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[54] **INTRUSION DETECTOR**

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[73] Assignee: **The United States of America as represented by the Secretary of the** Navy, Washington, D.C.

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[52] **U.S. Cl.** **307/232**; 340/224; 340/261
[51] **Int. Cl.** **H03k 5/18**
[58] **Field of Search** .... 340/224, 261, 16 R; 325/113; 307/232

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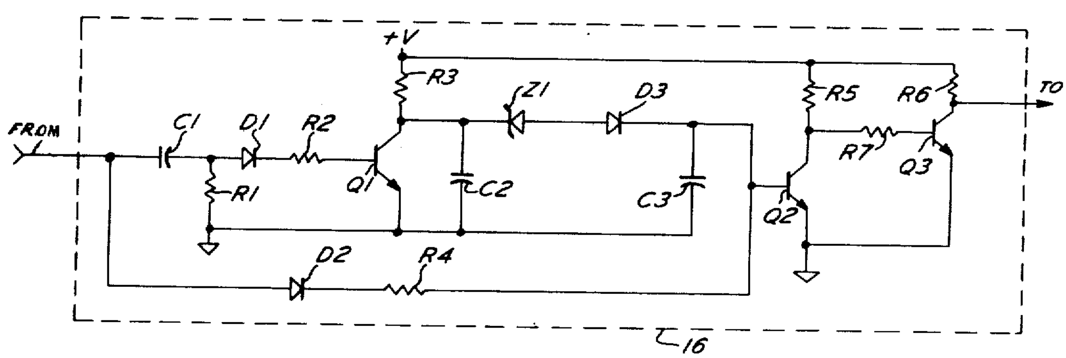
Attorney, Agent, or Firm—R. S. Sciascia; Henry Hansen

[57] **ABSTRACT**

A low-current detection device responsive to both audio and seismic input signals received over predetermined periods of time at preselected amplitude levels. At the end of the predetermined time periods a tone code generator combines the audio input signal with identifying tone codes. The combined audio signal and identifying tones are passed to a transmitter whose output is enabled for a predetermined period of time. A switch is provided to selectively power the transmitter for night operation only.

3 Claims, 3 Drawing Figures



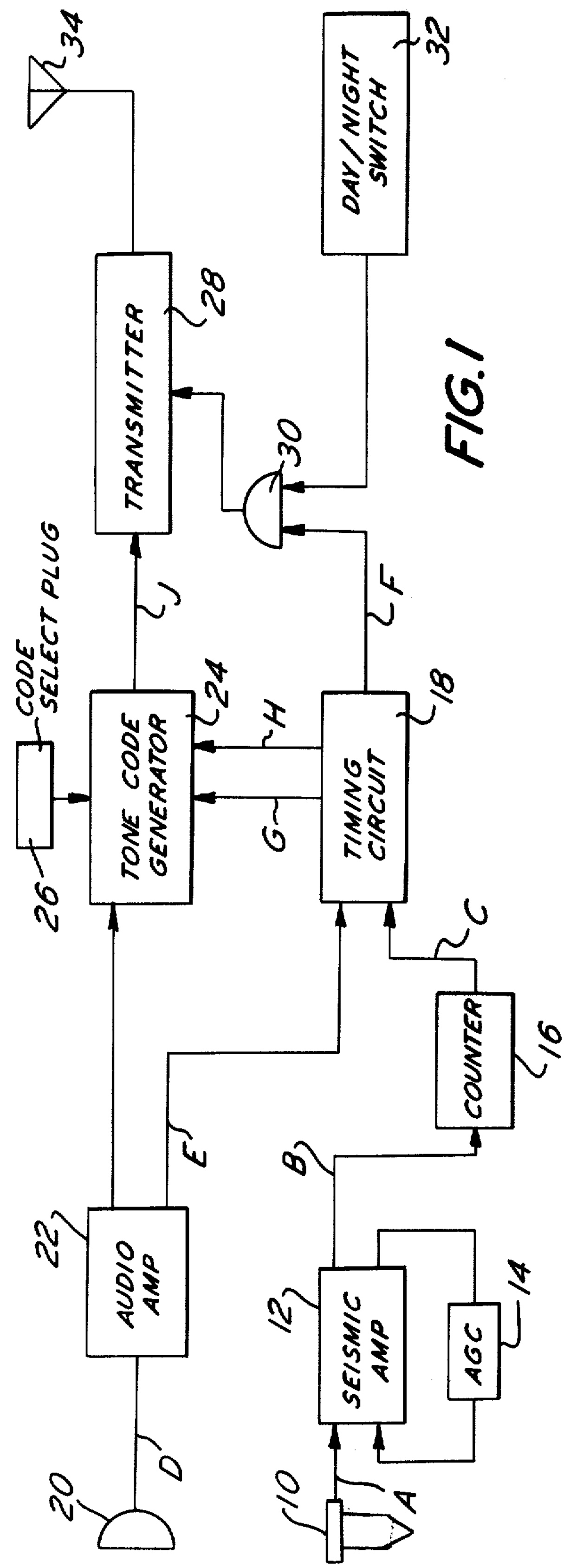

34
DAY/NIGHT SWITCH
32
TRANSMITTER
28
30
CODE SELECT PLUG
J
F
TONE CODE GENERATOR
24
H
TIMING CIRCUIT
18
26
G
C
COUNTER
16
E
B
22
AUDIO AMP
12
SEISMIC AMP
AGC
14
20
D
10
A

FIG. 1

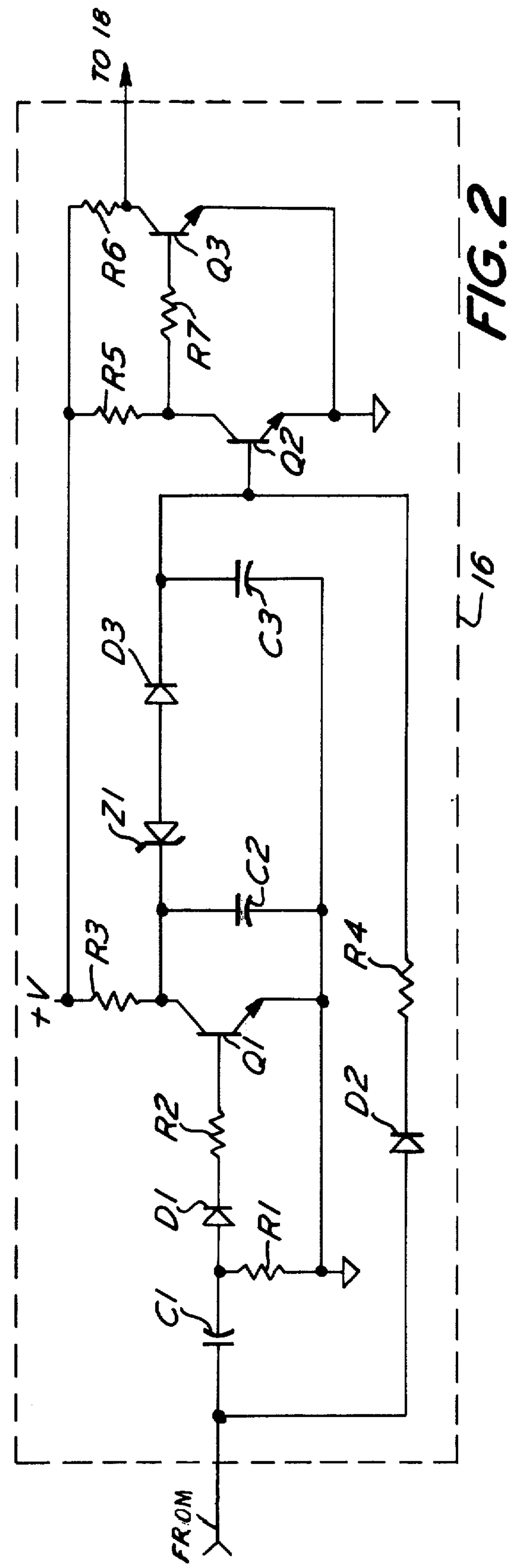

TO 18
R6
Q3
R7
R5
Q2
D3
C3
16
Z1
C2
+V
R3
R4
Q1
R2
D2
D1
R1
C1
FROM

FIG. 2

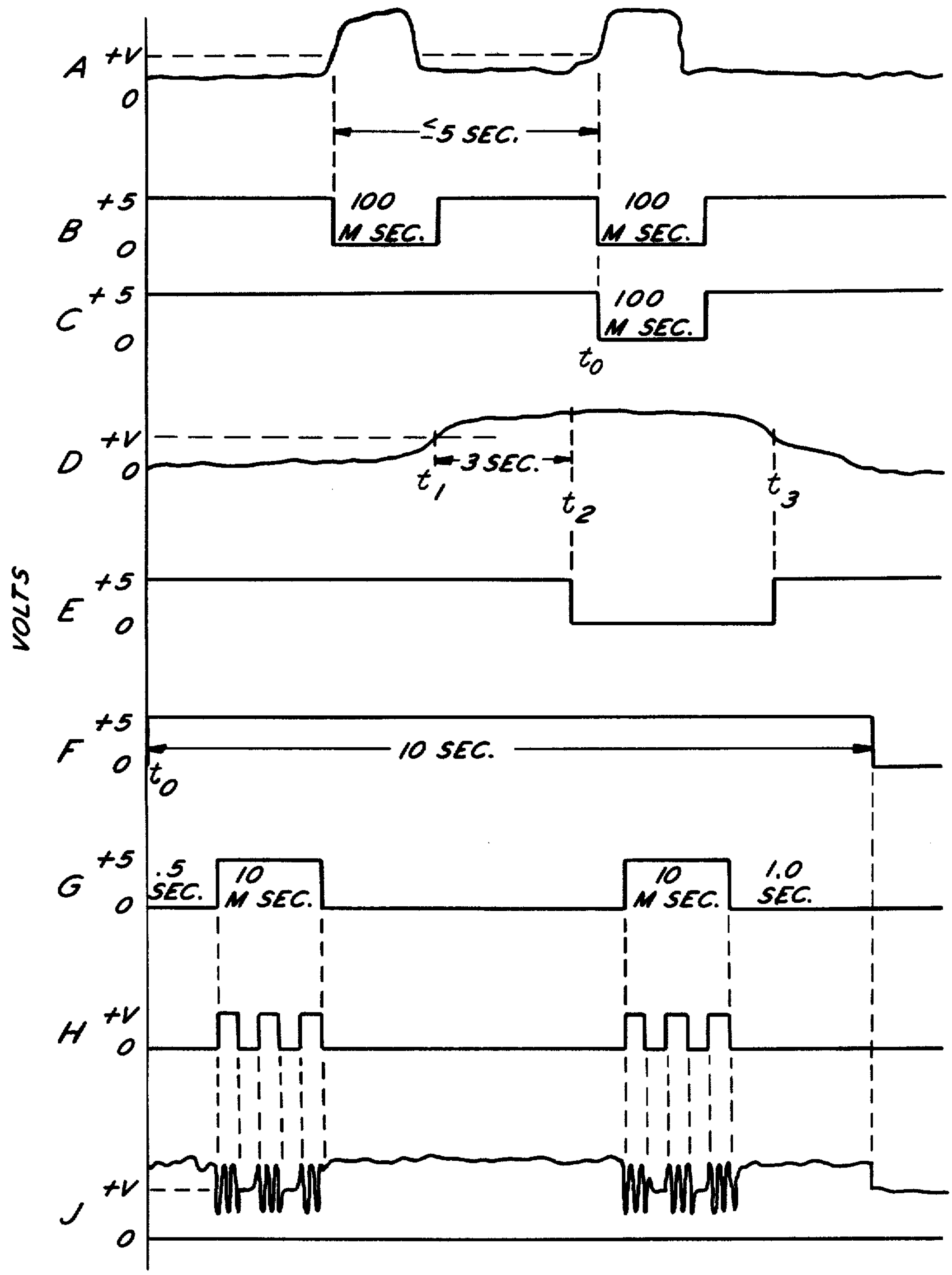

VOLTS
A
+V
0
≤5 SEC.
B
+5
0
100 M SEC.
100 M SEC.
C
+5
0
100 M SEC.
t_0
D
+V
0
t_1
3 SEC.
t_2
t_3
E
+5
0
F
+5
0
10 SEC.
t_0
G
+5
0
.5 SEC.
10 M SEC.
10 M SEC.
1.0 SEC.
H
+V
0
J
+V
0

FIG. 3

INTRUSION DETECTOR

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates generally to detection devices and more particularly to a soil implanted intrusion detector which utilizes only minimum current drain during monitor operation.

Intrusion detectors are often placed in hostile territory to detect the presence of personnel or vehicles and, once implanted, the detector is considered to be irrecoverable. It is most desirable therefore, that such detectors provide as long an operational life as possible. Prior art detectors having both audio and seismic detection capabilities often expend available power resources within a relatively short period of time due to high idling currents while in a monitor mode of operation. Moreover, prior art devices may transmit irrelevant noise information such as a falling tree limb or a single artillery shot. The result, therefore, is an overabundance of transmitted audio information which is not entirely useful and a premature depletion of the energy source which can no longer operate the device.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an intrusion detector which will operate in a monitor mode requiring only a minimum current drain of approximately 2 milliamperes upon a power source of 15 volts. Another object of the invention is to coordinate the transmission of audio information with the reception of preselected amplitude seismic signals within a predetermined period of time. Yet another object is to selectively permit the operation of the invention during night hours.

Briefly, these and other objects are accomplished by an intrusion detector device having a microphone and a geophone each connected to audio and seismic amplifier inputs respectively. The geophone senses soil perturbations in the area of the detector and determines if the perturbations are of a predetermined seismic amplitude. A counter measures the number of the predetermined amplitude seismic signals over a 5 second period of time. At the end of the 5 second time period and coincident with an audio signal of a predetermined amplitude, a tone code generator is activated and combines the audio output signal with preselected identifying tone codes. The combined audio and tone code signal is transmitted to a remote receiver. A switch is provided for optional selection of night operation.

For a better understanding of these and other aspects of the invention, reference may be made to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the present invention;

FIG. 2 is a schematic diagram of the counter shown within the block diagram of FIG. 1; and

FIG. 3 is a diagram of signal waveforms as they appear within the invention shown in the block diagram of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 there is shown a block diagram of one preferred embodiment of the present invention. A geophone **10** is connected to one input of a seismic amplifier **12** having an external AGC circuit **14** serially connected between a first output and a second input of the amplifier **12**. A second output of the amplifier **12** is connected to the input of a low-current drain counter **16** whose output is connected to one input of a timing circuit **18**. A microphone **20** is connected to the input of an audio amplifier **22** having a first output connected to a second input of the timing circuit **18** and a second output connected to a first input of a tone code generator **24**. A code selecting plug **26** is connected to a second input of the generator **24** which provides an output to the input of a transmitter **28**. Timing circuit **18** provides a first output to one input of an AND gate **30** having an output operatively connected to the power input of transmitter **28**. Third and fourth outputs of the timing circuit **18** are connected to third and fourth inputs of generator **24**. A day/night switch **32** has an output connected to the other input of gate **30**. Transmitter **28** provides an output connected to an antenna **34**.

Referring now to FIG. 2, there is shown a schematic diagram of the counter **16** shown in FIG. 1. The input of the counter **16** is connected to receive the second output signal from the seismic amplifier **12** through the series connection of a capacitor C_1, a diode D_1, a resistor R_2 and the base of a transistor Q_1. A resistor R_1 has one end connected to a junction point between capacitor C_1 and diode D_1 and the other end connected to ground. The collector of transistor Q_1 is commonly connected to one end of a capacitor C_2, the anode of a zener diode Z_1 and one end of a resistor R_3 and the other end of which is connected to a supply voltage +V. The emitter of transistor Q_1 is connected to ground as is the other end of capacitor C_2. The cathode of zener diode Z_1 is connected to the anode of a diode D_3 whose cathode is commonly connected to one end of a capacitor C_3, the base of transistor Q_2, and one end of a resistor R_4. The other end of capacitor C_3 is connected to ground. The input to the counter **16** coming from the output of the seismic amplifier **12** is also connected to the anode of a diode D_2 whose cathode is connected to the other end of the resistor R_4. The collector of transistor Q_2 is commonly connected to one end of a resistor R_7 and to one end of a resistor R_5 whose other end is connected to the supply voltage +V of approximately 10 volts. The other end of resistor R_7 is connected to the base of a transistor Q_3. Both the emitters of transistors Q_2 and Q_3 are connected to ground. The collector of transistor Q_3 is connected to one end of a resistor R_6 at which junction the output of the counter **16** is provided. The other end of resistor R_6 is connected to the supply voltage +V.

Preferable values of resistance and capacitance as well as commercial nomenclature for the diodes and transistors used in the circuit of FIG. 2 are given in the table hereinbelow:

R_1, R_5, R_6	=	100 K ohms	D_1, D_2, D_3	=	1N914
R_2, R_4, R_7	=	50 K ohms	Z_1	=	1N753
R_3	=	1.5 Megohms	Q_1, Q_2, Q_3	=	2N3904
C_1, C_2, C_3	=	1 μf.			

For purposes of better explaining the invention reference is now made to FIG. 3 which illustrates the audio, seismic and timing signal waveforms found within the invention, in conjunction with FIGS. 1 and 2. FIG. 3A illustrates an assumed input seismic signal having two distinct perturbations occurring above a threshold voltage +V within a time period of five seconds or less. Such an input signal might easily be accomplished, for example, by a man walking with slow but heavy footsteps within the soil area in which the geophone **10** is implanted. The low-current seismic amplifier **12** receives the input seismic signal A and provides a pulsed output as shown in FIG. 3B wherein a gate pulse having a period of 5 Hz is initiated upon the input seismic signal exceeding the predetermined threshold +V as determined by the AGC circuit **14**. Should the input seismic signal be a series of impulses within the five second period, the gated output signal B will continue to provide a sequence of pulses at a 5 Hz rate. The conventional seismic amplifier **12**, such as manufactured by Lansdale Micro Electronics Incorporated, part number LMI9001, requires only an extremely low current draw on the order of microamperes. The AGC circuit **14** is of a conventional selfcompensating type wherein an AGC threshold is varied to compensate for ambient noise level conditions and the design of which is well-known to those skilled in the art. The counter **16** as shown in FIG. 2 comprises circuitry which requires an idling current of approximately 90 microamperes which will be later explained. Counter **16** is designed to count the number of seismic perturbations from the output of the seismic amplifier **12** within a 5 second period. Should there be at least two such perturbations within a 5 second period, an output signal as shown in FIG. 3C is provided to the timing circuit **18**. Referring now to the circuitry as shown in FIG. 2 and without having any pulse input, the counter **16** is in a quiescent state having only a voltage of approximately five volts d.c. applied to the common junction of capacitor C_1 and the anode of diode D_2. Capacitor C_1 effectively blocks the d.c. voltage from triggering transistor Q , which, in its quiescent state is biased off by resistors R_1 and R_2 in its base emitter circuit. The 5 volt input is, however, transmitted via diode D_2 and biasing resistor R_4 to the base of transistor Q_2 which is turned on by forward biasing of the base emitter junction. Diode D_3 effectively blocks any charging of capacitor C_2 by the voltage present on the base of transistor Q_2. With transistor Q_2 on, current is drawn from the voltage supply +V through the collector resistor R_5 and ultimately to the ground referenced emitter of Q_2, thus lowering the collector potential sufficiently to back bias the base emitter junction of transistor Q_3 and effectively maintain transistor Q_3 in its off state. Since transistor Q_3 is in its quiescent off state, there is no substantial current drawn through resistor R_6 from the voltage supply +V and the output of the counter taken from the collector of transistor Q_3 provides a relatively high potential of approximately five volts to one input of the timing circuit **18**. During quiescent time periods, capacitor C_2 is permitted to charge towards the supply voltage of approximately 10 volts. Zener diode Z_1 has a breakdown

voltage of approximately 7 volts and allows forward bias to be applied to the base of transistor Q_2 through diode D_3 when capacitor C_2 charges to at least this value.

Upon excitation of the geophone **10** the first pulse shown in FIG. 3B is differentiated by capacitor C_1 into negative and positive going spikes of which only the positive going spike is conducted by diode D_1 to the base of transistor Q_1, thus momentarily turning on transistor Q_1 and discharging capacitor C_2. Once the charging potential of capacitor C_2 falls below the breakdown voltage of Z_1, forward biasing of transistor Q_2 due to the conduction of Z_1 is now removed. Since Q_2 continues to be biased by the voltage at resistor R_4, it remains in a conducting state thereby continuing a 5 volt signal at the collector output of transistor Q_3. The combination of resistor R_3 and capacitors C_2 and C_3 inhibits capacitor C_2 from charging to 7 volts within the 5 second time period. Upon receipt of a second input pulse as shown in FIG. 3B within the 5 second period, transistor Q_2 is made nonconductive upon the negative going edge of the second pulse due to the removal of forward biasing from the base of transistor Q_2. Upon removal of the forward bias, the collector of transistor Q_2 assumes a high voltage which forward biases the base emitter junction of transistor Q_3 through resistor R_7 and thus places transistor Q_3 in a conducting state. Collector current is drawn through resistor R_6 from the supply voltage +V and since the emitter of transistor Q_3 is at a ground potential, the output of the counter **16** is now at a low level for the duration of the second pulse of the input signal shown in FIG. 3C. As was earlier mentioned, counter **16** requires an extremely low supply current under quiescent input conditions. This is due to the fact that of the three active devices, i.e. transistors Q_1, Q_2 and Q_3 within counter **16**, only transistor Q_2 is maintained in the conducting state. Accordingly, the supply current will be the current drawn through collector resistor R_5 and with a typical supply voltage +V of 9 volts the current is quite small.

Referring now to FIG. 3D there is shown an input audio signal which traverses a threshold level +V and which is received by the microphone **20**. The audio amplifier **22** has an internal AGC circuit which sets the threshold. Upon receiving an input signal which exceeds the threshold +V for a period of 3 seconds an audio enable pulse as shown in FIG. 3E is provided to the second input of the timing circuit **18**. Waveform E is normally maintained at a 5 volt level during quiescent periods and assumes a ground level during excitation by the proper level of an audio input signal. The second output of the audio amplifier **22** provides amplified audio information to one input of the tone code generator **24**. Amplifier **22** is a low current conventional device such as manufactured by Lansdale Micro Electronics, Incorporated, part number LMI9030, and typically requires only 1 milliampere of current. Timing circuit **18** is connected to receive inputs from both the audio signal as shown in FIG. 3E and the seismic enable signal as shown in FIG. 3C and is activated when both of these input signals are in a low state. Either the audio enable signal or the seismic enable signal may be first in time. In the example shown in FIG. 3 the audio signal E is first in time to go low with the seismic enable signal C following. The turn-on time t_o of the timing circuit **18** is therefore defined, in this example, at that time at which the later seismic signal drops to its low state. The timing circuit **18** provides three different output signals F, G and H as shown in FIG. **3.** Waveform F is a high level 5 volt signal initiated at time t_o and continues at this high level for 10 seconds. The second output of timing circuit **18** as shown in waveform G is a series of two pulses each 10 milliseconds long and falling within the 10 second interval of waveform F one half second after t_o and the second 10 millisecond pulse is timed to end 1 second before the end of the 10 second interval shown in waveform F. A third output from the timing circuit as shown in waveform H is a double series of three positive going pulses with each series spaced within one of the ten millisecond pulses shown in waveform G. Each of the three pulses within the respective series is 2 milliseconds long with a 2 millisecond spacer thus occupying the entire 10 millisecond audio gate shown in waveform G. Output waveform H forms the tone gate input to the tone code generator **24** and signals that time during which appropriate tones will be combined with audio information. A timing circuit suitable for use within the present invention may be a conventional interval timer such as manufactured by United Aircraft Corporation, part number H2102 which embodies three different timing intervals as shown in waveforms F, G and H of FIG. **3.** The conventional tone code generator **24** receives the audio input from the amplifier **22** and both audio and tone gating signals from the timing circuit **18.** The generator **24** is preferably capable of three discreet tone frequencies which may be selected from within an approximate range for example, of 19 KHz. to 32 KHz. by means of a code select plug **26** which is inserted into the generator **24.** Generator **24** combines the audio input signal with the preselected identifying tones in the information stream as shown in waveform J of FIG. **3.** Waveform J is referenced to threshold level +V above which is transmitted the audio information interspersed at the proper time with two series of three identifying tones. Although the audio information is always above the threshold level, the identifying tones take on a fixed amplitude which swings both above and below the threshold level. A tone code generator suitable for use within the present invention may be, for example, one such as manufactured by United Aircraft Corporation, part number H2101. The combined audio and identifying tone information is received at one input of the transmitter **28** which transmits the information through antenna **34.**

In order that the operable life of the invention may be yet further extended there is preferably provided a conventional day/night switch **32** which may, for example, be operated by sun energy to provide a low output to a second input of the AND gate **30** such as to inhibit the operation of the gate **22.** The output of gate **22** is preferably connected to trigger a power switch (not shown) which will activate the transmitter **28.** At sunset the low signal coming from the output of the day/night switch **28** is changed to a high level and the gate **22** is opened thus allowing the transmitter **28** to transmit the combined audio and tone information by way of antenna **34** during selected **10** second intervals.

Thus it may be seen that there has been provided novel circuitry for substantially increasing the operable life of a remotely located intrusion detector. The total current draw of the present invention while in its quiescent idling state is approximately 2 milliamperes. There has also been provided timing circuitry for discriminating between impulse noises of a singular occurrence and those of a continuous origin occurring within a predetermined period of time. It is also contemplated within the embodiment of the present invention that either the audio or seismic portions of the invention may be separately utilized by simply grounding the enabling signal coming from the output of the unused amplifier or counter. By grounding the audio enable signal, all audio information will be processed without respect to a predetermined threshold and by grounding the seismic enable signal, all audio information above a predetermined threshold will be processed without regard to predetermined seismic perturbations.

Obviously many other modifications and variations of the invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described

What is claimed is:

1. A low current counting device for indicating the receipt of at least two pulses within a predetermined period of time, comprising, in combination:

first switching means including a first transistor having a base operatively connected to receive individual ones of said pulses, an emitter connected to ground, and a collector, and timing means having one terminal of a resistor, the cathode of a zener diode and one terminal of a first capactitor commonly connected to said collector, one terminal of a second capacitor operatively connected to the anode of said zener diode for providing an output signal for said predetermined period of time whereby said output signal is indicative of the end of the first one of said pulses, the other resistor terminal being connected to a voltage supply and the other first and second capacitor terminals being connected to ground;

second switching means having an input commonly connected to receive said first switching means output signal and said pulses for switching to a nonconductive state in response to the second one of said pulses within said first switching means predetermined period of time, and an output for providing a signal indicative thereof; and

third switching means having an input connected to receive said second switching means output signal for switching to a conductive state in response to said second switching means output signal, and an output for providing said counting device output signal.

2. A low current counting device according to claim **1** wherein said second switching means further comprises:

a second transistor having a base operatively connected to receive said pulses and said first switching means output signal, an emitter connected to ground, and a collector for providing said second switching means output signal.

3. A low current counting device according to claim **2** wherein said third switching means further comprises:

a third transistor having a base operatively connected to receive said second switching means output signal, an emitter connected to ground, and a collector for providing said counting device output signal.

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