Dec. 19, 1967 W. A. SCHANBACHER 3,359,558

RECEIVER ARRANGEMENT

Filed May 18, 1964

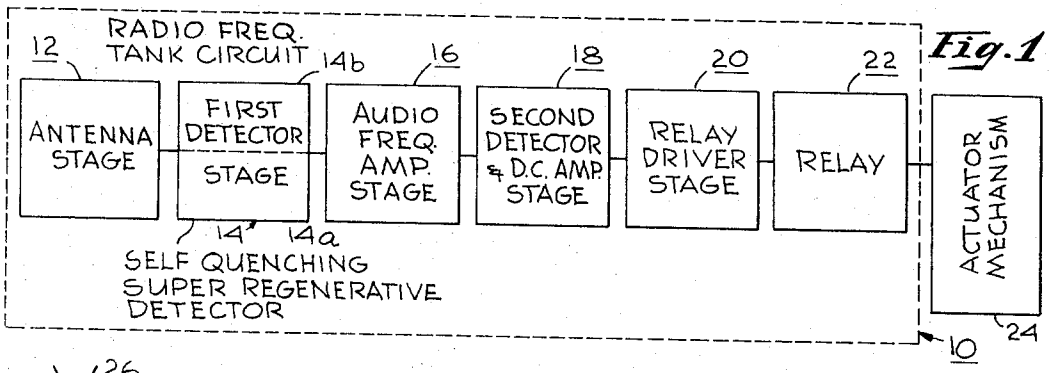


Fig. 1

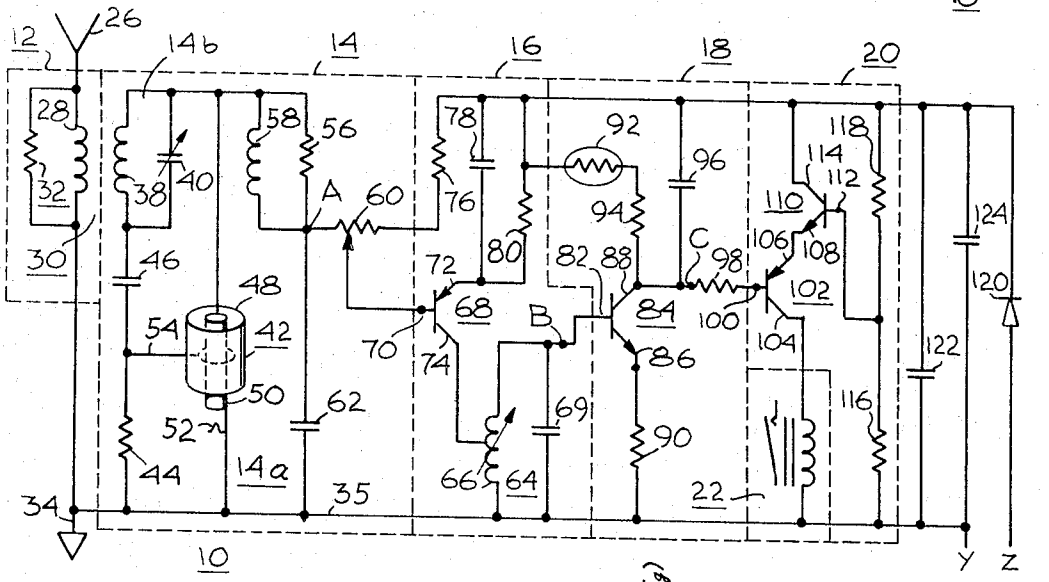


Fig. 2

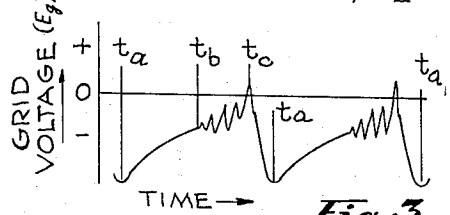


Fig. 3

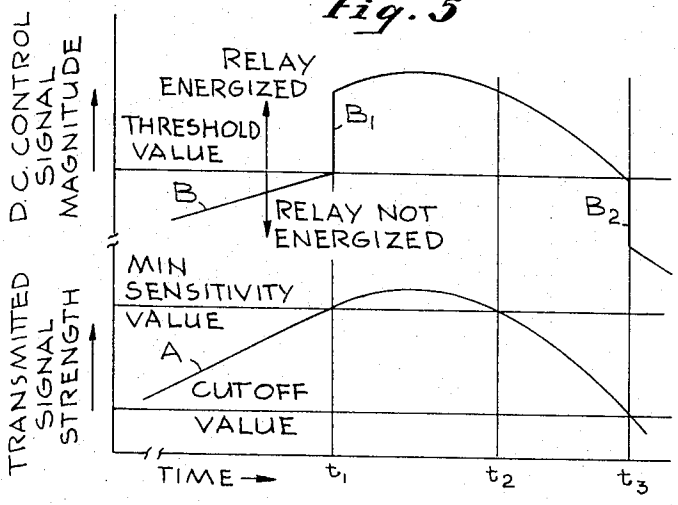


Fig. 5

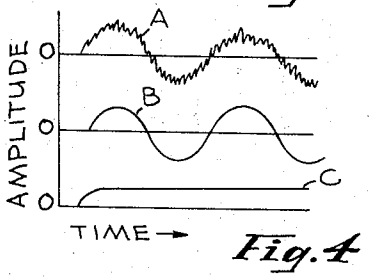


Fig. 4

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RECEIVER ARRANGEMENT

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ABSTRACT OF THE DISCLOSURE

There is described herein a command receiver arrangement providing remote controlled actuation of mechanisms upon receipt of a predetermined coded signal. The command receiver responds when the predetermined coded signal is present for a predetermined time period having a magnitude at least as great as a preselected value. The command receiver energizes a relay to control the mechanism and for the condition of the relay energized, the gain of the command receiver is increased over the gain when the relay is not energized so that the relay is and remains positively actuated even though the input signal decreased below the predetermined value as long as it is greater than a preselected cut-off value.

This invention relates to the receiver art and more particularly to an improved command receiver adapted to receive an audio frequency amplitude modulated radio frequency signal and to energize a relay in response thereto for ultimate actuation of another mechanism.

In many remotely controlled applications, such as automatic garage door openers and the like, it has long been necessary to provide a low power drain, selectively tuned receiver that is stable in operation over a wide range of ambient conditions and over comparatively long periods of time. Such a receiver, generally termed a command receiver, is adapted to receive a preselected coded signal and to positively initiate operation of, for example, a garage door actuator mechanism, upon receipt of such a coded signal, but not to operate the garage door actuator mechanism when signals other than this properly preselected coded signal are present. Since many similar actuator mechanisms and their command receivers may be located in close geographic proximity, it is highly desirable that the tuning of such receivers be exceptionally selective so that spurious operation of the garage door actuator mechanism does not occur when coded signals which may vary only slightly from the preselected coded signal for a particular receiver are present. Also, the FCC requirements limiting the amount of re-radiation from the command receiver must be complied with to avoid interference with other communications and with other similar command receivers.

It is preferred that such command receivers require only a minimum operating electrical power since they are generally in a stand-by condition, ready to operate upon receipt of the preselected coded signal. Further, it has long been desirable to provide a threshold detector and relay lock arrangement in such a command receiver so that if the preselected coded signal is present for a predetermined time interval and is strong enough to initiate energizing a relay, the relay will positively lock as long as the signal is present and will not chatter, or sequentially open and close, at input signal levels at or near the minimum input signal strength required for operation of the receiver.

Coding of the transmitted signal that is sent to the receiver is generally provided by audio-frequency amplitude modulation of radio frequency signal. Thus, applicant's improved receiver as described herein is particularly useful when utilized in conjunction with the improved transmitter described in applicant's copending

patent application filed Jan. 13, 1964, Ser. No. 337,354, now Patent No. 3,270,284 entitled Transmitter Arrangement. However, it will be appreciated that the improved command receiver described herein may have many other applications and while, for purposes of illustration of the utility of the preferred embodiment of applicant's invention, applicant's improved receiver is described as embodied in a garage door opening and closing arrangement, it will be appreciated that the invention herein is not so limited.

Accordingly, it is an object of applicant's invention to provide an improved command receiver.

It is another object of applicant's invention to provide an improved command receiver selectively tuned to initiate operation of an actuator mechanism upon receipt of only a preselected audio frequency amplitude modulated radio frequency signal and having a very low amount of re-radiation.

It is yet another object of applicant's invention to provide an improved command receiver that is highly stable over comparatively long periods of time and throughout extreme variations in ambient conditions.

The above and other objects are achieved, according to one aspect of applicant's invention, by providing, in a command receiver operating in the range of 6 to 24 volts DC, an antenna adapted to receive a transmitted signal, which signal comprises an audio frequency amplitude modulated radio frequency. A first detector stage is coupled to the antenna and the transmitted signal received thereby is coupled through a transformer into the first detector stage.

The first detector stage is adapted to establish a cyclical oscillatory condition therein at a preselected radio frequency corresponding to the radio frequency in the transmitted signal by means of a cyclical frequency generating means which, in this embodiment of applicant's invention, comprises a self-quenching super-regenerative circuit having a squelch frequency rate on the order of thirty times the audio frequency modulation frequency. The first detector stage includes means for adjusting the particular radio frequency of the oscillatory signal. Thus, a detected signal is provided resonant at the preselected radio frequency and amplitude modulated by the preselected audio frequency upon which is superimposed the squelch frequency.

The first detector stage also includes means for filtering both the preselected resonant radio frequency of the signal and the squelch frequency. The remaining detected audio frequency modulation of the signal is coupled into an audio frequency amplification stage. Coupling of the detected audio frequency signal to the audio frequency amplifier stage is achieved through a gain control variable resistor that establishes the command sensitivity of the receiver. The audio frequency signal is amplified in the audio frequency amplification stage through an audio frequency tank circuit resonant at the preselected audio frequency in the detected signal. This audio frequency tank circuit provides the audio frequency selectivity of the receiver. Means are included in this audio frequency tank circuit for adjusting the particular audio frequency at which the tank circuit is resonant so that the amplified detected audio frequency signal corresponds to the audio frequency of the transmitted signal received by the antenna.

A second detector and DC amplifier stage is coupled to the audio frequency amplification stage and receives the amplified audio frequency signal and rectifies it to a DC control signal having a magnitude proportional thereto. The second detector stage provides amplification of the DC control signal to any predetermined value.

The amplified DC control signal is fed into a relay driver stage that actuates a relay when the DC control

signal has a magnitude equal to or greater than a preselected threshold value. When the relay is so actuated by the DC control signal at a magnitude equal to or greater than the preselected threshold value, the gain of the first detector stage is increased so that the relay will lock and stay locked until the strength of the signal received by the antenna decreases to a value substantially below that required to initially provide the threshold value of the DC signal.

The receiver may be powered by a conventional 115 to 120 volt alternating current power source or by a DC power source. In either event the receiver power input is provided with suitable filtering of any radio frequency in the input signal as well as smoothing out any ripples in the input power. Further, if conventional alternating current power is utilized, means are incorporated to rectify the input power so that the receiver is powered by DC in the range of 6 to 24 volts.

The above and other objects are more fully described in the following detailed description taken together with the accompanying drawing wherein similar reference characters refer to similar elements throughout and in which:

FIGURE 1 is a block diagram of one embodiment of applicant's invention;

FIGURE 2 is a schematic diagram thereof;

FIGURES 3, 4 and 5 are graphical illustrations of the relationship between various parameters in one embodiment of applicant's improved command receiver.

Referring now to FIGURE 1, there is shown a block diagram for the various stages comprising applicant's improved command receiver, generally designated **10**. When applicant's improved receiver is utilized, for example, in a remotely controlled garage door opening and closing arrangement, the actuator for moving the garage door is not part of the receiver **10** itself, but is merely controlled through a relay by the receiver **10**. Thus, the receiver **10** has as its basic purpose the function of energizing the relay upon receipt of a preselected coded signal. The relay may be utilized to control, through appropriate circuitry, many devices other than garage door actuators. However, for purposes of illustration, applicant's improved command receiver **10** is described herein as utilized in such a garage door opening application.

The command receiver **10** comprises an antenna stage **12** adapted to receive a transmitted signal, which signal comprises an audio frequency amplitude modulated radio frequency signal in which both the frequency of the radio frequency signal and the frequency of the audio frequency amplitude modulation are preselected so that the receiver **10** energizes a relay, as described below, only when both the preselected radio frequency and the preselected audio frequency are in the transmitted signal and the signal is present at the antenna **12** for a predetermined time at or above a predetermined strength. The antenna receives such a transmitted signal and couples the signal into a first detector stage **14** coupled thereto.

As described below in detail, the first detector stage **14** comprises a cyclical frequency generating means which, in this embodiment of applicant's invention, comprises a self-quenching super-regenerative detector **14***a* that cyclically oscillates at the preselected radio frequency, corresponding to the radio frequency in the transmitted signal received by the antenna **12**, for which a radio frequency tank circuit **14***b* is selectively tuned. The amplitude of the oscillatory signal generated by the self-quenching super-regenerative detector **14***a* at the preselected radio frequency builds up in strength until it would be self-sustaining in the radio frequency tank circuit **14***b*, but at this point the gain of the self-quenching super-regenerative detector **14***a* is decreased and the oscillation dies. The basic cyclic frequency, that is, the squelch frequency, of the self-quenching super-regenerative detector **14***a* is selected to be, in the absence of a transmitted signal, for example, on the order of 2 to 50 times the frequency of the preselected audio frequency amplitude modulation of the transmitted signal received by the antenna **12**.

When the proper transmitted signal is received by the antenna **12**, it is coupled into the radio frequency tank circuit **14***b* and this increases the squelch frequency rate of the self-quenching super-regenerative detector stage **14***a*.

The increase in the squelch frequency rate is a function of the strength of the transmitted signal received by the antenna stage **12** which, of course, cyclically varies at the preselected audio frequency modulation rate. The oscillating period at the preselected radio frequency in the first detector stage **14** is constant and the average "on" time, that is the average time over a number of cycles during which an oscillation at the preselected radio frequency is present, and consequently the average current drawn by the self-generating super-regenerative detector **14***a* varies at the preselected audio frequency rate. This variation in average current drain at the preselected audio frequency rate provides the detected audio frequency signal utilized for operation of the command receiver **10**.

The first detector stage **14** also includes filtering means for filtering both the preselected radio frequency component and the self-quenching frequency component of the signal therein, and for coupling the detected preselected audio frequency signal into an audio frequency amplifier stage **16**. The audio frequency amplifier stage **16** includes an audio frequency tank circuit selectively tuned for a resonant frequency at the preselected audio frequency of the transmitted signal. Thus, when the transmitted signal received by the antenna **12** has this preselected audio frequency amplitude modulation component, the audio frequency amplifier stage **16** amplifies the detected audio frequency signal coupled thereto from the first detector stage **14** and feeds this amplified audio frequency signal into a second detector and DC amplifier stage **18**.

The second detector and DC amplifier stage **18** rectifies the amplified detected audio frequency signal to a DC signal and amplifies the DC signal to provide an amplified DC control signal having a magnitude proportional to the logarithm of the strength of the transmitted signal as received by the antenna **12**.

This amplified DC control signal is fed into a relay driver stage **20** to energize a relay **22** when the magnitude of the amplified DC control signal is greater than a first predetermined value called the threshold value, and the detected audio frequency signal is present for a sufficient time to provide this amplified DC control signal at or above the threshold value..

The relay driver stage **20** also includes, as described below, means for locking in the relay **22** once it has been energized and holding the relay **22** locked in even though the strength of the transmitted signal received by the antenna **12** decreases below the minimum sensitivity value required to provide the DC control signal of the threshold value. Therefore, once the relay **22** is energized, it stays energized even though the signal strength of the transmitted signal received by the antenna **12** decreases below the minimum sensitivity value for as long a time period as the strength of the transmitted signal remains above a cut-off value that is lower than the minimum sensitivity value by a predetermined amount. Thus, there is no chatter of the relay **22** once it has originally been energized and continuous energization of the relay **22** down to any desired lower level of strength of the transmitted signal received by the antenna **12** may be provided. Means are provided so that the cyclic variation in the transmitted signal strength due to the audio frequency modulation do not effect the magnitude of the DC control signal.

When the relay **22** is energized, an information signal is sent, through appropriate circuitry, to an actuator mechanism **24** for operation of, for example, opening and closing garage doors. The actuator mechanism **24** and circuitry associated therewith do not form a part of applicant's invention herein.

Referring now to FIGURE 2, there is shown a schematic diagram of the preferred embodiment of applicant's

invention of an improved command receiver **10**. It will be appreciated that the particular values designated for the various components of the receiver **10** illustrated by schematic diagram in FIGURE 2 is for illustrative purposes only and applicant's invention is not so limited to components having the same or equivalent values.

The antenna stage **12** comprises a receiving antenna **26** which, for example, may comprise a short length, on the order of seven inches, of No. 12 copper wire leading into a primary winding **28** of a radio frequency transformer **30**. The receiving antenna **26** is shunted by resistor **32** which, for example, may be on the order of 47 ohms, and this resistor **32** is a load terminating impedance of the receiving antenna **26** to provide a high frequency stability and, as described below, also tends to eliminate even the small amount of re-radiation of the oscillatory signal generated in the first detector stage **14** from the receiving antenna **26**. The other end of the primary winding **28** of the radio frequency transformer **30** provides the ground connection **34** to the command receiver **10** ground bus **35**.

The first detector stage **14** has the radio frequency tank circuit **14***b* coupled to the antenna stage **12** by the secondary winding **38** of the radio frequency transformer **30**. The secondary winding **38** of the radio frequency transformer **30** and a variable capacitor **40** comprise the radio frequency tank circuit **14***b*. The resonant frequency of the radio frequency tank circuit **14***b* is preselected by adjustment of the variable capacitor **40** so that it is selectively tuned to and resonant at the particular preselected radio frequency corresponding to the radio frequency in the transmitted signal received by the receiving antenna **26** for which operation of the receiver **10** is desired.

A signal at the predetermined radio frequency is cyclically supplied in the radio frequency tank circuit **14***b* by the self-quenching super-regenerative detector **14***a* comprising triode **42**, resistor **44** and capacitor **46**, as well as inductor **58**, resistor **56** and capacitor **62**. The triode **42** may, for example, comprise a Nuvistor such as Radio Corporation of America Nuvistor No. 7586 having a transconductance on the order of 4000 micromhos at an operating plate voltage of approximately 12 volts. The triode **42** has a plate **48**, a cathode **50**, cathode heater **52** and grid **54**. The grid **54** bias voltage of the triode **42**, that is, the voltage difference between the grid **54** and the cathode **50**, regulates the gain of the triode **42** and is controlled so that the radio frequency signal supplied to the radio frequency tank circuit **14***b* sequentially passes through a voltage range wherein oscillation will be sequentially supported and non-supported at the preselected radio frequency therein. This is illustrated in the curve of FIGURE 3 which shows the variation in the grid voltage (E_g) of the triode **42** with time. At time t_a when the grid **54** voltage is negative with respect to the cathode **50**, resistor **44** and capacitor **46** provide a specific discharge time constant, for example, on the order of 1.5×10^{-6} seconds$\pm0.75\times10^{-6}$ seconds, and as the grid voltage becomes more positive (less negative with respect to the cathode **50**) it reaches a value at time t_b when sufficient gain through the triode **42** is obtained. As this gain increases, the oscillation at the preselected radio frequency increases in magnitude and a time t_c the grid **54** voltage, as the oscillation builds up in value, becomes positive. At this time t_c, that is, when the grid **54** voltage becomes positive with respect to the cathode **50**, there is a discharge across capacitor **46** and the grid **54** voltage then becomes negative and the oscillation dies and the grid **54** voltage once again becomes negative with respect to the cathode **50**, as shown at time t_a. This cycle then repeats, in the absence of an input from the antenna **12** of a signal at the preselected radio frequency, at the self-quenching frequency provided by the discharge time constant of resistor **44**, capacitor **46** and the gain characteristics of triode **42**. Operation of the receiver **10** in the presence of such a signal is described below.

The combination of capacitor **46** and resistor **44** also provides the primary gain control of the first detector stage **14**.

While a resonant signal at the preselected radio frequency is thus cyclically generated in the radio frequency tank circuit **14***b* and is re-radiated out the receiving antenna **26** being supplied thereto by radio frequency transformer **30**, applicant has found that the very low operating power, that is, on the order of 0.1 milliwatt, together with the values of the components utilized herein, provide that the re-radiated signal does not affect operation of adjacent devices of a similar design and substantially eliminates emanation of radio frequency interference noises. Thus, applicant's improved command receiver **10** allows elimination of shielding or other re-radiation protective devices commonly utilized in prior art, super-regenerative command receivers.

The receiver **10** is always maintained in a stand-by condition in which the above-described resonant signal at the preselected radio frequency is cyclically supplied in the radio frequency tank circuit **14***b* through the action of the self-quenching super-regenerative detector **14***a*. The self-quenching frequency of the regenerative signal, that is, corresponding to the time interval from t_a to t_a in FIGURE 3, may be selected to be on the order of two to fifty times the frequency of the preselected audio frequency modulation signal component that is expected to be present in the transmitted signal received by the receiving antenna **26**.

In attempting to meet the above-described re-radiation limitations it has long been the practice in the command receiver art to include at least one isolation stage comprising, for example, a triode similar to triode **42** interposed between the antenna stage **12** and the first detector stage **14**. However, applicant has found that by providing an operating voltage to the command receiver **10** in the range of 6 to 24 volts DC with a plate **48** to cathode **50**, voltage on the order of 12 volts DC, all limitations on re-radiation are met without any shielding stage or other re-radiation shielding arrangement. This operating voltage range also permits applicant to utilize transistors in the command receiver **10** so that power consumption thereof is low and reliability is high.

When the receiving antenna **26** receives a transmitted signal having the selected radio frequency amplitude modulated by the preselected audio frequency it is coupled into the radio frequency tank circuit **14***b* even though the grid **54** bias voltage of the triode **42** is less than that necessary to support such an oscillation in the absence of the transmitted signal. Thus, the average oscillation "on" time over a number of cycles is increased above that obtained in the absence of a transmitted signal at the preselected radio frequency received by the receiving antenna **26**, and this increase in the average "on" time that oscillation at the preselected radio frequency is present in the radio frequency tank circuit **14***b* provides the detected preselected audio frequency modulation signal, which, as described below, provides desired operation of the command receiver **10** to actuate a relay. When the receiving antenna **26** so receives a transmitted signal having the preselected audio frequency amplitude modulation of the preselected radio frequency, oscillation is supported at shorter time intervals, at the preselected radio frequency, in the radio frequency tank circuit **14***b*.

Resistor **56** and inductor **58** provide a controlled load to the signal in the first detector stage **14** together with resistor **32** and the primary winding **28** of the radio frequency transformer **30**. The inductor **58** also provides an inductive impedance and is an audio by-pass to the detected audio frequency signal for the first detector stage **14** output. The inductor **58** compensates for electron transit time in the triode **42** so that phase lag of the triode **42** does not cause operation of the radio frequency tank circuit **14***b* at frequencies other than the preselected radio frequency. Applicant has found that in utilizing the above-described 6 to 24 volt DC operating voltage, compensa-

tion for the electron transit time provided, primarily, by the inductor **58** substantially eliminates any tendency towards spurious operation and signal drift induced by minor variations of operating voltage.

Variable resistor **60** and capacitor **62** provide filtering of the squelch frequency component of the signal in the radio frequency tank circuit **14***b* that is superimpressed on the signal therein. The variable resistor **60** also controls the basic sensitivity of the command receiver **10** and by suitably adjusting the resistor **60**, the predetermined value of the signal strength of the transmitted signal, that is, the minimum sensitivity value to result in the DC control signal at the threshold value, received by the antenna **26** that will allow ultimate operation of the relay **22** is adjusted. Inductor **58**, resistor **56**, variable resistor **60** and capacitor **62** also filter out the radio frequency component of the signal to allow transmission of the detected audio frequency modulation signal into the audio frequency amplifying stage **16**.

When the command receiver **10** is utilized in conjunction with the transmitter described in the copending patent application of applicant mentioned above, applicant has found that the following values for the components provide satisfactory operation of the first detector stage **14**: capacitor **46**, 100 picofarads±50 picofarads; capacitor **40**, variable between 1.5 and 9 picofarads; capacitor **62**, 1800 picofarads; inductor **58**, .82 microhenry; resistor **60**, variable between zero and 5,000 ohms. The preselected radio frequency is preferably within the range of 250 to 300 megacycles and the preselected audio frequency is preferably within the range of 12 to 24 kilocycles.

As noted above, the first detector stage **14** includes means for filtering the resonant signal in the radio frequency tank circuit **14***b* to remove both the radio frequency component and the regenerative frequency component therefrom to leave, substantially, the detected audio frequency signal to be coupled into the audio frequency amplifier stage **16**.

FIGURE 4 illustrates the wave forms associated with the signal transmitted through the command receiver **10** at various points therof. Curve A of FIGURE 4 illustrates the wave form as obtained at point A, that is, at the input to the variable resistor **60**. As shown, the radio frequency component has been substantially filtered out and the signal comprises the detected audio frequency signal upon which is superimposd the attenuatd squelch frequency. This is the detected audio frequncy signal that is fed into the audio frequency amplifier **16**. An audio frequency tank circuit **64** comprising variable inductor **66**, into which is tapped the detected audio frequency signal, and capacitor **69** is provided in the audio frequency amplifier stage **16**. The audio frequency tank circuit **64** is resonant for the preselected audio frequency that is expected to be in the transmitted signal received by the receiving antenna **26** and is adjusted therefor by suitably adjusting variable inductor **66**. The variable inductor **66** may be conveniently described as an audio coil and upon proper adjustment thereof the audio frequency tank circuit **64** is resonant only for the preselected audio frequency.

Transistor **68** having base electrode **70**, emitter electrode **72** and collector electrode **74** receives the audio frequency signal at its base electrode **70** from the variable resistor **60** and the collector electrode **74** is tapped into the variable inductor **66** to feed the detected audio frequency signal therein without significantly decreasing the selectivity of tank circuit **64**. The transistor **68** is a modulation amplifier transistor of the P-N-P type and, for example, may be a Radio Corporation of America number 2N414. Resistor **76** provides both a bias on the audio frequency modulation amplifier transistor **68**, as well as contributing to the gain control for the audio amplifier stage **16**. Filter capacitor **78** together with resistor **80** provide a high voltage gain through transistor **68** to the audio frequency tank circuit **64** and resistor **80** controls the current bias for the transistor **68**.

The signal at the base electrode **70** of the transistor **68** has only a slight ripple at the regenerative signal frequency superimposed upon the detected audio frequency signal. When the preselected audio frequency is present to establish the resonant condition in the audio frequency tank circuit **64**, filtering is virtually completed and at point B the signal is substantially a smooth sine wave at the detected audio frequency modulation frequency as illustrated by curve B in FIGURE 4.

This detected audio frequency sine wave is fed into the second detector stage **18** at the base electrode **82** of a DC amplifier transistor **84** having an emitter electrode **86** and a collector electrode **88**. The DC amplifier transistor **84** rectifies the audio frequency signal and provides a DC steady state control signal having a magnitude proportional to the logarithm of the magnitude of the audio frequency modulation signal in the transmitted signal received by the receiving antenna **26**. Thus, the DC amplifier transistor **84** which, for example, may be a Texas instrument 2N388 NPN type transistor, acts as an impedance multiplier at the base electrode **82** thereof, for resistor **90** connected to the emitter electrode **86** thereof. The amplification is controlled by the ratio of the sum of the resistance values of resistors **92** and **94** divided by the value of the resistance of the resistor **90**.

Thus, applicant has found that DC amplification is provided to result, in a DC control signal at a preselected magnitude and the preselected magnitude is proportional to the logarithm of the signal strength of the audio frequency amplitude modulation component of the transmitted signal received by the receiving antenna **26**.

Capacitor **96** provides noise filtering in combination with resistors **92**, **94** and **98** and filters against spurious operation of the receiver **10** due to noise at the receiver by having a comparatively long time constant. Thus, presence of a transmitted signal at the receiver antenna **26** at a predetermined strength and having the preselected radio frequency amplitude modulated by the preselected audio frequency for a sufficient long period of time, for example 0.5 second, provides the desired combination of parameters necessary for operation of the command receiver **10**. This time delay also provides that the DC control signal be substantially steady state and independent of the cyclic strength variations of the transmitted signal due to the audio frequency amplitude modulation.

Resistor **92** is a thermistor, such as Fenwal No. KA33J1 having a nominal value of 3000 ohms at 25° C. and provides temperature compensation for the audio frequency amplification stage **16** and second detector **18** stage over comparatively wide ranges of temperature to allow a substantially constant gain in the receiver **10**. The resistor **98** is essentially a coupling resistor and couples the amplified DC control signal, as it appears at point C and as shown in curve C on FIGURE 4, into the relay driver stage **20**.

This signal is fed into relay driver stage **20** through the base electrode **100** of a relay driver transistor **102** which, for example, may be a Radio Corporation of America No. 2N414 P-N-P type transistor and the collector electrode **104** thereof is coupled to the relay **22**. The emitter electrode **106** of the relay driver transistor **102** is coupled to the emitter electrode **108** of an impedance divider transistor **110**. The impedance divider transistor has a base electrode **112** and a collector electrode **114**. Impedance divider transistor **110** provides a very small current drain in the command receiver **10** during both stand-by operation and relay actuation. The impedance divider transistor **110** divides the impedance provided by resistors **116** and **118** and establishes the threshold voltage level for conduction in the relay driver transistor **102**.

When the magnitude of the DC control signal supplied to the base electrode **100** of the relay driver transistor **102** exceeds this threshold value, for example 3 volts as established at the emitter electrode **106** thereof by the

impedance divider transistor **110**, the relay driver transistor **102** commences to conduct and energizes the relay **22** connected to the collector electrode **104** thereof. This threshold value at which the relay driver transistor **102** commences to conduct is controlled by the resistors **116** and **118** in conjunction with the impedance divider transistor **110**.

Once the relay driver transistor **102** commences to conduct and the relay **22** is energized, the plate voltage on the triode **42** is decreased due to the increased load on the power supply (not shown), thereby increasing the gain in the circuit of the command receiver **10** so that the magnitude of the DC signal applied to the base electrode **100** of the relay driver transistor **102** increases abruptly to hold the relay **22** in the energized position, for a given transmitted signal strength. That is, if the input signal received by the receiving antenna **26** is strong enough to commence operation and energize the relay **22**, that is, at the minimum sensitivity value, once the relay **22** is closed it will stay closed, because of the increase in the gain of the receiver **10** for the same transmitted signal strength, until the transmitted signal strength drops below a predetermined value termed the cut-off value. The cut-off value of the input signal strength corresponds to that value of input signal strength that produces an amplified DC control signal at the relay driver transistor **102** having a magnitude just at the threshold value when the relay **22** is energized. Thus, once the strength of the transmitted signal received by the antenna **12** drops below the cut-off value, the magnitude of the DC control signal supplied to the relay driver transistor **102** decreases below the threshold value and the relay **22** is de-energized. This results in an abrupt decrease in the magnitude of the DC signal, since the gain of the command receiver **10** is suddenly decreased. Therefore, once the transmitted signal received by the antenna **12** reaches the minimum sensitivity value to provide a DC control signal to the relay driver transistor **102** at the threshold value and the relay **22** is thereby energized, the relay **22** remains energized even though the transmitted signal strength decreases below the minimum sensitivity value as long as it stays above the cut-off value. This substantially eliminates chatter and sequential opening and closing of the relay **22**.

The relationship between the transmitted signal strength as received by the receiving antenna **26** and the DC control signal magnitude supplied to the relay driver transistor **102** is illustrated on FIGURE 5. As shown on FIGURE 5, and with reference to FIGURE 2, curve A represents the strength of the transmitted signal received by the receiving antenna **26** and curve B represents the magnitude of the DC control signal supplied to the base electrode **100** of the relay driver transistor **102**. As noted above, the magnitude of the DC control signal is proportional to the logarithm of the transmitted signal strength.

Until time t_1 the transmitted signal strength is less than the minimum sensitivity value, which value is adjusted by variable resistor **60**. The DC control signal magnitude is similarly less than the threshold value for conduction of the relay driver transistor **102** as determined by impedance divider transistor **110**. At time t_1, when the transmitted signal strength reaches the minimum sensitivity value, the DC control signal magnitude reaches the threshold value and the relay **22** is energized. When the relay **22** is energized, there is a sudden increase in the gain of the command receiver **10** and this results in an abrupt increase in the magnitude of the DC control signal, as shown by portion B_1 of curve B. For all values of DC control signal magnitude greater than the threshold value, the relay **22** is energized and for all values less than the threshold value, the relay **22** is not energized.

At time t_2 the strength of the transmitted signal has decreased below the minimum sensitivity value but, because of the increased gain provided by the energized relay **22**, the DC control signal magnitude is still greater than the threshold value and, consequently, the relay **22** remains energized. When the transmitted signal strength decreases to the cut-off value, as shown at time t_3, which value is less than the minimum sensitivity value, the DC control signal magnitude drops below the threshold value and the relay **22** is de-energized. This results in a sudden drop in the gain of the command receiver **10** and the magnitude of the DC control signal abruptly decreases substantially below the threshold value, as shown by portion B_2 of curve B.

Thus, chatter of the relay **22** is uniquely eliminated in applicant's improved command receiver **10**, since transmitted signal strength variations between the minimum sensitivity value and the cut-off value, once the minimum sensitivity value has been achieved, do not affect the energizing or de-energizing of the relay **22**.

When utilized with conventional 115 to 120 volt alternating current power supply, the B plus voltage is applied at connection Z through diode **120** and the ground is applied at Y. A transformer (not shown) is preferably included so that approximately 6 volts may be applied at the cathode heater **52** of the triode **42**. Capacitors **122** and **124** filter the input power applied to the command receiver **10** to eliminate any alternating current therein and to eliminate any radio frequency that may be present in the input power supply.

When the receiver **10** is utilized to operate a relay to control the opening and closing of garage doors as described above, applicant has found that the components of the receiver **10** preferably have the following values: Capacitor **78**, 3.3 microfarads; capacitor **69**, .006 microfarad; capacitor **96**, 25 microfarads; capacitor **122**, 100 microfarads; capacitor **124**, 1000 picofarads, inductor **66** variable between 5 and 20 millihenries; transistors **68** and **102** of the 2N414 P-N-P type; transistors **84** and **110** of the 2N388 NPN type; resistor **76**, 1000 ohms; resistor **80**, 560 ohms; resistor **92** of the thermistor type having a nominal value of 3000 ohms at 25° C.; resistor **94**, 8200 ohms; resistor **118**, 3300 ohms; resistor **116**, 27,000 ohms, and the relay **22** is preferably a sigma No. 11FP2300G type relay. Diode **120** is preferably a Sylvania 1N462A diode.

When the receiver **10** is fabricated including components having the above-described values, applicant has found that the power drain in the stand-by condition is approximately 0.8 watt and, further, that the radiated power re-radiated from the receiving antenna **26** is virtually insignificant so that spurious signals that might tend to actuate similar receivers in geographic juxtaposition to the receiver **10** do not occur.

From the above it can be seen that applicant has provided an improved selectively tuned command receiver adapted to receive a transmitted signal comprising a radio frequency signal at a preselected frequency that is audio frequency amplitude modulated at a preselected audio frequency. Only when a transmitted signal at or above the minimum sensitivity value and having both the preselected radio frequency componet and the preselected audio frequency modulation component is received by the receiver **10** for a sufficient length of time is the relay **22** energized for appropriate operation of, for example, a garage door. Further, the receiver **10** not only uniquely eliminates, substantially, re-radiation, but also insures that once a transmitted signal strong enough to initiate operation of the relay **22** is received, the relay **22** will remain energized for all input signal strengths greater than a predetermined cut-off value and the predetermined cut-off value is less than the minimum sensitivity value sufficient to initiate the energizing of the relay **22**. From an examination of FIGURE 2, it can be seen that applicant's improved command receiver **10** is DC coupled between all stages, that is, there are no capacitors between stages to filter out DC components of the signal.

This concludes the description of applicant's improved

receiver. Those skilled in the art may find many variations and adaptations of applicant's invention herein and the following claims are intended to cover all such variations and adaptations falling within the true scope and spirit of applicant's invention.

I claim:

1. A command receiver of the type adapted to receive a transmitted signal, which signal has a preselected radio frequency amplitude modulated by a preselected audio frequency, and to energize a relay in response thereto comprising, in combination:

an antenna for receiving the transmitted signal;

a radio frequency transformer having a primary winding and a secondary winding, and said primary winding connected to said antenna;

a first detector having a first predetermined signal gain for a first condition of operation and a second predetermined signal gain greater than said first for a second condition of operation, and said first detector coupled to said secondary winding of said radio frequency transformer for receiving the transmitted signal coupled thereto by said secondary winding and said first detector having a cyclical frequency generating means for cyclically establishing therein at a predetermined squelch frequency rate, an oscillatory signal condition at said preselected radio frequency, modulated by said preselected audio frequency and said preselected squelch frequency and said first detector having filter means to filter said preselected radio frequency and said squelch frequency to provide a detected audio frequency signal at said preselected audio frequency;

amplification means coupled to said first detector for receiving said detected audio frequency signal and generating a DC control signal in a response thereto, said DC control signal having a magnitude proportional to the strength of the transmitted signal received by said antenna;

a relay;

a relay driver and gain control coupled to said amplification means and to said relay for receiving said DC control signal and energizing said relay in response thereto for the condition of said DC control signal being present for a predetermined time interval and having a magnitude at least as great as a predetermined threshold value; and

said first condition of operation comprising said relay de-energized and said second condition of operation comprising said relay energized, and said cyclical frequency generating means responsive to said energizing of said relay to provide said second predetermined signal gain for the condition of said relay energized and to provide said first predetermined signal gain for the condition of said relay de-energized; and

said predetermined threshold value of said DC control signal corresponding to a minimum sensitivity value of the transmitted signal for the condition of said relay de-energized and said minimum threshold value of said DC control signal corresponding to a cut-off value of the transmitted signal, less than said minimum sensitivity value for the condition of said relay energized.

2. The arrangement defined in claim 1 wherein said first detector comprises a radio frequency tank circuit resonant at said preselected radio frequency, and said cyclical frequency generating means thereof comprises a self-quenching super-regenerative detector for cyclically establishing said oscillatory signal having said preselected radio frequency at said predetermined squelch frequency rate.

3. The arrangement defined in claim 2 wherein

said radio frequency tank circuit resonant at said preselected radio frequency comprises said secondary winding of said radio frequency transformer and a variable capacitor;

and said self-quenching super-regenerative detector comprises: a triode having a plate, a cathode and a grid, said plate connected to a first end of said radio frequency tank circuit and said cathode connected to ground, a capacitor having a first conductor connected to a second end opposite said first end of said radio frequency tank circuit and a second conductor connected to said grid, a resistor connected between said cathode and said grid; and

signal varying means for applying a first predetermined DC voltage between said first end of said radio frequency tank circuit and ground to provide said first predetermined gain in said first detector for the condition of said relay being unenergized and said predetermined DC voltage being varied to a second predetermined DC voltage less than said first predetermined DC voltage to provide said second predetermined gain in said first detector greater than said first gain for the condition of said relay being energized.

4. The arrangement defined in claim 3 wherein said variable capacitor is variable between approximately 1.5 picofarads and 9.0 picofarads to tune said radio frequency tank circuit for a resonance at the preselected radio frequency in the range of 250 megacycles to 300 megacycles, said triode has a transconductance of approximately 4000 micromhos at a plate voltage on the order of 12 volts, and said resistor and said capacitor provide a time constant in the range of 0.75×10^{-6} seconds and 2.25×10^{-6} seconds, and said first predetermined DC voltage is in the range of 6 to 24 volts.

5. The arrangement defined in claim 1 wherein said preselected radio frequency is in the range of 250 megacycles to 300 megacycles, said preselected audio frequency is in the range of 12 kilocycles to 24 kilocycles, said predetermined squelch frequency is in the range of 2 to 50 times as great as said preselected audio frequency and is in the range of 24 kilocycles to 1200 kilocycles, and said DC control signal is proportional to the logarithm of the strength of said transmitted signal received by said antenna.

6. The arrangement defined in claim 1 wherein said relay driver and gain control comprises:

a relay driver transistor having base, emitter and collector electrodes, and said DC control signal is applied to said base electrode, and said relay is connected to said collector electrode and to ground;

an impedance divider transistor having base emitter and collector electrodes and said emitter electrode of said relay driver transistor is connected to said emitter electrode of said impedance divider transistor to establish said predetermined threshold value of said DC control signal for conductance of said relay driver transistor to energize said relay;

a first resistor connecting said base electrode of said impedance divider transistor to ground;

a second resistor connecting said base electrode of said impedance divider transistor to said collector electrode of said impedance divider transistor; and

means for applying a predetermined DC voltage between said collector electrode of said impedance divider transistor and ground.

7. The arrangement defined in claim 6 wherein said relay driver transistor is of the P-N-P type, said impedance divider transistor is of the N-P-N type and said preselected DC voltage at said collector electrode of said impedance divider transistor is positive with respect to ground.

8. The arrangement defined in claim 6 wherein said relay driver transistor is of the N-P-N type, said impedance divider transistor is of the P-N-P type and said preselected DC voltage at said collector electrode of

said impedance divider transistor is negative with respect to ground.

9. A command receiver of the type adapted to receive a transmitted signal, which signal has a preselected radio frequency amplitude modulated by a preselected audio frequency, and to energize a relay in response thereto comprising, in combination:

an antenna for receiving the transmitted signal;

a radio frequency transformer having a primary winding and a secondary winding and said primary winding connected to said antenna;

a first detector having a predetermined gain range and comprising a radio frequency tank circuit and a self-quenching super-regenerative detector, said radio frequency tank circuit comprising said secondary winding of said radio frequency transformer and a variable capacitor, said self-quenching super-regenerative detector comprising a triode having a plate, a cathode and a grid, said plate connected to a first end of said radio frequency tank circuit and said cathode connected to ground, a first capacitor having a first conductor connected to a second end opposite said first end of said radio frequency tank circuit and a second conductor connected to said grid, and a first resistor connected between said cathode and said grid, and means for applying a first predetermined DC voltage between said first end of said radio frequency tank circuit and ground, said self-quenching super-regenerative detector for cyclically establishing an oscillatory signal at said preselected radio frequency at a predetermined squelch frequency rate in said first detector whereby a detected audio frequency signal is generated in response to the transmitted signal and having said preselected audio frequency;

and filter means in said first detector for filtering said resonant radio frequency and said squelch frequency to transmit said detected audio frequency signal;

means coupled to said filter means for receiving said detected audio frequency signal and generating a DC control signal in response thereto, said DC control signal having a magnitude proportional to the strength of the transmitted signal received by said antenna;

a relay;

a relay driver and gain control coupled to said means and to said relay and comprising a relay driver transistor having base, emitter and collector electrodes, and said DC control signal is applied to said base electrode, and said relay is connected to said collector electrode and to ground, an impedance divider transistor having base, emitter, and collector electrodes and said emitter electrode of said relay driver transistor is connected to said emitter electrode of said impedance divider transistor to establish a predetermined threshold value of said DC control signal for conductance of said relay driver transistor to energize said relay, a second resistor connecting said base electrode of said impedance divider transistor to ground, a third resistor connecting said base electrode of said impedance divider transistor to said collector electrode of said impedance divider transistor, means for applying a second predetermined DC voltage different from said first predetermined DC voltage between said collector electrode of said impedance divider transistor and ground, whereby said relay is energized for the condition of said DC control signal having a magnitude at least as great as said predetermined threshold value and for the condition of said relay being energized, said first predetermined DC voltage is decreased to thereby increase the gain of said first detector to provide an increase in the magnitude of said DC control signal.

10. The arrangement defined in claim 9 wherein said preselected radio frequency is in the range of 250 megacycles to 300 megacycles, said preselected audio frequency is in the range of 12 kilocycles to 24 kilocycles, said predetermined squelch frequency is in the range of 2 to 50 times as great as said preselected audio frequency and is in the range of 24 kilocycles to 1200 kilocycles, and said DC control signal is proportional to the logarithm of the strength of said transmitted signal received by said antenna, and said first predetermined DC voltage is within the range of 6 to 24 volts.

11. The arrangement defined in claim 10 wherein said variable capacitor is variable between approximately 1.5 picofarads and 9.0 picofarads to tune said radio frequency tank circuit for resonance at the preselected radio frequency in the range of 250 megacycles to 300 megacycles, said triode has a transconductance of approximately 4000 micromhos at a plate voltage on the order of 12 volts, and said resistor and said capacitor provide a time constant in the range of 0.75×10^{-6} seconds and 2.25×10^{-6} seconds, said relay driver transistor is of the P-N-P type, said impedance divider transistor is of the N-P-N type and said second preselected DC voltage at said collector electrode of said impedance divider transistor is positive with respect to ground, and said first predetermined DC voltage is in the range of 6 to 24 volts.

References Cited

UNITED STATES PATENTS

2,931,956	4/1960	Van Arsdale	343—225
2,993,991	7/1961	Lundakl	343—228
3,001,177	9/1961	Adler	343—228
3,041,507	6/1962	Rose et al.	343—225
3,072,887	1/1963	Adler	343—228
3,151,297	9/1964	Toomin	325—429
3,106,646	10/1963	Carter	317—123
3,112,431	11/1963	Pederson	317—148.5

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