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Schulein

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[54] **ELECTRONIC PEST-CONTROL DEVICE HAVING PLURAL ULTRASONIC GENERATORS**

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[52] **U.S. Cl.** ..... **340/384 E;** 340/384 R

[51] **Int. Cl.** **G08b 3/00**

[58] **Field of Search** ..... 340/384 R, 384 E; 331/78

[56] **References Cited**

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[57] **ABSTRACT**

An electronic pest-control device which includes a plurality of electrically energizable ultrasonic transducers, each of which is operable within a different range of ultrasonic frequencies. Circuitry is provided for simultaneously energizing the transducers, with each generating ultrasonic waves whose frequencies are continuously randomly varied throughout the transducer's operating range. The ultrasonic waves generated by the device are directed into an area desired to be kept free from infestation by pests, such as rats, which are sensitive and responsive to ultrasonic energy. Through the use of a plurality of different, continually changing frequencies, the pests cannot become acclimated to the ultrasonic waves and thus become immune to their effect.

8 Claims, 4 Drawing Figures

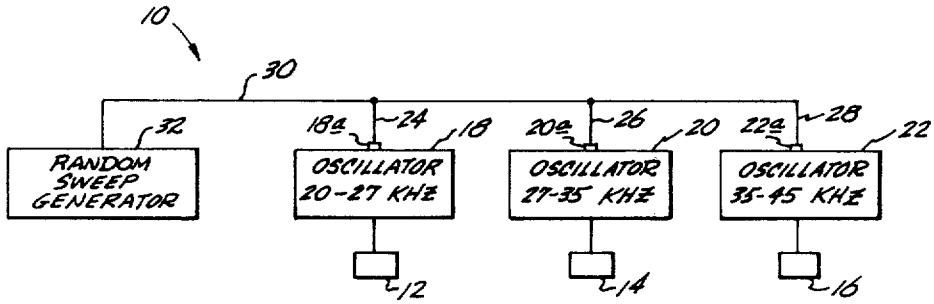


Fig. 1.

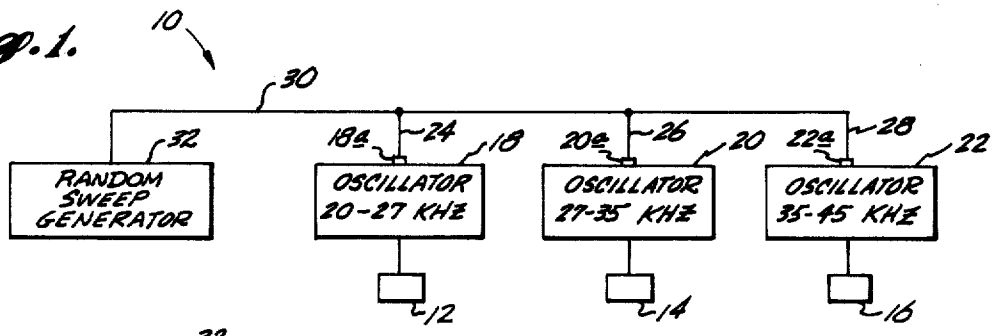


Fig. 2.

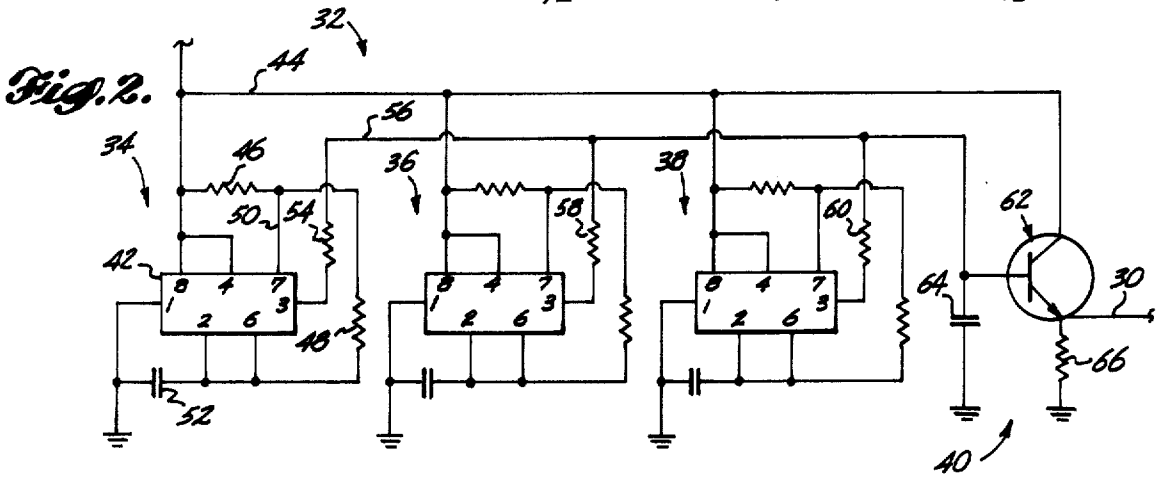


Fig. 3.

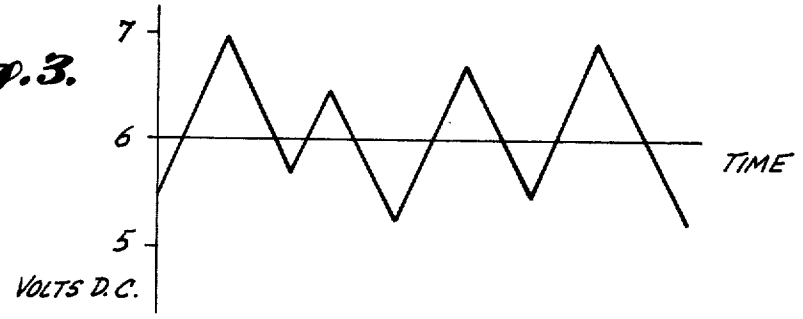
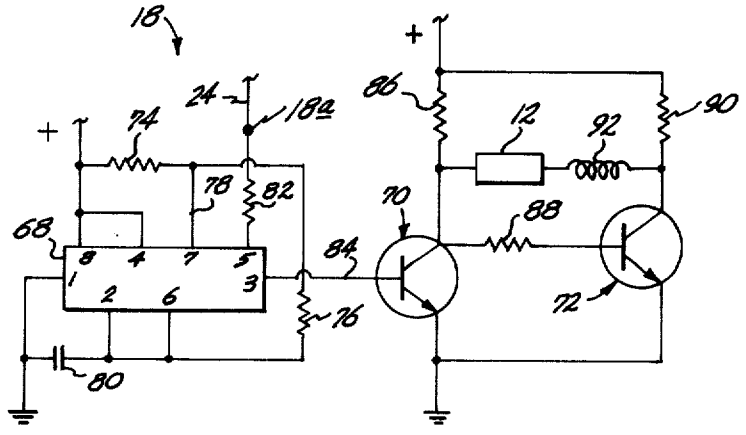


Fig. 4.



ELECTRONIC PEST-CONTROL DEVICE HAVING PLURAL ULTRASONIC GENERATORS

BACKGROUND AND SUMMARY OF THE INVENTION

The invention pertains to an electronic pest-control device, and more particularly, to such a device which uses ultrasonic waves. For the purpose of illustration herein, a preferred embodiment of the invention is disclosed in connection with a device suitable for protecting a facility, such as a food-storage warehouse, against infestation by rats.

In the processing and storing of various food constituents, such as grains, for example, rat infestation is a well-known problem. A general object of the present invention is to provide a novel electronic device which may be used simply, economically, continuously and effectively to protect against such infestation.

It is known that various kinds of pests, such as rats, are sensitive and responsive to ultrasonic frequencies. It is further known that such pests can be deterred from entering an area when such is subjected to certain ultrasonic frequencies. However, past experience strongly suggests, if not shows, that an animal, such as a rat, can become acclimated or immune to such frequencies if the frequencies are predictable.

The present invention rests on the concept that an effective control device is one capable of generating, continuously when in operation, a plurality of ultrasonic waves whose frequencies continuously change in a random fashion throughout different ranges. Accordingly, a preferred embodiment of the invention includes a plurality of electrically energizable, changeable-frequency ultrasonic transducers, each of which is operable within a different range of ultrasonic frequencies. Connected to these transducers for simultaneous energizing thereof is an energizing circuit which includes means capable of continuously randomly changing the respective operating frequencies of each of the transducers.

With devices of the type outlined installed in different facilities for controlling rats, effective rat deterrence has in fact occurred. What is believed to take place which has a deterrent effect is that a rat becomes exposed to a plurality of different continually changing frequencies, and to a plurality of different continually changing combined frequencies, which it finds extremely objectionable, and perhaps painful. With changes in such frequencies occurring randomly, a rat cannot become acclimated. And in this regard, it has been observed that even after an installation has been in operation for a considerable period of time, rats do not eventually become immune to the ultrasonic waves, and infestation does not occur.

As will become apparent from the description below, the proposed device is relatively simple in construction, and can easily be positioned and mounted for use. The device can readily be incorporated in a wide variety of different existing facilities where control is desired, without requiring any appreciable modifications in the facilities. Further, the device is characterized by relatively low cost, and has the capability of continuous performance.

These and other objects and advantages which are attained by the invention will become more fully apparent as the description which follows is read in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified block diagram illustrating an electronic pest-control device constructed in accordance with the present invention;

FIG. **2** is a circuit diagram, partly in block form, showing details of a random sweep generator included in the device of FIG. **1**;

FIG. **3** is a graph showing a special, random, time-varying voltage which is produced in the generator of FIG. **2**; and

FIG. **4** is a circuit diagram, partly in block form, illustrating the construction of a driver oscillator used in the device of FIG. **1**.

DETAILED DESCRIPTION OF THE INVENTION

Turning now to the drawings, and referring first to FIG. **1**, indicated generally at **10** is an electronic pest-control device as contemplated herein. According to the invention, a device **10** includes a plurality (two or more) of electrically energizable ultrasonic transducers, and herein contains three such transducers, shown in block form at **12, 14, 16.** Each of these transducers is of conventional construction, with each preferably being capable of operating within a different respective range of ultrasonic frequencies. A transducer suitable for use in the invention is that offered by the Massa Division of Dynamics Corporation of America. Transducer **12** herein is operable in the frequency range of about 20–27 KHz., transducer **14** in the range of about 27–35 KHz., and transducer **16** in the range of about 35–45 KHz.

Connected to transducers **12, 14, 16,** and also shown in block form in FIG. **1,** are driver oscillator circuits **18,** 20, 22, respectively. These oscillator circuits determine the specific operating frequencies of their respective associated transducers. As will be explained shortly, oscillators **18, 20, 22** can be controlled so as to determine at any given time what will be the operating frequency of its associated transducer. In particular, each driver oscillator circuit can be controlled so as continuously to vary such operating frequency within the operative range of the transducer. Included in oscillators **18, 20,** 22 for this purpose are control terminals **18***a*, 20*a*, 22*a*, respectively, the specifc instantaneous DC voltage levels on which effect the kind of control just mentioned.

Each transducer and its associated driver oscillator circuit constitute an ultrasonic source herein. Further, the three transducers and driver oscillator circuits are referred to collectively as ultrasonic circuit means.

Terminals **18***a*, 20*a*, 22*a* are connected through conductors **24, 26, 28,** respectively, to a conductor, or interconnecting means, **30** which connects, in turn, with a random sweep generator, or energizing circuit means, shown in block form at **32.** In general terms, generator **32** functions to produce a continuously randomly changing DC voltage on conductor **30,** which voltage is applied to the control terminals in oscillators **18, 20,** 22.

Turning now to FIG. **2,** generator **32** includes three non-synchronized, free-running sweep oscillators shown generally at **34, 36, 38.** Also included in the generator is an output circuit **40,** also referred to herein as an integrating circuit means.

Sweep oscillators 34, 36, 38, although constructed to operate at different specific frequencies as will be explained, are essentially the same in construction. Thus, and considering oscillator 34, it includes an integrated circuit device shown as a block at 42, which device, with the associated externally connected circuitry shown, performs as a free-running square wave oscillator. The particular integrated circuit device used herein is one made by Signetics, and identified by the reference NE555. The numbers contained within block 42 in FIG. 2 indicate the numbers of those terminals in the device with which connections are made herein.

Terminals 4 and 8 in device 42 are each directly connected to a positive voltage supply conductor 44. Positive voltage is also supplied terminals 2 and 6—such supply being through series resistors 46, 48. The junction between these resistors is connected by a conductor 50 to terminal 7 in device 42. Terminal 1 in the device is grounded, and also is coupled to terminal 2 through a capacitor 52. Terminal 3 in device 42 constitutes an output terminal in oscillator 34—this terminal being connected through a resistor 54 to an output conductor 56.

The operating frequency of oscillator 34 is determined by the resistances of resistors 46, 48 and the capacitance of capacitor 52. In oscillator 34, the values of these components are chosen to provide the oscillator with an operating frequency of about 0.8 Hz.

As can be seen, oscillators 36, 38 include the same sort of interconnections between integrated circuit devices like device 42 and external components. The terminal 3 of the integrated circuit device in oscillator 36 is connected to conductor 56 through a resistor 58, and the corresponding terminal in the device in oscillator 38 is connected to conductor 56 through a resistor 60. Oscillators 36, 38 operate at about 1 Hz. and about 1.2 Hz., respectively.

Output circuit 40 includes an NPN transistor whose collector is connected to previously mentioned conductor 44, and whose base is connected both to conductor 56, and to one side of a capacitor 64—the other side of which is grounded. The emitter in transistor 62 is connected both to previously mentioned conductor 30, and to one side of a resistor 66—the other side of which is grounded.

The square waves produced by sweep oscillators 34, 36, 38 combine in conductor 56 to produce therein a rectangular wave voltage having voltage pulses of randomly varying widths. The reason for this, of course, is that the operations of the sweep oscillators are in no way synchronized, and the operating frequencies thereof are not precisely controlled. The voltage wave form thus resulting in conductor 56 is integrated in circuit 40 to produce on conductor 30 a randomly time-varying (as to level) DC voltage having a sawtooth pattern similar to that shown in FIG. 3. In device 10, such a voltage on conductor 30 varies between about 0 and about 12 volts DC. This voltage, referred to herein as a control voltage, is applied to control terminals 18*a*, 20*a*, 22*a*.

FIG. 4 in the drawings illustrates the internal construction of driver oscillator circuit 18, and its connection to transducer 12. The other driver oscillator circuits, and their connections to the other transducers, are substantially the same. Included in circuit 18 are integrated circuit device 68, and a pair of NPN transistors 70, 72. Device 68 is the same in construction as previously mentioned device 42. Terminals 4 and 8 in device 68 are each connected to a suitable source of positive voltage which is also connected, through series resistors 74, 76 to terminals 2 and 6 in the device. The junction between resistors 74, 76 is connected through a conductor 78 to terminal 7 in the device. Terminal 1 in device 68 is grounded, and also is connected through a capacitor 80 to terminal 2. Terminal 5 in device 68 is connected through a resistor 82 to previously mentioned control terminal 18*a* in circuit 18.

Output terminal 3 in device 68 is connected through a conductor 84 to the base of transistor 70. The collector of this transistor is connected through a resistor 86 to a suitable source of positive voltage, and the emitter of the transistor is grounded. A resistor 88 interconnects the collector of transistor 70 and the base of transistor 72—the emitter of the latter-mentioned transistor also being grounded. Positive voltage from the same source supplying transistor 70 is supplied through a resistor 90 to the collector of transistor 72. Interconnected between the collectors of transistors 70, 72 are transducer 12 in series with a ferrite core inductor 92.

Integrated circuit device 68, and the components connected to its terminals 1, 2, 4, 6, 7, 8, perform as a free-running square wave oscillator. As distinguished, however, from previously described oscillators 34, 36, 38, the frequency of oscillation here is determined not only by the resistances of resistors 74, 76, and the capacitance of capacitor 80, but also by the specific DC voltage level on terminal 5. This circuit arrangement is set up herein whereby with the DC voltage applied to terminal 18*a* varying between about 0–12 volts DC, the voltage on terminal 5 (shown in FIG. 3) varies between about 5–7 volts DC. This results in the oscillating frequency of the circuit varying between about 20–27 KHz. Such frequency-varying oscillations are supplied the circuitry including transistors 70, 72, which circuitry drives transducer 12 at essentially the same varying oscillating frequency.

As has been previously mentioned, driver oscillator circuits 20, 22 are constructed in essentially the same manner as circuit 18. With the same range of DC voltages applied to control terminals 20*a*, 22*a*, and to the integrated circuit devices in oscillators 20, 22, oscillator 20 drives transducer 14 in the range of about 27–35 KHz., and oscillator 22 drives transducer 16 in the range of about 35–45 KHz.

It will thus be apparent that with device 10 operating, transducers 12, 14, 16 simultaneously generate different-frequency ultrasonic waves whose frequencies are continuously randomly varied throughout different ranges of frequencies. The power levels of operation selected for the transducers are, of course, a matter of choice, and may be varied to suit the particular application. Preferably, the transducers used in a device 10 are oriented therein so as to direct the waves which they produce generally into the same area adjacent the device.

The particular ranges of frequencies disclosed herein are not intended to limit the invention. Rather, they have been found to be particularly effective in instances where the device is used for the control of rats.

While in many instances a single device 10 may be adequate for control purposes, it will be obvious that a plurality of such devices may be used where desired. For example, if a facility has a number of areas which could potentially be infested by rats, a suitable number

of devices would typically be selected to cover these different areas.

While a device **10** has been shown herein including three ultrasonic transducers, it is appreciated that two transducers, or more than three transducers, may also be used if desired.

Thus, while a preferred embodiment of the invention, and certain modifications thereof, have been disclosed herein, it is appreciated that other variations and modifications may be made without departing from the spirit of the invention.

It is claimed and desired to secure by Letters Patent:

1. An electronic pest-control device comprising

an electrically energizable, changeable frequency source of ultrasonic waves operable when energized to generate such waves within a predetermined range of frequencies, said source including a control terminal, the instantaneous voltage level on which determines the specific operating frequency of the source, and

energizing circuit means for said source operatively coupled thereto and operable to energize the same in a manner causing the source to generate waves having continuously randomly changing frequencies within said range, said energizing circuit means including means operatively connected to said control terminal for changing the instantaneous voltage level thereon, comprising a plurality of free-running sweep oscillators, each having a different operating frequency and each including an output terminal, integrating circuit means operatively connected to said output terminal and operable with said sweep oscillators running to produce a control voltage having a continuously randomly changing level, and means operatively interconnecting said circuit means and said control terminal for applying to the latter said control voltage.

2. An electronic pest-control device comprising

at least a pair of electrically energizable, changeable-frequency sources of ultrasonic waves, each operable when energized to generate such waves within a different range of frequencies, and

circuit means operatively connected to said sources for energizing the same simultaneously in a manner causing the sources to generate waves which are characterized by continuously randomly changing frequencies within the respective ranges of the sources.

3. The device of claim **2**, wherein each source includes a control terminal the instantaneous voltage level on which determines the specific operating frequency of the source, and said circuit means includes means operatively connected to said control terminals for changing such voltage levels thereon.

4. The device of claim **3**, wherein said means in said circuit means which is operatively connected to said control terminals comprises a plurality of free-running sweep oscillators each having a different operating frequency and each including an output terminal, integrating circuit means operatively connected to said output terminals and operable with said sweep oscillators running to produce a control voltage having a continuously randomly changing level, and means operatively interconnecting said integrating circuit means and said control terminals for applying to the latter said control voltage.

5. An electronic pest-control device comprising

three electrically energizable changeable-frequency sources of ultrasonic waves, each operable when energized to generate such waves within a different range of frequencies, and

circuit means operatively connected to said sources for energizing the same simultaneously in a manner causing the sources to generate waves which are characterized by continuously randomly changing frequencies within the respective ranges of the sources.

6. The device of claim **5**, wherein each source includes a control terminal the instantaneous voltage level on which determines the specific operating frequency of the source, and said circuit means includes means operatively connected to said control terminals for changing such voltage levels thereon.

7. The device of claim **6**, wherein said means in said energizing circuit which is operatively connected to said control terminals comprises a plurality of free-running sweep oscillators, each having a different operating frequency and each including an output terminal, integrating circuit means operatively connected to said output terminals and operable with said sweep oscillators running to produce a control voltage having a continuously randomly changing level, and means operatively interconnecting said integrating circuit means and said control terminals for applying to the latter said control voltage.

8. An electronic pest-control device comprising

a plurality of electrically energizable ultrasonic transducers, each operable to produce ultrasonic waves within a different range of frequencies,

for each transducer a driver oscillator circuit operatively connected thereto and operable to drive the transducer for operation within the latter's said range, each driver oscillator circuit including a control terminal the instantaneous voltage level on which determines the specific operating frequency of the associated transducer,

a plurality of free-running sweep oscillators, each having a different operating frequency and each including an output terminal,

integrating circuit means operatively connected to said output terminals and operable with said sweep oscillators running to produce a control voltage having a continuously randomly changing level, and

means operatively interconnecting said integrating circuit means and said control terminals for applying to the latter said control voltage.

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