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Galvin

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[54] **VOLUMETRIC INTRUSION ALARM USING BOTH DOPPLER AND NET-CHANGE SIGNAL PROCESSING**

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[51] **Int. Cl.**[2] **G08B 13/24**

[58] **Field of Search** ..... 340/258 A, 258 B; 343/7.7

[56] **References Cited**

UNITED STATES PATENTS

3,665,443	5/1972	Galvin	343/7.7
3,725,888	4/1973	Solomon	340/258 A
3,760,400	9/1973	Galvin et al.	343/7.7
3,789,950	2/1974	Strenglein	340/258 A
3,863,240	1/1975	Galvin	343/7.7

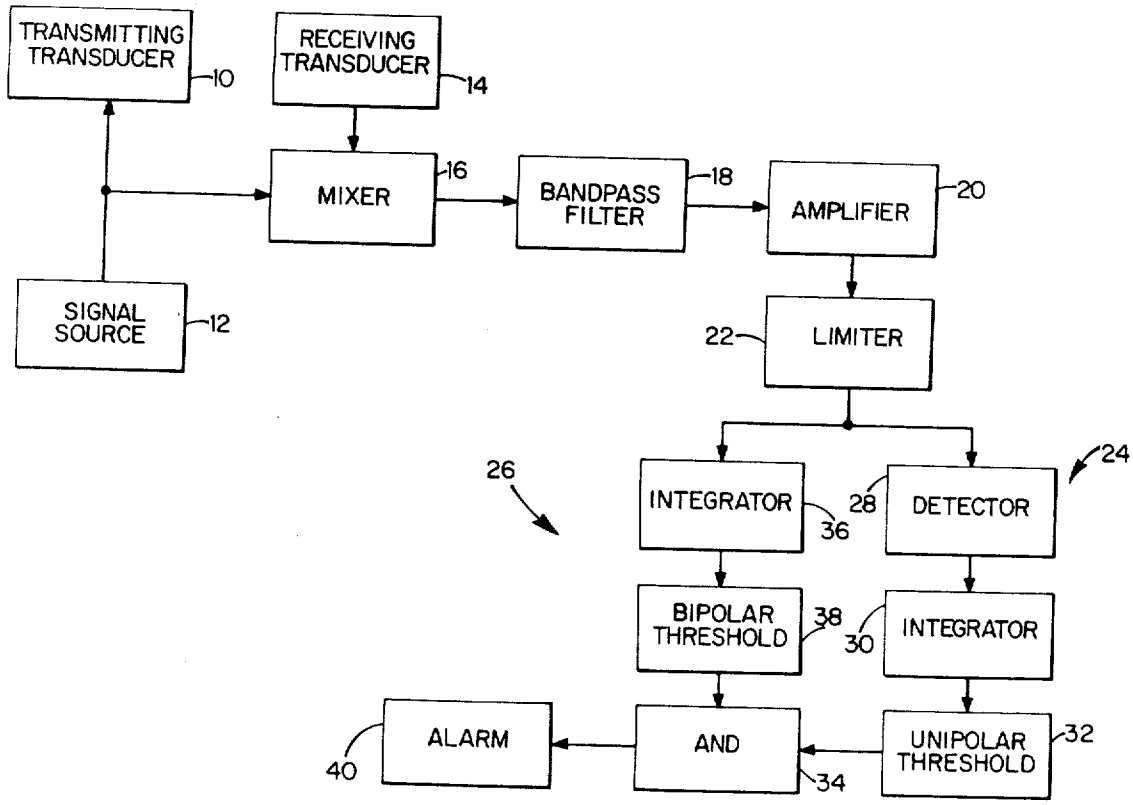
Primary Examiner—Glen R. Swann, III

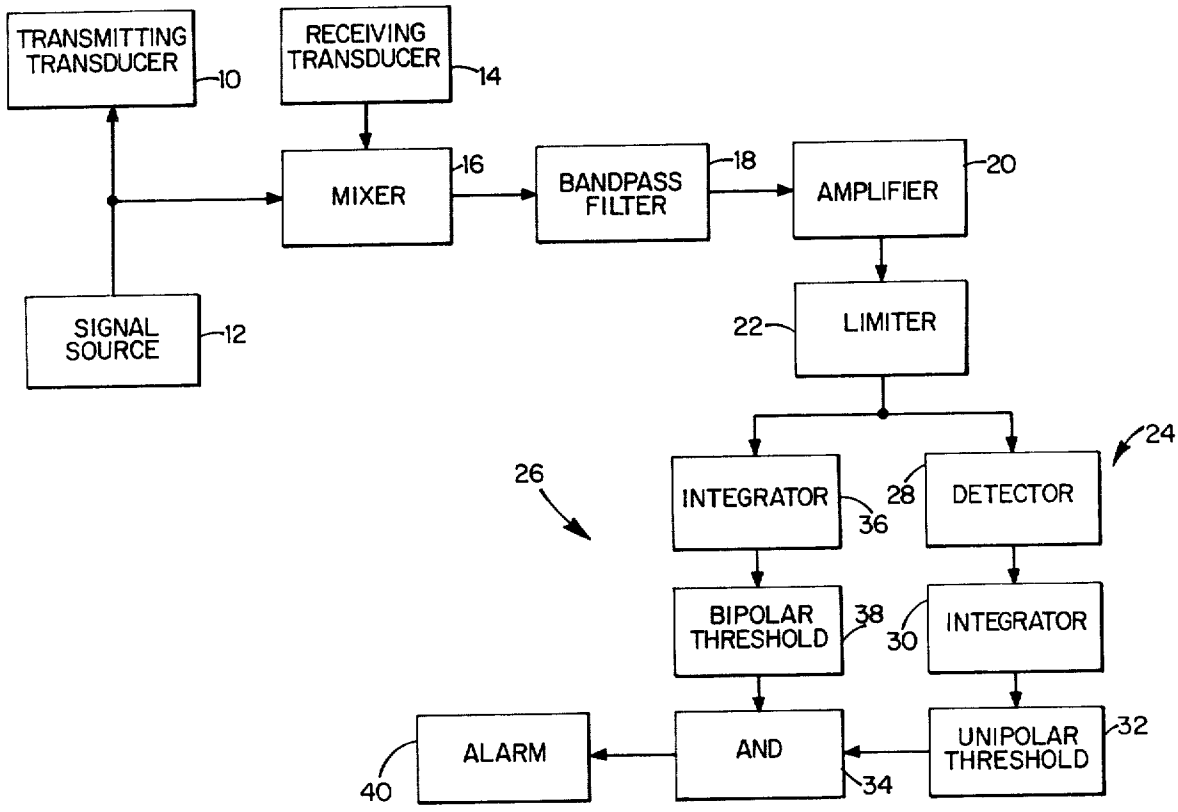
Attorney, Agent, or Firm—Weingarten, Maxham & Schurgin

[57] **ABSTRACT**

Signals returned from a zone under surveillance are precessed in two channels. One channel gives an output on detection of a Doppler signal greater than a predetermined threshold. The other channel gives an output in response to changes in the phase and/or amplitude of the returned signal (with reference to the transmitted signal) indicative of a net change in the position of objects in the zone greater than a predetermined threshold. An alarm is given only if outputs are present from both channels simultaneously.

7 Claims, 1 Drawing Figure




TRANSMITTING TRANSDUCER
10
RECEIVING TRANSDUCER
14
MIXER
16
BANDPASS FILTER
18
AMPLIFIER
20
SIGNAL SOURCE
12
22
LIMITER
24
26
INTEGRATOR
28
DETECTOR
36
BIPOLAR THRESHOLD
38
30
INTEGRATOR
ALARM
40
AND
34
UNIPOLAR THRESHOLD
32

VOLUMETRIC INTRUSION ALARM USING BOTH DOPPLER AND DOPPLER AND NET-CHANGE SIGNAL PROCESSING

FIELD OF THE INVENTION

This invention relates to intrusion alarm systems and more particularly to volumetric alarm systems and techniques.

BACKGROUND OF THE INVENTION

In a volumetric alarm system operative to detect the presence of an intruder within a protected zone, a major problem exists with respect to the production of false alarms caused by noise, spurious motion or other interfering phenomena within the protected zone. Such interfering phenomena are caused, for example, by air turbulence within the zone, vibrating walls or objects therein, swaying fixtures, moving curtains and the like as well as spurious signals and noise, all of which can give rise to a false indication of intruder presence. Any commercially realistic alarm system must include apparatus for discriminating between actual intruder presence and interfering phenomena.

Particularly effective systems employing a high degree of false alarm protection are shown in U.S. Pat. No. 3,665,443, issued May 23, 1972 and U.S. Pat. No. 3,760,400, issued Sept. 18, 1973, both assigned to the assignee of this invention and both of which relate to Doppler type intrusion alarm systems. An intrusion detection system of the non-Doppler type having reliable discrimination between actual intruders and spurious conditions is shown in copending application Ser. No. 313,613, filed Dec. 8, 1972, now U.S. Pat. No. 3,863,240, also assigned to the assignee of this invention. It would be useful and it is an object of the instant invention to incorporate many of the features of the above-mentioned inventions into the present invention in order to provide an alarm system which is highly immune to interfering phenomena. The above-identified disclosures are incorporated herein by reference.

SUMMARY OF THE INVENTION

Briefly, the invention provides a volumetric intrusion alarm system employing a dual-detection technique exhibiting complementary detection criteria. As a result, intrusion detection is provided which is substantially immune to false alarm conditions. Detection is accomplished by simultaneous motion detection and change of position detection, and output indication of intruder detection is provided only when both detection criteria have been established.

In apparatus embodying the invention, a first detection channel is responsive to Doppler energy returned from a zone under surveillance to provide a first signal indication of motion and therefore of possible intruder presence. A second detection channel is responsive to net changes in the amplitude and/or phase of energy returned from the surveillance zone to provide a second signal indication of net changes in position of objects in the surveillance zone and thus of possible intruder presence. Only when both signals for the first and second detection channels are present simultaneously is an output indication of intruder detection provided. It is highly unlikely that interfering phenomena could cause an alarm indication simultaneously in both channels as conditions which could cause false alarms in one channel will not usually cause false alarms in the other channel.

DESCRIPTION OF THE DRAWING

The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawing in which the single FIGURE is a block diagram representation of a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawing, there is shown a transmitting transducer **10** energized by an energy source **12** and operative to provide an acoustic electromagnetic pattern in a zone under surveillance. A receiving transducer **14** is operative to receive energy returned from the zone and to provide an output signal to a mixer **16.** A portion of the signal produced by the energy source **12** provides a local oscillator signal to the mixer **16.**

The mixer output provides a baseband signal which includes Doppler and sub-Doppler frequencies of the energy received from the surveillance zone. A bandpass filter **18** is operative to pass the baseband signal to an amplifier **20** and thence to a limiting circuit **22** for respective amplification and limiting. The limiting function prevents short duration, large amplitude spurious signals from causing the outputs of the subsequent integrators **30** and **36** to slew too rapidly, which might result in false alarms. The output signal from the aforementioned network is applied to a Doppler channel **24** and to a non-Doppler or net-change channel **26.**

In the Doppler channel **24,** a Doppler detector **28** provides an output signal representative of the Doppler content of the received energy. This signal is integrated by an integrator **20** to provide a time averaged output which is applied to a first reference threshold circuit **32.** The first reference thereshold circuit **32** preferably has a predetermined unipolar threshold level. This threshold level is established in accordance with the motion or dynamic characteristics of objects in the surveillance zone. When the output signal of the integrator exceeds the threshold level of the first threshold circuit **32,** a signal from the Doppler channel **24** activates an input of an AND gate **34.**

The net-change channel **26** forms a portion of a net-change detection circuit and includes an integrator **36** which provides a time averaged output signal to a second reference threshold circuit **38.** The second threshold circuit **38** preferably has bipolar threshold levels. These threshold levels are established in accordance with the static positional characteristics of the zone under surveillance and objects in the zone. As the output signal of the integrator **36** exceeds either of the bipolar threshold levels, a signal from the net-change channel **26** activates the second input of the AND gate **34.**

An output indication of intruder detection is provided by the AND gate **34** only in the presence of both input signals from respective threshold circuits **32** and **38.** The alarm indication signal is applied to an alarm apparatus **40** which may be an audible or visual alarm indicator or other utilization apparatus.

The threshold level of the threshold circuit **32** is determined to establish a minimum level above which the integrated signal of the Doppler channel represents sufficient Doppler energy to signify the possible presence of an intruder within the protected zone. The threshold levels of the threshold circuit **38** are determined to de-

fine the minimum levels in the net-change channel above which there must exist sufficient change in the net amplitude and/or phase of received energy to signify a possible net-change in the position of some target in the zone.

In general, wideband noise can cause false alarms in the Doppler channel **24**, but will not usually cause a false alarm in the net-change channel **26** by reason of the sufficiently narrow bandwidth provided by the filtering action of the predetection integrator **36**. Similarly, swaying or vibrating objects can also cause false alarms in the Doppler channel **24**, but which will not usually cause such false alarms in the net change channel **26** because of the balanced nature of signal returns from this type of spurious motion.

Single motion events such as the movement of a curtain from one position of rest to another position of rest will not cause a false alarm in the Doppler channel. However, the net unbalance in the amplitude or phase of the signal processed by the net-change channel which are caused by such single motion events can cause a false alarm in the net-change channel.

The processing channels **24** and **26** thus tend to be complementary in that spurious conditions which could cause false alarms in one channel will not in general cause false alarms in the other channel. The resultant false-alarm probability will thus be approximately the product of the probability of false alarms for each individual channel. The overall system thus exhibits an extremely low overall false alarm rate.

Various modifications and alternative implementations of the invention will occur to those versed in the art without departing from the spirit and true scope of the invention. Accordingly, it is not intended to limit the invention by what has been particularly shown and described except as indicated in the appended claims.

What is claimed is:

1. An intrusion alarm system for detecting a target in ghe presence of interfering phenomena, said system comprising:

means for transmitting signals into a zone under surveillance;

means for receiving signals returned from the surveillance zone;

positional characteristic sensing means including:

means operative in response to said received signals for providing a signal representing change in positional characteristics of objects in the zone;

means establishing a reference threshold in accordance with the static positional characteristics of the zone and stationary objects therein;

means for comparing said positional reference threshold with said positional signal to provide a change of position indication signal upon exceedance of said positional reference signal by said positional signal;

Doppler characteristic sensing means including:

means operative in response to said received signals for providing a signal representing the Doppler characteristics of objects in the zone;

means establishing a reference threshold in accordance with the Doppler characteristics of the zone and objects therein;

means for comparing said Doppler reference threshold with said Doppler signal to provide a motion indication signal upon exceedance of said Doppler reference threshold by said Doppler signal; and

means for producing an alarm only upon the simultaneous occurrence of said motion indication signal and said change of position indication signal.

2. An intrusion alarm system according to claim **1** wherein said signal receiving means comprises:

a receiving transducer operative to receive energy returned from the surveillance zone to provide an output signal;

a mixer operative to receive said receiving transducer output signal and to mix said transducer signal with a local oscillator signal for producing an output signal; and

a bandpass filter operative to pass both a spectrum of frequencies representing positional characteristics and a spectrum of frequencies containing the Doppler characteristics of objects within the surveillance zone.

3. An intrusion alarm system according to claim **2** wherein said receiving means further includes a limiting amplifier receiving said bandpass filter signal output for suppressing signal excursions above predetermined reference levels.

4. An intrusion alarm system according to claim **1** wherein:

said positional characteristic sensing means includes an integrator for providing a time averaged output to said positional reference threshold establishing means; and

wherein said positional reference threshold establishing means includes means establishing a bipolar reference threshold in accordance with the static amplitude and/or phase characteristics of objects under surveillance, such that said change of position indication signal is produced as said time averaged signal exceeds either bipolar reference threshold.

5. An intrusion alarm system according to claim **1** wherein:

said Doppler characteristic sensing means includes a detector for providing an output signal representative of the Doppler content of the received signal and an integrator for providing a time averaged output of said Doppler output signal; and

wherein said Doppler reference threshold establishing means includes means establishing a unipolar reference threshold in accordance with the Doppler characteristics of the zone under surveillance, such that said motion indication signal is produced as said time averaged signal exceeds said unipolar threshold.

6. An intrusion alarm system for monitoring a surveillance zone comprising:

a signal source;

a transmitting transducer deriving signals from said signal source;

a receiving transducer for receiving signals introduced into the surveillance zone by said transmitting transducer;

a signal mixer for receiving the signals from said receiving transducer and combining said signals with local oscillator signals from said signal source;

a bandpass filter for passing a predetermined spectrum of the signals produced by said mixer;

a limiting amplifier for limiting said bandpass filter output signals to prevent signal excursions above a predetermined reference level, said limiting amplifier producing output signals for a first channel and a second channel;

said first channel including a Doppler detector, a first integrator for integrating the output of said Doppler detector, and a unipolar threshold circuit, said first channel for producing a motion indication signal in response to signals from said first integrator exceeding a predetermined threshold level;

said second channel including a second integrator and a bipolar threshold circuit, said second channel for producing a change in position indication signal in response to said signals from said second integrator exceeding either one of said predetermined bipolar threshold levels and a gate circuit for producing an alarm signal only upon simultaneous occurrence of the motion indication signal and of the change in position indication signal.

7. A method for detecting an intruder in a zone under surveillance comprising the steps of:

transmitting signals into the surveillance zone;

receiving signals from the surveillance zone, said signals containing Doppler information indicative of motion within the zone and non-Doppler information indicative of the position of objects within the zone;

processing said signals to derive therefrom a position signal independent of motion in the zone to establish when a net change of position among the objects in the zone exceeds a predetermined threshold value;

processing said signals to derive therefrom a motion signal independent of said position information to establish when motion in the zone exceeds a predetermined value; and

indicating the presence of a target in the zone only upon the occurrence of both said motion and position signals.

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