

1

3,050,661

TRANSISTORIZED RECEIVER FOR DOOR
OPERATOR

Richard L. Jenkins, Kokomo, Ind., assignor to General
Motors Corporation, Detroit, Mich., a corporation of
Delaware

Filed Oct. 3, 1958, Ser. No. 765,196

7 Claims. (Cl. 317-147)

This invention relates to radiant energy operated relay control means and more particularly to electronic relay switching means which is actuated by a transmitted radiated signal. This system is a transistorized version of the electronic relay switching means shown and described in S.N. 617,490, Radiant Energy Relay Means, filed October 22, 1956, in the name of James H. Guyton issued as Patent 2,939,053 on May 31, 1960 and assigned to a common assignee.

Remote control means are presently commonly applied in a large number of situations and one of the more popular types of such control is in the use of radiant energy which does not require any physical connection between the control unit and the main operating device. Although my device may be generally used for the remote control of various types of apparatus, one illustrative use may be cited in the control of garage door operators to raise and lower garage doors from an automobile. In this instance, a transmitted high frequency signal from a car located near the door will actuate a door operator in the garage automatically. Since many of these devices may be used within a limited area, it is necessary that the transmitter-receiver device be coded in some manner, or selective, to operate only its associated device and not others.

It is an object in making this invention to provide a transistorized relay control switching means actuated from a spaced radiated signal to operate desired apparatus.

It is a further object in making this invention to provide a transistor relay control system operated from a distance by a radiated signal in the low frequency spectrum, said signal being a continuous unmodulated signal.

It is a further object in making this invention to provide a transistorized relay switching means actuated by low frequency unmodulated waves of coded frequencies.

With these and other objects in view which will become apparent as the specification proceeds, the invention will be best understood by reference to the following specification and claims and the illustrations of the accompanying drawing in which the FIGURE is a circuit diagram disclosing a transistorized relay control circuit embodying my invention.

The transmitted signals are unmodulated and the frequency span between 5000 and 10,000 cycles which it is proposed to use will provide fifty channels when spaced in constant frequency ratio between channels. This will give a sufficiently large number of code frequencies to allow a plurality of installations in any one given area without the accidental operation of neighboring installations.

Referring specifically to the FIGURE, there is shown therein a transistorized electronic relay switching means adapted to be actuated by a low frequency unmodulated signal including five low power transistors. The transmitted signal is received upon a ferrite rod antenna including a ferrite rod 2 upon which are wound two movable coils 4 and 6 connected electrically in series. The tuned resonant circuit is completed by two condensers 8 and 10 connected in parallel across the two series coils. The condenser 10 is temperature compensated so that the resonant circuit formed of these two condensers and the two coils will be stabilized. The two coils are positioned on the rod to resonate over the desired frequency

2

band and are then secured in position. The top coil 6 is tapped so that the proper impedance is fed into the input of the first transistor amplifier circuit. This tap is connected through line 12 to terminal 14 of a disconnect plug half 13 and the top of the same coil 6 is connected through line 16 with a second terminal 18 of the plug half 13, and to an electrostatic shield 11. These two terminals connect with terminals 20 and 22 of the other half 15 of the plug when the plug halves are secured together.

Terminal 22 is connected by line 24 directly with the emitter electrode 26 of the first transistor 28. Terminal 20, on the other hand, is connected through coupling condenser 30 with the base electrode 32 of transistor 28. This forms the input circuit for the first amplifier section which applies the signal across the base and emitter. A biasing resistor 34 is connected between the base 32 and ground to provide the proper bias for said base. The antenna circuit has a tendency to tune too sharply. It must be broad enough to accept a desired band width. In order to lower the Q of this antenna circuit and broaden and load the same, a further biasing resistor 36 of proper value is provided connected between the base and power line 38. The output circuit for this first amplifier stage is connected to the collector electrode 40 and includes a transformer 42 whose primary 44 is connected between the collector electrode 40 and ground. A resistance 46 is connected in shunt around the primary coil 44. A biasing resistor 48 is connected between power line 38 and the emitter electrode 26. A condenser 50 is connected in shunt across the biasing resistor 48.

The output of the first amplifier stage is applied from the primary 44 of the transformer 42 to the secondary winding 52, one terminal of which is connected directly through line 54 to the base electrode 56 of the second amplifier stage including transistor 58. A voltage divider including two resistances 60 and 62 in series is connected between the main power line and ground to provide the proper bias and the remaining terminal of secondary 52 is connected to a point intermediate these two resistances. A limiting resistor 64 is connected between that portion of the power line 66 and the remaining section 38. The second stage transistor has its emitter electrode 68 connected through a resistance 70 to the power supply line 66 and also through condenser 72 to a point intermediate resistor 60 and 62. Emitter 68 is likewise connected directly through resistor 74 to the automatic gain control line 76. This automatic gain control line is fed from one of the transformer windings in the frequency determining plug in section 77 and includes line 78 which is connected through a capacity-resistance time delay circuit formed of resistor 80 and condenser 82 to section 76 and thence further through a second section including resistance 84 and two condensers 86 and 88 connected from both ends of the resistance 84 to ground. From line 83 which is connected to resistor 84 and capacitor 88, resistance 49 is connected to emitter 26 of transistor 28 through line 24. Further, from line 83, resistor 87 is returned to power line 38.

The signal input from transistor 28 forming the first amplifier stage to transistor 58 forming the second amplifier is therefore applied by the secondary 52 across the base-emitter electrodes of the second stage. Similarly, the output of the second amplifier stage consists of a coupling transformer 90 whose primary 92 is connected in circuit between the collector electrode 94 and ground. The secondary winding 96 of the transformer 90 has one terminal connected directly to the base 98 of the driver amplifier stage transistor 100. The circuit connections between secondary transformer winding 96 and the driver transistor 100 are the same as that for the second amplifier stage and include a voltage divider consisting of two

series resistors 102 and 104 in series between line 66 and ground, a connection from the remaining terminal of secondary 96 to a point intermediate resistors 102 and 104 and a condenser 106 connected from the same location to the emitter electrode 114. A condenser 103 is connected in shunt around resistance 102 and a filtering condenser 110 is connected from line 66 to ground. A biasing or limiting resistor 112 is connected from power line 66 to the emitter electrode 114 to apply the proper bias thereto.

The driver transistor stage feeds into the tuned transformer unit 77 which is shown outlined in dash lines and this section determines the frequency response of the unit and should be matched to the transmitter frequency. It is a removable section and may be changed as desired if the operator wishes to change to a different operating or code frequency. The tuned transformer consists mainly of two closed magnetic circuit cup-core assemblies. The first of these includes a primary 116 which is tuned by two condensers 118 and 120 connected in parallel thereacross, condenser 120 being temperature compensated for stability. One side of this primary winding 116 is grounded through line 122. The secondary 124 is formed exactly like the primary, is not magnetically coupled thereto and has its own core and two condensers 126 and 128 connected in parallel thereacross to tune it to the same frequency. Condenser 128 is likewise temperature compensated. The top ends of the windings 116 and 124 are capacitatively coupled by a condenser 130. A tap 117 on primary 116 is connected to the collector electrode 119 of the driver transistor to apply the signal to the transformer section.

The transformer plug-in unit further includes two tickler coils 132 and 134 wound on the primary. Coil 132 supplies the automatic gain control voltage as previously mentioned and a restraining voltage signal. It has one terminal connected to line 78 and the other through line 136 to the base electrode 138 of the automatic gain control transistor 140. This is connected as an infinite impedance detector circuit. The emitter electrode 142 of this transistor is connected through a variable resistance 144 to the AGC line 78 and a condenser 146 is connected in shunt with resistor 144. The collector electrode 148 of transistor 140 is connected through a filter section including resistance 150 having condensers 152 and 154 connected from each end of the resistance to ground, to line 156. Line 156 is connected between primary winding 158 of transformer 164 and a variable tap 160 on resistance 162. The adjustment is provided to determine percentage modulation rejection. One terminal of resistance 162 is grounded as is the remaining terminal of primary 158. Primary 158 of the transformer 164 is in inductive relation with secondary winding 166.

The last transistor 168 may be referred to as the relay amplifier inasmuch as it directly controls the operation of the sensitive relay for actuating the device. This transistor has its base 170 connected through line 172 to a tap 246 on the secondary winding 124 of the plug-in transformer. The lower end of the secondary winding 124 is connected through line 174 to a point intermediate two rectifiers 176 and 178 which are serially connected but oppositely poled between one terminal of the tickler winding 134 and one terminal of the secondary winding 166 of the transformer 164. A condenser 180 is connected between the emitter electrode 182 of the transistor 168 and line 174 and a biasing resistor 184 is connected between the power line 186 and the emitter electrode 182. A bypass condenser 188 is connected between the emitter electrode 182 and ground. The power line section 186 is connected through a limiting resistor 190 to the power line section 66 previously described.

Returning to the selectively sharpening section fed by tickler coil 134, a potential divider is provided by resistors 192 and 194 which are connected in series between power line 185 and ground. The point intermediate

the two resistors is connected to one terminal of tickler coil 134. This supplies a fixed bias to the coil. A resistor 196 is connected between lines 185 and 174 across which different restraining voltages are developed from the tickler coils to apply to the base of the relay amplifier as will be described. A condenser 198 is connected in shunt to resistance 196.

The flow of current through the relay amplifier 168 determines the operation of the sensitive control relay 200. The collector electrode 202 of the transistor 168 is connected through line 204 to bypass capacitor 248 and to one terminal of the relay actuating coil 206, the opposite terminal of which is grounded. This relay coil 206 is adapted to attract armature 208 to engage upper contact 210. When the coil is deenergized, armature 208 falls back to engage the lower contact 213 of the relay. Armature 208 is connected directly to ground. Stationary contact 210 of the relay is connected through conductor 212 with terminal 214 of a disconnect plug 216 and controls the remote main power relay (not shown) for actuating the device. Lower stationary contact 213 is on the other hand, connected through limiting resistor 218 to power line 186 which is, in turn, connected through series resistor 222 to a rectifier 224 by line 187. Filter condensers 226 and 228 are connected between the opposite ends of resistance 222 and ground.

The power supply for the unit is obtained from terminals 230 and 232 across which the conventional 110 volt A.C. current is applied when the unit is plugged in. This 110 volt power is applied directly to the primary 234 of a power transformer 236 and induces current in the secondary winding 238. An intermediate tap 240 on the secondary is grounded and the top of the secondary is connected through line 242 and limiting resistor 244 to the rectifying diode 224 to apply power to line 187. The lower section of 238 supplies power through line 239 to contact 241 to the remote main power relay (not shown) for actuating the device.

In the operation of this control system when a signal of proper frequency is received by the antenna it is first amplified in the first amplifying stage including transistor 28, passed on to be further amplified in the second amplifying stage, and then applied to the driver amplifier 100. The tuned transformer plug-in section is very selective and will pass only an unmodulated signal of the proper frequency on to the relay actuating transistor amplifier 168 as both the primary and secondary capacitatively coupled sections are sharply tuned to the control frequency. At the same time, an automatic gain control signal is developed in the primary tickler winding 132 and applied through transistor 140 to the AGC line 78. When the carrier is applied and develops alternating current in coil 132 each negative half wave will so change the base bias on transistor 140 so that it may conduct, permitting more current to flow in the emitter amplifier resistors 48 and 70 to change the bias on transistors 28 and 58. One of these circuits may be traced as follows: from power line 38 through resistance 48, resistance 49, resistance 84, resistance 80, line 78, variable resistance 144, emitter 142, transistor 140, collector 148, resistance 150, tap 160 and part of resistance 162 to ground. As the current flow varies in this circuit, the voltage on the emitter 26 will vary to change the gain of the amplifier stage. A similar circuit can be traced for the bias on emitter 68 of transistor 58. As the amplitude of the carrier changes, the current flow through AGC transistor 140 is thus varied to in turn change the emitter bias on the amplifier stages in the opposite sense to compensate and thus control the gain. The potentiometer 144 and its associated condenser 146 have a relatively long time constant load. The potentiometer may be adjusted to control the effective level of the AGC system in order to get fast power rise for the relay circuit. The further AGC filtering provided by resistances 80 and 84 and condensers 82, 86, and 88 is fast time constant in order

5

to avoid the larger noise bursts acting to overload the receiver and cause false triggering.

This transistor 140 also provides a part of the system for developing a restraining voltage to be applied to the relay amplifier section due to any modulation of the signal. The application of the carrier signal developed in tickler coil 132 to the base 138 of the transistor 140 develops a current flow through the collector circuit which is completed through resistance 150 and transformer winding 158 to ground. If there is little or no change in the amplitude of the carrier, then there will be no change in current flowing through the primary winding 158 and no voltage will be induced in the secondary winding 166. However, if there is any modulation of the signal induced in the tickler coil 132, then the collector current flowing through transformer primary 158 will change with the modulation and a control restraining voltage will be induced in the secondary 166. This voltage is rectified by diode 178 and appears across resistance 196 connected in series across the secondary 166 with said diode. The polarity is such as to develop a positive voltage at the right hand end of the resistance 196. This voltage applied through line 174 opposes any actuating voltage applied to the base 170 and tends to prevent actuation of relay 200 if any modulation is present. The potentiometer 160—162 across the primary 158 may be adjusted for a predetermined modulation percentage rejection. Thus any modulation appearing in the signal will act to restrain the relay actuating transistor 168 from operating the relay.

As previously mentioned, the actuating signal for the operating transistor relay 168 is applied directly to the base 170 from the tuned secondary circuit 124 and is produced by the negative half cycles from the tapped portion of the secondary. The emitter resistor 184 and bypass condenser 188 form a time constant circuit which completes the detector circuit for carrier frequency application. The capacitor 180 extends the low temperature operating range by aiding the detector time constant as the impedance of the condenser 188 rises. A second restraining voltage is developed for application to the base circuit of this transistor across the same resistor 196. Resistance 196 and its parallel condenser 198 are connected across the second primary tickler coil 134 through rectifier 176 and the delay potential divider resistors 192 and 194. As the signal is tuned through the resonant frequency, this tickler coil has a signal induced therein whose amplitude versus frequency curve has a double hump outline with a central low point at the signal frequency and higher values on each side for a narrow band. Such a voltage is commonly used in signal seeking tuners to restrain actuation of the indexing device which receive either strong or weaker signals until the center of the band is tuned.

In the present instance it is desired to have only the signal frequency actuate the relay so restraining voltages caused by closely adjacent frequencies generate restraining signals represented by the higher hump portions which are used to develop a further restraining voltage. From potential divider 192—194, a fixed bias voltage is developed across tickler coil 134. Until this voltage is exceeded, no current will flow in the series circuit including coil 134, diode 176, resistance 196 and resistance 192. When sufficient voltage is induced in coil 134 by the input signal, current flows and is rectified by the diode 176 and also develops a restraining bias across resistance 196. This bias is higher just to each side of the code frequency than it is at code frequency and therefore tends to center the operation of the sensitive relay on code frequency. This restraining voltage may be termed the selectivity sharpening voltage. It is also applied in the same manner to base 170 of the relay amplifier 168. Thus, when the actuating voltage exceeds both the selectivity restraining voltage and the modulation produced voltage, the relay will be actuated.

The rectified and filtered actuating pulses from the

6

carrier pass through the relay output circuit or collector 202 circuit to operate the sensitive control relay 200. The relay is bypassed to remove carrier frequencies by condenser 248 and to, in addition, slow down the operating time so that the device will not be operated on short bursts. Thus, when a sufficiently strong unmodulated signal of the proper frequency is applied to the base 170 of the relay operating transistor 168 and is sufficient to overcome the restraining effects of any restraining voltage due to modulation and to any restraining voltage due to selectivity applied across resistance 196, the relay 200 will be actuated to attract its armature to engage the upper contact 210 which in turn will complete the circuit to the power relay (not shown) to operate the garage door or any other device which it may be desired to operate.

I claim:

1. In a control system, a source of electrical power, relay switching means connected to said source of electrical power, transistor amplifying means having an input and an output circuit, said output circuit being connected to said relay switching means to control the same, means for receiving and amplifying an unmodulated signal of a predetermined frequency, resonant circuits tuned to said predetermined frequency coupling said receiving and amplifying means to the input circuit of the transistor amplifying means to apply an actuating signal, said resonant tuned circuits being tuned to said predetermined frequency, means for generating and rectifying restraining signals from any modulation of the received signal connected to the resonant circuits and to the input circuit of the transistor amplifying means so poled as to be in opposition to the actuating signal to tend to prevent operation of the relay switching means if any modulation is present, and a second means for developing a further restraining voltage proportional to the peak value of the envelope of the applied signal connected to the resonant circuits and to the input of the transistor amplifying means also poled as to be in opposition to the actuating signal to provide higher selectivity.

2. In a control system, a source of electrical power, relay switching means connected to said source of electrical power, transistor amplifying means having an input and an output circuit, said output circuit being connected to said relay switching means to control the same, means for receiving and amplifying an unmodulated signal of a predetermined frequency, resonant tuned circuits coupling said receiving and amplifying means to the input circuit of the transistor amplifying means to apply an actuating signal, said resonant tuned circuits being tuned to said predetermined frequency, means for generating and rectifying restraining signals from any modulation of the received signal connected to said resonant tuned circuits and to the input circuit of the transistor amplifying means so poled as to be in opposition to the actuating signal to tend to prevent operation of the relay switching means if any modulation is present, a second means for developing a further restraining voltage proportional to the peak value of the envelope of the applied signal connected to the resonant tuned circuits and to the input of the transistor amplifying means so poled as to be in opposition to the actuating signal to provide higher selectivity, and a fixed bias on said second means for developing a further restraining voltage so that it will not become effective until a certain value is exceeded.

3. In a control system, a source of electrical power, relay switching means connected to said source of electrical power, transistor amplifying means having an input and an output circuit, said output circuit being connected to said relay switching means to control the same, means for receiving and amplifying an unmodulated signal of a predetermined frequency, resonant circuit means tuned to a given frequency coupled between the means for receiving and amplifying an unmodulated signal and the input circuit of the transistor amplifying means to apply an actuating signal to the latter and cause the relay switching means

7

to be operated, means connected to the resonant circuit means to develop a restraining voltage due to any modulation on the received signal, further means connected to said resonant circuit means to develop a second restraining voltage for increasing selectivity from the envelope of the applied signal and conductive means connecting both of the last named means for developing a first and second restraining voltage to the input circuit of the transistor amplifying means to restrain operation of the relay switching means when modulation is present and until the exact resonant frequency of the resonant circuit is applied.

4. In a control system, a source of electrical power, a relay switching means connected to said source of electrical power, a transistor having an input and an output circuit, said output circuit being connected to said relay switching means and to the source of electrical power to control the relay switching means, receiving and amplifying means for receiving a radiated signal, coupling means interconnecting the input circuit of the transistor with the receiving and amplifying means to apply an actuating signal to said transistor input upon receipt of an unmodulated signal of the proper frequency, said coupling means comprising a tuned primary and a tuned secondary circuit and a plurality of tickler coils associated with said primary, a first circuit connected to one of the tickler coils and including rectifier and transformer means in which a signal is developed due to modulation on the received signal, resistance means connected to said first circuit across which a restraining voltage is developed by said modulation, a second circuit connected to a second tickler coil and including rectifying means connected to the resistance means and developing a further restraining voltage due to the envelope of the signal to increase selectivity and means connecting said resistance to the input circuit to the transistor to restrain actuation of the relay switching means when modulation is present on the incoming signal and until the exact resonant frequency is applied.

5. In a control system, a source of electrical power, a relay switching means connected to said source of electrical power, a transistor having an input and an output circuit, said output circuit being connected to said relay switching means and to the source of electrical power to control the relay switching means, receiving and amplifying means for receiving a radiated signal, coupling means interconnecting the input circuit of the transistor with the receiving and amplifying means to apply an actuating signal to said transistor input upon receipt of an unmodulated signal of the proper frequency, said coupling means comprising a tuned primary and a tuned secondary circuit and a plurality of tickler coils associated with said primary, a first circuit connected to one of the tickler coils and including rectifier and transformer means in which a signal is developed due to modulation on the received signal, resistance means connected to said first circuit across which a restraining voltage is developed by said modulation, a second circuit connected to a second tickler coil and including rectifying means connected to the resistance means and developing a further restraining voltage due to the envelope of the signal to increase selectivity, means for applying a fixed bias to this second circuit so that no restraining

8

voltage will be developed until the second tickler coil voltage exceeds a given value, and means connecting said resistance to the input circuit of the transistor to restrain actuation of the relay switching means when modulation is present on the incoming signal and until the exact resonant frequency is applied.

6. In a control system, a source of electrical power, a relay switching means connected to said source of electrical power, a transistor having an input and an output circuit, said output circuit being connected to said relay switching means and to the source of electrical power to control the relay switching means, receiving and amplifying means for receiving a radiated signal, coupling means interconnecting the input circuit of the transistor with the receiving and amplifying means to apply an actuating signal to said transistor input upon receipt of an unmodulated signal of the proper frequency, said coupling means comprising a tuned primary and a tuned secondary circuit and a tickler coil associated with said primary, a first circuit connected to the tickler coil and including rectifier and transformer means in which a signal is developed due to modulation on the received signal, resistance means connected to said first circuit across which a restraining voltage is developed by said modulation, conductive means connecting said first circuit to said receiving and amplifying means to control the gain thereof, and a second conductive means connecting said resistance to the input circuit of the transistor to apply a restraining voltage due to modulation.

7. In a control system, a source of electrical power, a relay switching means connected to said source of electrical power, a transistor having an input and an output circuit, said output circuit being connected to said relay switching means and the source of electrical power to control the relay switching means, receiving and amplifying means for receiving a radiated signal, coupling means interconnecting the input circuit of the transistor with the receiving and amplifying means to apply an actuating signal to said transistor input upon receipt of an unmodulated signal of the proper frequency, said coupling means comprising a tuned primary and a tuned secondary circuit and a tickler coil associated with said primary, a first circuit connected to the tickler coil and including rectifier and transformer means in which a signal is developed due to modulation on the received signal, resistance means connected to said first circuit across which a restraining voltage is developed by said modulation, conductive means connecting said first circuit to said receiving and amplifying means to control the gain thereof, a second conductive means connecting said resistance to the input circuit of the transistor to apply a restraining voltage due to modulation, and variable resistance means in said first circuit to adjust the amplitude of the restraining voltage developed by modulation.

References Cited in the file of this patent

UNITED STATES PATENTS

2,739,273	Andrews et al. -----	Mar. 20, 1956
2,834,879	Bauman -----	May 13, 1958
2,939,053	Guyton -----	May 31, 1960