Oct. 22, 1946. L. V. LEWIS 2,409,697

TRANSMITTING APPARATUS FOR REMOTE CONTROL SYSTEMS

Original Filed March 6, 1943 5 Sheets-Sheet 1

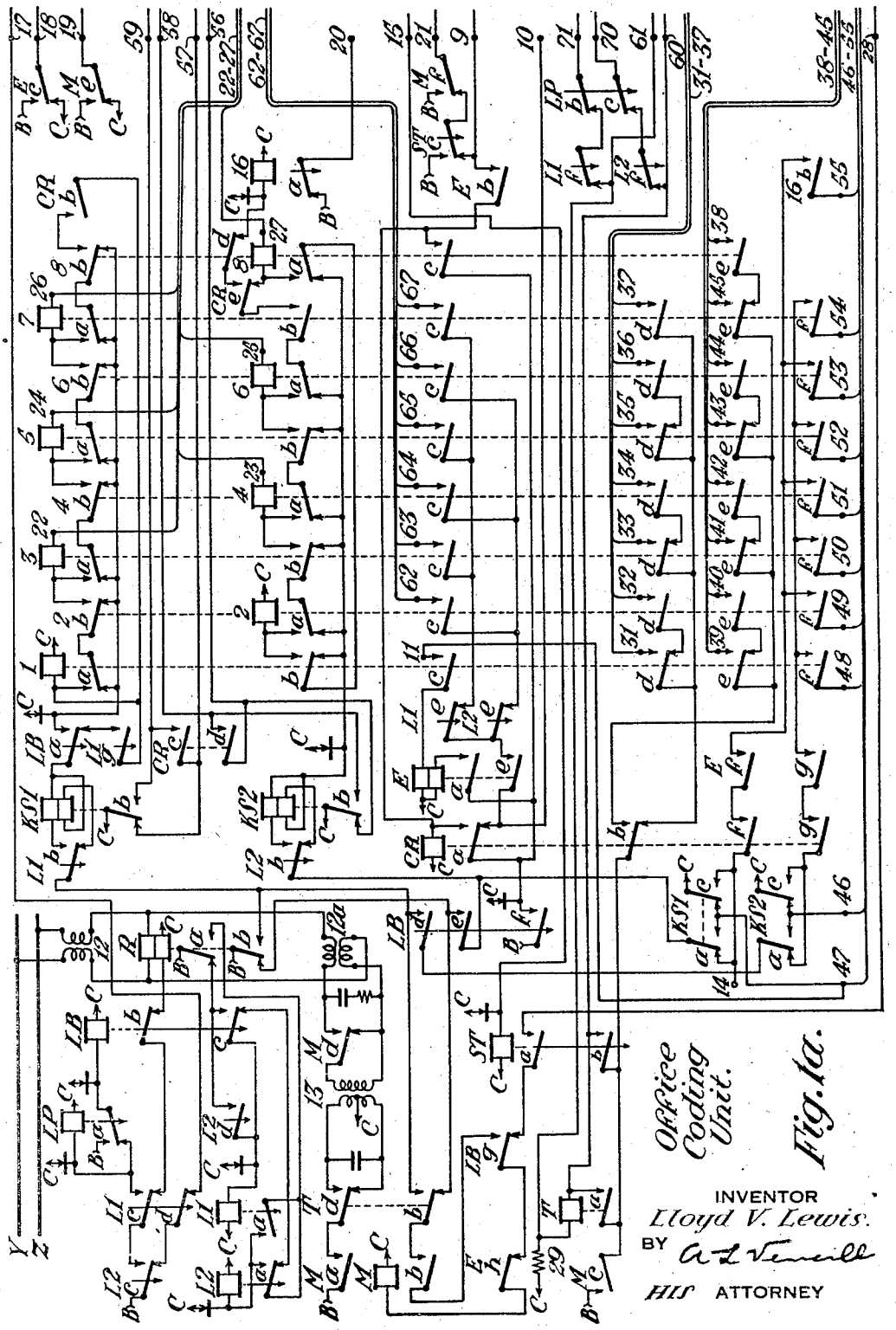


Fig. 1a.

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TRANSMITTING APPARATUS FOR REMOTE CONTROL SYSTEMS

Original Filed March 6, 1943 5 Sheets-Sheet 2

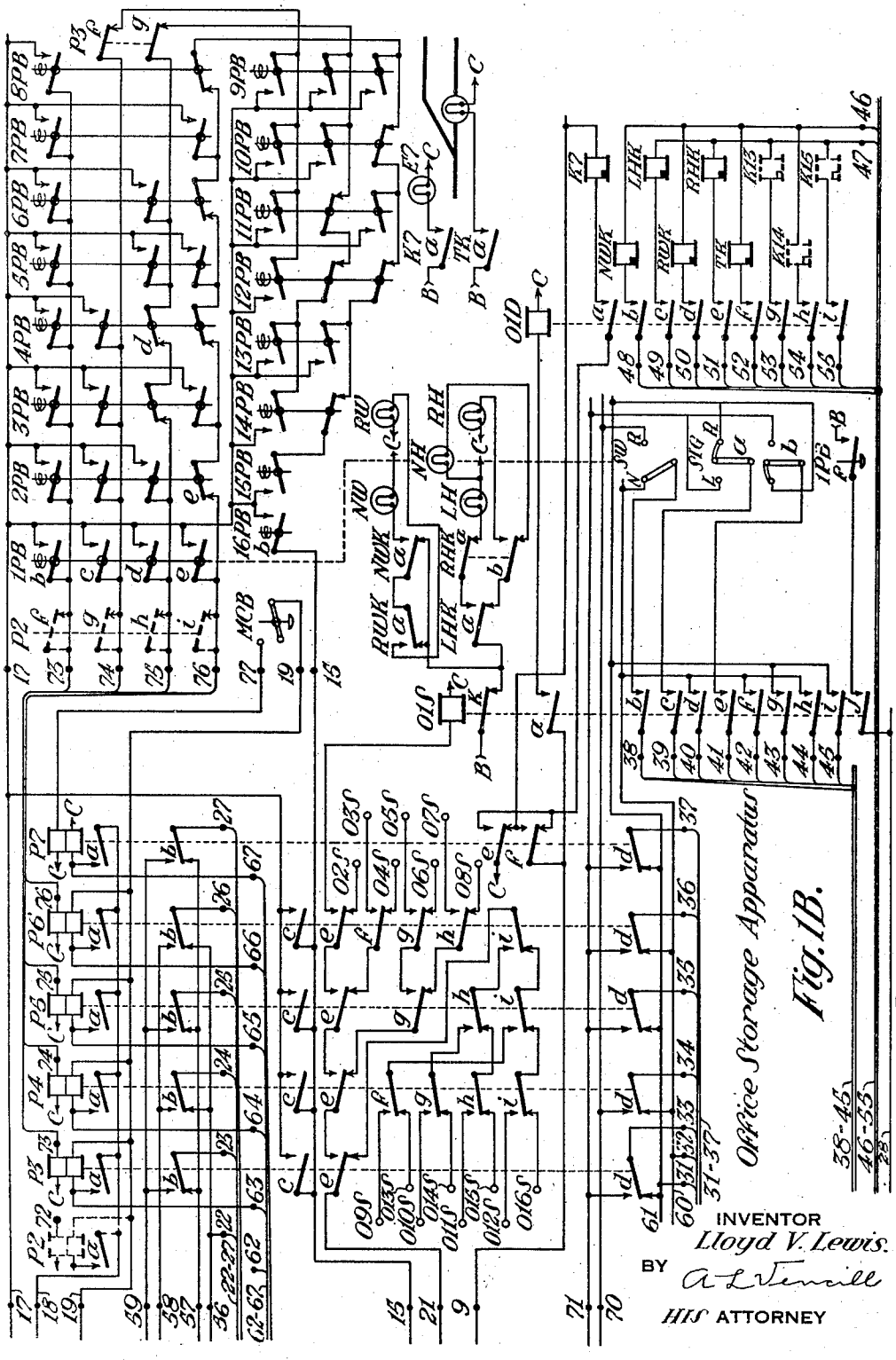


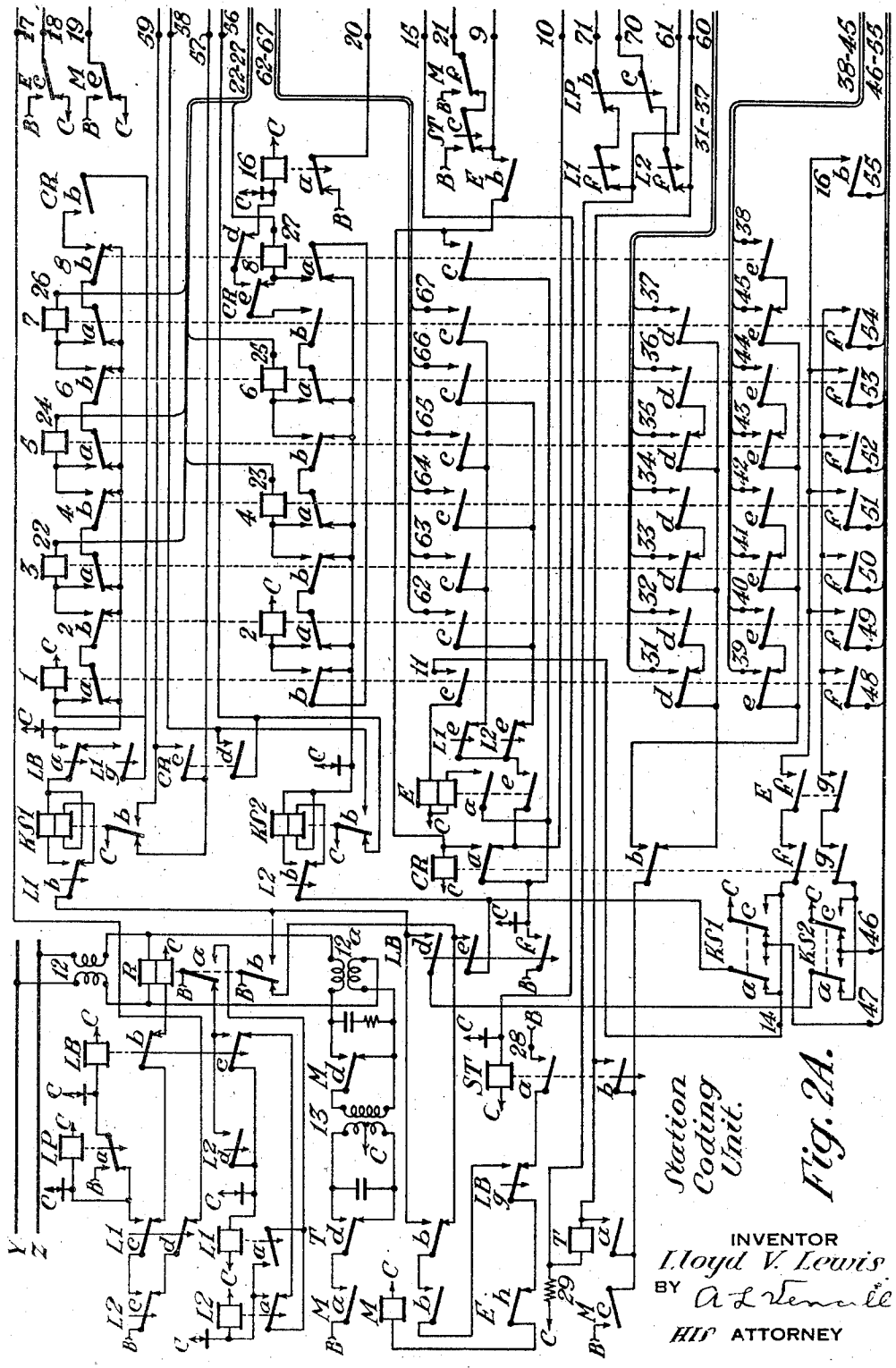
Fig. 1B.

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TRANSMITTING APPARATUS FOR REMOTE CONTROL SYSTEMS

Original Filed March 6, 1943 5 Sheets-Sheet 3



Station Coding Unit.

Fig. 2A.

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TRANSMITTING APPARATUS FOR REMOTE CONTROL SYSTEMS

Original Filed March 6, 1943 5 Sheets-Sheet 4

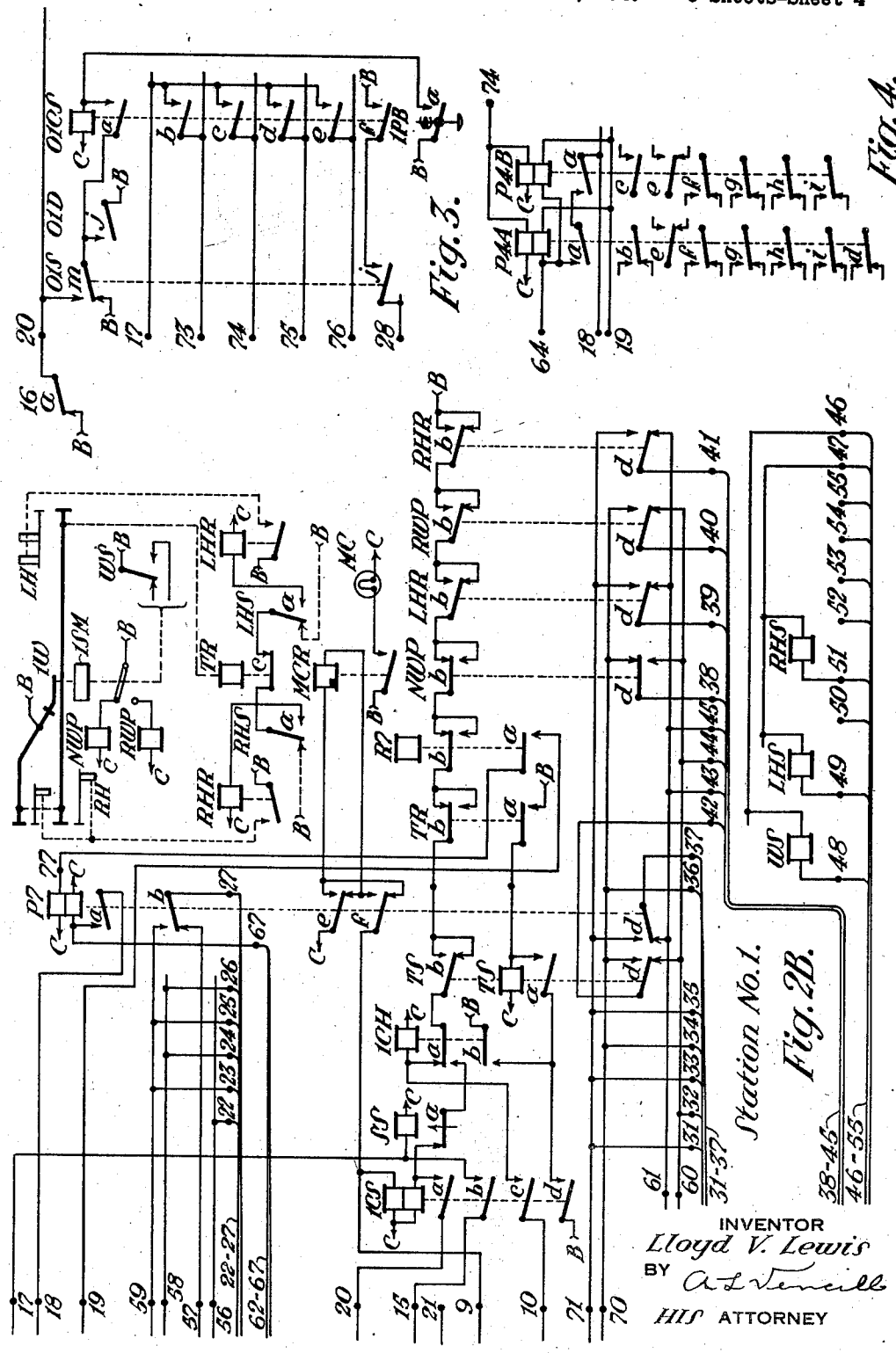


Fig. 3.

Fig. 4.

Fig. 2B.

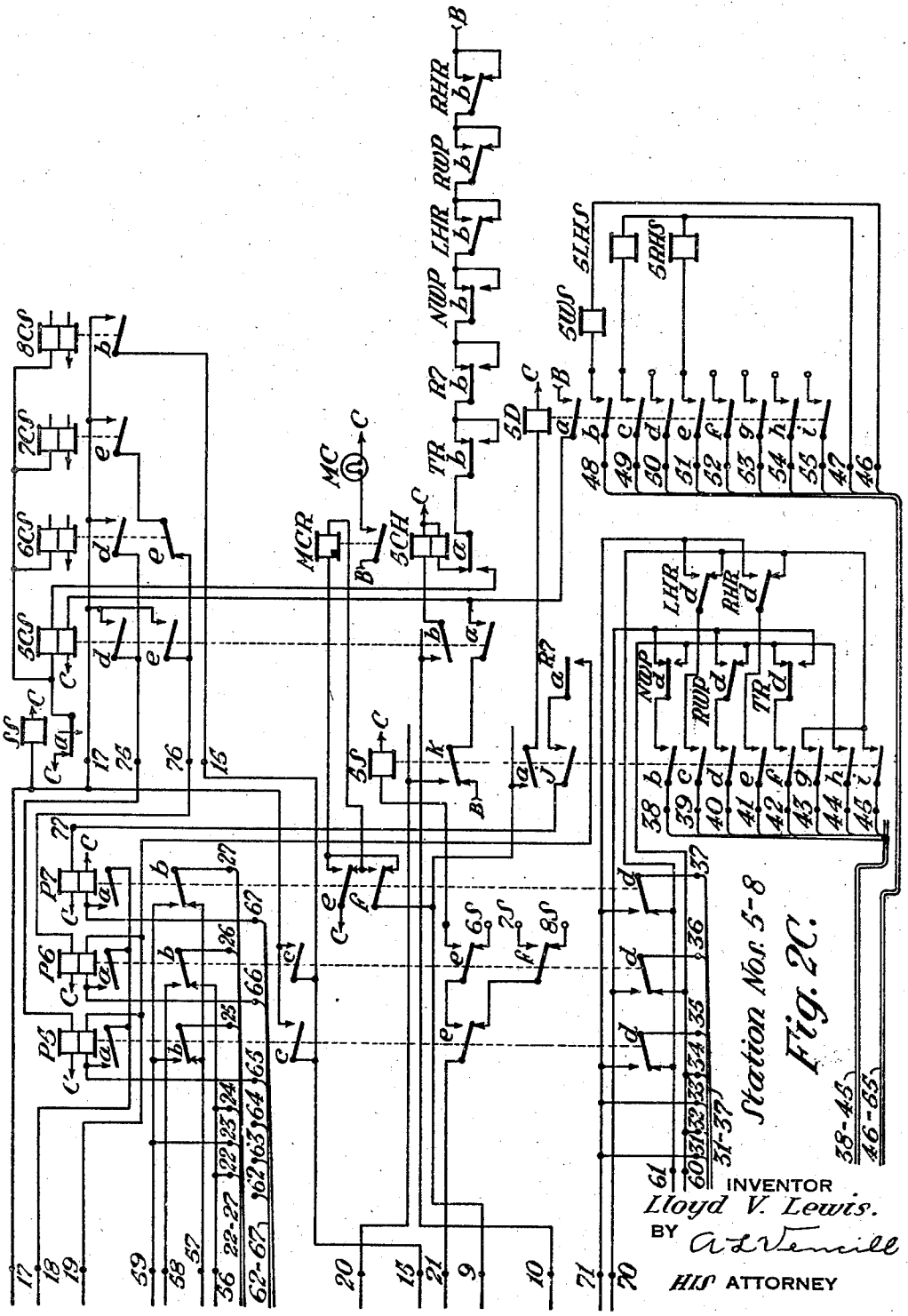
Station No. 1.

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TRANSMITTING APPARATUS FOR REMOTE CONTROL SYSTEMS

Original Filed March 6, 1943 5 Sheets-Sheet 5



Patented Oct. 22, 1946

2,409,697

UNITED STATES PATENT OFFICE

2,409,697

TRANSMITTING APPARATUS FOR REMOTE CONTROL SYSTEMS

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Original application March 6, 1943, Serial No. 478,252. Divided and this application August 12, 1944, Serial No. 549,276

14 Claims. (Cl. 177—353)

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My invention relates to transmitting apparatus for remote control systems, and more particularly to centralized traffic control systems for railroads in which a central office is connected with a plurality of field stations by line wires over which code signals are transmitted at times for controlling selected devices at the stations, and at other times for indicating the condition of station devices at the office.

This application is a division of my copending application, Serial No. 478,252, filed March 6, 1943, for Remote control systems, and is an improvement upon that disclosed in my Letters Patent of the United States No. 2,229,249, granted January 21, 1941, for Remote control systems.

One object of my invention is the provision of a remote control system which is particularly adapted to the use of existing line wires without interfering with their joint use for telephone or telegraph communication or for other purposes. To this end the system of my invention employs code signals of the alternating current type in which each code comprises a series of impulses of current of alternately opposite polarity and the time spacing of successive impulses determines the code character. One advantage of this type of code is that the line signals may be generated inductively and consequently no line battery is needed.

Another advantage is that signals of this type will pass readily through transformers or repeating coils, permitting line circuits to be used which are not available for battery systems. My system, however, does not require the insertion of any apparatus in series with the line, nor is a metallic connection to the line wires essential. Furthermore, the apparatus at the office and at the several stations is connected to the line wires in parallel and the operation of the system is independent of the relative location of the office and the several stations, one advantage of which is that in the event of an interruption due to a break in the line service may be quickly restored by main office switching, for example, by connecting the line in parallel with a spare line at its opposite ends.

A feature of my invention comprises the provision of interference preventing means which serves when two or more codes are initiated at the same time to effect their transmission sequentially in a given order, and also to stop the transmission of a code which is interfered with by impulses of foreign current. The interrupted code may then be reinitiated manually or automatically for retransmission in its entirety.

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Another feature of my invention relates to the more efficient utilization of the code elements. In the system of the prior patent mentioned, only the long steps of the code are registered and for a system capacity of 35 stations seven steps of the code are used. In the system herein disclosed, both the short and long code elements are registered positively and the number of available combinations is greatly increased, six steps for example, being sufficient for the selection of 64 stations. In respect to this feature, my invention is an improvement upon that shown in Letters Patent of the United States to Snavely et al., No. 2,183,155, issued December 12, 1939, for Remote control systems.

Another feature of my invention relates to a reduction in the number of relays required for selecting purposes. The selection of the stations is effected by the operation of a group of pilot relays, and generally requires but one such relay for each selecting step of the code. The operation of the pilot relays is so checked as to permit their utilization in both the picked up and released positions.

Another feature of my invention comprises the provision of a pair of relays of the stick polar type arranged to remain in their last operated position when deenergized, for registering the short or long character of the code elements. These relays are operated alternately by the code elements as received and serve to store their character for delivery to the proper storage relay while the next element in turn is being received.

Another object of my invention resides in provisions for allowing only one code to be stored at the control office at a time, thereby insuring that a series of codes set up manually in a given order will be transmitted in the same order rather than in an arbitrary order of code superiority. This arrangement is of advantage, for example, in the operation of a series of track switches to set up a route and in effecting the clearing of a signal governing traffic movements over the route as soon as it is fully set up and eliminates the need for a route circuit network for governing the order of transmission of the codes as required heretofore. In accordance with this feature of my invention the character of the code to be transmitted is determined by the momentary operation of a selected starting button without the use of individual code determining or starting relays as generally used heretofore. The apparatus is also arranged that the latter may be used to store a plurality of codes for transmission

in a fixed order without interference when desired.

The system of my invention employs a chain of counting relays similar in number and arrangement to those of my prior patent, but includes novel arrangements for governing the operation of these relays to render them responsive only to a particular code, no other selecting relays being needed except when it is desired to have them respond to more than one code.

Another feature of my invention resides in the connection of the stick polar relays for registering code character, in series with the counting relays, whereby each counting relay together with the polar relay energized in series therewith functions like a polar-neutral relay in providing checks against improper operation. That is to say, those circuits which include polar contacts also include neutral front contacts the closing of which checks the energization of the polar relay in the normal or reverse direction and thereby indicates that its contacts are in a proper position.

Another feature of my invention resides in improved arrangements for controlling a transmitter relay for generating the code, in which each operation of the relay depends upon the closing of a different one of a series of successively prepared circuits.

Another feature of my invention relates to the provision of improved means for preventing undue delay in the transmission of codes from the different stations under conditions of heavy traffic, due to the fact that the stations normally have access to the line in a fixed order of code superiority.

A leading object of my invention is the provision of a system of the desired scope in a form which can be readily maintained to minimize service interruptions and which is readily adaptable to widely different conditions. On the one hand, maintenance is facilitated by mounting the relays in one or more unit housings with detachable connections, while on the other hand, different conditions require a variety of units some of which may contain idle relays and may be more efficiently provided for by the use of separately mounted relays wired individually according to their location. To meet these diverse requirements those relays which are invariable, that is to say, those the functioning of which is required regardless of their location or of the scope of the installation are mounted in a detachable coding unit such as is provided in the system of my prior patent, having detachable connections to which those storage relays may be connected which vary according to the location. One improvement resides in the arrangement of the coding unit so that it may be used at the office or at any station, only one spare unit being required for each installation, while other improvements comprise arrangements whereby the number of variable relays has been decreased.

A further feature of my invention resides in the arrangement of the coding unit or that certain of the steps of the code may be used to provide additional controls and indications in installations in which they are not required for station selection.

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

In the accompanying drawings:

Figs. 1A and 1B taken together, show in condensed form the apparatus at the control office

in a typical centralized traffic control system embodying my invention, Fig. 1A showing the office coding unit and Fig. 1B the associated office storage apparatus.

Figs. 2A and 2B, taken together, show the corresponding apparatus at a typical field location, Fig. 2A showing a coding unit which is structurally similar to that at the office but which has different terminal connections, and Fig. 2B the storage apparatus at a station having only one unit group of devices to be controlled, each such group being identified as a station.

Fig. 2C illustrates a modification which is to be substituted for Fig. 2B at each field location where the number of devices to be controlled exceeds the capacity of a single station or panel.

Fig. 3 shows a modification of the office selecting circuits which may be substituted for a portion of Fig. 1B, to provide for the storage of control codes for transmission in a given order, as hereinbefore referred to.

Fig. 4 shows a pair of relays which may be substituted for any one of the pilot relays P of the other views to obtain the requisite contact capacity when this exceeds the capacity of a single relay.

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

Referring to Figs. 1A, the reference characters Y and Z designate a pair of line wires which provide a line circuit for the centralized traffic control system of my invention. It is to be understood that these wires extend continuously the length of the territory controlled by the centralized traffic control system, and that they may be used jointly for telephone and telegraph communication like the similarly designated line wires shown in Letters Patent of the United States to Baughman et al., No. 2,303,875, issued December 1, 1942, for remote control systems. The system of my invention utilizes the line wires to provide a channel for the transmisison of low frequency alternating current of the order of six cycles per second, and communication between the office and stations is effected by means of codes each comprising a series of alternations or impulses of alternately opposite polarity having a low frequency of the order mentioned, with pauses interposed to provide code character. The C. T. C. line channel in its normal idle condition comprises the line wires Y and Z in series, with a connection bridged across the line wires through the coils 12 of a low pass filter and the high resistance winding of a line relay R at the office, as shown in Fig. 1A, and also at each station, as shown in Fig 2A, the transmitting apparatus at the office and at each station being normally disconnected from the line. Each line relay R is of the stick polar type, like relay OR of the above-mentioned Baughman et al. patent, and is arranged to hold its contacts magnetically in their last-operated position when the line is idle and also during the pauses between successive impulses of a code, the contacts of each line relay R normally occupying their left-hand posision, as shown.

Each coding unit, such as the one shown in Fig. 1A, includes transmitting apparatus governed by its line relay R, consisting of a starting relay ST, a master relay M, a transmitter relay T and an impulse transformer 13, this apparatus functioning as follows: Relay M is picked up, and is held energized to condition the coding unit for transmission, by momentarily energizing relay ST. The closing of front contact *a*

of relay M then completes a circuit from the supply terminal B of a suitable local source of current over back contact *d* of relay T and through the lower primary coil of transformer 13 to the common return terminal C of the local source. At the same time the closing of front contact *d* of relay M connects the secondary winding of transformer 13 across the line wires Y and Z through the coils 12 and 12*a* of a low-pass filter and the closing of front contact *c* of relay M completes the first of a series of circuits governed by the associated line relay R in a manner hereinafter described, by means of which relay T is operated periodically at intervals spaced in accordance with the desired code. Each time relay T picks up, the operation of its contact *d* reverses the direction of the current through transformer 13. The periodic operation of relay T thus causes transformer 13 to deliver induced impulses of alternately opposite polarity to the line circuit, the time spacing of which characterizes the code. Each code normally comprises sixteen impulses, providing fifteen code elements of selectable character.

Each line relay R controls a group of slow release timing relays L1, L2, LP, and LB, corresponding to the similarly designated relays of my prior patent. The timing of these relays is governed by means of electronic rectifiers as shown, in the manner explained in the patent, the rectifiers also serving to prevent contact sparking and to minimize contact wear.

In response to the first impulse of a code, each line relay R reverses, and its right hand contact *a* completes a circuit from terminal B over back contact *a* of relay L2, back contact *c* of relay LB, through relay L1 to terminal C. Relay L1 then picks up and its contact *a* completes a circuit for relay L2, whereupon relay L2 picks up and completes circuits over front contacts *c* of relays L2 and L1 to pick up relays LP and LB, which relays, as will be apparent from the drawings, are arranged to pick up simultaneously and to release successively following the release of relay L1 or L2. When relay L2 picks up, its contacts *a* and *d* shift the circuit for relay L1 to the left-hand contact *a* of relay R so that relay L1 becomes deenergized, and during the remainder of the code relay L1 is energized by relay R over front contact *c* of relay LB when relay R is in its normal position, while relay L2 is energized over its own front contact *a* when relay R is reversed. Relays L1 and L2 remain picked up during the brief intervals between succesive impulses constituting the short elements of the code, and one or the other of these relays releases during each pause constituting a long element and they thus serve to indicate code character. Relay LP is deenergized upon the release of relay L1 or L2 and governs the length of the long code elements transmited by the associated transmitter relay T. Relay LB is a bridging relay which remains picked up for the duration of a code and controls various local circuits as hereinafter pointed out.

Since relay R is normally deenergized, it may happen that it will be reversed accidentally when the system is in its normal at rest condition as, for example, by an impulse of foreign current. If this occurs, relays L1, L2, LP, and LB will pick up as described and then relays L1, LP, and LB will release in that order, relay L2 remaining picked up to close a local restoring circuit for relay R extending from terminal B at front contact *c* of relay L2 over back contacts *c* and *b* of

relays L1 and LB and the local winding of relay R to terminal C. Relay R will thereby be restored to normal, reenergizing relays L1, LP, and LB, and then the timing relays will release in the order L2, LP, LB, and L1. Each code consists of sixteen impulses and hence relay R is operated to normal by the final impulse and the timing relays release in the order last mentioned at the end of each code. A code may be initiated only when relays L1 and L2 are both released, and it follows that successive codes are spaced by an interval which is materially longer than any interval between successive impulses of a code.

Each line relay R also controls a chain of counting relays 1 to 8 and 16 for counting the code impulses, and in series therewith controls a pair of stick polar relays KS1 and KS2 which are operated to normal or reverse to register code character in accordance with the time spacing of the impulses. When relay R reverses in response to the first impulse of a code, the energization of relay L1 as above described completes a circuit from terminal B at the right-hand contact *b* of relay R over front contact *b* of relay L1 through the upper winding of relay KS1, back contact *a* of relay LB, front contact *g* of relay L1 through relay 1 to terminal C. Relay 1 therefore picks up and relay KS1 is held normal, as shown. Relay LB then picks up and shifts the circuit for relays KS1 and 1 to the branch path extending from the right-hand terminal of relay KS1 over front contact *a* of relay LB, back contact *b* of relay 2 and thence over the front contact *a* and winding of relay 1 to terminal C.

If the first element of the code is short, relay KS1 is left deenergized with its contacts normal as shown, when relay R is operated to the left by the second impulse, but if the first element is long, relay L1 releases before the second impulse is received and the closing of its back contact *b* shifts the circuit for relay 1 to include the lower winding of relay KS1 in place of its upper winding, thereby reversing the direction of energization of relay KS1 to cause the contacts of relay KS1 to move to the right. In this case relay KS1 is left deenergized with its contacts reversed when relay R is operated by the second impulse.

In response to the second impulse of a code relay R closes a circuit from terminal B at its left-hand contact *b* over front contacts *e* of relay LB and *b* of relay L2 through relay KS2, back contact *a* of relay 8, front contact *b* of relay 1 through relay 2 to terminal C, whereby relay 2 is picked up and relay KS2 energized in the normal direction as shown. If relay L2 releases before the third impulse is received, relay KS2 will be reversed thereby, that is, relay KS2 is left deenergized in its normal or reverse position depending on whether the second element is short or long, while the third element is being received. Relays 3 to 8 are provided with circuits generally similar to those for relays 1 and 2 and are arranged to pick up one at a time in the same way in response to the corresponding impulses of the code, each in series with relay KS1 or KS2 as described.

When relay 8 picks up, a chain repeat relay CR is energized over a circuit extending from terminal B at the front contact *f* of relay LB over contact *c* of relay 8 and the winding of relay CR to terminal C, and relay CR picks up completing a stick circuit at its contact *a* whereby relay CR is held energized until the end of the code. Con-

tact *b* of relay CR prepares a circuit for energizing relay 1 next in order after relay 8, and relays 1 to 7 operate through a second cycle in response to impulses 9 to 15 of the code. Contact *e* of relay CR serves to cause relay 16 to be operated in place of relay 8 in response to the sixteenth or final impulse. It will be understood that on each step except the last, relay KS1 or KS2 is positioned to normal or reverse in accordance with the short or long character of the corresponding code element and is held deenergized in its last operated position to store the code character for the duration of the next succeeding code element. As explained in more detail hereinafter, contacts *b* of relays KS are included in circuit portions leading over wires 56–59 to coding unit terminals which may be adjustably connected externally to those terminals which lead over wires 22—27 to the right-hand terminals of the counting relay windings. These circuit portions provide selectively controlled connections to the common terminal C of the local source which serve during the first cycle of operation of the counting relays to prevent their continued response to a code to which the apparatus is not adjusted to respond and to check the positions of the pilot relays P of Fig. 1B. During the second cycle of operation of the counting relays, the closing of contacts *c* and *d* of relay CR connects wire 56 to wire 58, and wire 57 to wire 59, and thus renders the operation of the counting relays independent of the position of contacts *b* of KS1 and KS2, and during this cycle the pole changer contacts *a* and *c* of the relays KS control the polarity of the current supplied to a series of circuits prepared by the closing of front contacts *f* and *g* of relay CR, completed externally by suitable connections to the coding unit terminals over wires 46—55, which as shown in Fig. 1B control the indication relays K. Relay KS1 also controls relay E in accordance with the character of the first element of the code, which is made a short element in each control code transmitted from the office and a long element in each indication code transmitted from a field station. The energization of relay E conditions the coding unit to function as a receiver.

The application of the apparatus of my invention to a specific installation will now be explained, assuming for sake of illustration that it is employed in a centralized traffic control system for controlling spaced groups of traffic governing devices such as the one shown in the track plan in Fig. 2B. This group comprises a track switch 1W and a group of signals LH and RH which as indicated diagrammatically on the drawings are arranged to be controlled by code by the operation of a group of polar stick relays including a switch control relay WS and the signal control relays LHS and RHS. It is to be assumed that the installation includes not more than sixteen such locations, each having a coding unit arranged as in Fig. 2A and connected by line wires Y and Z with one at the control office arranged as in Fig. 1A. At the location of switch 1W, the coding unit connections are arranged precisely as in Fig. 2B, this location being identified as "station No. 1," the connections at the other stations being differently arranged so that each is responsive to a distinctive code call.

At the office, the coding unit connections are arranged as shown in Fig. 1B, and include a control panel for each station containing the usual complement of control levers and indication lamps, of which only the one for station No. 1 is shown, this including a starting button 1PB for initiating the transmission of a control code containing the code call for station No. 1, a switch lever SW and a signal lever SIG for controlling the switch and signal relays at station No. 1, the levers being operatively associated with the coding unit by the energization of a selector relay O1S. The indication lamps of the panel are controlled by a group of indication relays K, which are operatively associated with the coding unit by the energization of a delivery relay O1D, energized in response to an indication code received from station No. 1.

Each code call comprises a distinctive combination of long and/or short steps, four steps providing sixteen such code calls. The office coding unit is arranged to transmit control codes of sixteen steps or code elements, in which the first and second are short; steps three to six, comprising the code call, either short or long; and steps seven to fifteen either short or long, to selectively control nine devices at the selected station, step sixteen governing the return of the apparatus to normal at the end of the code. In the specific arrangement chosen for illustration the code call for station No. 1 comprises four long steps; the seventh step is used to control a maintainer's call signal lamp MC, at the selected station, by closing a key MCB, and steps eight, nine, and eleven are used to control the relays WS, LHS, and RHS in accordance with the positions of the control levers SW and SIG. The remaining steps, not needed for control purposes, are made short steps.

Each code call is set up for transmission by positioning a group of four pilot relays, P3 to P6, Fig. 1B, in a distinctive pattern, the contact *d* of each of these relays controlling relay T to generate a long step of corresponding number if the relay P is picked up and to generate a short step if such relay remains released.

The step by step transmission of a control code to station No. 1, in response to the operation of the starting button 1PB will now be described, assuming the control levers to occupy their normal positions as shown.

The transmission of a code by any coding unit may be initiated only when the coding unit is in its normal at rest condition, so that relays L1 and L2 are both deenergized. In that case terminal B at back contact *c* of relay L2 is connected over back contact *d* of relay L1 to wire 17, and a code may then be initiated by connecting wires 17 and 15 together to complete a circuit to pick up the starting relay ST.

Assuming that button 1PB is operated, under the condition described, the connection from terminal B at wire 17 will be extended over contacts *b* to *e* of button 1PB to wires 73 to 76 and thence through the upper windings of each of the relays P3 to P6 to terminal C. Relays P3 to P6 pick up, as required for the code call of four long steps identifying station No. 1, and extend the connection from terminal B at wire 17 over their contacts *c* to wire 15 and thence through relay ST to terminal C. Relay ST picks up, and completes a circuit from terminal B over its front contact *c*, shown at the right in Fig. 1A, over back contact *f* of relay M to wire 21 and thence over contacts *e* of relays P3 to P6 in series, through relay O1S to terminal C. Relay O1S picks up, and the closing of its front contact *j* connects terminal B at contact *f* of button 1PB to wire 28 to complete a circuit over front con-

tact *a* of relay ST, back contacts *g* and *h* of relays LB and E through relay M to terminal C. The energization of relay M over the circuit just traced energizes the impulse transformer 13 and connects it to the line as already explained. It is to be understood that when transformer 13 is energized over the branch including back contact *d* of relay T the resultant line impulse is of normal polarity to operate each line relay R to the left, and when it is energized over front contact *d* of relay T the resultant impulse is of reverse polarity to operate each line relay R to the right. The initial impulse due to the closing of contact *a* of relay M therefore tends to operate the relays R to the position they already occupy and is not part of the code, its purpose being to insure the proper initial magnetization of transformer 13.

When relay OIS picks up, the opening of its back contact *k* extinguishes any of the indication lamps of the panel, such as lamp NH, which may be lighted, thereby indicating to the operator that the code has been initiated. When relay M picks up, it completes a stick circuit for the pilot relays P extending from terminal B at front contact *e* of relay M to wire 19, and through the lower winding and front contact *a* of each of the relays P3 to P6, to wire 18, and thence to terminal C at back contact *c* of relay E. The closing of front contact *f* of relay M connects terminal B directly to wire 21, to hold relay OIS picked up, and the operated starting button IPB may now be released.

As soon as relay M picks up, relay T becomes energized over the circuit extending from terminal B at contact *c* of relay M, contact *b* of relay ST, through the winding of relay T and resistor 29 to terminal C, and relay T picks up to deliver the first impulse of the code to the line to reverse all line relays R in unison, each of which operates its timing relays and counting relay 1 as already described. In the coding unit which is transmitting the code the energization of relay LB transfers relay M to a holding circuit having one branch extending from terminal B over the normal contact *b* of relay R and back contact *b* of relay T, and another branch extending from terminal B over the reverse contact *b* of relay R and the front contact *b* of relay T; thence over front contacts *b* and *g* of relays M and LB, back contact *h* of relay E and the winding of relay M to terminal C. Relay ST becomes deenergized but is made sufficiently slow release by the provision of a rectifier unit as shown so that although its energizing circuit is opened when relay L1 picks up, it remains picked up long enough to permit relay LB to pick up to complete the stick circuit for relay M. When relay T picks up it is held energized independently of relay ST over a stick circuit including its own front contact *a*. When relay 1 picks up, a connection extends from terminal B at contact *c* of relay M over back contact *b* of relay CR and front contact *d* of relay 1 to wire 31. The wires 31 to 45, inclusive, provide external connections for completing a series of circuits, closed one at a time by the counting relays, for controlling the periodic operation of relay T to determine the desired character for each of the elements one to fifteen, respectively, of the code. Any of these wires connected to terminal B over a contact *d* or *e* of an odd-numbered counting relay may be connected externally to wire 61 or 71 to extend the connection of terminal B to the left-hand terminal of relay T so as to shunt the relay to cause it to release. If the connection is made to wire 61 a short odd-numbered code element will be generated for the reason that relay T will be shunted as soon as the corresponding counting relay picks up. If the connection is made to wire 71, a long element will be generated, relay T being held energized after the counting relay has picked up until relays L1 and LP release and the connection is completed by the closing of back contact *b* of relay LP.

The even-numbered code elements are similarly controlled by external connections to wires 60 and 70. The second element, for example, will be a short element when wire 32 is connected to wire 60 because a circuit will be closed to pick up relay T, at back contact *d* of relay 1 as soon as relay 1 is released following the energization of relay 2. If on the other hand wire 32 is connected to wire 70, a long element will be generated, relay T remaining deenergized until relays L2 and LP release to close the pick-up circuit at back contact *c* of relay LP.

It follows therefore that after relay T is initially picked up by the operation of relay ST it continues to operate periodically to generate a code, provided relay M remains picked up and the associated counting relays respond. Each time relay T picks up it is held energized over its stick circuit until the associated line relay R reverses to pick up an odd-numbered counting relay, contact *d* or *e* of which connects terminal B over wire 61 or 71 to the left-hand terminal of relay T to release it by short circuiting its winding. Each time relay T releases, relay R is operated to normal to pick up an even-numbered counting relay, whereupon the last operated odd-numbered relay releases to prepare a pick-up circuit for relay T closed over wire 60 or 70.

In the control code being described, the first step is short, due to the fact that relay T is shunted by the connection over front contact *d* of relay 1 and wires 31 and 61, Fig. 1B, as soon as relay 1 picks up, the code being thereby distinguished from an indication code transmitted from a field station which has a long first step. The second step is made a fixed short step by a connection over back contact *d* of relay 1 and front contact *d* of relay 2, over wires 32 and 60, over which relay T is picked up in response to the release of relay 1. The front contacts *d* of relays P3 to P6 are now closed, so that wires 33 to 36 are connected to wire 70 or 71 and the closing of the circuits including the front contacts *d* of relays 3 to 6 is delayed until relay LP releases on each of the steps three to six, thereby making these steps long. Assuming key MCB to be open, relay P7 will occupy its released position, and the seventh step will be made short due to the connection from wire 37 over back contact *d* of relay P7, to wire 61.

The code transmission continues through the seven steps as described only if the code delivered to the line by which relays KS1 and KS2 are operated, is of the corresponding pattern. Unless the first step is short, the office relay E picks up as hereinafter described, and its back contact *h* opens the circuit for relay M to stop further transmission. Unless relay KS2 remains normal to register a short second step, relay 3 is not operated, its circuit extending from its right-hand terminal over wires 22 and 56 to terminal C at the normal contact *b* of relay KS2. Similarly, the operation of relay 4 is dependent upon the reversal of relay KS1 to register the long third step, the circuit for relay 4 extending from wire 23 over front contact *b* of relay P3 to wire 59 and

thence to terminal C over the reverse contact *b* of relay KS1. Relays 5 to 7 are controlled over similar circuits including front contacts *b* of relays P4 to P6, while relay 8 is controlled over a circuit including back contact *b* of relay P7. It follows therefore that the office relay 8, and relay CR controlled thereby, is operated only if steps one to seven of the control code are of the desired character.

When relay CR picks up on the eighth step, its contact *b* transfers the control of relay T from the *d* contacts of the counting relays to a series of eight similar circuits extending from contacts *e* of relays 8 and 1 to 7, respectively, to wires 38 to 45 extending over contacts *b* to *i* of relay OIS, for controlling the character of steps eight to fifteen in accordance with the positions of the levers of the selected panel in the same manner as the preceding steps are controlled by contacts *d* of the relays P, as above described. The circuit for step eight, for example, extends from wire 38 over contact *b* of relay OS1 and lever SW to wire 60 or 70, and is therefore made a short step if lever SW is normal and a long step if lever SW is reversed. The signal lever SIG controls the character of steps nine and eleven, both of which are made short when lever SIG is normal as shown. Step nine is made long and step eleven short when lever SIG occupies its left-hand position, and step nine is made short and step eleven long when lever SIG occupies its right-hand position, as will be clear from the drawings. The remaining steps, in the specific arrangement decribed, are made short steps by the provision of direct connections from contacts *d* and *f* to *i* of relay OIS to wires 60 and 61.

The transmission of the code being described is terminated with the dropping of relay T to begin the sixteenth step, during which the apparatus returns to its normal at rest condition. Relay 16 is the first to release, then relays L2, LP, and LB release. Relay LB releases relays M, CR, and L1, and relay M releases relays P3 to P6 and OIS, and finally, relay L1 releases.

Considering now the manner in which the control code just described is selectively received at station No. 1, and referring to Fig. 2A, since a coding unit like that shown in this view is provided at each field location, each of which is similar to that of Fig. 1A except for its external connections, it follows that the line relays R and the timing relays at all stations operate in unison with the corresponding office relays in response to the control code, likewise relays 1, 2, and 3.

Each station coding unit is conditioned to function as a receiver by the energization of its relay E on the second step, as hereinafter described.

At station No. 1, relays 4 to 7 pick up on the corresponding steps because wires 23 to 26 of Fig. 2B are connected to wire 58 or 59 and the circuits for relays 4 to 7 are similar to those established for the corresponding office relays when relays P3 to P6 are picked up, as already described.

It is to be understood that at each other station one or more of the wires 23 to 26 is connected to wire 56 or 57 instead of to wire 58 or 59, as illustrated in Fig. 2C, for example, and consequently at each such station the operation of the counting relays terminates before reaching the eighth step of the code containing the code call for station No. 1.

At station No. 1, however, the counting relays operate until the sixteenth step is reached, in unison with the office relays, and when relay CR picks up on the eighth step, a branch of its circuit is closed from terminal B over front contact *b* of relay E to wire 9, thence through relay MCR to terminal C, over the pole changer contacts *e* and *f* of relay P7, whereby relay MCB is energized in the normal direction if relay P7 is released, and in the reverse direction if relay P7 is picked up.

It is to be understood that relay MCB is of a magnetic stick type and that it closes its contact to light lamp MC when energized in the reverse direction, and assumes the released position when energized in the normal direction, remaining in its last operated position when deenergized.

Assuming the eighth step of the code being received to be short, relay KS2 will occupy its normal position and the polar stick relay WS of Fig. 2A will be energized momentarily in the normal direction at the beginning of the ninth step over a circuit extending from terminal B at the right-hand contact *b* of relay R, contact *d* of relay LB, normal contact *a* of relay KS2, contacts *g* of relays CR and E, contact *f* of relay 1, wire 48, relay WS, wire 46 and thence to terminal C at the normal contact *c* of relay KS2. If lever SW had been reversed to make the eighth step long, relay KS2 would be reversed, and relay WS would be energized in the reverse direction on the ninth step. Relays LHS and RHS are similarly controlled in accordance with the character of steps nine and eleven, respectively, as reflected by the position of relay KS1, these relays being operated to normal or reverse on steps ten and twelve, as will be clear from the drawings.

Each station coding unit is adapted to be conditioned to transmit indication codes in response to the energization of a code storing stick relay, such as the relay ICS of Fig. 2B.

When relay ICS is energized, it connects wire 17 over its front contact *b* to wire 15, to which the starting relay ST of Fig. 2A is connected, and this relay ST when energized completes a connection from terminal B over wire 20 and its front contact *a* to pick up relay M. The energization of relay ICS thus corresponds to the operation of the starting button IPB in the control code already described, that is to say, it is effective when the system is at rest, to pick up relays ST and M to initiate the transmission of an indication code by relay T at station No. 1.

Relay ICS may be picked up in response to changes in the condition of any of the indicating relays at station No. 1, as hereinafter described in detail; but it is also picked up upon the delivery of a control code to station No. 1 over the circuit extending from terminal B at wire 9 through its upper winding to terminal C.

The transmission of a control code to station No. 1 will thus be followed by a transmission of an indication code from station No. 1, in which the operation of the station transmitter relay T, of the line relays R and of the timing and counting relays controlled thereby are generally similar to those already described. The indication code comprises sixteen steps in which the first is made a long step by connecting wire 31 to wire 71, as shown in Fig. 2B, instead of to wire 61. Wires 32 to 37, in Fig. 2B, provide connections similar to those provided for the office relay T in the control code described. Consequently steps two and seven will be short and steps three to six long, the connections of wires 33 to 36 to wire 70 or 71 providing for the transmission of the code call of four long steps identifying station No. 1.

It is to be understood that at each other sta-

tion one or more of the wires 33 to 36 is connected to wire 60 or 61, as illustrated in Fig. 2C, for example, to effect the transmission of different code calls.

When the coding unit of Fig. 2A is in the transmitting condition, terminal B at contact *e* of relay M is connected to wire 19, preparing a circuit which may be completed at contact *a* of relay R7 through the upper winding of relay P7 to terminal C, whereby relay P7 may be controlled to make the seventh step short or long, in accordance with the position of an indicating relay R7. The circuit by which relay P7 is held energized in the receiving condition is ineffective when relay P7 is subject to control by relay R7, wire 18 being connected to terminal C, at back contact *c* of relay E.

Steps eight to fifteen of each indication code may be used to indicate the condition of eight other station devices by suitable connections to wires 38 to 45. As shown, wires 38 to 42, controlling the transmission of steps eight to twelve, are connected to contacts *d* of the indicating relays NWP, LHR, RWP, RHR, and TS, while wires 43, 44, and 45 are connected to wires 61, 60, and 61, respectively, so as to make these steps short. Since all the connections, except the one for the first step, are similar to those for the office relay T already described, no further description of the detailed operations involved in transmitting an indication code is deemed necessary.

Since the first step is long, relay E at the transmitting station is not operated. This is also true of relay E at each other field station, and consequently none of these are conditioned to receive the code.

Since each transmitter has access to the line when it is free, it may happen that two or more are set into operation at the same time. If this occurs, interference is avoided by stopping the delivery of impulses to the line by any coding unit which is transmitting a code if its line relay R is operated by a received impulse during a pause in the operation of the associated transmitter T. If relay R is thus operated to a position out of step with the relay T it controls, the stick circuit for relay M is opened at contact *b* of relay R, releasing relay M to disconnect the transmitter from the line, the coding unit then being in condition to transmit its code in its entirety when the line is again free.

Since the line relays R are of the stick polar type, relay R at a station which is transmitting a long code element is temporarily deenergized and in condition to respond to an impulse received from the line as required for the operation of this feature.

It will be readily apparent, therefore, that the use of the line is allotted to the different stations in accordance with the relative superiority of their code calls, a short element taking precedence over a long element in each instance. Control codes transmitted from the office are given precedence over indication codes transmitted from the stations by the provision of a short first element in each control code and of a long first element in each indication code, as already explained. Thus when a control code and an indication code are initiated at the same time, the line relays at the office and at each station will be operated by the second impulse of the code delivered by the office relay T, energizing relays 2, L1, and LP in each coding unit. Since the connection for shunting relay T at each field station includes wires 31 and 71, it will remain open and the station relay T will remain picked up until the associated relay M is released to disconnect transformer 13 at that station from the line, leaving the office transmitter in control to continue the code.

It has already been mentioned that the coding unit at each field location is arranged to receive control codes as identified by a short first element by suitable connections for relay E. Thus in Fig. 2A, wire 11 is connected to wire 14, and since relay KS1 remains in its normal position, the station relay E is energized in multiple with relay 2 at the beginning of the second step over a circuit extending from terminal B at the left-hand contact *b* of relay R, front contact *e* of relay LB, normal contact *a* of relay KS1, wires 14 and 11, contact *c* of relay 1 and the upper winding of relay E to terminal C. Relay E therefore picks up, and completes a stick circuit over its contact *a* and lower winding, extending to terminal B at contact *f* of relay LB.

By referring again to Fig. 1A, it will be seen that the office coding unit is conditioned to receive indication codes having a long first element by connecting wire 11 to wire 47, in which case the pick-up circuit for the office relay E extends to terminal B over the reverse contact *a* of relay KS1. As already explained, relay KS1 occupies its reverse position during the second step only if the first element of the code is long.

Referring now to Fig. 1B, it is to be understood that the key MCB controls the character of the seventh step of a control code initiated by the operation of any one of the buttons 1PB to 16PB, to operate a maintainer's call signal at the selected station, and the operation of this feature will now be described. Assuming that key MCB is closed, and that button 1PB is operated, a control code will be initiated as already described. When relay M picks up, a circuit is closed from terminal B at its front contact *e*, Fig. 1A, over wire 19 and the contact of MCB, Fig. 1B, wire 77 and the upper winding of relay P7 to terminal C. Relay P7 therefore picks up, and its contact *d* shifts the connection of wire 37 from wire 61 to wire 71, causing relay T to generate a long seventh step during which relay L1 releases to reverse relay KS1, the control code being in other respects similar to the one already described in detail.

At station No. 1, the release of relay L1 on the seventh step completes a circuit from terminal B at contact *f* of relay LB, Fig. 2A, over back contact *a* of relay CR, front contact *e* of relay E, back contact *e* of relay L1, contact *c* of relay 7, wire 67 through the lower winding of relay P7 of Fig. 2B, to terminal C, so that the station relay P7 picks up completing a stick circuit over its contact *a* and wire 18, extending to terminal B at front contact *c* of relay E.

At the office and at station No. 1, a circuit is prepared for relay 8 extending from wire 27 over front contact *b* of relay P7, wire 59 and the reverse contact *b* of relay KS1 to terminal C, so that relays 8 and CR pick up on the eighth step and at station No. 1, terminal B is connected to wire 9, energizing relay MCR in the reverse direction over front contacts *e* and *f* of relay P7 to light lamp MC, as required. The remaining operations are similar to those occurring on the corresponding steps of the control code already described.

In describing the step-by-step operation of the system, it has been assumed that the apparatus of Fig. 1B has been arranged for sixteen stations,

using the elements three to six of the code in different combinations of long and short elements to provide the sixteen code calls. Step two of the code is made a fixed short element by connecting wire 32 to wire 60. A pilot relay P is provided for each of the steps three to seven, having a contact *d* for controlling the transmission; that is to say, each of these steps is made long or short according to the position of the associated relay P. Relays P2 to P6 may be arranged in sixteen different ways to complete a circuit from wire 21 over their contacts *e* to *i* to select any one of sixteen S relays, as indicated by the references O1S to O16S, in Fig. 1B.

By the addition of a pilot relay P2 to the group of relays P3 to P6, to control the character of the second step, the number of stations which the system is adapted to control is doubled, five steps providing code calls for thirty-two stations. Relay P7, as shown, provides an additional control or indication element in each code, but this relay may be used for station selection by arranging its circuits like those for relays P3 to P6, and it follows that the system may employ codes having either five selecting steps and nine function control steps, or six selecting steps and eight function control steps, the latter arrangement providing for the control of sixty-four stations.

For the control of sixteen stations, as shown, the circuits controlled by contacts *e* to *i* of the relays P consist of two sets of circuits for eight S relays each, selected over front and back contacts *e* of relay P3. Similarly, to control thirty-two stations, two sets of circuits for sixteen S relays, each set like the one shown, but connected to wire 21 over front and back contacts, respectively, of a relay P2, may be used. To obtain the requisite number of contacts one or more additional relays may be provided for any of the steps. Thus for the two sets of sixteen circuits mentioned, relay P4 may be replaced by a pair of relays P4A and P4B, having their windings connected in parallel and their contacts *a* in series, as shown in Fig. 4, likewise relays P5 and P6. Any of the thirty-two circuits thus provided may be branched over front and back contacts of relay P7 to provide circuits for two S relays, as is obvious.

The pilot relays have a dual function. When the coding unit is in the receiving condition, with relay E picked up, the relays P are picked up one at a time in response to corresponding long elements of the code as received, and current is supplied to wire 21 by relay CR to pick up the selected relay S on the eighth step of the code.

The relays P also serve to condition the coding unit to transmit a code. That is to say, they may be set up in any desired combination and the corresponding S relay energized when the system is at rest by the operation of a starting button or code determining relay to initiate the transmission of a code, in which case the P relays determine the pattern of the station code call, as already mentioned.

The step-by-step operation of the apparatus of Figs. 1A and 1B in receiving an indication code will now be described. It will be assumed that the code received is one transmitted from station No. 1 as above described, in which steps one and three to six are long steps, and steps two and seven to fifteen are short, and it will be understood that the office line relay R responds to the received impulses and controls the associated timing relays, and that relays 1 and 2 respond as in the codes already described. Since the first step is long, relay KS1 is operated to reverse in series with relay 1 and its right-hand contact *a* prepares a circuit including wires 47 and 11 over which relay E, Fig. 1A, picks up. On the second step, the closing of front contact *e* of relay E prepares pick-up circuits for the relays P which may be traced from terminal B at contact *f* of relay LB, back contact *a* of relay CR, front contact *e* of relay E, back contact *e* of relay L1 or L2, contacts *c* of relays 2 to 7 and the corresponding wires 62—67, through the lower windings of relays P to terminal C. In the case of relays P2 to P6, the connection to terminal C includes wire 19 and back contact *e* of relay M.

Since the third step is long in the code being described, relay P3 will pick up over wire 63 and front contact *c* of relay 3 in response to the closing of back contact *e* of relay L1 on that step, and relays P4, P5, and P6 will pick up over corresponding circuits on steps four, five, and six. Since the seventh step is short, relay P7 remains released.

A stick circuit is completed by each relay P which picks up in response to the closing of back contact *e* of relay L1 or L2, which includes its own front contact *a* and extends over wire 18 to terminal B at front contact *c* of relay E.

A check to insure against the failure of the relays P to assume the positions required for the code call being received is provided by the connections for the counting relays 3 to 8 which extend to terminal C over wires 22—27 and contacts *b* of the relays P, wires 56—59 and contact *b* of relay KS1 or KS2. In response to each long element, relay KS1 or KS2 is reversed and completes a connection to terminal C over wire 58 or 59 and front contact *b* of that one of the relays P which is picked up by the same long element, to prepare a circuit for the counting relay next to be operated. If the element is short, relay KS1 or KS2 remains in its normal position and the relay P is not operated, and the circuit prepared for the next counting relay includes wire 56 or 57 and a back contact *b* of the relay P. In case a pilot relay such as P2 is omitted, as in the case being described, the corresponding wire such as wire 22 is connected directly to wire 56 or 58, and as shown, relay 3 responds to the third impulse only if the second step is short.

It follows that relay 8 responds to the eighth impulse of a code to pick up relay CR only when the relays P have been set up in a combination representing the code call received by the relays 1 to 7 and KS. If the first code element is long, as assumed, so that relay E is picked up, relay 8 completes a circuit extending from terminal B at contact *f* of relay LB, contact *c* of relay 8, contact *b* of relay E, back contacts *c* and *f* of relays ST and M, to wire 21, and thence as already described in connection with Fig. 1B over front contacts *e* of relays P3—P6 and the winding of the selector relay O1S to terminal C. Relay O1S is thus energized in multiple with relay CR and the closing of front contact *a* of relay CR completes a stick circuit for holding both of these relays picked up until the end of the code. When relay O1S picks up, a branch of its circuit extending from terminal B over contact *b* of relay E to wire 9 is closed at contact *a* of relay O1S through the winding of relay O1D to terminal C, whereby relay O1D is energized. The closing of contact *a* of relay O1D then completes a circuit for operating the indication relay K7 in accordance with the character of the seventh element, this circuit having a connection to terminal B at wire 9

whereby relay K7 is energized in the normal or reverse direction according to the position of contacts *e* and *f* of relay P7. The indication relays may be of the ordinary stick polar type, but preferably are of the type shown in Letters Patent of the United States to Agnew No. 2,301,992, granted November 17, 1942, for Electrical relays, which relays are operable to their picked up and released positions by current of normal and reverse polarity, respectively, and are adapted to remain in their last operated position when deenergized.

Contacts *b* to *i*, inclusive, of relay OID prepare circuits for operating the relays K connected thereto in accordance with the character of steps eight to fifteen of the code. For example, the operation of relay R to the right in response to the ninth impulse connects terminal B to contact *a* of relay KS2, which relay is then held deenergized in its normal or reverse position to store the character of the eighth element. Relay 1 picks up, completing a circuit from terminal B to terminal C over contacts *a* and *c* of relay KS2, including contacts *g* of relays CR and E, contact *f* of relay 1, wires 48 and 46, contact *b* of relay OID and the winding of relay NWK, whereby relay NWK is energized normal or reverse to correspond with the position of relay KS2. The operation of relay R to the left in response to the tenth impulse opens the circuit for relay NWK and connects terminal B to contact *a* of relay KS1, and also restores relay KS2 to normal and energizes relay 2, while relay KS2 is held deenergized in its normal or reverse position to store the character of the ninth element. Relay 2 completes a circuit from terminal B to terminal C over contacts *a* and *c* of relay KS1, including contacts *f* of relays CR and E, contact *f* of relay 2, wires 49 and 47, contact *c* of relay OID and the winding of relay LHK, whereby relay LHK is energized normal or reverse to correspond with the position of relay KS1.

The operations occurring during the remaining steps of the code are similar to those described, as will be readily apparent.

It follows that on steps eight to thirteen, respectively, relays K7, NWK, LHK, RWK, RHK, and TK will each be operated to a position reflecting that of the corresponding indicating relay at station No. 1. Steps thirteen to fifteen are fixed short steps in the code being described, but additional indication relays K13 to K15 may be provided for indicating the character of these steps if required. The operation of relay R to the left in response to the sixteenth impulse picks up relay 16, and contact *b* of relay 16 completes the circuit for operating relay K15 to a position in accordance with the character of the fifteenth element. Relay 16 is not provided with a stick circuit and releases after a short interval. Relay R remains in its normal position, consequently relays L2, LP, and LB release in that order. Relay LB releases relays CR, E, OIS, and OID, and relay E releases the energized P relays, thereby placing the apparatus in condition to receive a new code. Relay LB also deenergizes relay L1, which is the last to release. The release of relay L1 connects terminal B to wire 17, thereby placing the apparatus in condition to initiate the transmission of a new code.

Considering now the transmitting condition of the apparatus of Fig. 1B, with reference more particularly to the upper right-hand portion of that view, which shows circuits controlled by the buttons for controlling the relays P2—P6 as required by various code calls. The front contacts *b* to *e*, etc., of buttons PB, which provide a connection from wire 17 to wires 73—76, correspond to the long elements in each of the fifteen code calls set up by the operation of buttons 1PB to 15PB. The sixteenth code call, assigned to button 16PB, does not require the energization of any of the relays P3 to P6. It follows that the code combination assigned to each of the panels may be readily identified from the drawings.

Terminal B is connected to wire 17 only when the system is at rest, or at the end of a relatively long time interval following the sixteenth impulse of a code, as already explained, under which condition the operation of any of the buttons except 16PB extends the connection from terminal B to one or more of the wires 73—76 and thence through the upper windings of the corresponding relays P to terminal C, thereby energizing a relay P for each long element of the selected code call. The energized relays P by closing their contacts *c* complete a connection from wire 17 to wire 15 to pick up relay ST. The operation of button 16PB completes a connection from wire 17 over its contact *b* to wire 15 to pick up relay ST without operating any of the relays P, the code call for this button comprising four short steps.

When relay ST picks up, a circuit is closed from terminal B at its front contact *c* over back contact *f* of relay M to wire 21 to pick up the relay S which corresponds to the combination set up by the relays P, opening back contact *k* of the operated relay S to extinguish the indication lights of the selected panel. If the relays P have been positioned properly this panel will be the one containing the operated button. That is to say, relay OIS will be energized only if each of the relays P3 to P6 pick up in response to the operation of button 1PB, whereupon terminal B at contact *f* of button 1PB will be connected over contact *j* of relay OIS to wire 28 and thence over contact *a* of relay ST, to pick up relay M, thereby setting relay T into operation to transmit the code as already described.

It is to be understood that the connection to wire 28 over contact *f* of each of the starting buttons 1PB to 16PB includes contact *j* of the corresponding S relay. It follows that relay M will not pick up if, due to a fault, the pilot relays P do not occupy the positions required for the code call identifying the operated starting button.

When relay M picks up, its front contact *e* connects terminal B over wire 19 and the lower windings and contacts *a* of the energized relays P2 to P6 to wire 18 and thence to terminal C at back contact *c* of relay E, and it follows that the operated button may be released as soon as relay M picks up to initiate the code.

The condition of relays P2 to P6 cannot be disturbed by further operation of any of the starting buttons PB because when a code is being sent or received, terminal B is disconnected from wire 17.

As previously explained, when relay M is picked up, wires 31—37 afford connections over contacts *d* of the counting relays to wires 60, 61, 70, and 71 for governing the operation of relay T to generate the first seven elements of the code, the character of the variable elements being determined by the positions of the contacts *d* of the pilot relays P in the circuits. At the beginning of the eighth step, contact *b* of relay CR picks up to shift the circuits for relay T to contacts *e* of the counting relays and wires 38—45, and thence

over contacts *b* to *i* of that one of the selector relays O1S to O16S which is energized, and contacts of the control levers of the corresponding panel to wires 60, 61, 70, and 71, or directly to wire 60 or 61 when a control step is idle, and determines the character of the ninth to fifteenth elements, in the manner already pointed out.

When relay T drops in response to the energization of wire 45 to transmit the final impulse of the code, it remains released. Relay R therefore remains in its normal position, and relays 15, L2, LP, LB, and L1 release in that order. Relay LB releases relays M, CR, and the energized selector relay S, and then relay M releases the energized relays P. Relay L1, which is the last to release, connects terminal B to wire 17 to render the buttons PB effective to control the initiation of the next code.

It is to be noted that each operation of relay T to generate either a short or long code element is dependent upon the closing of a circuit over one of the wires 31—37 or 38—45. A failure of any of the circuits to close would make the element indefinitely long, allowing the timing relays to release as at the end of the code to reset the transmitting apparatus in its normal condition. A similar release at the receiving station prevents the registration of the uncompleted element.

It may readily occur that an indication code will be initiated by a station at the same time that a control code for a different station is initiated. Normally the control code will take precedence by reason of its short first element, but if due to a fault, the short first element is not properly transmitted the station transmitter will retain control of the line to deliver a long first element. If this occurs, the office relay E will pick up in response to the second impulse as in the case of a normal indication code, releasing the office relay M by the opening of back contact *h* of relay E. Those relays P at the office which were picked up to initiate the code will now release, due either to the dropping of relay M or to the reversal of polarity of the current supplied to their stick circuits over wires 18 and 19, when relay E picks up. It follows that the office apparatus will be conditioned at the beginning of the second step to respond to the received code, that is, to pick up the relay P for any of the steps two to seven in accordance with the code as received.

It may also happen that two or more starting buttons are operated at the same time. The code determining contacts controlled by the starting buttons and connected to wires 72—76 are so arranged, however, that irrespective of the number of sets operated, only one set of code determining contacts is effective to determine the code and no interference occurs, due to the provision of novel circuit arrangements as will now be explained.

By reference to the drawings it will be seen that each odd-numbered button PB has a front contact *e* for energizing wire 76, and that wire 76 must be deenergized to set up the combination for any even-numbered button. Each of the latter has a back contact *e* in the connection to wire 76 which opens when the button is operated, to prevent the energization of wire 76 by operation of any higher-numbered button. Similarly, when button 3PB or 4PB is operated, the opening of back contact *d* of the operated button prevents the energization of wire 75 by operation of any higher numbered button. In place of back contacts in the sets of code determining contacts, back contacts of the P relays may be used with the same effect; thus back contacts *f* and *g* of relay P3, which open in response to the operation of relay P3 by any of the buttons 5PB—8PB, prevent the energization of wires 74 and 75 by operation of any higher numbered button. It will be clear from the drawings that the sets of code determining contacts are connected to the conductors 73—77 in such an order that they are effective only one set at a time, in a fixed order of code superiority.

It is believed that the modification of the code determining circuits to provide code calls of five or six steps as required for the control of additional stations will be obvious from the circuits as shown. Thus, for example, to control thirty-two stations, two groups of sixteen contact sets each may be used, each similar to the one shown except that in one group each set will have an additional contact for energizing relay P2, while the contacts of the other group will be connected over back contacts *f* to *i* of relay P2, as indicated by dotted lines in Fig. 1B.

In certain applications of the centralized traffic control system of my invention, particularly in connection with the control of train movements on single track railroads, it may be preferable to provide for the storage of codes at the control office so that when several starting buttons are operated in a rapid sequence the codes will be transmitted in order without further attention, as in the system of my prior patent. This may be accomplished by the provision of a code determining relay CS for each panel, each controlled as shown in Fig. 3.

In this modification the contacts *b* to *f* of each starting button are replaced by similarly functioning contacts of the associated relay CS in the circuits of Fig. 1B, each starting button having only a single contact *a*. In this modification a storing relay such as O1CS is picked up at once in response to the operation of the associated button 1PB regardless of the condition of the coding apparatus, and is then held energized over the stick circuit extending to terminal B at back contact *m* of the associated selector relay O1S. When wire 17 becomes energized, contacts *b* to *f* of the lowest numbered one of the operated relays CS will be effective to operate the P relays as required to pick up the associated selector relay S and to connect terminal B to wire 28 to initiate the code as described in connection with the circuits of Fig. 1B, as will be readily apparent. In response to the operation of relays P3 to P6 by relay O1CS for example, relay O1S is picked up and its contact *m* inserts back contact *a* of relay 16 in the stick circuit for relay O1CS as shown in Fig. 3, whereby the circuit is opened to release relay O1CS in response to the transmission of the sixteenth impulse of the corresponding control code to allow the next energized relay CS in order to initiate the next code to be transmitted.

A contact *j* of the assoociated delivery relay O1D provides a connection to terminal B which serves to prevent the release of relay O1CS by relays O1S and 16 at the end of an indication code, in the event that the starting button 1PB is operated and relay O1CS picked up, during the reception of an indication code.

Referring now to Fig. 2B, it has already been explained that this view together with Fig. 2A shows an arrangement suitable for use at a field location having a limited number of controlled

devices within the capacity of a single office control panel such as the one shown in Fig. 1B, these devices being those required for the control of a single track switch 1W, and a group of signals LH and RH, located at one end of a passing siding on a single track railroad, as indicated by the track plan shown. Suitable circuits for the safety control of such devices are well known, one arrangement being shown, for example, in my prior patent hereinbefore referred to, and accordingly these circuits are shown herein only in diagrammatic form, to indicate how a typical group of traffic governing devices may be controlled by code by means of stick polar relays. Wires 46—55 leading to the coding unit of Fig. 2A provide circuits for the control of eight stick polar control relays, of which but three are required for the simple layout shown, namely, the switch control relay WS which governs the operation of the switch machine 1SM, and the signal control relays LHS and RHS which govern the signal relays LHR and RHR to clear the signals for the desired direction of traffic movement and for putting the signals manually to stop.

It has also been explained that the apparatus of Fig. 2B is arranged as required at station No. 1 by connecting wires 22—27 to wires 56—59 in such a manner as to render the counting relays selectively responsive to the code call set up by operation of the starting button 1PB of Fig. 1B. It will be apparent that the operation of the counting relays will be discontinued on one step or another of any control or indication code containing a different code call. More particularly, the station relay E responds to a short first element, indicating the office as the place of origin, and relay CR responds only if the second element is short and elements three to six are long, indicating station No. 1 as the intended destination, and if relay P7 corresponds in position to the character of the seventh element as received. Since the station coding unit in this case responds selectively to only one code call, selector and delivery relays corresponding to relays O1S and O1D are not required, the closing of the contacts *f* and *g* of relays CR and E in the circuits including wires 46—55 being sufficient to indicate the selective response of the coding unit. In other respects the circuits for controlling the stick polar relays such as WS are similar to those for the indication relays K of Fig. 1B, as will be readily apparent.

Although the apparatus of Fig. 2B is arranged specifically for use at only one location, namely, at station No. 1, it will be readily apparent that similar arrangements may be provided at each other location for which nine controls or indications suffice, and at each such location one or more of the wires 23 to 26 will be connected to wire 56 or 57 instead of to wire 58 or 59, the connections at each such location being arranged in a distinctive pattern to render the counting relays selectively responsive to the code call set up by the corresponding one of the starting buttons PB. Furthermore, the connections of wires 33 to 36 by which relay T is controlled will be arranged at each station in a pattern corresponding to the connections for the counting relays at that station.

The initiation of indication codes by the apparatus of Fig. 2B is governed by a group of three relays, comprising a change relay 1CH, a storing relay 1CS, and a station sequence relay SS, as will now be described.

It has already been explained that an indication code is initiated by picking up relay 1CS to connect wire 17 to wire 15, and that relay 1CS may be picked up by manual control by transmitting a control code to station No. 1. An indication code is also initiated automatically, in response to a change in position of any of the indicating relays which control the character of steps seven to fifteen of the code. In the specific arrangement shown, a relay R7 controls the character of the seventh element, the eighth and tenth elements are controlled in accordance with the positions of contacts *d* of switch indication relays NWP and RWP, and the signal relays LHR and RHR similarly control the ninth and eleventh elements. The track relay TR for the detector track section including switch 1W controls the character of the twelfth element by the operation of a storing relay TS.

Relay 1CH, as shown, is normally held energized over a stick circuit extending from terminal B at contact *b* of relay RHR over contacts *b* of the indicating relays mentioned, and the front contact *a* and winding of relay 1CH to terminal C. Relay 1CH is released in response to a change in position of any of these relays to extend the connection from terminal B over its back contact *a* and front contact *a* of a relay SS through the lower winding of relay 1CS to terminal C. Relay SS is a slow pick-up relay normally energized over wire 17 and consequently is released when the line is in use and becomes reenergized following the release of relay L1 at the end of a code. Relay 1CS therefore picks up in response to the closing of contact *a* of relay SS, after the line has been free for a time sufficient to enable relay SS to pick up, and the closing of front contact *b* of relay 1CS connects terminal B at wire 17 to wire 15 to pick up relay ST. In Fig. 2A, wire 28 is connected directly to terminal B, so that relay M picks up at once to initiate the code. When relay LB picks up in response to the first code impulse, a circuit is closed from terminal B at front contact *f* of relay LB over back contact *a* of relay CR to wire 10 and thence over contact *c* of relay 1CS through relay 1CH to terminal C, whereby relay 1CH is picked up to reestablish its stick circuit. Relay 1CS is held energized until the final step of the indication code is transmitted, over a stick circuit including its contact *a* and wire 20, extending to terminal B at back contact *a* of relay 16, and thus maintains the coding unit in condition to initiate an indication code repeatedly, if necessary, until such code is transmitted in its entirety.

Relay CR disconnects terminal B from wire 10 on the eighth step, consequently a change in the position of any of the indicating relays occurring after relay CR picks up is effective to release relay 1CH to effect the transmission of a second code.

An indication code follows each control code received by the station, even though the control code causes no change in the position of any of the indicating relays, for the reason that during each control code received, the delivery wire 9 is connected to terminal B as already explained, and as will be clear from Fig. 2B, relay 1CS is thereby energied over its upper winding to establish the stick circuit including its lower winding. At the end of a control code, wire 9 remains connected to terminal B until after relay 16 releases to reestablish the connection to terminal B at wire 20, consequently relay 1CS remains picked up.

Relay TS provides means for insuring the

transmission of an indication of the occupancy of the track section controlling relay TR, even though the section is vacated before the indication is transmitted. Relay TS picks up in response to the release of relay TR and if relay TR then picks up again, relay TS is held energized over a stick circuit including back contact *b* of relay 1CH until relay 1CS picks up, and then over front contact *d* of relay 1CH, releasing after the transmission of the corresponding "track occupied" code, provided relay TR is then energized. When relay 1TS releases, its contact *b* operates to release relay 1CH to effect the transmission of a "track clear" code.

In installations having a large number of stations and controlling heavy traffic it may happen that the number of changes occurring is sufficient to keep the apparatus in continuous operation for considerable periods of time, resulting in undue delay in the delivery of codes from inferior stations if the stations are given access to the line in a given order of code superiority as described.

Relay SS provides means for preventing undue delay under this condition. Assuming for example, that several stations initiate codes at the same time, it will be evident that the codes will be transmitted in a fixed order, each relay CS which picks up at the beginning of the series of codes being released at the end of its code, until all are released. When wire 17 becomes energized at the end of each code, a relay ST will be picked up to initiate the next code before relay SS has had time to close its contact *a*. Consequently no additional relays CS can be picked up. In other words, each station unit is allowed to transmit only one code if some other station has a code stored for transmission, for the reason that its relay CS cannot be picked up in response to a change in station conditions unless the line has been free for an interval somewhat longer than the normal interval between successive codes.

Referring now to Fig. 2C, this view together with Fig. 2A shows the apparatus required at a field location at which the number of controlled devices exceeds the capacity of a single office panel, as for example, would be the case in the control of a remotely controlled interlocking as indicated by the track plan in Fig. 11 of my prior patent. In Fig. 2C as shown, it is assumed that the location includes four groups of devices each similar to that of Fig. 2B, comprising stations Nos. 5 to 8, inclusive of which only station No. 5 is shown.

The code combination required for each of the different stations may be readily ascertained from the connections of the starting button contacts as shown in Fig. 1B. In view of the description of that view and of Fig. 2B already given, it will be readily apparent that the apparatus of Fig. 2C is connected to respond to the code calls set up by the operation of buttons 5P to 8P, in which step three is long and step four short. These code calls differ one from another only in respect to steps five and six, and the two relays P5 and P6 provide circuits for the selection of four relays 5S to 8S similar to the correspondingly numbered selector relays O5S to O8S of Fig. 1B.

With the apparatus of Fig. 2C in the receiving condition it is clear that any one of the four codes to which it is adapted to respond will suffice for the operation of the maintainer's call signal MC, accordingly this feature is arranged as in Fig. 2B.

The circuits for operating the stick polar relays such as relay 5WS differ from those of Fig. 2B in that they are selected over contacts of the associated delivery relay 5D, and they are consequently similar to those for the indication relays K of Fig. 1B, already described.

The step-by-step operation of the apparatus of Figs. 2A and 2C in response to a control code transmitted to station No. 5, for example, will now be described.

Assuming the system to be in its normal at rest condition, the operation of the office starting button 5PB picks up relays P2, P4, and P5 of Fig. 1B, energizing relay ST of Fig. 1A to pick up relay O5S, thereby connecting terminal B to wire 28 to pick up relay M of the office coding unit to initiate the code, which differs from the one already described in detail, by having a short fourth step. It is to be understood that the coding unit for stations 5 to 8 is the only one responsive to codes having a long third step and a short fourth step and consequently the only one at which relay 5 picks up. Relay E, Fig. 2A picks up in response to the short first step and prepares a circuit closed when relay L1 releases on the long fourth step, over wire 65, to pick up relay P5, Fig. 2C. Relay L1 reverses relay KS1, and the closing of front contact *b* of relay P5 connects wire 25 to wire 59 extending to terminal C at the reverse contact *b* of relay KS1 so that relay 6 of the station coding unit picks up in unison with the office relay 6, which is energized over a similar circuit. In a similar manner, relay P6 of Fig. 2C is picked up on the sixth step to prepare a circuit for relay 7. At the office and at the location of stations Nos. 5 to 8, relay 7 picks up on step seven, and then on step eight, relays 8 and CR pick up, and at the field location terminal B is connected to wires 21 and 9 to pick up relays 5S and 5D, in turn, and to operate relay MCR in accordance with the character of step 7. The closing of contact *a* of relay 5D completes a circuit from terminal B through the lower winding of relay 5CS to terminal C, so that relay 5CS picks up. The closing of contacts *b*, *c*, and *e* of relay 5D connects relays 5WS, 5LHS, and 5RHS to the wires 48, 49, and 51 leading to the coding unit to prepare circuits for operating these relays in accordance with the character of steps eight, nine, and eleven, respectively, as already described. When the sixteenth step is reached, the apparatus restores to normal in the usual manner, but relay 5CH remains picked up over a stick circuit extending from terminal B at back contact *k* of relay 5S over its own front contact *a* and lower winding to terminal C.

If button 8PB had been operated in place of button 5PB, for example, steps five and six of the code would have been short steps and relays P5 and P6 would have remained released, resulting in the operation of a selector relay 8S and the corresponding delivery relay 8D, not shown, to deliver the code to station No. 8. If, however, due to a fault, relay P5 or P6 at the station fails to pick up on the corresponding long steps of a code for station No. 5, relay 8S is not operated for the reason that in that case the station counting relay 6 or 7 will not be operated.

The transmission of indication codes by the apparatus of Fig. 2C is effected by the provision of a pair of relays such as the relays 5CH and 5CS for each group of devices, together with a single relay SS, which relays function like the corresponding relays of Fig. 2B.

In Fig. 2C each relay CS is provided with additional contacts for operating the station pilot

relays P over circuits similar to those controlled by the starting buttons PB in Fig. 1B, in other words, they function as described in connection with relay OICS of Fig. 3, except that the check circuit including wire 28 is omitted. It follows that if relay 5CS is picked up, the release of relay LI at the end of the control code described completes a circuit from terminal B at wire 17 over contacts *d* and *e* of relays 5CS, wires 75 and 76 through relays P5 and P6 to terminal C so that relays P5 and P6 pick up, extending the connection of terminal B over their contacts *c* to wire 15 to pick up the station starting relay ST, which in turn picks up relays 5S and M to initiate an indication code in which steps one, five, and six are long and steps two and four are short, to select the office panel for station No. 5, and in which steps seven to fifteen are controlled by a group of indicating relays selected by relay 5S. It will be clear that in Fig. 2C, the connections from wire 17 to wires 75 and 76 are so arranged that if the relays 5CS to 8CS are all energized at the same time, the corresponding codes will be transmitted one at a time in order without interference.

Relay SS in Fig. 2C controls the connection to terminal C for the upper winding of each of the relays 5CS to 8CS, and functions as described in connection with Fig. 2B, so that codes for indicating changes occurring after the relays CS have been picked up will be stored by the relays CH and the corresponding relays CS cannot be reenergized until each of the relays CH energized at the beginning of the series has transmitted its code.

In the event the office and one or more stations initiate codes at the same time, the transmission of the second impulse by the office transmitter to make the first step short will open the stick circuit for each field station relay M, if closed, and will also pick up relay E at each field location, and at each location such as that of Fig. 2C at which one or more relays P have been picked up, these relays will be released due to the reversal of the polarity of the current supplied to their stick circuits as already explained in connection with the similar relays of Fig. 1B. Consequently only the office transmitter remains in operation and the apparatus at each station is in proper condition to respond to a control code containing the corresponding station code call. In Fig. 2C, the release of the P relays prepares a circuit for a selecting relay 8S similar to relay 5S shown, but this relay will not be operated unless the corresponding code call is received so as to enable the counting relays to respond to the first eight impulses of the code.

In view of the similarity of Fig. 2C to Fig. 1B, it will be readily apparent that additional relays P controlled over one or more of the steps two to seven of the code may be provided to expand the capacity to eight, sixteen, thirty-two, or sixty-four stations, at the same field location, and that any of the code calls not used at a given location may be used at other locations.

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

Having thus described my invention, what I claim is:

1. A code transmitter for generating different multiple element codes comprising a master relay and a transmitter relay, a group of pilot relays including one for each element in a group of selecting elements in each code, a plurality of sets of contacts including one set for each of the possible combinations of said pilot relays in their operated and released positions, circuits closed in response to the momentary operation of any set of contacts for energizing each pilot relay occupying an operated position in the combination identifying said set of contacts, a circuit controlled by all of the pilot relays which is closed only when each occupies its energized or released position as required for said combination for energizing said master relay when said combination is set up, means controlled by said master relay when energized for setting said transmitter relay into operation to generate a code in which the character of each selecting element is controlled in accordance with the position of the pilot relay for that element, and circuit means effective to prevent any change in the combination of pilot relays set up during the transmission of said code.

2. A code transmitter for generating different multiple element codes all including the same number of selecting elements comprising, a group of pilot relays including one for each element for arranging the selecting elements in different combinations, a plurality of sets of contacts for setting up the different combinations by energizing one or more of said pilot relays in a combination which is distinctive for each set of contacts, a starting relay, a transmitter relay, a plurality of selector relays including one for each combination, a circuit closed in response to the energization of any of said pilot relays for energizing said starting relay, a circuit for each selector relay including a front contact of said starting relay and a front or back contact of each pilot relay so arranged that each selector relay is energized only when the corresponding combination is set up, a circuit including one contact in the operated set of contacts and a contact of the corresponding selector relay closed when such relay picks up for setting said transmitter relay into operation to generate a code in which the character of each selecting element is controlled in accordance with the position of the pilot relay for that element, and circuit means effective to prevent any change in the combination of pilot relays set up during the transmission of said code.

3. Code transmitting apparatus comprising a two position neutral relay having pick-up and stick circuits, means for transmitting a code element in response to the operation of said relay to either of said two positions, circuits including a group of four conductors for operating said relay so arranged that when the relay is in its released position the energization of the first or second conductor completes a pick-up circuit therefor to operate the relay to its energized position in which said stick circuit is closed to hold the relay energized after such conductor is deenergized, the subsequent energization of the third or fourth conductor being effective to operate the relay to its released position by short circuiting its winding, timing means effective to delay the operation of said relay to its energized or released position when said second or fourth conductor becomes energized to thereby prolong the corresponding code element, and means for energizing said conductors in a predetermined or-

der to operate said relay repeatedly in accordance with a particular code.

4. In combination with a line circuit, code transmitting apparatus comprising a transmitter relay of the neutral type for controlling said line circuit, a series of contacts arranged to be closed one at a time in order in response to the alternate pick-up and release of said transmitter relay, a series of pick-up circuits for said relay each providing a connection from one terminal of its winding of a source of current over a different contact of the series, each such contact being one which is closed in response to the release of said transmitter relay, a stick circuit for said relay independent of said series of contacts providing a connection from said one terminal of the relay winding to said source of current over a front contact of said relay, a series of circuits for shunting said transmitter relay each providing a connection from the other terminal of the relay winding to said source of current over a different contact of the series each such contact being one which is closed in response to the operation of the relay to its picked up position, timing means set into operation to close said contacts at the end of a predetermined time interval following each operation of said transmitter relay, and means for interposing a contact of said timing means in any of said circuits prepared by said series of contacts to delay the next operation of said transmitter relay for a predetermined time interval.

5. In a remote control system, a transmitter for generating a series of code elements each of which may have one selected character or another arranged in different code patterns each pattern constituting a distinctive code, a group of code determining conductors including one for each element of said series, means for determining the character of each code element generated by the transmitter in accordance with the condition of energization of a different conductor in said group, a plurality of contact sets, one for each different code pattern, one set being effective when operated to supply energy to all of said conductors as required to form its code pattern, others to supply energy to certain of said conductors only and still others to supply energy to said remaining conductors as required to form their respective code patterns, and interference preventing means comprising additional contacts in certain sets only which open when a contact set is operated to supply energy to certain of said conductors only, said additional contacts serving to disconnect other contact sets from said remaining conductors so that when a plurality of sets are operated only one set is effective to determine which of the conductors are to be energized.

6. In a remote control system, a transmitter for generating a series of code elements each of which may have one selected character or another arranged in different code patterns each pattern constituting a distinctive code, a group of code determining conductors including one for each element of said series, means for determining the character of each code element generated by the transmitter, in accordance with the condition of energization of a different conductor in said group, and means for selecting different code patterns for successive transmission comprising a code determining relay for each code pattern, said code determining relays having front contacts which when closed supply energy to said conductors, one relay being arranged to supply energy to all of the conductors others to supply energy to selected conductors only as required to form the different code patterns, interference preventing means comprising back contacts of certain ones only of those relays which supply energy to selected conductors, said back contacts being connected in series with the remaining conductors so as to render only one such relay effective to determine the code pattern when a plurality of such relays are energized at the same time, means for independently energizing said code determining relays effective only when said code transmitter is not in operation, means for setting said transmitter into operation in response to the energization of any of said code determining relays, and means controlled by said transmitter for selectively releasing each code determining relay in response to the transmission of a series of code elements having the corresponding code pattern.

7. In a remote control system, a transmitter for generating a series of code elements of one selected character or another arranged in different code patterns each constituting a distinctive code, a group of code determining conductors including one conductor for each code element of the series, means for generating a code element of one character when the corresponding conductor is energized and of another character when such conductor is deenergized, a plurality of contact sets including one set for each of the different code patterns in which said elements may be arranged, each set except one including one or more normally open contacts which are effective when the set is operated to supply energy to only those conductors the energization of which is required to form the corresponding code pattern said sets being arranged in a given order of code superiority, and interference preventing means rendering only one contact set effective to determine the code pattern regardless of the operation of other sets, comprising normally closed contacts controlled by certain of the sets by which superior code patterns are formed which serve to disconnect those conductors the deenergization of which is required to form such code patterns, so arranged that the operation of one contact set to form a superior code pattern serves to energize one or more conductors and to disconnect another conductor from the contacts of other sets by which inferior code patterns are formed if the deenergization of such conductor is required in order to form the superior code pattern corresponding to said one contact set.

8. In a remote control system, a transmitter for generating a series of code elements of selected character arranged in different code patterns each constituting a distinctive code, a group of code determining conductors including one conductor for each code element of the series, means for generating a code element of one character when the corresponding conductor is energized and of another character when such conductor is deenergized, a plurality of contact sets including one set for each of the different code patterns in which said elements may be arranged, each set except one including one or more normally open contacts which are effective when the set is operated to supply energy to only those conductors the energization of which is required to form the corresponding code pattern, and interference preventing means rendering said conductors subject to control by said contact sets one set at a time in a given order of code superiority, comprising normally closed contacts included in only those

sets by which superior code patterns are formed, by means of which any conductor may be disconnected from the contacts of inferior sets in response to the operation of a superior set if the deenergization of such conductor is required in order to form the code pattern corresponding to said superior set.

9. In a remote control system, a transmitter for generating a series of code elements of selected character including a group of selecting elements arranged in different code patterns, additional elements the character of which is determined by the positions of movable devices there being a group of such devices for each different code pattern, a group of pilot relays including one for each selecting element of the series, a selecting relay for each group of movable devices, means for governing said transmitter to cause each selecting element to have one character or another in accordance with the energized or released condition of the corresponding pilot relay, a plurality of contact sets including one set for each of the code patterns in which said selecting elements may be arranged, means comprising the contacts of each set for energizing each pilot relay the energization of which is required to form the corresponding code pattern, means for energizing each selector relay comprising a circuit including contacts of all of the pilot relays completed when the pilot relays occupy the positions required for the corresponding code pattern, means for setting the transmitter into operation in response to the operation of any one of said contact sets when the corresponding code pattern has been set up, means controlled by the energized selector relay for governing the character of the additional elements of said series each in accordance with the position of a different one of the movable devices in the corresponding group, and means controlled by the transmitter for maintaining each pilot relay in its operated or released position as required to maintain such selector relay energized until the series of code elements has been generated.

10. In a remote control system, a transmitter for generating a series of code elements of selected character arranged in different code patterns each constituting a distinctive code, a group of pilot relays including one for each element of the series, means for generating an element of one character or another in accordance with the energized or released condition of the corresponding pilot relay, a plurality of contact sets arranged in a given order of code superiority including one set for each of the code patterns in which said elements may be arranged, means comprising normally open contacts in each except one of said sets, which when any of such sets is operated complete circuits for energizing each pilot relay the energization of which is required to form the corresponding code pattern, and means comprising back contacts of one pilot relay which is energized in response to the operation of one contact set to form a superior code pattern for opening a contact in the circuit for another pilot relay to maintain it released as required for the code pattern of said one contact set even though another contact set controlling an inferior code pattern is operated to close a contact in the energizing circuit for said other pilot relay.

11. In a remote control system, a code transmitter for generating a series of code elements of selected character arranged in different code patterns, a group of pilot relays including one for each element of the series, means for controlling the character of each element generated by said transmitter in accordance with the energized or released position of the corresponding pilot relay, a plurality of sets of code determining contacts including one set for each of the code patterns in which said elements may be arranged, a plurality of selector relays including one selector relay for each set of contacts, means responsive to the operation of any one of said sets of contacts for first energizing only those pilot relays the energization of which is required to form the corresponding code pattern and for then selectively energizing the corresponding one of said plurality of selector relays, the energizing circuit for each selector relay being closed in accordance with the energized or released positions of all said pilot relays only when they are arranged to form the code pattern identifying the corresponding set of contacts, and a circuit including an additional contact in the operated set of code determining contacts and a front contact of the associated selector relay for setting said code transmitter into operation to generate said series of code elements.

12. In a remote control system, a code transmitter for generating a series of code elements of selected character arranged in different code patterns, a group of pilot relays including one for each element of the series, means for controlling the character of each element generated by said transmitter in accordance with the energized or released position of the corresponding pilot relay, a plurality of push buttons including one for each different code pattern to be transmitted, means responsive to the momentary operation of any push button when said transmitter is not in operation to energize one or more of the pilot relays if such energization is required to set up the code pattern for the operated button, a starting relay, an energizing circuit for said starting relay controlled by all of the pilot relays and arranged to be closed in response to the operation of any of said push buttons when said transmitter is not in operation but only if the pilot relays occupy the positions required for the corresponding code pattern, means acting when said starting relay is energized to set the transmitter into operation to generate a series of code elements having a code pattern in accordance with the positions of the pilot relays, and means controlled by the transmitter for preventing a change in the position of any of said pilot relays during the transmission of a code.

13. In a remote control system, a code transmitter for generating a series of code elements of selected character including a group of selecting elements arranged in different code patterns and additional elements the character of which is determined by the positions of movable devices, a plurality of groups of such movable devices including one group for each code pattern, a normally energized change relay, a selector relay and a code determining relay for each group, means for releasing each change relay in response to a change in position of any movable device in its group, means for energizing each code determining relay in response to the release of the corresponding change relay, a group of code determining conductors, means for determining the character of each of the selecting elements in each series, each in accordance with the condition of energization of a different conductor in said group, circuits controlled by each code determining relay when energized for setting said

code transmitter into operation and for supplying energy to one or more of said conductors to cause the selecting elements of the resulting code to have a distinctive pattern identifying a particular code determining relay which is energized even though a plurality of such relays are energized at the same time, means controlled over said conductors for energizing the selector relay for the group of devices identified with said particular code determining relay, circuits controlled by said energized selector relay for governing the character of the additional elements of said series each in accordance with the position of a different one of the movable devices in its group, means for reenergizing each change relay having its storage relay energized when said transmitter is set into operation, means for holding each energized code determining relay picked up until the corresponding code is completed, and means effective when one or more code determining relays have been energized for preventing the energization of any other code determining relay in response to the release of its change relay until after all of said energized code determining relays have been released.

14. In a remote control system, a code transmitter for delivering to a line circuit a series of code elements including a fixed number of selecting elements arranged in different code patterns each constituting a distinctive code, a plurality of code determining relays arranged in a given order of code superiority including one for each different code pattern, means effective when a code determining relay is energized and the line circuit has been free for at least a brief time interval to set the code transmitter into operation to deliver a code to said line circuit, a group of conductors including one for each selecting element for controlling the pattern of the transmitted codes, means including front contacts of each code determining relay for supplying energy selectively to one or more of said conductors as required to form the code pattern identifying such relay, certain of said relays having back contacts connected in series with the remaining conductors so arranged that but one such relay is effective at a time to select the code pattern even though other code determining relays having inferior code calls are also energized, circuits controlled in accordance with the pattern of the transmitted codes for releasing each energized code determining relay at the end of a code of corresponding pattern, said circuits being so arranged that a plurality of code determining relays energized at the same time effect the delivery of their codes one at a time in a fixed order, a slow pick-up relay, means for energizing each code determining relay effective only when said slow pick-up relay is in its picked up position, and means for energizing said slow pick-up relay only when the line is free, said relay assuming its picked up position only when the line remains free for a time interval which is longer than the brief time interval required to set the code transmitter into operation if a code determining relay is already energized.

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