

June 6, 1944.

G. W. BAUGHMAN ET AL

2,350,668

REMOTE CONTROL SYSTEM

Filed Aug. 21, 1942

4 Sheets-Sheet 1

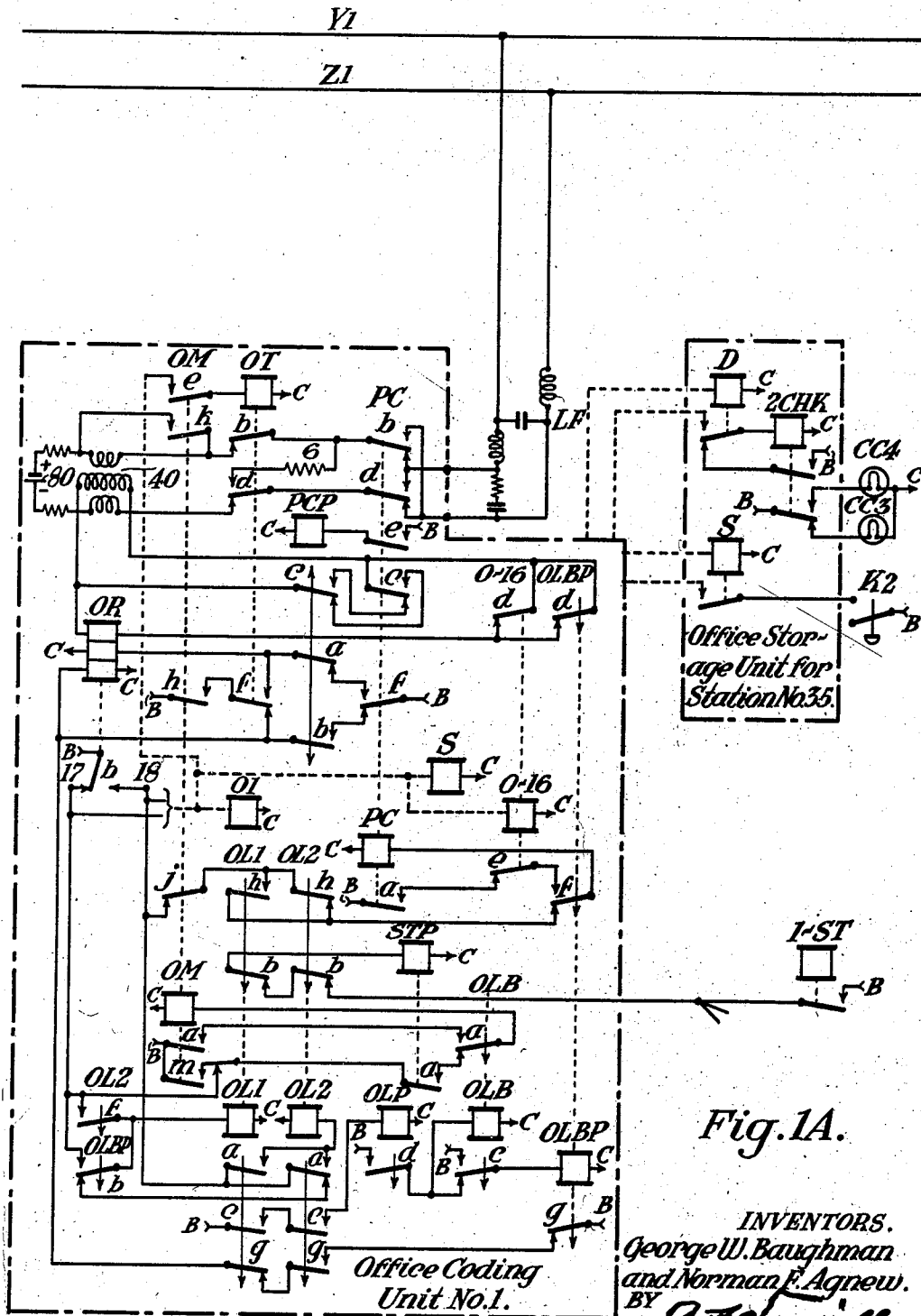


Fig. 1A.

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June 6, 1944.

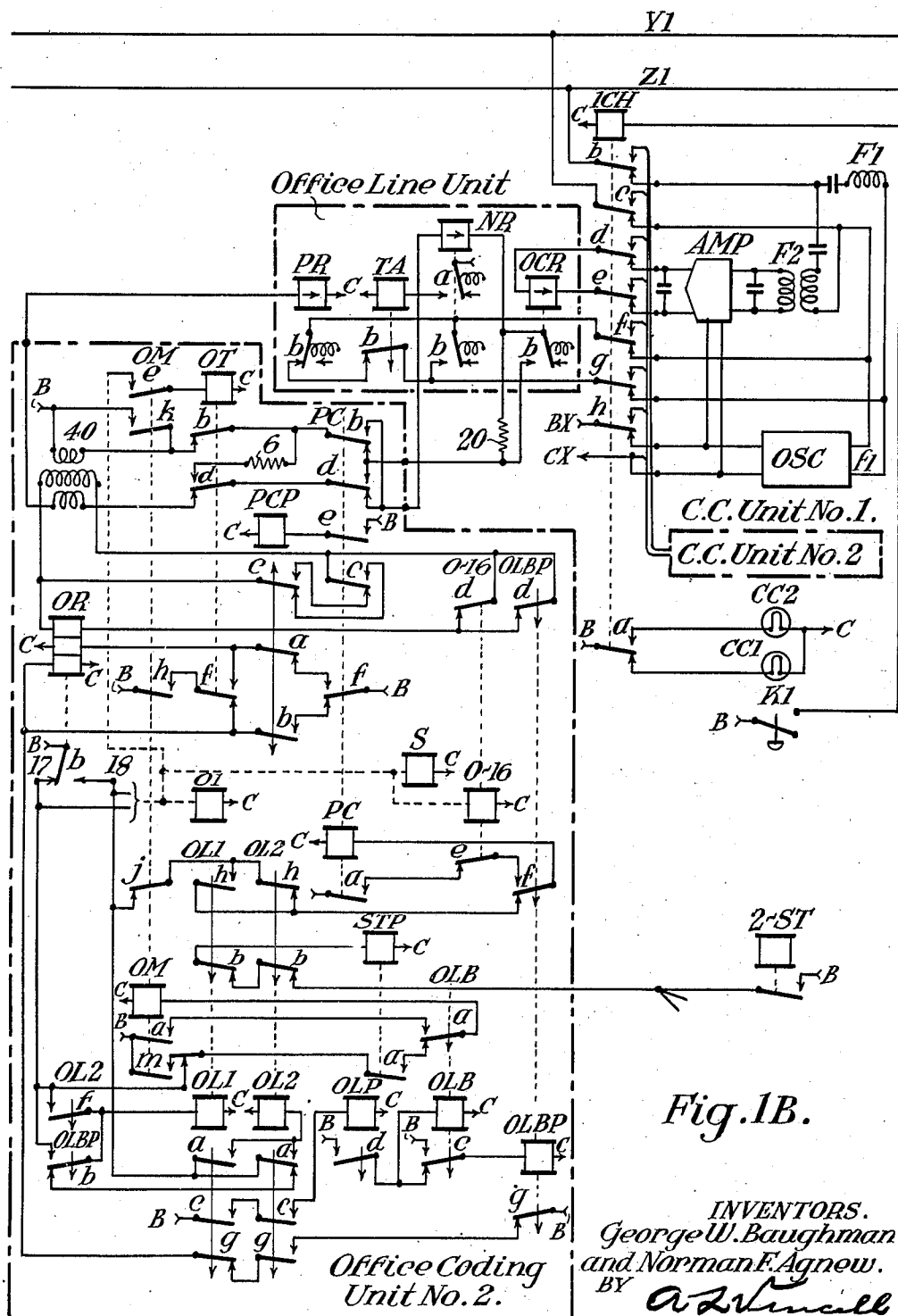
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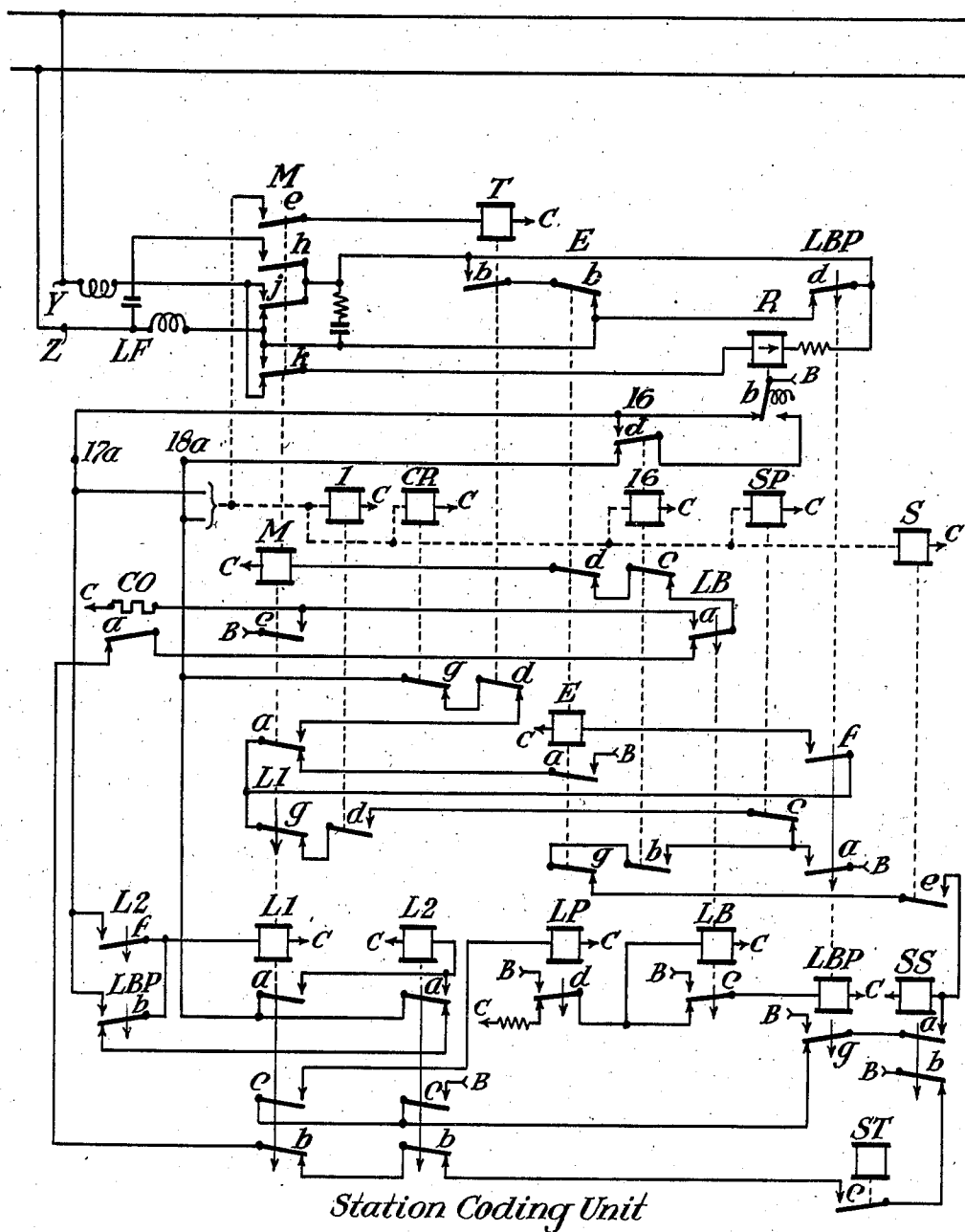


Fig. 2A.

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4 Sheets-Sheet 4

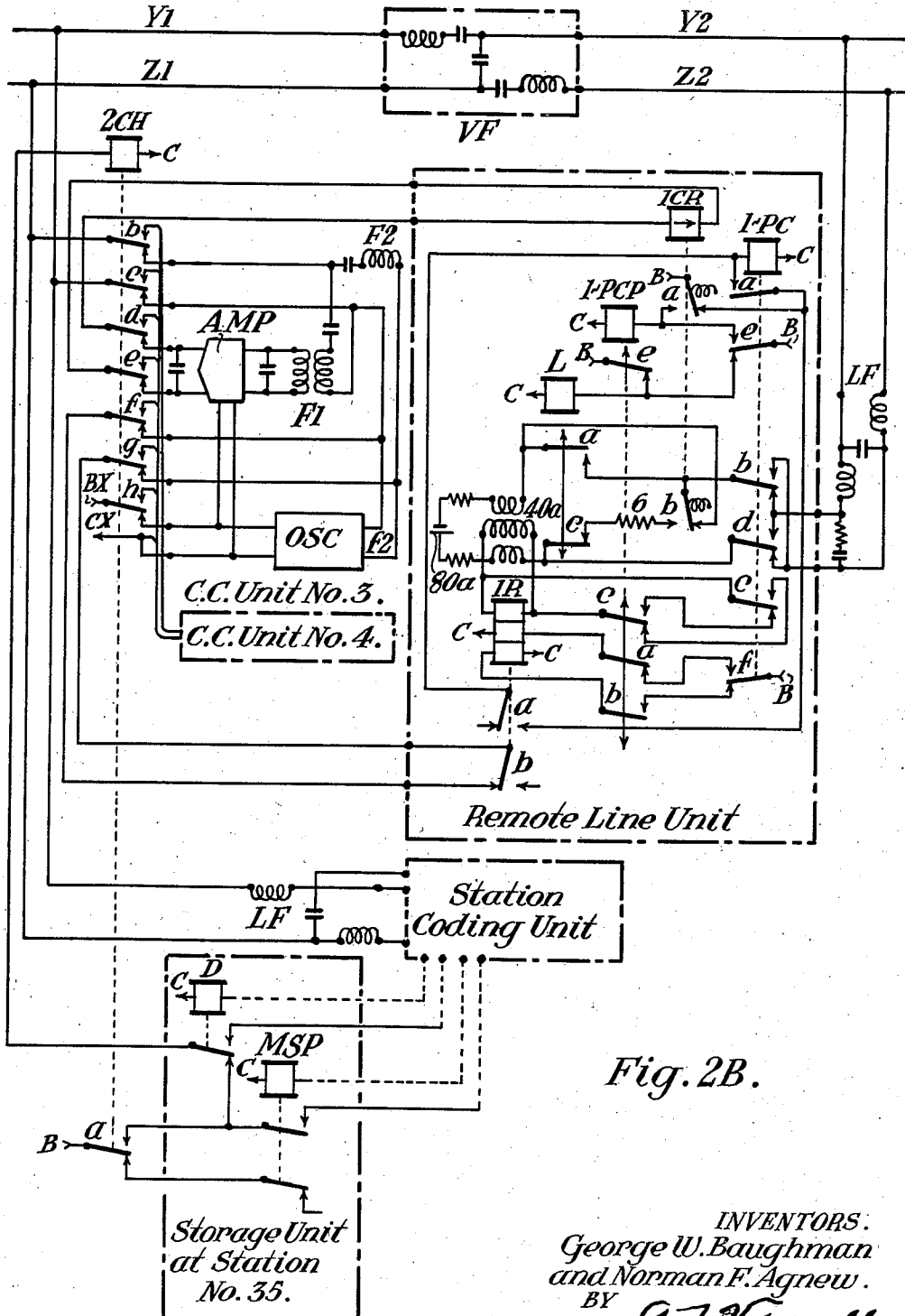


Fig. 2B.

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UNITED STATES PATENT OFFICE

2,350,668

REMOTE CONTROL SYSTEM

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Application August 21, 1942, Serial No. 455,577

13 Claims. (Cl. 177—353)

Our invention relates to remote control systems, and more particularly, to the communication or line circuits for such systems.

Our invention is particularly adapted for, though in no manner limited to, centralized traffic control systems for railroads, in which a train dispatcher's office or other suitable point of control is connected with a plurality of field stations by line wires, over which impulse codes of signals are transmitted for controlling selected track switches and railway signals at the stations, and for indicating, at the control office, the condition of the controlled switches and signals, and for also indicating the positions of trains in the controlled territory.

Our invention may advantageously be applied, for example, to the centralized traffic control system of the "time code" type, such as is disclosed in Letters Patent of the United States No. 2,229,249, granted January 21, 1941, to L. V. Lewis, for Remote control systems.

In Letters Patent of the United States No. 2,208,446, granted July 16, 1940, to G. W. Baughman, for Remote control apparatus, means are disclosed for providing additional communication channels for telephone communication or for code signaling, or both, over the series line circuit of the system of the above-mentioned Lewis patent, and for utilizing these additional channels to provide a multiplex C. T. C. system in which a plurality of sets of coding apparatus employ the same line wires without interference. In accordance with this arrangement, when the number of stations or the length of the line is greater than can be well handled by the system as shown in the Lewis patent, the line is divided into sections by means of electrical filters or the like at one or more points, each section providing a battery line circuit for the control of the usual number of way stations, and the code signals transmitted between the control office and the stations included in the remote sections are relayed over the intervening sections by the use of two non-interfering one way carrier current channels, employing alternating currents of different frequencies.

In our prior application, Serial No. 326,440, filed March 28, 1940, now Patent No. 2,303,875, issued December 1, 1942, for Remote control systems, we have disclosed improvements upon the time code system above referred to, employing a central battery bridged line circuit, which has the advantage over the series line circuit as used, for example, in the system of this Baughman patent, that the station line relays and code trans-

mitting contacts are bridged across the line wires so that the line wires do not require to be sectionalized at any way station. In other words, our prior application discloses a remote control system of the central battery type, in which communication is effected in two directions between the office and stations over line wires which are maintained continuous from end to end, as is required, for example, when the line is simplexed to provide a ground return telegraph channel. This arrangement greatly facilitates the non-interfering use, by the C. T. C. system, of line wires already equipped to provide a plurality of channels for telephone or telegraph communication or for other purposes, as described more fully in our prior application.

The present invention relates to improvements upon the system of this prior application, comprising the adaptation of that system to multiplex operation along the lines of the above-mentioned Baughman patent. In accordance with our invention, one of the plurality of non-interfering communication channels which two line wires afford provides a central battery bridged line circuit for one set of C. T. C. apparatus comprising the office and station coding units of the Lewis patent, while one or more additional sets of similar apparatus each having its own line circuit are arranged to be governed from the same central office by remote control, each additional set employing two one-way channels including the same line wires, over which alternating currents of different frequencies modulated in accordance with the codes are transmitted. Line units of a novel type are interposed between the office coding unit and the battery end of the line circuit to which the station coding units are connected, at each end of the alternating current line, for effecting the transmission of the alternating current codes and for other purposes incidental to the proper operation of the system, as will now be pointed out.

In our central battery bridged line system, the transmission of indication codes from the stations to the office is effected by periodically connecting the line wires together at the transmitting station through a low-pass filter so as to vary the current delivered by the line battery in accordance with the code. These codes of current variations are received at the office by a polar line relay connected to the line through a transformer, and thereby rendered responsive to the variations. This line relay is of the magnetic stick type, arranged to be held in its last operated position when deenergized, and is so con-

trolled by timing relays included in the office coding unit that it is automatically restored to its normal position after a time interval if it is accidentally reversed, and the relay is in that manner maintained in its normal position when no signals are being transmitted over the line.

A feature of the present invention is the provision of means for similarly governing a line relay of this type, without the provision of corresponding timing relays, when the relay is located at a point remote from the office, at which no coding unit is available.

Another feature of our system as disclosed in our prior application relates to provisions for preventing interference when two or more transmitters initiate their codes at the same time. These provisions include the use of current of a normal polarity for control codes, and of a reverse polarity for indication codes. The line polarity is reversed by the action of the office coder in response to the first impulse of an indication code, and the station transmitter is thereby conditioned to complete its code. The office transmitter takes precedence if it happens to start at the same time as a station, while if two or more stations start at the same time, but one remains in control of the line dependent upon the relative superiority of their respective codes. The system as disclosed herein operates similarly, and a feature of the present invention resides in the provisions for reversing the polarity of the remote line circuit for the transmission of an indication code, and for restoring it to normal upon the receipt of a complete code at the control office.

A further feature of our invention, dependent upon the foregoing, resides in the provisions for reinitiating a station transmitter if its indication code is not received complete at the control office even though the code is transmitted over a one-way channel the condition of which is not observable at the sending station.

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

Two forms of apparatus embodying our invention will now be described, and the novel features thereof will then be pointed out in claims.

Referring to the accompanying drawings, Figs. 1A and 1B illustrate the office equipment, and Figs. 2A and 2B the field equipment for a multiplex C. T. C. system embodying our invention. More particularly, Fig. 1A shows in diagrammatic form the office apparatus employed for the direct control of a group of stations located at spaced points adjacent the line wires Y1 and Z1 each equipped as shown in Fig. 2A. Figs. 1B and 2B show the apparatus located respectively at the office and at the control end of a remote line, as arranged for the remote control of a second group of stations located at spaced points adjacent the line wires Y2 and Z2, each of which stations is also equipped as shown in Fig. 2A. This remote control apparatus of Figs. 1B and 2B is adapted to employ the same line wires Y1 and Z1 as those used for direct control and additional sets of the remote control apparatus may be superimposed upon these line wires and also upon the line wires Y2 and Z2 as required, without interference.

Referring to Fig. 1A, the apparatus enclosed within the dot-and-dash line and bearing the legend "Office coding unit No. 1" comprises a portion of the office coding unit of Fig. 1 of the Lewis Patent No. 2,229,249, modified in accordance with our invention and corresponding gen-

erally to the portion marked "Office" in Fig. 1 of our prior application hereinbefore referred to. This coding unit is interposed in the usual manner in the connections between the line battery 30 and the line wires Y1—Z1 to which the stations controlled by this office coding unit are connected. It will be understood that the remainder of this coding unit, not shown herein, and likewise the office storage units which it controls, of which one is to be provided for each panel containing the levers and lamps required for the control of a station, are arranged as described in the Lewis patent. A portion of one of these storage units is shown at the right in Fig. 1A.

In Fig. 1B a portion of a coding unit is shown, bearing the legend "Office coding unit No. 2," which is identical with the No. 1 unit in respect to its internal connections, but which is arranged to control a second group of stations located along a remote line circuit, by means of connections to an "Office line unit," comprising a group of four relays, which in turn, is connected to the line wires Y1 and Z1 through a carrier current unit containing a suitable oscillator and amplifier, and designated "C. C. unit No. 1."

The interposed line and C. C. units serve to transform the control codes of interrupted direct current produced by the coding unit No. 2 into modulated alternating current of frequency f_1 in the line Y1—Z1, and to receive modulated alternating current of a different frequency f_2 from the line and to transform it into codes of battery current variations to govern the line relay 30R of the coding unit.

As insurance against an interruption of service, a reserve C. C. unit No. 2, similar to the No. 1 unit, is arranged to be interposed in place of No. 1 by the operation of a changeover relay 1CH, in response to the closing of a manually operable key K1.

Fig. 2A shows a portion of the station coding unit of Fig. 6 of the above-mentioned Lewis patent, but modified in accordance with our invention and corresponding generally to the portion marked "C. T. C. station" in Fig. 1 of our prior application above referred to. It will be understood that the remainder of the station coding unit, not shown herein, and likewise the station storage unit or units which it controls, function as described in the Lewis patent, and that one such coding unit is to be located at each controlled station. The line terminals Y and Z of the coding unit at each station controlled by office coding unit No. 1 are to be connected across line wires Y1 and Z1, while those of the coding unit at each station controlled by additional office coding units such as No. 2 are to be connected across the line wires of the corresponding remote line circuit.

Fig. 2B shows the apparatus located at the control or battery end of each such remote line circuit, the line wires of the remote line shown herein being designated Y2 and Z2. This apparatus is interposed between these line wires and another pair extending toward the office, such as Y1 and Z1, and its purpose is to transform the modulated alternating current of frequency f_1 received from the office into control codes of interrupted direct current in line Y2—Z2, and to transform the indication codes of battery current variations received from that line into modulated alternating current of frequency f_2 in line Y1—Z1. The two lines shown in Fig. 2B may be different sections of the same through telephone

line, isolated with respect to the coded currents by a band-pass filter VF or otherwise. The apparatus of Fig. 2B includes a "Remote line unit" comprising a group of five relays, and a carrier control unit designated "C. C. unit No. 3" structurally identical with the C. C. units at the office but with the coils and condensers F1 and F2, comprising filters for selectively passing the corresponding frequencies f_1 and f_2 , interchanged in position. It is to be understood that other sets of apparatus as shown in Fig. 2B may be arranged to employ the same line wires by the use of different filters arranged to pass other frequencies as required, and that the oscillators OSC of the carrier current units may be adjusted by the operation of a suitable switch, not shown, to deliver any one of the frequencies used in the system.

A reserve carrier current unit, here designated No. 4, is arranged to be interposed in place of No. 3 by the operation of a changeover relay 2CH. This relay, moreover, is arranged to be remotely controlled from the office by transmitting a code to the last station, designated No. 35, on the first section of the line. Thus the operator at the office, by positioning a manually operable key such as K2, Fig. 1A, is enabled to transmit a code over any section to replace the C. C. unit which governs the transmission of codes over the next succeeding section of the through line. The particular carrier current units in service at any time are indicated at the office by the lighting of correspondingly numbered lamps CC shown in Figs. 1A and 1B, those for the units at the office being controlled directly by relay 1CH, and those for the units at the remote location being governed by indication codes transmitted by station No. 35 in accordance with the position of relay 2CH.

It is also to be understood that the line wires may also be used for the operation of a telephone call selector system, arranged either as shown in our prior application above referred to or in other ways, such for example as shown in our application, Serial No. 401,092, filed July 5, 1941, now Patent No. 2,332,191, issued October 19, 1943, for Remote control systems.

A feature of our invention, as will be apparent from the foregoing, is the construction of a system of the character described from interchangeable units of a relatively few types and in the provision of arrangements for insuring continuity of service, a factor of importance in view of the large amount of apparatus that may be involved, and in view of the use of existing line wires which may extend over relatively long distances.

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

The relays shown herein which correspond with relays of the Lewis patent are designated by the same reference characters as employed in the patent, the office relays being distinguished by the prefix O and those of the remote line unit by the prefix I, where corresponding relays are used in the office and in the field. In the patent, all of the code system relays are of the same general type, but some of the relays shown herein are of other types. For example, the line relays OR and IR are of the stick polar type, each being adapted to hold its contacts in the last operated position when the relay is deenergized. These relays may be, for example, of the type shown in Letters Patent of the United States No. 2,140,604, granted December 20, 1938, to C. S. Snively. The

station line relay R of Fig. 1B, and likewise relays PR, NR and OCR of the office line unit of Fig. 1B and relay ICR of the remote line unit of Fig. 2B are of the biased polar type, such for example, as shown in Letters Patent of the United States No. 2,283,270, granted May 19, 1942, to R. M. Laurenson, each of these relays being identified by a horizontal arrow to indicate that it is responsive only to current flowing in the corresponding direction.

It is to be understood that each biased or stick polar relay shown herein responds to close its left-hand contacts when the positive terminal B of a suitable source of current is connected to its winding at the left, with the negative or common return terminal C of the same source connected to its winding at the right, and that when these connections are interchanged the relay is operated to its right-hand position, the latter position being the one to which the biased relays move their contacts when they become deenergized.

Wires 17 and 18 connected to the normal and reverse contacts of relay OR in Figs. 1A and 1B correspond to the wires leading from the office coding unit to the front and back points, respectively, of contact b of relay OR of Fig. 1 of the Lewis Patent No. 2,229,249, while wires 17a and 18a in Fig. 2A correspond with those leading from the station coding unit to contact b of the station line relay R of the patent.

Considering first the direct control system of Figs. 1A and 1B, the normally closed line circuit may be traced from the line battery 80 through the primary of transformer 40, back contacts b and d of the transmitter relay OT and of the pole changer relay PC through a low pass filter LF to the line wires Y1 and Z1, and thence in multiple, to the terminals Y and Z of the coding unit at each station of the group controlled by office coding unit No. 1, where a branch is completed as shown in Fig. 2A through the coils of a similar filter LF, back contacts j and k of the master relay M and the winding of the line relay R, each station line relay being normally energized as shown. The condensers associated with the station filter LF are normally disconnected from the line, thereby materially increasing the impedance to voice frequencies, of the connections across the line at each station, which is of obvious advantage since there may be a large number of such connections bridged across the same telephone line. This arrangement has the further advantage of protecting these condensers against lightning. When relay M picks up, however, the left-hand condenser of the station filter LF is connected across terminals Y and Z at its front contact h, and the right-hand condenser at its front contact j, and the filter functions in the usual manner to render the transmitted code inaudible.

With the system in its normal at rest condition, relay OR is connected to the line circuit through transformer 40, and is thereby rendered responsive to a change in line current of a suitable amount, irrespective of its actual magnitude, and it is to be understood that contact b of relay OR is operated to the right upon an increase in line current, and to the left, as shown, upon a decrease in line current. When relay M of Fig. 2A is picked up, the closing of contact b of relay T connects the line terminals Y and Z together through filter LF to increase the line current to operate contact b of relay OR to the right, and

the line current decreases to its normal value to restore the contact of relay **OR** to its left-hand position when contact *b* of relay **T** opens.

Although relay **OR** is normally deenergized with its contact *b* held in its last operated position, its contact *b* normally occupies the left-hand position, corresponding to the normally energized position of the station line relay **R**, for the following reason: Assume relay **OR** to become reversed as a result of a momentary accidental cross between line wires **Y1—Z1**, for example; its contact *b* connects terminal **B** of the local source of current to wire **18**, causing the timing relays **OL1**, **OL2**, **OLP** to pick up in order, and then relays **OLB** and **OLBP** pick up, as explained in the Lewis patent. Relay **OL1** becomes deenergized again, upon the opening of back contact *a* of relay **OL2**, and if relay **OR** remains reversed, relays **OL1**, **OLP**, **OLB** and **OLBP** then release one at a time in order, each upon completion of its respective release period, relay **OL2** being held energized over its contact *a*. When relay **OLBP** releases, a restoring circuit is closed from terminal **B** over the contacts *g* of relays **OLBP**, **OL2** and **OL1** through the lower winding of relay **OR** to the other terminal **C** of the local source of current, thereby restoring relay **OR** to normal, as shown.

The reversal of relay **OR** has the further effect of completing a circuit from terminal **B** over wire **18**, back contact *j* of relay **OM**, back contact *h* of relay **OL2** or front contact *h* of relay **OL1**, back contact *f* of relay **OLBP** through the pole changer relay **PC** to terminal **C**, and relay **PC** picks up to complete its stick circuit at its contact *a* when relay **OLBP** picks up. Contacts *b* and *d* of relay **PC** reverse the polarity of the current in line **Y1—Z1**, releasing the line relays **R** at each station controlled thereover. By reference to Fig. 2A it will be seen that each relay **R** upon releasing connects terminal **B** to wire **18a**, to cause operations of the station timing relays substantially in unison with the corresponding office timing relays as above described, opening the pick-up circuit for the station master relay **M** at contact *b* of relay **L1** or **L2** to prevent any station from initiating a code at this time.

At the office, relay **PC** is released to restore the line polarity to normal when relay **OLBP** releases to restore relay **OR** to normal. When relay **PC** picks up, the closing of its contact *e* energizes a slow-acting repeater relay **PCP**, which relay picks up shortly thereafter and releases again shortly after relay **PC** releases. The operations of pole-changer contacts *b* and *d* of relay **PC** necessarily causes some variation in the line current through transformer **40**, but the effect of this is nullified by a shunt closed momentarily across the secondary terminals of transformer **40** and the upper winding of relay **OR** at contacts *c* of relays **PC** and **PCP** each time relay **PC** picks up or releases. Furthermore, when relay **PC** picks up upon the reversal of relay **OR**, a local circuit is closed momentarily from terminal **B** over contacts *f* and *a* of relays **PC** and **PCP** and the middle winding of relay **OR** to terminal **C** to maintain relay **OR** reversed, and when relay **PC** release, a second local circuit is closed momentarily over contacts *f* and *b* of relays **PC** and **PCP** and the lower winding of relay **OR** to maintain relay **OR** normal.

When relay **OR** is restored to normal as above described, relay **OL1** becomes energized over wire **17** and front contact *f* of relay **OL2**, reenergizing relays **OLP**, **OLB** and **OLBP**, and then relays **OL2**, **75**

OLP, **OLB** and **OLBP** release, conditioning the apparatus to receive a code, and finally, relay **OL1** is released by the opening of front contact *b* of relay **OLBP** to condition the apparatus to transmit a code. When the station relays **R** pick up in response to the release of relay **PC**, the station timing relays are similarly operated.

It will be seen therefore, that although relay **OR** is arranged to remain deenergized in either position to which it is operated on the successive steps of a code, it is always restored to normal if it remains reversed for a time interval materially longer than that required for the normal operation of the system, and that an accidental operation of that relay which leaves it in an abnormal position merely suspends the operation of the system for but a relatively short period which in practice is in no way detrimental.

The transmission of a control code by the apparatus of Fig. 1A will now be briefly explained, starting with the apparatus in its normal condition, as shown.

The starting relay **1ST** corresponds to any one of the starting relays identified by a code number such as relay **234** in the Lewis patent, and when relay **1ST** is picked up in response to the operation of the corresponding push button as described in the patent, a circuit is closed over back contacts *b* of relays **OL1** and **OL2** to pick up relay **STP**, completing a circuit from terminal **B** at wire **17**, contact *m* of relay **OM**, contacts *a* of relays **STP** and **OLB** through relay **OM** to terminal **C**. Relay **OM** picks up and at its contact *k*, shunts the upper primary winding of transformer **40**, rendering relay **OR** non-responsive to the operation of the transmitting contacts *b* and *d* of relay **OT** in the line circuit, and prepares a circuit at its contact *h* to enable relay **OR** to be controlled locally by the operation of contact *f* of relay **OT**. Relay **OM** also opens its contact *j* in the circuit for relay **PC** to prevent the operation of that relay, and by closing its contact *e*, energizes relay **OT** which then transmits a code of line open and line closed steps as described in the Lewis patent, the line relay **R** at each station operating in unison with relay **OR**. A control code is therefore transmitted by the office coder and received at the selected station in the manner described in the patent.

The transmission of an indication code by the apparatus of Fig. 2A will now be explained, assuming terminals **Y—Z** to be connected across line **Y1—Z1**.

It will be understood that a change in condition of a station device having indications to transmit picks up the start relay **ST**, and if the line relay **R** is steadily energized so that relays **L1** and **L2** are both released, contact *c* of relay **ST** completes a circuit from terminal **B** over back contacts *b* of relays **SS**, **L2** and **L1**, contacts *a* of relays **CO** and **LB**, contact *c* of relay **16**, contact *d* of relay **E**, through relay **M** to terminal **C**.

Relay **M** picks up to initiate the code by closing a shunt across terminals **Y—Z** over its front contact *j* and back contact *d* of relay **LBP**, thereby reversing the office line relay **OR** and releasing the station line relay **R**. The front contacts *h* and *j* of relay **M** connect the condensers of the station filter **LF** across terminals **Y—Z** as already described, and front contact *e* of relay **M** completes the circuit for the transmitter relay **T**, which then picks up to shunt terminals **Y—Z** over contacts *b* of relays **T** and **E**, while contacts *j* and *k* of relay **M** reverse the connections of

relay R to terminals Y and Z to render that relay responsive only to line current of reverse polarity. Relays OR and R initiate the operation of their respective timing relays as already described, relay PC picking up to reverse the line polarity, thereby releasing relays R at all other stations at which relay M is released, these relays remaining released for the duration of the code to lock out their respective stations. Relay T is rendered effective to transmit the indication code by the opening of back contact *d* of relay LBP upon the initial energization of that relay, and then relay T operates its contact *b* repeatedly in the usual manner to transmit the code, relay R at the transmitting station responding to the current of reverse polarity in the line, being released each time relay T picks up and energized each time relay T releases, and relay OR is operated in unison with relay R in response to the current variations impressed on the line by the operation of contact *b* of relay T. The coding units therefore function in the usual manner and the indication code is transmitted by the station and received at the office as described in the patent. As explained therein, each indication code has sixteen steps, the last step comprising the return of the line circuit to normal, a relay 16 at the transmitting station and a similar relay 0-16 at the office being picked up momentarily on this step. In the patent, all line relays assume their normal positions at the beginning of this step, but in the present case this is true of relay OR and of relay R at the transmitting station only.

At the office, relay 0-16 opens its contacts *d* and *e*, opening the circuit over the upper winding of relay 6R to hold relay OR normal, and releasing relay PC, which then releases relay PCP, thereby restoring the line polarity to normal as already described. At the transmitting station, contact *d* of relay 16 disconnects the right-hand contact of relay R from wire 18a and connects it to wire 17a, to prevent further operation of the coding unit by relay R, and contact *c* of relay 16 opens the circuit for relay M, releasing relay M to restore the connections of relay R to normal. The remaining operations of restoring the system to normal are effected in the usual manner as described in the patent.

Code interference is prevented as follows: First, a code cannot be initiated until the line relays have been restored to normal to release relays L2, and relays LBP and L1 have also released, as already described. Second, the direction of transmission is determined in accordance with the character of the first impulse, which is long in each control code and short in each indication code. Relay E is responsive to the long first step of a control code, and in the event the office and a station start at the same time, the line is held open by the office transmitter until after the timing relay L1 of Fig. 2A is released, relay I being picked up on this step, and a circuit is closed from terminal B at front contact *a* of relay LBP, back contact *c* of a relay SP, front contact *d* of relay I, back contact *g* of relay L1, front contact *f* of relay LBP through relay E to terminal C. Relay E picks up and its contact *d* opens the circuit for relay M, which then releases, completing a stick circuit for relay E and conditioning the station unit to receive the control code, and the indication code is stored by relay ST to be transmitted subsequently as described in the Lewis patent. Third, the shunt applied to the line by relay M and relay T is

effective to release the line relay R at any station more remote from the office, which has been conditioned to respond to current of reverse polarity by having its relay M picked up. When two or more stations start to transmit indication codes at the same time, they may continue in operation as long as the code elements of their respective codes are alike, but when a difference occurs one or another is locked out by means of an additional pick-up circuit provided for the station relay E. In this case relays R and T will be out of step, that is, when relay T releases to remove the line shunt, relay R remains released due to the shunt maintained by relay T at another station, completing a circuit from terminal B to wire 18a, back contact *g* of a relay CR, back contact *d* of relay T, front contact *a* of relay M, front contact *f* of relay LBP through relay E to terminal C. Relay E will pick up, opening its contact *d* in the circuit for relay M, and then relay M will release, restoring the connections of relay R to normal. Relay R is thereby rendered non-responsive to the line current of reverse polarity and remains released until the indication code transmitted by the other station is completed, releasing its timing relays and consequently releasing relay E by the opening of contact *f* of relay LBP, as well as releasing the other coding relays, as occurs under similar conditions in the system as described in the patent. It follows therefore that a plurality of indication codes stored by different stations at the same time are transmitted one at a time in order in a definite order of code superiority, as explained more fully in our prior application, Serial No. 326,440.

The apparatus of Fig. 2A includes an additional feature by which undue delay in transmission of codes from the inferior stations is avoided. In transmitting an indication code from any station, a selector relay S is picked up in response to the transmission of the corresponding code call for that station, and at the end of the code, relay SS picks up over a circuit from terminal B at contact *a* of relay LBP, front contact *b* of relay 16, back contact *g* of relay E, front contact *e* of relay S, through relay SS to terminal C. Relay SS therefore picks up at the end of the code transmitted by the same station, and is held energized over a stick circuit extending to terminal B at front contact *g* of relay LBP. As already mentioned, the release of relay LBP during the clearing out operation at the end of a code conditions the apparatus at the corresponding station to receive the next code. The opening of front contact *b* of each relay LBP, due to the release of relay LBP following the release of relay L2 at the end of the code, deenergizes the associated relay L1, and release of relay L1 at any station having its relay ST picked up and its relay SS released initiates the transmission of a code by that station. The relay SS at the station which has just completed its code becomes deenergized upon the release of relay LBP, provided relay L2 is released at the same time as relay L1, but has a longer release period, and so holds the starting circuit open at its contact *b* until after the next code is started, provided another section had a code stored at the same time, whereupon relay SS becomes reenergized and is held picked up for the duration of that code by the closing of front contacts *c* and *g* of relays L2 and LBP. Consequently, when there are a plurality of indication codes stored, the transmission of a second code by any station is delayed until each other

station has had a chance to transmit one code, and the maximum delay in the transmission of any code is measured by the time required to transmit one code from each station.

The operation of the remotely controlled C. T. C. system comprising Figs. 1B and 2B will now be explained, assuming that a plurality of station units of Fig. 2A similar to the one just described are connected to the line Y2—Z2.

The office line unit of Fig. 1B, which is identical with that of Fig. 1A already described, is connected to a dummy line circuit including the oppositely connected biased polar relays PR and NR of the office line unit. This circuit may be traced from terminal B of the local source of current through the upper primary winding of transformer 40, back contacts *b* of relays OT and PC, resistor 20, relay NR, back contacts *d* of relays PC and OT, the lower primary winding of transformer 40 through relay PR to the other terminal C of the same source. Relay PR is normally energized and serves as a direct repeater of relay OT to transmit control codes, while relay NC is normally held in its released position and is picked up only when its connections are reversed by relay PC as occurs when an indication code is being received.

In the carrier control unit No. 1 the oscillator OSC is normally supplied with energy at its left-hand terminals from a local alternating current source indicated by the terminals BX and CX, over back contact *h* of relay ICH, and constantly delivers current of frequency *f*1 at its right-hand terminals, which are connected through filter F1 over back contacts *b* and *c* of relay ICH to line Y1—Z1, but this current of frequency *f*1 is normally shunted over back contacts *f* and *g* of relay ICH and contact *b* of relay PR, and is supplied to the line only when relay PR is released, that is, when relay OT is picked up on the odd-numbered steps of a code.

The current of frequency *f*1 thus is modulated by the operation of contact *b* of relay PR in accordance with the code, and this modulated current is supplied over line Y1—Z1 and back contacts *b* and *c* of relay 2CH, Fig. 2B, through the filter F1 of C. C. unit No. 3, and it is then amplified and demodulated by a suitable amplifier as indicated by the device AMP, energized from the local alternating current terminals BX and CX as shown, and is supplied over back contacts *d* and *e* of relay 2CH to the normally deenergized biased polar relay ICR of the remote line unit.

The remote line circuit is normally energized from the line battery 80a over the primary of transformer 40a, contact *b* of relay ICR, contacts *b* and *d* of the pole changer relay IPC through a low pass filter LF connected to the line Y2—Z2.

The line relay IR of the remote line unit of Fig. 2B is connected to the line Y2—Z2 through transformer 40a, and controls the pole changer relay IPC and its repeater IPCP and in turn is controlled by these relays in a manner generally similar to that already described in connection with relay OR. Relay IPCP however has an additional energizing circuit extending to terminal B at the front contact *a* of relay ICR, so that relay IPCP is energized on each odd-numbered step, and remains picked up for the duration of each control code. Relay IPCP holds relay IR energized in its normal position, as shown, by the energization of the lower wind-

ing of relay IR over the restoring circuit including front contact *b* of relay IPCP. Relay IPC has a pick-up circuit extending from terminal B at the right-hand contacts *a* of relays ICR and IR which is thus held open by relay IR, and relay IPC remains released for the duration of a control code, and the normally energized slow acting relay L remains energized over back contact *e* of relay IPC.

Since the connections from battery 80a to the line are similar to those for battery 80 except that a contact *b* of relay ICR, which is a direct repeater of the office transmitter relay OT, replaces the contacts of the latter relay, it will be apparent that control codes will be delivered to line Y2—Z2 by office coding unit No. 2 similar to those delivered to line Y1—Z1 by office coding unit No. 1 as already described, these codes being received by the coding units of Fig. 2A which are connected to line Y2—Z2 in a manner which will be readily understood without further description.

The line relay IR serves to receive the indication codes comprising battery current variations in line Y2—Z2 and to retransmit them as modulated alternating current of frequency *f*2 over line Y1—Z1 and its operation will now be described.

In the carrier control unit No. 3, the oscillator OSC is arranged to constantly deliver current of frequency *f*2 at its right-hand terminals, which are connected through filter F2 over back contacts *b* and *c* of relay 2CH to line Y1—Z1, but this current of frequency *f*2 is normally shunted over back contacts *f* and *g* of relay 2CH and contact *b* of relay IR, and is supplied to the line only when relay IR is reversed. Each "on" period of the alternating current indication code delivered by relay IR therefore corresponds to an increase in the current supplied to line Y2—Z2, due to the closing of contact *b* of a station transmitter relay T to transmit an odd-numbered step of an indication code. The current of frequency *f*2 thus modulated by the operation of contact *b* of relay IR in accordance with the code is supplied over line Y1—Z1 and back contacts *b* and *c* of relay ICH, Fig. 1B, through the filter F2 of C. C. unit No. 1, and it is then amplified and demodulated by amplifier AMP and is supplied over contacts *d* and *e* of relay ICH to the normally deenergized biased polar relay OCR of the office line unit. When relay T picks up, therefore, the current in line Y2—Z2 is increased, relay IR is operated to the right and current of frequency *f*2 is supplied to line Y1—Z1 to energize relay OCR, which relay closes its contact *b* to shunt resistor 20 to cause an increase in current through transformer 40 to reverse relay OR. Relay OR is therefore a direct repeater of relay IR. Since relay IR is of the stick polar type, it remains to be shown how this relay is arranged to be normally self restoring.

If relay IR becomes reversed as a result of a momentary accidental cross between line wires Y2—Z2, for example, its contact *b* removes the shunt from the line channel of frequency *f*2 causing relay OCR to pick up, thereby reversing relay OR of Fig. 1B. Relay IR also closes its contact *a* causing relays IPC and IPCP to pick up successively, reversing the polarity of the current supplied to line Y2—Z2, thereby releasing the line relays R at each station controlled thereover, and preventing any station from initiating a code at this time. The opening of back contacts *e* of relays IPC and IPCP deenergizes relay L, which releases. Back contact *a* of relay L now closes,

shunting contact *b* of relay ICR to prevent the opening of line Y2—Z2 in response to a control code impulse of frequency *f*1, relay L also opening its contact *c* in the shunt across line Y2—Z2 which includes the left-hand contact *b* of relay ICR and resistor 6. This shunt normally provides a discharge path for the distributed capacity of the line as is desirable when the line is in cable, and corresponds to the similar ones associated with the relays OT and described in the Baughman Letters Patent of the United States No 2,208,446, hereinbefore referred to.

At the office, the reversal of relay OR of Fig. 1B causes the timing relays and relays PC and PCP to be operated as already described in connection with the reversal of relay OR of Fig. 1A, but in the present instance, the operation of contacts *b* and *d* of relay PC reverses the connections to relay NR, causing that relay to close its left-hand contacts *a* and *b*; contact *b* of relay NR applies a shunt across the oscillator output terminals, and contact *a* of relay NR completes the circuit for a slow release relay TA which picks up and at its contact *b* opens the shunt across the oscillator terminals normally closed over contact *b* of relay PR. Relay NR now replaces relay PR in preventing the delivery of current of frequency *f*1 to line Y1—Z1. The office timing relays, with the exception of relay 6L2, now release in sequence, relay 6LBP, the last to release, restoring relay OR and deenergizing relay PC as already described. Relay PC, upon releasing, restores relay NR to its normal position as shown, and relay NR by opening contact *b* allows current of frequency *f*1 to be delivered to the line to energize relay ICR. Contact *a* of relay ICR is therefore operated to the left, releasing relay IPC but holding relay IPCP energized, and these relays cause the energization of the lower winding of relay IR over their respective contacts *f* and *b* to operate relay IR to normal and to hold it energized in that position.

The restoration of relay NR to normal by relay PC opens the circuit for relay TA which releases after an appropriate time interval to terminate the impulse of current of frequency *f*1, whereupon relay ICR releases, and in turn releases relay IPCP.

The release of relay IPC reenergizes relay L and restores the polarity of the current in line Y2—Z2 to normal, reenergizing the station line relays, and finally the timing relays L1—LBP become energized and release in the usual manner to condition the system to send and receive codes.

The transmission of an indication code by the apparatus of Fig. 2A will now be explained, assuming terminals Y—Z to be connected across a line Y2—Z2 having its connections to the control office effected over line Y1—Z1 by means of the two one-way carrier channels provided by the apparatus of Figs. 1B and 2B.

Assuming the apparatus to be in its normal condition as shown, when the start relay ST of Fig. 2A is operated, relays M and T pick up as already described, shunting line Y2—Z2 to cause relay IR of Fig. 2B to reverse, thereby supplying current of frequency *f*2 to line Y1—Z1 to energize relay OCR and consequently increasing the current through transformer 40 to cause relay OR of Fig. 1B to reverse. Relays PC, PCP and the timing relays and in addition the relays NR and TA become energized, and in Fig. 2B, relays IPC and IPCP become energized, deenergizing relay L, as already described. Since relay ICR is

not energized at this time, relay IPC remains energized over its stick circuit regardless of the operation of relay IR and reverses the polarity of the current supplied to line Y2—Z2 to allow relay T at the transmitting station to deliver its code to operate relay IR. Current of frequency *f*2 modulated by the operation of contact *b* of relay IR in accordance with the code is supplied over line Y1—Z1 to operate relay OCR, and consequently to operate relay OR of the office coding unit No. 2, these operations being carried out in the usual manner as already described in connection with the office coding unit No. 1, until the last step, comprising the return of the line circuits to normal is reached, at which time relays 16 and 9—16 pick up and relays PC and PCP release. In the present case relays NR and TA now release successively to transmit a single brief impulse of frequency *f*1 over line Y1—Z1, energizing relay ICR to release relay IPC and thereby restore the polarity of the current in line Y2—Z2 to normal. Relay L is reenergized upon the release of relay IPC, but this relay is of the slow pick-up type and does not operate until after relay ICR has released at the end of the impulse, consequently relay ICR does not repeat this impulse through the remote line unit to the remote station as it does in the case of the control code impulses. The remaining operations of restoring the apparatus to normal follow in the usual manner as already described.

In the event that a control code and an indication code are initiated by the operation of their respective starting relays at about the same time, it will be evident that the control code will take precedence unless relay OR is reversed before relay 6M has closed its front contact *m* and that in the latter case the indication code will take precedence because relay 6M will be unable to pick up, because relay OR will have disconnected terminal B from wire 17 in the pick-up circuit for relay 6M. Otherwise the control code will take precedence, even though relay IPC has been picked up, in which case the operation of relay ICR by the long first step of the control code releases relay IPC immediately and holds the remote line circuit open to condition the stations to receive the control code, just as if relay IPC had not been operated. It will be clear that all of the features of the system by which interference is prevented as described in connection with the direct control of the stations function in the normal manner when the carrier current control is interposed.

Since the indication codes are used for reporting trains it is desirable to guard against their loss in transmission, due to temporary disturbances in the transmitting medium. In the system of the Lewis patent this result is attained by registering each element of the code by the receiver at the transmitting station, and in releasing the starting relay only in response to the delivery to the line circuit of a complete code. It follows that a code which is interrupted due to a temporary cross or open in the line will stop the operation of the line relay at the transmitting station, and the code will be re-initiated when the line is restored. If the station does not succeed in completing its code after several attempts, a thermal relay CO is operated to temporarily discontinue the operation of the station transmitter to allow other stations to transmit their codes.

It will be manifest from Fig. 2A that these provisions are effective in both the direct control

and the remote control forms of the system as disclosed herein insofar as the battery line circuit is concerned, since the operation of the station line relay R is dependent upon the integrity of the line circuit over which the station delivers its codes, but that on the other hand, the condition of the carrier current channel over which the indication codes are transmitted is not directly observable at the transmitting station.

However, the office receiving apparatus functions in such a manner that if the delivery of an indication code is interrupted due to a temporary cross or open in the carrier current channel, the resultant stopping of the periodic operation of the line relay OR will cause the transmission to be stopped and then re-initiated.

Upon the initiation of an indication code by a station on the remote line circuit, relay IPC is picked up by relay IR and relay PC by relay OR, along with the timing relays including relay OLBP, and relay PC energizes relays NR and TA, while relay IPC energizes relay IPCP, which then releases relay L. Relay PC releases either upon the energization of relay O—16 at the end of a complete code or upon the release of relay OLBP due to the stopping of the periodic operation of relay OR before the code is completed, and upon releasing, releases relays NR and TA successively to transmit a single impulse of current of frequency f_1 over the line to pick up relay IC and thereby release relay IPC as already explained. Relay IPC upon releasing restores the polarity of the remote line to normal, and if this occurs before the code is completed the periodic operation of relay R at the transmitting station will cease because this relay is at the time responsive only to line current of reverse polarity, thereby releasing relay M to stop further transmission of the incomplete code, the apparatus then resetting to normal to initiate a new code in the usual manner.

It will also be apparent that the carrier current system as herein disclosed is suitable for use over electrically long lines and that the carrier current units together with their receiving relays are adapted to be used without change to serve as direct repeaters for insertion at an intermediate point in such lines when required. Thus, for example, a pair of C. C. units such as Nos. 1 and 3 may be located at such a point, C. C. unit No. 3 receiving modulated current of frequency f_1 to control a relay CR governing the transmission of control codes by C. C. unit No. 1, and the latter unit receiving modulated current of frequency f_2 to control another relay CR governing the transmission of indication codes in the opposite direction by C. C. unit No. 3. The line circuits of the system of our invention are highly flexible in respect to their applicability to a wide variety of conditions likely to be encountered in practice, and in different installations may vary widely in their arrangement. For example, it may be inconvenient to locate the control station at the junction of the two line sections as shown in Fig. 2B. If this is the case, it may be located at any other point on line Y2—Z2, for example, at the distant end, with respect to the location of the central office, in which case the filter VF would be replaced by one adapted to pass the frequencies f_1 and f_2 as well as voice frequencies. Furthermore, although the office coding unit No. 2 controls a local "dummy line" this may as well be an actual line circuit like that controlled by Office coding unit No. 1, to control one or more

stations between the office and the location of the receiving relay OCR, the remainder of the office line unit being retained at the office, as shown. Alternatively, the office line unit may be located at the distant end of this line, in which case relay PR would be replaced by one responsive to either polarity and the unit would be connected across the distant end of the line through a suitable filter LF.

Although we have herein shown and described but two forms of apparatus embodying our invention and several modifications thereof, it will be understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of our invention.

Having thus described our invention, what we claim is:

1. In a remote control system, a remote line circuit extending from a control station through a plurality of remote stations, line wires providing a plurality of non-interfering communication channels and extending from said control station to a central office, a stick relay at said control station, a code transmitter at each remote station adapted when initiated to deliver a multiple impulse code to said remote line circuit, means preventing the initiation of any code transmitter except when said stick relay is released, means preventing any code transmitter which has been initiated from completing its code unless said stick relay is energized, a repeating relay at said control station adapted to deliver the codes received from said remote line circuit to one of said channels, means controlled by said repeating relay in response to the first impulse of a code received over said remote line circuit to operate said stick relay, a code receiver at the office responsive to codes received over said one channel, a code transmitter at the office adapted when initiated to deliver multiple impulse codes to another of said channels, a repeating relay at said control station adapted to deliver the codes received over said other channel to said remote line circuit to control code responsive devices at the remote stations, means controlled by said office code receiver for delivering a single impulse to said another channel upon the reception of a predetermined number of impulses constituting a complete code over said one channel, means controlled by the repeating relay at the control station in response to said single impulse for releasing said stick relay, and means preventing the delivery of said single impulse to said remote line circuit when said repeating relay responds to said impulse.

2. In a remote control system, a line circuit extending from a control station through a plurality of remote stations, line wires extending from said control station to a central office, a stick relay at said control station, a code transmitter at each remote station adapted when initiated to deliver a multiple impulse code to said line circuit, means preventing the initiation of any code transmitter except when said stick relay is released, means preventing any code transmitter which has been initiated from transmitting its code unless said stick relay is energized, a repeating relay at said control station adapted to repeat said codes over said line wires to the central office, means controlled by said repeating relay in response to the first impulse of a code to operate said stick relay, a code receiver at the office responsive to the codes repeated over said

line wires, and means controlled by said code receiver for releasing said stick relay upon the reception of a predetermined number of impulses constituting a complete code.

3. In a remote control system, a line circuit 35 extending from a control station through a plurality of remote stations, line wires extending from said control station to a central office, a code transmitter at each remote station adapted when initiated to deliver a code to said line circuit, a repeating relay at the control station responsive to said codes, means including contacts of said repeating relay for delivering the codes to said line wires, a code receiver at the office responsive to the codes delivered to said line wires 40 by said repeating relay, a stick relay at the control station, means for energizing said stick relay in response to the first operation of said repeating relay upon the initiation of a code by any transmitter, means controlled by the stick relay when energized for conditioning such transmitter to complete its code, and means remotely controlled by the code receiver at the office for releasing said stick relay upon the reception of 45 a complete code.

4. In a remote control system, a line circuit extending from a control station through a plurality of remote stations, line wires extending from said control station to a central office, a stick relay at said control station, a code transmitter at each remote station adapted when initiated to deliver a multiple impulse code to said line circuit, means preventing the initiation of any code transmitter except when said stick relay is released, means preventing any code transmitter which has been initiated from transmitting its code unless said stick relay is energized, a repeating relay at said control station adapted to repeat said codes over said line wires to the central office, a line relay at the office responsive to the successive impulses of each code repeated over said line wires, and means effective in the event the operation of said line relay is discontinued after it has responded to one or more impulses of a code for releasing said stick relay to re-initiate such code.

5. In a remote control system, line wires extending from a central office to a distant control station, a line circuit extending from said control station to a remote station, a code transmitter at said remote station adapted when initiated to deliver a multiple impulse code to said line circuit, a repeating relay at said control station adapted to deliver said codes to said line wires, a line relay at the office responsive to the codes delivered to said line wires by the repeating relay, and means remotely controlled by said line relay and effective if its operation is discontinued after it has responded to one or more impulses of a code for re-initiating the operation of said code transmitter.

6. In a remote control system, a line circuit extending from a control station through a plurality of remote stations, line wires extending from said control station to a central office, a code transmitter and a line relay for governing its operation at the office and at each remote station, a repeating relay at said control station controllable from the office over said line wires for delivering codes to said stations to which the station line relays are responsive, means controlled by said office code transmitter for operating the office line relay locally in accordance with a code and for simultaneously operating said repeating relay in accordance with such code, 55

and means including a repeating relay at the office controlled over said line wires by the station code transmitters for operating the office line relay in accordance with other codes.

7. In a remote control system, line wires extending from a central office to a control station, a line circuit extending from said control station to a remote station and including a source of direct current, a normally deenergized line relay of the two position stick polar type arranged to be held in its last operated position when deenergized, a transformer at said control station interposed between the relay and said line circuit for causing said relay to operate to reverse and to normal in response to variations in the current from said source, a code transmitter at said remote station adapted to periodically vary the current delivered to said line circuit to operate the line relay in accordance with a code, means including contacts of the line relay for delivering said code to the line wires extending to the office, a repeating relay at the office controlled over said line wires and repeating the operation of said line relay, and means controlled by said repeating relay for delivering an impulse over said line wires to restore said line relay to its normal position in the event it remains reversed for more than a predetermined time interval.

8. In a remote control system, line wires extending from a central office to a control station and affording two one way communication channels, a line circuit extending from said control station to a remote station and including a source of direct current, a normally deenergized line relay of the two position stick polar type arranged to be held in its last operated position when deenergized located at said control station, a transformer interposed between the relay and said line circuit for causing said relay to operate to reverse and to normal in response to variations in the current from said source, a repeating relay at the office controlled over one of said channels by said line relay and repeating its operation, and means controlled by said repeating relay for delivering an impulse over the other of said channels to restore said line relay to its normal position in the event it remains reversed for more than a predetermined time interval.

9. In a remote control system, line wires extending from a central office to a distant control station, a line circuit extending from the control station to a remote station and normally supplied with direct current at said control station, a code transmitter at said remote station adapted when initiated to deliver an impulse code to said line circuit but only if current of reverse polarity is being supplied thereto at said control station, means for initiating said transmitter to deliver the first impulse of such code effective only when current of normal polarity is being steadily supplied to said line circuit, a repeating relay at said control station responsive to said code, means including contacts of said repeating relay for delivering said code to said line wires, a line relay at the office responsive to codes delivered to said line wires by said repeating relay, means controlled by said repeating relay in response to the first impulse of a code for reversing the polarity of the current supplied to said line circuit, and means remotely controlled by the line relay and rendered effective when it has responded to the first impulse of a code delivered by said repeating relay, for 60 65 70 75

restoring the polarity of the line circuit to normal upon the termination of such code.

10. In a remote control system, two line wires extending from a control office through a first group of way stations to a control station, a first line circuit including said line wires and arranged to provide code communication between the office and said stations, a second line circuit arranged to provide code communication between said control station and a second group of way stations, two alternating current channels superimposed upon said first line circuit and arranged for code transmission in opposite directions between the office and said control station and providing communication between the office and the stations of the second group, two sets of similar apparatus at said control station each adapted to supply current for code transmission over one of said superimposed channels and to amplify the current received from the office over the other, a changeover relay at said control station, means for connecting one set or the other of said apparatus to said channels, according to the position of said changeover relay, and means for transmitting codes over said first line circuit to effect the remote control of said changeover relay from the office and to indicate its position at the office.

11. In a remote control system, two line wires extending from a control office through a first group of way stations to a control station, a first line circuit including said line wires and arranged to provide code communication between the office and said stations, a second line circuit arranged to provide code communication between said control station and a second group of way stations, two alternating current channels superimposed upon said first line circuit and arranged for code transmission in opposite directions between the office and said control station and providing communication between the office and the stations of the second group, two sets of similar apparatus at each end of said alternating current channels each including an oscillator for supplying current to one channel and an amplifier responsive to current received over the other, a changeover relay at each end of said alternating current channels, means for connecting one set or the other of said apparatus to said channels at each end, according to the position of the associated changeover relay, and means including manually operable levers at the office for operating said changeover relays, such operation being effected when the changeover relay is at a point remote from the office, by means of codes transmitted over said line wires.

12. In a remote control system, two communication channels including the same line wires arranged to provide code communication in opposite directions, each having relay contacts at one end which control a receiving relay at the opposite end, a code transmitter and receiver located at a central office having a transmitter relay and a line relay of the stick polar type, a normally closed circuit extending from said office to one end of said channels including a source of direct current, contacts of said transmitter relay and the primary of a transformer, said line relay of the stick polar type being connected to the secondary of said transformer, and thereby rendered responsive to current variations in said circuit, a repeating relay in said circuit responsive to the operation of said transmitter relay contacts, means comprising said repeating relay for controlling the contacts in one channel to govern the receiving relay at its distant end, and means comprising the receiving relay of the other channel for varying the current in the circuit including said transformer to thereby control said line relay.

13. In a remote control system, two communication channels including the same line wires arranged to provide code communication in opposite directions, each having relay contacts at one end which control a receiving relay at the opposite end, a code transmitter and receiver located at a distant station having a transmitter relay and a line relay, a normally closed line circuit including said line relay and extending to a point adjacent one end of said channels, said circuit also including a source of direct current, contacts of the receiving relay of one channel and the primary of a transformer, a relay of the stick polar type controlling the contacts of said other channel, and having a winding connected to the secondary of said transformer to render the relay responsive to current variations in said line circuit, a slow acting relay controlled by the receiving relay of said one channel, a holding circuit for said stick polar relay controlled by said slow acting relay and effective to prevent its response to variations in the current in said line circuit due to the operation of the receiving relay of said one channel, and means comprising contacts of the transmitter relay at the distant station for varying the current in said line circuit to control said stick polar relay.

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