

[54] **ULTRASONIC RODENT CONTROL**

[75] Inventor: **Joseph G. Mancone**, Cheektowaga, N.Y.

[73] Assignee: **Sierra Research Corporation**, Buffalo, N.Y.

[22] Filed: **Jan. 15, 1973**

[21] Appl. No.: **323,631**

[52] U.S. Cl. .... **340/15; 331/163; 43/124**

[51] Int. Cl. .... **H04b 11/00**

[58] Field of Search ..... 43/124; 331/172, 173, 163; 181/5 J, .5 AG; 340/15

[56] **References Cited**

**UNITED STATES PATENTS**

|           |         |                  |         |
|-----------|---------|------------------|---------|
| 3,061,795 | 10/1962 | Byrd et al. .... | 331/172 |
| 3,185,939 | 5/1965  | Moss et al. .... | 331/172 |
| 3,307,118 | 2/1967  | Svec. ....       | 331/163 |
| 3,384,764 | 5/1968  | Ferrigno ....    | 331/172 |
| 3,517,226 | 6/1970  | Jones ....       | 340/15  |
| 3,689,781 | 9/1972  | Kawada ....      | 331/163 |
| 3,739,299 | 6/1973  | Adler. ....      | 340/15  |

**OTHER PUBLICATIONS**

QST Magazine, 11-71, p. 13, American Radio Relay League.

QST Magazine, 1-72, p. 55, American Radio Relay League.

Primary Examiner—Maynard R. Wilbur

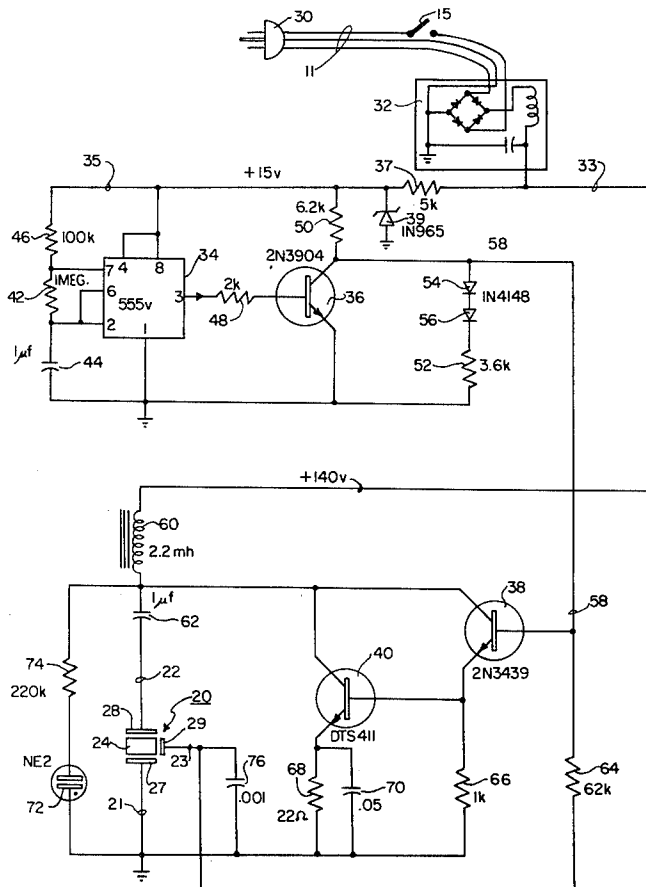
Assistant Examiner—T. M. Blum

Attorney, Agent, or Firm—Dowell & Dowell

[57] **ABSTRACT**

Apparatus for generating and radiating ultrasonic sounds at frequencies known to adversely affect the nervous systems of pests, such as rats, the apparatus comprising a housing for electronic circuitry, a transducer for emitting the sound, and a reflector for concentrating the radiated sound in one direction; said electronic circuitry including a novel Darlington oscillator circuit using a crystal transducer having a feed-back electrode and the crystal also establishing in conjunction with an inductive tank circuit the frequency of oscillation, the apparatus also including a visual indicator to show the "on" and the "off" condition of the oscillator since the oscillation is outside the audible range of humans.

**2 Claims, 3 Drawing Figures**



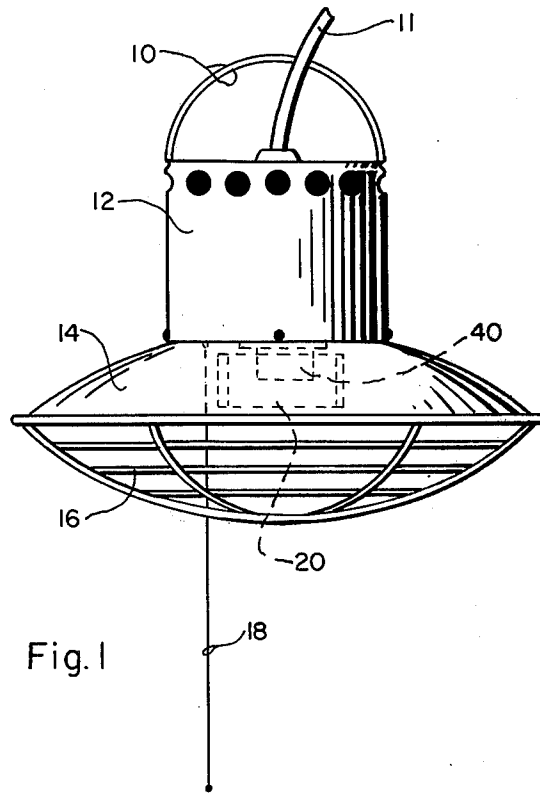


Fig. 1

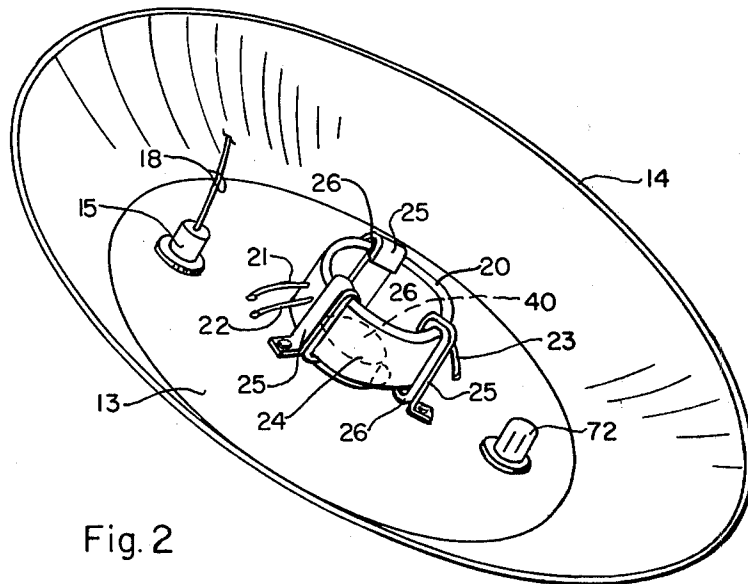


Fig. 2

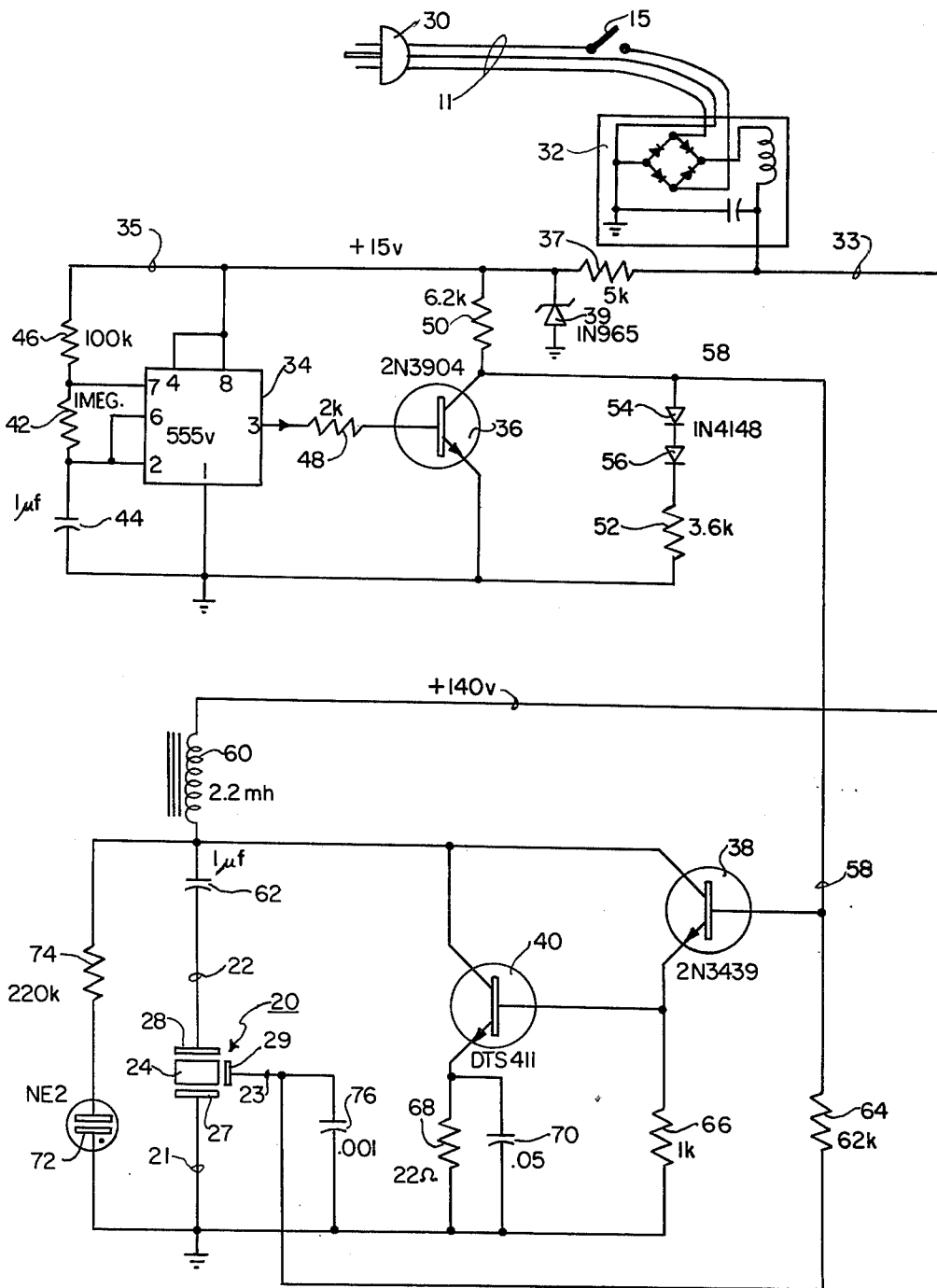


Fig. 3

## ULTRASONIC RODENT CONTROL

This invention relates to apparatus for generating and radiating ultrasonic sounds for the control of pests, especially rodents, in a frequency range known to be upsetting to the nervous systems of specific species of rodents, and the invention more particularly relating to specific electronic generator and sound radiating means to accomplish the purpose.

## BACKGROUND

Considerable research has been done on the effects of loud ultrasonic sounds upon the neurological systems of certain species of rodents, the research having been carried out by Japanese Scientists and also by the U.S. Army, among others. Their tests have shown that common species of rodents are greatly disturbed by loud ultrasonic sounds radiated in their presence, which cause them to display aggressive intolerant attitudes toward each other, and which tend to prevent them from mating and even eating with the result that they either die or else seek other noise-free areas to occupy. A satisfactory ultrasonic frequency range according to these experiments is about 19 KHz to 25 KHz or higher, these frequencies being especially effective against common species of rats. The prior art not only suggests such a frequency range, it also recognizes that even more severe stresses on the rodent nervous system can be achieved by intermittently pulsing or modulating the ultrasonic sound radiated, for instance, as suggested in U.S. Pat. Nos. 3,305,824 and 3,503,039, or by varying the frequency of the sound as suggested in U.S. Pat. No. 3,058,103.

## THE INVENTION

The present disclosure is based upon these prior art teachings to the extent that it provides a pulsed ultrasonic sound radiated within the frequency range mentioned above, but it further teaches improved apparatus for accomplishing the desired results.

The apparatus comprises a piezoelectric crystal transducer which forms part of an oscillatory tank circuit and is driven by solid state means to oscillate at its natural frequency while using the crystal transducer as the radiating element for the sound waves. The apparatus includes a reflector dish around the transducer for directing the sound waves substantially downwardly toward the floor area of a room in which it is suspended. Above this dish there is a housing in the bottom of which the transducer mounts and which houses the oscillatory circuit, a power supply, and a suitable intermittent timer and driver circuit for pulsing the oscillations on and off. Since the ultrasonic sound is inaudible to human beings, the present structure is also provided with an indicator lamp which is driven by the ultrasonic signal across the transducer for the purpose of indicating when the ultrasonic wave is present and when it is absent, and thereby visually confirming proper intermittent operation of the device. Continuous illumination of the light indicates a failure of the intermittent timer circuit or the driver transistor coupling it to the oscillator, whereas continuous extinguishment of the light indicates general failure of the ultrasonic generator, or the power source.

It is therefore an object of this invention to provide a rodent control system having visual means for indicating proper operation of the system, which means is

so connected to the electronic generator as to make failure of the system without accompanying indication thereof almost impossible.

It is another important object of the invention to provide an oscillation generating system in which the same crystal structure not only generates the ultrasonic sound, but also controls its frequency when taken together with other in-circuit components. It is another object of the invention to provide a system capable of use with several similar crystal transducer means each provided with a different natural period of oscillation alternatively attachable to the same solid state electronics without requiring retuning thereof, so that the over-all frequency of oscillation of a unit can be changed merely by changing the crystal transducer. In each case the transducer has a reactance which is peculiar to its natural frequency and differs for different frequencies. The transducer reactance is so matched to the other oscillatory generator tank circuit components that the insertion of a transducer having a particular natural frequency of oscillation automatically tunes the remainder of the generator tank circuit to the correct frequency, whereby the same oscillatory tank circuit components can be used with any of the transducers within the frequency range of interest.

Still another object of the invention is to provide pest-control ultrasonic generating and radiating apparatus employing an integrated circuit timer coupled to the oscillatory circuit through a driver transistor to thereby control the on and off duty cycle of the generator.

Still a further object of the invention is to provide a generator in which the oscillatory tank circuit includes a crystal transducer of a type having a third electrode from which feedback can be taken at the tank circuit of the oscillator and coupled to provide regenerative feedback to the oscillator input in order to sustain oscillation. Oscillators using crystals having an auxiliary feedback electrode are of course not unknown in the prior art, as shown for example in U.S. Pat. No. 3,689,781. In the present circuit the transducer is not, by itself, the oscillatory source, but instead must be driven correctly or it will not oscillate. For this purpose, the present disclosure teaches the coupling of the transducer to a proper inductance which remains the same for all frequencies of oscillation within the range of transducers useful for this purpose. The transducer itself behaves as a capacitor, the capacity of which varies from transducer to transducer inversely as the resonant frequency so that the higher the frequency of the transducer the lower its capacity, whereby the tank automatically tunes itself to whatever transducer forms a part of it. The present transducer comprises a barium titanite crystal.

It is another object of this invention to provide an oscillating transducer crystal circuit in which the aging process increases the frequency of oscillation by about 1 percent after a few hundred hours of use, whereby the possibility of the transducer dropping down into the audible spectrum is effectively negated.

Other objects and advantages of this invention will become apparent during the following discussion of the drawings, wherein:

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation view showing a complete apparatus for rodent control;

FIG. 2 is an inverted perspective view showing the crystal transducer mounted on a reflector dish together with other circuit components; and

FIG. 3 is a schematic diagram illustrative of a suitable timing and generating circuit according to the present invention, specific circuit values having been shown in the drawing to provide a practical working embodiment.

#### DESCRIPTION OF WORKING EMBODIMENT

Referring now to FIG. 1, this drawing shows a typical apparatus adapted to be suspended from the ceiling on a wire 10 which attaches to the upper end of a circular housing 12 supporting a reflector dish 14 at its lower end, and the reflector having a guard grill 16 across the face of it. Within the reflector area which is covered by the grill 16 is the transducer 20 mounted on the lower surface 13 of the reflector 14. Accidental contact with the transducer can not only be damaging to the transducer but it can also be very damaging to a person if he touches it accidentally while it is oscillating, since a peak-to-peak voltage of about 220 volts with respect to ground appears across it. The grill 16 serves to prevent such contact. A pull cord 18 hangs down from the housing 12 and is attached to an on — off switch 15 which will be discussed hereinafter. The unit derives electric power through a cable 11.

FIG. 2 shows in more detail the lower surface 13 of the reflector 14 on which the transducer 20 is mounted. The transducer 20 as shown in FIG. 3 is an annular crystal 24 having wires 21 and 22 extending from its main two electrodes 27 and 28 and having a wire 23 extending from its auxiliary electrode 29 as will be seen in FIG. 3. In the present illustrative embodiment it is supported on the reflector dish 14 by three nylon clamps 25 placed at 120° spacings and screwed to the surface 13, and there is a rubber cushion 26 at the location of each clamp and serving to pad the transducer against contact both with the clamp 25 and with the surface 13. The main power transistor 40 of the oscillator is mounted in heat-sink relationship to the surface 13 in the center of the transducer annulus, as can be seen in FIGS. 1 and 2.

Referring now to the schematic diagram of FIG. 3, this diagram shows the electric power cable 11 attached to a plug 30 at one end, and attached to a power supply 32 at the other end, the power supply including a full wave rectifier and an LC filter, and delivering DC output on wire 33 to power the solid state electronic generator and timer which is also shown in FIG. 3.

The four active solid state components comprise an integrated circuit timer 34, a driver transistor 36 coupling the timer to the oscillator, and a Darlington oscillator comprising the transistors 38 and 40, the latter being the power transistor of the oscillator. The function of the integrated circuit 34 is to turn the oscillator on and off at predetermined intervals. In the circuit presently being manufactured the on/off duty cycle is approximately 1 second on and 1 second off, plus or minus a half a second, this being an arbitrarily selected pulsing pattern. The integrated circuit timer 34 is a standard module made by Signetics and designated 555V, and is connected using the various pin numbers as shown in FIG. 3. This type of circuit is well known per se, for instance being described in Radio Electronics Magazine in an article beginning on page 62 of the October 1972 Edition. The time constant is determined

by the resistors 42 and 46 and by the capacitor 44, these components being coupled with pins 7, 6, and 2 of the integrated circuit and supplied with DC power through the current-limiting resistor 46. Pins 4 and 8 of the integrated circuit are connected to the B+ supply line 35 while pin 1 is grounded. The output of the integrated circuit is an on/off square wave which is substantially symmetrical and has approximately a 2 second period, the output appearing at pin number three of the integrated circuit is coupled through a resistor 48 to drive the base of the driver transistor 36. This transistor has a grounded emitter, and its collector is connected with the B+ line 35 through a load resistor 50 which forms part of the direct coupled base circuit of the next transistor 38 including a resistor 52 and two diodes 54 and 56. When the transistor 36 is non-conductive, the base of the first Darlington oscillator transistor 38 tends to rise to a potential limited by the two diodes 54 and 56 and by the IR drop across the resistor 52; whereas when the driver transistor 36 is conductive the base of the first transistor 38 is essentially grounded, thereby biasing off the oscillator comprising the transistors 38 and 40. Note that regenerative feedback is supplied via the resistor 64 to the base of the transistor 38, although this feedback is effective to sustain oscillation only when the driver transistor 36 is nonconductive. This will be described in greater detail hereinafter.

The Darlington oscillator comprises an emitter-follower transistor 38 and a power transistor 40 connected across the capacitive half of a resonant tank circuit including the inductance 60, the capacitor 62 and the transducer 20. The collectors of the Darlington transistors derive B+ through the inductance 60 whose other end is connected to the DC supply line 33. The resistor 37 and the Zener diode 39 are used to regulate the DC voltage down to 15 volts at which level it can be supplied to the timer 34 and to the driver transistor 36 via the wire 35. The capacity of the capacitor 62 is so much greater than the internal capacity of the transducer 20 that the capacitor 62 should be thought of as merely a direct-current blocking device which has no appreciable impedance at the oscillatory frequency of the transducer. Therefore, the phase across the transducer 20 should be considered as opposite to the phase across the inductance 60. The feedback electrode 29 of the transducer 20 is located with respect to the crystal 24 of the transducer in such a way as to provide a correct feedback phase to be applied to the base of the transistor 38. This feedback is applied through the resistor 64 and the wire 58 and causes the Darlington circuit to oscillate. The resistor 66 develops drive from the emitter of the transistor 38 to the base of the transistor 40, while the resistor 68 together with the capacitor 70 provide a bias level on the emitter of the transistor 40 sufficient to limit its current when in the fully conductive condition.

The remaining circuitry to the left of the transducer 20 comprises an NE—2 indicator light 72 connected via the resistor 74 across a portion of the tuned tank circuit. The loading caused by the neon bulb 72 is minimal. The capacitor 76 forms a feedback divider when taken with the capacity of the auxiliary electrode 29.

The presently described illustrative embodiment is operated with any one of several transducers manufactured by the Murata Manufacturing Company, Japan, and designated type 3—T—74—30—suffix. The suffix can be, for example, either 19F, 20F, 22F, 24F, . . . de-

pending upon the nominal oscillation frequency of the transducer in KHz. Another source of a similar transducer is Matsushita Electric Company, Japan, their transducers having the designation EFE—T53T157RI plus a suffix of either 19, 20, 22, or 24, again designating the nominal frequency in kilohertz. The tuning capacity effect of the transducer in the tank circuit is measured across the electrodes 28 and 27, varies between about 18,000 and 20,000 picofarads. The total input power to the oscillator is about 40 watts peak, and the output frequency depends upon the particular transducer used and varies between about 19 and 24 KHz. The output sound level is about 105 db measured 2 feet from the center of the reflector, and the on off time is about 1 second each, although this time can easily be varied by varying the resistor 42 at the timer. The reflector 14 is about 1 foot in diameter and the device is highly effective for the purpose intended to about 15 meters from the reflector. If more coverage is needed, additional units should be placed at spaced intervals in the area being controlled. It is also recommended that different frequencies in adjacent units can be highly effective to produce beat notes having much higher peak powers. The use of several frequencies at independently controlled rates has a more devastating effect upon the rodents.

This invention is not to be limited to the exact form shown in the drawings, for obviously changes may be made within the scope of the following claims.

What is claimed is:

1. Apparatus for generating and radiating ultrasonic sound waves for the control of pests, comprising:

- a. a housing and a concave dish-shaped reflector having a central portion fixed to one face of the housing;
- b. a ring-shaped piezoelectric transducer resiliently

mounted in cushioned relationship within the concave reflector on said central portion opposite the housing, the transducer comprising a vibratory crystal element having main electrodes and having a feedback electrode;

- c. oscillatory tank circuit members mounted in the housing and including an inductance coupled to the main electrodes of the crystal element to form therewith a tuned tank circuit resonant at an ultrasonic frequency;
  - d. transistor oscillator-amplifier means including a power oscillator transistor mounted in heat-sink relationship with the central portion of said reflector means and including transistor electrodes coupled with said tank circuit, and said oscillator amplifier means further including a driver amplifier transistor coupled to drive said power transistor, and the driver transistor including a control electrode coupled to receive a feedback signal from the feedback electrode of the transducer; and
  - e. a timing circuit continuously delivering an output waveform alternating between high and low levels, and means coupling said output waveform to said control electrode of the driver transistor, said feedback signal combining with said output waveform at the control electrode to alternately bias the latter into and out of a bias range in which the oscillator-amplifier means can sustain oscillations.
2. Apparatus as set forth in claim 1, including an indicator lamp circuit coupled by impedance means directly across said tank circuit to extract oscillation energy therefrom and glow when the timing circuit is biasing the oscillator-amplifier means into oscillation and to extinguish when the timing circuit is biasing the oscillator-amplifier means out of oscillation.

\* \* \* \* \*

40

45

50

55

60

65