

Feb. 17, 1942.

C. S. SNAVELY ET AL

2,273,231

REMOTE CONTROL SYSTEM

Filed Aug. 3, 1938

5 Sheets-Sheet 1

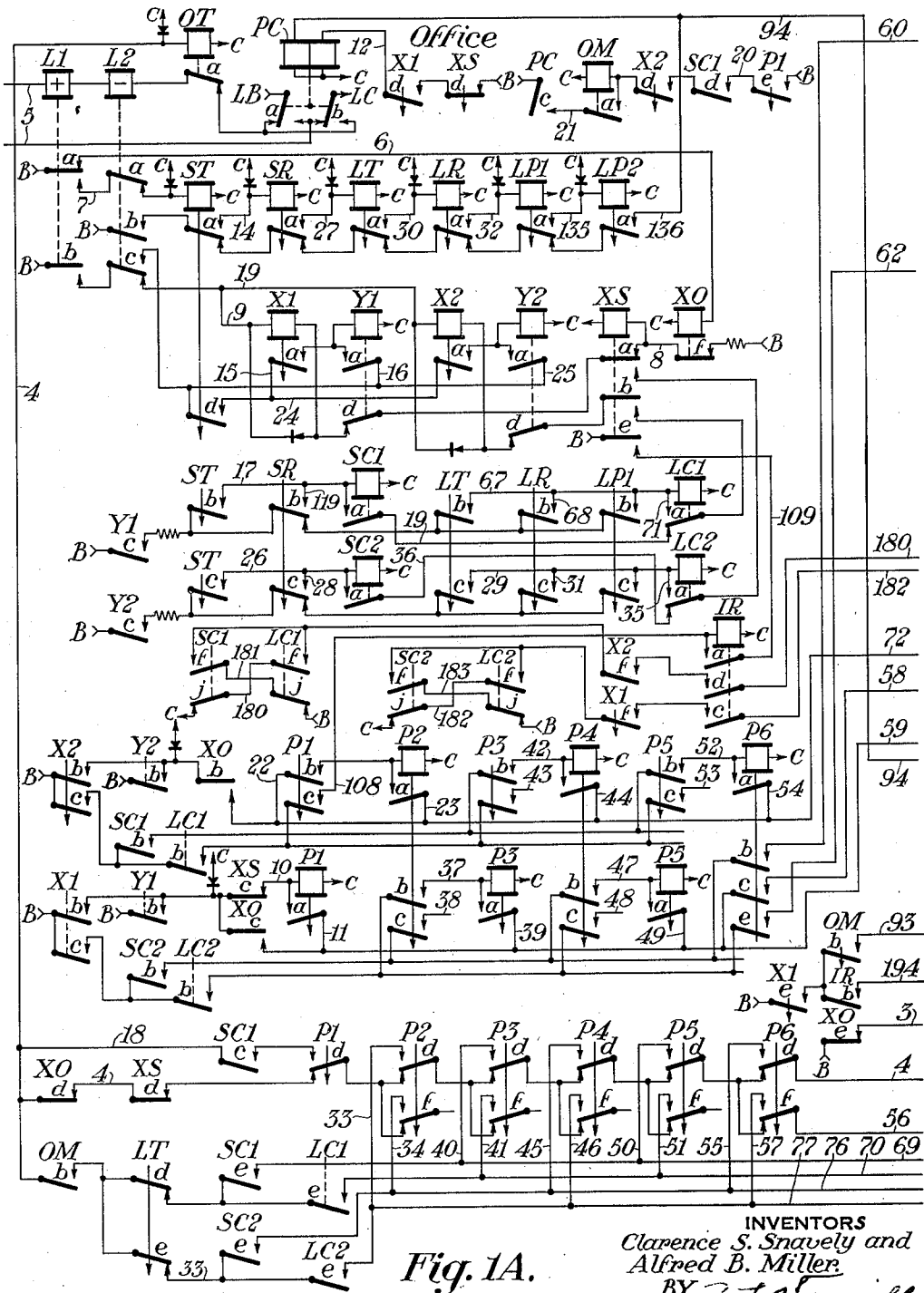


Fig. 1A.

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5 Sheets-Sheet 2

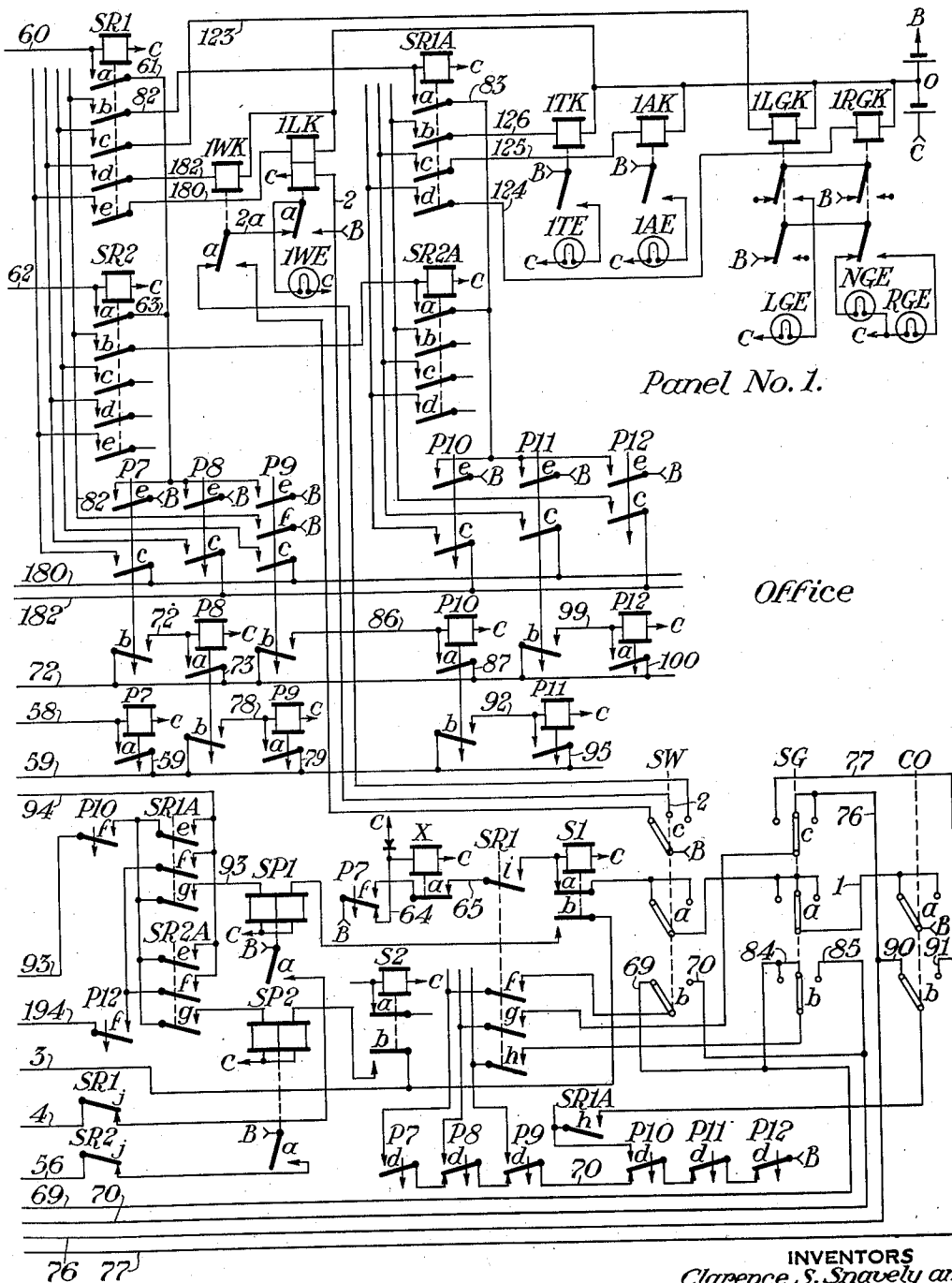


Fig. 1B.

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5 Sheets-Sheet 3

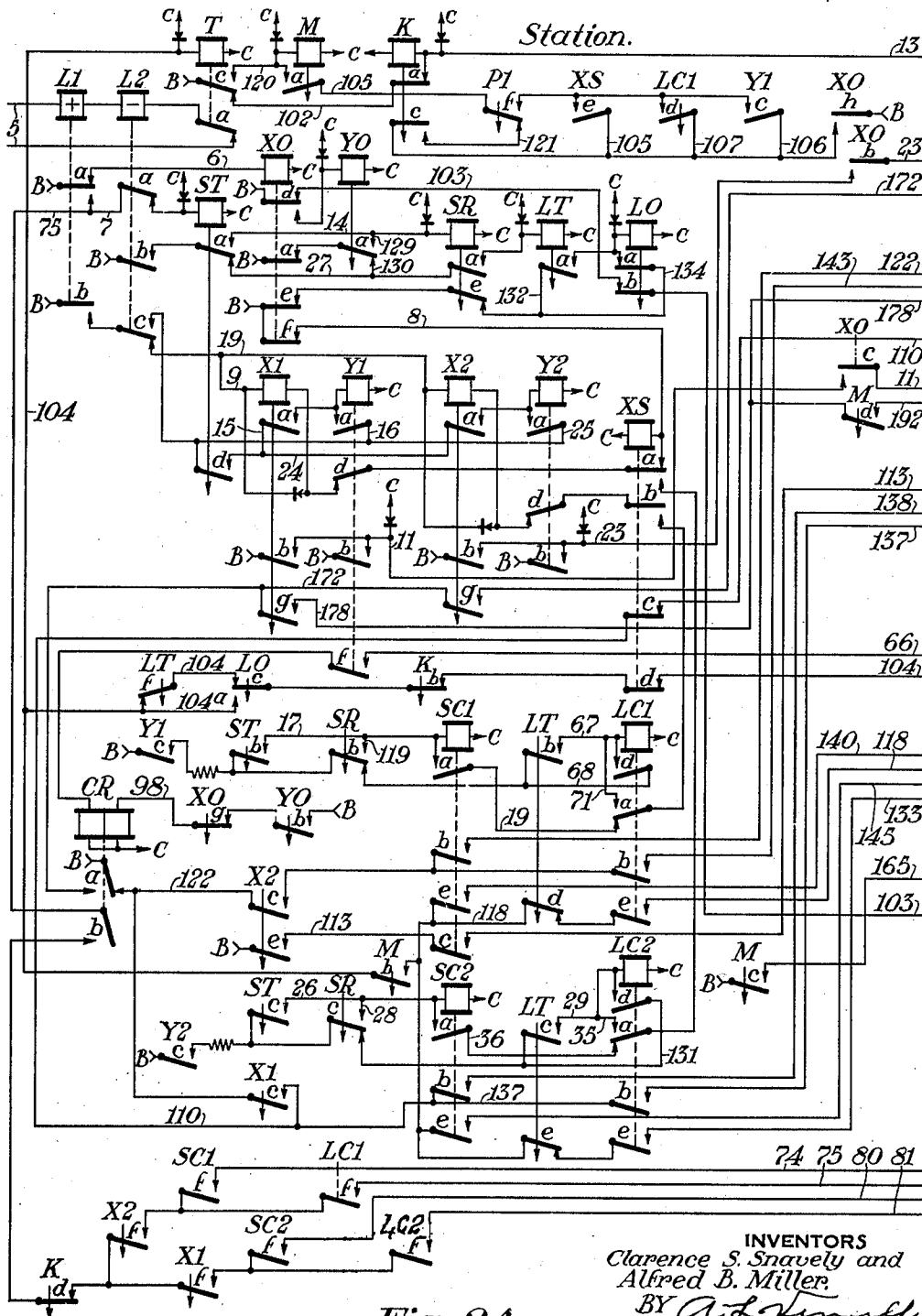


Fig. 2A.

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5 Sheets-Sheet 4

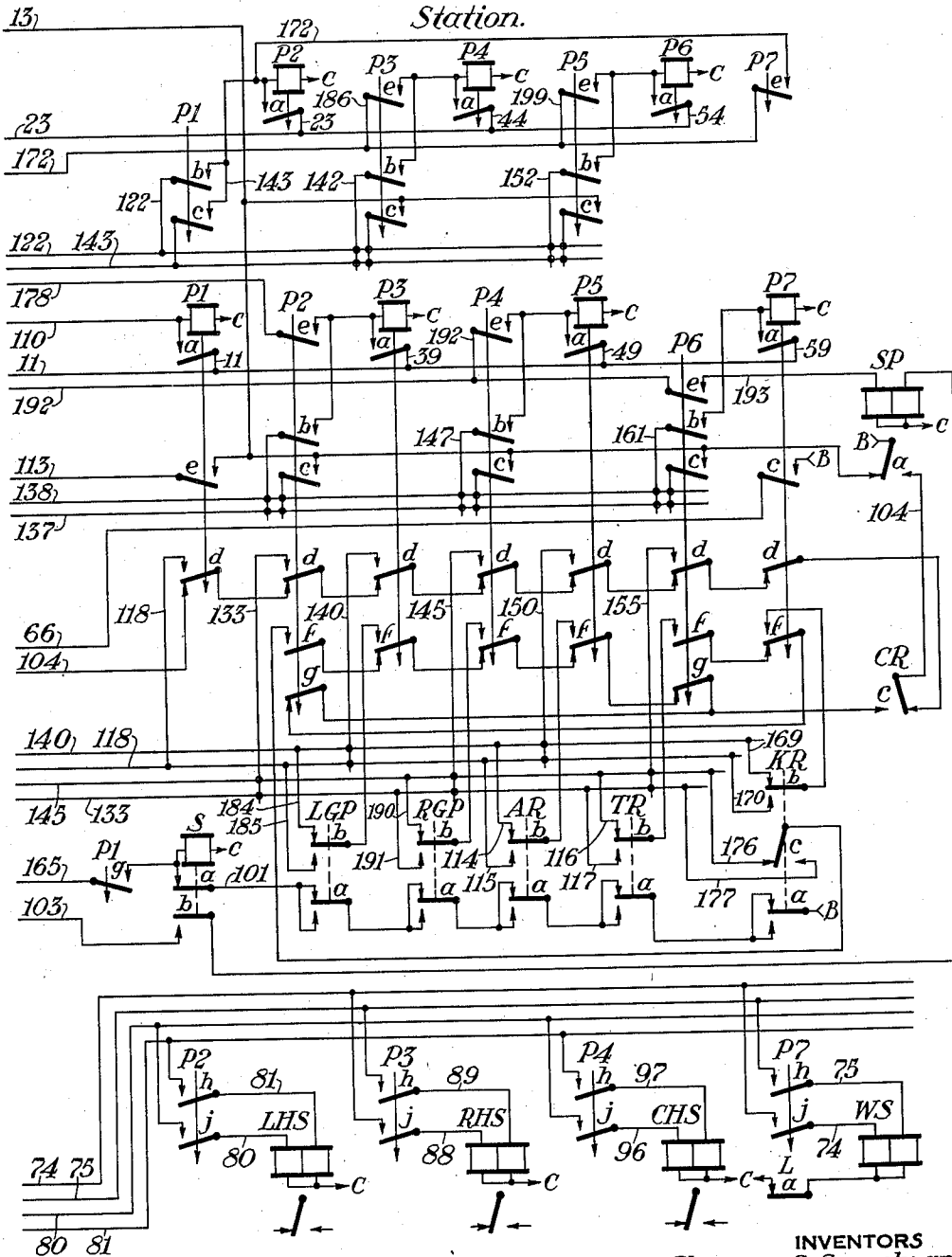


Fig. 2B.

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5 Sheets-Sheet 5

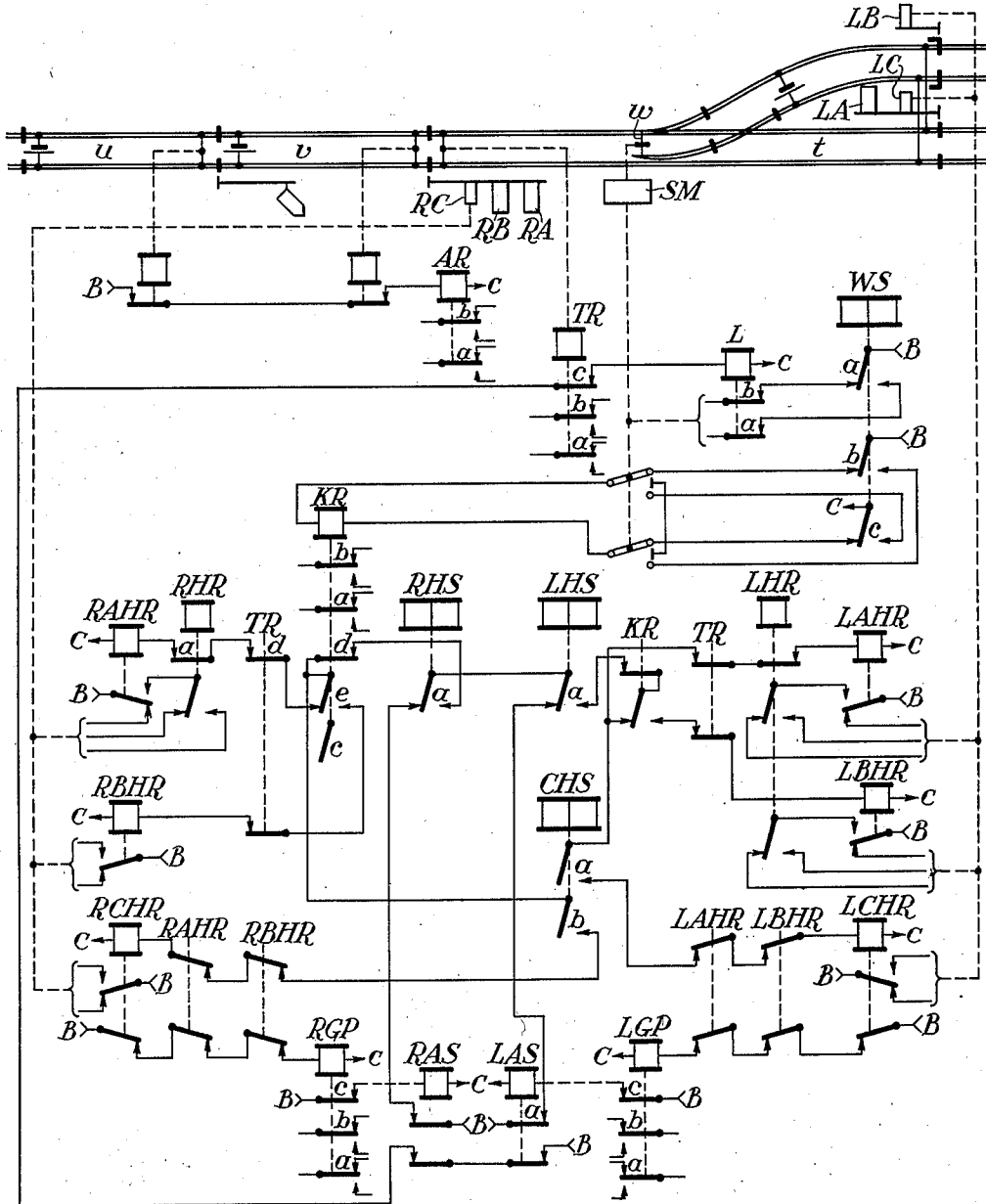


Fig. 3.

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UNITED STATES PATENT OFFICE

2,273,231

REMOTE CONTROL SYSTEM

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Application August 3, 1938, Serial No. 222,860

42 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 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 momentarily and then a code of short and long impulses of current of the reverse polarity is transmitted, so that in a series of codes, the code impulses are all of the reverse polarity but the successive codes are spaced definitely by single 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 these respects our invention is an improvement over that disclosed in a copending application, Serial No. 31,592, filed July 16, 1935, by Snavelly, Miller & Jackel, for Remote control systems, now Patent No. 2,183,155, granted December 12, 1939.

Another object of our invention relates to the provision of means whereby a plurality of codes initiated and stored at different stations while the line is in use are transmitted substantially in the order in which they are stored. This is accomplished by preventing a station which has transmitted a code from initiating the transmission of another code until other stations which have codes stored for transmission have each effected the transmission of one code. When a plurality of codes are initiated simultaneously they are transmitted in a given order in accord-

ance with the relative code superiority of the code calls assigned to the different stations.

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 will briefly explain the general plan and organization of our apparatus.

In the specific embodiment of our invention as herein illustrated, each control code consists of a series of ten steps, while each indication code has twelve steps. Each step comprises an impulse of line current the length of which is selectively controlled, followed by a brief interval of no current. The line-open intervals are not employed for code selection as in the Snavelly, Miller and Jackel system hereinbefore referred to, but serve merely to space the impulses. The first

impulse is short in a control code and relatively long in an indication code, and is employed for selection between controls and indications. The next five steps 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 code. The remaining impulses are described as "function" steps, and in the case of a control code, the lengths of the seventh, eighth, ninth and tenth steps are determined each in accordance with the position of one of the control levers of the corresponding panel. The seventh step is controlled by the switch lever SW, Fig. 1B, the eighth and ninth steps by the signal lever SG, 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 operates a polar stick relay WS, LHS, RHS or CHS, Fig. 2B, to a position corresponding to that of the associated lever, these relays controlling 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 as illustrated in Fig. 2B by the switch indication relay KR of Fig. 3, 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 while 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, these steps control indication relays IWK and ILK of Fig. 1B governing a lamp IWE, which lamp becomes lighted whenever lever SW is moved and also when the switch is unlocked or when its indicated position does not correspond to that of the associated lever SW.

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 relays ILGK and IRGK, which 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 an approach relay AR, Fig. 3, which is released when a train occupies the approach zone comprising sections *u* and *v*, and by the track relay TR for the switch section *t*. These relays when released cause the transmission of long impulses to reverse the respective indication relays IAK and ITK, thereby lighting a lamp IAE or ITE 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 polar stick 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 a back contact *a* 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 over contacts 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 only 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.

Each line relay L2 controls two groups of relays, a series of intermediate stepping relays X1, Y1, X2 and Y2, which are operated successively and repeatedly to count the steps of the code, and a series of cascade-connected timing relays ST, SR and LT, which measure the lengths of the successive steps. These relays control two groups of character registering relays, SC1, LC1, and SC2, LC2, which are used alternately to register the short or long character of the successive steps and to operate a main series of stepping relays P progressively, one for each step. 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 five relays P2 to P6, inclusive, constituting the station or panel selection. On succeeding steps, which are described as "function" steps, relays P prepare circuits for the polar stick control or indication relays successively so that each such relay will be positioned in accordance with the relative length of a different impulse.

At the office, the stepping relays of the main series include relays P1 to P12, inclusive, while at the station there are but seven P relays, relays P2 to P6 being operated through a second cycle under the control of a chain repeat relay CR when the office relays P7 to P12 are operated. Each relay P is operated during the line-open period which precedes the correspondingly numbered impulse of the 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 a relay XO and is then placed under the control of the 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 timing and character registering relays as to give the desired character to the next impulse, the action being such that when once initiated relay T or OT is oper-

ated by each P relay in turn 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 OT, 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 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 relays T, ST, SR, LT, 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, for Electrical relays, now Patent No. 2,178,289, granted October 31, 1939.

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 such as LA and RA for governing traffic movements over the switch, and 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 contacts *b* permit the energization of the switch indication relay KR in a direction corresponding to the positions 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, a 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 contacts *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 is approach locked. A contact *a* of relay L, shown in Fig. 2B in the circuit for relay WS, prevents the operation of that relay by code except when the signals are at stop and the approach locking is released.

Contacts *a* and *b* of the track relay TR and of

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 governing signal RA, for example, which is typical, is controlled by reversing relay RHS and may be traced from one terminal B of a suitable local battery at 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, and winding of relay RAHR to the other terminal C of the local battery. Thus 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. It is believed that the remaining circuits of Fig. 3 will be understood without further description.

The transmission of typical control codes 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 station code call for station No. 1 is represented by one long impulse followed by four short impulses.

Referring now to Fig. 1B, it will be seen that the reversal of lever SW at its contact *a* opens a normally closed starting circuit 1 which may be traced from terminal B, contacts *a* of levers CO, SG and SW of panel No. 1, contact *a* and the winding of the starting relay S1 to terminal C. At the middle contact *c* of lever SW, a circuit 2 is closed momentarily as the lever is moved from normal to reverse the polar stick relay LK. This causes the switch disagreement lamp WLE to become lighted, as will be apparent from the drawings.

Relay S1 releases, and at its contact *b* completes a circuit 3 from terminal B at contact *e*

of relay XO, Fig. 1A, contact *b* of relay S1, the right-hand winding of the polar stick relay SP1 to terminal C. Relay SP1 operates its contacts to the right, and closes a circuit 4 for the transmitting relay OT from terminal B at its contact *a* over the back contact *j* of relay SR1, back contacts *d* of relays P6, P5, P4, P3, P2, P1, front contacts *d* of relays XS and XO, relay OT to terminal C. Relay OT therefore picks up and at its contact *a* opens the line circuit 5, deenergizing the plus line relays L1 at the office and at each station.

When each line relay L1 releases, its contact *a* opens a normally closed circuit 6, deenergizing the associated relay XO as shown in Figs. 1A and 2A. At the same time, a circuit 7 is closed from terminal B over back contacts *a* of each line relay L1 and the associated line relay L2, through the winding of relay ST to terminal C. When each relay XO releases, it opens the pick-up circuit 8 for the normally energized stick relay XS at its contact *f*, but relay XS is held energized and relay X1 picks up over a circuit 9 which closes when relay L1 releases and which may be traced from terminal B, back contact *b* of relay L1, back contact *c* of relay L2, relay X1, contact *d* of relay Y1, front contact *a* and winding of relay XS to terminal C.

At the office as shown in Fig. 1A, relay X1 at its contact *b* closes a circuit 10 from terminal B over contact *c* of relay XS, through relay P1 to terminal C, and relay P1 picks up, completing a stick circuit 11 from terminal B, at contact *b* of relay X1 over back contact *c* of relay XO, contact *a* and winding of relay P1 to terminal C.

At each station, relay X1 completes a pick-up circuit 110 for relay 1P which may be traced in Figs. 2A and 2B from terminal B over the right-hand contact *a* of the chain repeat relay CR, contacts *c* of relays X1 and XS relay P1 to terminal C, and each station relay P1 picks up and completes its stick circuit 11 similar to the office circuit 11 already traced.

The office relay X1 also closes a circuit 12 shown at the top of Fig. 1A which extends from terminal B, contacts *d* of relays XS and 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 line 5 will be reversed.

When the office relay XO releases as above described, it opens circuit 4 at its contact *d*, deenergizing relay OT, and after a short interval, relay OT releases to close line 5 at its back contact *a* 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 deenergized until the end of the code.

Each line relay L2 at its front contact *b* completes a circuit 14 from terminal B over front contact *a* of relay ST to terminal C, and each relay SR picks up.

Each line relay L2 at its front contact *c* completes a circuit 15 from terminal B, back contact *b* of relay L1, front contact *c* of relay L2, contact *d* of relay ST, contact *a* of relay X1, relay Y1 to terminal C, and each relay Y1 picks up and completes its stick circuit 16. Circuits 9 are opened at back contacts *c* of relays L2 and

relays X1 and XS release, but relays X1 have sufficient retardation to delay their release until circuits 15 have been effectively energized.

Each relay Y1 now completes a circuit 17 from terminal B at its contact *c*, contact *b* of relay ST, relay SC1 to terminal C, and at its contact *b* connects terminal B to circuit 11 to maintain relay P1 energized after relay X1 releases. Circuits 7 were opened at back contacts *a* of relays L2 and relays ST are now deenergized, but relays ST have a release period sufficient to prevent their release until relays SR are fully energized and pick up. After relay SR picks up, relay SC1 is held energized over a branch 119 of circuit 17.

When the office relay SC1 picks up, it completes at its contact *c* a branch 18 of circuit 4 over front contact *d* of relay P1 so that relay OT picks up and opens line 5.

Each line relay L2 now releases, opening circuit 16 and closing circuit 7, thereby releasing relay Y1 and reenergizing ST, and also closing a circuit 19 to pick up relay X2 and to hold SC1 energized, which may be traced in Fig. 1A or 2A from terminal B, contact *b* of relay L1, back contact *c* of relay L2, relay X2, back contact *d* of relay Y2, back contact *b* of relay XS, back contact *a* of relay LC1, contact *a* and winding of relay SC1 to terminal C.

When the office relay X2 picks up it completes a circuit 20 shown at the top of Fig. 1A which extends from terminal B over contact *e* of relay P1, contacts *d* of relays SC1 and X2, relay OM to terminal C. Relay OM picks up and completes its stick circuit 21 which extends to terminal B at contact *c* of relay PC.

The office relay X2 also completes a pick-up circuit 22 for relay P2 from terminal B over contacts *b* of relays X2, XO and P1, relay P2 to terminal C. Each station relay X2 completes a corresponding circuit 122 from terminal B, right-hand contact *a* of relay CR, contact *c* of relay X2, contacts *b* of relays SC1 and P1, relay P2 to terminal C. Each relay P2 picks up and completes its stick circuit 23 extending from terminal B, contacts *b* of relays X2 and XO, contact *a* and winding of relay P2 to terminal C. Each relay Y1 upon releasing opens circuit 11 so that relays P1 become deenergized. The asymmetric unit connected to circuit 11 however delays their release until after the relays P2 have picked up.

When the office relay P2 picks up, it opens circuit 18 at its back contact *d* and relay OT releases to close line 5.

Second step—Long

When each line relay L2 picks up, it opens circuits 7 and 19, deenergizing relays ST, X2 and SC1, closes circuit 14 to pick up relay SR, and also closes a circuit 24 from terminal B, contact *b* of relay L1, front contact *c* of relay L2, contact *d* of relay ST, contact *a* of relay X2, relay Y2 to terminal C. Each relay Y2 picks up and completes a stick circuit 25, and at its contact *c* closes a pick-up circuit 26 for relay SC2 over contact *c* of relay ST. Each relay SC2 now picks up and at the end of a brief interval each relay ST releases, opening circuit 14 and closing a branch 27 of circuit 14 over front contact *a* of relay SR to pick up relay LT. Relay SC2 is now held energized over the branch 28 of circuit 26 including front contact *c* of relay SR. Relay SR releases after a brief interval, opening circuit 28 to release SC2 and closing a circuit

29 over contact *c* of relay LT to pick up relay LC2.

Each relay SR upon releasing opens circuit 27 deenergizing relay LT, and at the office, a branch 30 of circuit 27 is closed to pick up relay LR, which relay at its contact *c*, closes a branch 31 of circuit 29 to hold relay LC2 energized after relay LT releases. At each station, relay LC2 is held energized after LT releases over a stick circuit 131 including its front contact *d*.

Relays LT now release after a brief interval. The office relay LT opens circuit 30 and closes a branch 32 of circuit 30 over contact *a* of relay LR to pick up relay LP1, and at its back contact *e* closes a branch 33 of circuit 4 from terminal B over front contact *d* of relay P2, contacts *e* of relays LC2 and LT, contact *b* of relay OM, relay OT to terminal C. Relay OT now picks up to open line 5.

It is to be understood that there are sixteen stations for which the first element of the station call is a long impulse, and for selecting any one of these stations the branches of circuit 4 are arranged as shown to effect the energization of circuit 33 over front contact *d* of relay P2. For selecting any one of the remaining stations, for which this element is short, the circuits include the branch 34 over front contact *f* of relay P2, contact *e* of relay SC2 and contact *e* of relay LT. Since contact *e* of relay LT is closed when relay SC2 picks up at the beginning of the second step of the code, it will be apparent that the second step will be short when circuit 34 is used.

When relays L2 release at the end of the line-closed portion of the long second stem, circuits 25 and 32 are opened and a circuit 35 closes comprising a branch of circuit 9 from terminal B through relay X1, back contact *d* of relay Y1, back contact *a* of relay XS, contact *a* and winding of relay LC2 to terminal C. Circuit 7 is also closed so that relays ST and X1 pick up, relay LC2 is held energized, and relays Y2 and LP1 release.

It is to be noted that if this had been a short step, relay SC2 would have been held energized instead of relay LC2 over a circuit 35, similar to 35, in series with relay X1.

In case of a long second step, when the office relay X1 picks up a circuit 37 is closed from terminal B at its contact *c* over contacts *b* of relays LC2 and P2 to pick up relay P3, while if the step is short, a corresponding relay, not shown, of a different series is picked up over a circuit 38 including contact *b* of relay SC2 and contact *c* of relay P2.

At each station for which the code includes a long second step, the jumper connections to contacts *b* and *c* of relay P2 are arranged as shown in Fig. 2B and relay P3 is picked up at these stations only, over a circuit 137 extending from terminal B, contact *a* of relay CR, contact *c* of relay X1, contacts *b* of relays LC2 and P2, relay P3 to terminal C. At each station arranged to receive a short second step, the connections of contacts *b* and *c* of relay P2 to circuits 137 and 138 are interchanged so that when a code having a short second step is received relay P3 will be picked up over circuit 138 including contacts *b* of relay SC2 and P2. When each relay P3 picks up it completes its stick circuit 39 comprising a branch of the stick circuit 11 for relay P1.

At the office and at each station, circuit 23 is opened by the release of relay Y2 to deenergize relay P2, but the asymmetric unit connected to

circuit 23 delays the release of the relay P2 until after relay P3 has picked up. No further progression occurs at those stations at which relay P3 is not energized.

The office relay P3 at its back contact *d* now opens circuit 33 or 34 to release relay OT to close line 5.

It is to be understood that the office relays P are connected in pyramid formation, and that the apparatus when arranged for the control of the full complement of thirty-two stations includes two relays like P3, each of which controls two relays like P4. Each of the latter control two relays like P5, each of which in turn controls two relays like P6. There will be sixteen series of relays P1 to P12 inclusive, one for each of the relays P6, each series controlling the circuits for the levers and indication relays of two panels.

Third step—Short

When each line relay L2 picks up, it closes circuits 14 and 15 to pick up relays SR and Y1, and opens circuits 7 and 35 or 36 to release relays ST, X1 and LC2 or SC2. Relay Y1 closes its stick circuit 16 and also closes circuit 17 to pick up relay SC1.

When the office relay SC1 picks up, a branch 40 of circuit 4 is closed to pick up relay OT over front contact *d* of relay P3, contact *e* of relay SC1 and contact *d* of relay LT, to produce a short third step. Relay OT may be also picked up over a circuit 41, analogous to circuit 33 already described, to produce a long third step, as will be apparent from the drawing.

When relay OT picks up, relays L2 release, closing circuits 7 and 19 to pick up relays ST and X2, and to hold relay SC1 energized, and opening circuits 14 and 16 to release relays SR and Y1.

When the office relay X2 picks up it completes a circuit 42 from terminal B at its contact *c* over contacts *b* of relays SC1 and P3, relay P4 to terminal C.

At eight of the sixteen stations at which relay P3 is energized, the jumper connections are so arranged that relay P4 is picked up over a circuit 142 comprising a branch of circuit 122 including contact *b* of relay P3.

As will be clear from the drawings, similar circuits such as the office circuit 43 including contacts *b* of relay LC1 and P3 may be provided to pick up different relays P4 when the code includes a long third step.

When each relay Y1 releases, it opens the stick circuit 39 to release the energized relays P3. Each relay P4 that picks up completes a stick circuit 44.

The office relay P4 at its back contact *d* opens circuit 40 or 41 to release relay OT to close line 5.

Fourth step—Short

When each line relay L2 picks up it closes circuits 14 and 24 to pick up relays SR and Y2, and opens circuits 7 and 19 to release relays ST, X2 and SC1. Relay Y2 closes its stick circuit 25 and also closes circuit 26 to pick up relay SC2.

When the office relay SC2 picks up, a branch 45 of circuit 4 is closed to pick up relay OT over front contact *d* of relay P4, to produce a short fourth step. Relay OT may also be picked up over a circuit 46 to produce a long fourth step, as will be apparent from the drawings.

When relay OT picks up, relays L2 release, closing circuits 7 and 36 to pick up relays ST and X1 and to hold SC2 energized, and opening circuits 14 and 25 to release relays SR and Y2.

When the office relay X1 picks up it completes a circuit 47 over contacts *b* of relays SC2 and P4 to pick up relay P5.

At four of the eight stations at which relay P4 is energized, the jumper connections are so arranged that relay P5 is picked up over a branch 147 of circuit 138 already described.

As will be clear from the drawing, circuits such as the branch 48 of circuit 47, including contact *b* of relay LC2 may be provided to pick up a different office relay P5 when the code includes a long fourth step, and similarly, the station jumper connections may be arranged to pick up the station relay P5 over a branch of circuit 137.

When each relay Y2 releases, it opens the stick circuit 44 to release the energized relays P4. Each relay P5 that picks up completes a stick circuit 49 comprising a branch of circuit 11.

The office relay P5 at its back contact *d* opens circuit 45 or 46 to release relay OT to close line 5.

Fifth step—Short

When each line relay L2 picks up, it closes circuits 14 and 15 to pick up relays SR and Y1, and opens circuits 7 and 36 to release relays ST, X1 and SC2. Relay Y1 closes its stick circuit 16 and also closes circuit 17 to pick up relay SC1.

When the office relay SC1 picks up, a branch 50 of circuit 4 is closed to pick up relay OT over front contact *d* of relay P5 to produce a short fifth step. Relay OT may also be picked up over a circuit 51 to produce a long fifth step, as will be apparent from the drawings.

When relay OT picks up, relays L2 release, closing circuits 7 and 19 to pick up relays ST and X2 and to hold relay SC1 energized, and opening circuits 14 and 16 to release relays SR and Y1.

When the office relay X2 picks up it completes a circuit 52 over contacts *b* of relays SC1 and P5 to pick up relay P6.

At two of the four stations at which relay P5 is energized, the jumper connections are so arranged that relay P6 is picked up over a circuit 152 comprising a branch of circuit 122.

As will be clear from the drawings, a circuit 53 may be provided and circuit 152 arranged as a branch of circuit 147, so as to pick up different relays P6 when the code includes a long fifth step.

At each of the four stations, when relay Y1 releases it opens the stick circuit 49 to release the energized relays P5. Each relay P6 that picks up, completes a stick circuit 54.

The office relay P6 at its back contact *d* opens circuit 50 or 51 to release relay OT to close line 5.

Sixth step—Short

When each line relay L2 picks up, it closes circuits 14 and 24 to pick up relays SR and Y2 and opens circuits 7 and 19 to release relays ST, X2 and SC1. Relay Y2 closes its stick circuit 25 and also closes circuit 26 to pick up relay SC2.

When the office relay SC2 picks up, a branch 55 of circuit 4 is closed to pick up relay OT over front contact *d* of relay P6 to produce a short sixth step.

It will be noted at this point that the codes which originate at panel No. 2 are initiated by releasing relay S2 and operating relay SP2 to the right, in which case a circuit 56 is closed which corresponds to circuit 4 and extends from terminal B at contact *a* of relay SP2 over contact *j* of relay SR2, back contact *f* of relay P6 to contact *d* of relay P5 and thence over the same paths as the branches of circuit 4 already traced through

relay OT to terminal C. That is, the branches 33, 40, 45 and 50 of circuit 4 are also branches of circuit 55, and hence codes originating at panel No. 2 will have steps 1 to 5, inclusive, similar to those already described, but will have the sixth step long because relay OT will be energized over a branch 57 which includes front contact *f* of relay P6 and contacts *e* of relays LC2 and LT.

In either case, when relay OT picks up, relays L2 release, and assuming the sixth step to be short, relays L2 close circuits 7 and 36 to pick up relays ST and X1 and to hold SC2 energized, and open circuits 14 and 25 to release relays SR and Y2.

When the office relay X2 picks up it completes a branch 58 of circuit 11 to pick up relay P7, over contact *c* of relay P6, irrespective of the character of the sixth step, and relay P7 completes a stick circuit 59. If the step is short, a circuit 60 is completed at this time over contacts *b* of relays SC2 and P6 to pick up relay SR1 which relay then closes a stick circuit 61 extending to terminal B over contacts *e* in multiple, of relays P7, P8 and P9, so that relay SR1 is held up during the next three steps of the code and is then released.

If the sixth step is long, a circuit 62 is completed over contact *b* of relay LC2 and contact *e* of relay P6 to pick up relay SR2, which is then held energized over a branch 63 of circuit 61.

When the office relay P7 picks up it opens the normally closed circuit 64 for relay X at its contact *f* and closes circuit 65 momentarily over contact *i* of relay SR1 to pick up the starting relay S1, which then is held energized over its stick circuit 1 until the next movement of a lever of panel No. 1 takes place.

At one of the two stations at which relay P6 is energized, the jumper connections are so arranged that relay P7 picks up over a branch 161 of circuit 138 when the office relay SR1 picks up, the station relay P7 then completing its stick circuit 59.

At each of these two stations, when relay Y2 releases it opens circuit 54 to release relay P6. It follows that the apparatus at only one station is responsive to the remainder of the code.

When relay SR1 or SR2 picks up, it opens circuit 55 or 57 at its back contact *j* to release relay OT to close line 5.

Seventh step—Long

When each line relay L2 picks up, it closes circuits 14 and 15 to pick up relays SR and Y1, and opens circuits 7 and 36 to release relays ST, X1 and SC2. Each relay Y1 closes its stick circuit 16, and closes circuit 17 to pick up relay SC1. Relay Y1 at the selected station closes a circuit 66 from terminal B, contact *c* of relay P7, contact *f* of relay Y1 through the left-hand winding of relay CR to terminal C, causing relay CR to operate its contacts to the left.

The character of the seventh step is determined by the position of the switch lever SW, and with this lever reversed, as assumed, the seventh step is long. Consequently, relay OT remains deenergized so that relay ST releases, opening circuit 14, and closing circuit 27 to pick up relay LT. Relay SR releases, deenergizing relay LT, and closing circuit 30 at the office to pick up relay LR, and at the same time, relay SR opens circuit 119 releasing relay SC1 and closes a circuit 67 over contact *b* of relay LT to pick up relay LC1. Relay LT then releases, but

relay LC1 remains energized over a branch 68 of circuit 67. The office relay LT upon releasing completes a circuit 70 for relay OT from terminal B, back contacts *d* of relays P12, P11, P10, P9 and P8, front contacts *d* of relay P7, contact *f* of relay SR1, right-hand contact *b* of lever SW, contact *e* of relay LC1, back contact *d* of relay LT, contact *b* of relay OM, relay OT to terminal C, so that relay OT picks up and opens line 5 to produce a long seventh step.

If the code had been initiated by a movement of lever SW from reverse to normal, a circuit 69 similar to circuit 70 would have been closed as soon as relay SC1 picks up to produce a short seventh step, as will be apparent from the drawings.

The line relays L2 now release, closing circuit 7 to pick up relay ST and also closing a branch 71 of circuit 19 to pick up relay X2 and to hold relay LC1 energized in series with X2, and opening circuits 16 and 30 to release relays Y1 and LR.

When the office relay X2 picks up a branch 72 of circuit 22 is closed over contact *b* of relay P7 to energize relay P8, which picks up and closes its stick circuit 73. At the same time, relay X2 at the selected station completes a pick-up circuit 172 for relay P2 from terminal B, left-hand contact *a* of relay CR, contact *g* of relay X2, contact *e* of relay P7, relay P2 to terminal C. Relay P2 picks up and closes its stick circuit 23.

The station relay X2 also completes a circuit 74 or 75 momentarily to position the polar stick switch control relay WS at this time. Since relay LC1 is picked up, circuit 75 is effective to position relay WS to the right, and may be traced from terminal B, contact *a* of line relay L1, contact *b* of relay CR, contact *d* of relay K, contacts *f* of relays X2 and LC1, contact *h* of relay P7, the right-hand winding of relay WS, contact *a* of the switch locking relay L of Fig. 3, to terminal C. Similarly, when relay SC1 is picked up, circuit 74 including front contact *f* of relay SC1 and contact *j* of relay P7 is effective to position relay WS to the left.

The release of relays Y1 at this time opens circuits 59 so that relays P7 become deenergized and release shortly after relay WS is operated.

When relay P8 picks up, it opens circuit 69 or 70 releasing relay OT, to close line 5.

Eighth step—Short

When each line relay L2 picks up, relays SR, Y2 and SC2 are reenergized, and relays ST, X2 and LC1 or SC1 become deenergized.

The character of the eighth step is determined by the position of the signal lever SG, and with this lever normal, as shown, or in its right-hand position, relay OT is picked up over a circuit 76 extending from terminal B at contact *d* of relay P12 over front contact *d* of relay P8, contact *g* of relay SR1, contact *c* of lever SG and contact *e* of relay SC2, to produce a short eighth step, while if lever SG has been moved to the left, the similar circuit 77 including contact *e* of relay LC2 is effective to produce a long eighth step, as will be apparent from the drawings. When relay OT picks up, relays L2 release, relays ST and X1 pick up and SC2 or LC2 is held energized, and relays SR and Y2 release.

When the office relay X1 picks up it completes a branch 78 of circuit 59 to pick up relay P9. At the same time the station relay X1 completes a circuit 178 from terminal B, left-hand contact *a* of relay CR, contact *g* of relay X1, con-

tact *e* of relay P2, relay P3 to terminal C. The office relay P9 and the station relay P3 therefore pick up and complete their respective stick circuits 79 and 39.

The station relay X1 also completes a circuit 80 or 81 momentarily to position the signal control relay LHS in accordance with the character of the eighth step, circuit 80 including contact *f* of relay SC2 and contact *j* of relay P2, while circuit 81 includes contact *f* of relay LC2 and contact *h* of relay P2, these circuits being otherwise similar to those for relay WS already described.

The release of relays Y2 at this time opens circuits 73 and 23 so that relays P8 and P2 release.

When relay P9 picks up it closes a circuit 82 from terminal B over its contact *f*, contact *b* of relay SR1, relay SR1A to terminal C. Relay SR1A picks up and prepares a stick circuit 83 which extends to terminal B over contacts *e* of relays P10, P11, and P12, in multiple. Relay P9 at its back contact *d* opens circuit 76 or 77 so that relay OT releases to close line 5.

Ninth step—Short

When each line relay L2 picks up, relays SR, Y1 and SC1 are reenergized, and relays ST, X1 and SC2 or LC2 become deenergized.

The character of the ninth step is determined by the position of contact *b* of the signal lever SG, and relay OT is picked up on this step over a branch 84 or 85 of the circuit 69 or 70 already described to produce a short step when lever RG is normal or has been moved to the left and a long step when it has been moved to the right. As shown, relay OT picks up over circuit 84 when SC1 picks up and then relays L2 release, relays ST and X2 pick up, relay SC1 is held energized, and relay Y1 releases.

When the office relay X2 picks up it closes a branch 86 of circuit 72 for relay P10, and the station relay X2 at the same time closes a similar branch 186 of circuit 172, for the station relay P4, and these relays pick up and close their stick circuits 87 and 44, respectively. The station relay X2 also completes a branch 88 or 89 of the circuit 74 or 75 already described, over contact *j* or *h* of relay P3 to position the signal control relay RHS in accordance with the character of the ninth step.

The release of relays Y1 at this time opens circuits 79 and 39 so that relays P9 and P3 release, and P9 opens circuit 61, releasing relay SR1. When relay P10 picked up it completed the stick circuit 83 for relay SR1A, so that that relay remains energized.

Relay P10 also opens circuit 84 or 85 at its back contact *d* so that relay OT releases to close line 5.

Tenth step—Short

When each line relay L2 picks up, relays SR, Y2 and SC2 are reenergized, and relays ST, X2 and SC1 or LC1 become deenergized.

The character of the tenth step is determined by the position of contact *b* of the call-on signal lever CO, and relay OT is picked up on this step over a branch 90 or 91 of the circuit 76 or 77 already described to produce a short step when lever CO is normal and a long step when it is reversed. The branches 90 and 91 each include front contact *d* of relay P10 and contact *h* of relay SR1A and may readily be traced from the drawing.

As shown, relay OT picks up when SC2 picks up and then relays L2 release relays ST and X1

pick up, relay SC2 is held energized and relay Y2 releases.

When the office relay X1 picks up it closes a circuit 92 for relay P11, a circuit 93 for relay SP1 and a circuit 94 for relay PC. Circuit 92 is a branch of circuit 59 already traced while circuits 93 and 94 have a common portion extending from terminal B over contact *e* of relay X1, contact *b* of relay OM, contact *f* of relay P10, and then extend over contacts *g* and *e*, respectively, through the left-hand windings of relays SP1 and PC to terminal C. Therefore, when relay X1 picks up, relay P11 is picked up to close its stick circuit 95, and relays SP1 and PC are positioned to the left, but the corresponding station relay P5 is not operated because its circuit 192 includes the open contact *d* of relay M.

The station relay X1 now closes a branch 96 or 97 of circuit 80 or 81 over contact *j* or *h* of relay P4 to position the stick relay CHS in accordance with the character of the tenth step.

The release of relays Y2 at this time opens circuits 87 and 44 so that relay P10 and the station relay P4 release, relay P10 opening circuits 92, 93 and 94. Relay PC now opens circuit 21 so that relay OM releases. Relay P11 at its back contact *d* opens circuit 90 or 91 so that relay OT releases to close line 5, but since the contacts *a* and *b* of relay PC have been restored to their normal left-hand position, the current delivered to line 5 is now of positive polarity. Each line relay L1 now picks up, releasing relays ST, X1 and SC2 or LC2, and closing circuit 6 to pick up relay XO, which closes circuit 8 to pick up relay XS. The office relay XO opens circuit 95 releasing relay P11, and at its contact *e* connects terminal B to circuit 3. If a code has been "stored" at the office by the release of a starting relay such as S1 or S2, the corresponding relay SP1 or SP2 will now reverse closing circuit 4 to initiate the transmission of the new code.

The station relay YO, which picked up when relay XO released at the beginning of the code, now becomes deenergized, but before it releases, a circuit 98 is closed momentarily from terminal B over contacts *b* of relay YO, contact *g* of relay XO, through the right-hand winding of relay CR to terminal C, to operate the contacts of relay CR to the right. At the same time, circuit 129 is closed momentarily from terminal B, contacts *a* of relays XO and YO, relay SR to terminal C so that the station relay SR picks up.

The office apparatus is now in condition to transmit, and both the office and station apparatus are in condition to receive a new code, but the station apparatus is not yet fully conditioned to initiate the transmission of a code, because relay LO, which was released by relay XO at the beginning of the code is still deenergized. Relay YO which became deenergized when relay XO picked up, now releases, opening circuit 129 and closing circuit 130 to deenergize relay SR and to pick up relay LT. Relay SR then releases, opening circuit 130 and closing circuit 132 to deenergize relay LT and to pick up relay LO over contact *a* of relay LT. Relay LT then releases, relay LO being held energized over its stick circuit 134. The station apparatus is now fully restored to normal as shown in the drawings.

The transmission of typical indication codes will now be described. As shown in Fig. 2B, the station starting relay S has a normally closed holding circuit 101, similar to circuit 1, which is opened to release relay S upon a change in posi-

tion of any of the indication transmitting devices at the station. It will be assumed that the coding apparatus is in its normal condition, as shown, but that the operation of the switch machine SM at the station has been initiated as a result of the reversal of relay WS by the control code already described, and consequently the associated switch indication relay KR releases, opening circuit 101 at its contact *a*. This initiates the code, and it is to be understood that the station code call is 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 the function elements of the code are all short steps except the one controlled by contact *b* of relay KR, which is long to indicate the "switch open" condition.

The release of relay S, at station No. 1, completes a circuit 103 from terminal B, contact *d* of relay XO, Fig. 2A, contacts *b* of relays LO and S, through the right-hand winding of relay SP to terminal C. Relay SP operates its contacts to the right, closing circuit 104 from terminal B at its right-hand contact *a* over the right-hand contact *c* of relay CR, back contacts *d* of the P relays, contact *d* of relay XS, contact *b* of relay K, front contact *c* of relay LO, back contact *f* of relay LT, relay T to terminal C.

Relay T picks up and at its contact *a* opens line 5, releasing the plus line relays L1. Relay T at its contact *c* closes the pick-up circuit 120 for relay M and opens the stick circuit 102 for relay K, so that relay M picks up and relay K becomes deenergized and releases.

At the office and at each station, when relay L1 releases, relay XO is released, relays ST and X1 pick up, relay P1 picks up, and relay XS is held energized in series with X1, and at the office, relay X1 reverses relay PC, as at the beginning of the control code already described. The station relays XO upon releasing open circuits 134 to release the relays LO.

The station relay P1 at its contact *g* completes a pick-up circuit 165 for relay S extending to terminal B at contact *c* of relay M. Relay S therefore picks up and closes its stick circuit 101.

When the station relay P1 picks up a branch 105 of the stick circuit for relay M is closed from terminal B, contact *h* of relay XO, contact *e* of relay XS, front contact *f* of relay P1, contact *a* and winding of relay M to terminal C. Relay P1 opens circuit 104 at its back contact *d* so that relay T releases and closes line 5.

Since relay PC is now reversed, relays L2 pick up, deenergizing relays ST, X1 and XS and picking up relays SR and Y1 as hereinbefore described. After relay XS releases, relay M is held energized over a second branch 106 of its stick circuit including contact *e* of relay Y1. Relay Y1 also closes circuit 17 to pick up relay SC1. When relay ST releases, relay SR is deenergized, relay LT picks up over circuit 27, and relay SC1 is held energized over circuit 119. Then when relay SR releases, circuits 27 and 119 are opened, relay LT becomes deenergized, relay SC1 is released and circuit 67 closes to pick up relay LC1. Relay LT at the sending station then releases and at its back contact *d* closes a branch 118 of circuit 104 including front contact *d* of relay P1, front contact *e* of relay LC1, back contact *d* of relay LT, and front contact *b* of relay M, thereby energizing relay T to complete the first step. Since relay T does not pick up over circuit 118 until after relay LC1 is picked up and

relay LT released, the first step of the indication code is a long step.

When relay T picks up, the line relays L2 release and relay X2 picks up in series with relay LC1 over circuit 71 and relay Y1 releases. Since relay SC1 is now deenergized, the pick-up circuit 20 for relay OM at the office remains open and relay T at the station remains in control of the line. When relay Y1 releases, the station relay M is held energized over a third branch 107 of its stick circuit including contact d of relay LC1.

At the office, when relay X2 picks up, relay P2 is energized over circuit 22, and an indication register relay IR is energized over a circuit 108 from terminal B, contact c of relay X2, contact b of relay LC1, contact c of relay P1, relay IR to terminal C. Relay IR is held energized over a stick circuit 109 extending to terminal B at back contact e of relay XS until the code is completed. At each station, when relay X2 picks up, relay P2 is energized over a branch 143 of circuit 122 including contact b of relay LC1 and contact c of relay P1. Relays P2 complete their stick circuits 23 and relays P1 release.

The release of relay P1 at the sending station completes a fourth branch 121 of the stick circuit for relay M, extending from terminal B, contact h of relay XO, contact c of relay K, back contact f of relay P1, contact a and winding of relay M to terminal C, over which relay M is energized to maintain relay T in operation to complete the code.

The operations occurring during the second to sixth steps, inclusive, of the indication code are identical with those occurring during the corresponding steps of the control code already described, except that the transmission is governed by the station relay T. That is, corresponding relays P3, P4, P5, P6 and P7 at the office and sending station are operated successively and at the transmitting station the P relays control relay T over branch circuits 133, 140, 145, 150 and 155 similar respectively to the circuits 33, 40, 45, 50 and 55 over which the office relay OT is energized on the corresponding steps of a control code.

Since each field station responds to a different code, the progression will continue beyond the sixth step at the office and at the sending station only.

The apparatus as shown is arranged to indicate a total of six two-position functions. That is, there are two more function steps in an indication code than in a control code, and the operation of the stepping relays therefore includes two additional steps. On the seventh to ninth steps, inclusive, relays P8, P9 and P10 at the office are operated in unison with the station relays P2, P3 and P4, respectively, and relays SR1 and SR1A are operated on the sixth and eighth steps in the same way as in a control code. Relay CR likewise closes its left-hand contacts at the beginning of the seventh step, and at its left-hand contact c prepares a new series of transmitter control circuits 169, 170, 176, 177, 184, 185, 190 and 191 for relay T similar respectively to the circuits 69, 70, 76, 77, 84, 85, 90 and 91 for relay OT already described. The length of the seventh step is governed by the neutral contact b of the switch indication relay KR and is short when the track switch is locked normal or reverse and is long when the switch is unlocked. The eighth step is controlled by the polar contact c of relay KR and is short or long according as the indicated position of the switch is normal

or reverse. The ninth and tenth steps are controlled by the signal indication relays LGP and RGP and each is short when the respective signal is at stop and long when it has been cleared.

At the end of the tenth step, relay P11 is operated over circuit 92 as already described, and the station relay P5 is operated over a circuit 192 which may be traced from terminal B, left-hand contact a of relay CR, contact g of relay X1, contact d of relay M, contact e of relay P4, relay P5 to terminal C, so that relays P11 and P5 pick up and close their respective stick circuits 95 and 49. The station relay P5 at its contact f prepares a circuit 114 or 115 to control relay T to produce a short or long eleventh step to indicate the clear or occupied condition, respectively, of the approach zone controlled by relay AR. Circuit 94 over which the office relay PC was restored to normal on the tenth step of the control code is now open at contact b of relay OM, so that the eleventh, and likewise the twelfth step of the indication code, are of negative polarity to operate relays L2.

At the end of the eleventh step, relay P12 is operated over a branch 99 of circuit 72 and the station relay P6 is operated over a branch 199 of circuit 172, and these relays pick up and close their respective stick circuits 100 and 54. The station relay P6 at its contact f prepares a circuit 116 or 117 to control relay T to produce a short or long twelfth step in accordance with the position of the detector section track relay TR.

The operation of the indication relays of the office panel No. 1 in accordance with the character of the seventh to twelfth steps, inclusive, of the indication code will now be described. When the office relay L2 releases at the end of the line-closed position of the seventh step, relay X2 picks up in series with SC1 or LC1 over circuit 19 or 71, depending upon whether the seventh step is short or long. The polar stick indication relay 1LK, it will be remembered, was reversed over circuit 2 when lever SW was operated to its reverse position to initiate the control code previously described and this code deenergized the switch indication relay KR to initiate the indication code now being described. When relay X2 picks up on the second step, relays IR, P7 and LC1 will be energized, and a circuit 180 will be closed to deenergize relay 1LK momentarily in the reverse direction. This circuit may be traced from the mid-point terminal O of the local battery, Fig. 1B, relay 1LK, contact e of relay SR1, contact c of relay P7, contact d of relay IR, contacts f of relays X2 and LC1, contact j of relay SC1 to terminal C. Lamp 1WE therefore remains lighted. When the track switch becomes locked reverse, another indication code will be transmitted, in which, on the seventh step relay 1LK will be operated to the left, over a branch 181 of circuit 180 extending to terminal B over front contact f of relay SC1 and back contact j of relay LC1. Lamp 1WE is now lighted over a circuit 2a because lever SW and relay 1WK are in non-corresponding positions. When relay X1 picks up on the eighth step of this code, relays IR, P8 and LC2 will be energized and a circuit 182 will be closed momentarily to reverse relay 1WK, which extends from terminal O, relay 1WK, contact d of relay SR1, contacts c of relays P8 and IR, contacts f of relays X1 and LC2, contact j of relay SC2 to terminal C. Relay 1WK therefore operates its contact a to the right to open circuit 2a and extinguish lamp 1WE. Similarly, when the indication code includes a short

eighth step, relay *lWK* is operated to the left over circuit *183*.

In a similar manner, the signal indication relay *lLGK* is positioned to the left or right over branch *123* of circuit *180* or *181* on the ninth step, and relay *lRGK* over branch *124* of circuit *182* or *183* on the tenth step, either to cause lamp *NGE* to be lighted to indicate that the signals are at stop, or to cause lamp *LGE* or *RGE* to be lighted to indicate that the corresponding signal has been cleared. Likewise, the track indication relays *lAK* and *lTK* are positioned to the left or right over branches *125* and *126* on the eleventh and twelfth steps to indicate the condition of the corresponding track sections, lamps *lAE* and *lTE* being lighted when the respective sections are occupied.

When relays *XI* pick up at the end of the twelfth step, relay *PC* is restored to normal by the energization of a branch *194* of circuit *94* extending from terminal *B*, contact *e* of relay *XI*, contact *b* of relay *IR*, contacts *f* of relays *P12* and *SR1A*, through the left-hand winding of relay *PC* to terminal *C*, and at the sending station, a branch *193* of circuit *192* is closed from terminal *B*, over contact *e* of relay *P6* through the left-hand winding of relay *SP* to terminal *C*, so that relay *SP* opens its right-hand contact *a* in the branch *116* or *117* of circuit *104* to deenergize relay *T* and thereby restore line *5* to its normally closed condition. Circuit *13* is now closed from terminal *B*, left-hand contact *a* of relay *SP*, relay *K* to terminal *C* so that relay *K* picks up, completing its stick circuit *102* and at its contact *c* opening circuit *121* to release relay *M*.

The release of relays *Y2* now opens circuits *100* and *54* so that relay *P12* and the station relay *P6* release.

Since relay *PC* has been restored to normal, when relay *T* releases, current of positive polarity is delivered to line *5* so that each line relay *L1* picks up, releasing the relays *ST*, *X1*, and *SC2* or *LC2* and reenergizing relays *XO* and *XS*.

The station relay *XO* deenergizes relay *YO*, and as at the end of the control code hereinbefore described relay *CR* is energized momentarily to the left and relays *SR*, *LT* and *LO* are successively energized, relays *SR* and *LT* releasing and relay *LO* remaining energized over its stick circuit *134*.

When relay *LO* picks up, it closes its contact *b* in circuit *103*, and completes that circuit to again reverse relay *SP*, provided any station device has changed its position during the code to release relay *S*. If relay *SP* reverses, circuit *104* will close to initiate a new indication code as soon as relay *LT* releases.

All of the coding apparatus is now in its normal condition, as shown.

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 selected order.

No relay *SP* can be operated to the right during transmission because its circuit *3* or *103* is opened by relay *XO* when the line circuit is opened at the beginning of a code. It may happen, however, that two or more relays *SP* are operated at the same time. Since all circuits for the station transmitter relay *T* except the initiating circuits *104* and a branch *104a* hereinafter described 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 *120* for relay *M* is controlled by a front contact of relay *T*, consequently relay *M* can pick up on the first step only, that is, when relay *T* is energized over circuit *104* or *104a*.

If the office and one or more stations start simultaneously, the office relay *OT* picks up over circuit *18* and opens line *5* to terminate the first impulse as soon as relay *SC1* picks up, and consequently the first step is short, the line relays *L2* release, and the apparatus controlled thereby functions in the manner already explained in the description of the short first step of a control code. When each line relay *L2* releases, it opens circuit *16*, thereby deenergizing relay *Y1*. At this time, relays *P1* and *SC1* are picked up and relays *XO*, *XS* and *LC1* are released, consequently, the station relays *T* are deenergized, the corresponding circuits *118* for these relays being open at contacts *e* of relays *LC1*. The only circuit available for holding the station relays *M* energized at this time is circuit *106*, but this circuit is opened without closing circuit *107* upon the release of relay *Y1* at the end of the short line-closed portion of the first step. Relay *P1* is also deenergized by relay *Y1* but circuit *121* for relay *M* does not close because relay *K* picks up over a circuit *113* closed momentarily from terminal *B*, contact *e* of relay *X2*, contact *c* of relay *SC1*, contact *e* of relay *P1*, relay *K* to terminal *C*, consequently, relay *M* releases, relay *T* remains deenergized and holds relay *K* energized over circuit *102*, and the station apparatus is therefore in condition to receive the control code being transmitted from the office.

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 step while another station is transmitting a short line closed step, its operation will be discontinued by the release of relay *M* due to the opening of circuit *121* by relay *K*. Thus the apparatus of Fig. 2B as shown is arranged to send and receive codes having a long second step, but a jumper connection over contact *c* of relay *P2* is provided between circuits *138* and *13* so that relay *K* will pick up to open circuit *121* in case a short second step is received. Furthermore, it will be noted that further progression of the *P* relays at the station at which relay *K* is operated on the second step is prevented because relay *P3* is not operated.

It will be apparent from the drawings that the *c* contacts of the station relays *P2* to *P6* are so connected 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 relays *SP1*, *SP2* are reversed simultaneously. That is, either the office relay *XO* may pick up at the end of a code after a plurality of relays *S1*, *S2*, etc., have been deenergized, or a plurality of these relays may be released in unison, to provide a multiple energization of relay *OT* over circuits *4*, *56*, etc., to initiate different control codes. On any station selecting step, it is obvious that the circuit such as circuit *55* for picking up relay *OT* to produce a short step will be closed before the cor-

responding circuit 57 for producing a long step can be closed, and will effect the energization of the proper relay P to render the latter circuit ineffective. Consequently, but one relay SP will remain in control of relay OT and no interference between the stored codes will occur. Each code sending relay, such as SP2, for example, will be restored to normal at the end of the corresponding code by the operation of the relay SR2A which such relay governs, and the stored codes will be transmitted one at a time in order.

As explained more fully in the Snavely, Miller & Jackel application 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 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 may be a plurality of relays SP at a station reversed 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 station 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 SG 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. However, unless they are completed before the end of the sixth step when the pick-up circuit 65 for relay S1 is closed, relay S1 will be in its released position at the end of the code and will initiate the transmission of a second control code, thereby insuring that the function steps of the code correspond to the final positions of the levers.

In the event one or more of the indication controlling devices change their position during the transmission of an indication code from the corresponding station, relay S will be in its released position at the end of the code and will initiate the transmission of a second indication code, because the pick-up circuit 165 for relay S is closed only on the first step of a code.

In accordance with a feature of our invention, our apparatus is so arranged that indication 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.

It has already been explained that if the line is available and a control code and an indication code are initiated simultaneously, that the control code will take precedence by reason of code superiority, that is, because the code initiated jointly by the office and station will have a short first step, and that corresponding conditions apply on each station selecting step in case two or more stations initiate codes simultaneously, the indication codes being transmitted one at a time in the order of their code superiority.

Our apparatus is also so arranged that when any station obtains control of the line, one indication code will be transmitted from each station which at that time has a code stored for transmission, before any station can transmit a second code which becomes stored subsequently, even though the later stored code is superior.

To explain this feature of our invention, we

will assume that devices at station No. 1 and at an inferior station No. 3 change positions at the same time, or while the line is not available, so that the code sending relays SP at the two stations are operated to the right over circuits 103 at the same time in response to the release of the starting relays S, to jointly initiate an indication code, and that after the code transmission has started, a device at a superior station No. 2 changes its position to release relay S at that station also.

By reason of code superiority, as already described, the first code transmitted will be the one from station No. 1, since this was initiated to open circuit 103 at station No. 2 before relay S at station No. 2 released. At the beginning of this code, relay LO releases at each station, and as soon as relays XO and XS become energized in response to the energization of the plus line relay L1 at the end of the code, relay T picks up at station No. 3, at which relay SP is already reversed, to begin a second code over the branch 104a of circuit 104 including back contact c of relay LO. That is, the two codes are separated by a short positive impulse, relays LT do not pick up at the end of the first code, relays LO remain deenergized and the circuit 103 for reversing the code sending relay SP at the superior station No. 2 is held open at contact b of relay LO. Consequently, the second code is transmitted by the inferior station No. 3.

At the end of the second code the apparatus is restored to normal just as if there were no more codes to be transmitted, as in the case of the codes hereinbefore described, that is, when the plus line relay L1 picks up it closes circuit 6 to energize relay XO, and relay XO picks up, deenergizing relay YO and closing circuit 129, and then relay YO releases to open circuit 129 and to close circuit 130. Relays SR and LT are picked up and released successively by the momentary closing of circuits 129 and 130, and then relay LO picks up over circuit 132. Relay LO at station No. 2 completes circuit 103 at its contact b, reversing relay SP, and when relay LT releases, circuit 104 is completed to initiate the code from station No. 2. It will be seen that in this case the two codes from stations Nos. 3 and 2 are separated by a long positive impulse, and are transmitted in the order in which they were stored.

It will be apparent that under conditions of heavy traffic, codes will be transmitted from each station in turn until all the stored codes are transmitted, and that new code storages established subsequently at superior stations can not interfere with these codes stored previously at inferior stations. Under these conditions the indication codes are transmitted in groups separated by relatively long positive impulses, while the successive codes of a group being separated by short positive impulses are transmitted more rapidly than otherwise. Furthermore, the successive codes of a group are transmitted in a given order of code superiority and include indications of only those changes occurring during the transmission of the preceding group of codes, so that a cumulative delay in transmission from inferior stations is avoided. In the absence of this feature it is apparent that the inferior stations would be able to transmit indication codes only when no superior station had indications to transmit, with the result that the transmission of certain code messages might be delayed to an extent greater than could be well tolerated.

Another result, accomplished by this feature of our invention is that the more superior stations are prevented from transmitting codes for longer time intervals than otherwise due to the more equal division of line time between the stations. Several successive changes in the condition of the devices 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 140 and is holding line 5 open as already described, but that relay P4 fails to pick up to break circuit 140. Relay T will not remain energized to prevent further use of the line, because relays Y1 and P3 will release successively and relay P3 will then open circuit 140 at its front contact d to release relay T, closing line 5, which will now remain closed with the L2 relays picked up. At the office, circuits 14, 27, 30 and 32 will be closed successively to pick up and release relays SR, LT, LR and LP1 and when relay LR releases a circuit 135 is closed to pick up relay LP2. Relay LP1 then releases and closes circuit 136 over contact a of relay LP2 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, as hereinbefore described, with the exception that relay SP at the station which failed has not been restored to normal, and consequently circuit 13 has not been closed and relay K at that station remains deenergized. It will be found that the initial energizing circuits 104 and 104a for relay T at the station which failed are now open at contact b of relay K, and consequently, that station remains inactive. The next code transmitted over line 5 will pick up relay K at the station which failed, either over circuit 113 in the case of a control code, or over a branch of circuit 13 including contact c of one of the relays P2 to P6, in case the next code is an indication code transmitted by another station, thereby restoring circuit 104a and permitting the station which failed to initiate transmission following the completion of the code last mentioned. It will be apparent that 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 a failure occurs during a line-closed period it will also prevent further progression, and relays LT, LR, LP1 and LP2 will operate successively to actuate relay PC, thereby releasing the relays L2 and energizing relays L1 to restore the apparatus to normal. At each station, relay L1 then disconnects terminal B from the circuits such as circuit 75 for energizing the polar stick relay WS. It follows that if one of the function steps of a control code is prolonged as a result of an apparatus failure, the corresponding polar stick relay at the selected station is not actuated. Furthermore, 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, circuit 14 is

closed only long enough to fully energize relay SR. If relay SR fails to pick up, relay SC1 will be released by relay ST before relay L2 releases to prepare its stick circuit 19, and since relays LT and LC1 do not become energized, the progression is stopped. The selection as to whether an impulse is registered as short or long depends upon the release period of relay SR provided by the associated rectifier unit. If the circuit for this unit is open, relay SR will release quickly and open the circuit 27 before relay LT picks up, so that neither SC1 nor LC1 are energized.

It will be apparent from the drawings that insurance against improper operation such as are provided in the few instances just described are 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 each code is marked by an impulse of a character different from any step of a code, the number of steps in a code may be varied as required without sacrifice in the reliability of the apparatus.

Although a control code has been described as having four function steps and an indication code as having six function steps preferably each code in practice will have only as many function steps as there are devices to be controlled or indicated. It will be apparent that the apparatus may readily be modified to provide the appropriate number of stepping relays at each station and the same number in the corresponding series of stepping relays at the office. In each code, the transmission of negative impulses will continue until relay PC is actuated over circuit 94 or 194. These circuits, as shown, are completed over contacts f of relays P10, P12 and SR1A to provide a control code of ten steps and an indication code of twelve steps for station No. 1, and it is readily apparent that the corresponding circuits for other stations may be controlled over other P relays to provide a different number of code steps if desired, and that each code is definitely terminated and the apparatus conditioned to initiate a new code, when a circuit such as 94 or 194 becomes closed, or in case a code is not completed, when circuit 136 becomes closed.

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 line circuit, a code transmitter at each station effective when initiated to transmit an impulse code of timed impulses of a given polarity over said line circuit, 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 timing device at each station, means for selectively operating the timing devices in accordance with the lengths of said impulses, a series of stepping relays at each station, means controlled by each timing device for selectively operating selected stepping relays of the associated series, each in accordance with the relative length of a particular impulse of

a code but only if such 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 at a selected station only at which the selected stepping relays have been fully operated in response to additional impulses of a code, means controlled by the timing device at the selected station for selectively controlling the movable devices at such station one for each additional stepping relay operation, means for energizing said line circuit by current of the opposite polarity upon the completion of said code, and means dependent upon the energization of said line circuit at least briefly by current of said opposite 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 series of stepping relays operable one at a time in sequence in response to a series of current impulses transmitted over said line circuit, means responsive only to current of said given polarity for operating the first relay of said series, and means responsive only to current of the opposite polarity for operating each succeeding relay of said series.

3. In a remote control system, a line circuit normally energized by current of a given polarity, two line relays one responsive only to current of said given polarity and the other responsive only to current of the opposite polarity in said line circuit, a series of stepping relays arranged to be operated one at a time in sequence, means controlled by one line relay for operating the first relay of said series, and means controlled by the other line relay for operating each succeeding relay of said series, a different relay being operated in response to each operation of said other line relay.

4. In a remote control system, a line circuit normally energized by current of a given polarity, a series of stepping relays arranged to be operated one at a time in sequence when said line circuit is opened repeatedly, means responsive only to current of said given polarity for operating the first relay of said series, means responsive only to current of the opposite polarity for operating each succeeding relay of said series, means for repeatedly opening said line circuit to produce a code of time spaced impulses of selected lengths, a line pole changer, means operating said pole changer to reverse the polarity of the line current when the line is initially opened and for restoring it to normal after the final impulse of a code, and code responsive means selectively responsive to the lengths of selected impulses of said code.

5. Means for selectively controlling a plurality of movable devices comprising a line relay, means for energizing said relay repeatedly for selected time intervals, a timing device, means for selectively operating said timing device in accordance with the lengths of said time intervals, a series of stepping relays adapted to be operated one at a time in order and arranged in two groups, means controlled by said timing device for selectively operating the relays of the first group, one for each operation of said line relay, but only if the successive time intervals are arranged in accordance with a particular code to which said relays are arranged to respond, means controlled by said line relay and the last relay of said first

group for operating the relays of said second group, one for each succeeding operation of said line relay, and means controlled by said timing devices and by each relay of said second group for selectively operating a different one of said movable devices.

6. In a remote control system, a line relay, means for supplying to said relay a series of current impulses each of selected character to effect its repeated energization, a chain of stepping relays arranged to be operated one at a time in order, means controlled by said line relay for operating each of said relays in turn, each in accordance with the character of a different impulse of a first group of impulses in said series, a series of movable devices, one for each relay of said chain, means rendered effective when the last chain relay has been operated for reoperating said relays one at a time in order as said line relay is operated by impulses of a second group in said series of impulses, irrespective of their character, and means controlled by each such impulse of the second group and the chain relay operated by the next preceding impulse for selectively operating a different one of said movable devices.

7. 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, a slow release relay which releases a predetermined time after said two-position relay is operated to said one position, two stick relays, pick-up circuits for consecutively energizing said stick relays including a contact closed when the two-position relay is operated to said one position and also including front and back contacts respectively of said slow release relay, a stick circuit for each stick relay including its own front contact and a contact which closes when the two-position relay is operated to its other position, and means dependent upon which stick relay is energized when the two-position relay assumes said other position for controlling a particular one of said devices.

8. 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, a slow release relay, means energizing said slow release relay momentarily each time said two-position relay is operated to said one position to condition it to assume its deenergized position at the end of a predetermined time interval, two stick relays, pick-up circuits for consecutively energizing said stick relays when the two-position relay is operated to said one position and also including front and back contacts respectively of said slow release relay, a stick circuit for each stick relay including its own front contact and a contact which closes when the two-position relay is operated to its other position, and means dependent upon which stick relay is energized when the two-position relay assumes said other position for controlling a particular one of said devices.

9. 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, a slow release relay, means energizing said slow release relay momentarily each time said two-position relay is operated to said one position to condition it to assume its deenergized position at the end of a

predetermined time interval, two register relays, circuits for consecutively energizing said register relays including a contact closed when the two-position relay is operated to said one position and also including front and back contacts respectively of said slow release relay, and means dependent upon which register relay is picked up when said two-position relay assumes its other position for controlling a particular one of said devices.

10. 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, a slow release relay which becomes deenergized when said two-position relay is operated to said one position, a second slow release relay having an energizing circuit including a front contact of the first slow release relay and closed when the two-position relay is operated to said one position, two register relays, circuits for consecutively energizing said register relays including a contact closed when the two-position relay is operated to said one position and also including front and back contacts respectively of said second slow release relay, and means dependent upon which register relay is energized when said two-position relay assumes its other position for controlling a particular one of said devices.

11. 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, a slow release relay which becomes deenergized when said two-position relay is operated to said one position, a second slow release relay having an energizing circuit including a front contact of the first slow release relay and closed when the two-position relay is operated to said one position, a third slow release relay having an energizing circuit including a front contact of the second slow release relay, two register relays, circuits for consecutively energizing said register relays including a contact closed when the two-position relay is operated to said one position, the circuit for one register relay including a front contact of the second slow release relay and the circuit for the other including back and front contacts respectively of said second and third slow release relays, and means dependent upon which register relay is energized when said two-position relay assumes its other position for controlling a particular one of said devices.

12. In a remote control system, a line relay, means for operating said line relay by different codes of time spaced impulses, a chain of stepping relays arranged to be operated one at a time in order, means controlled by said line relay for operating a different relay of said chain each time the line relay is released provided the length of the preceding impulse is in accordance with a particular code, a chain repeat relay, means operating said chain repeat relay when the last relay of the chain is operated, means for reoperating the relays of said chain one at a time in order in response to succeeding operations of said line relay irrespective of the lengths of the impulses if said chain repeat relay has been operated, a plurality of movable devices, and a plurality of code responsive means, one for each chain relay, selectively controlled in accordance with the length of the impulse following the one which effects the second operation of such relay.

13. 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, a series of stepping relays arranged to be operated one at a time in sequence, time controlled means controlled by said line relay and selectively operable in accordance with the relative lengths of said time intervals, means responsive only to line current of the opposite polarity for operating the first relay of said series, means governed in accordance with the condition of said time controlled means 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 time controlled means for selectively operating said movable device.

14. 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, a slow release relay, means for releasing said slow release relay, a predetermined time after said two-position relay is operated to said one position, two pairs of register relays, circuits for consecutively energizing the register relays of one pair closed during each alternate operation of the two-position relay to said one position and for consecutively energizing the register relays of the other pair closed during each intervening operation of the two-position relay to said one position the circuits for the two relays of each pair also including front and back contacts respectively of said slow release relay, and means dependent upon which register relay is picked up when said two-position relay assumes its other position for controlling a particular one of said movable devices.

15. In a remote control system, a series of cascade-connected relays including a normally energized first relay, an energizing circuit for each relay except the first including a front contact of the next preceding relay of the series and a normally open control contact, the circuit for each such relay except the first and second also including a back contact of the second preceding relay of the series, means including an asymmetric unit for each relay for delaying its release when its circuit is opened until the next relay is fully energized, and means for deenergizing said first relay and closing said control contact to cause the successive pick-up and release of the remaining relays of the series.

16. In a remote control system, a line relay, means for operating said line relay repeatedly, two intermediate relays, circuits for said intermediate relays for energizing them alternately, one being energized in response to each operation of said line relay to a given position, a series of stepping relays, a circuit for the first stepping relay including a contact which opens after a first operation of said line relay, a circuit for each remaining stepping relay including a front contact of the next preceding relay of the series, means controlled by one intermediate relay for completing the circuits for the alternate stepping relays of the series, and means controlled by the other intermediate relay for completing the circuits for the remaining stepping relays of the series.

17. In a remote control system, a line relay, means for operating said line relay repeatedly by impulses of different lengths, two pairs of register relays, means for picking up the relays of each pair one at a time at spaced intervals in response to alternate operations of said line relay, a stick circuit for each register relay including its own front contact and a contact which closes at the end of each impulse, a series of stepping relays, means for operating the first relay of said series at the beginning of a series of operations of said line relay, and means controlled alternately by the register relays of said two pairs for operating each of the remaining stepping relays one at a time in sequence, each at the end of a different impulse, each of said remaining stepping relays being selected for operation depending upon which stick relay is energized at the end of the corresponding impulse.

18. In a remote control system, a normally closed line circuit, means for energizing said line circuit repeatedly by current impulses of different lengths, a series of slow release stepping relays, having pick-up and stick circuits, means closing the pick-up circuit for the first relay at the beginning of a series of impulses, means for preparing the pick-up circuit for each succeeding relay at the end of a different current impulse but only if the next preceding relay is then picked up, means for closing each such circuit only if the corresponding impulse is of a selected length, and means effective when each relay is picked up for maintaining its stick circuit closed only until the pick-up circuit for the next succeeding relay has been prepared.

19. In a remote control system, a normally closed line circuit, code transmitting apparatus comprising starting means effective when operated to initially open said line circuit, a series of stepping relays adapted to be energized one at a time in order, a pick-up circuit for the first stepping relay closed only when the line circuit is initially opened, means for closing said line circuit upon the energization of each stepping relay of the series, timing means set into operation each time the line circuit becomes closed for opening it at the end of a selected time interval dependent upon which stepping relay is then energized, a pick-up circuit for each stepping relay except the first including a front contact of the next preceding relay and a contact selectively closed in accordance with the length of time the line circuit is closed, each such circuit being completed when the line is opened, a stick circuit for each stepping relay for maintaining it energized until the line circuit is again closed, and means for maintaining each stepping relay picked up after its stick circuit is opened for a time interval greater than the pick-up time of the next stepping relay of the series.

20. In a remote control system, a two-position line relay, means for operating said line relay repeatedly, a series of four intermediate stepping relays, means for operating said intermediate relays successively and repeatedly one at a time in order, the first or third relay of the series being operated when the line relay moves to one position and the second or fourth relay being operated when the line relay moves to its other position, a main series of stepping relays arranged to be operated one at a time in order, pick-up and stick circuits for the relays of said main series, means controlled by the first and third intermediate stepping relays for alternately controlling the pick-up circuits for the relays

of said main series, and means controlled by the second and fourth intermediate stepping relays for alternately controlling the stick circuits for the relays of said main series.

21. In a remote control system, a line relay, means for operating said line relay by impulses of different lengths, two register relays having pick-up and stick circuits, means closing the pick-up circuit for one register relay when the line relay is operated at the beginning of a particular impulse, means for opening said pick-up circuit and for closing that for the other register relay when the length of the impulse exceeds a predetermined value, means effective at the end of the impulse for closing the stick circuit for the register relay then energized, a selector relay, and means for selectively operating said selector relay dependent upon which register relay is held energized after the impulse is terminated.

22. In a remote control system, a line relay, means for operating said line relay by impulses of different lengths, a stepping relay, two register relays having pick-up and stick circuits, each stick circuit including the winding of said stepping relay, means closing the pick-up circuit for one register relay when the line relay is operated at the beginning of a particular impulse, means for opening said pick-up circuit and for closing that for the other register relay when the length of the impulse exceeds a predetermined value, means effective at the end of the impulse for closing the stick circuit for the register relay then energized to pick up said stepping relay, a selector relay, and means effective when said stepping relay picks up for selectively operating said selector relay dependent upon which register relay is then energized.

23. In a remote control system, a line relay, means for operating said line relay by impulses of different lengths, two register relays having pick-up and stick circuits, means closing the pick-up circuit for one register relay when the line relay is operated at the beginning of a particular impulse, means for opening said pick-up circuit and for closing that for the other register relay when the length of the impulse exceeds a predetermined value, means effective at the end of the impulse for closing the stick circuit for the register relay then energized, a stick polar relay, and means for selectively and momentarily operating said stick polar relay in one direction or the other depending upon which register relay is held energized after the impulse is terminated.

24. In a remote control system, a two-position line relay, means for operating said line relay repeatedly, a set of four intermediate stepping relays, energizing circuits for the first and third relays of the set each including a contact closed when the line relay is operated to one position and also including back contacts of the second and fourth relays of the set, respectively, pick-up circuits for the second and fourth relays of the set each including a contact closed when the line relay is operated to the other position and also including front contacts of the first and third relays of the set, respectively, and stick circuits for said second and fourth relays including their own front contacts and a contact closed when said line relay occupies said other position.

25. In a remote control system, a line relay, means for operating said line relay repeatedly comprising a series of impulses of different

lengths, a series of stepping relays arranged to be operated one at a time in order, means for operating the first stepping relay at the beginning of a series of impulses, means controlled by said line relay for operating the remaining stepping relays successively, one for each impulse, the operation of each such relay being dependent upon the operation of the next preceding relay of the series, selecting means controlling the operation of certain of said relays and effective to prevent further operation of said series of relays unless the corresponding impulses are of selected relative lengths, a plurality of movable devices one for each of a plurality of the succeeding relays of said series, and means controlled by each relay of said plurality for selectively operating the corresponding device to one position or another in accordance with the relative length of the corresponding impulse.

26. In a remote control system, a line relay, means for operating said line relay repeatedly by impulses of different lengths arranged in two groups, a series of stepping relays arranged to be operated one at a time in order, means controlled by said line relay for operating said relays successively, one for each impulse, selecting means controlling the operation of certain of said relays in response to the impulses of the first group and effective to prevent further operation of the relays unless the corresponding impulses are of selected relative lengths, a plurality of movable devices, means controlled by the last stepping relay of the series for rendering the first relay of the series responsive to the first impulse of the second group, whereby said relays are reoperated one at a time in order in response to the operation of said line relay by the impulses of said second group and means controlled by each of a plurality of the stepping relays when reoperated for operating a different movable device, each in accordance with the relative length of the corresponding impulse of said second group.

27. In a remote control system, a line relay, means for operating said line relay repeatedly by impulses of different lengths, a series of stepping relays arranged to be operated one at a time in order, means controlled by said line relay for operating said relays successively, one for each impulse, selecting means controlling the operation of certain of said relays and effective to prevent further operation of the relays unless the corresponding impulses are of selected relative lengths, two selector relays each adapted to be operated when a stepping relay operable after the last of said certain relays is operated, means for selectively operating one selector relay or the other in accordance with the length of the corresponding impulse, a set of movable devices for each selector relay, each set including one device for each remaining stepping relay of said series, and means controlled by each said remaining stepping relay and by the operated selector relay for selectively operating the device associated therewith, each in accordance with the relative length of the corresponding impulse.

28. In a remote control system, an office and a plurality of stations connected by a closed line circuit normally energized by current of a given polarity, a code transmitter at the office and at each station effective when initiated to transmit a code of current impulses of selected lengths over said line circuit, means effective when the line is initially opened at the beginning of a code to reverse the polarity of the line current,

means effective upon the completion of a code to restore the polarity of the line current to normal, and means for initiating the operation of each code transmitter effective only when the line circuit is energized by current of normal polarity.

29. In combination, a line circuit, a code transmitter operating when initiated to deliver an impulse code to said line circuit, a plurality of movable devices, a normally energized stick relay, means controlled in accordance with the position of each movable device for determining the character of a particular impulse of said code, means responsive to a change in position of any such device to release said stick relay, a stick polar relay, means reversing said polar relay when said stick relay is released provided no code is then being delivered to said line circuit, means controlled by said polar relay when reversed but effective only when no code is being delivered to said line circuit to initiate the operation of said code transmitter means controlled by said polar relay when reversed for determining the character of a plurality of the impulses of the code delivered by said code transmitter, said plurality of impulses constituting a station code call, means responsive to a code impulse transmitted prior to the transmission of the impulses controlled by said movable devices and comprising the last impulse of said station code call for picking up said stick relay, and means effective only if said code is fully transmitted for restoring said polar relay to normal.

30. In combination, a line circuit normally energized by current of a given polarity, a code transmitter operating when initiated to deliver a code of impulses of selected lengths and all of the reverse polarity to said line circuit, a plurality of movable devices, a normally energized stick relay, means controlled in accordance with the position of each movable device for determining the relative length of a particular impulse of said code, means responsive to a change in position of any such device to release said stick relay, a code sending relay, means operating said code sending relay when said stick relay is released but only if said line circuit is energized by current of said given polarity, means controlled by said code sending relay in its operated condition but effective only when said line circuit is energized by current of said given polarity to initiate the operation of said code transmitter, means responsive to a code impulse of reverse polarity transmitted prior to the transmission of the impulses controlled by said movable devices for picking up said stick relay, and means dependent upon the transmission of a predetermined number of impulses all of reverse polarity and corresponding to a complete code for restoring said code sending relay to normal.

31. In a remote control system, an office and a plurality of stations connected by a single line circuit normally energized by current of a given polarity, a code transmitter at the office operating when initiated to deliver codes of impulses of selected lengths and all of the reverse polarity to said line circuit, means for restoring the polarity of the line current to normal at the end of each transmitted code, a code receiver at each station, means for initiating the operation of said code transmitter to effect the transmission of a series of codes one at a time in order, and means requiring the energization of said line circuit at least briefly by current of normal polarity after

each code to condition each receiver to respond to the next succeeding code.

32. In combination, a line circuit, a code transmitter operating when initiated to deliver an impulse code to said line circuit, a normally energized lock-out relay, a code sending relay, means controlled by said code sending relay when operated but only if no code is being delivered to said line circuit to initiate the operation of said code transmitter, means releasing said lock-out relay in response to the initial operation of said code transmitter, means restoring said code sending relay to normal and reenergizing said lock-out relay when said code is completely transmitted, and means preventing the initiation of said code transmitter by said code sending relay unless said lock-out relay is energized, whereby in the event the code is not completely transmitted the reinitiation of said code transmitter is prevented.

33. In combination, a line circuit, a plurality of code transmitters each operating when initiated to deliver a different impulse code to said line circuit, means for initiating each code transmitter when no code is being delivered to said line circuit, said initiating means when operated remaining effective to govern the associated transmitter until said code is fully transmitted, a lock-out relay for each code transmitter, means operating each lock-out relay in response to the initial operation of the corresponding code transmitter, means restoring such lock-out relay to normal at the end of the complete code which such transmitter delivers, and means effective in the event such code is not completed to prevent further control of the line circuit by said code transmitter as long as said lock-out relay remains in its operated condition.

34. In combination, a line circuit, a plurality of code transmitters each operating when initiated to deliver a different impulse code to said line circuit, means for initiating each code transmitter when no code is being delivered to said line circuit, said initiating means when operated remaining effective to govern the associated transmitter until said code is fully transmitted, a lock-out relay for each code transmitter, means operating each lock-out relay in response to the initial operation of the corresponding code transmitter, means restoring each lock-out relay to normal at the end of the complete code which such transmitter delivers, means effective in the event such code is not completed to prevent further control of the line circuit by said code transmitter as long as said lock-out relay remains in its operated condition, and means restoring said lock-out relay to normal in response to the delivery of a code to said line circuit by another code transmitter, to thereby effect the reinitiation of said code transmitter.

35. In combination, a line circuit, a plurality of code transmitters each operating when initiated to deliver different impulse code to said line circuit, means for initiating each code transmitter when no code is being delivered to said line circuit, said initiating means when operated remaining effective to govern the associated transmitter until said code is fully transmitted, a lock-out relay for each code transmitter, means operating each lock-out relay in response to the initial operation of the corresponding code transmitter, means restoring said lock-out relay to normal at the end of the complete code which such transmitter delivers, means effective in the event two or more code transmitters initiate dif-

ferent codes at the same time to restore the lock-out relays for all but one transmitter to normal in accordance with the relative superiority in code character of the impulses of the different codes, and means controlled by each lock-out relay when restored to normal during the transmission of a code to prevent further control of the line circuit by the associated code transmitter until the code then being transmitted is completed.

36. In combination, a line circuit, a plurality of code transmitters each operating when initiated to deliver a different impulse code to said line circuit, means for initiating each code transmitter when no code is being delivered to said line circuit, said initiating means when operated remaining effective to govern the associated transmitter until said code is fully transmitted, a lock-out relay for each code transmitter, means operating each lock-out relay in response to the initial operation of the corresponding code transmitter, means restoring said lock-out relay to normal at the end of the complete code which such transmitter delivers, other means effective in the event two or more code transmitters initiate different codes at the same time for restoring each lock-out relay to normal during the transmission of said codes provided any impulse being delivered by the associated code transmitter is changed in character by the operation of another code transmitter, and means controlled by each lock-out relay when restored to normal by the operation of another code transmitter to prevent further control of the line circuit by the associated code transmitter until the code then being transmitted is completed.

37. In combination, a line circuit connecting a plurality of stations, a code transmitter relay at each station each operating when initiated to deliver an impulse code to said line circuit which includes a distinctive code call for that station, a code sending relay and a stick relay at each station, means responsive to the actuation of a code sending relay and effective when no code is being delivered to the line circuit to initiate the transmission of a code by the associated code transmitter relay, means restoring the actuated code sending relay to normal when and only when the corresponding code is fully transmitted, means for picking up each stick relay at the end of a code after the line circuit has been free for a time interval greater than that required for the initiation of a new code by an actuated code sending relay, means for releasing said stick relay when a code is initiated, and means for actuating each code sending relay effective only when the associated stick relay is picked up.

38. 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 first and a second stick relay, a timing relay, means energizing the first stick relay when said two-position relay is operated to said one position, means for releasing said timing relay a predetermined time after said two-position relay is operated to said one position, means releasing said first stick relay and energizing said second stick relay if said two-position relay remains in its one position until said timing relay releases, means for holding each stick relay energized if such relay is energized when the two-position relay assumes its other position, and means for selectively con-

trolling a particular one of said movable devices depending upon which stick relay is held energized.

39. 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, a timing relay, means for releasing said timing relay a predetermined time after said two-position relay is operated to said one position, two pairs of stick relays, means for energizing the first stick relay of one pair or the other alternately when the two-position relay is operated repeatedly to said one position, means for releasing the energized stick relay and for energizing the second stick relay of the same pair if said two-position relay remains in said one position until said timing relay releases, means for holding each stick relay energized if such relay is energized when the two-position relay assumes its other position, and means dependent upon which register relay is held energized for controlling a particular one of said devices.

40. In a remote control system, a line circuit normally energized by current of a given polarity, a code transmitter effective when initiated to transmit a series of code impulses all of the opposite polarity over said line circuit, a series of stepping relays, means responsive only to current of said given polarity transmitted over said line circuit for operating the first stepping relay of the series, means responsive only to current of the opposite polarity transmitted over said

line circuit for operating each succeeding relay of said series, means for energizing said line circuit by current of said given polarity after said transmitter has transmitted a predetermined number of impulses, and other means for energizing said line circuit by current of said given polarity if said transmitter fails after having transmitted a lesser number of impulses.

41. In a remote control system, a line circuit, a code transmitter effective when initiated to transmit impulses of a given polarity over said line circuit, means for counting said impulses, means selectively controlled for reversing the polarity of the current delivered to said line circuit after a selected number of impulses has been transmitted, and means responsive to current of the opposite polarity for stopping the operation of said transmitter until it is again initiated.

42. In a remote control system, a line circuit, a code transmitter effective when initiated to transmit different codes of timed impulses of a given polarity over said line circuit, a plurality of code responsive means each selectively responsive to the relative lengths of selected impulses of a different code, means responsive to current of the opposite polarity for stopping the operation of said transmitter until it is again initiated, and means controlled by each code responsive means for reversing the polarity of said line circuit after a number of impulses has been transmitted equal to the number of impulses in the corresponding code.

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