

March 5, 1946.

A. L. G. DE BEY

2,396,091

REMOTE CONTROL SYSTEM BY VARIABLE FREQUENCY SIGNALS

Filed Dec. 9, 1940

4 Sheets-Sheet 1

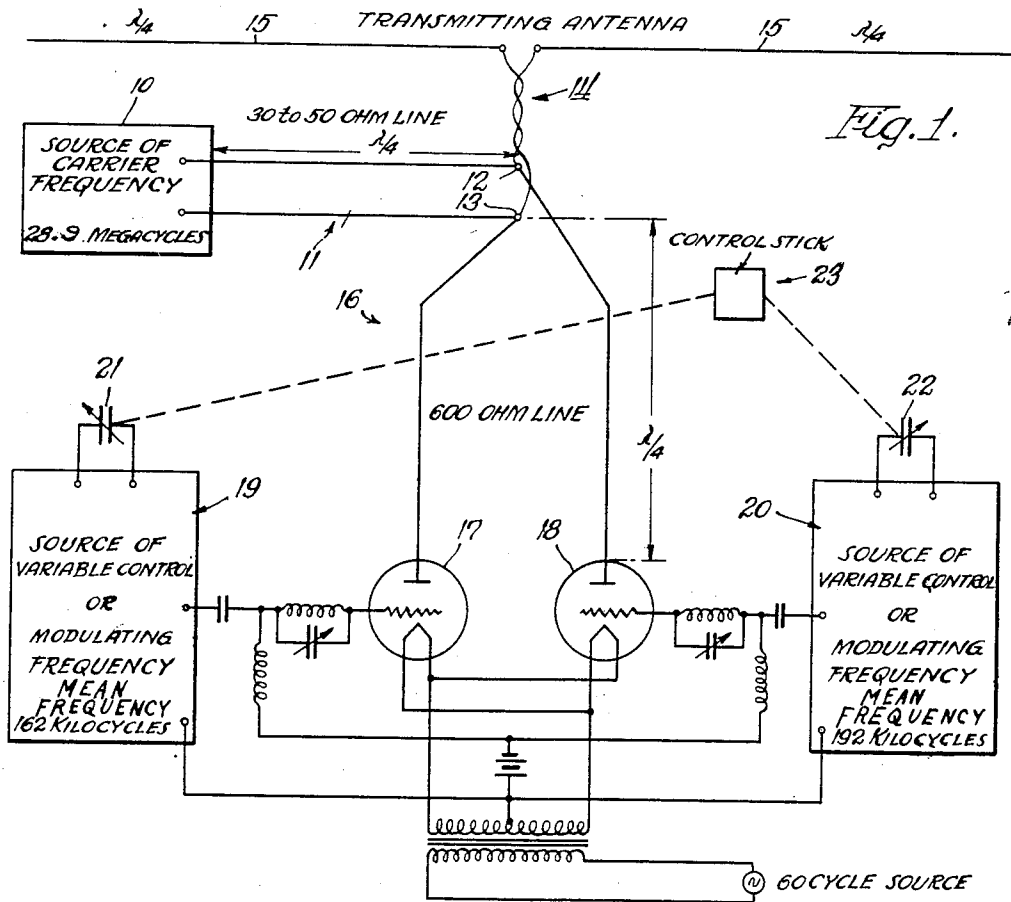


Fig. 1.

TX 50,

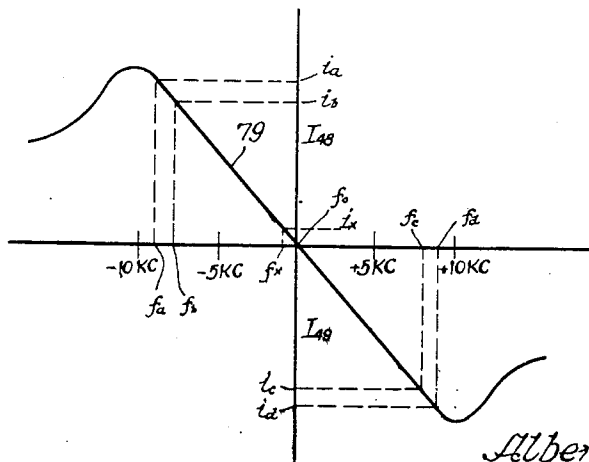


Fig. 5.

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March 5, 1946.

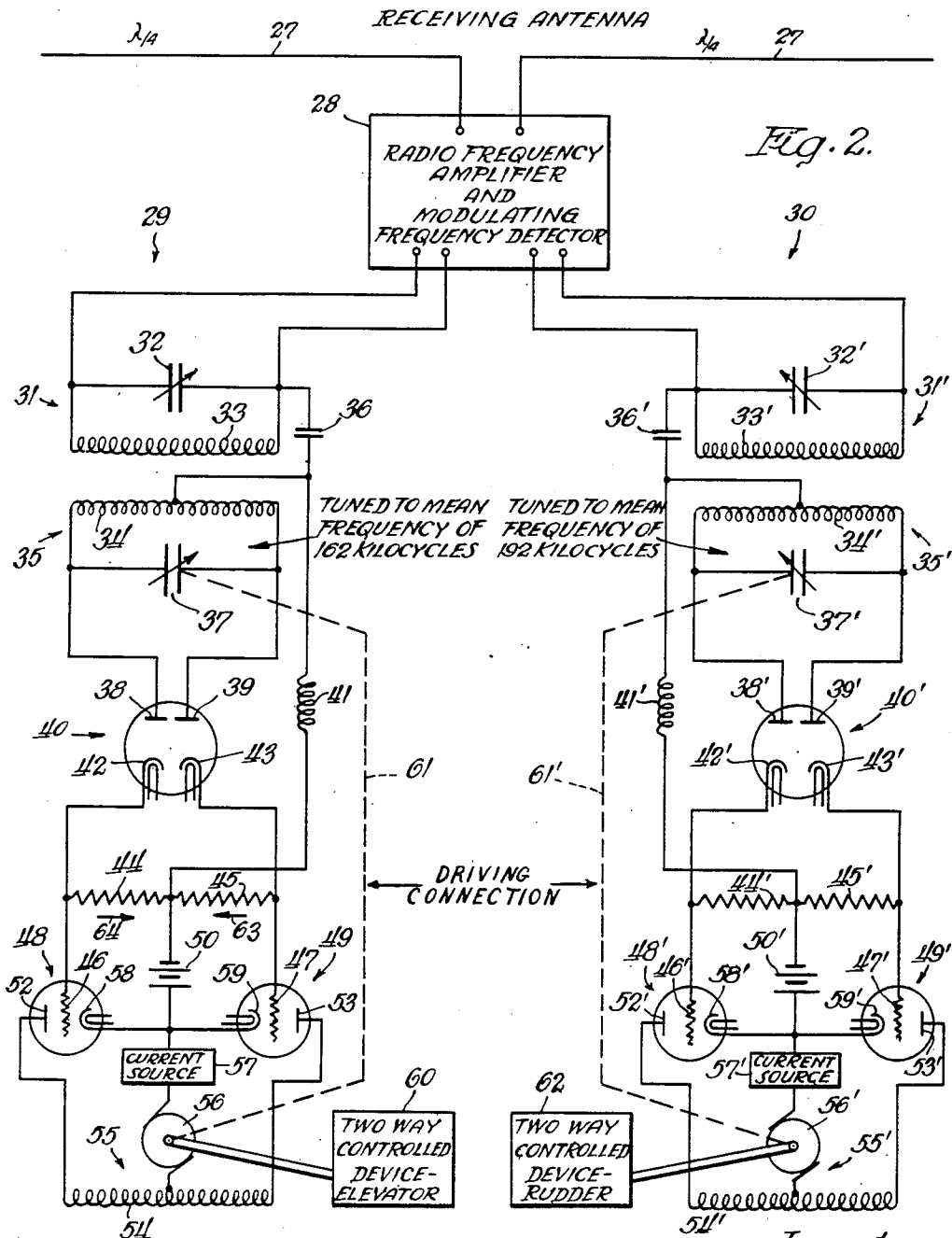
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REMOTE CONTROL SYSTEM BY VARIABLE FREQUENCY SIGNALS

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4 Sheets-Sheet 2



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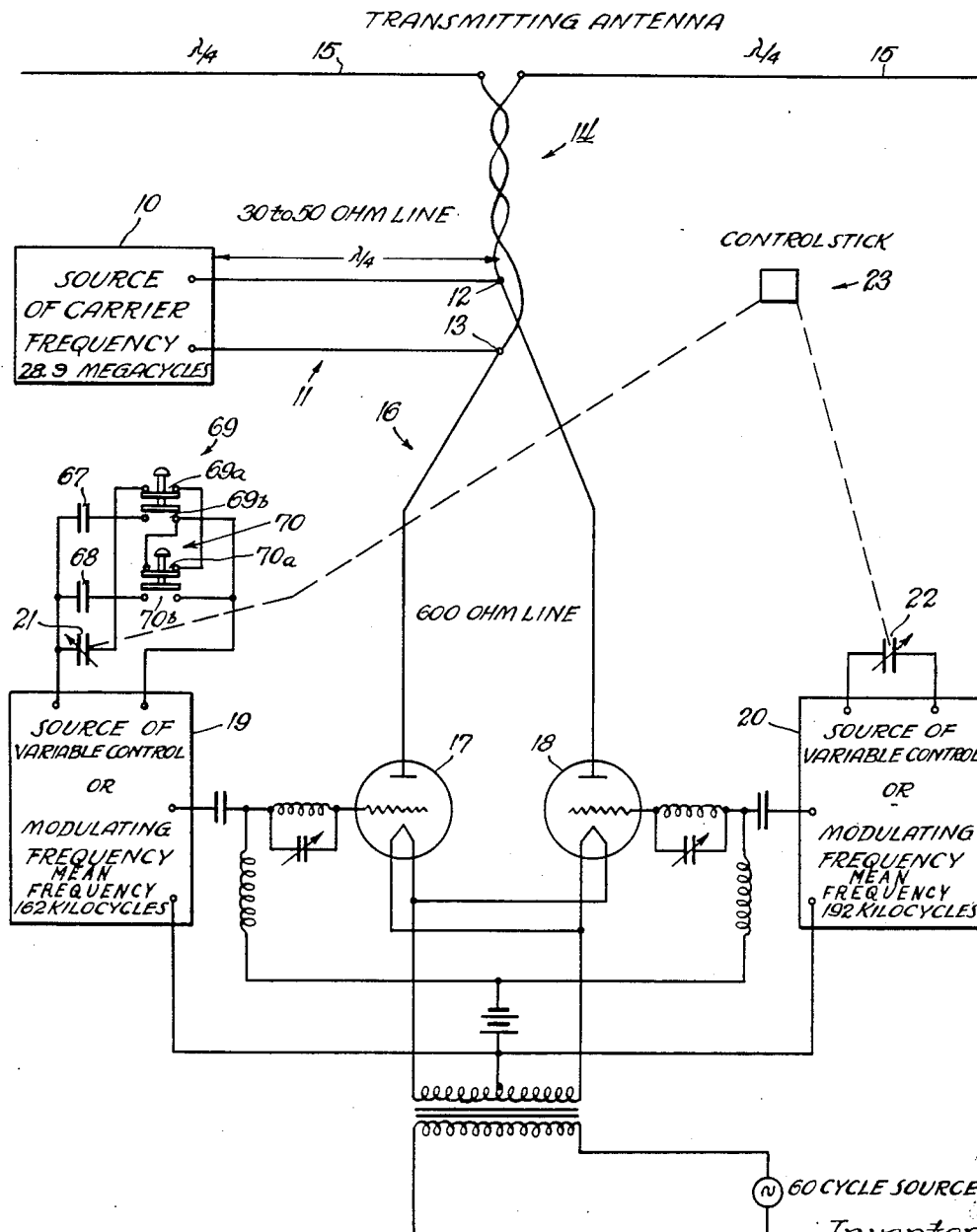
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REMOTE CONTROL SYSTEM BY VARIABLE FREQUENCY SIGNALS

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4 Sheets-Sheet 3

Fig. 3.



By *Brown* *for* *Albert Lee Gerard de Bey.* *Inventor.*
Boucher *Dinner* *Attys.*

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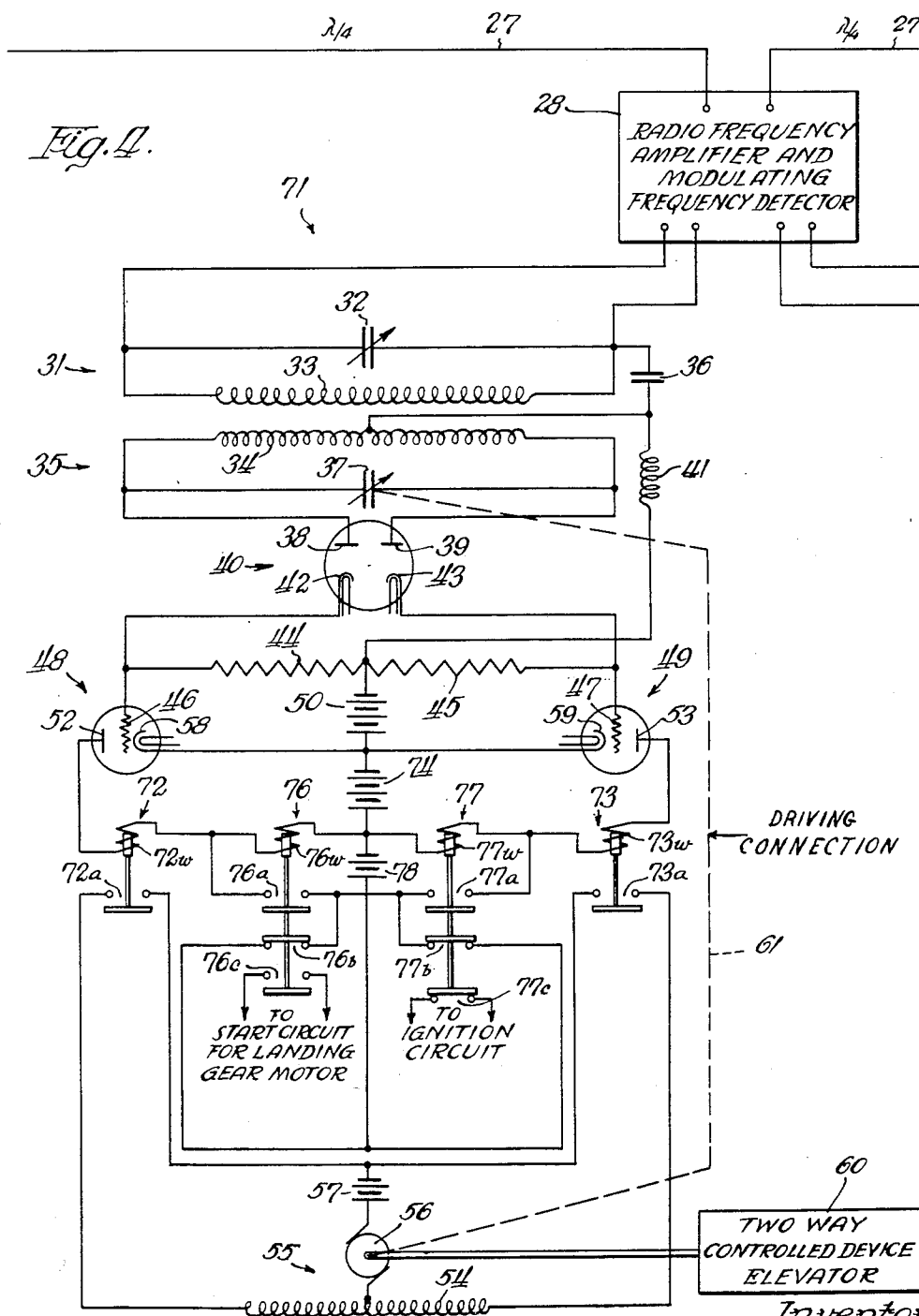
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REMOTE CONTROL SYSTEM BY VARIABLE FREQUENCY SIGNALS

Filed Dec. 9, 1940

4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,396,091

REMOTE CONTROL SYSTEM BY VARIABLE
FREQUENCY SIGNALS

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Application December 9, 1940, Serial No. 369,216

10 Claims. (Cl. 250—2)

My invention relates, generally, to remote control systems and it has particular relation to means for directing or controlling a mechanical movement or movements by means of variable frequency signals.

An object of my invention is to effect movement at a point remote from a control point in accordance with variable frequency signals transmitted from the control point to the remote point.

Another object of my invention is to translate the continuous movement of a control member at the control point into corresponding continuous movement of a controlled member at the remote point.

Still another object of my invention is to simultaneously effect different movements at the remote point in accordance with different bands of variable frequency signals transmitted from the control point.

A further object of my invention is to provide for transmitting a band of frequencies from the control point to the remote point, each frequency corresponding to a position of a movable control member at the control point, so as to operate controlled means at the remote point from any previous position corresponding to a frequency in the band to another position corresponding to another frequency therein.

A still further object of my invention is to automatically tune the receiving means at the remote point to the control frequency being received so as to thereby arrest further movement of the controlled means as long as the control frequency remains constant.

It is another object of my invention to provide for effecting operations at the remote point in addition to those performed in accordance with the variable frequency signals.

It is a further object of my invention to prevent the additional operations to be performed on receipt of the variable frequency signals.

Other objects of my invention will, in part, be obvious and in part appear hereinafter.

For a more complete understanding of the nature and scope of my invention reference can be had to the following detailed description, taken in connection with the accompanying drawings in which:

Figure 1 illustrates, diagrammatically, the transmitting apparatus at the control point;

Figure 2 illustrates, diagrammatically, the receiving apparatus at the remote point, such as an airplane;

Figures 3 and 4 illustrate, diagrammatically, circuits similar to those shown in Figures 1 and

2, respectively, and in addition indicate how special operations can be performed at the remote point under the control of means at the control point; and

5 Figure 5 graphically illustrates certain relationships between the modulating frequencies and the plate current flow in the tubes controlled thereby.

The present invention is particularly useful in connection with controlling operation of airplanes from a control point on the ground or in another airplane. Such a control is desirable for many reasons.

When model airplanes are tested in a wind tunnel so as to permit observation of the effects of air flow, it is desirable to operate the control members of the airplane as they would be operated during flight. This can be accomplished by providing controls, such as wires, to each of the movable members and then moving them as desired. However, this has the disadvantage that it does not represent true flight conditions. By placing radio receiving apparatus on the airplane model and then providing suitable transmitting means outside of the wind tunnel, it is possible to control the various movable parts of the airplane in the wind tunnel as desired without in any way interfering with the air flow therepast.

The present invention is also useful in controlling the operation of model airplanes which are capable of making relatively short free flights. It is possible to control the altitude and direction of flight of the model airplane from a point on the ground so as to permit the making of tests on the model under actual operating conditions.

The invention is applicable to remote control generally. It is particularly useful to operate the controls of an automotive vehicle from a stationary or from a movable remote control station. Torpedoes or moving devices that require one or more guiding operations may be guided and controlled by my invention.

According to a preferred embodiment of my invention I provide for modulating a carrier frequency with two bands of modulating frequencies which are sufficiently spaced apart so as not to overlap. The modulating frequency in each band is arranged to be continuously controlled by a single control device such as the control stick which corresponds to a similar device on an airplane. The control stick is arranged to vary the frequency in one band of modulating frequencies in accordance with movement in one plane and the frequency in the other band of modulating frequencies in accordance with movement in a

plane generally at right angles to the first-mentioned plane. On the airplane, receiving circuits are provided which are individually responsive to the different bands of modulating frequencies and are incapable of responding to other frequencies. For each of these receiving means a reversible motor or its equivalent is provided, one motor being arranged to operate an elevator and the other being arranged to operate the rudder. Each of the motors is also arranged to automatically tune its receiving circuit to the modulating frequency being transmitted so that when the receiving circuit is tuned to this frequency the motor stops and remains at rest as long as this particular frequency is received. Thereby the controls of the airplane are operated by remote control under the control of the control stick in the same manner that they would be operated if mechanically connected to the control stick.

In a modification of the invention means are provided for transmitting from the control point one or more control frequencies outside of the band of frequencies used for controlling the two-way controlled devices on the airplane. This permits the turning off of the ignition of the motor on the airplane and the starting of the landing gear motor or other operations that may be desired, which should be independent of the control of the elevation and direction of the airplane itself.

The continuously variable movement control system disclosed herein can be used to provide a means of remotely tuning a radio receiver to any frequency within its tuning range without the necessity of presetting the remote selector. A dial, duplicating that at the receiver proper, can be operated at the remote point to cause an identical movement of the tuning capacitor in the receiver. The variable frequency can be transmitted directly as a carrier over short distances and need not be superimposed on a separate carrier frequency. To provide remote volume control at the same time two separate channels can be provided or the two channels can be combined on one carrier frequency as in the case of aircraft control.

The system can be used to advantage in connection with anti-aircraft or anti-tank guns. At present a problem exists to relay data, rapidly and accurately, from a range finder position to a gun crew. Either a wired or wireless link between such stations can be used, adapting the variable movement control system to keep the gun automatically aimed at the target upon proper operation of the range finder by its crew. This would eliminate delay in transmitting fire control information.

The system is also applicable to wired and especially wireless telautograph transmission. Since continuously variable movements in at least two dimensions are possible, the reproduction of combinations of movements in two dimensions at a remote point is feasible. This can be particularly applied to the rapid transmission of hand drawn maps in aerial reconnaissance from airplane to ground. The time required for transmission will be shorter than for various types of facsimile transmission now used.

Wireless telemetry is another application of the system disclosed herein. The reading of one electrical or other indicating instrument can be duplicated at a remote point for each channel used in this system.

The system can be used to provide control of the rotation of rotating beam antennae such as

used in television. The variable control frequency can be transmitted to the receiving unit mounted near the rotating antenna structure either by wireless or by a wired-radio system. In the latter, the low frequency variable signal can be transmitted on the same transmission line used to carry the high frequency television carrier, by the use of suitable isolating filters at each end of the line.

Referring now particularly to Figure 1 of the drawings, it will be observed that the reference character 10 designates a source of carrier frequency which is connected by a quarter wave length transmission line, shown generally at 11, across terminals 12 and 13. A low impedance twisted pair of wires, shown generally at 14, serves to interconnect the terminals 12 and 13 and a half wave dipole antenna 15. In the work which I have done in developing the present invention, I have found that a carrier frequency of 28.9 megacycles is satisfactory. However, it will be understood that other carrier frequencies can be employed without departing from the scope of this invention.

For modulating the carrier frequency, a transmission line, shown generally at 16, is connected across the terminals 12 and 13 and has connected therein modulator tubes 17 and 18, the operation of which is controlled by oscillators 19 and 20, respectively. The oscillators 19 and 20 each constitute a source of variable control or modulating frequency which it will be understood is superimposed on the carrier frequency provided by the source 10 thereof.

Each of the oscillators 19 and 20 is arranged to generate bands of frequency which are entirely separate and distinct from each other. For example, the oscillator 19 can be arranged to generate a band of frequency beginning at 152 kilocycles and ending at 172 kilocycles and having a mean frequency of 162 kilocycles. Likewise the oscillator 20 can be arranged to generate a band of frequencies beginning at about 182 kilocycles and ending at about 202 kilocycles with a mean frequency of 192 kilocycles. It will be observed that these bands of frequencies do not overlap and that there is little likelihood of interference due to harmonics.

The frequencies generated by the oscillators 19 and 20 are controlled by variable capacitors 21 and 22, respectively.

As shown, the positions of the capacitors 21 and 22 are controlled by a control stick, shown generally at 23. The control stick is arranged in a conventional manner so that its movement in one plane will effect movement of the capacitor 21, for example, while movement in a plane at right angles thereto will effect movement of the capacitor 22. It will be understood that the positions of the capacitors 21 and 22 will correspond to any position of the control stick in either of these two planes and that the movement of the control stick can take place in one plane or the other plane or in both planes simultaneously to effect corresponding movements of the capacitors 21 and 22. In turn, corresponding movement or movements of a controlled device at the remote point on an airplane, for example, are effected. It will be understood that it is unnecessary to wait for one movement to be completed before the other movement is effected. Both movements can be accomplished simultaneously.

The transmitting apparatus shown in Figure 1 will be located on the ground in a position where

the controlled airplane will be visible either in a wind tunnel or during free flight. The apparatus shown in Figure 1 can also be located on another airplane which accompanies the controlled airplane during its flight.

Referring now particularly to Figure 2 of the drawings, it will be understood that the apparatus there diagrammatically illustrated is located at the remote point, such as on an airplane whose movement is to be controlled. The apparatus includes a conventional type antenna 27, similar to the antenna 15 of the transmitter which is connected to a conventional type of receiving apparatus 28 comprising a radio frequency amplifier and modulating frequency detector as indicated. The receiving apparatus 28 is arranged to feed or energize two circuits, shown generally at 29 and 30, one circuit being individual to one band of modulating frequency and the other circuit being individual to the other band of modulating frequency. For example, the circuit 29 may be tuned to respond to the band of modulating frequencies generated by the oscillator 19 while the circuit 30 can be arranged to respond to the band of modulating frequencies generated by the oscillator 20.

The circuit 29 comprises a circuit, shown generally at 31, which includes a variable capacitor 32 and an inductor 33. The capacitor 32 and inductor 33 are tuned to the band of frequencies individual to the circuit 29. The inductor 33 is inductively coupled to an inductor 34 forming a part of another circuit, illustrated generally at 35. A capacitor 36 serves to capacitively interconnect the circuit 31 with the midpoint of the inductor 34. The circuit 35 includes the variable capacitor 37 which is arranged to be moved automatically, as will be hereinafter set forth, so as to tune the circuit 35 to the modulating frequency generated by the oscillator 19.

It will be observed that the circuit 35 is connected to plates 38 and 39 of a double diode tube, shown generally at 40. The tube 40 is provided with indirectly heated cathodes 42 and 43, each associated with a plate 38 and 39, respectively. It will be understood that the cathodes 42 and 43 can be individually and directly heated by batteries if desired. Resistors 44 and 45 are serially connected across the cathodes 42 and 43 and their common connection is connected, as shown, to the midpoint of the inductor 34 through an impedance 41.

The cathodes 42 and 43 are connected, respectively, to control electrodes 46 and 47 of control tubes shown generally at 48 and 49. A battery 50 or other suitable direct current source serves to normally apply a negative biasing voltage on the control electrodes 46 and 47, so as to maintain the tubes 48 and 49 in the non-conducting state.

The tubes 48 and 49 also include plates 52 and 53 which, as shown, are connected to the terminals of a field winding 54 of a reversible series type motor, shown generally at 55. The motor 55 includes an armature 56 which is connected to a midpoint of the field winding 54 and through a current source 57 to indirectly heated cathodes 58 and 59 of the tubes 48 and 49, respectively. The current source 57 can be direct current, alternating current, or interrupted direct current depending upon the type of the tubes 48 and 49, as will be readily understood.

The armature 56 of the motor 55 is connected, as shown, to move a two-way controlled device such as an elevator 60.

The armature 56 of the motor 55 is also con-

nected, as indicated by the broken line 61, to the capacitor 37 so that it is moved at the same time that the armature 56 is rotated. As will hereinafter appear, as long as the modulating frequency applied to the circuit 35 differs from the frequency to which it is tuned by the combination of the inductor 34 and the capacitor 37, the motor 55 will continue to operate in one direction or the other until the capacitor 37 has been moved to such position that the circuit 35 is tuned to the received modulating frequency. When this condition exists, further operation of the motor 55 ceases and it remains inoperative until the modulating frequency applied to the circuit 35 is either increased or decreased.

The sharpness of tuning of the circuits 31 and 35 is determined by the manner in which the circuit 29 is to be operated. If it is desired to vary the modulation frequency over a relatively wide range, then the circuits 31 and 35 should be correspondingly broadly tuned. If the change in modulation frequency is over a relatively narrow range, then these circuits should be more sharply tuned. The rate at which the modulation frequency is varied is also a factor. If the modulation frequency is varied at such a rate that the motor 55 cannot keep the circuit 35 tuned in step with it, then the circuits 31 and 35 should be sufficiently broadly tuned so that the straight line portion of the discriminator characteristic (see Figure 5) referred to the abscissa will be long enough to include the greatest frequency shift that may occur.

It will be observed that the circuit 30 is identical with the circuit 29 and, for this reason, the reference characters applied thereto are the same as applied to the circuit 29 except that they are primed. For the circuit 30, the circuits 31' and 35' are tuned for receiving a different band of modulating frequencies, such as a band having a mean frequency of 192 kilocycles, such as generated by the oscillator 20. The motor 55' is arranged to control the operation of a two-way controlled device such as a rudder indicated at 62.

In describing the operation of the system shown in Figures 1 and 2 of the drawings, it will be assumed that initially the position of the control stick 23 is correlated with the positions of the elevator 60 and the rudder 62 so that subsequently the positions of the latter two devices can be controlled by movement of the control stick 23 to definite predetermined positions which can be marked or otherwise indicated adjacent the mounting thereof. Under these assumed conditions, the frequencies generated by the oscillators 19 and 20 are those to which the circuits 35 and 35' are tuned and, as a result, the motors 55 and 55' remain stationary. This is due to the fact that the control tubes 48, 48' and 49, 49' are maintained in the non-conducting state, thereby preventing current flow in either direction through the field windings 54 and 54'.

It will now be assumed that the control stick 23 is moved so as to effect movement of the capacitor 21 without moving the capacitor 22. It will also be assumed that the movement of the capacitor 21 is such that the frequency generated by the oscillator 19 is increased. This increased frequency is superimposed on the carrier frequency generated by the oscillator 10 and is applied to the antenna 15. The modulated frequency is received on the antenna 27, is amplified and demodulated by the receiver 28. The increased modulating frequency is applied to the circuit 29 and to the circuit 35 which is tuned

to a lower frequency. Because of the phase differences in the voltages induced in the inductor 34 by the inductive and capacitive coupling with the circuit 31, the resultant voltages appearing across the plate 38 and the cathode 42 on the one hand and the plate 39 and the cathode 43 on the other hand will be different. It will be assumed that the voltage across the latter will be the greater and, consequently, the voltage drop across the resistor 45 will be larger than the voltage drop across the resistor 44. This is due to the fact that the current flow indicated by the arrow 63 in the resistor 45 is greater than the current flow indicated by the arrow 64 in the resistor 44. The negative potential applied to the control electrode 47 by the battery 50 is then overcome and the tube 49 becomes conducting. Current then flows from the current source 57 through the tube 49 and the right-hand half of the field winding 54 and the armature 56 so as to operate the latter in one direction, thereby effecting a corresponding operation of the elevator 60. At the same time, because of the mechanical connection indicated by the broken line 61 between the armature 56 and the capacitor 37, the latter is moved in a direction to tune the circuit 35 to the modulating frequency being received thereby. The armature 56 continues to move until the circuit 35 is tuned to the modulating frequency. When this condition exists, the voltage drop across the resistor 45 equals the voltage drop across the resistor 44 and the voltage applied to the control electrode 47 again becomes negative. The tube 49 then is no longer conducting and current no longer flows through the armature 56. It then stops and remains in this position until the modulating frequency received by the circuit 29 is changed.

If the control stick 23 has been moved to such position that the capacitor 21 decreased the frequency generated by the oscillator 19, then the current flow indicated by the arrow 64 would become greater than the current flow indicated by the arrow 63 and the tube 48 would become conducting. In this instance the lefthand half of the field winding 54 would be energized in series with the armature 56 to operate the latter in a reverse direction thereby effecting a corresponding movement of the elevator 60.

It will be understood that the motor 55' is controlled in a manner similar to that described for the motor 55 on movement of the variable capacitor 22 by the control stick 23. It will also be understood that both of the variable capacitors 21 and 22 can be moved at the same time thereby effecting operation of the motors 55 and 55' at the same time. Of course, if desired, individual controls could be provided for the variable capacitors 21 and 22. However, it is obviously preferable to employ single control means such as the control stick 23 so as to permit the operator at the control stick to substantially duplicate the functions of a human pilot on the airplane which is otherwise remotely controlled.

In addition to permitting control from the ground of the direction and elevation of the airplane, it may be desirable to provide for controlling additional means on the airplane. For example, it may be desirable to permit interruption of the ignition circuit on the airplane at the will of the operator on the ground. It may also be desirable to initiate from the ground the operation of landing gear on the airplane preparatory to its landing. It is for these purposes

that the system shown in Figures 3 and 4 of the drawings can be used.

The circuit connections and apparatus shown in Figures 3 and 4 of the drawings are generally the same as shown in Figures 1 and 2 of the drawings. Accordingly, in so far as possible the same reference characters have been employed.

Referring first to Figure 3, it will be observed that, in addition to the variable capacitor 21 for the oscillator 19, two fixed capacitors 67 and 68 have been provided together with switches 69 and 70. The switches 69 and 70 are provided with break contact members 69a and 70a and make contact members 69b and 70b, respectively, for controlling the connections of the capacitors 21, 67, and 68 to the oscillator 19.

With the switches 69 and 70 in the positions shown in the drawings, the oscillator 19 is under the control of the capacitor 21 which in turn is operated by the control stick 23 as previously described. It will be noted that the capacitor 21 is connected to the oscillator 19 through the break contact members 69a and 70a of the switches 69 and 70. Operation of either of these switches will interrupt the circuit between the capacitor 21 and the oscillator 19. Likewise, operation of the switch 69 will connect the capacitor 67 to the oscillator 19 while operation of the switch 70 will connect the capacitor 68 thereto. The capacitors 67 and 68 are arranged to control the operation of the oscillator 19 in such manner as to cause it to generate frequencies above or below the band of frequencies generated thereby under the control of the capacitor 21. Use is made of these outside frequencies, as will be indicated hereinafter, to effect the desired special control functions on the airplane.

Referring now particularly to Figure 4, it will be observed that the circuit shown generally at 71 thereon is similar to the circuit 29 of Figure 2. Certain additions and changes in the circuit connections have been made.

Associated with the control tubes 48 and 49 are control relays shown generally at 72 and 73 having operating windings 72w and 73w and normally open contact members 72a and 73a, respectively. When the tubes 48 and 49 are rendered conducting, it will be understood that the relays 72 and 73 are respectively energized to effect corresponding operation of the motor 55 as previously described. Current for energizing the windings 72w and 73w is obtained from a suitable source such as the battery 74.

For performing the additional operations control relays shown generally at 76 and 77 are provided. These relays have operating windings 76w and 77w. The relay 76 is provided with normally open contact members 76a and 76c and normally closed contact members 76b. Likewise, relay 77 is provided with normally open contact members 77a and normally closed contact members 77b and 77c.

The normally closed contact members 77c can be connected in the ignition circuit of the motor which drives the airplane. The ignition circuit can be so arranged that, when the contact members 77c have been opened, the ignition circuit is not re-established even though the contact members 77c are again closed.

The normally open contact members 76c can be connected in a circuit which initiates the operation of the landing gear motor. As long as they remain closed this circuit is energized. It will be understood that suitable limit switches can be

employed in connection with the landing gear motor so as to stop it when the landing gear has been fully extended.

An auxiliary current source such as a battery 78 is provided for maintaining the operating windings 76w and 77w energized after they have been initially energized.

The operating windings 76w and 77w are so arranged and constructed that they are insufficiently energized to effect operation of their associated movable contact members as long as the received modulated frequency is within the band of frequencies under the control of the capacitor 21. In order to effectively energize the operating windings 76w and 77w, it is necessary to go outside of this band of frequencies.

For a better understanding of the marginal operation of the relays 76 and 77, reference can be had to the curve 79 shown in Figure 5 of the drawings. The curve 79 represents the current flow in the plate circuits of the tubes 48 and 49 with variations in the received modulated frequency. As indicated this curve will be linear if the tubes 48 and 49 are operated as Class A amplifiers. It will be observed that variations in frequency from a mean frequency f_0 are plotted as abscissae and variations in plate current are plotted as ordinates, the ordinates above the x axis indicating the plate current I_{a3} for the tube 48 and the ordinates below the line indicating the plate current I_{a3} for the tube 49. The capacitor 21 is arranged to control the oscillator 19 in the band of frequencies between f_c and f_b . At these frequencies, currents i_a and i_b flow through the windings 72w and 76w on the one hand and through windings 77w and 73w on the other hand. These currents and any currents of less value are insufficient to energize the operating windings 76w and 77w to effect operation of their contact members.

When it is desired to operate the relay 77, the switch 69, for example, can be operated. When this is done, the capacitor 21 is disconnected from the oscillator 19 and the capacitor 67 is connected thereto. The capacitance of the capacitor 67 is such that the generator 19 is caused to generate a frequency outside of the band of frequencies generated thereby under the control of the capacitor 21 and this frequency can be represented as the frequency f_a on Figure 5. As a result, an increased current i_a flows in the plate circuit of the tube 49 which is sufficient to effect the movement of the contact members of the relay 77 to their alternate positions.

Contact members 77c are then opened to open the ignition circuit as previously described. A holding circuit for the relay 77 is then completed at contact members 77a through normally closed contact members 76b of relay 76 to the battery 78. It is then unnecessary to hold the switch 69 in the operated position and maintain the frequency f_a any longer than is necessary to operate the relay 77 to the closed position.

The time required to effect the operation of the relay 77 as previously described is extremely small and consequently, even though the relay 73 will be energized at the same time, it will be promptly de-energized as soon as the switch 69 is released. Consequently, because of the inertia of the motor 55 and the apparatus connected therewith, it will not be energized for a time sufficiently long to permit it to change its position.

The relay 77 can be deenergized and the relay 76 energized by operating the switch 70. When the switch 70 is operated, the capacitor 21 is

disconnected from the oscillator 19 and the capacitor 68 is connected thereto. The capacitor 68 is arranged to cause the oscillator 19 to generate a frequency, such as the frequency f_a which is lower than any frequency generated by the oscillator 19 under the control of capacitor 21. A current i_a then flows in the plate circuit of the tube 48 which is sufficient to effect operation of the relay 76.

At contact members 76c a circuit is completed, as previously indicated, for starting the operation of the landing gear motor. At contact members 76b the holding circuit for the relay 77 is opened and it is deenergized. At contact members 76a a holding circuit for the relay 76 is partially completed which is fully completed on closure of contact members 77b.

It will be understood that the relay 76 can be deenergized by again operating the switch 69 to again effect the operation of the relay 77.

Since certain further changes can be made in the foregoing constructions and circuit arrangements and different embodiments of the invention can be made without departing from the scope thereof, it is intended that all matter shown in the accompanying drawings and described hereinbefore shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. Apparatus for remotely controlling an airplane or the like from a control point on the ground or in another airplane comprising, in combination, means at the control point for transmitting a carrier frequency, means for simultaneously modulating the carrier frequency with a plurality of independently variable frequencies, means for varying each frequency in accordance with individually desired movements on the remotely controlled airplane, means on the controlled airplane for receiving the modulated carrier frequency, a plurality of means on the controlled airplane each individually movable in opposite directions in synchronism with increase or decrease of the received individual modulating frequency from a previous value to effect said desired movements, and means individual to each of the last named means and operable in accordance with the movement thereof for tuning the modulating frequency receiving means individual thereto to the modulating frequency received thereby.

2. Apparatus for remotely controlling an airplane or the like from a control point on the ground or in another airplane comprising, in combination, means at the control point for transmitting a carrier frequency, means for simultaneously modulating the carrier frequency with a plurality of different bands of frequencies, means for continuously varying the modulating frequency in each band of frequencies in accordance with a plurality of different movements of a control stick or the like from one position to another each movement corresponding to desired change in position of one of a plurality of controlled means on the controlled airplane, means on the controlled airplane for receiving the modulated carrier frequency, a plurality of means on the controlled airplane each continuously movable in opposite directions individually in response to its one of the received modulating frequencies for operating the controlled means individual thereto in synchronism with increase or decrease of its modulating frequency from a previous value in its band of frequencies, and means

operable in accordance with the movement of each controlled means for tuning its modulating frequency receiving means to the received modulating frequency whereby each controlled means remains in any position to which it has been operated as long as the modulating frequency individual thereto remains constant.

3. Apparatus for remotely controlling an airplane or the like from a control point on the ground or in another airplane comprising, in combination, means at the control point for transmitting a carrier frequency, means for simultaneously modulating the carrier frequency with a plurality of different bands of frequencies, variable impedance means for continuously varying the modulating frequency in each band of frequencies in accordance with a plurality of different movements of a control stick or the like from one position to another each movement corresponding to desired change in position of one of a plurality of controlled means on the controlled airplane, means on the controlled airplane for receiving the modulated carrier frequency, a reversible motor for each controlled means for operating the same, a plurality of circuit means each individually energized from said receiving means and tuned to be responsive only to the band of modulating frequencies individual thereto, variable impedance means for tuning each circuit means to any particular frequency in its band of frequencies, means controlled by each circuit means for operating one of said motors in one direction in synchronism with increase in the modulating frequency in its band above said particular frequency and in the opposite direction in synchronism with decrease in the modulating frequency below said particular frequency, and means operatively interconnecting each motor and the variable impedance means individual thereto for tuning its circuit means to the modulating frequency being received thereby whereby each controlled means remains in any position to which it has been operated as long as the modulating frequency individual thereto remains constant.

4. Apparatus for remotely controlling an airplane or the like from a control point on the ground or in another airplane comprising, in combination, means at the control point for transmitting a carrier frequency, means for modulating the carrier frequency with a variable frequency, means for varying the modulating frequency within predetermined limits in accordance with a desired movement on the remotely controlled airplane, means for modulating the carrier frequency with a frequency outside of said limits, means on the controlled airplane for receiving the modulated carrier frequency, means on the controlled airplane movable in opposite directions, means on the airplane responsive to increase or decrease of the received modulating frequency, means operatively interconnecting said frequency responsive means and said means movable in opposite directions so as to move the same in synchronism with increase or decrease of the received modulating frequency from a previous value to effect said desired movement, and operating means on the controlled airplane incapable of responding to any received modulating frequency within said limits but capable of responding on receipt of said modulating frequency outside of said limits.

5. Apparatus for remotely controlling an airplane or the like from a control point on the ground or in another airplane comprising, in

combination, means at the control point for transmitting a carrier frequency, means for modulating the carrier frequency with a variable frequency, means for varying the modulating frequency within predetermined limits in accordance with a desired movement on the remotely controlled airplane, means for modulating the carrier frequency with a frequency outside of said limits, control means for the last named means when operated being effective to discontinue the application of the modulating frequency within said limits so as to modulate said carrier frequency only with said frequency outside of said limits, means on the controlled airplane for receiving the modulated carrier frequency, means on the controlled airplane movable in opposite directions in accordance with increase or decrease of the received modulating frequency from a previous value to effect said desired movement, means operable in accordance with the movement of said movable means for tuning the modulating frequency receiving means to the received modulating frequency, and operating means on the controlled airplane incapable of responding to any received modulating frequency within said limits but capable of responding on receipt of said modulating frequency outside of said limits on operation of said control means.

6. Apparatus for remotely controlling an airplane or the like from a control point on the ground or in another airplane comprising, in combination, means at the control point for transmitting a carrier frequency, means for modulating the carrier frequency with a band of frequencies, means for continuously varying the modulating frequency in said band of frequencies in accordance with the movement of a control stick or the like from one position to another corresponding to desired change in position of controlled means on the controlled airplane, means for modulating the carrier frequency with a frequency outside of said limits, control means for the last named means when operated being effective to discontinue the application of the modulating frequency in said band of frequencies so as to modulate said carrier frequency only with said frequency outside of said limits, means on the controlled airplane for receiving the modulated carrier frequency, means responsive to the received modulating frequency for operating said controlled means in opposite directions continuously in accordance with increase or decrease of the received modulating frequency from a previous value in said band of frequencies, and operating means on the controlled airplane incapable of responding to any received modulating frequency within said band of frequencies but capable of responding on receipt of said modulating frequency outside of said band of frequencies on operation of said control means.

7. Apparatus for remotely controlling an airplane or the like from a control point on the ground or in another airplane comprising, in combination, means at the control point for transmitting a carrier frequency, means for modulating the carrier frequency with a band of frequencies, variable impedance means for continuously varying the modulating frequency in said band of frequencies in accordance with the movement of a control stick or the like from one position to another corresponding to desired change in position of controlled means on the controlled airplane, fixed impedance means for modulating the carrier frequencies, control means for said fixed impedance means when operated being effective

to disconnect said variable impedance means and discontinue the application of the modulating frequency in said band of frequencies so as to modulate said carrier frequency only with said frequency outside of said band of frequencies, means on the controlled airplane for receiving the modulated carrier frequency, reversible motor means for operating said controlled means in opposite directions, means responsive to change in the received modulating frequency for operating said motor means in opposite directions continuously in accordance with increase or decrease of the received modulating frequency from a previous value in said band of frequencies, variable impedance means operable in accordance with the movement of said motor means for tuning the modulating frequency receiving means to the particular modulating frequency being received whereby said motor means is deenergized and remains in the position corresponding to said particular frequency as long as the modulating frequency remains constant, and operating means on the controlled airplane incapable of responding to any received modulating frequency within said band of frequencies but capable of responding on receipt of said modulating frequency outside of said band of frequencies on operation of said control means.

8. Apparatus for remotely controlling an airplane or the like from a control point on the ground or in another airplane comprising, in combination, means at the control point for transmitting a carrier frequency, means for modulating the carrier frequency with a variable frequency, means for varying the modulating frequency within predetermined limits in accordance with a desired movement on the remotely controlled airplane, means for modulating the carrier frequency with two frequencies one above and the other below the frequencies within said limits, means on the controlled airplane for receiving the modulated carrier frequency, means on the controlled airplane movable in opposite directions in accordance with increase or decrease of the received modulating frequency from a previous value to effect said desired movement, and two operating means on the controlled airplane each incapable of responding to any received modulating frequency within said limits but one being capable of responding on receipt of one of said modulating frequencies outside of said limits and the other being capable of responding to the other of said modulating frequencies outside of said limits.

9. Remote control apparatus comprising, in

combination, means for receiving a variable control frequency including a tunable circuit having a variable impedance device, a resistor, means interconnecting said tunable circuit and said resistor whereby current flow through the latter is controlled according to the degree that said tunable circuit is out of tune with the received frequency, and a pair of electric valves each having an anode, a cathode and a control electrode, said cathodes of said valves being interconnected and said control electrodes being connected to said resistor so that the conductivity of said valves is controlled in accordance with the magnitude and direction of current flow there-through; a reversible electric motor interconnected between said anodes of said valves and the connection between said cathodes thereof through a current source and adapted to rotate in one direction or the other depending upon which of said valves is conducting, and means operatively interconnecting said motor and said variable impedance device for moving the latter to tune said circuit to the frequency applied thereto, whereupon said valves are rendered non-conducting and said motor is deenergized.

10. Remote control apparatus comprising, in combination, means at a control point for transmitting a variable frequency to a remote point; means at the remote point for receiving the transmitted frequency including a tunable circuit having a variable impedance device, a resistor, means interconnecting said tunable circuit and said resistor whereby current flow through the latter is controlled according to the degree that said tunable circuit is out of tune with the received frequency, and a pair of electric valves each having an anode, a cathode and a control electrode, said cathodes of said valves being interconnected and said control electrodes being connected to said resistor so that the conductivity of said valves is controlled in accordance with the magnitude and direction of current flow there-through; a reversible electric motor interconnected between said anodes of said valves and the connection between said cathodes thereof through a current source and adapted to rotate in one direction or the other depending upon which of said valves is conducting, and means operatively interconnecting said motor and said variable impedance device for moving the latter to tune said circuit to the frequency applied thereto, whereupon said valves are rendered non-conducting and said motor is deenergized.

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