes to said line circuit, means controlled by each code sending relay when actuated to deliver a characteristic code including one or more elements identifying the position of the corresponding lever, said means being effective when a plurality of code sending relays are actuated simultaneously to cause the delivery of the corresponding codes one at a time in a given order of code superiority, means for actuating each starting relay in response to a movement of the corresponding lever, means controlled by each code for restoring the corresponding starting relay to normal, means restoring each actuated code sending relay to normal effective only when the corresponding code is fully transmitted, and means effective only when all actuated code sending relays have been restored to normal for simultaneously actuating each code sending relay having its starting relay actuated, whereby codes corresponding to starting relays actuated while codes are being delivered are delivered subsequently irrespective of their relative superiority.

13. In combination, a line circuit, a plurality of starting relays, a code sending relay for each starting relay, a code transmitter operating when initiated to deliver different impulse codes to said line circuit, means controlled by each code sending relay when actuated to initiate the operation of said code transmitter to deliver a characteristic code to said line circuit, said means being effective when a plurality of code sending relays are actuated simultaneously to cause the corresponding codes to be delivered one at a time in order, independent means for actuating said starting relays, means controlled by each code for restoring the corresponding starting relay to normal, means for maintaining each actuated code sending relay in its actuated condition until the corresponding code is fully delivered, and means effective only when all actuated code sending relays have been restored to normal for simultaneously actuating each code sending relay having its starting relay actuated.

14. Apparatus for the control of movable devices comprising, a plurality of movable control levers, one for each device, a starting relay and a code sending relay for each lever, a line circuit, a code transmitter operating when initiated to deliver different impulse codes to said line circuit, means actuating each starting relay when the corresponding lever is moved from one position to another, means effective only when all the code sending relays are normal for actuating each code sending relay having its starting relay actuated, means controlled by each actuated code sending relay for initiating the function of said code transmitter to deliver a code having selecting elements identifying the corresponding lever followed by function elements identifying the position of such lever, said means being effective when a plurality of code sending relays are actuated simultaneously to cause the corresponding codes to be delivered one at a time in order, means restoring each actuated starting relay to normal as soon as the selecting elements of the corresponding code are delivered, and means restoring each actuated code sending relay to normal only when the delivery of the corresponding code is completed.

15. In combination, a line circuit, a plurality of starting relays, means for operating each starting relay, a master relay, a code transmitter operating when initiated to deliver different impulse codes to said line circuit, means controlled by each operated starting relay for initiating the

delivery of a code by said transmitter characteristic of the operated starting relay, means responsive to the first impulse of a code to energize said master relay, storing means effective when a plurality of codes are initiated simultaneously to effect their delivery one at a time in order and for maintaining said master relay energized until all such codes are transmitted, and means preventing the initiation of a code by an operated starting relay except when said master relay is deenergized.

16. In combination, a line circuit, a plurality of starting relays, means for operating each starting relay, a code transmitter operating when initiated to deliver different impulse codes to said line circuit, means controlled by each operated starting relay for initiating the delivery of a code by said transmitter characteristic of the operated starting relay, including storing means effective when a plurality of codes are initiated simultaneously to effect their delivery one at a time in order, means controlled by each code for restoring the corresponding starting relay, and means delaying the initiation of a code by a starting relay operated while a code is being delivered until all previously initiated codes have been delivered.

17. In combination, a normally closed line circuit connecting a plurality of stations, a code transmitter at each station operating when initiated to deliver a characteristic impulse code to said line circuit, a starting relay at each station, means effective when a starting relay is actuated to initiate the operation of the associated code transmitter, means restoring each actuated starting relay to normal when the associated transmitter has initiated its code, lock-out means effective when a plurality of code transmitters are initiated simultaneously to effect the delivery of the corresponding codes in a predetermined order without restoring the line circuit to its normally closed condition between successive codes, and means for delaying the initiation of each code transmitter having its starting relay actuated while a code is being delivered, until the line circuit has been restored to its normally closed condition.

18. In a remote control system, a normally closed line circuit connecting a control office with a plurality of stations, a movable device at each station, a code transmitter at each station each operating when initiated to deliver a code indicating the condition of the associated movable device over said line circuit to said office, means responsive to a change in the condition of each movable device for initiating the operation of the associated code transmitter, storing means effective if a plurality of codes are initiated simultaneously to effect their delivery, one at a time in order, but without restoring the line circuit to its normally closed condition between successive codes, and means preventing the initiation of each code transmitter in response to a change in the condition of a movable device occurring during the delivery of a code until the line circuit has been restored to its normally closed condition.

19. In a remote control system, a normally closed line circuit, a plurality of movable devices, means operating when initiated to deliver codes to said line circuit each indicating the condition of a different movable device, means responsive to a change in the condition of each movable device for initiating the corresponding code, storing means effective if a plurality of codes are initiated simultaneously to effect their delivery, one at a time in a predetermined order of relative code superiority without restoring the line circuit to its normally closed condition between successive codes, and means preventing the initiation of a code in response to a change in condition of a movable device occurring during the delivery of a code irrespective of its relative superiority until said line circuit has been restored to its normally closed condition.

20. In combination, a plurality of stations connected by a line circuit, a coding unit at each station comprising a starting relay, a master relay, and a code transmitter operating when initiated to deliver an impulse code characteristic of the station to said line circuit; means for operating each starting relay, means controlled by each operated starting relay for initiating the delivery of its code by the associated transmitter, means responsive to the first impulse of each code for energizing the master relay at the station at which the code is initiated, lock-out means effective in the event a plurality of stations initiate their codes simultaneously to effect the delivery of such codes one at a time in order and for maintaining the master relay energized at each such station only until the corresponding code is transmitted, and means preventing the initiation of a code by each starting relay operated while a code is being delivered until all the energized master relays have been released.

21. In combination, a line circuit connecting a plurality of stations, a code transmitter at each station operating when initiated to deliver a characteristic impulse code to said line circuit, a code sending relay and a master relay at each station, means effective when a code sending relay is actuated to initiate the operation of the associated code transmitter, means restoring each actuated code sending relay to normal when the associated transmitter has delivered its code, lock-out means effective when a plurality of code transmitters are initiated simultaneously to discontinue the operation of all but one, means for energizing each master relay when a code is initiated by the associated code sending relay and for maintaining such master relay energized until the associated code sending relay is released at the end of a code, and means preventing the initiation of a code by an actuated code sending relay at a station at which the master relay is not energized, as long as the master relay at another station is energized.

22. In a remote control system, a line circuit, a code transmitter effective when initiated to automatically deliver an impulse code to said line circuit at a predetermined rate, means for causing said transmitter to deliver its code at a slower rate, under manual control comprising a line relay, a manually operable key effective when operated to include the winding and a front contact of said relay in the line circuit, a second key, and means responsive to a momentary manual operation of said second key for bridging said front contact to close said line circuit effective only as long as said line relay is released.

23. In a remote control system, a line circuit, a code transmitter effective when initiated to automatically deliver an impulse code to said line circuit at a predetermined rate, means for causing said transmitter to deliver its code at a slower rate, under manual control comprising a line relay, a manually operable key effective when operated to include the winding and a front contact of said relay in the line circuit, a second key, a stick relay, pick-up and stick circuits for

said stick relay including a reverse contact of said second key and a front contact of said stick relay, respectively, each including a back contact of said line relay, and means for closing said line circuit to pick up said line relay including a normal contact of said second key and a front contact of said stick relay.

24. In a remote control system, a plurality of movable devices, a line relay, means for operating said line relay repeatedly to one position and for retaining the relay in said one position for different time intervals, two series of cascade-connected relays, energizing circuits for the first relay of each series, each such circuit including a front contact of a different relay of the other series, an energizing circuit for each remaining relay of each series, each including a front contact of the next preceding relay of the same series and a back contact of each relay of the other series, the circuit for each such relay except the first and second also including a back contact of the second preceding relay of the same series, means associated with each relay for delaying its release when its circuit is opened until the next relay to be operated is fully energized, means responsive to successive operations of said line relay for alternately energizing the circuits for one series of relays or the other to effect the successive energization of such relays, and means rendered effective in response to an operation of said line relay for selectively controlling a particular one of said movable devices in accordance with the number of cascade-connected relays energized during the next preceding operation of said line relay.

25. In a remote control system, a two-position line relay, means constituting a series of impulses of selected character arranged in accordance with a code for operating said line relay repeatedly, a main series of stepping relays including one relay for each impulse of said series, a set of four intermediate stepping relays each having two windings, energizing circuits for the first and third relays of the set each including one winding of the relay and a contact closed when the line relay is operated to one position and also including a front contact and one winding of the fourth and second relays of the set, respectively, energizing circuits for the second and fourth relays of the set each including one winding of the relay and a contact closed when the line relay is operated to the other position and also including a front contact and the other winding of the first and third relays of the set, respectively, circuits prepared alternately by said second and fourth intermediate relays for energizing the relays of said main series one at a time in order, one for each impulse of said series, means for completing each prepared circuit only if the corresponding impulse is of a character in accordance with said code, a movable device, and means for selectively operating said movable device requiring the operation of a predetermined number of the stepping relays of said main series.

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