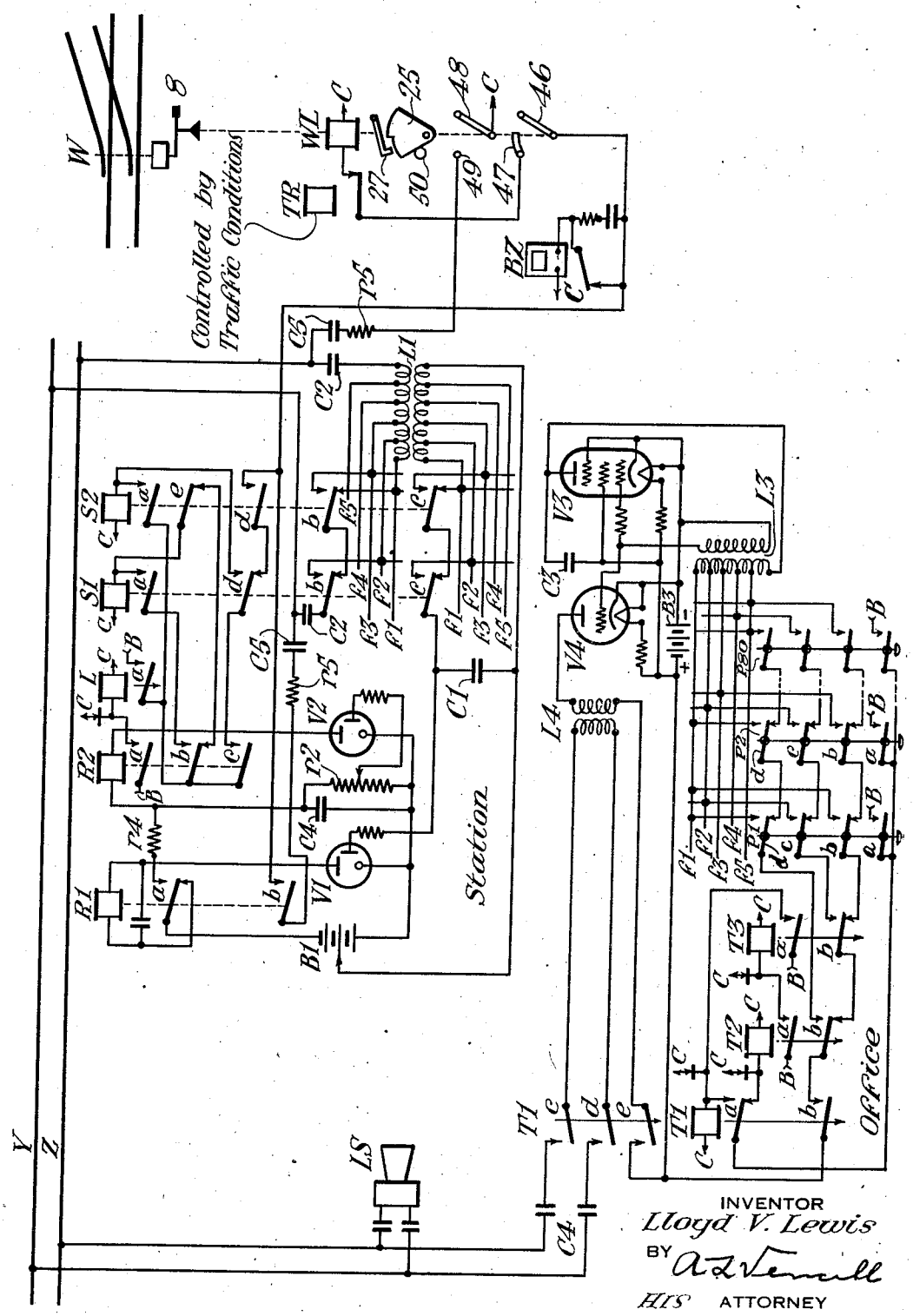
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REMOTE CONTROL SYSTEM

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REMOTE CONTROL SYSTEM

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9 Claims. (Cl. 177—353)

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My invention relates to remote control systems, and more especially to apparatus suitable for use in centralized traffic control systems for railroads.

In systems of this character, as illustrated by Letters Patent of the United States Nos. 2,303,875 and 2,350,668, for example, it is customary to provide a code type communication system for controlling track switches and railway signals over an extensive stretch of territory by means of codes of direct current impulses transmitted from the dispatcher's office, and to provide a dispatcher's telephone line usually using the same line wires by means of which the crews of trains at various way stations may communicate with the dispatcher. A selective calling system is also needed in order to enable the dispatcher to establish telephone communication with the field stations, and since the selector systems commonly used employ codes of low frequency impulses which are of such a character as to interfere with the operation of the centralized traffic controlling system it has been necessary to provide means for suspending the operation of the latter while the line is in use for selective calling. Furthermore, the selectors present an additional load on the line circuit for the centralized traffic control system, and for these reasons the selector system decreases the capacity of the centralized traffic control system to some extent even though the two systems are non interfering.

One object of my invention is the provision of a code system of remote control suitable for selective calling or the like which employs codes of alternating current impulses of different frequencies suitable for transmission over a telephone line without interfering with the transmission of low frequency code impulses over the same line.

Another object of my invention is the provision of a remote control system particularly suitable for use for the control and indication of outlying traffic governing devices, such as electric switch locks for hand throw switches, the control of which heretofore has required the installation of line wires often extending several miles from the switch location to the nearest field station of the centralized traffic control system.

My invention is an improvement upon that disclosed in application for Letters Patent of the United States Serial No. 514,641, filed December 17, 1943, now U. S. Letters Patent 2,396,134 granted March 5, 1946, by A. J. Sorensen, for Remote control systems.

A feature of my invention is the provision of

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code receivers responsive to a plurality of frequencies and connected to a line through different tuned circuits, one circuit at a time, so as to present a high impedance to the line.

Another feature of my invention is the provision of code receivers of the electronic type which are normally deenergized and employ local sources of direct current as their sole source of energy so that they may be efficiently employed at isolated locations, with infrequent maintenance.

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

Referring to the accompanying drawing, the reference characters Y and Z designate a pair of line wires which provide a communication channel for my remote control system extending from a control office equipped with transmitting apparatus as shown in the lower portion of the drawing, through a plurality of stations located at spaced points along a stretch of railway at each of which a receiver similar to the one shown in the upper portion of the drawing is located. Each receiver is adapted to control an electro-responsive device such as a bell or buzzer BZ, or the magnet WL of an electric switch lock, or the like.

The system of my invention employs alternating current codes each comprising a series of steps marked by periodic changes in the frequency of the line current, without interposed pauses, each frequency combination comprising a station code call. In its specific embodiment as shown herein, the system is arranged to use five frequencies, designated *f1* to *f5*, and three code steps. The first code step may have any one of five frequencies. Any one of the four not used for the first step are available for the second step, and any one of the four not used for the second step may be used for the third step, providing $5\times4\times4=80$ different code calls for the selection of the corresponding number of stations. The frequencies may be in or above the voice frequency band depending upon the circuit requirements. In the form shown herein, the line currents are generated by an oscillator tube V3 controlled by a tuned circuit comprising a coil L3 having an adjustable number of effective turns and a condenser C3 so as to deliver any one of the five frequencies *f1*–*f5*. The tube V3 controls an amplifier tube V4 by which the alternating current of the selected frequency is delivered through a coupling transformer L4 to the line wires Y and Z. The transmitting apparatus includes a series of push buttons or keys P1–P80,

of which but three are shown, by which the various frequency combinations are selected, and which control a group of slow release relays T1, T2 and T3 for supplying the selected frequencies successively to the line at suitable intervals. The office apparatus also includes the usual local battery having the terminals B and C for energizing the relays and a battery B3 for energizing the electron tubes V3 and V4. Tubes V3 and V4 are of the hot cathode type, with their filaments normally energized, as shown. The plate circuits, however, are disconnected from battery B3 by contacts *b* and *e* of relay T1 so that tubes V3 and V4 are normally inactive.

Each station receiver includes five relays R1, R2, L, S1 and S2, two electron tubes V1 and V2 of the cold cathode, controlled ionization type, and a transformer L1 having an adjustable primary tuned by condenser C2 connected across the line and an adustable secondary turned by condenser C1 by means of which the receiver at each station is rendered selectively responsive to a distinctive sequence of frequencies supplied to the line by the operation of the corresponding one of the keys P1–P80.

Each station is provided with the usual local battery having the terminals B and C for energizing the relays L, S1 and S2, and the buzzer BZ and magnet WL, and for supplying an "answer back" signal to the line in response to the operation of the electric switch lock controlled by magnet WL, and has a second battery B1 for energizing the electron tubes V1 and V2 and the relays R1 and R2 connected in series therewith.

The station apparatus as shown is connected to respond selectively to the code combination *f*1, *f*2, *f*3, as indicated by the connections to contacts *b* and *c* of relays S1 and S2, the office key which is similarly connected and which therefore controls the station shown being the key P2.

It is believed that my invention may be most readily understood from a description of its mode of operation, and accordingly I shall now assume that the operator presses the key P2 to operate a calling device illustrated as a buzzer BZ at the station shown.

The closing of contact *a* of key P2 completes a circuit from terminal B of the local source of current over back contact *a* of relay T1 through relay T2 to terminal C. Relay T2 picks up and by closing its contact *a* energizes relay T3 which in turn closes its contact *a* to energize relay T1.

Relay T1 completes a stick circuit at its contact *a* so that it is held picked up as long as the key P2 is pressed, and closes a circuit from the positive terminal of battery B3 over the front contacts b of relays T1 and T2, back contact *d* of key P1 and front contact *d* of key P2 through the primary of transformer L3 to the plate of tube V3. Relay T1 completes a connection over its contact *e* from the positive terminal of battery B3 through the primary of transformer L4 to the plate of tube V4, and the closing of contacts *c* and *d* of relay T1 connects the secondary of transformer L4 through the condensers C4 across the line wires Y and Z. The frequency to which the adjustable tuned circuits are responsive are indicated by the references *f*1—*f*5 adjacent the transformer connections on the drawings, and as shown, the front contact *d* of key P2 is connected to a wire marked *f*1, indicating that coil L3 and condenser C3 are tuned to that frequency. In response to the closing of key P2, therefore, tube V3 is caused to generate current of frequency *f*1 and to supply it through tube V4 to the line.

When relay T1 picks up, the energizing circuit for relay T2 is opened. Relay T2 releases after a suitable interval and shifts the connection of the positive terminal of battery B3 from contact *d* of key P2 to the branch circuit including front contact *b* of relay T3, back contact *c* of key P1 and front contact *c* of key P2, tuning the circuit L3—C3 to the frequency *f*2.

The frequency of the line current thus shifts from one frequency to another upon the release of relay T2, the second frequency being determined by the connection to contact *c* of the operated key, this being frequency *f*2 in the case being described.

When relay T2 releases, it opens the energizing circuit for relay T3, and the second frequency is supplied only until relay T3 releases, after which the frequency is again shifted, the frequency of the third impulse being determined by the connection to contact *b* of the operated key, this being frequency *f*3 when key P2 is operated, or frequency *f*1 when key P1 is operated, as will be seen from the drawing, the third impulse being terminated by the release of relay T1, following the release of the operated key.

Each code thus comprises a sequence of three impulses without interposed pauses, the last of which, comprising the operating or delivery impulse of the code, may be prolonged as long as desired by holding the operated key depressed.

Considering now the station apparatus, it is to be understood that the primary of transformer L1 is tuned by condenser C2 and presents a relatively high impedance to the line, and that due to line losses, the tuning is somewhat broad, so that if this were the only tuned circuit provided, the receiver would respond more or less to a band of frequencies as required for certain applications, as illustrated, for example, by Letters Patent of the United States No. 2,272,786, granted February 10, 1942, to Norman A. Agnew. In accordance with the requirements of the present invention, a sharper selectivity is required, and this is accomplished by the provision of a second tuned circuit, comprising a loosely coupled low resistance secondary for transformer L1 which is tuned by a condenser C1.

Normally, transformer L1 is tuned by circuits completed over back contacts *b* and *c* of the relays S1 and S2, and at the station shown these are tuned to the frequency *f*1, so that a resonant voltage is developed across the terminals of condenser C1 when current of that frequency is supplied to the line.

Relay R1 is connected in series with the plate circuit of tube V1 across battery B1, the voltage of which is insufficient to start ionization of the tube V1, consequently relay R1 is normally deenergized. An adjustable positive potential derived from battery B1 is supplied to the grid of tube V1 in series with the alternating potential across condenser C1 due to the line current, by means of which ionization is caused to start in response to line current of the proper value and frequency, so as to cause the plate circuit of tube V1 to become conducting and relay R1 to become energized. The voltage applied to the plate circuit by battery B1 although insufficient to start ionization, is capable of maintaining the tube in the conducting condition so as to hold relay R1 energized after the tube is once "fired" by the application of the proper positive potential to the grid circuit, even though this potential is

applied but momentarily, and it is necessary to deionize the tube before it can again serve as a detector. This is accomplished by including a back contact of relay R1 in the plate circuit so that as soon as relay R1 becomes energized the source of current B1 becomes disconnected, tube V1 becomes deionized and relay R1 releases.

Relay R1 therefore responds but once to a single positive impulse applied to its grid circuit and operates repeatedly only in the event a sustained resonant A. C. voltage of a predetermined value is present across condenser C1. As used in practice the constants of its circuit are such that relay R1 vibrates at the rate of about twenty times per second.

In order to differentiate between the random operation of relay R1, due to impulse or shock excitation or the like, and periodic operation in response to sustained oscillations, a second tube V2 is provided. Each time relay R1 is energized, the potential of battery B1 is applied across a resistor *r4* of relatively low value and in series therewith, a condenser C4 and a resistor *r2* having a high resistance, in parallel. The potential across condenser C4 is applied through relay R2 to the plate of tube V2 and a positive potential derived therefrom is applied over an adjustable connection to resistor *r2* to the grid of tube V2. When relay R1 is energized, condenser C4 charges at a rate determined by the product of the values of *r4* and C4, and when relay R1 is released, condenser C4 discharges slowly through resistor *r2*. The potentials thus applied to the grid and plate circuits of tube V2 increases step by step in response to the vibration of relay R1 until they reach values sufficient to cause tube V2 to "fire" whereupon relay R2 becomes energized. The energy stored in condenser C4 causes current to continue to flow through relay R2 during the intervals when, due to its vibration, the front contact *a* of relay R1 is open, so that relay R2 is held picked up as long as relay R1 continues to vibrate. When relay R1 ceases to operate, condenser C4 discharges and tube V2 is deionized so that relay R2 releases following a relatively short pause in the operation of relay R1.

At each station responsive to a first code step of frequency *f1*, therefore, relay R1 vibrates and energizes relay R2, which in turn energizes a slow release relay L over its front contact *a*.

When the frequency of the line current is shifted to the second frequency *f2*, the energized relays R1 cease to vibrate and the associated relays R2 release, for the reason that the impulse of frequency *f1* to which the circuits for these relays are adjusted to respond has been terminated. Each such relay R2 then closes a pick-up circuit for a first stepping relay S1 which extends from terminal B at contact *a* of relay L over back contact *b* of relay R2, back contact *e* of relay S2 through relay S1 to terminal C, so that relay S1 becomes energized.

Assuming that there are eighty stations, arranged in five groups with respect to the frequency to which they respond on the first step, the receivers at sixteen stations will operate as described, and of these, a group of four will have the tuning circuit which include front contacts *b* and *c* of relay S1 connected so as to respond to frequency *f2*. At each station of this group, when relay S1 picks up the tuning adjustment at that station is shifted from frequency *f1* to the frequency *f2* which is being supplied to the line at the time and consequently relays R1 and R2 become reenergized to hold the slow release relay

L picked up, while at the others relays R1 and R2 remain released so that their relays L and S1 release. Each energized relay R2 completes a stick circuit for relay S1 extending from terminal B at contact *a* of relay L over front contact *b* of relay R2 and the front contact *a* and winding of relay S1 to terminal C, and completes a pick-up circuit for the second stepping relay S2 extending from terminal B at contact *a* of relay L over front contact *c* of relay R2, front contact *d* of relay S1 and the winding of relay S2 to terminal C so that relay S1 is held energized and relay S2 picks up on the second step.

When the frequency of line current is shifted to the third frequency *f3*, the termination of the impulse of frequency *f2* causes the relays R1 and R2 to release at each of the four stations at which relays S1 and S2 are energized, and each such relay S1 releases, due to the opening of its stick circuit at contact *b* of relay R2. Each energized relay S2 is held picked up by relay L over a stick circuit including its front contact *a*.

It will be understood that at each station of the selected group, the tuning circuits which include the back contacts *b* and *c* of relay S1 and the front contacts *b* and *c* of relay S2 are differently connected, those at only one station of the group being arranged as shown in the drawing to respond to frequency *f3*. At this one station, therefore, the release of relay S1 due to the termination of the impulse of frequency *f2* shifts the tuning adjustment from frequency *f2* to the frequency *f3* which at this time is being supplied to the line, and at that station, relays R1 and R2 are reenergized to hold relay L energized, while at the others relays R1 and R2 remain released so that their relays L and S2 release.

At the selected station, the response of relay R2 to the third step completes a "delivery" circuit extending from terminal B at contact *a* of relay L, front contact *c* of relay R2, back contact *d* of relay S1, front contact *d* of relay S2 through buzzer BZ to terminal C.

The buzzer BZ at only one station is thus sounded selectively in response to the operation of the corresponding key P2, and continues to sound until the key P2 is released.

It will be understood that the apparatus at those stations arranged to respond to a first frequency *f2* or *f3* will respond to the second or third frequency of the code described but at none of these will the delivery circuit be closed, and at the end of the code the apparatus at these stations will be restored to normal after responding to only one or two of the code steps.

It will be seen that the number of tuned circuits which are resonant to the line current at any given time is relatively small in comparison with the number of stations, consequently the impedance presented by the apparatus to the line may be made sufficiently high to adapt the system readily for use on electrically long lines.

Considering now the application of the system of my invention to the control of an electric switch lock; the diagram at the upper right in the drawing indicates a portion of railway track which includes a hand throw switch W, the unauthorized operation of which is prevented by the provision of an electric switch lock. This device, as shown, is to be understood to be of the type shown in Letters Patent of the United States No. 1,126,834, issued February 2, 1915, to Neubert et al., comprising a rotatable shaft carrying a segment 25 and two contacts 46 and 48, which shaft in the position shown locks the op-

erating lever 8 of the switch in a position to maintain the track switch W locked normal, while the shaft in turn is locked in the position shown by a padlock having a bail 50.

To unlock the switch the padlock must first be removed by the train crew, after obtaining permission by telephone from the operator at the dispatcher's office, thus permitting the segment to be moved a short distance to a position to engage the locking dog 27 and to close contacts 46—47. Then if traffic conditions are proper as indicated by the energization of a relay TR, a magnet WL may be energized over a circuit including contacts 46—47 to lift the locking dog 27, permitting segment 25 to be moved to its full reverse position in which the switch lever 8 is free to be operated.

It is desirable to insure that the operations described are carried out only with the knowledge and cooperation of the central office operator, and this may readily be accomplished by controlling magnet WL over the delivery circuit of my receiver as shown.

In accordance with the preferred mode of operation, a member of the train crew advises the operator by telephone when he is ready to reverse segment 25; the operator then presses key P2 to selectively energize the delivery circuit and cause buzzer BZ to sound at the location of switch W, thereby informing the train crew that the switch is electrically unlocked, and energizing magnet WL when contacts 46—47 are closed by the train crew. When the buzzer signal is heard, therefore, the segment may be moved to full reverse, whereupon the closing of contacts 48—49 connects terminals B and C of the local source of current across the line wires through resistors r5 and condensers C5, the connection comprising a branch of the delivery circuit which includes in addition, a front contact *b* of relay R1. A variable potential is thus applied to the line due to the vibration of relay R1 which produces an audible "answer back" signal in the operator's loud speaker LS which is readily distinguishable from the frequency generated by tube V3, assuming the latter to be within the audio range.

The operator therefore holds the key P2 pressed until the "answer back" signal is received, indicating that the unlocking operations have been completed.

It is to be noted that the answer back impulses impressed upon the line by the closing of front contact *b* of relay R1 are incapable of controlling the tube V1 so as to continue relay R1 in vibration after key P2 is released, corresponding to the mode of operation described in the Agnew patent hereinbefore referred to, for the reason that the impulses are applied to the line over front contacts *b* of relay R1 at a time when tube V1 is deenergized by the opening of back contact *a* of relay R1.

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

Having thus described my invention, what I claim is:

1. In a remote control system having a pair of line wires to which different codes are supplied, each comprising a sequence of alternating current impulses of successively different frequencies, a receiver including a plurality of tuned circuits each tuned to a different frequency and each coupled to a sharply tuned local circuit tuned to the same frequency for determining the frequencies of the line current to which such receiver is responsive, and stepping means controlled by said receiver in response to the code impulses for connecting said tuned circuits across the line wires only one at a time and for simultaneously connecting the local circuits tuned to the corresponding frequencies to said receiver only one at a time to render the receiver responsive to a distinctive sequence of impulses constituting a code call.

2. In a remote control system having a pair of line wires to which different codes are supplied each comprising a sequence of alternating current impulses of successively different frequencies, a receiver including an adjustable tuned circuit connected to the line wires for governing its operation, said tuned circuit being normally adjusted to render the receiver selectively responsive to line current having a selected one of said frequencies, stepping means controlled by said receiver and acting in response to the termination of an impulse of a particular frequency to change the adjustment of said tuned circuit to render the receiver selectively responsive to the next impulse of a distinctive sequence of impulses constituting a code, and a delivery circuit prepared by said stepping means and closed by said receiver in response to the last impulse of said code.

3. In a remote control system, a receiver responsive to a sequence of alternating current impulses of successively different frequencies, comprising a receiving relay, an electron tube having an input circuit supplied with said impulses over one of a plurality of tuned circuits each tuned to a different one of said frequencies, and an output circuit for controlling said receiving relay, a series of stepping relays, a slow release relay, means controlled by said receiving relay for intermittently energizing said slow release relay to maintain it picked up as long as the receiving relay continues to respond to said impulses, means controlled jointly by said receiving relay and by said slow release relay for energizing said stepping relays one at a time to count the impulses, means controlled by said stepping relays for connecting the grid circuit of said tube to different ones of said tuned circuits one at a time to render said receiver responsive to a distinctive sequence of impulses constituting a station code call, and a delivery circuit prepared by said stepping relays and closed by said receiving relay in response to the last impulse of said distinctive sequence.

4. In a remote control system, a receiver responsive to a sequence of alternating current impulses of successively different frequencies supplied to a line circuit, comprising a line relay controlled by said impulses and a series of stepping relays operable one at a time in order in response to different operations of the line relay to count the impulses as received, means comprising a plurality of adjustable tuned circuits for rendering the line relay responsive only to line current of a particular one of said frequencies, means controlled by said stepping relays for shifting the connections of said tuned circuits to condition the line relay to respond to successive impulses of different frequencies, and a delivery circuit closed by the line relay and by the last stepping relay of the series when said

line relay has responded to a predetermined number of impulses.

5. In a remote control system, a receiver responsive to a code of alternating current impulses of successively different frequencies, comprising an electron tube having a plate circuit connected to a local source of current and a grid circuit to which said impulses are supplied, a receiving relay controlled by the current in said plate circuit, a plurality of tuned circuits each selectively responsive to a different one of said frequencies one of which circuits is normally interposed in said grid circuit to render said tube effective to operate the relay in response to the first impulse of a code only when such impulse is of the corresponding frequency, adjustable connections controlled by said relay for interposing different ones of said tuned circuits in said grid circuit successively as the impulses are received, said connections being arranged in a distinctive code pattern corresponding to a code of impulses identifying said receiver and serving to render the tube effective to operate the relay in response to the succeeding impulses of said code only when they have said distinctive code pattern, and a delivery circuit closed by said relay only when it responds to the last impulse of said code.

6. In a remote control system, a receiver responsive to a code of alternating current impulses of successively different frequencies, comprising an electron tube having a plate circuit connected to a local source of current and a grid circuit to which said impulses are supplied, a receiving relay controlled by the current in said plate circuit, a series of stepping relays controlled by said receiving relay, a plurality of tuned circuits each selectively responsive to a different one of said frequencies one of which circuits is interposed in said grid circuit to render the tube effective to operate the relay in response to the first impulse of a code only when such impulse is of the corresponding frequency, adjustable connections selected by the operation of said stepping relays for interposing different ones of said tuned circuits in said grid circuit one for each operation of said receiving relay said connections being arranged in a distinctive code pattern corresponding to a code of impulses identifying said receiver, and serving to render the tube effective to operate said receiving relay only so long as the received impulses conform to said code pattern, and a delivery circuit prepared by said stepping relays and closed by said receiving relay when it has responded to each of the impulses of a code.

7. In a remote control system, a receiver responsive to a code of alternating current impulses of successively different frequencies, comprising an electron tube having a plate circuit connected to a local source of current and a grid circuit to which said impulses are supplied, a receiving relay controlled by the current in said plate circuit in response to said impulses, a series of stepping relays, circuits controlled by said receiving relay for operating the stepping relays one at a time in order to count the impulses as received, adjustable connections controlled by said stepping relays for interposing differently tuned circuits in said grid circuit, one for each impulse, to render the tube effective to operate the receiving relay in response to the successive impulses of a code only when their frequencies have a particular pattern constituting a distinctive code call, and a delivery circuit prepared by said stepping relays and closed by said receiving relay when it has responded to each of the impulses of a code.

8. In a remote control system having a line circuit supplied with codes each comprising a sequence of alternating current impulses of successively different frequencies, a receiver comprising an electron tube having a plate circuit and a grid circuit, a receiving relay controlled by current supplied to said plate circuit, a plurality of primary tuned circuits each responsive to a different frequency, stepping means controlled by said receiving relay, means controlled by the stepping means for connecting said primary tuned circuits to the line circuit one at a time in order, a plurality of secondary tuned circuits each responsive to a different frequency and each coupled loosely to that one of said primary circuits which is tuned to the same frequency, means controlled by the stepping means for connecting each secondary tuned circuit to the grid circuit of the tube when the corresponding primary circuit is connected to the line circuit to render the tube effective to operate said receiving relay, and means controlled by said receiving relay when it releases upon the termination of a code impulse of a particular frequency for operating said stepping means to change the connection of said tuned circuits to render the tube responsive to a succeeding impulse of another particular frequency.

9. In a remote control system, a code receiver responsive to a sequence of alternating current impulses of different frequencies, comprising a first electron tube of the controlled ionization type having a plate circuit normally connected to a source of direct current, a receiving relay responsive to the current which flows in said plate circuit when the tube is ionized, a grid circuit including tuned circuit elements for causing the tube to become ionized to effect the energization of said relay when alternating current of a particular frequency only is supplied thereto, means for deionizing said tube comprising a back contact of said relay in said plate circuit for interrupting the flow of current when said relay becomes energized causing said relay to vibrate as long as alternating current is supplied to said grid circuit, a second electron tube of the controlled ionization type having a plate circuit connected to a source of current over a front contact of said receiving relay, a second relay responsive to the current which flows in its plate circuit when said second tube is ionized, said second tube having a grid circuit connected to a condenser which is charged through a resistor by the repeated operation of said receiving relay for causing said second tube to become ionized to energize said second relay only in response to the sustained vibration of said receiving relay, a series of stepping relays, circuits controlled by said second relay for operating said stepping relays one at a time to count each alternating current impulse as received, means controlled by said stepping relays for changing the connections of said tuned circuit elements as each impulse is received to render said first tube responsive only to current having the frequency of the next impulse of a particular code, and a delivery circuit prepared by said stepping relays and closed when said second relay has responded to each of the impulses of said code.

LLOYD V. LEWIS.

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