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2,724,074

RADIO REMOTE CONTROL SYSTEM

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Fig. 1.

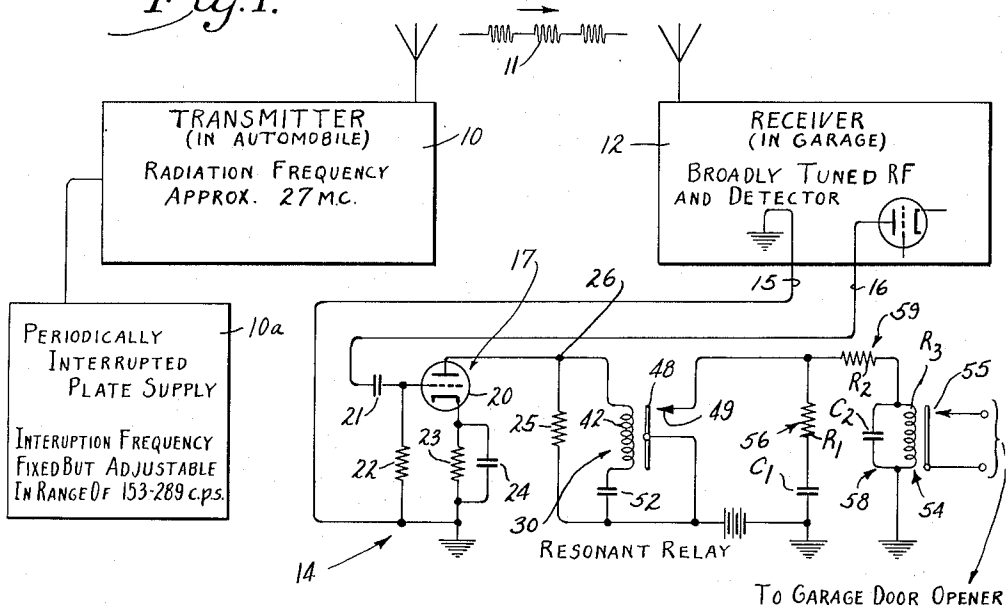


Fig. 2.

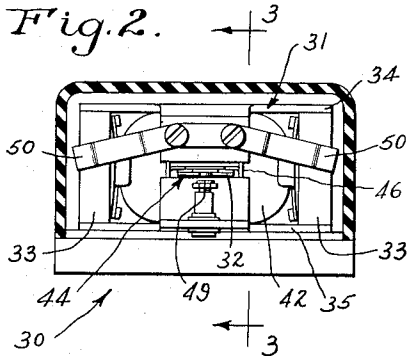


Fig. 3.

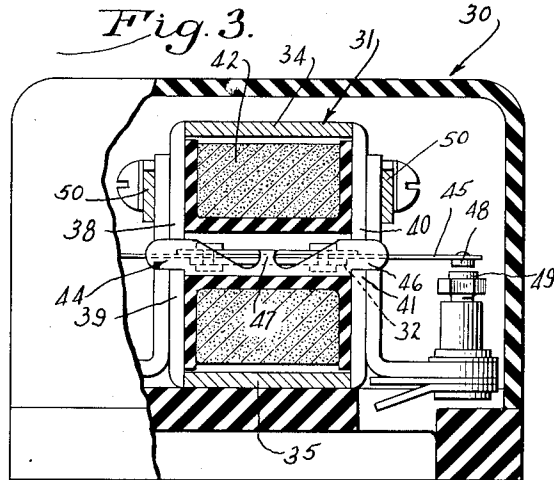
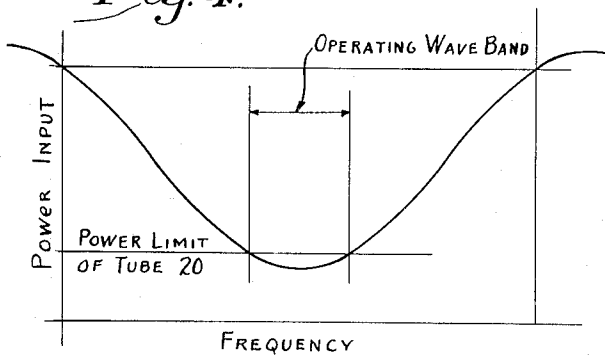


Fig. 4.



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RADIO REMOTE CONTROL SYSTEM

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10 Claims. (Cl. 317—147)

The present invention relates to radio control devices for remote operation of garage doors or the like.

It is an object of the present invention to provide an improved radio control system which is reliable in operation and which will respond only to signals sent out by the transmitter unit, being insensitive to atmospheric disturbances and spurious trains of man-made impulses. It is a further object to provide a receiving station for remote control purposes which will respond only to a periodically interrupted carrier sent out by a particular transmitter unit, being insensitive to carriers having a different interruption frequency, even though the amplitude of such carriers may be many times greater in magnitude.

It is a further object to provide a radio control arrangement including a sensitive vibratory relay which is capable of controlling relatively large amounts of power without transient overloading and consequently sticking of the relay contacts. It is a related object to provide a receiving arrangement using a minimum number of tubes and requiring a minimum amount of standby power. Finally, it is an object to provide improved remote control apparatus which is simple and inexpensive to construct and maintain.

Other objects and advantages will become apparent as the discussion proceeds and in the light of the attached drawing in which:

Figure 1 shows the improved remote control arrangement partially in block form.

Fig. 2 is a view in elevation of the preferred form of vibratory relay employed in the circuit of Fig. 1.

Fig. 3 is a transverse section taken along the line 3—3 of Fig. 2.

Fig. 4 is a curve showing the power input to the vibratory relay to cause operation at different frequencies.

While the invention is susceptible of various modifications and alternative constructions and uses, I have shown in the drawing and will herein describe in detail one embodiment of the invention. It is to be understood, however, that I do not intend to limit the invention by such disclosure but aim to cover all modifications and alternative constructions and uses falling within the spirit and scope of the invention as expressed in the appended claims.

Referring to the drawings, Figure 1 shows the complete remote control system which includes a transmitter 10, a receiver 12, and a control unit 14. Both the transmitter and receiver are shown merely in block form since they are of conventional design readily understood by one skilled in the art. The control unit 14, however, has been set forth schematically and will be described in detail as the discussion proceeds. In practical installations such control unit forms a part of the receiver and is mounted on the same chassis as the receiving components. It is here considered as a separate unit so that the invention may be understood without burdening the disclosure with circuits which are well known.

The transmitter 10 mounted in the automobile may

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consist of a simple oscillator having a carrier frequency of 27 megacycles and in which oscillation is interrupted at a rate which is low in the audible range. The plate voltage may be supplied from the low voltage automobile electrical system through a power supply 10a which may include any desired means for interrupting the voltage at a predetermined rate within the range of, say 153 to 289 cycles per second. Since the transmitter radiates only during the interval that voltage is applied to the plate circuit, the output wave is chopped into a series or train of wave impulses as shown at 11. Simply stated, the modulation consists merely in turning the 27 megacycle carrier signal on and off at the rate of roughly 200 times per second, a type of emission known in the art as ICW. As will later appear the rate at which the carrier is turned on and off constitutes the "key" which causes such wave to "unlock" the garage door for which it is tuned.

The receiver indicated in block form at 12 is also of conventional design including a broadly tuned R. F. stage and a detector, the output of the detector appearing at output leads 15, 16. The band width is made sufficiently great to accommodate drift in the carrier frequency and to make tuning of the receiver less critical. The detector output is amplified by a stage of amplification 17 which is preferably resistance coupled and may be compared to a conventional audio amplifier. It includes a tube 20 having the usual cathode, grid and plate, coupling to the grid being effected by a capacitor 21 and an input grid resistor 22. Bias is secured from a cathode resistor 23 which has an appropriate by-pass capacitor 24 connected in parallel therewith. Plate voltage is supplied through a series plate resistor 25 with the output voltage of the stage appearing at a terminal 26.

In accordance with the present invention the signal is fed into a resonant vibratory relay which is tuned to the interruption frequency of the transmitter, and a novel RC circuit is employed for coupling such resonant relay to a non-vibratory output relay. The latter in turn serves to energize the motor employed for opening or closing the garage door.

Prior to discussing the circuit in detail it will be helpful to refer briefly to the preferred form of resonant relay which is set forth in Figs. 2 and 3. This relay is a modification of the polarized relay which is covered in the Bullen and Anderson Patent 2,443,784 which issued on June 22, 1948. Reference is made to such patent for details of construction. It will suffice to state, for present purposes, that the relay indicated at 30 has a stator 31 and an armature 32 torsionally pivoted therein. The stator includes a pair of block-shaped permanent magnets 33 made of Alnico or other material having a high degree of retentivity spanned by upper and lower bridges 34, 35. In turned from the opposite side edges of each of the bridges 34, 35 are integral ears constituting pairs of opposed pole pieces 38, 39, 40, 41. The magnets are so arranged that the poles 38, 40 are of one polarity while the poles 39, 41 are of opposite polarity.

Encircling the transverse centerline of the stator is an actuating winding 42. Arranged within the winding 42 and with its ends extending outwardly through the gaps between the pole pieces is an armature assembly 44 made up of the armature 32 and a carrier 46. The armature is made of ferro-magnetic material and the carrier is fastened thereto by thin and torsional flexible projections 47. Such projections serve to permit rocking of the armature about its transverse center axis and to keep the armature normally centered between the pole pieces. The armature carries an electrical contact 48 which is mounted cantilever fashion on a flexible arm 45 for cooperation with an adjustable fixed contact 49. The armature assembly is made resonant at a particular frequency by adjusting the moment of inertia with respect to the elastic constant

of the spring mount. It will be obvious to one skilled in the art that increasing the stiffness of the spring or decreasing the moment of inertia of the armature will cause a corresponding increase in the resonant or "natural" frequency at which the armature will tend to vibrate.

The contacts 48, 49 are adjusted to be closed for a short period of time during each vibration and since the movable contact is flexibly mounted, the damping effect of the contacts is minimized. As fully covered in the above-mentioned patent, magnetic shunts 50 are employed to vary the sensitivity of the relay and to balance the magnetism between the pairs of pole pieces.

In practicing the present invention the winding 42 is connected to the output terminal 26 of the amplifier stage. In order to prevent direct current from flowing through the winding 42 a series capacitor 52 is employed. With the relay connected as shown and with the frequency of interruption in the transmitter made the same as the natural frequency of the relay, the relay will vibrate with sufficient amplitude to cause positive making and breaking of its contacts.

In accordance with one of the aspects of the invention the tube 20 feeding the relay 30 has very limited power output relative to the power requirements of the relay so that it is capable of causing operation of the relay only when the predetermined "unlocking" frequency is being received. Stated in other words, the amplifier stage also acts as a power limiter so that the control unit can discriminate against signals of incorrect interruption frequency no matter how powerful they may be.

The discriminating action will be made clear upon considering the operating characteristics of the relay 30. The present relay is so constructed that varying the frequency of the voltage applied to the winding 42 in either direction from the resonant frequency causes a sharp increase in the power required to cause closure of the contacts 48, 49. A generalized curve showing the way in which the required power input varies with frequency is shown in Fig. 4. By limiting the power supplied to winding 42 from tube 20 to the level shown in this figure, the range of frequency at which the armature can be made to vibrate is narrowed to the desired operating wave band. The stage is incapable of supplying enough power for operation outside of this band. In the present instance limiting is accomplished by supplying the resonant relay power from a tube having a high gain but a low power output. Thus, as the strength of the applied signal is increased, the tube merely saturates to give the flat characteristic shown. The width of the band may be readily adjusted by one skilled in the art so that it is suitable for the transmitter being employed. Security is maximum when the band is as narrow as possible; this reduces the chances that the vibratory relay will respond to a spurious signal in which interruption does not take place at the predetermined rate. On the other hand, the operating band must be wide enough so that a slight drift of the interruption frequency in the transmitter will not result in a failure of the receiving apparatus to respond.

In a manufactured receiver which is illustrative of a practical embodiment of my invention, some specific types and component values affecting discrimination by limiting are:

Tube 20..... Half of a type 12AT7 twin triode.
Capacitor 21 02 microfarad.
Resistor 22 470,000 ohms.
Resistor 23 270 ohms.
Capacitor 24 ... 20 microfarads.
Resistor 25 22,000 ohms.
Relay 42 8,000 ohms resistance and .3 henry inductance.
Capacitor 52 ... 2.0 microfarads.
Plate voltage ... 125 volts.

The characteristics of the type 12AT7 triode section being what they are, the power limit of the amplifiers stage

is thus readily selected as previously mentioned to meet the power input required to operate the vibratory relay 30 only over a narrow operating wave band including its minimum power requirement at resonance as indicated in Fig. 4.

Vibration of the resonant relay is utilized to cause closure of an output relay 54 having contacts 55 which control an electric motor or the like. Interposed between the resonant relay and the output relay for operating the latter is a novel RC network so arranged that a sustained series of closures of contacts 48, 49 is necessary to operate relay 54 and close contacts 55. This RC network is energized from a high voltage source and includes an input leg 56, an output leg 58 and a series or coupling leg 59. The input leg consists of an input RC circuit having a resistor R_1 and a capacitor C_1 in series therewith to ground. The output leg consists of an RC circuit in which the coil of the relay 54 provides a resistance which may be designated R_3 and which has a capacitor C_2 connected in parallel therewith. The series leg 59 has a resistor R_2 and is connected to transfer energy from the input leg to the output leg. Omitting the resistance R_3 from consideration, it will be seen that the resistor R_2 is connected to ground through the capacitor C_2 so that the coupling leg 59 may be considered to consist of an RC circuit R_2C_2 . In summary, therefore, it will be seen that the network includes input and output legs R_1C_1 and R_3C_2 respectively coupled together by a circuit which may be referred to as R_2C_2 .

The purpose of the present arrangement as previously stated, is to enable sustained vibrations in the resonant relay 30 to effect solid closure of the output relay and to prevent random intermittent vibrations from doing so. It is found that this can be accomplished by making the time constant of R_1C_1 less than about one millisecond while making the time constant of the output leg R_3C_2 fall in the range of 50 to 500 milliseconds. The time constant of the coupling leg R_2C_2 in accordance with the invention should also lie within the range of 50 to 500 milliseconds. In a practical embodiment it was found that a high degree of energy transfer could be effected between the resonant relay and the output relay by employing resistance and capacitance as follows:

R_1	270 ohms.
R_2	1200 ohms.
R_3	5000 ohms.
C_1	.25 microfarad.
C_2	80 microfarads.

For best results using an interruption frequency in the range of 153-289 cycles per second the time constant of the input leg R_1C_1 should be in the range of .05 to .5 millisecond.

Employing time constants in the three legs within the ranges given above it is found that a wide diversity of conflicting requirements may be met. Thus, R_1 is large enough with respect to C_1 so that the initial or transient current impulse flowing through the contacts of the resonant relay is not sufficiently great as to cause the contacts to stick even after extended periods of use. R_1 is nevertheless sufficiently low compared to C_1 as to enable appreciable transfer of charge to C_1 from the high voltage source during the extremely small interval of time that the resonant relay contacts are in engagement during each vibration.

Turning next to the coupling leg R_2C_2 , further conflicting requirements are met. In the first place R_2 is great as compared to C_2 so that very little charging of C_2 from the high voltage source can take place during the interval of contact closure, thus preventing an initial current surge through C_2 which might cause the contacts to stick. On the other hand, R_2 is sufficiently small so as to enable appreciable charge to be drained from the capacitor C_1 over a period of time, it being understood

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that during such time the charge in capacitor C_1 is repeatedly replenished.

With regard to the output leg, employing a time constant in the range of 50 to 500 milliseconds insures that the time constant will be many times greater than that of the input leg. Thus, there will be no substantial discharge of the capacitor C_2 through the shunted relay coil R_3 between the pulses of the resonant relay. Stated another way, employing a time constant in the above range insures that the charge will be built up on capacitor C_2 to the point where the pull-in voltage required to cause closure of the output relay is reached after a short time delay and closure is positively maintained. The time delay employing the present teachings will normally be on the order of a half-second. On the other hand the time constant is sufficiently short so that upon interruption of the impulses the output relay will either fail to close or will quickly drop out.

Using a relatively long time constant in the output leg has the additional advantage that the time delay, on the order of one-half second or so, makes the remote control system unresponsive to impulse trains of shorter duration, even where the proper interruption frequency is used. This insures that the garage door will not open either as a result of atmospheric disturbances or static or as the result of short bursts of man-made impulses such as may be produced by motors, ignition systems and the like. It can be shown that the drop-off in voltage across the output relay occurs along an inverse exponential curve so that once the train of impulses is interrupted a new train of impulses of appreciable length must be applied before the capacitor C_2 is charged up to a voltage which is sufficient to cause positive closure of the output relay. It will be seen from the above that the present arrangement, in spite of its simplicity, requires that three conditions be met before the garage door will operate: proper carrier or RF frequency, proper interruption frequency, and an impulse train which is substantially unbroken for an interval of time on the order of one-half second or more.

Because of the extreme sensitiveness of the polarized resonant relay employed in the preferred embodiment, and the limited power output of the preceding amplifier stage 17, the number of vacuum tubes employed in the receiver and its associated control unit may be kept to an absolute minimum. Consequently, the standby power drain may be reduced to a few watts (8 watts or less in a practical design) so that the cost of keeping the system in operation is negligible.

Since the number of stages is very low there is a corresponding reduction in the number of components. The resistors and capacitors employed in the network are standard and may be assembled at extremely low cost. Since appreciable power is available for operating the output relay it need not be of special design but may be of conventional and inexpensive construction so long as the winding thereon falls within the appropriate resistance range. It will be apparent, therefore, that the entire system is not only inexpensive to construct but also requires a minimum of maintenance while insuring reliable operation over extended periods of time.

I claim as my invention:

1. In a remote control system having a transmitter for producing an interrupted continuous wave at a predetermined interruption frequency, a receiving station, comprising in combination, means for converting the wave into electrical impulses at the interruption frequency, a limiter coupled to said means for receiving said impulses, said limiter having power output capabilities which are limited to a predetermined maximum value, and a resonant vibratory relay coupled to the output of the limiter, said relay having a minimum power requirement at resonance which is slightly less than but substantially equal to said maximum value of the power output of the limiter, the power requirements of the relay being greater than said maximum value for frequencies outside a narrow

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band centered on the resonant frequency of the relay, so that the relay cannot respond to signals outside said band.

2. A control unit responsive to a train of electrical signals of a selected frequency, comprising, in combination, an input relay, said relay having an energizing winding, a vibratory armature tuned to resonant vibration at said selected frequency, and circuit opening and closing contacts actuated by armature vibration; a first storage circuit comprising a first capacitor and first resistor connected in series and having a time constant of the order of magnitude of the closed period of said contacts when said input relay is operated at said resonant frequency, means for connecting said storage circuit and said contacts in series with a source of charging voltage, a second capacitor connected across said first storage circuit through a charging resistor, and a resistive energizing winding of an output relay for operating a controlled device shunting said second capacitor, said resistive winding and said second capacitor having a time constant several times larger than that of said first circuit for actuation of said output relay when said second capacitor is substantially charged.

3. A control unit responsive to a train of electrical signals of a selected frequency, comprising, in combination, an input relay, said relay having an energizing winding, a vibratory armature tuned to resonant vibration at said selected frequency, and circuit opening and closing contacts actuated by armature vibration; a first storage circuit having a time constant of the order of magnitude of the closed period of said contacts when said input relay is operated at said resonant frequency, means for connecting said storage circuit and said contacts in series with a source of charging voltage, a second storage circuit having a capacity and a time constant several times larger than that of said first storage circuit coupled to said first storage circuit, and an energizing winding of an output relay for operating a controlled device coupled to said second circuit, said energizing winding being operable to actuate said output relay when said second storage circuit is substantially charged.

4. A control unit responsive to a train of impulses at a predetermined frequency comprising, in combination, a vibratory input relay, said relay having an energizing winding, a vibratory armature tuned to resonant vibration at said predetermined frequency, and relay contacts periodically opened and closed in response to armature vibration, a first storage circuit including serially connected capacitance means and resistance means having a time constant of the order of magnitude of the closed period of said contacts when said relay is operated at said resonant frequency, means for connecting said storage circuit and said contacts in series across a source of charging voltage, and a second storage circuit including a serially connected second capacitance means and second resistance means having a much larger time constant than that of said first storage circuit coupled to said first storage circuit, and an energizing winding of an output relay coupled to said second circuit.

5. A control unit responsive to a train of impulses of predetermined frequency comprising, in combination, a vibratory input relay, said relay having an energizing winding, a vibratory armature tuned to resonant vibration at said predetermined frequency, and relay contacts periodically opened and closed in response to armature vibration, a first storage circuit including serially connected capacitance means and resistance means having a time constant of the order of magnitude of the closed period of said contacts when said relay is operated at said resonant frequency, means for connecting said storage circuit and said contacts in series across a source of charging voltage, a second storage circuit including serially connected second capacitance means and second resistance means having a time constant many times larger than that of said first storage circuit connected in parallel with said first storage circuit and a resistive energizing winding

of an output relay connected in circuit across said second capacitive means to provide a time constant several times higher than that of said first storage circuit so that the operating voltage for said output relay is attained only after receipt of a train of said impulses.

6. A control unit responsive to a train of impulses of predetermined frequency comprising, in combination, a vibratory relay having a winding connected to receive said impulses and having an armature tuned to vibrate in resonance at said interruption frequency and circuit opening and closing contacts operable thereby at said vibratory frequency, a first resistance-capacitance circuit including a first resistor and a first capacitor in series, means for connecting said contacts and said first resistance-capacitance circuit in series circuit with a source of unidirectional charging voltage, said first circuit having a time constant of a magnitude permitting substantial charging of the first capacitor upon each closure of said contacts, an output circuit including a second resistor in series with a second capacitor and a resistive energizing winding of an output relay connected in parallel with said second capacitor, and means connecting said output circuit in parallel with said first resistance-capacitance circuit for charging therefrom, the time constants of both said second resistor with said second capacitor and of said output relay winding with said second capacitor being many times larger than that of said first circuit so that several vibrations of said relay at said predetermined frequency are required to energize said output relay winding.

7. In a remote control system having a transmitter for producing an interrupted continuous wave at a predetermined interruption frequency and a receiver for converting such wave into a train of electrical impulses at said interruption frequency, a receiver control unit responsive to such a train of impulses comprising in combination a vibratory relay having a winding connected to receive said impulses and having an armature tuned to vibrate in resonance at said interruption frequency and circuit opening and closing contacts operable thereby at said vibratory frequency, a first resistance-capacitance circuit including a first resistor and a first capacitor in series, means for connecting said contacts and said first resistance-capacitance circuit in series circuit with a source of unidirectional charging voltage, said first circuit having a time constant of a magnitude permitting substantial charging of the first capacitor upon each closure of said contacts, an output circuit including a second resistor in series with a second capacitor and a resistive energizing winding of an output relay connected in parallel with said second capacitor, and means connecting said output circuit in parallel with said first resistance-capacitance circuit for charging therefrom the time constants of both said second resistor with said second capacitor and of said output relay winding with said second capacitor being many times larger than that of said first circuit so that several vibrations of said relay at said predetermined frequency are required to energize said output relay winding.

8. A receiver control unit responsive to a series of electrical impulses at a predetermined frequency comprising, in combination, a vibratory relay having an energizing winding for receiving said electrical impulses and having an armature tuned to vibrate in resonance at said predetermined frequency together with a pair of contacts opened

and closed by armature vibration, an output network including a storage capacitor and a resistor, means for connecting said capacitor and resistor in series with said pair of contacts and across a source of charging voltage, said resistor and said capacitor having a time constant several times the period the contacts are closed during each vibration at said frequency, and an energizing coil of an output relay coupled in shunt with said storage capacitor, said coil having a resistance value sufficiently high whereby the time constant of said coil and said capacitor is also several times higher than said closed period of said vibratory contacts so that sustained operation of the vibratory relay is required to energize the output relay coil.

9. In a remote control system having a transmitter for producing an interrupted continuous wave at a predetermined interruption frequency and a receiver for converting the wave into a series of electrical impulses at said interruption frequency, a receiver control unit, comprising, in combination, a vibratory relay having an energizing winding for receiving said electrical impulses and having an armature tuned to vibrate in resonance at said predetermined frequency together with a pair of contacts opened and closed by armature vibration, an output network including a storage capacitor, and a resistor, means for connecting said capacitor and resistor in series with said pair of contacts and across a source of charging voltage, said resistor and said capacitor having a time constant several times the period the contacts are closed during each vibration at said frequency, and an energizing coil of an output relay coupled in shunt with said storage capacitor, said coil having a resistance value sufficiently high whereby the time constant of said coil and said capacitor is also several times higher than said closed period of said vibratory contacts so that sustained operation of the vibratory relay is required to energize the output relay coil.

10. A control unit responsive to a train of electrical signals of a selected frequency comprising, in combination, means for limiting the amplitude of the signals supplied thereto to a predetermined maximum value, a resonant vibratory relay having an energizing winding, means for supplying the limited signals to said relay winding, said relay having a minimum energizing power requirement at a resonant frequency corresponding to said selected frequency, which requirement is slightly less but substantially equal to said maximum amplitude of the limited signals, the power requirements of the relay being greater than said maximum amplitude for frequencies outside a narrow band centered on said resonant relay frequency so that the relay cannot respond to signals outside said band.

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