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HIGH FREQUENCY RELAY CONTROL CIRCUIT

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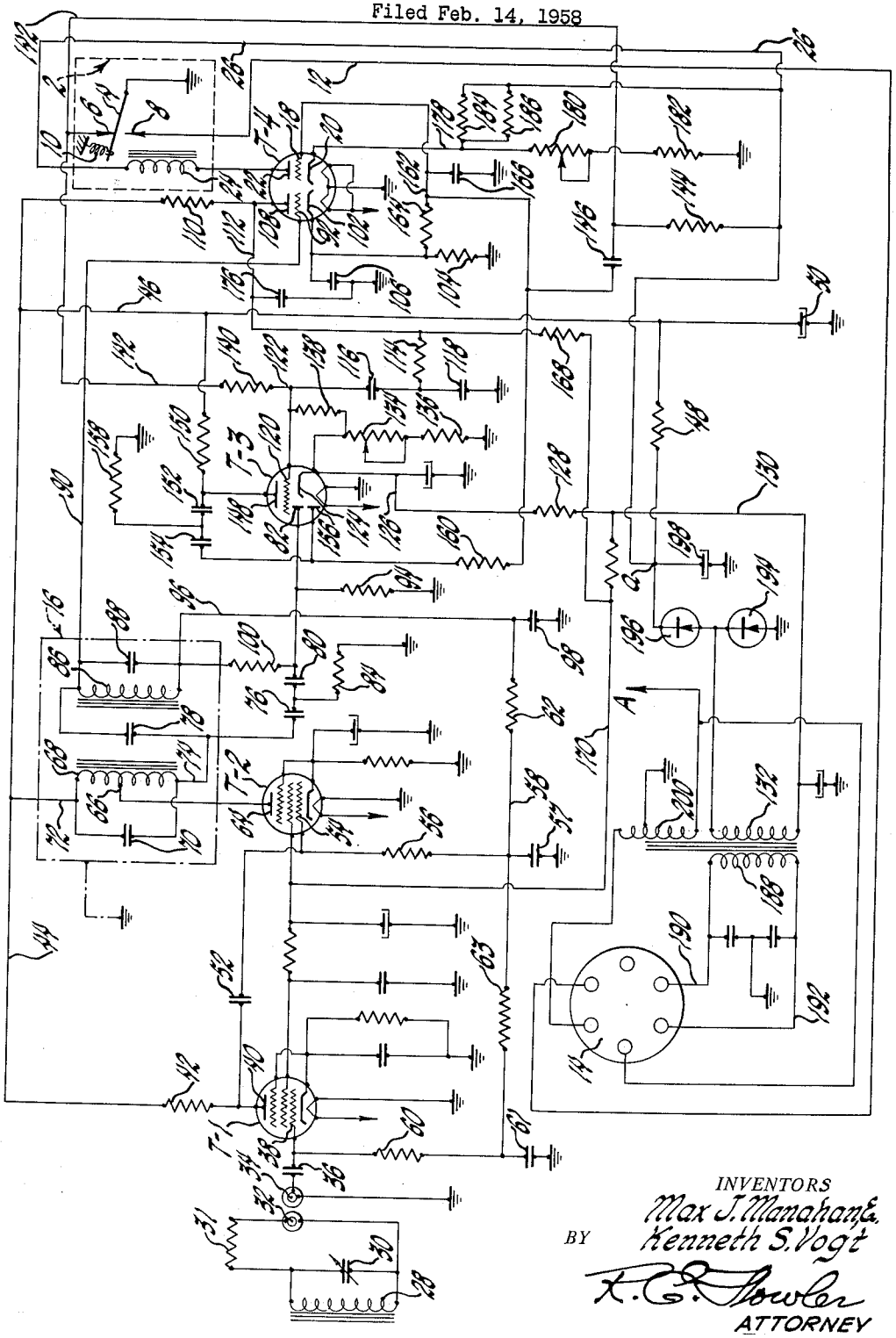

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HIGH FREQUENCY RELAY CONTROL CIRCUIT

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This invention relates to a radiant energy relay operating means and more particularly to electronic relay switching means which is operable from a transmitted radiated signal.

Electronically controlled relay means are in considerable use at the present time for operating devices at a distance without the necessity for interconnecting wires. As illustrative only of a possible use of such equipment is that of providing control means for automatically raising and lowering garage doors which may be operated from a transmitting unit in an automobile located at a distance from the door which it is desired to raise or lower.

The current invention is similar to and an improvement over the control system disclosed in U.S. application Serial No. 617,490 in the name of James H. Guyton filed October 22, 1956, entitled Radiant Energy Relay Means which is assigned to a common assignee, and now Patent No. 2,939,053.

It is therefore an object in making this invention to provide electronically controlled relay switching means which is operable from a remote signal generator to actuate desired apparatus.

It is a further object in making this invention to provide radiant energy actuated relay switching means for the operation of desired apparatus from a remote point which is operable in the low frequency spectrum by continuous unmodulated carrier waves.

It is a further object in making this invention to provide relay switching means which will ignore modulated signals, including noise created by electrical appliances, and operate only upon unmodulated carrier signals.

With these and other objects in view which will become apparent as the specification proceeds, our invention will be best understood by reference to the following specification and claims and the illustrations in the accompanying drawing in which:

The figure is a circuit diagram of a radiant energy operated electronic switching means embodying our invention.

In radiant energy operated remote switching means, various sources of radiant energy may be used as the operating signal. As an illustration, it could be used for automatic garage door operation. It is desired to have an automobile having means thereon capable of controlling the garage door operator so that it may have admittance to the garage space.

In this illustrated instance, therefore, the automobile would be equipped with a transmitter for emitting waves of a constant signal frequency and amplitude. Upon the driver approaching the garage, a switch would be closed energizing the transmitter to send out radiating waves to the electronic switching means such as that disclosed herein. The present means should be capable of picking up the radiating signal, amplifying the same, and causing the operation of a switching relay which would control the motor to raise and lower the garage door. In the current example the relay would remain in actuated position only so long as the transmitter is energized and would drop out as soon as the transmitter is cut off.

The present type of control system is proposed to operate in the VLF (very low frequency) band. This would include that band of frequencies from 5,000 to 10,000 cycles. While this is suggested, it is appreciated, however, that our invention is equally applicable to other lower and higher frequency operation and should not be limited to only these frequencies. In supplying electronic relay switching means for such a suggested use as garage door operator, it is necessary to provide a plurality of codes so that adjacent installations will not cause spurious operation. In the present case, this is accomplished by providing transmitters that are adjusted to operate at certain definite spaced frequencies and to cooperate with receivers adjusted to receive only one frequency and filter out adjacent frequencies. In the band from 5,000 to 10,000 cycles there is adequate room for a large number of different operating frequencies so that neighboring installations will not interfere with each other. However, each installation must operate accurately on its own frequency and be substantially unresponsive to associated waves on either side of that frequency.

Referring now more specifically to the drawing, there is shown therein an electronic controlled relay switching means for controlling a power relay such as may be associated with a garage door operator. In the current system, the relay **2** is provided to control the power relay controlling the motor operating the garage door. This relay **2** includes an armature **4** which is grounded and two spaced stationary contacts **6** and **8** between which the armature **4** may oscillate. It is spring biased toward the upper contact **6** by biasing spring **10**. The lower contact **8** is connected through line **12** to a disconnect plug half **14** and thence would be connected to a power relay controlling a motor. The relay **2** is controlled by the final triode section in the last tube T–4. The three preceding tubes T–1, T–2, and T–3 are conventional multielement tubes. Tube T–1 is used as a high frequency amplifying tube to amplify the signal appearing on the antenna. Tube T–2 is a second stage of a high frequency amplifier and further amplifies the incoming signal and then applies it to a tuned transformer section **16** where it is filtered and then applied to the detector section of the tube T–4. Tube T–3 acts as an amplifier for the detected modulation in any wave which may be received by the set and then further rectifies the same to develop a restraining voltage as will later be described.

Power for operating the electronic relay system is provided by a power supply section connected to the disconnect plug **14** and shown in the lower central and left portions of the diagram. Control grid **18** of the second triode section of the tube T–4 controls the flow of current between the cathode **20** and the plate **22** thereof. Plate **22** is connected through coil **24** of the relay **2** and thence through line **26** to the power supply section at point *a*. This provides plate voltage for plate **22** and also operating voltage for the relay coil **24**. If control grid **18** is sufficiently positive to permit adequate current to flow between cathode **20** and plate **22** then relay coil **24** will attract armature **4** moving it from its upper illustrated position to contact with lower contact **8** and complete an energizing circuit for the garage door motor.

The antenna in the current application consists of a winding **28** wound on a suitable core structure which is tuned by an adjustable condenser **30** connected thereacross. A resistor **31** connected in series with a common terminal of the winding **28** and condenser **30** filters out

spurious high frequency signals. This antenna section is connected through a disconnect plug 32, 34, and thence through a coupling condenser 36 to the control grid 38 of the first tube T–1. Grid 38 is also connected through resistor 60 to biasing resistor 63 and to bypass condenser 61. The opposite end of resistor 63 connects to line 58. The connection between the antenna section and the disconnect plug 32 is through a shielded wire, the shield being grounded. The plate 40 of the amplifier tube T–1 is connected through resistor 42 to plate power supply line 44. Line 44 is connected to the main power supply line by tieline 46 and limiting resistor 48. Line 46 is likewise connected to ground through condenser 50. The plate 40 is capacity coupled through condenser 52 to control grid 54 of the second stage amplifier T–2. Control grid 54 is connected through resistance 56 to line 58. Line 58 extends from one terminal of biasing resistor 63 to one terminal of grid biasing resistor 56 and thence to one terminal of resistance 62 connected to the transformer section 16. Condenser 57 is connected between line 58 and ground. Thus the signal received upon the antenna section is applied to control grid 38, amplified by tube T–1 and applied to control grid 54 of the second tube T–2 and amplified therein.

The plate 64 of the tube T–2 is connected to a tap 66 on the primary 68 of the tuned transformer section 16. A condenser 70 for tuning the transformer primary to the desired operating frequency is connected directly across said primary winding. One terminal of the primary 68 is connected through tieline 72 to plate power supply line 44 and the other terminal connected through tieline 74 to a point intermediate to condensers 76 and 78. A further series condenser 80 connects the remaining terminal of condenser 76 to diode anode 82 of the tube T–3. The point intermediate the condensers 76 and 80 is connected through resistor 84 to ground. The secondary winding 86 of the transformer 16 is tuned to the desired operating frequency by condenser 88 which is directly connected across its terminals. The remaining terminal of coupling condenser 78 is connected to the upper terminal of the secondary winding 86 which winding terminal is connected through conductor 90 with control grid 92 of the first triode section of the tube T–4. This applies the operating signals to this section of the tube T–4 where they are detected. A biasing resistance 94 is connected between diode anode 82 and ground. The lower terminal of secondary winding 86 is connected through line 96 with resistance 62 as previously described to provide automatic volume control and also through filtering condenser 98 to ground. A resistor 100 is connected between line 96 and anode 82 of the tube T–3.

The amplified and filtered signals which pass through the transformer 16 and appear on control grid 92 of the first section of the tube T–4 produce two different control voltages, depending upon their characteristics. If the signal is a continuous high frequency signal containing no modulation, it is then detected between grid 92 and cathode 102 and appears as a positive voltage across resistance 104 connected between cathode 102 and ground. A bypass condenser 106 is also connected between cathode 102 and ground to provide a certain time period. On the other hand, if the signal is modulated, then in addition to this positive voltage, a so-called restraining voltage is detected between grid 92 and plate 108 of the first triode section of the tube T–4, which voltage is applied to the triode amplifying section of the tube T–3. Specifically, this latter circuitry includes a resistor 110 connected between the plate voltage supply line 44 and the plate 108 and a conductor 112 which extends from plate 108 to a filtering section including coupling resistor 114 which is connected to a point between two condensers 116 and 118. The remaining terminal of capacity 118 is connected to ground and the remaining terminal of condenser 116 connected directly to the control grid 120 of the triode section of the tube T–3 through line 122. In this manner the detected pulsating voltage appearing in the plate 108 is filtered and applied to grid 120.

The cathode 124 of the tube T–3 is connected through line 126 to the power supply section through resistance 128 and line 130 which extends to one terminal of the secondary coil 132. A potentiometer including a variable resistance 134 and a further series resistance 136 is connected directly between the cathode 124 and ground. A resistor 138 is connected across the grid and cathode. Line 122 is connected to one terminal of a resistor 140, the opposite terminal of which is connected through line 142 to the back contact 6 of control relay 2 and thence to a point intermediate a resistor 144 and a condenser 146. The opposite terminal of resistor 144 is connected to previously described power supply line 26. Plate 148 of the tube T–3 upon which the amplified pulsating voltage created by a modulated signal appears, is connected through a resistor 150 to power line 46 to apply the proper voltage to the plate, and also through a pair of condensers 152 and 154 to the diode anode 156 of the tube. A point intermediate the two series condensers 152 and 154 is connected to ground through a resistance 158. Through this connection the pulsating amplified voltage on plate 148 is rectified and develops a voltage across a resistance 160 which has one terminal connected to anode 156 and the other connected directly to line 162 which extends to the control grid 13 of the second triode section of the tube T–4. This line is also connected to one terminal of condenser 146. A resistance 164 is connected between line 162 and cathode 102 of the first triode section of the tube T–4. A condenser 166 is connected between line 162 and ground. Line 112 extending from the plate 108 to the input of the amplifying section of the tube T–3 is also connected through resistor 168 to line 170 which extends back to the power supply. A condenser 176 is connected between line 112 and ground. The cathode 20 of the last triode stage of the tube T–4 is connected through line 178 and thence through two series resistances 180 and 182 to ground. The first of these resistances 180 is variable. Line 178 is likewise connected through two parallel resistors 184 and 186 to power supply line 26.

Power is supplied for the various components of the current system from a power line connected to the disconnect plug 14 which applies power to the primary 188 of a power transformer through lines 190 and 192. Secondary 132 of this power transformer has one terminal connected to lead 130 whose connections have previously been described, and another terminal connected between diodes 194 and 196 to provide a voltage doubler section. The lower terminal of diode 194 is grounded and the upper terminal of diode 196 is connected to point *a*. This point is also connected to ground through condenser 198 providing conventional voltage doubling action. A second secondary winding 200 on the power transformer has one terminal grounded and its other terminal connected to the filaments of the various tubes as indicated by the arrow marked "A." It is to be noted that each of the filament circuits also includes an arrow connection to which this point would be conductively coupled.

As previously mentioned, the present circuit is adapted to receive a continuous high frequency unmodulated wave and to utilize that wave for operating a control relay 2 to energize and deenergize a power relay controlling a motor for raising and lowering a garage door or operating any other desired equipment. Assuming that a frequency of 5,000 cycles has been selected as the frequency of the transmitter and that frequency to which the present circuit is to respond, a 5,000 cycle transmitter is energized at a remote point and transmits a signal which is received on the antenna circuit 28 generating a certain signal therein. This signal is amplified through stages T–1 and T–2 and applied to the selective transformer circuit 16. The output of the secondary 86 is applied

through line 90 to grid 92 of the detecting stage. The 5,000 cycle continuous signal develops a voltage across resistor 104 which may be called the actuating voltage for the relay. If there is little or no modulation of the signal or if no other signal containing modulation is simultaneously received which reaches this point, then the actuating voltage developed across resistor 104 applies a positive voltage to the grid 18 of the second section of T–4 and that section of the tube conducts a sufficient amount of current to cause the relay coil 24 to attract armature 4 so that it engages stationary contact 8 which completes an energizing circuit to the external power relay and the control motor and, for example, the garage door is raised or lowered.

As soon as the received signal is discontinued, grid 18 returns to a sufficiently negative bias to reduce conduction through this half of the tube and the spring 10 returns the armature 4 to its upper position, breaking the energizing circuit. If modulated noise signals are received, then such modulated waves are detected between grid 92 and plate 108. This produces a series of pulses on line 112 which pulses are conducted and applied through the filter and coupling network consisting of resistor 114 and condensers 116 and 118 to the grid 120 of the amplifying section of the tube T–3. Such signal is there amplified and then taken from the plate 148 through the coupling capacitors 152 and 154 and rectified by anode 156 and cathode 124. The results of this rectification develop a voltage across the potentiometer consisting of resistances 160, 164 and 104 in series to provide a negative voltage on line 162 which opposes the actuating voltage developed across resistance 104. This, therefore, tends to reduce the voltage on control grid 18 and depending upon the relative amplitudes of the actuating and restraining voltage may, or may not, cause the relay 2 to be operated. By this method the system assures that the relay will not be spuriously operated through some noise or unwanted modulated signal but that it will be operated only by a continuous unmodulated signal. The amount of negative voltage which is applied to the line 162 as a result of the modulated signal is determined by the ratio of the resistors 160 and 164 of the potential divider system, by the values of resistors 110 and 168 and by the percentage of modulation of the received signal. The resistance 160 together with the condenser 166, acts as a filter in the opposing voltage line.

When the system receives a signal and actuates the relay 2, a certain amount of ambient signal noise is developed due to the opening and closing of switch contacts, etc., which might produce a restraining signal causing the relay to return to its inactive position. Therefore, some hold-down means must be provided to make the relay control circuit insensitive for a short time period until such noises disappear. In the present instance there has been provided a back contact 6 on the control relay 2 which grounds line 142 when the relay is open. However, when an operating signal is applied to this system and relay 2 is actuated to move armature 4 to the front position engaging stationary contact 8 it simultaneously opens the circuit at stationary contact 6. This opening of the circuit between 4 and 6 ungrounds the upper end of resistor 144, and this permits condenser 146 connected thereto to charge up by drawing current through the resistance 144. This produces a positive pulse on the opposite plate of the condenser 146 which is directly connected to the grid 18 and thus for a short period of time, determined by the value of the condenser 146 and the resistance 144, an additional positive operating pulse is provided on grid 18 to keep the tube conducting and the relay actuated. This positive pulse will override any drop which may appear due to current noise for a short time.

When no signal is being received and the receiver is in standby condition, the biasing on tube T–3 is determined by the resistor 140 which is connected between the grid and ground and the resistor 138 in series therewith between the cathode and grid. Under these standby conditions, a bias voltage of some 1 volt is developed. At this time also, a relatively high voltage is applied to the plate 148 which results in ample amplification. If a signal is now received and the relay moves to its lower position, the bias on tube T–3 is still determined by resistors 138 and 140 but the upper end of resistance 140 now assumes a much higher value, approximately twice, so T–3 now has a zero bias and the plate voltage drops to almost zero. This also immunizes the amplifying system for noise and it is disabled after the relay has once operated. This prevents a chattering of the relay.

We claim:

1. In a control system, a relay coil, an armature for control switching actuated by said relay coil, electronic means having an input and an output circuit, said relay coil being connected in said output circuit and the energization of said relay coil determined by the flow of current through said electronic means, a first rectifying means including a resistance for developing an actuating signal connected to the input circuit of the electronic means, means for applying a high frequency unmodulated wave to said first rectifying means so that said actuating signal is developed by said unmodulated wave, a second rectifying means including a second resistance also connected directly to said input circuit to apply a restraining signal of opposite sign from the first, and means for applying detected modulated wave signals to said second rectifying means so that modulated waves will develop restraining voltages to prevent the relay coil from being energized but unmodulated wave signals will cause it to attract its armature.

2. In a control system, a relay coil, an armature for control switching actuated by said relay coil, electronic means having an input and output circuit, said relay coil being connected in said output circuit and the energization of said relay coil determined by the flow of current through said electronic means, a first rectifying means including a resistance for developing an actuating signal connected to the input circuit of the electronic means, means for applying a high frequency unmodulated wave to said first rectifying means so that said actuating signal is developed by said unmodulated wave, a second rectifying means including a second resistance also connected directly to said input circuit to apply a restraining signal of opposite sign from the first, means for applying detected modulated wave signals to said second rectifying means so that modulated waves will develop restraining voltages to prevent the relay coil from being energized but unmodulated wave signals will cause it to attract its armature, and a time delay circuit including a condenser and resistance connected to the input circuit and to the armature switching means to apply an operating signal to said electronic means after actuation for a given period regardless of any other signals.

3. In a control system, a source of electrical power, a relay operating coil connected thereto, switching means associated with said coil and actuated by energization thereof, electronic means connected in series with the relay operating coil and controlling the current flow therethrough, said electronic means having a control electrode, high frequency amplifying means connected to the source of electric power, tuned coupling means connected to said high frequency amplifying means and resonant to a given desired frequency, a first rectifying means connected to said tuned coupling means, and supplied therefrom by a high frequency unmodulated wave, said first rectifying means being connected to said control electrode to apply an actuating signal thereto upon the receipt of an amplified unmodulated signal of the frequency of the tuned coupling means, detecting means connected to the tuned coupling means, filtering coupling means connected to

said detecting means, a second rectifier means connected to said filtering coupling means and directly to said control electrode and supplied with detected modulated waves developing voltage of opposite polarity to that of the first rectifying means from modulation of the amplified high frequency wave to prevent conduction of the electronic means if modulation is present.

4. In a control system, a source of electrical power, a relay operating coil connected thereto, switching means associated with said coil and actuated by energization thereof, electronic means connected in series with the relay operating coil and controlling the current flow therethrough, said electronic means having a control electrode, high frequency amplifying means connected to the source of electrical power, tuned coupling means connected to said high frequency amplifying means and resonant to a given desired frequency, a first rectifying means connected to said tuned coupling means and to said control electrode to apply an actuating signal thereto upon the receipt of an amplified unmodulated signal of the frequency of the tuned coupling means, a second rectifier means connected to said tuned coupling means and directly to said control electrode developing voltage of opposite polarity to that of the first rectifying means from modulation of the amplified high frequency wave to prevent conduction of the electronic means if modulation is present, and amplifying means connected between the tuned coupling means and the second rectifying means to amplify the detected voltage from which the restraining voltage is developed and means for adjusting the sensitivity of the last-named amplifying means.

5. In a control system, a source of electrical power, a relay operating coil connected thereto, switching means associated with said coil and actuated by energization thereof, electronic means connected in series with the relay operating coil and controlling the current flow therethrough, said electronic means having a control electrode, high frequency amplifying means connected to the source of electrical power, tuned coupling means connected to said high frequency amplifying means and resonant to a given desired frequency, a first rectifying means connected to said tuned coupling means and to said control electrode to apply an actuating signal thereto upon the receipt of an amplified unmodulated signal of the frequency of the tuned coupling means, a second rectifier means connected to said tuned coupling means and directly to said control electrode developing voltage of opposite polarity to that of the first rectifying means from modulation of the amplified high frequency wave to prevent conduction of the electronic means if modulation is present, and biasing means including switching means actuated by said relay coil connected to said source of power and to the control electrode to apply an actuating voltage to said control electrode for a predetermined time after switching regardless of any other factor.

6. In a control system, a source of electrical power, a relay operating coil connected thereto, switching means associated with said coil and actuated by energization thereof, electronic means connected in series with the relay operating coil and controlling the current flow therethrough, said electronic means having a control electrode, high frequency amplifying means connected to the source of electrical power, tuned coupling means connected to said high frequency amplifying means and resonant to a given desired frequency, a first rectifying means connected to said tuned coupling means and to said control electrode to apply an actuating signal thereto upon the receipt of an amplified unmodulated signal of the frequency of the tuned coupling means, a second rectifier means connected to said tuned coupling means and directly to said control electrode developing voltage of opposite polarity to that of the first rectifying means from modulation of the amplified high frequency wave to prevent conduction of the electronic means if modulation is present, amplifying means connected between the tuned coupling means and the second rectifying means to amplify the detected voltage from which the restraining voltage is developed, means for adjusting the sensitivity of the last-named amplifying means, and biasing means including switching means actuated by said relay coil connected to said source of power and to the control electrode to apply an actuating voltage to said control electrode for a predetermined time after switching regardless of any other factors.

7. In a control system, a source of high frequency unmodulated waves, a relay coil, an armature for control switching actuated by said relay coil, electronic means having an input and an output circuit, said relay coil being connected in said output circuit and the energization of said relay coil determined by the flow of current through said electronic means, a first rectifying means connected to said source of high frequency unmodulated waves and including a resistance for developing an actuating signal connected to the input circuit of the electronic means, a detecting means for detecting any undesirable modulations on said high frequency waves also connected to said source of high frequency waves, amplifying means connected to said detecting means, a second rectifying means including a second resistance connected to said amplifying means and across which a restraining signal is developed by said unwanted modulation of said high frequency waves connected to said resistance across which the actuating signal is developed in such a manner as to oppose the polarity of the actuating signal in the input circuit, the resulting signal of the combination controlling the current flow through the electronic means and time delay means connected to the input circuit to apply an actuating signal to the input circuit for a predetermined time period after actuation of the armature by the relay coil regardless of any other signal.

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