

Nov. 21, 1950

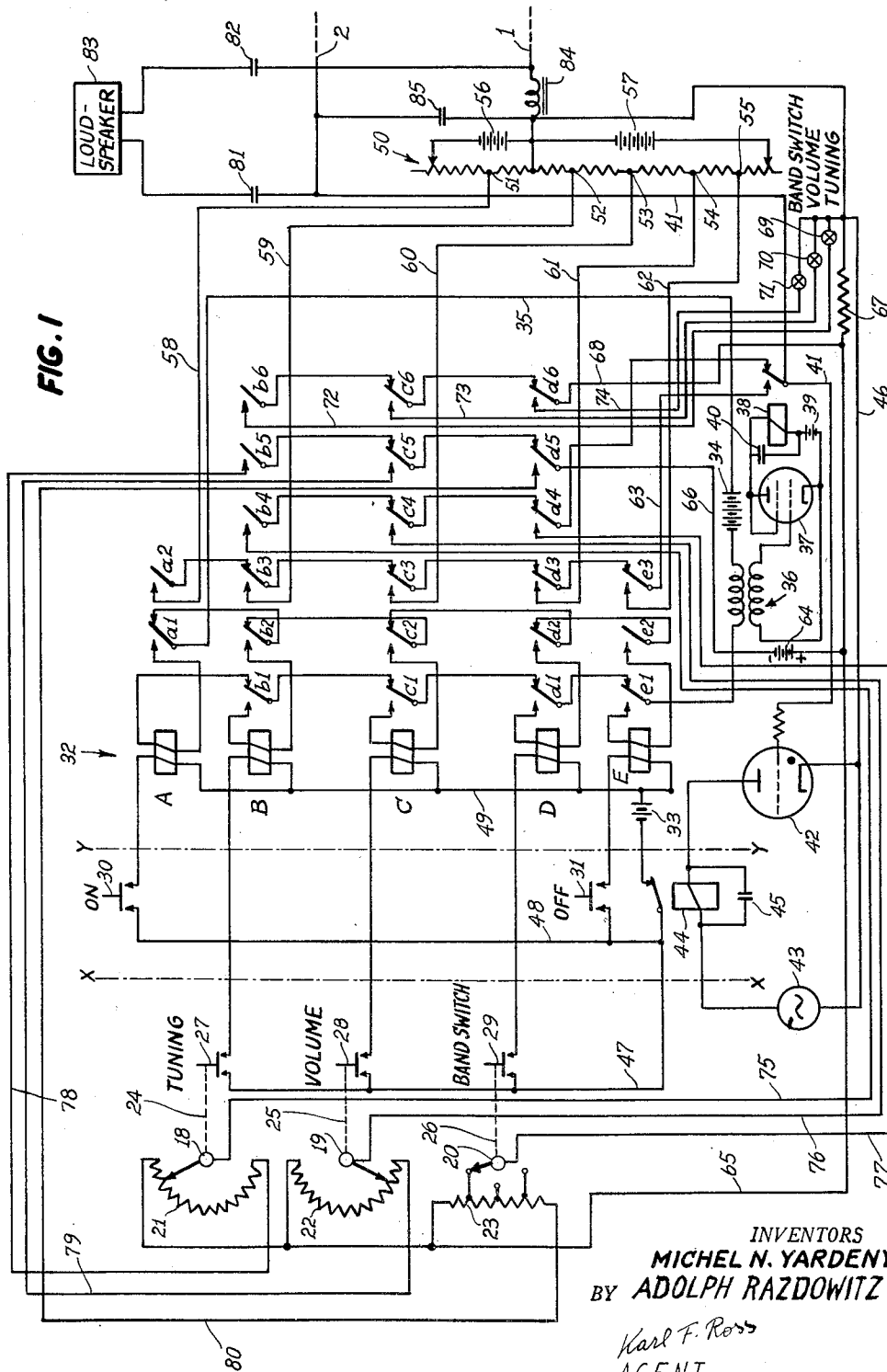
M. N. YARDENY ET AL

2,531,187

SWITCH-OVER SYSTEM

Filed April 23, 1948

3 Sheets-Sheet 1



Nov. 21, 1950

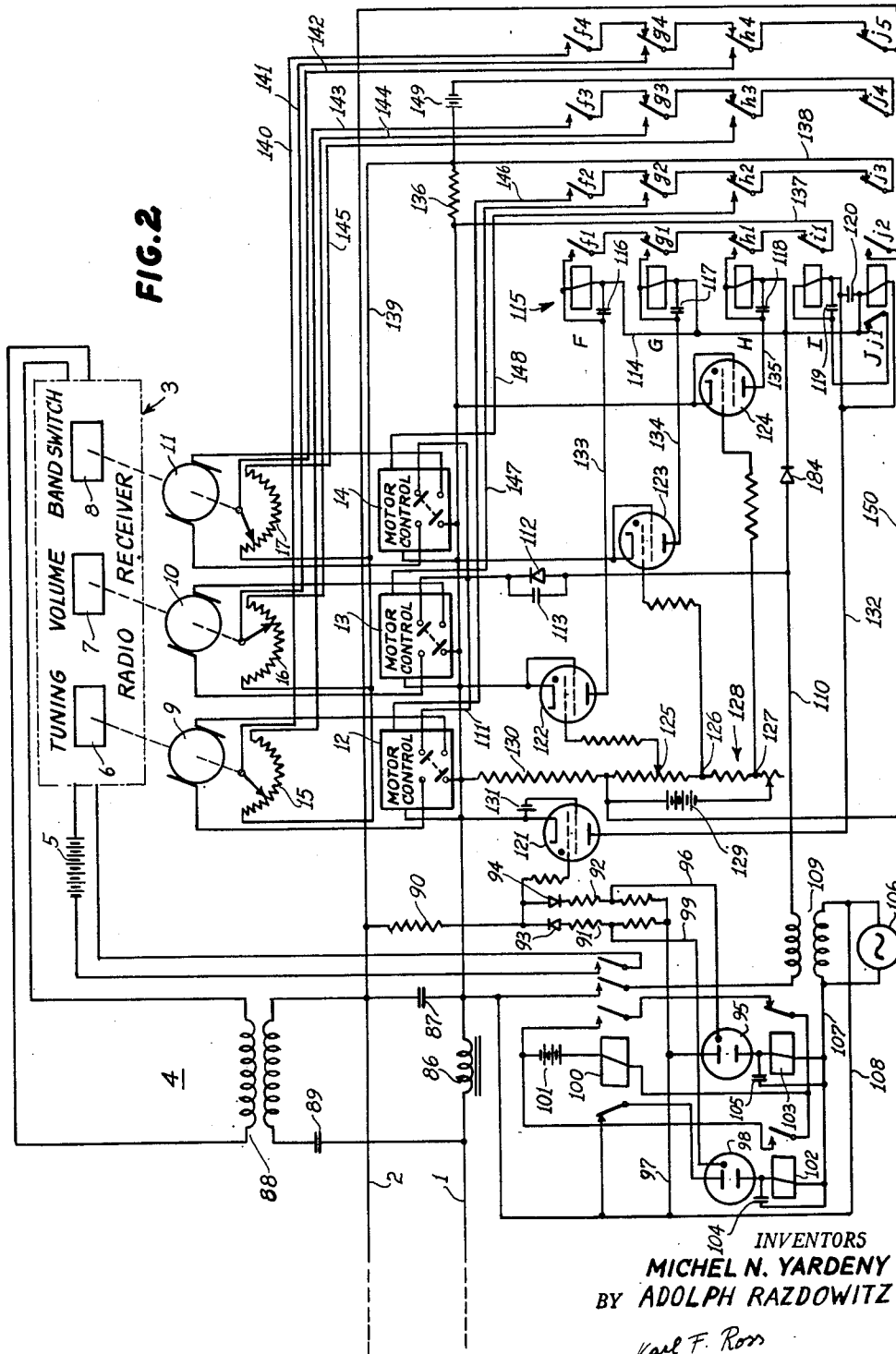
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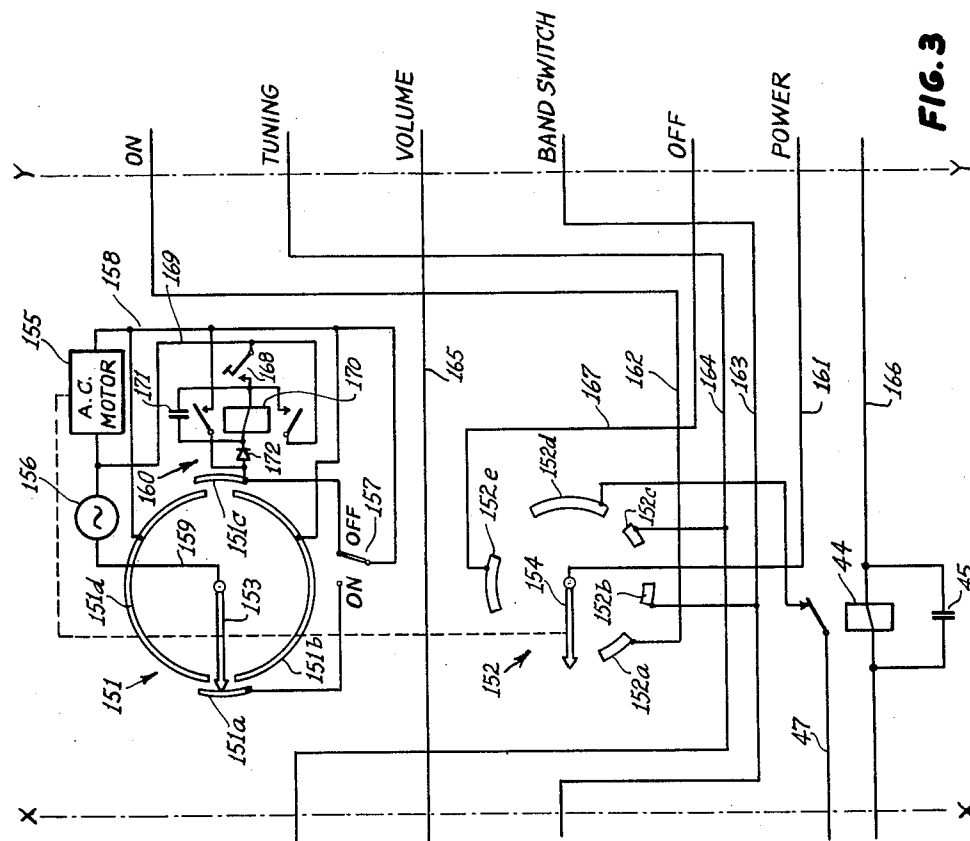


FIG. 3

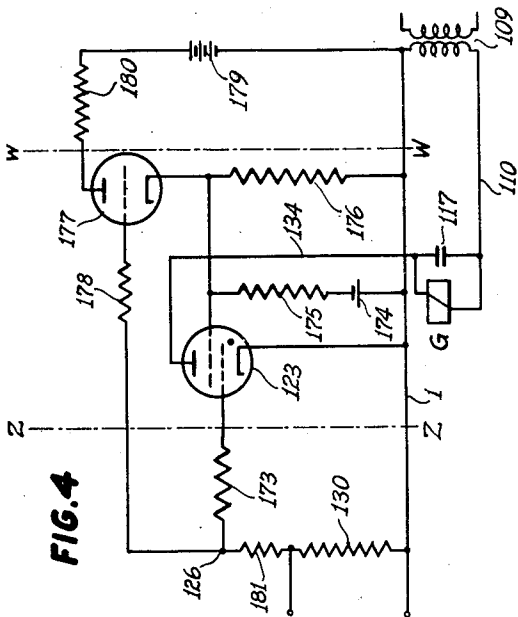


FIG. 4

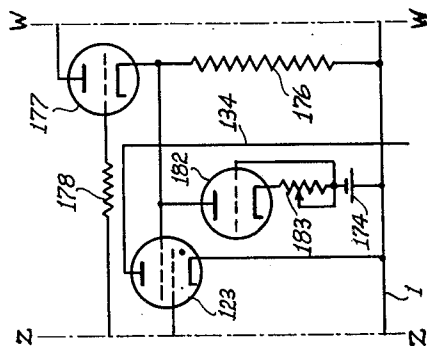


FIG. 5

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2,531,187

SWITCH-OVER SYSTEM

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Application April 23, 1948, Serial No. 22,863

19 Claims. (Cl. 171-97)

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The present invention relates to remote control systems for selectively connecting a plurality of loads to a control circuit over a transmission channel, a system of this general description having been disclosed in the co-pending United States patent application of Michel N. Yardeny and Robert Bernas, Ser. No. 5,276, filed January 30, 1948, now abandoned. In that system, a transmission channel is used to operate a plurality of loads, such as the various controls of a radio receiver located at a remote station, from a control station, the transmission channel serving both as a path for the receiver output and as means for transmitting signals to select and operate the various controls. As further disclosed in our said co-pending application, the positioning of the various loads can be effected by connecting a pair of potentiometers across the control end and the remote end of the transmission channel, respectively, a load-operating motor at the remote station determining the position of the second potentiometer and being energized as long as the voltages applied to the transmission channel by the two potentiometers differ.

An object of the present invention is to provide means for selectively operating a plurality of loads in a remote control system particularly, though not exclusively, of the type described in our aforesaid co-pending application.

Another object of the invention is to provide simple and dependable means for selectively connecting one of several loads to the remote end of a control channel.

A further object is to provide, in a remote control system comprising a transmission line adapted to transmit D.-C. voltages, means for selective load switching utilizing D.-C. voltages of one polarity only while reserving the D.-C. voltages of opposite polarity for other control operations, such as the actuation of the respective load selected.

Stated briefly, a now preferred embodiment of the invention resides in a remote control system comprising a transmission line interconnecting a control station and a remote station, a voltage source at the control station operable to apply to the line a D.-C. pulse of selected magnitude, the internal impedance of said source being low compared with the impedance terminating the line at the remote end whereby the D.-C. pulse will be transmitted to the remote end without substantial attenuation, and a D.-C. responsive selector circuit at the remote station adapted to actuate one of several switching elements, according to the magnitude of the pulse received, and to maintain such switching element actuated after the pulse has subsided.

Preferably, the selector circuit is designed so that each new switching pulse received at the

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remote end of the line restores the previously selected switching element to its initial position before resulting in the actuation of the particular switching element corresponding to the magnitude of the new pulse. The invention also provides certain safeguards to prevent false operation and means designed to enhance the selectivity of the system, in order to render the operation virtually fool proof and to reduce the range of potentials required for carrying out any given number of switching operations.

The above and other features and objects of the invention will become more apparent from the following description, taken in conjunction with the accompanying drawing in which:

Fig. 1 is a typical circuit diagram of a control station according to the invention;

Fig. 2 is a typical circuit diagram of a remote station according to the invention;

Fig. 3 illustrates a timer circuit adapted to be used in combination with the arrangement of Fig. 1;

Fig. 4 illustrates a biasing circuit for the selector tubes of Fig. 2; and

Fig. 5 is a partial modification of the biasing circuit of Fig. 4.

Referring now to the drawing in detail, there is shown a control station (Fig. 1) and a remote station (Fig. 2) interconnected by suitable transmission means illustrated as a two-wire transmission line comprising conductors 1 and 2. The remote station is shown to comprise a radio receiver 3 having an audio output indicated at 4, a power supply shown as a battery 5 and a plurality of controls including a tuning control 6, a volume control 7 and a band switch 8. These three controls are driven by respective motors 9, 10, and 11 responsive to motor controls 12, 13, and 14, respectively, the latter being selectively connectable to the line 1, 2 in a manner subsequently to be described. The shafts of motors 9, 10, and 11 also entrain the pointers of respective potentiometers 15, 16 and 17.

The actuating elements for the respective receiver controls are represented, at the control station, by knobs 18, 19 and 20 determining the setting of associated potentiometers 21, 22 and 23, respectively. Each of these knobs is connected by way of a linkage 24, 25, 26 with an associated switch 27, 28, 29 which will close momentarily when the respective knob is being displaced; linkages 24, 25 and 26 may each be a conventional switching device which will automatically restore the associated switch 27, 28, 29 to open position when the respective knob 18, 19, 20 is released. A novel switching device particularly suitable for this purpose is disclosed in the co-pending application of Michel N. Yardeny and Robert Bernas, Ser. No. 17,883, filed March 30, 1948. In addition, there is pro-

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vided an "On" switch 29 and an "Off" switch 31 each of which, in the simplified embodiment of the invention shown in Fig. 1, may be a manually operated push button.

The switches 27 through 31 control a group of five relays, generally indicated at 32, which include an "On" relay A, a "tuning" relay B, a "volume" relay C, a "band switch" relay D and an "Off" relay E. Each of these relays is provided with two windings one of which is connectable in series with a battery 33 by the actuation of a respective switch. These relays are arranged so that energization of any one of them will close a locking circuit which includes a back contact of each of the other relays, whereby the continued energization of more than one relay will be impossible. The several armatures of relays A, B etc. are indicated at *a1*, *a2*, *b1*, *b2* and so forth.

The locking circuit for the relays 32 includes a battery 34 connected to a conductor 35 and the primary of a transformer 36, the secondary of this transformer being connected in the grid circuit of a vacuum tube 37 shown as a tetrode. The load circuit of the tube 37 includes a relay 38 in series with a battery 39 and shunted by a condenser 40. The armature of relay 38 is connected to wire 2 by way of a conductor 41, the latter also serving to connect the grid of a thyatron tube 42 to the wire 2.

Tube 42 is energizable from a source of alternating current 43 connected in series with a relay 44 which is shunted by a condenser 45. A conductor 46 connects the cathode of the thyatron 42 to the wire 1 whereby the input circuit of the thyatron is connected across the transmission line 1, 2. Thyatron 42 is biased or designed so that it will become conductive whenever the potential of conductor 41 exceeds a given positive value relative to conductor 46. The armature of relay 44 normally connects battery 33 to conductors 47 and 48 which, together with a bus conductor 49, form part of the energizing circuit for relays 32.

Line wire 1 is also connected to the neutral terminal of a voltage divider 50 having a negative terminal 51 and four positive terminals 52, 53, 54, and 55, the potentials for these terminals being obtained from batteries 56 and 57, respectively. Preferably, the potential of terminal 51 is of the same order though opposite polarity as that of terminal 55. Terminal 51 is connected by conductor 58 to the front contact of armature *a2*; the negative terminals 52 through 55 are similarly connected by conductors 59, 60, 61 and 62 to the front contact of armatures *b3*, *c3*, *d3* and *e3*, respectively. A conductor 63 connects armature *e3* to the front contact of relay 38.

A battery 64 has its positive terminal connected to a bus conductor 65 for potentiometers 21, 22 and 23 and has its negative terminal connected to armature *d5* by a conductor 66. Between the conductors 65 and 46 there is inserted a resistor 67 having one terminal connected to armature *d6* by way of a conductor 68, its other terminal being connected to a set of unbalance indicators 69, 70, 71 shown here schematically as lamps. Indicators 69, 70 and 71 are connected by conductors 72, 73 and 74 to the front contacts of armatures *b6*, *c6* and *d6*, respectively.

The pointers of potentiometers 18, 19 and 20 are connected to the front contacts of armatures *b4*, *c4* and *d4* by conductors 75, 76 and 77, respectively. The remaining terminals of these potentiometers are connected to the front contacts

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of armatures *b5*, *c5* and *d5* by conductors 78, 79 and 80, respectively.

Connected across the line 1, 2 in a non-galvanic manner, as by way of two condensers 81, 82, is a loudspeaker or other reproducing device 83 responsive to alternating currents arriving over the line. A suitable filter, shown here as an audio frequency choke 84 in series with wire 1 and a condenser 85 shunted across the line, prevents these alternating currents from reaching the control circuit just described.

Referring now again to Fig. 2, there is shown a similar line-terminating filter consisting of a choke 86 in series with wire 1 and a shunt condenser 87. Connected across the line ahead of the filter 86, 87 is the secondary of a transformer 88 whose primary forms part of the audio output circuit 4 of receiver 3. The provision of a condenser 89 in series with this secondary is necessary in order to prevent a virtual short-circuiting of the line for direct current.

Connected permanently across the line 1, 2, in series with a resistor 90 whose magnitude should be large compared with that of voltage divider 50 (Fig. 1), are a pair of parallel voltage dividers 91, 92 each in series with a respective rectifier 93, 94. Rectifiers 93 and 94 are oppositely poled. A portion of voltage divider 92 is connected between the cathode and the auxiliary electrode of a cold-cathode tube 95, by means of conductors 96 and 97; and a portion of voltage divider 91 is connected between the cathode and the auxiliary electrode of a cold-cathode tube 98, by means of conductors 97 and 99 and the left-hand armature of a relay 100.

The energizing circuit of relay 100 includes a battery 101 and leads over the armature and front contact of a relay 102 in series with the anode of tube 98, a similar relay 103 being in series with the anode of tube 95. Relays 102 and 103 are shunted by condensers 104 and 105, respectively. A source of alternating current 106 is connected across the main gap of tube 95 by means of conductors 107, 108, 97 and across the main gap of tube 98 by means of conductors 107, 108 and the left-hand armature of relay 100.

Source 106 is also connected across the primary of a transformer 109 whose secondary has one terminal connected to a conductor 110 and the other to the center right-hand armature of relay 100. Raw rectified current from transformer 109 is fed to the bus bar 111 of motor controls 12, 13 and 14 by way of a rectifier 112 shunted by a condenser 113. Conductor 110 also connects with a bus conductor 114 of a set of relays generally indicated at 115, comprising the relays F, G, H, I and J. Each of the relays 115 is shunted by a respective condenser 116, 117, 118, 119 and 120; the holding circuit of these relays includes a rectifier 121 inserted in the conductor 113.

Connected across the line 1, 2 is further the input circuit of a thyatron 121 of the screen grid type, its cathode being connected to wire 1 as are the cathodes of three further, similar thyatrons 122, 123 and 124. The grids of thyatrons 122, 123 and 124 are connected, over the usual current limiting resistors, to terminals 125, 126 and 127, respectively, of a voltage divider 128 associated with a battery 129 whose positive terminal is connected to wire 1 over a very large resistor 130. The function of resistor 130 is to maintain the control grids of tubes 122, 123 and 124 at the correct bias potentials preparatory to the commencement of the switching operations described hereinafter. A bias potential is also

applied to the screen grid of tube 121 by means of a battery 131.

The anode of tube 121 is connected to the windings of relays I and J in parallel by a conductor 132, the anodes or plates of tubes 122, 123 and 124 being similarly connected to the windings of relays F, G and H, respectively, by means of respective conductors 133, 134 and 135. A resistor 136, in series with line wire 1, has one terminal connected to armature *i1* by a conductor 137 and the other to armature *j3* by a conductor 138, the latter terminal being also connected to the bus conductor 139 of potentiometers 15, 16 and 17. The pointers of these potentiometers are connected by conductors 140, 141, 142 to the front contacts of armatures *f4*, *g4* and *h4*, respectively, while the remaining potentiometer terminals are connected by conductors 143, 144 and 145 to the front contacts of armatures *f3*, *g3* and *h3*, respectively. Conductors 146, 147 and 148 connect motor controls 12, 13 and 14 to the front contacts of armatures *f2*, *g2* and *h2*, respectively. A battery 149 has its positive terminal connected to bus conductor 139 and its negative terminal to the armature *j4*. Relay J, which may be slightly slow-operating, has armatures *j5* and *j2* connected to wire 2, the front contact of armature *j2* being connected to the positive terminal of battery 129 by conductor 150.

The operation of the control circuit at the local station (Fig. 1) is as follows:

Whenever one of the switches 27 through 31 is actuated, it connects battery 33 in series with the left-hand winding of the associated relay 32 which locks over its right-hand winding, sending a current impulse through the primary of transformer 36. This impulse is applied to the grid circuit of tube 37 with such a polarity as to render this tube momentarily conductive, energizing relay 38 which closes its front contact and connects wire 2 to a terminal of voltage divider 50 over a front contact of the operated relay 32. This pulse will be negative if the switch actuated was the "On" switch 30 (relay A operated) and will be positive in all other instances. The duration of the pulse will be determined by the time relay 38 remains energized, dependent in turn on the value of condenser 40, and should be sufficient to permit the full potential of the selected divider terminal to be developed at the far end of the transmission line.

After the relay 38 releases, its armature falls back and, if the operated relay 32 is one of the switching-device-actuated relays B, C and D, connects wire 2 over a front contact of such relay to the wiper of a respective potentiometer 21, 22 or 23. It should be noted that, in the exemplification illustrated, this latter operation will drive conductor 2 negative with respect to conductor 1, but to a less extent than when an "On" pulse is applied to the line; hence there will be no interference between the negative control voltages from the potentiometers, on the one hand, and either the negative "On" pulse or the positive "Off" or switching pulses, on the other.

When the highly negative "On" pulse arrives at the remote station (Fig. 2) after a period of inactivity, it will be of such a polarity as to pass the rectifier 93 and to set up a voltage difference across the exciting gap of tube 98 sufficient to ionize the latter, resulting, in turn, in the energization of relay 102 which loses its front contact and operates relay 100. Relay 100 locks over its inner right-hand front contact and armature and over the armature and back contact of relay 103,

at the same time removing the power from the main gap of tube 98 at the back-contact of its left-hand armature. Relay 100 also connects power to receiver 3 at its outer right-hand armature and front contact, and further connects the secondary of transformer 109 to wire 1 and, hence, to the cathodes of tubes 121 through 124 at its center right-hand armature and front contact.

If, now, a positive switching pulse is received, tube 121 as well as one or more of the progressively biased thyratrons 122, 123 and 124 will be momentarily ionized, depending on the magnitude of the pulse. The ionization of tube 121 energizes relay I and, immediately thereafter, relay J which opens the energizing circuit of relay I, causing it to release after an interval which is short compared with the duration of the pulse received. During the brief period of its operation, relay I at the back contact of its armature opens the holding circuit of any relay F, G, H that may have been operated. Since one or more thyratrons 122, 123, 124 are conducting at this time, one or more relays F, G, H will be energized but only the one corresponding to the tube with the highest bias will lock after relay I releases. After the pulse has subsided, all the relays 115 except the one that has locked will be unoperated, their de-energization making it possible for the operated relay to connect a particular motor control 12, 13, 14 across the resistor 136 and the associated potentiometer 15, 16, 17 across the line 1, 2.

The potential applied to conductor 2 by the selected potentiometer 15, 16 or 17 will be of the same polarity as that of a respective control potentiometer 21, 22 or 23 simultaneously connected across the line by a particular relay 32, although not necessarily of the same magnitude. If the two potentials differ, the line will be unbalanced and current will flow through resistor 67 (Fig. 1), lighting one of the unbalance indicators 69, 70, 71. In practice, it will generally be necessary to amplify the voltage drop across resistor 67. Current will also flow through resistor 136 (Fig. 2), causing the respective motor control 12, 13 or 14 to respond and to energize the associated motor 9, 10 or 11 in such a sense as to decrease this potential difference; when the line is again in balance, the motor stops.

When an "Off" pulse is received, this pulse will pass through rectifier 94 and voltage divider 92 and will place a voltage difference across the exciting gap of tube 95 which ionizes, energizing relay 103 and breaking the holding circuit of relay 100 at the back contact and armature of relay 103. Power is disconnected from the receiver 3 and from the cathodes of thyratrons 121 through 124. The release of relay 100 again connects the generator 106 across the main gap of tube 98, placing this tube in readiness to respond to the next "On" pulse.

Considering the operation of the system in greater detail, we shall assume that the operator at the local station (Fig. 1) has depressed the "On" switch 30 for an instant, the remote station being in the idle condition following the reception of an "Off" signal. Relay A energizes: Battery 33, back contact and armature of relay 44, conductor 48, switch 30, left-hand winding of relay A, conductor 49; and locks: Battery 34, secondary of transformer 36, armatures and back contacts *e1*, *d1*, *c1* and *b1* in series, right-hand winding of relay A, front contact and armature *a1*, conductor 35. Relay 38 energizes and con-

nects high negative potential to wire 2: Terminal 51, conductor 58, front contact and armature a2, back contacts and armatures b3, c3, d3, and e3 in series, conductor 63, front contact and armature of relay 38, conductor 41. Tube 98 ionizes, causing relays 100 and 102 to be energized. Power is connected to receiver 3 and the output of this receiver, as determined by the setting of the controls 6, 7 and 8, will be transmitted to the loudspeaker 83 over transformer 88 and line 1, 2.

Assume, now, that the operator desires to switch to a different frequency band, actuating the knob 20 for that purpose. Switch 29 is closed momentarily, energizing relay D: Battery 33, back contact and armature of relay 44, conductor 47, switch 29, left-hand winding of relay D. Relay D releases relay A by opening the holding circuit thereof at the back contact of its armature d1, then locks: Battery 34, secondary of transformer 36, armature and back contact e1, right-hand winding of relay D, front contact and armature d2, back contacts and armatures c2, b2, all in series, conductor 35. Relay 38 energizes momentarily and connects the positive potential of terminal 54 to wire 2: Terminal 54, conductor 61, front contact and armature d3, back contact and armature e3, conductor 63, front contact and armature of relay 38, conductor 41.

At the remote station, the positive pulse fires thyatron 121, relay I energizes: Cathode of tube 121, front contact and center armature of relay 100, secondary of transformer 109, conductor 110, conductor 114, back contact and armature j4, conductor 132, plate of tube 121; relay J operates in parallel with relay I, releases relay I and at j2 connects wire 2 to conductor 150. The high resistor 139 is now connected across the line but is of such magnitude that the level of the pulse will not decrease appreciably. This pulse is now applied to the inputs of thyatrons 122, 123 and 124 in opposition to the bias voltages developed across the voltage divider 128. Since the pulse has been obtained from the highly positive terminal 54 of voltage divider 50, its magnitude will be sufficient to ionize all three thyatrons 122, 123 and 124. Relays F, G and H energize: Wire 1, front contact and center armature of relay 100, secondary of transformer 109, conductor 110, conductor 114, windings of relays F, G and H in parallel, conductors 133, 134 and 135, respectively. Relay H, alone, locks: Wire 1, conductor 137, armature and back contact i1, armature and front contact h1, conductor 110; and at h2, h3 and h4 prepares the circuits for connecting band switch motor control 14 and potentiometer 17 to the line.

At the control station, the positive pulse applied to the line 1, 2 has also fired the thyatron 42 whose exciting potential should be not higher than the lowest positive pulse used in the system, i. e. the potential of terminal 52. Thyatron 42 energizes relay 44 which opens its armature, thereby preventing for the time being the actuation of a different relay 32. This is necessary in order to forestall false operation such as might occur if a new switching operation were initiated before the previous pulse had decayed sufficiently to de-ionize tube 121 and release relay J. If necessary, relay 44 may be made slightly slow-releasing.

After relay J becomes de-energized, motor control 14 is connected across resistor 136: Wire 1, motor control 14, conductor 148, front contact and armature h2, back contact and armature j3, 75

conductor 138. At the same time, battery 149 is connected across potentiometer 17; conductor 139, potentiometer 17, conductor 145, front contact and armature h3, back contact and armature j4. Also, the wiper of potentiometer 17 is connected to wire 2: Conductor 142, front contact and armature h4, back contact and armature j5. Meanwhile, at the control station, the end of the pulse has been marked by the release of relay 38 which now connects the wiper of band switch control 23 to wire 2: Conductor 77, front contact and armature d4, back contact and armature of relay 38, conductor 41. Earlier, the energization of relay D had connected the negative terminal of battery 64 to potentiometer 23: Conductor 66, front contact and armature d5, conductor 78. At the same time, the unbalance indicator 71 had been connected across resistor 67: Conductor 74, front contact and armature d6, conductor 68.

If the cause of the actuation of switch 29 has been a downward displacement of the contact arm associated with knob 20, then the control voltage applied to the line by potentiometer 23 will have become more negative than the balancing voltage from potentiometer 17 and current will flow through resistor 136 from left to right, causing the control device 14 to close its contacts in such a manner that motor 11 will rotate the wiper of potentiometer 17 in counter-clockwise direction. Lamp 71 will be lit until the two voltages are equal, at which time the motor 11 will cease to rotate. In similar manner the potentiometers 15 and 16 may be brought into a desired position, relay H being released at 11 when the next switching pulse is transmitted.

When the "Off" signal is given, relay E operates and locks, tube 95 fires and relay 100 releases as previously described. While this is a positive pulse, tubes 121 through 124 will be energized only for an instant since power will be removed therefrom as soon as the armatures of relay 100 are restored to unattracted position. The receiver 3 and the selector circuit of Fig. 2 now remains quiescent until the next "On" pulse is sent over the line.

Where the "On" pulse is used to connect not only the plates but also the heaters (not shown) of tubes 121-124 to their respective sources of current, false operation may result from the transmission of a switching pulse before these tubes have had time to warm up sufficiently. Another source of error resides in the possibility that a control knob be displaced, either at the local or at the distant station, while the two stations are not interconnected for remote control (i. e. before an "On" pulse or after an "Off" pulse has been transmitted). Although subsequent manipulation of the disaligned control, after remote control has been established, will immediately restore the correlated potentiometers to corresponding positions, it may happen that the operator desires to leave this particular control in its position and the maladjustment may remain unnoticed for a prolonged period.

Assume, for example, that the band switch knob 20, Fig. 1, had been brought into the position shown while the remote station was quiescent. After the "On" switch has been depressed, the operator, being satisfied with the positioning of that knob and believing the receiver to be adjusted accordingly, proceeds with the manipulation of tuning control 18 and volume control 19, unaware that he is receiving an unwanted band of frequencies. Since no "band switch" pulse is

ever transmitted, potentiometer 17 will remain unaffected and retain a setting which is different from that of the corresponding control potentiometer 23.

A similar situation may arise with respect to tuning control, but not with respect to volume control where the operator will be able to determine immediately if the setting of the receiver is satisfactory.

In accordance with another feature of the invention, the above inconveniences may be avoided by the provision of a timer circuit as shown in Fig. 3. As indicated, the circuit of Fig. 3 replaces that part of the control circuit which is shown between the lines X—X and Y—Y in Fig. 1, including "On" switch 30, "Off" switch 31 and conductor 48. This timer is provided with two banks of contacts 151, 152 having wipers 153, 154 driven from an A.-C. motor 155 which is energized by a source of alternating current 156. Contact bank 151 comprises the arcs or segments 151a, 151b, 151c and 151d; contact bank 152 comprises the arcs or segments 152a, 152b, 152c, 152d and 152e.

A manually operable "On-Off" switch 157 has its "On" contact connected to arc or segment 151a and its "Off" contact to arc or segment 151c; segments 151b and 151d are connected to a conductor 158, as are the movable arm of switch 157 and one terminal of motor 155. Conductor 159 connects motor 155 and source 156 in series to the wiper 153. There may further be provided a synchronization circuit generally indicated at 160.

A conductor 161 connects wiper 154 to its power source (battery 33). Conductors 162, 163 and 164 connect segments 152a, 152b and 152c to the "On" relay A, the "band switch" relay D and the "tuning" relay B, respectively; conductors 163 and 164 also connect relays D and B to their respective actuating switches 29 and 27. The "volume" relay C is through-connected to its actuating switch 28 by a conductor 165 having no connection with the timer. Conductor 166 connects the winding of relay 44 in series with generator 43 and tube 42, its armature connecting conductor 47 to arc 152d.

The "Off" relay E is connected to segment 152e over a conductor 167.

The operation of the timer circuit is as follows:

Since the energizing circuit of motor 155 is open at switch 157, nothing will happen until the switch is brought into its "On" position where it will be left as long as communication with the distant station is desired. Motor 155 now energizes: Conductor 158, switch 157, segment 151a, wiper 153, conductor 159, generator 156. Wiper 153 begins to travel in a counterclockwise direction and, on reaching segment 151b, closes the following circuit: Conductor 158, segment 151b, wiper 153, conductor 159, generator 156, motor 155. The motor remains energized until the wiper reaches segment 151c.

Wiper 154 is displaced synchronously with wiper 153. As it reaches segment 152a, relay A is energized, sending an "On" pulse over the line: Battery 33, conductor 161, wiper 154, segment 152a, conductor 162, left-hand winding of relay A, conductor 49. After an interval sufficient to place the remote station in full operative condition, wiper 154 engages segment 152b and a band switch synchronizing pulse is transmitted by the energization of relay D: Battery 33, conductor 161, wiper 154, segment 152b, conductor 163, left-hand winding of relay D, conductor 49. Similarly, a tuning control synchronizing pulse

is subsequently sent out by the energization of relay B over a circuit which includes segment 152c and conductor 164.

When the timing motor stops, wiper 154 is in contact with arc 152d. In this position, conductor 47 is connected to battery 33 via the armature and back contact of relay 44, segment 152d, wiper 154 and conductor 161, thus placing the relays B, C and D under the control of their respective clutch-operated switches 27, 28 and 29 for the first time. False operation is again prevented by the energization of relay 44 when a positive pulse appears across the transmission line 1, 2.

When the switch 157 is thrown into "Off" position, motor 156 again energizes: Conductor 158, switch 157, segment 151c, wiper 153, conductor 159, generator 156. Wiper 153 continues to advance and maintains motor 155 energized, over segment 151d, until it comes to rest in the position illustrated. As the wiper 154 passes segment 152e, relay E is energized: Battery 33, conductor 161, wiper 154, segment 152e, conductor 167. Thus an "Off" pulse is sent to the selector circuit at the remote station.

The transmission of the "band switch" and "tuning control" synchronization pulses insures that the settings of the respective potentiometers at the remote station correspond to the settings of those at the control station when the system is ready for manual control. It will, of course, be understood that a receiver or other apparatus to be operated in the manner described may have a larger number of controls than herein illustrated and that quite a few of these controls may be of such nature that the operator cannot readily ascertain the absence of synchronization. In such cases the transmission of three, four or more synchronizing pulses by the timer may be required before the system is placed in condition for manual operation.

The synchronization circuit 160 comprises a manual switch 168 connected to generator 156 over a conductor 169, and a relay 170 shunted by a condenser 171 and connected to segment 151c by way of a rectifier 172. The provision of this circuit enables the operator to check the synchronization of the controls referred to when the timer is in its operative position (wiper 153 on arc 151c, wiper 154 on arc 152d). When the switch 168 is momentarily depressed, rectified current from generator 156 flows through relay 170 by way of conductor 169, wiper 153, segment 151c and conductor 169, relay 170 locking over its lower armature. At its upper armature relay 170 connects motor 155 to segment 151c, causing the wipers to advance just as if switch 157 had been placed in its "Off" position. When the wiper 153 leaves segment 151c, relay 170 releases. When the wiper finally reaches segment 151a, it does not stop in the position shown in the drawing because switch 157 is still in its "On" position. Thus the timer steps round until it returns to its operative position, having thus completed a full cycle during which, successively, an "Off" pulse, an "On" pulse and the synchronizing pulses for the band switch and tuning control were sent over the line. Proper synchronization has thereby been insured and the transmission continues.

A further refinement, designed to eliminate errors due to variations in the firing point of the thyratrons, is illustrated in Figs. 4 and 5. It is known that external factors, such as changes in the ambient temperature and fluctuations in the power supply, may critically affect the biasing

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voltage at which a gas-filled tube, for example a thyatron, becomes ionized. Such instability would, of course, necessitate a wide separation of the various pulse levels which, in turn, would lead to very high signaling voltages if the number of functions to be controlled is large.

The biasing arrangement in Fig. 4 is adapted to enhance the stability of the firing point of a thyatron, e. g. thyatron 123, Fig. 2, so as to render the same responsive to switching pulses of accurately predeterminable minimum amplitude only. Tube 123 obtains its biasing potential from terminal 126 of potentiometer 128 to which its control grid is connected by way of a current limiting resistor, indicated at 173. The screen grid of tube 123 is biased negatively by means of a battery 174 connected across a voltage divider which consists of the resistances 175 and 176. The element 176 also functions as the cathode resistor of a vacuum tube 177 whose grid is connected to terminal 126 by way of a resistor 170. At 179 there is shown a battery delivering anode voltage to the plate of tube 177 by way of a resistor 180. The input resistor 181 corresponds to that portion of voltage divider 128 across which the bias voltage for thyatron 123 is developed.

The provision of battery 174 and voltage divider 175, 176 biases the screen grid of the thyatron so that the firing potential is increased beyond that of the pulse to which the thyatron should respond. Also, tube 177 is biased to cutoff by the potential normally existing on terminal 126. If, however, a positive pulse of the desired magnitude is received, tube 177 becomes conductive and a voltage drop appears across resistor 170 which opposes the bias impressed upon the screen grid of the thyatron by the battery 174, thereby lowering the exciting voltage of tube 123 to that corresponding to the incoming pulse.

The critical adjustment of the bias on two grids of a thyatron tends considerably to stabilize the minimum voltage at which the tube becomes conductive. Even more effective in this regard is the arrangement of Fig. 5, showing a modification of the portion of the circuit of Fig. 4 which is between lines Z—Z and W—W. In this modification the resistor 175 is replaced by a vacuum tube 182 having a variable cathode resistor 183. The effect of the arrangement of Fig. 5 is that, as soon as the tube 177 becomes conductive, the current through tube 182 will increase whereby, due to the cathode follower effect of resistor 183, the inner resistance of tube 182 will increase, thereby driving the screen grid of tube 123 even more sharply positive when a pulse sufficient to render tube 177 conductive is received. The variability of resistor 183 allows for the accurate adjustment of the bias of tube 123.

It will be understood that the arrangement of Fig. 4 or 5 may be applied not only to the thyatrons of Fig. 2 but also to tube 42 of Fig. 1, if desired.

Although the invention has been described with reference to the remote control of a radio receiver, it is by no means limited to a system of this character but may be adapted to a variety of purposes. An obvious field for its application is, for example, in combination with automatic telephone systems wherein the control station represents a calling subscriber and the controlled station a central office having means for connecting the calling subscriber with a selected one of a plurality of other subscribers. Again, the subscriber may be a broadcast listener connected by way of a transmission line to a central station

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receiving a plurality of programs, transmission of a particular switching signal enabling such subscriber to be connected to a specific one of the programs received at the central station.

Furthermore, it is to be understood that the specific circuit elements disclosed, or their relative arrangement, may be modified in various ways without departing from the spirit or exceeding the scope of the invention. It will be possible, for example, to replace the two-wire transmission line herein referred to by a single wire with ground return, by a coaxial cable, or by any other transmission channel capable of transmitting D.-C. voltages. What we claim as novel, and desire to secure by Letters Patent, is:

1. In a remote control system, in combination, a conductive transmission channel, a source of D.-C. potential at one end of said channel, means including said source for applying a selected one of a plurality of predetermined D.-C. voltages to said channel for transmission to the other end of said channel, a plurality of loads at said other end, a plurality of selectively biased selector elements at said other end, means including said selector elements for connecting a respective one of said loads to said channel as determined by the magnitude of the selected voltage, and a plurality of switching elements actuatable by the said selector elements, respectively, and provided with locking means, said locking means being interconnected so that only an end element in a chain of actuated switching elements will remain actuated after the associated selector elements have become inoperative.

2. The combination according to claim 1, wherein each of said loads is connectable to said channel by means of a respective switching circuit arranged to be completed when all but a corresponding one of said switching elements are unactuated.

3. A remote control system comprising a control station, a remote station and a conductive channel interconnecting said stations; said control station comprising a plurality of sources of different but fixed potentials, and pulse generator means operable to connect a selected source of potential to said channel whereby a D.-C. voltage pulse of a magnitude corresponding to the potential of said selected source is transmitted to said remote station; said remote station comprising a plurality of voltage-responsive elements, biasing means making each of said elements responsive to a respective minimum voltage only, said minimum voltages substantially corresponding to said fixed potentials, respectively, a plurality of switching elements each actuatable by a respective voltage-responsive element when the latter responds, locking means interconnected so that only an end element in a chain of actuated switching elements will remain actuated after the response of the associated voltage-responsive elements has ceased, a plurality of loads, and a plurality of switching circuits each arranged to connect a respective load to said channel when all but a respective one of said switching elements are unactuated.

4. A system according to claim 3, wherein said channel is terminated at the remote station in an impedance which is high relative to the internal impedance of any of said potential sources.

5. A system according to claim 3, wherein said voltage-responsive elements are normally disconnected from said channel, and wherein an additional voltage-responsive element is provided responsive to any of said pulses and arranged to

connect all of said normally disconnected elements across said channel at the beginning of each pulse.

6. A remote control system comprising a control station, a remote station and a transmission line interconnecting said stations; said control station comprising a plurality of sources of different but fixed potentials, a plurality of manually controllable switches, and pulse generator means operative upon actuation of any one of said switches to connect a respective one of said sources across said line for a predetermined period, whereby a D.-C. voltage pulse of a magnitude corresponding to the potential of said respective source is transmitted to said remote station; said remote station comprising a plurality of normally non-conductive electronic devices, voltage-responsive means for connecting the inputs of said devices in parallel across said line, biasing means arranged to render each of said devices conductive upon application thereto of a minimum voltage corresponding to the potential of a respective one of said sources, a plurality of relays each operable upon excitation of a respective one of said devices, said relays having armatures connected in circuit in the order of the magnitudes of the exciting voltages of the associated electronic devices, at least certain of said relays having front and back contacts, the connection of said armatures being such that a holding circuit is closed only for that one of a series of operated relays which is controlled by the electronic device having the highest exciting voltage, a plurality of loads, and circuit means including a front contact of the respective relay and back contacts of all other of said relays for respectively connecting each of said loads across said transmission line.

7. A system according to claim 6, wherein said voltage-responsive means comprise an additional electronic device responsive to pulses derived from any of said sources, and a further relay operative upon excitation of said additional device.

8. A system according to claim 7, comprising yet another relay operative upon excitation of said additional device to open the holding circuit of any relay previously operated, and circuit means including said further relay for de-energizing said other relay shortly after the beginning of a pulse.

9. A system according to claim 6, wherein said pulse generator means include a set of control relays each energizable upon actuation of a respective one of said manually controllable switches, each of said control relays being provided with a holding circuit including back contacts of all other control relays whereby only one control relay will remain energized subsequent to the actuation of said respective switch.

10. A system according to claim 9, wherein said pulse generator means further include a reactance in series with all of said holding circuits, and relay means operable in response to a current surge through said reactance to disconnect said respective source of potential from said line.

11. A system according to claim 6, further comprising an electronic device connected across said transmission line and responsive to voltages derived from any of said sources to disable all of said manually operable switches until the pulse applied to the line has decayed below a predetermined level.

12. A remote control system comprising a control station, a remote station and a transmission line interconnecting said stations; said control

station comprising a source of positive potential, a source of negative potential, a plurality of additional sources of fixed but different potentials of given polarity, first switch means operable to connect one of the two first-mentioned sources across said line whereby an "On" signal is sent to said remote station, second switch means operable to connect the other of the two first-mentioned sources across said line whereby an "Off" signal is sent to said remote station, and a plurality of third switch means each operable to connect a respective one of said additional sources across said line whereby a respective switching signal is sent to said remote station; said remote station comprising a plurality of loads, a plurality of electronic selector means each adapted to connect a respective one of said loads across said line in response to a respective one of said switching signals, a first electronic switch responsive to said "On" signal to connect power to said electronic selector means so as to place the same in condition to respond to said switching signals, and a second electronic switch responsive to said "Off" signal to disconnect power from said electronic selector means.

13. A system according to claim 12, wherein said "Off" signal is of the same polarity as said switching signals.

14. A system according to claim 13, wherein said "Off" signal is of greater magnitude than any of said switching signals.

15. A system according to claim 12, wherein said switch means include a timer operable to send at least certain of said pulses over said line in a predetermined order.

16. In a control system, in combination, a gas-filled electron tube having a cathode, an anode and at least two grids, a source of control voltage connectable across said cathode and one of said grids, a biasing circuit for the other of said grids normally maintaining said other grid at a potential sufficiently negative to prevent application of said control voltage to said one grid from ionizing said tube, an electronic control device having an input circuit and an output circuit, an impedance common to said output and biasing circuits, and a connection for applying said control voltage to said input circuit so that a voltage drop sufficient to render said tube conductive will be developed across said impedance.

17. The combination according to claim 16, wherein said control device is a vacuum tube biased to cutoff in the absence of said control voltage.

18. The combination according to claim 16, wherein said common impedance is a cathode resistor of said control device.

19. The combination according to claim 18, wherein said biasing circuit comprises a resistor and a vacuum tube having at least three elements, said elements including an anode connected to said impedance, a cathode connected to said resistor and a grid connected to a point of fixed potential.

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