United States Patent

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Indianapolis, Ind.
Continuation of application Ser. No. 621,596, Mar. 8, 1967, now abandoned.

[54] **AUDIBLE ALARM UNIT**
2 Claims, 6 Drawing Figs.

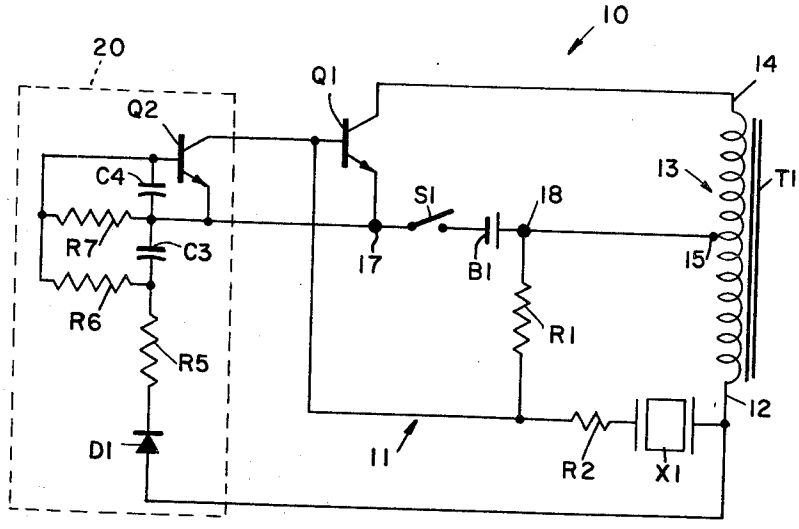
[52] **U.S. Cl.** **340/384,** 331/112
[51] **Int. Cl.** **G08b 3/00**
[50] **Field of Search** ..... 340/384, 384 (G), 321; 331/174, 112

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ABSTRACT: A piezoelectric electroacoustical transducer is in series with the feedback path of a compact, encapsulated audio oscillator operating on a voltage compatible with those produced by a single electrical cell. The necessary voltage stepup for the transducer is obtained by a feedback transformer. Internal pulser circuits provide an output tone which is interrupted at a subaudio frequency. Provision is made for an internal power source and for an internal sensor switch.



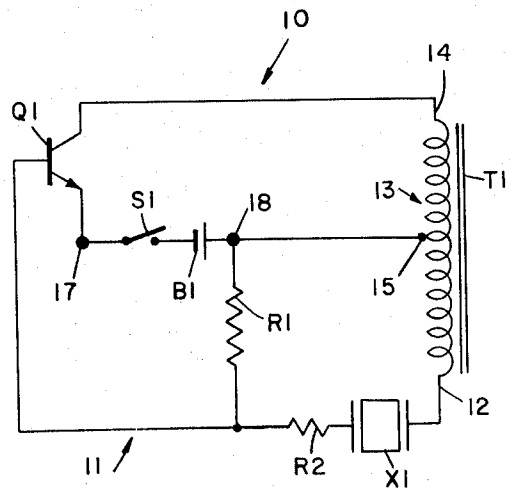


FIG. 1

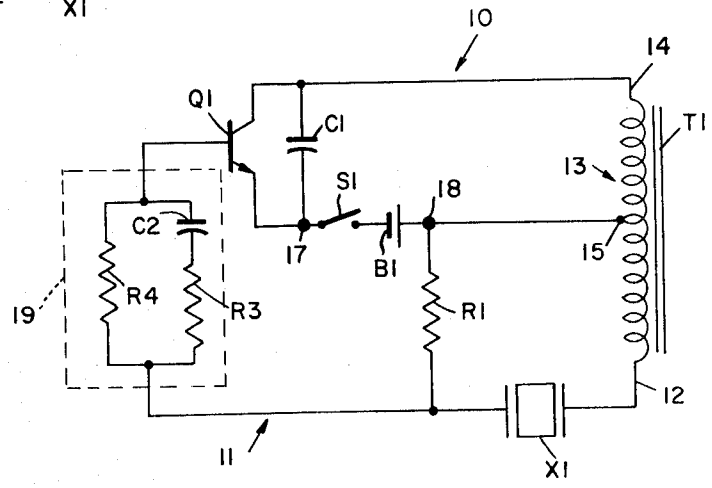


FIG. 2

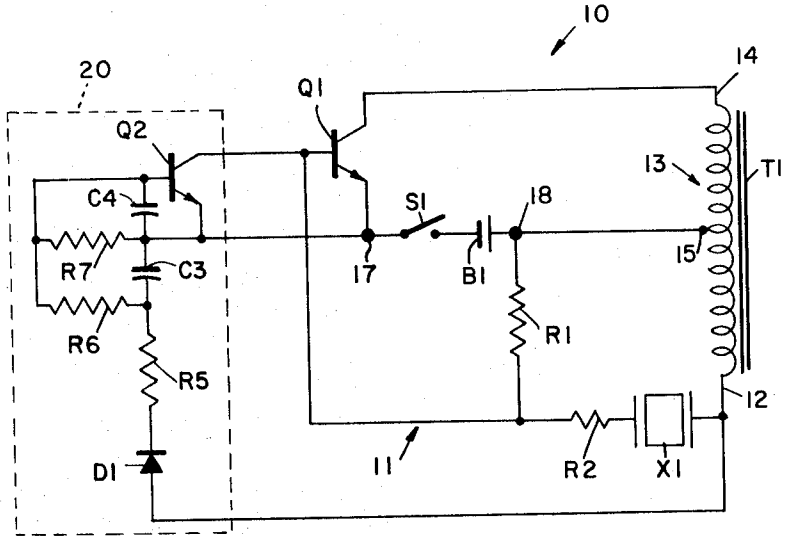


FIG. 3

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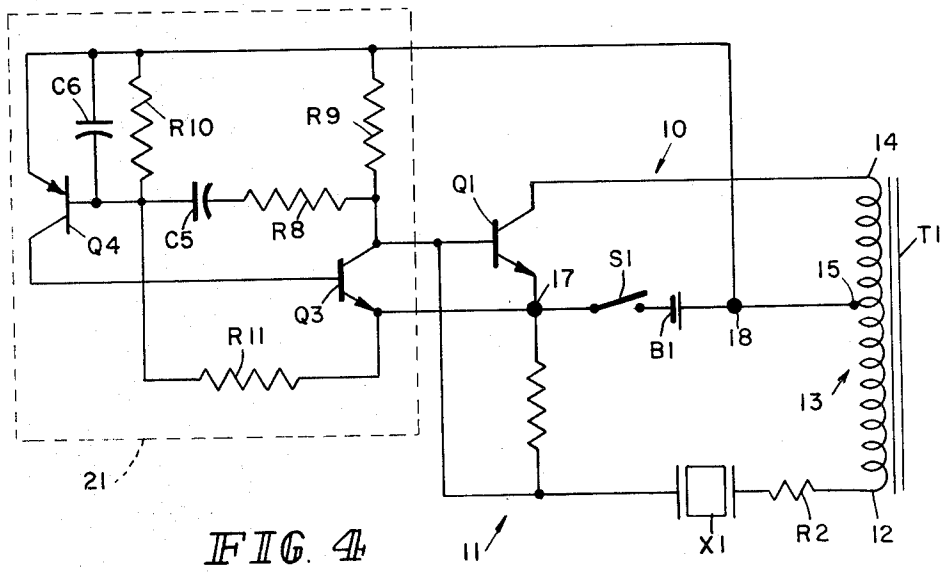


FIG. 4

FIG. 5

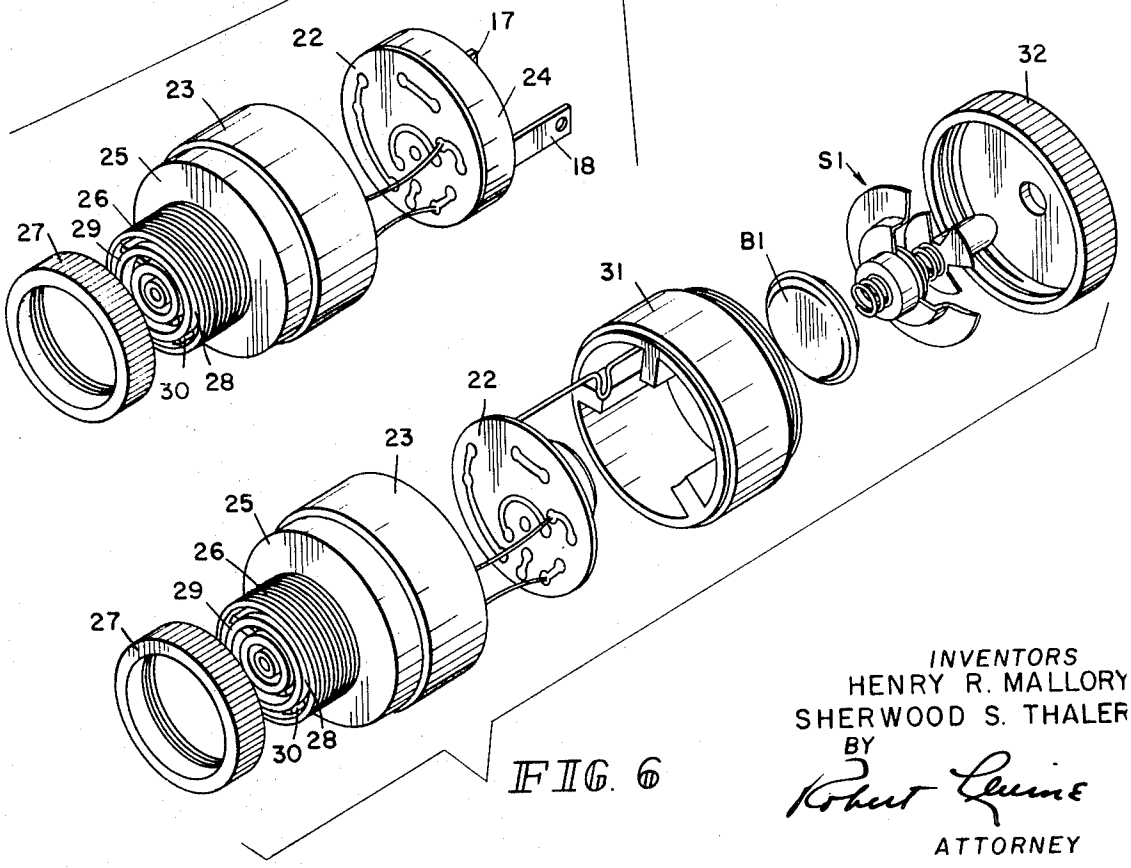


FIG. 6

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AUDIBLE ALARM UNIT

This is a continuation of Ser. No. 621,596 filed Mar. 8, 1967 now abandoned.

The advantages of an audible presentation of an alarm signal over a visual or other type of presentation have been recognized in many areas, but these advantages have often been outweighed by the large size, physical complexity and high power requirements of available alarms. The advent of the miniature transistor oscillator and the unitary ceramic electroacoustical transducer, however, have made it possible to construct a compact alarm unit whose power requirement is sufficiently small that the unit can be permanently cast in a protective material with but two terminals brought out. Such an alarm may be used as a direct replacement for other types of indicators (for a pilot light, for instance), since no separate power supply is required. Also, such an alarm may be designed to emit a pulsed or interrupted tone for use in surroundings in which a continuous tone would be masked by a high ambient noise level.

Conventional oscillator circuits used with this type of alarm, however, require supply voltages on the order of 6 to 30 volts DC for actuation. In view of the extremely high energy conversion efficiency of the ceramic transducer coupled with the desirability of using the electrical signal itself to power the alarm, this limitation to relatively high signal voltages is a significant disadvantage. The objective of the present invention of providing an alarm capable of actuation by low-voltage signals is important in several respects. It is of course obvious that a low-voltage alarm can replace a higher-voltage unit merely by adding an external dropping resistor and/or a Zener diode, so that the low-voltage unit inherently has a wider range of application. The low voltage and power requirements of the present unit commends its use in battery-powered equipment for portable or emergency use.

Since the present alarm operates on voltages on the order of those produced by a single electrical cell, the unit may be designed to operate with its own power source as an integral part. This would allow it to indicate a condition of a nonelectrical nature by the addition of a sensor capable of closing an electrical circuit upon the occurrence of the condition; such sensors abound in many areas, including mechanical switches, pressure indicators, fluid flow and level sensors and many more. In fact, the sensor itself, in the form, for instance, of a push button switch, may also be incorporated into the alarm as an integral part. Accordingly, another object of the invention is to provide an audible alarm useful in settings in which external electrical power is not readily available.

The present alarm unit is intended to substitute directly for a wide variety of indicator units, and therefore it should be simple and compact, physically rugged, reliable, and inexpensive to manufacture. The attainment of these ends is a further object of the invention.

The present alarm also allows the inclusion, either as a separate or an integral part, of circuitry to provide a pulsed or interrupted output tone, while still retaining its other advantages. Furthermore, a wide range of duty cycles is easily attainable.

Further objects of the invention, as well as modifications and substitutions obvious to those skilled in the art, will appear in the following description of several preferred forms of the invention and in the accompanying drawings, in which:

FIG. 1 is a schematic diagram of a first form of the invention;

FIG. 2 is a diagram of a second embodiment;

FIG. 3 shows another embodiment;

FIG. 4 is a circuit diagram of a further form of the invention;

FIG. 5 is an exploded perspective view of an encapsulated alarm unit according to the invention; and

FIG. 6 illustrates another form of encapsulating the present alarm unit.

Referring more particularly to the drawings, FIG. 1 shows a basic form of the invention, capable of producing a continuous tone upon energization. The transistor oscillator, designated generally by the numeral 10, consists of a transistor Q1, a DC base biasing resistor R1 and a feedback transformer T1. The electroacoustical transducer X1 and a small-valued resistor R2 are placed in series in the feedback path 11, which runs from the base of transistor Q1 to the end 12 of the transformer winding 13. The end 14 of the winding 13 is coupled to the collector of Q1. The tap 15 of the winding 13 is brought out to one polarity of the battery B1, the emitter of Q1 being brought out to the other polarity of B1. This battery is a representation of the voltage which serves as both signal and power for the oscillator 10; it is here shown to be controlled by a sensor switch S1.

Closing the switch S1 causes the battery voltage to appear across the collector-emitter circuit of Q1 and a DC bias current to be drawn through R1; the resistance of the transducer X1 is significantly higher than that of R1, and does not appreciably affect the DC bias current. The switching transient also induces a voltage at the winding end 12, causing the circuit to oscillate by the alternating bias developed at the end 12 and transferred to the base of Q1 through the feedback path 11. The voltage necessary to produce an output from the transducer X1, which is higher than the voltage of the battery B1, is obtained by stepping up the AC voltage in the winding 13 by adjustment of the turns ratio of the winding. The circuit is designed so that the feedback voltage developed in T1, less the voltage drop through X1 and R2, is sufficient to sustain the oscillations. R2 is a low-value resistor which in many cases has been found necessary to ensure proper starting of the oscillator 10 under all conditions; other types of transducer might not require the use of this resistor. The placement of R1 deviates from the usual connection of the biasing resistor directly between the base and collector of Q1; such a connection would introduce an AC negative feedback path which would detract from the efficiency of the oscillator 10. For a typical ceramic transducer, the transformer T1 has a winding 13 of 700 turns of 038 wire, tapped at 225 turns from the end 14; Q1 is a type 2N3414 NPN transistor, R1 may range between 330 and 560 ohms and R2 lies between approximately 68 and 220 ohms; these component values allow proper oscillation and adequate output for battery voltages from 0.8 volt to above 1.5 volts.

In addition to the simple and efficient voltage stepup achieved thereby, placing the transducer X1 in series in the feedback path 11 allows a self-adjustment of the oscillator frequency to match the resonant frequency of the transducer. Within wide limits of component values, the series-resonant frequency of the transducer determines the frequency of the oscillator 10, and there is no need for close-tolerance components or adjustment of individual circuits in order to assure maximum sound output. Also, this self-adjustment feature, combined with the extreme simplicity of the circuit and its efficient biasing arrangement, render the present alarm capable of being manufactured in a small package at a very low cost.

In many situations in which an audible alarm indication is advantageous, an alarm producing a single continuous tone would not be satisfactory. A high ambient noise level will tend to mask such a tone, and any continuous sense impression loses its attention-seeking ability in a short time. Furthermore, such a tone may in some cases be mistaken for a machinery noise; that is, it may not sufficiently identify itself as an alarm signal. The basic circuit of the present invention, however, lends itself easily to several simple modifications which will enable the oscillator 10 to produce an arresting pulsed or interrupted output tone while retaining its other advantages. Additionally, the use of a pulsed tone will reduce the power drain of the alarm unit, while actually increasing its effectiveness.

FIG. 2 illustrates a simple modification to the oscillator circuit to produce a pulsed tone having a relatively low duty cycle (typically about 20 percent to 50 percent). In this circuit a pulsing circuit 19, composed of a capacitor C2, a charging resistor R3 and a discharging resistor R4, is inserted in series in the feedback path 11 in order periodically to block the oscillator 10. The addition of the pulsing circuit 19 effectively

converts the oscillator **10** into a sinewave oscillator at the alarm signal frequency plus a relaxation oscillator at a subaudio pulsing frequency. When a voltage step is applied to the circuit by closing the switch S1, the large-valued capacitor C2 is effectively a short circuit, and DC bias current flows to the base of transistor Q1 through the bias resistor R1 and the small resistor R3. This current is sufficient to start the oscillator **10**. As the capacitor C2 accumulates a charge, however, the current flowing through it decreases to a point where base current is insufficient to sustain oscillations.

At this point, Q1 cuts off and the out put tone from X1 ceases. The relatively high resistance R4 then bleeds off the charge on C2 until the oscillator **10** can restart, and the cycle begins anew. The capacitance of C2 is large enough that it passes the alarm frequency easily, so that Q1 is not deprived of its AC feedback signal until it is cut off by insufficient DC bias. Therefore, the transducer X1 and the pulser **19** operate independently of each other even though they are in series in a common feedback path **11**. The capacitor C1 acts to suppress transients at the subaudio pulsing frequency, which transients would otherwise appear in the output as objectionable clicks, and which might be radiated as electromagnetic interference.

A typical pulsed oscillator according to FIG. **2**, having a pulsing rate of 5 (20 percent duty-cycle) pulses per second, a 3000 Hz. tone and an average power drain of approximately 2.7 milliwatts would utilize the same transformer T1, transducer X1 and battery B1 as the circuit of FIG. **1**. The transistor Q1 may be a type 2N3606, R=100Ω, R3=270Ω, R4=27K Ω, C1=0.22μfd, and C2=35μfd, 3-volt electrolytic. The resistance of R3 in the feedback path **11** obviates the need for a starting resistor such as R2 of FIG. **1**.

The circuit of FIG. **3** has essentially the same output characteristics as that of FIG. **2** except that it is capable of substantially higher power output, typically about 9.5 milliwatts for the component values listed hereafter. Whereas the pulser **19** of FIG. **2** changes the DC operating point of Q1 continuously until it is cut off, the pulser **20** of FIG. **3** allows transistor Q1 to run at a constant DC operating point until it is sharply cut off at the end of a tone burst. To this end, a portion of the audio voltage is taken from the end **12** of the transformer winding **13**, rectified by the diode D1, and applied to the charging circuit composed of resistor R5 and capacitor C3. While the rectified audio voltage charges C3 through R5, the transistor Q2 is cut off, and the oscillator **10** produces an audio tone as heretofore described. At a certain point, however, the voltage on C3 will become sufficiently large that the current flowing through resistor R6 will saturate Q2; this transistor then clamps the emitter and base of Q1 together, depriving Q1 of its bias and thereby halting its oscillation. When the oscillation ceases, charging voltage is removed from the pulser **20** and the charge on C3 leaks off through the resistors R6 and R7 and the base of Q2, until transistor Q2 again becomes cut off and allows the oscillator **10** to restart. The capacitor C4 softens the switching of Q2 to prevent transients and interference. Placing the capacitor C4 in the pulser circuit **20** has the advantage that none of the oscillator power is bypassed through it, thus increasing the efficiency of the alarm unit.

Typical component values for a 20 percent duty-cycle audio pulse are as follows: Q1=Q2=2N3606, R1=330 Ω, R2=470Ω, R5=1,000Ω, R6=3.9K Ω, R7=10K Ω, C3=35μfd, C4=0.22 μfd. It will be appreciated that Q2 in this circuit operates in the switching mode; i.e., it is either in a high-impedance state or a low-impedance state. Therefore, transistor Q1 maintains a constant, predetermined operating point during the tone burst and is completely cut off during the intervals between bursts. This constant operating point may then be chosen for optimum efficiency of the oscillator **10**.

The direct use of an RC relaxation circuit, as in the pulsers **19** and **20**, limits the duty cycle practicably attainable to less than about 50 percent. Higher duty cycles call for reduction of the discharging resistors to values on the order of the charging resistors, resulting in a substantial loss of output by heating the discharging resistors during the charging interval; this dissipative loss then increases with increasing duty cycle. The pulser **21** of FIG. **4**, however, avoids this result and allows efficient operation of the alarm unit at duty cycles of 80 percent and beyond. This pulser is a subaudio-frequency oscillator complete in itself, deriving its power from the battery B1 by connections to the terminals **17** and **18**. The transistors Q3 and Q4 switch between fully-on and fully-off states at a rate determined by the timing circuit composed of resistor R8 and capacitor C5; the capacitor C6 acts to suppress switching transients. Transistor Q3 alternately clamps and unclamps the base of transistor Q1 in the manner previously described, thus preserving the advantages of the pulser **20** of FIG. **3**. It will be obvious that other types of oscillator circuits may be employed with equal success in the pulser **21**, the only requirement being that the circuit provide an alternately low-impedance and high-impedance path between the base and emitter of Q1.

A typical alarm unit according to FIG. **4** will produce about 5 pulses per second of 80 percent duty cycle and will draw approximately 21 milliwatts of power from a 1.35-volt battery. Typical component values are: Q1=2N3414 (NPN), Q3=2N 3606 (NPN), Q4=2N1303 (PNP), R1=1,000Ω, R2=100Ω, R8=2.2K Ω, R9=220Ω, R10=10KΩ, R11=22K Ω, C5=10μfd, C6=0.1μfd. It will be noted that the addition of the pulser to the basic oscillator **10** requires but one internal connection (none if the transducer contacts are available externally) to the oscillator **10**, namely, at the base of Q1; therefore, a pulser such as **21** may conveniently be manufactured either as an integral part of the alarm unit or as a separate add-on section by bringing the base lead of Q1 out to an external contact.

Because of the intended uses for the present alarm unit, its mechanical configuration also becomes important. FIG. **5** shows an exploded perspective view of an encapsulated alarm unit for use with an external electrical signal source and switch for actuation of the alarm. In this form, a round printed-circuit board **22** containing the electrical components is potted within a plastic housing **23**, the external terminals **17** and **18** projecting from a rearward surface **24**. The forepart of the housing **23** contains a shoulder **25** and a projecting threaded neck **26** carrying a mounting ring **27** for mounting the alarm unit on a panel or the like. Sound from the transducer X1 is then projected through an aperture **28** in the neck **26**; a number of diffuser rings **29**, supported by struts **30**, serve to spread the emerging sound into a broader beam. This alarm may be operated directly from a low-voltage source or from a higher-voltage source through a voltage-dropping means such as a resistor or Zener diode. Loudness of the output sound may be controlled by such a means without affecting the frequency of the alarm signal.

The low voltage and power requirements of the alarm unit also make it especially advantageous for applications in a nonelectrical environment. FIG. **6** shows an exploded perspective view of such an adaptation. In this form the housing **23** includes a shell **31** for carrying a single miniature electrical cell B1. The shell **31** in turn is adapted to receive a screw cap **32** holding a conventional pushbutton switch assembly S1. The mechanical switch S1, however, is used only as an example of a sensor which may be integrally associated with the present alarm; obviously many other types of condition-responsive means may be employed in this configuration.

We claim:

1. A substantially integratable low-voltage audible alarm comprising:

a transistor having a collector, emitter and base;

an autotransformer comprising a coil having two ends and a center tap, one end of said coil connected to the collector of said transistor;

a transducer means connected to the base of said transistor and the other end of said coil;

pulsing means connected between the base of said transistor and the juncture point of said resistor and transducer;

resistive means connected between the base of said transistor and the center tap of said coil;

a pulser means comprising a discharging resistor in parallel with a series combination of a capacitor and a charging resistor and switching means including a switching transistor having a collector, base and emitter, the collector of said switching transistor connected to the base of said first transistor, a first and second capacitor, a first resistor and a rectifier all connected in series across the base of said switching transistor and the juncture point of said transducer and said coil, a second resistor connected between the base of said switching transistor and the juncture point of said capacitor, and a third resistor connected to the base of said switching transistor and the juncture point of said second capacitor and said first resistor; and

said alarm adapted to produce an audible signal when a source of power is applied to the emitter of said transistor and the center tap of said coil.

2. A substantially integratable low-voltage audible alarm comprising:

a transistor having a collector, emitter and base;

an autotransformer comprising a coil having two ends and a center tap, one end of said coil connected to the collector of said transistor;

a transducer means connected to the base of said transistor and the other end of said coil;

pulsing means connected between the base of said transistor and the juncture point of said resistor and transducer,

resistive means connected between the base of said transistor and the center tap of said coil;

a pulser means comprising a second transistor having a collector, base and emitter, the collector of said second transistor connected to the base of said first transistor, the emitter of said second transistor connected to the emitter of said first transistor, a third transistor having a collector, base and emitter, the collector of said third transistor connected to the base of said second transistor, a capacitor-resistor series combination connected between the base of said third transistor and the collector of said second transistor, a resistor-capacitor parallel combination connected between the emitter and base of said third transistor, a resistor connected between the emitter of said third transistor and the collector of said second transistor, and a resistor connected between the base of said third transistor and the emitter of said second transistor; and

said alarm adapted to produce an audible signal when a source of power is applied to the emitter of said transistor and the center tap of said coil.