

[54] ENVIRONMENTAL TEST SWITCH FOR INTRUDER DETECTION SYSTEMS
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[51] Int. Cl. **G08b 29/00**
[58] Field of Search **340/258 R, 258 B, 258 A, 340/214, 410, 261**

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[57] **ABSTRACT**
A method and apparatus for optimizing the sensitivity of intruder and fire detection systems for a predesired margin of safety against false alarming. The apparatus comprises means for selectively increasing the system sensitivity by a calibrated amount above an optimum operating level, and means for adjusting the selectively increased system sensitivity, to a level at which the system just responds (or just fails to respond) to the background noise level. Thus, when the sensitivity is returned to its normal operating level, a built-in margin of safety is provided against false alarming from noise signals.

3 Claims, 3 Drawing Figures

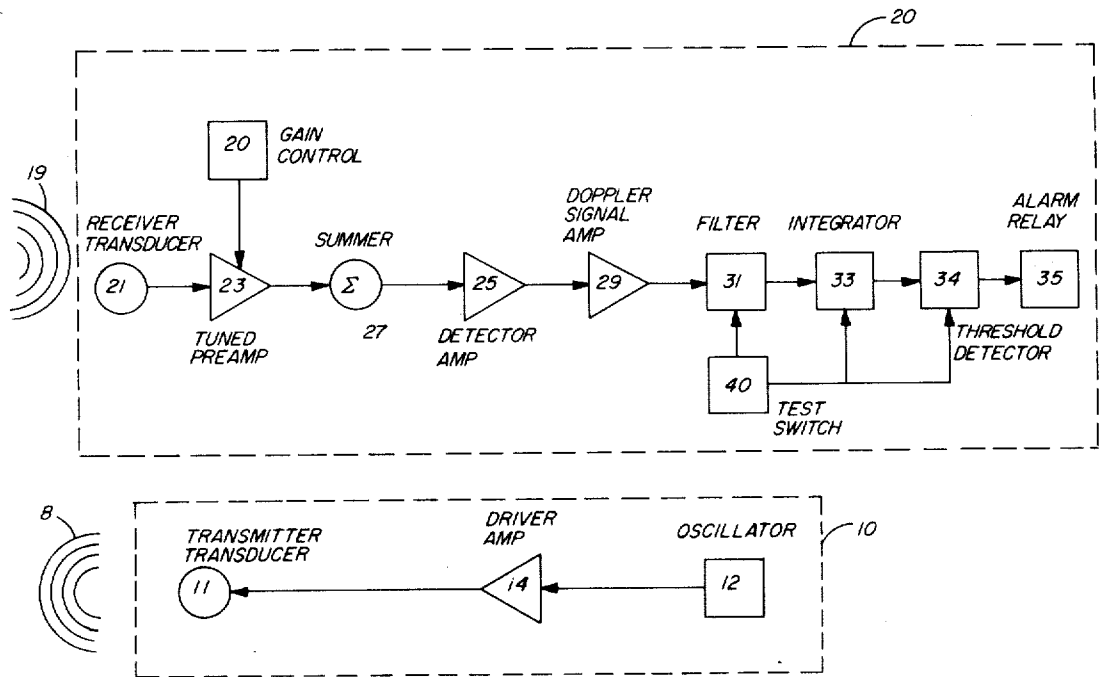


FIG. 1

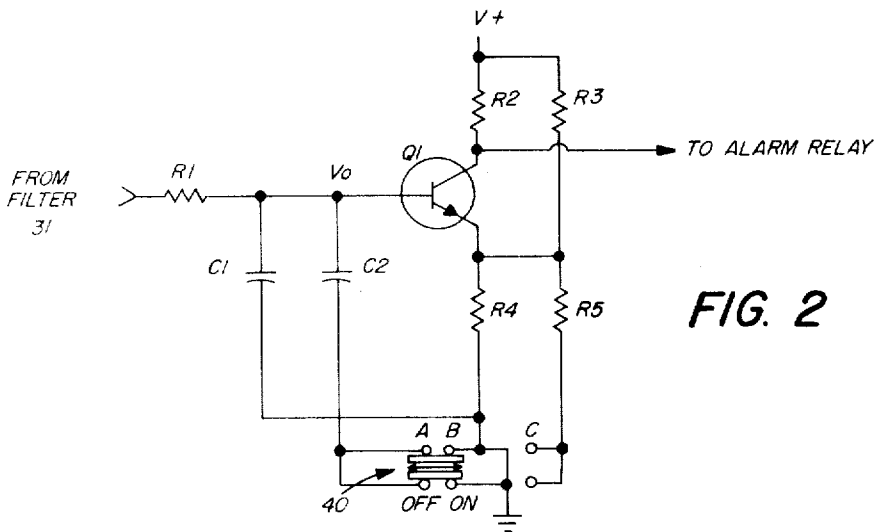
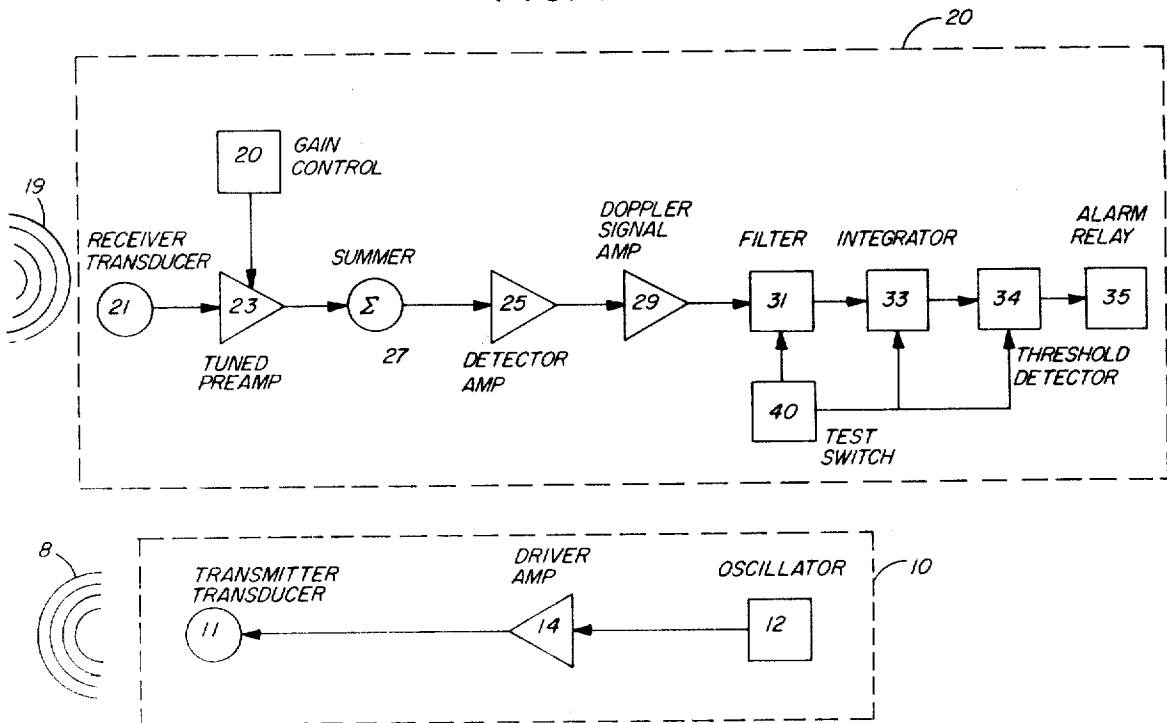


FIG. 2

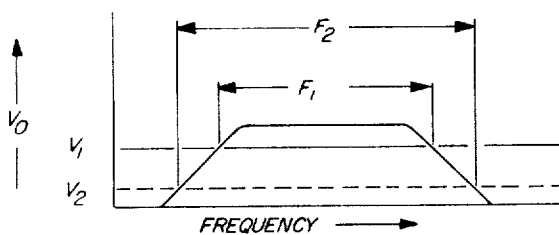


FIG. 3

ENVIRONMENTAL TEST SWITCH FOR INTRUDER DETECTION SYSTEMS

BACKGROUND OF THE INVENTION

The present invention relates to intruder and fire detecting systems, and, in particular, to a method and apparatus for optimizing the sensitivity of such systems for a predesired margin of safety against false alarming due to spurious sources comprising the background noise.

Proper installation of conventional electronic intruder detecting systems requires that the installer have some knowledge of the characteristics of the background against which the intruder is to be detected. In general, he should know the amplitude of the background noise within the bandpass of the receiver component of the system, as well as the duration and frequency of occurrence of transient signals which arise within such bandpass. Having gained this knowledge, the installer can then adjust the sensitivity of the system to a level which provides optimum protection; i.e., a level which provides a high degree of sensitivity to the event of interest without rendering the system prone to false alarming.

The most effective determination of the signal characteristics of the background noise is, of course, to monitor the output of the signal processing circuitry of the system, with an electronic oscilloscope or some other electronic test device. Ideally, such monitoring is done after the installer has activated all conceivable sources of noise in the environment wherein the system is situated. This approach, however, suffers the drawback of requiring costly equipment, in addition to a certain amount of skill and judgment on behalf of the installer. Typically, the amplitude of the noise signal fluctuates wildly, requiring the installer to make what amounts to an educated guess as to the maximum noise level, frequency of occurrence, and duration of transients which might be encountered during the use of the system. The problem with such guessing, of course, is that if the installer guesses wrong, the result is either a high frequency of false alarms, resulting from a system sensitivity which is set too high, or inadequate protection, resulting from a system sensitivity which is set needlessly low.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to take the guesswork out of properly adjusting system sensitivity in installing intruder detection and other types of condition-responsive systems.

Another object of the invention is to provide an improved intruder detection system in which the system sensitivity can be readily optimized for a predefined margin of safety from false alarms without the need for costly electronic test equipment and substantial skill on behalf of the installer.

These and other objects of the invention are achieved by the provision of an electronic condition-responsive system which includes in addition to a means for adjusting the system sensitivity, circuit means for increasing at any time the system sensitivity by a calibrated amount. According to a preferred embodiment, such circuit means, when activated, preforms one or more of the following functions: (1) widens the bandwidth of the bandpass filters of the signal processing circuitry;

(2) reduces the alarm-activating threshold of such circuitry; (3) reduces the integration time of the integrator component of the signal processing circuitry; (4) increases the gain of one or more receiver amplifiers; and (5) increases the output of the transmitter. All of the above functions are carried out so as to increase the system sensitivity by a known factor, such factor representing a predesired margin of safety from responding to false alarm-producing background noise. According to the inventive process, system sensitivity is optimized for the predesired margin of safety by merely (1) activating the circuit means, thereby increasing the system sensitivity by a known amount; (2) adjusting the system sensitivity to a level which is just high enough not to respond to the maximum steady state noise signal in the environment where the system is used; and (3) inactivating the circuit means to reduce the system sensitivity by said known amount level.

The above objects of the invention, as well as its various advantages, will become immediately apparent to those skilled members of the art from the ensuing detailed description, reference being made to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an ultrasonic intruder detection system embodying the invention;

FIG. 2 is an electrical schematic of the integrator and threshold sensing components of the system illustrated in FIG. 1, together with preferred circuitry for increasing the sensitivity of such components; and

FIG. 3 illustrates the effect which an adjustment in threshold has on the bandwidth of the signal processing circuitry.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

In FIG. 1, an ultrasonic intruder detection system embodying the invention is illustrated in block diagram form. Such a system operates on the well known Doppler effect, being of the type disclosed in my copending application Ser. No. 273,472, filed on July 20, 1972 now U.S. Pat. No. 3,803,539. It should be understood from the outset that this particular system merely typifies the types of detection system in which the invention has utility.

Ultrasonic energy waves 8 emanating from a transmitter 10 are directed into a region in which the motion of an intruder is to be detected. Transmitter 10 preferably comprises a piezoelectric ceramic transducer 11 which is driven at an ultrasonic frequency (e.g., 40 KHz), by a crystal-controlled oscillator 12 via driver amplifier 14. The exact frequency control afforded by the use of a crystal-controlled oscillator permits several Doppler systems to operate in the same general area without generating undesirable beat frequencies.

Ultrasonic energy waves 19 reflected back toward the receiver 20 are sensed by a receiver transducer 21, also ceramic, which converts the ultrasonic energy into an electrical signal having an instantaneous frequency, phase and amplitude characteristic of the resultant ultrasonic energy wave at the receiver transducer 21. Transducer 21 has a bandpass characteristic which, in combination with a tuned preamplifier 23, through which the output of transducer 21 is passed, causes the device to respond only to those signals centered within a few kilohertz of the transmitter frequency. Such

"front end" tuning enables the system to ignore ordinary audible noises.

As long as there is no motion in the region under surveillance, the received signal level will be constant, except for slow drifts produced by changes in temperature and humidity which affect the speed of sound, and the frequency will be identical to that of the transmitted energy wave. However, in the event an object within said region moves so as to have a component of motion toward or away from the receiver, sound waves reflected from it will fluctuate in both amplitude and frequency which, in turn, will produce similar fluctuations in the output of transducer 21.

Amplitude changes in the output of preamplifier 23 are sensed by detector amplifier 25 which is biased such that there is more gain for excursions of one polarity than for equal excursions of the opposite polarity. This non-linear operation, together with some built-in capacitance, serves as an envelope detector with gain; the envelope frequency being, of course, equivalent to the Doppler frequency.

In addition to sensing the Doppler frequency via amplitude changes in the received signal, the Doppler frequency is also sensed via a signal injection technique. Prior to being fed to the input of detector amplifier 25, the output of preamplifier 23 is combined with a large constant amplitude signal of the transmitter frequency which is injected from the output of driver amplifier 14. Actually, the injected signal is algebraically summed with the preamplifier output via summer 27. When the injected signal and received signal are in phase, they reinforce each other producing an increase in the output from summer 27. When the injected and received signals are out of phase, a decrease in the summer output is produced. This amplitude variation, arising from frequency or phase shifts generated by a moving target, is also detected by detector amplifier 25 which contains a low pass filter which removes the 40 KHz carrier frequency, leaving only a signal which fluctuates at a rate equal to target-related Doppler amplitude and frequency changes.

While serving as a reference against which the frequency (or phase) of the received signal is compared for the purpose of detecting the Doppler signal, injection also serves to stabilize the sensitivity of the Doppler device. Preferably, the injected signal is larger than the maximum anticipated output of tuned preamplifier 23. Because of this, the amplitude of the carrier signal remains relatively constant even though there is considerable variation in received energy at the receiver transducer due to phase cancellations. This tends to maintain constant sensitivity notwithstanding device placement and substantial changes in environmental conditions. When a null condition exists and the output of the receiver transducer is substantially zero, the injected signal serves to overcome forward diode-drop in the detector. The injected signal, therefore, provides a bias to maintain the detector at uniform sensitivity.

The Doppler signal output of detector amplifier 25 is next fed to the Doppler signal amplifier 29 which comprises a conventional high-gain audio amplifier preferably having a bandwidth encompassing the Doppler frequencies of interest. The gain of amplifier 29 is sufficient to produce an overdriven "squared" signal for targets within the sensitivity range of the device. The output of amplifier 29 is then fed to a filter 31, preferably a digital filter circuit such as that disclosed in U.S.

Application Ser. No. 20,887, filed Mar. 19, 1970, to further eliminate signals uncharacteristic of the motion of interest. After integration of the filter output by integrator 33 to eliminate the effects of transients, the signal is then used to trip an alarm relay 35 or the like.

The sensitivity of the above-described system (i.e., its responsiveness to motion) is governed by a variety of parameters including, for instance, the gain of amplifiers 23, 25 and 29, the intensity of transmitted waves 8, the bandpass of filter 31, the time constant of integrator 33 and the threshold level of threshold detector 34. By adjusting these parameters collectively or separately, the system can be hypersensitized to the extent that it will respond to the slightest movement of a small distant target. On the other hand, the adjustment of these same parameters can result in a desensitization of the system to the extent that it will fail to respond to a moving target, regardless of its size, rate or direction of movement, or its proximity to the system. The optimum values of these parameters commonly depend upon two factors: (1) the noise level of the environment in which the system is used; and (2) the characteristics of the electrical signals which can be anticipated from the object of interest.

Since the system manufacturer is usually aware of the target signal characteristics, most of the parameters can be set at an optimum value before the system is shipped to the customer. In fact, it is common for the manufacturers to fix all but one of the system sensitivity-governing parameters prior to sale. Usually, the one parameter which remains adjustable is the gain of the tuned preamplifier which receives the reflected energy waves. By leaving this parameter adjustable, the ultimate customer or installer can adjust the sensitivity to an optimum level which, in turn, is governed by the environmental noise level. As indicated above, however, the noise level is difficult to ascertain without the use of rather expensive test equipment.

In accordance with the present invention, means are provided for facilitating the proper adjustment of system sensitivity. Such means includes an environmental test switch 40 which, when activated, serves to increase the system sensitivity, via circuitry to be described, by a predesired factor, which represents a predesired margin of safety against false alarms. Preferably, when switch 40 is "on" or in an active position, the effective bandpass of filter 31 is widened, the time constant of integrator 33 is reduced, and the threshold of detector 34 is reduced. By appropriately adjusting these parameters, the combined effect is the predesired increase in system sensitivity.

Upon activating switch 40, thereby increasing the sensitivity by a desired factor, the installer then adjusts the gain of tuned preamplifier 23 to a level just under that where the alarm relay is tripped or activated by the background noise. This level can be achieved by merely increasing the preamplifier gain until alarm activation is produced, and then gradually decreasing the gain until no alarm is produced. When the environmental test switch is turned "off" or inactivated, thereby returning the system sensitivity to a level which is a known factor less than that at which it was set when switch 40 was "on," the system sensitivity is properly set for a given margin of safety. For the ultrasonic detection system described herein, a system sensitivity approximately four times less sensitive than the maximum level at which the sensitivity could be set for a given

steady state noise level has been found to provide an adequate margin of safety against false alarming from electrical or acoustical transients in the background which exceed such steady state level, without substantially sacrificing the level of security provided by the system. This safety margin also prevents false alarms from occurring due to range expansion associated with changes in temperature and humidity in the protected area.

The manner in which switch 40 can be used to increase the sensitivity of the system illustrated in FIG. 1 is readily understood with reference to FIGS. 2 and 3. In FIG. 2, typical circuitry for integrator 33 and threshold detector 34 is shown schematically. Integrator 33 comprises capacitor C1 and C2 and resistor R1, and threshold detector 34 comprises resistors R2-R5 and transistor Q1. FIG. 3 illustrates the frequency response of filter 31 and the alarm tripping threshold when switch S is in on and off positions. When the environmental test switch is off, as in the position shown (shunting terminals A and B), the system sensitivity is set at the normal operating level. The time constant of integrator 33 is determined by both capacitors C1 and C2, and the alarm activating threshold of detector 34 (i.e., the voltage V_0 at which transistor Q1 conducts) is governed by the ratio of R3 to R4. The threshold voltage required to produce alarm activation when switch 40 is off is indicated by V_1 in FIG. 3. At this level, only input signals having frequencies within the bandpass F_1 and an amplitude exceeding V_1 are effective in producing an output from the threshold detector.

When switch 40 is turned on, capacitor C2 is disconnected from the integrator circuit, thereby reducing the time constant of integration. Simultaneously, resistor R5 is connected in parallel with resistor R4 thereby reducing the threshold level of detector 34 to a new level V_2 . As is apparent in FIG. 3, when the threshold is at V_2 , the effective bandpass of the system is increased to the range F_2 . Thus, by merely turning switch 40 on, the system becomes hypersensitized because (1) input signals of lower amplitude produce an alarm signal due to the reduction of threshold from V_1 to V_2 ; (2) input signal frequencies normally outside the alarm-tripping bandpass are capable of producing an alarm signal due to the widening of the bandpass from F_1 to F_2 ; and (3) input signals of shorter duration can produce an alarm signal due to the reduction in the time constant of the integrator. By properly adjusting the values of the capacitors and resistors, any desired increase in system sensitivity can be achieved.

As indicated above, ultrasonic intruder detection systems are merely exemplary of the detection systems wherein the invention has utility. In addition, the invention also has utility with electro-optical, microwave and various other "active" systems, as well as with a variety of "passive" detection systems, including ionization and smoke-sensing fire detection systems and infrared-sensing intruder detection systems.

I claim:

1. For use in a detection system for sensing the occurrence of an event of interest amid a variety of sources of background noise, the system comprising means for distinguishing electrical signals characteristic of the event of interest from electrical signals characteristic of background noise, and means for activating an alarm in response to the sensing of an electrical signal having an

amplitude which rises above or drops below a predefined threshold level, the improvement comprising, in combination:

switch means for temporarily increasing the level of sensitivity of the system by a predesired factor above an initial level; and

means for setting the sensitivity of the system, at a time when said switch means is effective to produce such a temporary increase in sensitivity, to a level at which electrical signals characteristic of background noise have an amplitude substantially equal to said threshold level of the activating means, whereby the system sensitivity, upon being unaffected by said switch means, is set at a level which provides a predesired margin of safety against alarming due to background noise signals.

2. In an intruder detection system comprising means for transmitting energy waves into a region wherein intrusion is to be detected; means for receiving said transmitted energy waves upon being reflected and/or modified by objects within said region and for converting said energy waves into a first electrical signal having an instantaneous amplitude and frequency proportional to that of the resultant energy wave received; detecting means for generating a second electrical signal in response to changes in said first electrical signal; integrating means operatively coupled to said detecting means for smoothing out rapid variations in the amplitude of said second electrical signal, the degree of such smoothing being governed by the time constant of the integrating circuit, and a threshold sensor operatively coupled to said integrating means for activating an alarm when the amplitude of said second electrical signal exceeds a predefined threshold level, the improvement comprising, in combination: switch means operatively coupled to said integrating means for temporarily decreasing the time constant of said integrating means by a predetermined factor, thereby temporarily increasing the sensitivity of the system by a predefined factor; and means operatively coupled to said receiving means for adjusting the amplitude of said first electrical signal, at a time when said switch means is effective to temporarily increase the system sensitivity and when no intruder is present in said region, to a level at which background noise is just effective to produce alarm activation, whereby the system sensitivity, upon being unaffected by said switch means, is set at a level which provides a predesired margin of safety against alarming due to signals characteristic of only background noise.

3. In an intruder detection system comprising means for transmitting energy waves into a region wherein intrusion is to be detected; means for receiving said transmitted energy waves upon being reflected and/or modified by objects within said region and for converting said energy waves into an electrical signal having an instantaneous amplitude and frequency proportional to that of the resultant energy wave received; threshold-sensing means operatively coupled to said receiving means for transmitting an alarm activating signal in the event the amplitude of said electrical signal exceeds a predefined threshold level; the improvement comprising, in combination;

switch means operatively coupled to said threshold-sensing means for temporarily reducing the threshold level of said threshold-sensing means by a pre-

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determined factor, thereby temporarily increasing the sensitivity of the system by said predetermined factor; and
means operatively coupled to said receiving means for adjusting the amplitude of said electrical signal, 5
at a time when said switch means is effective to temporarily increase the system sensitivity and when no intruder is present in said region, to a level

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at which background noise is just effective to produce alarm activation, whereby the system sensitivity, upon being unaffected by said switch means, is set at a level which provides a predesired margin of safety against alarming due to signals characteristic of only background noise.

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