Aug. 14, 1945. E. E. FRAZIER 2,382,557

OBSTRUCTION WARNING DEVICE

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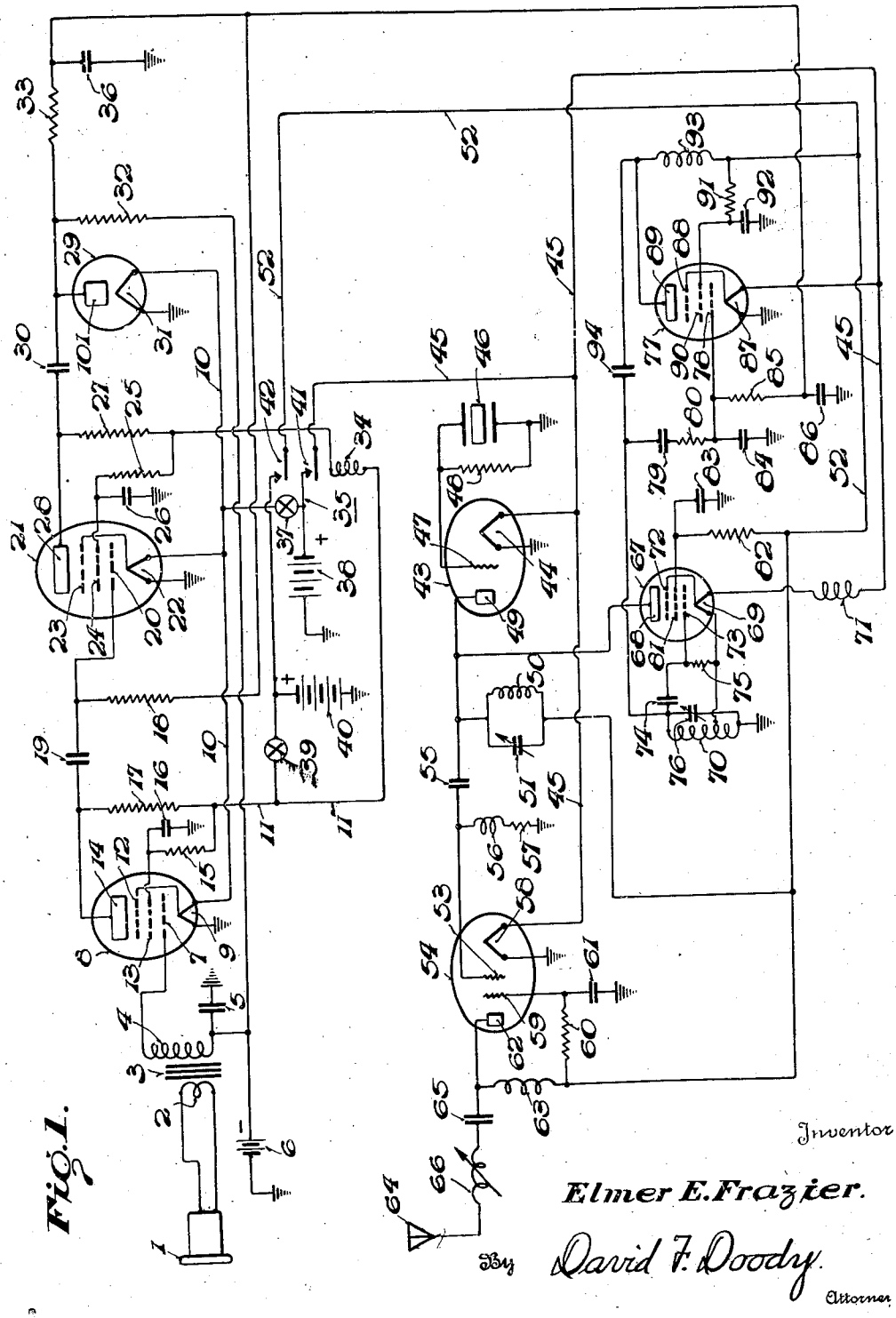


FIG. 1.

Inventor

Elmer E. Frazier.

By David F. Doody.

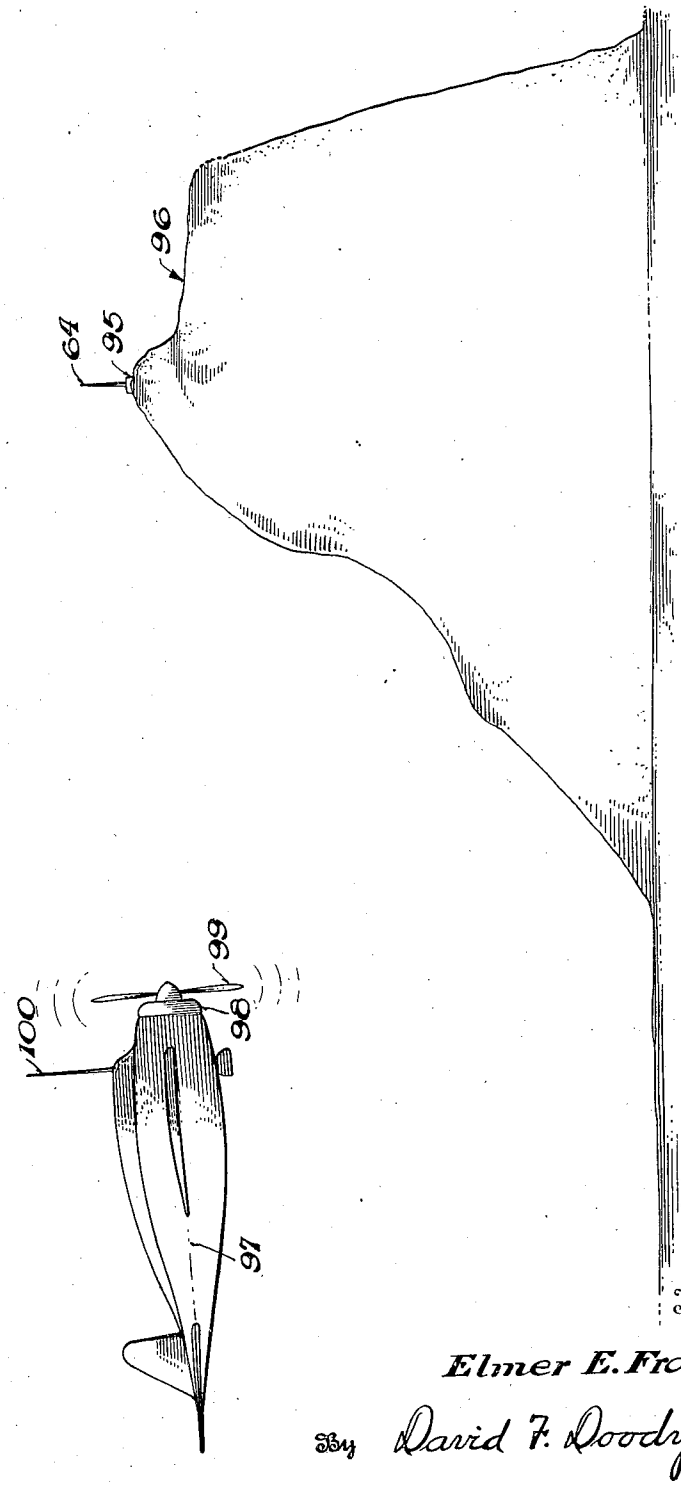
Attorney

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Fig. 2.



Inventor

Elmer E. Frazier.

By David F. Doody.

Attorney

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2,382,557

OBSTRUCTION WARNING DEVICE

Elmer E. Frazier, Halethorpe, Md., assignor to Bendix Aviation Corporation, New York, N. Y., a corporation of Delaware

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8 Claims. (Cl. 250—17)

This invention relates to obstruction markers, and more particularly to obstruction markers of the type emitting warning radiation in response to an acoustic stimulus.

The use of the sound or acoustic energy radiated from an operating aircraft to control means for emitting radiant energy is well known. In one of these devices, receipt of the sound energy is utilized to turn on the landing lights at a landing field being approached, while in another, the appearance of noises similar to those produced by a operating aircraft halts the rotation of a revolving beacon and causes the beam to indicate the direction of the nearest landing field. For warning of the presence of a high obstruction to aerial navigation, it is possible to install a system based on the first described device on the top of the obstruction, with the sound energy setting a light beacon into operation whenever the sound intensity exceeds a predetermined value, but this system fails to deliver a warning indication which may be easily perceived during periods of poor visibility and fog. As a further objection, the distance of the warning from the aircraft cannot be easily determined because of the negligible parallax existing at the observer's location.

One of the principal objects of this invention is to provide a new and novel obstruction warning device indicating the proximity of the warned craft to said obstruction by a change in the nature of the warning radiation.

Another object of the invention is to provide new and novel obstruction warning means radiating electromagnetic radiation in response to and controlled by acoustic stimuli.

Still another object of the invention is to provide new and novel obstruction warning means radiating radio frequency energy in response to acoustic stimuli with a modulation frequency controlled by the intensity of said acoustic stimuli.

The above objects and advantages of the invention are accomplished by mounting a microphone upon the obstruction, amplifying the output of this microphone, turning on a radio transmitter when the sound input to the microphone exceeds a certain value, and modulating the radiated carrier with a frequency which is controlled in accordance with the sound intensity present at the microphone.

Other objects and advantages of the invention will in part be disclosed and in part be obvious when the following specification is read in conjunction with the drawings in which:

Figure 1 is a schematic diagram illustrating the essential features of the invention.

Figure 2 is a pictorial diagram illustrating the installation and operation of the invention.

Referring now to Figure 1, there is shown a microphone 1, which may be of the dynamic type, connected to the primary winding 2 of the input transformer 3. The secondary winding 4 of the transformer 3 is connected to ground through the bypass capacitor 5 and the bias battery 6 at one end, and to the control grid 7 of the audio frequency amplifier 8 at the other end. Electron emission for the operation of amplifier 8 is supplied by the filament 9 connected at one end to ground and at the other end to the filament feed line 10. The center of the filament 9 is connected to the suppressor grid 12 located between the space charge grid 13 and the anode 14 of the amplifier 8. Space charge grid 13 connected to the anode feed line 11 through the dropping resistor 15 is connected to ground by the bypass capacitor 16, enabling it to perform simultaneously the required functions of space charge reduction and shielding. The anode 14 is connected to the anode feed line 11 through the load resistor 17, which is coupled at the anode end to the grid end of the resistor 18 through the coupling capacitor 19.

The junction of resistor 18 and capacitor 19 is connected to the control grid 20 of the amplifier tube 21, which is provided with the filament 22 connected at its extremities to ground and to the filament feed line 10 and connected at its center to the suppressor grid 23. The space charge grid 24 of the amplifier 21 is connected to the anode feed line 11 through the dropping resistor 25, and the operating winding 34 of the relay 35. Grid 24 is grounded for currents of signal frequency by the bypass capacitor 26 connected between the grid end of resistor 25 and ground. A load resistor 27 is connected between the low potential terminal of winding 34 and the anode 28, and the potentials appearing across the resistor 27 are impressed on the anode 101 of the diode rectifier 29 through the coupling and blocking capacitor 30. Also located in the diode 29 is the filament 31 connected between ground and the filament feed line 10. The anode 29 is normally maintained at a negative potential with respect to the filament 31 by the bias potential from the source 6 impressed thereon through the resistor 32, and when the peak value of the signal exceeds this normally present bias voltage, additional negative potentials appear at the anode 101 which are proportional to the amplitude of the signal

voltages. In addition to this rectified D. C. component, a large amount of signal energy is present at this point which is removed by the resistance-capacity filter including resistor 33 connected between the anode 101 and the end of resistor 18 remote from the control grid 20 and the capacitor 36 connected between the junction of resistors 33 and 18 and ground. A filament switch 37 is connected between the positive terminal of source 38 and the filament feed line 10, while the anode supply to the stages described is controlled by the anode switch 39 connected between the positive terminal of the source 40 and the anode feed line 11.

The elements already described illustrate an audio amplifier which receives signals from the microphone or electromechanical transducer 1 and amplifies them, delivering to the anode 23 an amplified replica of the input energy. The gain of amplifier stage 21 is regulated in accordance with the signal strength by rectifying the output to provide a negative voltage proportional to the signal output and impressing this rectified voltage on the control grid 20, thereby causing the anode and space charge grid currents drawn by this stage to vary. The anode and space charge grid currents for stage 21 pass through the relay winding 34 of the relay 35 having the separable contacts 41 and 42 which are maintained in the open position whenever the current through the winding 34 exceeds a predetermined value. As the sound intensity present at the microphone 1 increases, the current through winding 34 gradually decreases due to the increasing negative bias on this stage and, at an input level determined by the gain of the amplifier, which may be adjustable, the winding current falls below the value necessary to maintain the contacts 41, 42 in separated relationship, permitting them to close. The entire combination therefore comprises an acoustically operated switch which is closed whenever the sound level at the microphone 1 exceeds a predetermined value.

Radio transmitting apparatus operates in conjunction with the above described apparatus and is controlled in operation by the relay 35 and the potentials appearing across the condenser 36. The transmitting apparatus includes a vacuum tube 43 having a filament 44 connected between the transmitter filament feed line 45 and ground. A piezo-electric resonator unit 46 is connected between the control grid 47 of the tube 43 and ground, and is shunted by the grid leak resistor 48 to provide a direct current grid return path. The anode 49 of the tube 43 is connected to the transmitter anode supply line 52 through the parallel resonant circuit of inductance 50 and capacitance 51, and this circuit oscillates at a frequency determined by the resonance frequency of the piezo-electric resonator 46 in the well-known manner so long as the parallel resonant circuit 50, 51 is tuned to a frequency higher than the natural resonance frequency of the resonator. Energy at the frequency of oscillation of the resonator 46 is conveyed to the control grid 53 of the power amplifier tube 54 through the coupling capacitor 55 and this control grid is connected to ground through the series combination of the radio frequency choke 56 and the grid leak resistor 57. The grid current flowing through the resistor 57 due to grid rectification provides the operating bias for control grid 53 and the choke 56 prevents excessive loss of radio frequency power in the resistor 57. The filament 58 is located within the tube 54 and is connected between ground and the transmitter filament feed line 45. The space charge grid 59 is situated in the tube 54 on the other side of the control grid 53 from the filament 58 and is connected to the transmitter anode supply line 52 through the dropping resistor 60 which is connected to ground at the grid end for radio frequency currents by the bypass capacitor 61. The anode 62 is connected to the supply line 52 by the transmitter output choke 63, and the energy in the output circuit of amplifier 54 is impressed on the antenna 64 through the blocking capacitor 65 and the loading inductor 66. The antenna 64 is proportioned to suitably load the output circuit of amplifier 54 and any negatively reactive component of its impedance is neutralized by the adjustable loading inductor 66, while the capacitor 65 serves only to isolate the antenna 64 from the high, direct current potentials normally existing in radio frequency power amplifier anode circuits.

The transmitting portion of the apparatus also includes another oscillator 67, having an anode 68 connected to the anode 49 of the oscillator 43. Electron emission for the operation of oscillator 67 is provided by the filament 69 connected at one end to ground through a portion of the oscillator coil 70 and at the other end to the transmitter filament feed line 45 through the radio frequency isolating choke 71. The center of the filament 69 is connected to the suppressor grid 72 which minimizes the effects of secondary emission from the anode 68. Adjacent the filament 69 is the control grid 73 connected to the ungrounded terminal of the coil 70 through the grid condenser 74 and to the low potential end of the filament 69 by the grid leak resistor 75. The space charge grid 81 of the tube 67 is connected to the transmitter anode supply line through the dropping resistor 82, and is grounded for radio frequency energy by the capacitor 83 connected from grid 81 to ground. The mean frequency of oscillator 67 is controlled by the resonant frequency of the coil 70 with the variable capacitor 76 connected across the extremities thereof. The oscillator tube 67 with the above described circuit components connected as outlined, comprises what is known as an electron coupled Hartley oscillator and provides an alternating current component in the circuit including anode 68 whose frequency coincides very closely with the natural period of the coil 70 and the capacitor 76.

The oscillation frequency of the tube 67 may not only be controlled by the variable capacitor 76, but may also be altered by the variable reactance tube 77 which is connected to the coil 70 and the capacitor 76. The control grid 78 of the tube 77 is connected to the high potential terminal of the coil 70 through the capacitor 79 and the resistor 80 and is connected to ground by the capacitor 84. The reactance of capacitors 79 and 84 is small with respect to the resistance of the resistor 80, with the result that the phase of the voltage impressed on the control grid 78 lags the phase of the voltage across the coil 70 by approximately 90 degrees. Bias for the control grid 78 is supplied from the rectifier 29 by the connection of the resistor 85 between control grid 78 and the ungrounded terminal of the filter capacitor 36, and this bias is seen to be controlled by the amplitude of the sound energy impressed on the microphone 1. Reaction between the

transmitter and control portions of the apparatus is prevented by the additional audio and radio frequency filtering effect of the capacitor 86 connected between ground and the end of resistor 85 remote from the control grid 78. A filament 87 is situated within the tube 77 which is connected at its extremities to ground and the transmitter filament feed line 45 and at its center to the suppressor grid 88 located between the anode 89 and the space charge grid 90. The space charge grid 90 is energized from the transmitter anode supply line 52 through the dropping resistor 91, and is grounded for radio frequency currents by the capacitor 92 connected between grid 90 and ground. The anode 89 is also connected to the transmitter anode supply line 52 through the choke 93 and is connected to the oscillator coil 70 by the capacitor 94 which has negligible impedance at the operating frequency of the oscillator 67. The reactor tube 77 is preferably of a type having fairly high plate impedance, such as the type commercially designated 1A4P, and the plate current drawn by this tube from the oscillation circuit 70, 76 is in phase with the voltage on control grid 78 which lags the phase of the oscillating circuit voltage by 90 degrees, causing the tube 77 to appear to the circuit of parallel inductance 70 and capacitance 76 as a shunt inductance. The mutual conductance, or magnitude of alternating current component in the anode circuit of tube 77 for unit value of input voltage applied to control grid 78, may be varied by altering the steady bias on the control grid 78, whereupon the apparent inductance presented by the tube 77 may be made to vary correspondingly. The oscillation frequency generated by the tube 67 is thus a function not only of the inductance 70 and capacitance 76, but also of the apparent inductance presented by the tube 77, which may in turn be controlled by the bias on grid 78.

In operation, the output frequency of the tube 67 is adjusted by means of the capacitor 76 to be about 500 cycles per second lower than the output frequency of the tube 43 when the voltage across the capacitors 36 and 86 is equal to the potential of source 6, and increasing negative voltage across capacitor 36 causes the apparent inductance presented by the tube 77 to increase, with a resultant decrease in the output frequency of oscillator 67. The output energy from the radio frequency amplifier 54 is amplitude modulated at a frequency equal to the difference in the output frequencies of oscillators 43 and 67, and the magnitude of this difference increases with increasing negative bias on the control grid 78. The output energy from amplifier 54 is radiated from the antenna 64, and may be received, amplified and detected in an amplitude modulation receiver of any of the well known types, delivering a musical note to the observer, whose pitch is controlled by the bias on control grid 78.

The transmitting apparatus is supplied with power through the contacts 41, 42 of the relay 35, which are connected, respectively, between the transmitter filament feed line 45 and the positive terminal of source 38; and between the transmitter anode supply line 52 and the positive terminal of source 40. When the current flowing in winding 34 exceeds a predetermined value, contacts 41 and 42 are maintained in separated relationship, thereby preventing operation of the transmitting apparatus, but when the current falls below this value restoring springs force the contacts 41 and 42 into the engaged position and connect the transmitting apparatus to the power sources 38 and 40.

The overall operation of the system may be described briefly as follows: In the absence of noise or acoustic energy at the microphone 1, no signals appear at the output of amplifier 21, and this tube is therefore operating at minimum bias or maximum anode current, maintaining the relay 35 in the energized position and preventing operation of the transmitting apparatus. Assume now that the noise level at the microphone 1 gradually increases, developing increasing output voltage from the amplifier 21 which is rectified and fed back to the control grid with negative polarity. This increasing bias decreases the anode current to the tube 21 and a point is finally reached at which the magnetic force arising from winding 34 is insufficient to maintain contacts 41 and 42 separated, whereupon they close and energize the transmitter circuits, radiating a carrier wave from the antenna 64 which is amplitude modulated at a frequency equal to the difference in frequencies of oscillator 43 and oscillator 67. With a further increase in the noise or sound intensity at microphone 1, the negative bias voltage on the control grid 78 of the variable reactance tube 77 increases, lowering the mutual conductance of this tube and causing it to present a higher shunt inductance to the tuned circuit of inductance 70 and capacitor 76, whereupon the output frequency of oscillator 67 decreases and increases the frequency of the amplitude modulation present in the emitted carrier. In the presence of decreasing sound intensities at the microphone 1, the above chain of events repeats itself in reverse order, the transmitter finally being disconnected when the sound intensity drops below the value necessary to maintain relay 35 in the deenergized position.

An application of the invention is shown in Figure 2, in which the apparatus described is located within a box 95 fitted with the radiating antenna 64 and mounted on top or near the top of the obstruction to aerial navigation 96, which may be a mountain near an established air route. Such mountains are now sometimes equipped with a continuously illuminated warning visual beacon, but in the presence of heavy clouds such beacons are of little value. The aircraft 97 is shown traveling in the vicinity of the mountain 96 and the sounds emanating from the motor 98 and the propellor 99 impinge on the microphone 1, which may be located within the box 95. Radio signals from antenna 64 are intercepted by the receiving antenna 100 mounted on the aircraft which is connected to a suitable receiver. A pilot or observer may be provided either with headphones for monitoring the output of this receiver or may have a visual indicating meter located nearby which is responsive to the receiver output. If the aircraft approaches the mountain more closely than is safe, the sound waves at the microphone 1 cause the anode current to the amplifier 21 to drop and engage the contacts 41 and 42, placing the transmitting equipment in operation. In case the craft continues to approach the mountain, the sound waves at the microphone 1 increase in intensity and cause the frequency difference between oscillators 43 and 67 to increase, so that the observer is warned of the continuing approach of the craft to the obstruction by an increase in the pitch of the note in the headset, or by a change in meter indication. Upon receipt of this warning, the

pilot alters the course of the craft until the note is found to remain constant or to decrease in pitch, indicating that the separation between the craft and the obstruction is remaining constant or is increasing, thereby insuring against collision therewith. As the craft recedes from the microphone 1, the sound level of motor and propeller noise decreases, until finally the contacts 41 and 42 of the relay 35 move to the energized position and shut down the transmitter.

With this system, the radio transmitter operates only when its radiation is needed to guide a nearby aircraft, and a large number of the transmitters may be tuned to the same operating frequency and located on prominent topographical projections in the same general region without danger of interference between one another. The operation only during the needed periods also effects a substantial saving in the power requirements of this apparatus, which is of considerable importance as equipment of this nature must operate unattended for extended intervals. The microphone amplifier is necessarily in continuous operation, but by the use of vacuum tube types characterized by very low power drain, this drain may be reduced to an extent permitting intervals of satisfactory length between replacing or recharging of batteries.

There are a number of other ways in which one skilled in the art may employ the teachings of the above specification to devise apparatus for the transmission of electromagnetic energy in response to acoustic stimuli with a characteristic controlled by said stimuli, for example, the percentage of modulation might be regulated in accordance with the strength of the stimulus, or frequency modulation rather than amplitude modulation might be employed. It is obvious that many changes and modifications may be made in the invention without departing from the spirit thereof as expressed in the foregoing description and in the appended claims.

I claim:

1. In an obstruction warning device, the combination of acoustic responsive means, means for transmitting radio frequency energy, means for modulating the output of said radio frequency transmitting means, means responsive to the output of said acoustic responsive means for energizing said transmitting means when the acoustic input to said acoustic responsive means exceeds a predetermined value, and means for varying the modulating frequency impressed by said modulating means in response to variations in the envelope of said acoustic input above said predetermined value.

2. In an obstruction warning device, the combination of acoustic responsive means for transmitting radio frequency energy having a predetermined frequency, means for generating radio frequency energy at a frequency differing from said predetermined frequency, means for combining the output of said transmitting means and said generating means, means responsive to the output of said acoustic responsive means for energizing said transmitting means when the acoustic input to said acoustic responsive means exceeds a predetermined value, and means responsive to the envelope of the output of said acoustic responsive means for varying the frequency of said radio frequency generating means.

3. In an obstruction warning device, the combination of an acoustic-electrical transducer, an amplifier connected to said transducer, an antenna, a radio frequency amplifier connected to said antenna, a radio frequency oscillator of substantially constant frequency connected to the input of said radio frequency amplifier, a second radio frequency oscillator connected to the input of said radio frequency amplifier and having a controllable frequency, a source of electrical energy, relay means connected between said energy source and said radio frequency devices and responsive to the output of said first mentioned amplifier, and means responsive to the envelope of the output of said first mentioned amplifier for controlling the frequency of said controllable frequency oscillator.

4. In an obstacle warning device, the combination of an acoustic-electrical transducer, an amplifier connected to said transducer, means for deriving a direct current potential from the output of said amplifier, an antenna, a radio frequency amplifier connected to said antenna, a radio frequency oscillator of substantially constant frequency connected to the input of said radio frequency amplifier, a second radio frequency oscillator connected to the input of said radio frequency amplifier, means for controlling the oscillating frequency of said second mentioned oscillator, a source of electrical energy, relay means connected between said energy source and said radio frequency devices and responsive to said direct current potentials, and means for impressing said direct current potentials on said frequency controlling means.

5. In an obstruction warning device, the combination of an acoustic-electrical transducer, an amplifier connected to said transducer, means for deriving a direct current potential proportional to the output of said amplifier, an antenna, a radio frequency amplifier connected to said antenna, a radio frequency oscillator of substantially constant frequency connected to the input of said radio frequency amplifier, a second radio frequency oscillator connected to the input of said radio frequency amplifier, means for controlling the oscillation frequency of said second mentioned oscillator, a source of electrical energy, relay means connected between said energy source and said radio frequency devices and responsive to said direct current potential, and means for impressing said direct current potential on said frequency controlling means.

6. In an obstruction warning device, the combination of an acoustic-electrical transducer, an amplifier connected to said transducer, means for deriving a direct current potential proportional to the output of said amplifier, an antenna, a radio frequency oscillator of substantially constant frequency connected to the input of said radio frequency amplifier, a second radio frequency oscillator connected to the input of said radio frequency amplifier, means for controlling the oscillation frequency of said second mentioned oscillator, a source of electrical energy, relay means connecting said energy source and said radio frequency devices through separable contacts and responsive to said direct current potentials, said contacts being maintained in the open position for all values of said direct current potential above a predetermined value, and means for impressing said direct current potential on said frequency controlling means.

7. In an obstruction warning device, the combination of an acoustic-electrical transducer, an amplifier connected to said transducer and having a plurality of cascaded stages, each of said stages including an electric discharge device

with a control grid and an anode, means for deriving a direct current potential proportional to the output of said amplifier, means for impressing said potential on the control grid of one of said electric discharge devices, an antenna, a radio frequency amplifier connected to said antenna, a radio frequency oscillator of substantially constant frequency connected to the input of said radio frequency amplifier, a second radio frequency oscillator connected to the input of said radio frequency amplifier, means responsive to said direct current potentials for controlling the frequency of said second oscillator, a source of electrical energy, and electromagnetic relay means selectively connecting said energy source to said radio frequency devices and having an operating winding connected to the anode circuit of said one of said electric discharge devices.

8. In an obstruction warning device, the combination of an acoustic-electrical transducer, an amplifier connected to said transducer and having a plurality of cascaded stages, each of said stages including an electric discharge device with a control grid and an anode, means for deriving a direct current potential proportional to the output of said amplifier, means for impressing said potential on the control grid of one of said electric discharge devices, an electromagnetic winding connected to the anode circuit of said one of said electric discharge devices, an antenna, a radio frequency amplifier connected to said antenna, a radio frequency oscillator of substantially constant frequency connected to the input of said radio frequency amplifier, a second radio frequency oscillator connected to the input of said radio frequency amplifier, means responsive to said direct current potential for controlling the frequency of said second mentioned oscillator, a source of electrical energy, and electrical contacts selectively connecting said energy source to said radio frequency devices responsive to the magnetic field of said electromagnetic winding.

ELMER E. FRAZIER.