

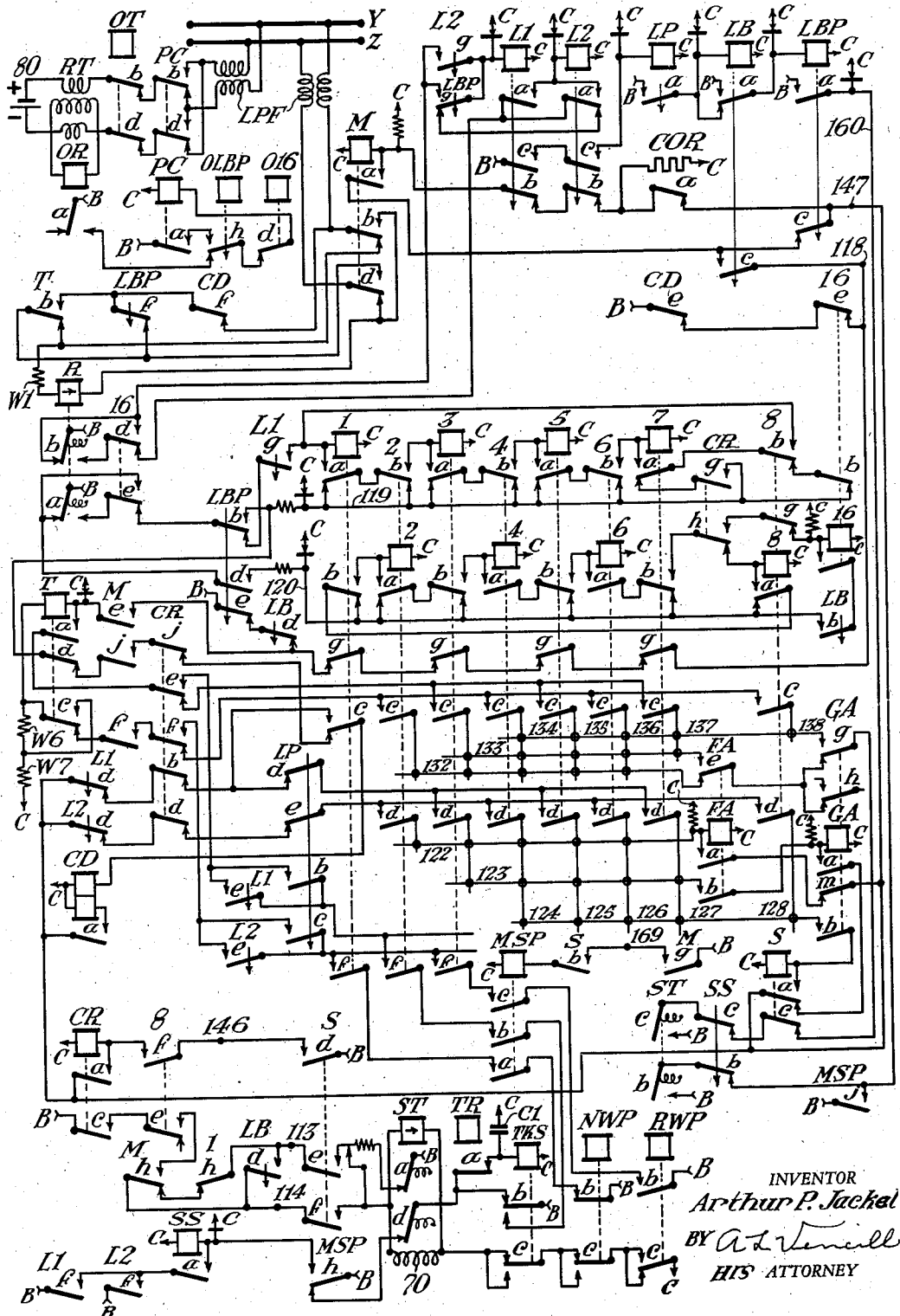
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TRANSMITTING APPARATUS FOR REMOTE CONTROL SYSTEMS

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TRANSMITTING APPARATUS FOR REMOTE CONTROL SYSTEMS

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My invention relates to transmitting apparatus for remote control systems, and more particularly for centralized traffic control systems for railroads comprising an office and a plurality of stations connected by line wires over which impulse code signals are transmitted to effect the operation of traffic governing devices located along the trackway, and to indicate the condition of such devices at the office.

This application is a division of my co-pending application, Serial No. 496,907, filed July 31, 1943, for Remote control systems.

The system of my invention is of the time code type, employing codes of long and short elements which are transmitted one at a time over a single line circuit, and is based upon the system shown in Letters Patent of the United States No. 2,229,249, granted January 21, 1941, to L. V. Lewis, for Remote control systems. My system includes also certain improvements upon the system of this patent relating to the use of a central battery line circuit of the bridged type first shown in Letters Patent of the United States No. 2,303,875, granted December 1, 1942, to G. W. Baughman and N. F. Agnew, for Remote control systems.

The components of the system of my invention are preferably assembled in the form of coding and storage units each containing a group of relays. The system employs a station coding unit at each field location for transmitting indication codes and for selectively receiving control codes, together with a station storage unit for each unit group of controlled traffic governing devices, for associating such devices with the station coding unit. The office equipment preferably includes an individual control panel for each unit group of controlled traffic governing devices, and an office coding unit which is connected over the line circuit with the station coding units to establish communication selectively between each panel and the corresponding station storage unit.

The invention of the present application relates to improvements in the station coding and storage units and to the transmitting apparatus associated therewith, employed for the transmission of indication codes from the several stations to the control office.

One feature of my invention comprises the provision of a starting relay of the normally energized type in each station storage unit, which is so controlled that it takes the place of two relays as required heretofore, and is also more efficient in operation.

Another feature of my invention relates to im-

proved means for the transmission of indications of train movements, comprising an improved "track OS storage" arrangement for insuring the transmission of an indication of a train movement through a particular track section even though the line circuit is not available when the train movement takes place.

The system of my invention also includes circuit improvements whereby the timing of the relays which measure the lengths of the code elements is more accurately controlled, as will hereinafter be pointed out, thereby increasing the margin of reliability of the system, and causing it to function properly through a wider range of variation of local battery voltage.

Other features, purposes and objects of my invention will be pointed out as the description proceeds.

One form of apparatus embodying my invention will now be described and the novel features thereof will then be pointed out in claims.

In the accompanying drawing I have illustrated in condensed form the field station equipment employed in one form of centralized traffic control system embodying my invention, for generating and delivering indication codes to the line circuit, comprising the transmitting portion of the station coding unit together with a portion of one storage unit, arranged as required when there is but one unit group of movable devices at the location, to be indicated at the office.

Referring to the drawing, the reference characters Y and Z designate a pair of line wires which extend from the office through the several stations and provide a line circuit for the centralized traffic control system of my invention. This line circuit, as shown, is normally energized by current from the office line battery 80, the positive terminal of which is normally connected to line wire Y and the negative terminal to line wire Z over back contacts b and d of a pole changer relay PC and of an office transmitter relay OT and the coils of a low pass filter LPF. The circuit also includes the primary windings of an impulse transformer RT, by means of which the office line relay OR is controlled when receiving indication codes. Relay OR is of the stick polar type, as described and claimed in Patent No. 2,303,875, and responds to impulses of alternately opposite polarity delivered by transformer RT when the line current is varied by the operation of a station transmitter relay T. Indication codes are transmitted by energizing the master relay M and then operating relay T repeatedly to connect the line wires together periodically

through an impedance of relatively low value in comparison with the normal impedance of the line circuit, comprising the coils of a low pass filter LPF similar to the one at the office, which is interposed between the line and the station apparatus.

At each field station, as shown, a high resistance line relay R is connected across the line wires Y and Z in series with a resistor W1, the connection normally including back contacts b and d of the master relay M and the coils of the low pass filter LPF. The station line relays R are of the biased polar type and are normally energized, in parallel, by current supplied by battery 80, each relay R closing its left-hand contacts a and b, as shown, when its left-hand terminal is positive, and closing its right-hand contacts a and b when energized in the reverse direction with its right-hand terminal positive, or when deenergized.

Each station line relay R controls a group of slow release timing relays L1, L2, LP, LB and LBP. These timing relays are normally deenergized and are controlled by relay R to govern the transmission of codes in accordance with line conditions like the similarly designated relays of Patent No. 2,229,249, hereinbefore referred to. Their release times are likewise governed by electronic rectifiers, as shown, the rectifiers also serving to prevent contact sparking and to minimize contact wear, as explained in this patent. Certain of the relays shown herein, such as the relays FA, GA and 16, are provided with a discharge circuit including a resistor in lieu of the usual rectifier. These resistors are of relatively high value in comparison with the resistance of the relay winding and provide less retardation, but otherwise serve the same purpose as a rectifier.

The system of my invention is arranged to employ indication codes each having sixteen steps, and in each indication code delivered by a station transmitter relay T, the front contact b of relay T closes to shunt the line circuit at the beginning of each odd-numbered step, short circuiting the associated line relay R to cause it to release, and increasing the current delivered to the line by battery 80, so that relay OR assumes its reverse position. Front contact b of relay T is opened at the beginning of each even-numbered step and relays OR and R then assume their normal positions as shown. Each step is made relatively short or long to provide code character, both the open and closed periods constituting code elements.

When the line relay R releases at the beginning of a code, its right-hand contact b completes a circuit from the positive or supply terminal B of a suitable local source of current over a back contact d of relay 16, back contact a of relay L2, back contact g of relay LBP through relay L1 to the negative or common return terminal C of the source. Relay L1 then picks up and its front contact a completes a circuit from terminal B at the right-hand contact b of relay R through relay L2 to terminal C, so that relay L2 picks up, completing a stick circuit at its own front contact a and also completing a circuit from terminal B over front contacts c of relays L1 and L2 to pick up relay LP, which relay in turn completes circuits over its front contact a to pick up relays LB and LBP. Relay LBP becomes energized in tandem with relay LB when the latter closes its front contact a so that these relays release successively after relay LP is re-

leased. When relay L2 picks up on the first step of a code, its contacts a and g shift the connections of relay L1 from the right-hand to the left-hand contact b of relay R, and then contact g of relay LBP is picked up to maintain the latter connection until the code is terminated. It follows that relays L1 and L2 are energized alternately, relay L1 over the left-hand contact b of relay R, and relay L2 over the right-hand contact b of relay R, in response to the periodic operation of relay R. Relays L1 and L2 remain picked up for the duration of short code elements, relay L1 releasing during each odd-numbered long element and relay L2 during each even-numbered long element. These relays serve, therefore, to indicate code character in a code to which relay R responds, and together with relay LP they serve to control the lengths of the long steps of a code generated by the associated transmitter relay T. Relay LB and its repeater relay LBP are bridging relays which remain picked up for the duration of a code and serve to prepare various local circuits when the code operation of relay R begins and to open them when it ceases.

The office line relay OR controls a similar group of timing relays including a bridging relay OLBP, which function in a similar manner. Relay OR, however, is normally deenergized and is adapted to hold its contacts in either position to which it is operated by a momentary impulse, and hence it may become accidentally reversed. If this occurs, relay OR is restored automatically to normal by the action of the timing relays in a manner explained in my prior application, Serial No. 496,907, and it may be assumed therefore that relay OR, although deenergized, occupies its normal position corresponding to that of the normally energized station line relays R, when the system is in its normal at rest condition.

Each line relay R controls a chain of counting relays 1 to 8 and 16, over circuits generally similar to those of Patent No. 2,229,249. In response to the first of a series of operations of relay R, a pick up circuit for relay 1 is closed momentarily from terminal B at the right-hand contact a of relay R over back contact e of relay 16, back contact b of relay LBP, front contact g of relay L1, through relay 1 to terminal C. Relay 1 therefore picks up on the first step of a code upon the energization of relay L1, and when relay LBP picks up, it opens the circuit just traced and closes a stick circuit for relay 1 extending over front contact b of relay LBP, wire 119, back contact b of relay 2, front contact a and winding of relay 1 to terminal C. When relay R is operated to normal to begin the second step of a code, terminal B is disconnected from relay 1, which remains picked up due to the discharge path provided by the rectifier connected to wire 119, and a circuit is closed from the left-hand contact a of relay R over front contact d of relay LBP, wire 120, back contact a of relay 8, front contact b of relay 1 through relay 2 to terminal C. Relay 2 therefore picks up and completes its stick circuit extending to terminal B at wire 120 over its front contact a and back contact b of relay 3. The operation of contact b of relay 2 disconnects relay 1 from the rectifier but closes a second discharge path for relay 1 comprising the winding of relay 3, whereby relay 1 releases shortly after relay 2 picks up but without sparking at its contact a, the dropping of which connects relay 3 to wire 119 to condition that relay to respond to the third step of the code. Relays 4 to 8 are

similarly controlled one at a time by current supplied alternately over wires 119 and 120 in response to the fourth to eighth steps of the code. If the various operations associated with these steps are properly carried out, a chain repeat relay CR is picked up on the eighth step, as hereinafter described, to prepare a pick-up circuit for relay I over front contact b of relay 8 so that relay I will operate as the next in order after relay 8, relays I to 7 being then operated through a second cycle on the ninth to fifteenth steps of the code, relay 16 responding in place of relay 8 on the sixteenth step, during which the apparatus is restored to its normal at rest condition.

As explained in my prior application, Serial No. 496,907, the line wires Y and Z are used for two-way transmission, that is, to transmit indication codes from the stations to the office, at times, and at other times to transmit control codes from the office to the stations, and to make the station coding units function as selective receivers of the codes which originate at the office, the first step of each control code is made a long step to distinguish it from an indication code in which the first step is relatively short.

On the first step of a control code, a delivery control relay CD is selectively operated at each station, in response to the release of relay L1, due to the long character of the step, over a circuit extending from terminal B at front contact a of relay LBP, wire 160, back contact d of relay L1, back contact b of relay CR, front contact c of relay I, through the upper winding of relay CD to terminal C. When relay CD picks up, it completes a stick circuit from terminal B at wire 160 over its contact a and lower winding to terminal C.

Relay CD does not pick up on the first step of an indication code transmitted by the associated station transmitter, unless it happens that a control code is initiated by the office transmitter OT at the same time. When this occurs, relay CD serves as a lock out relay to prevent further transmission of the indication code until the control code is completed, as hereinafter explained.

The second to eighth steps of each code may be arranged in any one of thirty-five different combinations of three long and four short steps to form station code calls, which are identified by three-digit numbers in which the digits represent the long steps of the code call. Thus the code call, assigned to the station storage unit shown, is the one identified by the number 234, in which the second, third and fourth steps of the code are long, and the fifth to eighth steps are short. The code call is generated by completing holding circuits for relay T over three of the wires 132-138, which circuits extend to terminal B at contact c of the station starting relay ST. To verify the correct transmission of the code call, this is registered at the transmitting station by the energization of a set of three selector relays FA, GA and S, which may be adjustably connected to contacts d of the counting relays so as to respond to any one of the thirty-five code calls, the connections being arranged so that relay S is responsive to the code call delivered by the associated transmitter. The circuits for the selector relays which respond on even-numbered steps extend from terminal B at front contact a of relay LBP, over wire 160, back contact d of relay L2, back contact d of relay CR, back contact e of relay LP and thence over front contacts d of relays 2, 4, 6 and 8 to wires 122, 124, 126 and 128. As shown,

a connection to wire 122 provides a circuit for energizing relay FA on the second step, relay FA having a stick circuit extending to wire 160 over its own front contact a and a back contact m of relay GA. The circuits for the selector relays which respond on odd-numbered steps extend from terminal B at wire 160 over back contact d of relay L1, back contact b of relay CR, back contact d of relay LP, and thence over front contacts d of relays 3, 5 and 7 to wires 123, 125 and 127. As shown, a connection to wire 123 provides a circuit over contact b of relay FA for energizing relay GA, the stick circuit for which extends to terminal B at wire 160 over its own front contact a and back contact a of relay S. Similarly, a connection to wire 124 provides a circuit over contact b of relay GA for energizing relay S, the stick circuit for which is connected directly to terminal B at wire 160 over its own front contact a.

It is to be noted that the selector relays FA, GA and S are operated in response to the release of relay LP, following the release of relay L1 or L2. These relays control relay T by opening the connections to the wires 132-138 and thereby serve to terminate the long steps of the station code call.

It is to be understood that the relays FA at the different stations may be connected to any of the wires 122 to 128, and the relays GA to any of the wires 123 to 127 at the right of the one to which relay FA is connected, while relay S may be connected to any of the wires 124 to 128 at the right of the one to which relay GA is connected.

The energization of relay S prepares a pick-up circuit for relay CR completed on the eighth step. This circuit extends from terminal B at contact d of relay S, wire 146, contact f of relay 8, relay CR to terminal C, and when relay CR picks up, its front contact a completes its stick circuit extending to terminal B over wire 160. Front contact g of relay CR completes a connection from wire 119 over back contact a of relay 7 to contact b of relay 8 for effecting the operation of relay I on the ninth step, and front contact h of relay CR completes a connection over back contact g of relay 8 for energizing relay 16 in place of relay 8, on the sixteenth step. The ninth to fifteenth steps of the code may be made long or short to indicate the condition of seven movable devices at the station. To simplify the drawing only three such devices are shown, these comprising the repeating relay TKS controlled by the indicating relay TR, and the indicating relays NWP and RWP. The station apparatus is arranged to initiate an indication code automatically in response to a change in position of any of these indicating relays, each such code being stored for transmission when the line circuit becomes available, by the release of the station starting relay ST. Relay ST is normally held energized over a stick circuit extending from terminal B at its own front contact a, over back contact e of relay S, the winding of relay ST and thence over a front or back contact c of each of the several indicating relays, in series, to terminal C. Heretofore a normally energized starting circuit of this type has been objected to because of the necessity for a special adjustment of the contacts of the indicating relays in order to insure the release of the starting relay during the brief period the circuit is opened during the transit of the contact from one position to another. This difficulty has been overcome in the circuits as shown by the use of a sensitive relay of the biased polar type having an inductance 70 connected across its terminals. The en-

ergy stored in coil 70 when relay ST is energized provides a source of induced current for operating relay ST to its reverse position to open its stick circuit in response to any sudden increase in circuit resistance due to the movement of one of the indicating relay contacts c, even though the time such contact is actually open is substantially zero, consequently no special adjustment of these contacts is needed.

I shall now describe the transmission of an indication code by the station coding unit, assuming the code to be initiated as the result of the release of the indicating relay TR. The opening of contact a of relay TR opens the normally closed stick circuit for relay TKS extending to terminal B at its front contact b, and also opens its pick-up circuit extending from terminal B at back contact h of relay MSP, left-hand contact d of relay ST and front contact a of relay TR through relay TKS to terminal C, and relay TKS releases, its contact c in turn opening the stick circuit for relay ST causing it to release.

If the line circuit is available, the starting circuit is closed, extending from terminal B over back contacts b of relays ST and SS, wire 147, contact a of a cut-out relay COR, back contacts b of relays L2 and L1 through relay M to terminal C. Relay M picks up, completing a temporary stick circuit over its contact a extending to terminal B at wire 147 over back contact c of relay LBP. Contacts b and d of relay M reverse the connections of relay R to line wires Y and Z, front contact d of relay M also closing a low impedance shunt path from line Y over back contacts f of relays CD and LPB to line Z.

When the line circuit is shunted by relay M, the associated line relay R releases and the increase in current delivered by battery 80 causes transformer RT at the office to deliver an impulse operating relay OR to reverse substantially in unison with relay R.

Relay R operates the associated timing relays and relay I, the closing of contact c of relay LB completing the normal stick circuit for relay M extending over wire 118 and back contacts e of relays 16 and CD to terminal B.

Relay OR operates timing relays similar to those shown, including a relay OLBP, and in addition, a circuit is completed from terminal B at the right-hand contact a of relay OR over back contact h of relay OLBP and back contact d of a relay O16 through relay PC to terminal C. Relay PC therefore picks up and its contacts b and d reverse the polarity of the current delivered to the line. The variations in the line current due to the operation of relay PC, are devoid of effect upon relay OR, due to the operation of local holding circuits for that relay as described in my prior application, Serial No. 496,907. When relay PC picks up, it is held energized over a stick circuit including its front contact a and front contact h of relay OLBP until relay O16 picks up, relay O16 being operated in unison with the station relay 16 upon the return of relay OR to normal at the end of the code.

The shunt across line wires Y and Z applied by relay M at the transmitting station as described will also short circuit and consequently release the line relays R at stations more remote from the office. If the transmitting station is at a considerable distance from the office it may be that the voltage across the line, which varies from nearly the full voltage of battery 80 at the office to substantially zero at the point where

the shunt is applied, will remain sufficient to keep the relays R picked up at stations near the office. These relays, however, will be released by the reversal of line polarity by relay PC. It follows that all line relays R release substantially in unison when any relay M picks up to initiate a code, each relay R operating its timing relays L and first counting relay I.

At each station at which relay M is not operated, relay R remains released, holding relay L2 energized but allowing L1 to release to pick up relay CD, and then relays LP, LB, LBP, I and CD release in that order.

At the transmitting station, the closing of front contact e of relay M completes the pulsing circuit for relay T, which extends from terminal B at back contact e of relay CD, over back contact e of relay 16 and back contacts g of relays 1, 5, 3 and I, contact e of relay M through relay T and resistors W6 and W1 to terminal C. Relay T transmits the code by the operation of its contact b which is rendered effective when relay LBP picks up on the first step to open its back contact f in parallel therewith. Each time relay T picks up, a low resistance shunt path is closed from line Y over back contact f of relay CD, front contact b of relay T and front contact d of relay M to line Z, and at the same time, the circuit for relay R which now extends from the positive wire Z over front contact d of relay M, back contact b of relay T, resistor W1, relay R, front contact b of relay M to wire Y, is opened by relay T, thereby releasing relay R more quickly than if it was merely short circuited by the closing of front contact b of relay T.

Although the first step of an indication code is short in comparison with the first step of a control code, it is slightly longer than the other short steps, since it begins before relay T picks up, and because relay T is held energized until relay LB picks up, which occurs shortly after relay I picks up to open the pulsing circuit due to the provision of a connection from terminal B at back contact e of relay LBP over back contact d of relay LB to contact e of relay M, and thence through relay T to terminal C.

The response of the apparatus at the transmitting station as required to allow the transmission to continue is also dependent upon conditions at the office. Since the connections of relay R to the line have been reversed by relay M, relay R picks up in response to the release of relay T to begin the second step only if relay PC has been picked up to reverse the polarity of the line current, this indicating that the office apparatus is in the proper receiving condition.

When relay R picks up to begin the second step, the operation of its contact b re-energizes relay L1 and de-energizes relay L2, and the operation of contact a of relay R causes relay 2 to pick up and relay I to release.

The closing of back contact g of relay I completes the pulsing circuit for relay T over contact e of relay M, this circuit functioning repeatedly to generate the short steps of the code. The pick-up time of relay T depends upon the time constant of the circuit including its winding and resistors W6 and W1. When relay T picks up, its front contact c short circuits resistor W6 so that the energization of relay T rises quickly to a higher value than would otherwise be the case, and consequently providing a more constant release period under conditions of variable voltage. Its release period, it will be noted, is determined by the time constant of the

circuit including its winding and resistor W7 only, and it follows that its pick-up and release periods may be adjusted independently.

The circuits for relay T which include contacts *e* and *f* of relay CR provide connections for holding relay T picked up or released to generate the long steps of the code. Certain of these connections include front contact *a* of relay T, and are controlled by the selector relays on steps 2—8, and by relays L1 and LP on steps 9—15, so as to hold relay T picked up after its pulsing circuit opens, to generate the long odd-numbered steps. The remaining connections include contact *f* of relay M and back contact *c* of relay T, and provide connections from terminal B controlled by the selector relays on steps 2—8 and by relays L1 and LP on steps 9—15, to the left-hand terminal of relay T which are effective to short circuit its winding and thereby serve as "hold-down" circuits to hold relay T released after its pulsing circuit closes, to generate the long even-numbered steps of the code.

In the code being described, it is assumed that the code call is 234, and the second step is prolonged by the closing of a hold-down circuit for relay T extending from terminal B over back contacts *c* of relays ST, SS and S, back contact *g* of relay GA, back contact *e* of relay FA to wire 132, thence over contact *c* of relay 2 and back contact *f* of relay CR, contact *f* of relay M, and back contact *c* of relay T to its left-hand terminal, thereby short circuiting relay T. On the second step, relay FA picks up in response to the closing of back contact *e* of relay LP over the circuit already traced which includes back contact *d* of relay L2 and wire 122, and the operation of contact *e* of relay FA transfers the connection of terminal B from wire 132 to wire 133, opening the hold-down circuit for relay T to allow it to pick up to begin the third step. The third step is prolonged by the operation of the stick circuit for relay T extending from terminal B over front contact *e* of relay FA to wire 133, thence over contact *c* of relay 3, back contact *e* of relay CR, contact *a* of relay T, the winding and front contact *c* of relay T and resistor W7 to terminal C. On the third step, relay GA picks up in response to the closing of back contact *d* of relay LP over the circuit which includes back contact *d* of relay L1, wire 123, and contact *b* of relay FA, and the operation of contact *g* of relay GA transfers the connection of terminal B from wire 133 to wire 134, opening the stick circuit for relay T to allow it to release to begin the fourth step, which like the second, is prolonged by the operation of a hold-down circuit for relay T, the circuit for generating the long fourth step including front contact *g* of relay GA, wire 134 and contact *c* of relay 4. Relay GA, by opening its contact *m*, releases relay FA, and on the fourth step, the station selector relay S picks up in response to the closing of back contact *d* of relay LP over the circuit which includes back contact *d* of relay L2, wire 124 and contact *b* of relay GA, and the opening of back contact *c* of relay S allowing relay T to release to begin the fifth step, while the opening of back contact *a* of relay S releases relay GA.

When relay S picks up it completes the circuit for the repeating relay MSP, extending from terminal B at front contact *g* of relay M, over wire 169, contact *b* of relay S through relay MSP to terminal C. Relay MSP therefore picks up on the step corresponding to the last digit of the code call, remaining energized until the end of

the code. The code call being 234 in the case being described, relay S is operated on the fourth step, and the fifth to eighth steps are short steps generated by the operation of relay T over its pulsing circuit. Relay CR picks up on the eighth step over the circuit extending from terminal B at contact *d* of relay S, wire 146, contact *f* of relay 8 through relay CR, to terminal C, relay CR completing its stick circuit extending to terminal B at wire 160 by closing its front contact *a*.

When relay CR picks up, it completes a pick-up circuit for the normally energized starting relay ST extending from terminal B at contact *c* of relay CR over front contact *e* of relay 8, front contact *h* of relay M, wire 114, front contact *f* of relay S through relay ST and coil 70, in parallel, and thence over the front or back contacts *c* of the indicating relays TKS, NWP and RWP to terminal C. Relay ST picks up and establishes a temporary stick circuit extending from terminal B at its front contact *a* over front contact *e* of relay S, wire 113, front contact *d* of relay LB, to wire 114, and thence as traced above through relay ST and coil 70 to terminal C.

On the eighth step, relay CR establishes connections from terminal B at the contacts *b* of the indicating relays NWP, TKS and RWP, over contacts *a*, *b* and *c*, respectively, of relay MSP, which are completed successively over contacts *f* of relays 1, 2 and 3 on steps nine, ten and eleven of the code, either over contact *e* of relay L1 and contact *b* of relay LP, in parallel, front contact *e* of relay CR and front contact *a* of relay T to the right-hand terminal of relay T, or over contact *e* of relay L2 and contact *c* of relay LP, in parallel, front contact *f* of relay CR and back contact *c* of relay T to the left-hand terminal of relay T, to hold relay T up or down, as the case may be, until relay LP releases. Steps twelve to fifteen may also be controlled in a similar manner, each storage unit being capable of indicating the positions of seven movable devices in the same code.

When the sixteenth step is reached, relay R at the transmitting station picks up, energizing relay 16 which opens its back contact *e* to disconnect terminal B from the pulsing circuit for relay T and from the stick circuit for relay M. Relay T remains released and relay M releases, reversing the connections for relay R to render it responsive only to line current of normal polarity. At the office, relay OR is operated to normal, energizing relay O16, which relay by opening its back contact *d* releases relay PC, thereby restoring the line polarity to normal so that relay R will remain steadily energized after relay M releases. Relay OR remains in its normal position and is not affected by the operation of relay PC, due to the provision of local holding circuits hereinbefore referred to.

The restoration of the line polarity to normal by relay PC causes the line relay R at each of the other stations to pick up. At these stations, relays L1, LP, LB and LBP pick up and then relays L2, LP, LB, LBP and L1 release in order.

At the transmitting station, even though relay M releases at the exact instant that the line polarity is restored to normal, relay R may be momentarily deenergized, but since relay 16 is picked up, its contacts *d* and *e* connect the right-hand and left-hand contacts *a* and *b* of relay R together so that the circuits controlled by relay R remain in the same condition as if relay R remained steadily energized. Consequently the timing relays L at the transmitting station re-

lease in order, slightly in advance of those at the other stations. Relay MSP is released by relay M, relay 16 is released by relay LB and relays CR and S are released by relay LBP. When relay M releases, its back contact *h* connects wire 113 over back contact *h* of relay 1 to wire 114 to maintain the temporary stick circuit for relay ST closed after relay LB releases. When relay S releases, the dropping of its continuity transfer contact *e* reestablishes the normal stick circuit over which relay ST is held energized until a change occurs in the position of one of the indicating relays to initiate a new code.

A change in position of one of the indicating relays may occur during the transmission of the indication code just described. If this occurs prior to the transmission of any of the indicating steps nine to fifteen, relay ST will be reenergized on the eighth step and but one code will be transmitted. Since the pick-up circuit for relay ST is opened at the beginning of the ninth step, the temporary stick circuit by which relay ST is held energized will be opened to cause it to release again if a change in the position of any of the indicating relays occurs subsequent to the transmission of the eighth step. Thus a new indication code will be transmitted to indicate the new condition.

It may also occur, due to a fault, that the transmission is interrupted before the sixteenth step is reached to restore the normal stick circuit for relay ST. If an extended pause in the operation of relay R occurs after relay ST has been picked up, relay L1 or L2 will release, releasing relay LB. In this instance relay LB will open its contact *d* before relay M releases, to release relay ST and thereby condition the apparatus to retransmit the code in its entirety when the line becomes available.

Heretofore in connection with starting relays of the normally energized type, as illustrated for example by the relay S of the Letters Patent of the United States No. 2,273,231, issued February 17, 1942, to C. S. Snively et al., it has been necessary to provide a repeating relay such as the relay SP of this patent, which relay is restored to normal at the end of a complete code, in order to make sure that a code interrupted on any of the steps following the one on which the starting relay is picked up, will be retransmitted. This result is attained in accordance with my invention by the provision of a temporary holding circuit as above described, in addition to the normal holding circuit for the station starting relay ST.

A feature of my invention is the provision of indication storing means as illustrated by the repeating relay TKS for the indicating relay TR, which insures that an indication of the release of relay TR will be transmitted to the office, even though the line circuit does not become available for the transmission of the indication until after relay TR has been picked up again. Relay TKS is normally held energized over a stick circuit extending from terminal B at its front contact *b* over front contact *a* of relay TR through relay TKS to terminal C. The release of relay TR therefore releases relay TKS to open its stick circuit and to connect terminal B over back contact *b* of relay TKS to contact *b* of relay MSP, to condition the unit to transmit an indication code including a long tenth step, indicating that relay TR is released. Relay ST is released by the dropping of contact *c* of relay TKS, and opens its contact *d* in the pick-up circuit for relay TKS extending to terminal B at back contact *h* of relay

MSP, so that relay TKS remains released until a code including a long tenth step is transmitted. During the transmission of this code, back contact *h* of relay MSP opens prior to the closing of contact *d* of relay ST, which occurs on the eighth step, and when back contact *h* of relay MSP closes again on the sixteenth step, relay TKS becomes reenergized, provided ST is picked up, indicating that the code including the long tenth step has been transmitted and provided also that relay TR is picked up. When relay TKS picks up, the opening of its back contact *c* releases ST again, to initiate a code including a short tenth step for indicating the corresponding condition, but since relay ST is extremely fast, the energizing circuit for relay TKS is opened by relay ST before relay TKS is fully picked up to establish its stick circuit. A condenser C1 of relatively large capacity becomes charged over the pick-up circuit for relay TKS and provides sufficient energy storage to prolong the energization of relay TKS until its front contact *b* closes to establish its stick circuit, under the condition described.

I shall next describe how the system is restored to normal in the case of a fault.

If an indication code is terminated on an odd-numbered step, as for example, would be the case if relay T remained picked up due to a fault, the office line relay OR remains reversed until relay OLBP releases, and is then restored to normal by the operation of a local circuit as described in my application, Serial No. 496,907.

At the transmitting station, relay R remains released, and the timing relays L1, LP, LB and LBP release. Relay LB releases relay M, which relay releases relay T and removes the line shunt applied by relay T, and also reverses the connections for relay R so that relay R remains released, the apparatus assuming the same condition as at the other stations where relay R and the timing relays stand released with relay L2 picked up.

When relay OR is restored to normal, the office timing relays are reenergized, and relay PC is deenergized and releases before relay OLBP picks up. The office timing relays then release in the normal order, as at the end of a complete code.

When relay PC releases, it restores the line polarity to normal so all the line relays R pick up in unison, reenergizing their timing relays, and the timing relays at each station then release in the normal order, substantially in unison with those at the office, so that all the coding units are restored to their normal at rest condition at substantially the same time.

If an indication code is terminated on an even-numbered step prior to the sixteenth step, due to the failure of relay T to pick up, relay OR remains normal until the office timing relays release, the release of relay OLBP in this instance completing a circuit for operating relay OR to reverse, as described in application, Serial No. 496,907.

At the transmitting station, relay R remains picked up and the timing relays L2, LP and LB release. Relay LB releases relay M and reverses the connections for relay R so that relay R releases, reenergizing the timing relays which then release in the order L1, LP, LB and LBP, the apparatus assuming the same condition as at the other stations where relay R and the timing relays stand released, with relay R2 picked up.

At the office, relay OR is reversed upon the release of relay OLBP, as above mentioned, to

place this relay in a condition corresponding to that of the station line relays R, and since the pick-up circuit for relay PC is closed when its stick circuit opens, relay PC remains picked up. The office timing relays are reenergized and then release again, due to the fact that relay OR remains in its reversed position, and relay OR is restored to normal upon the release of relay OLBP as in the preceding example. When relay OR is restored to normal, the office timing relays are reenergized and relay PC deenergized, relay PC releasing before relay OLBP picks up. The office timing relays then release in the normal order, and relay PC restores the line polarity to normal to pick up the station line relays, the station timing relays being reenergized and releasing in the normal order, as in the preceding examples.

It will be seen that in each case, regardless of their initial positions, the line relays OR and R are all restored to normal at substantially the same time so that each releases its timing relays in the normal order to restore all of the coding units to their normal at rest condition before any of the relays L1 release to permit the initiation of the next code.

If due to a fault, an indication code is interrupted before the starting relay is reenergized, the apparatus remains in condition to initiate a new code upon the release of relay L1 after the unit has assumed its normal at rest condition, while if an indication code is interrupted after the station starting relay ST is reenergized, relay ST will be released again due to the release of relay LB before relay M releases. It will be clear, therefore, that each interrupted indication code will be reinitiated for transmission in its entirety after the line becomes again available.

It may also happen that relay OR is operated by one or more impulses of foreign current, or as the result of a temporary line cross or open when the system is in its normal at rest condition. In this case the first reversal of relay OR picks up relay PC, reversing the line polarity and releasing the line relays R to prevent the initiation of a code by any station. When the interference terminates, the system restores itself to normal in the same manner as in the case of an interrupted indication code, as described above.

I shall next describe the means for preventing interference and for transmitting codes one at a time in the desired order, when two or more transmitters have codes stored for transmission. The inclusion of the back contacts b of relays L1 and L2 in the pick-up circuit for each relay M, and the provision of a similar circuit for the transmitter relay OT at the office, prevents the initiation of a code except when the line is free, but it may readily happen that the office and one or more stations initiate codes at substantially the same time. It has already been pointed out that each control code transmitted from the office begins with a long step which serves to hold the station line relays released for a time sufficient to pick up the delivery control relay CD at each station. At any station at which relay M has been picked up to initiate an indication code, when relay CD picks up, the opening of its back contact e disconnects terminal B from wire 118, thereby releasing the energized relay M. Consequently all station coding units are conditioned to receive the control code on the first step, the indication codes being stored for transmission subsequently.

In the event the coding units at two or more

locations initiate indication codes at the same time and by their joint action place the office coding unit in the receiving condition, the shunts applied to the line by that relay T which is nearer the office will govern the operation of the line relays R at more remote locations as well as that at the same location, and the relays T will operate in unison as long as corresponding steps of the respective code calls are of like character. When one relay T holds a shunt applied to the line to generate a long odd-numbered step, it will overrule any relay T which releases at a more remote location for which the code call requires a short step, and when relay T at the nearer station picks up to apply a shunt to the line, terminating a short even-numbered step, it will overrule any relay T which is held down at a more remote station as required for a long step. In either case, the relays R and T at the more remote locations will occupy their released positions simultaneously on one of the steps of the station code call for a time sufficient to energize a lockout circuit extending from terminal B at the right-hand contact a of relay R, back contact e of relay 16, front contact b of relay LBP, back contact d of relay T, front contact j of relay M, back contact j of relay CR, back contact c of relay I through the delivery control relay CD to terminal C. Relay CD will therefore pick up and by opening its back contact e will disconnect terminal B from wire 118 releasing the associated relay M. Since the line is now supplied with current of reverse polarity, the release of relay M at the inferior station renders the associated relay R non-responsive to the remainder of the code, causing the timing relays L and the energized counting relay at that station to release, its code being stored for subsequent transmission when the line is again free.

It will be seen therefore in respect to line action, a long odd-numbered step takes precedence over a short one and a short even-numbered step takes precedence over a long one. For this reason it is desirable to assign the code calls to the several locations in a geographical order so that each call is superior to those for more remote locations and inferior to those for stations nearer the office. In respect to line action, the order of superiority of the code calls is as shown by the following table, in which each code call is superior to those below it in the same column and to all those in other columns at the right.

357	368	578	458	235	257	268
358	345	567	456	237	258	245
356	347	568	478	238	256	247
378	348	678	467	236	278	248
367	346	457	468	234	267	246

It will be clear from the foregoing that no interference occurs when a plurality of starting relays ST at the office and stations are released at the same time, or when the line is in use, and that the codes will be transmitted one at a time in order in accordance with the relative superiority of their respective code calls.

The system of my invention also includes provisions for preventing those stations having superior code calls from monopolizing the use of the line under conditions of heavy traffic, or in the event the station starting relay ST fails to pick up at the end of a code, comprising the provision of a station sequence relay SS in each station storage unit. Relay SS serves to prevent the initiation of a second indication code by

any station storage unit which has transmitted a code as long as any other station storage unit has a code stored for transmission. This feature is an improvement upon the arrangements for the same purpose shown in Letters Patent of the United States to Snively et al., Nos. 2,273,231 and 2,273,383, dated February 17, 1943, for Remote control systems.

Referring to the drawing, it will be seen that relay SS is picked up on the step representing the third digit of the station code call, over front contact *h* of relay MSP, and relay SS is then held energized over a stick circuit including its own front contact *a* extending to terminal B at front contact *f* of relay L1 or L2, which circuit is opened by relay L1 when the system assumes its normal at rest condition at the end of a code. Relay SS is slow to release and its back contacts *b* and *c* hold the starting circuit open and also those which govern the transmission of the station code call for an additional interval following the restoration of the apparatus to its normal at rest condition, during which another station may initiate a code, and thereby hold relay SS picked up. It follows that when relay SS has been picked up, the station coding unit is rendered incapable of initiating a second code until after the line has been free for a time which is longer than the normal interval between successive codes. Each storage unit having a code stored, at which relay SS has not been actuated, is given access to the line upon the release of relay L1 at the end of a code. Consequently each such storage unit will transmit one code during which its relay SS becomes energized. At the end of this series of codes, a longer period will elapse to allow the relays SS to release, whereupon the station units will be again conditioned to transmit codes one at a time in sequence.

It will also be evident that each relay SS serves also to prevent continued initiation of incomplete codes by a station storage unit due to a fault, if other units have codes stored for transmission, provided the fault is not of such nature as to prevent relay SS from becoming energized, as would be the case, for example, if the code transmitted by a station coding unit having a superior code call does not progress far enough to pick up the station relay S at that station.

To protect against this and other conditions, a thermal relay COR is provided, which relay is energized whenever an indication code is initiated by the storage unit, from the time the starting relay ST releases to store the code for transmission until such code is fully transmitted. Relay SS is picked up by relay MSP on the station selecting step of the code, and until relay SS picks up, relay COR is energized over the circuit extending from terminal B over back contacts *b* of relays ST and SS, wire 147, the back contact *a* and the heating element of relay COR to terminal C. When relay MSP picks up it remains energized until the end of the code and provides a connection from terminal B to wire 147 at its front contact *j* for energizing relay COR.

The time of energization of relay COR may exceed the time required to transmit a code from the associated storage unit, even if no fault exists, by the time required to transmit one code from each storage unit having a more superior code call, which interval, in practice, but rarely exceeds one minute. On the other hand, in the event of a fault which prevents the reenergization of relay ST, relay COR is energized substantially continuously. Relay COR is made selec-

tively responsive to a fault by adjusting it to open its contact *a* after it has been energized for a time interval of about two minutes, the opening of its contact *a* deenergizing its heating element and also the pick-up circuit for relay M. Contact *a* of relay COR is of the snap action type and remains open for about two minutes, and after reclosing, if terminal B remains connected to wire 147, will operate cyclically with closed periods of one minute and open periods of two minutes, approximately. It follows that relay COR operates in such a manner as to prevent the defective transmitter from obtaining access to the line for periods of about two minutes during each three minute interval, as long as the fault persists.

In the foregoing description of the operation of the system it has been assumed that only one storage unit is associated with each coding unit. It is the usual practice to include one storage unit in the case containing the station coding unit since at least one is always required, and to provide terminals for connecting to the coding unit one or more auxiliary storage units each comprising a suitable housing containing a group of relays S, MSP, ST and SS, when the number of devices to be controlled or indicated exceeds the capacity of one storage unit. For example, when relay S is connected to wire 124 over contact *b* of relay GA, so as to respond selectively to the code call 234, the relays S of four auxiliary storage units may be connected over other contacts, similar to contact *b* of relay GA to wires 125 to 128 to respond to the code calls 235 to 238, respectively. In this case, a back contact of each of the relays S is included in the stick circuit for relay GA so that relay GA will be released in response to the last digit of any of the code calls 234 to 238 as required.

Each storage unit also requires a connection from contact *c* of its relay S to a different contact such as the contact *h* of relay GA, which contact in its released position establishes a connection to contact *e* of relay FA and in its energized position to one of the wires 135—138, to determine the third digit of the corresponding code call. The remaining connections to each auxiliary storage unit are arranged like those of the one shown; that is to say, the remaining wires leading to the station coding unit are "bus wires" connected to correspondingly numbered terminals of each of the storage units in turn.

When a group of storage units are connected directly to the station coding unit as above described, relay FA may be controlled on any of the steps two to five, and relay GA on any of the steps three to six which follow the one to which relay FA is assigned, as indicated on the drawing. It will be readily apparent that the number of storage units which may be controlled directly by the coding unit in this manner is limited to a group of from one to five using code calls which differ only in respect to the third digit. Other arrangements whereby larger numbers of storage units may be controlled as described in my prior application, Serial No. 496,907.

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

Having thus described my invention, what I claim is:

1. In a remote control system, a group of movable devices, a line circuit, a coding unit for delivering to said line circuit a code comprising two groups of code elements the first constituting a station code call and the second identifying the positions of each of said devices, a normally energized starting relay, a normal stick circuit for said relay including contacts of the movable devices which open momentarily to release the relay in response to a change in position of any of said movable devices, means effective when said starting relay is released for initiating the delivery of a code by said coding unit, means for reenergizing said starting relay upon the delivery of said first group of code elements, a temporary stick circuit closed when said starting relay picks up including said contacts of the movable devices and also including a contact which opens if the delivery of the second group of code elements is interrupted, and means for transferring the energization of such relay from its temporary stick circuit to its normal stick circuit when the delivery of said second group of code elements is completed.

2. In a remote control system, a coding unit including a transmitter for delivering a multiple step code to a line circuit, a normally energized starting relay, a normal stick circuit for said relay including a series of contacts each of which is adapted to open momentarily at times to release the relay, means for initiating the transmission of a code by said coding unit in response to the release of said starting relay, a pick-up circuit for said relay closed momentarily upon the delivery of an intermediate step of said code to the line circuit by the coding unit, a temporary stick circuit for maintaining said relay picked up including said series of contacts and an additional contact which remains closed only when the coding unit is delivering a code to the line circuit, and means for transferring the energization of such relay from its temporary stick circuit to its normal stick circuit on the last step of said code.

3. In a remote control system, a coding unit including a transmitter for delivering a multiple step code to a line circuit, a starting relay of the biased polar type, a normally closed stick circuit for said relay including its own front contact and also including a movable contact adapted to open the circuit momentarily at times, means comprising an inductance coil connected in parallel with the winding of the relay to provide a source of current for driving the relay to the released position in response to the momentary opening of its stick circuit by said movable contact, means for initiating the transmission of a code by said coding unit in response to the release of said relay, and means controlled by said coding unit when delivering a code to said line circuit for reenergizing said relay to establish said normally closed stick circuit.

4. In a remote control system, a coding unit including a transmitter for delivering different multiple step codes to a line circuit, each such code including a group of elements comprising a distinctive code call and another group of elements for indicating the positions of movable devices, a plurality of terminals on said coding unit for connecting different storage units thereto to control said coding unit, each storage unit including a selector relay and a starting relay, a normal stick circuit for each starting relay for holding such relay energized irrespective of the condition of the associated coding unit, said nor-

mal stick circuit including a back contact of the associated selector relay and contacts controlled by one or more movable devices which are adapted to open the circuit momentarily at times in response to changes in the positions of said devices, means including circuits closed in response to the release of such starting relay for initiating the transmission of a code by said coding unit, said code including a distinctive code call identifying the particular starting relay which is in its released position, and also including an element identifying the position of the movable device which released said starting relay, means for energizing the associated selector relay in response to such code call, means for closing a pick-up circuit to energize such starting relay momentarily when the associated selector relay becomes energized to thereby establish a temporary stick circuit for such starting relay including its own front contact and said movable device contact and also including a timing relay contact in said coding unit, means for maintaining said timing contact closed only as long as the coding unit remains in operation to complete the transmission of said code, and means for releasing said energized selector relay at the end of said code to reestablish the normal stick circuit for such starting relay before said timing contact opens.

5. In a remote control system, a coding unit including a master relay, a transmitter in said coding unit for delivering a multiple step code to a line circuit when said master relay is energized, a normally energized starting relay for controlling said coding unit, a timing relay in said coding unit, means for maintaining said timing relay picked up only as long as said coding unit is delivering a code to said line circuit, a pick-up circuit for energizing said master relay to initiate a code closed momentarily in response to the release of said starting relay, a stick circuit for holding said master relay energized to continue the transmission of such code including a front contact of the timing relay and a contact which opens to release the master relay prior to the release of said timing relay at the end of a complete code, a pick-up circuit for said starting relay closed momentarily on an intermediate step of the code, and a stick circuit for maintaining said starting relay energized including its own front contact, a normally closed movable contact included in the stick circuit for said starting relay and adapted to open the circuit momentarily at times to release the starting relay, and means in said starting relay stick circuit comprising a front contact of the timing relay and a back contact of the master relay in parallel for releasing the starting relay in the event of an interruption in the transmission of a code occurring after said starting relay has been picked up on said intermediate step.

6. In a communication system of the code type, a normally energized starting relay for initiating the operation of said system, an indicating relay, a repeating relay for controlling said system to indicate the condition of said indicating relay, a pick-up circuit for the repeating relay including front contacts of the starting relay and of the indicating relay, a stick circuit for the repeating relay including its own front contact and a front contact of said indicating relay, a normally closed stick circuit for the starting relay including its own front contact and a back contact of the repeating relay, the opening of said back contact being effective to release the start-

ing relay in response to the energization of the repeating relay prior to the closing of the front contact of said repeating relay, and means comprising a condenser which is charged over the pick-up circuit for the repeating relay and discharges through its winding for maintaining such relay energized from the time its back contact opens until its front contact closes.

7. In a remote control system, code apparatus for delivering a multiple step code to a line circuit, comprising a transmitter relay, a pulsing circuit for intermittently energizing the relay, said circuit including the relay winding and two resistors in series therewith to regulate the pick-up time of the relay, and means including a front contact of the relay for short circuiting one of said resistors when the relay is picked up to regulate the release time of the relay.

8. In a remote control system, code apparatus for delivering a multiple step code to a line circuit, comprising a transmitter relay, a pulsing circuit for intermittently energizing the relay, said circuit including the relay winding and two resistors in series therewith to regulate the pick-up time of the relay, means including a front contact of the relay for short circuiting one of said resistors when the relay is picked up to regulate the release time of the relay, a stick circuit for holding the relay picked up at times after its pulsing circuit opens including its front contacts and winding and the other of said two resistors, and connections including a back contact of the relay for short circuiting its winding at times to prevent the relay from picking up in response to the closing of said pulsing circuit.

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