ABSTRACT

An intrusion detection system comprises a fence mounted coaxial electret cable connected to remote signal processing apparatus which includes both automatic alarm circuits and a loudspeaker, the latter producing sounds generated by audio frequency signals propagating on the cable. The automatic alarm circuit responds to cable signals that meet predetermined criteria for bandpass, amplitude and duration to indicate a suspected intrusion; the loudspeaker reproduces sounds caused by the condition which produces the alarm and permits the operator to aurally determine the nature of the condition for verifying in real time its valid or spurious character. The signals on the cable may be manually or automatically switched to the loudspeaker or may be continuously connected to it as required or desired.

8 Claims, 4 Drawing Figures
INTRUSION DETECTION SYSTEM AND METHOD USING AN ELECTRET CABLE

BACKGROUND OF THE INVENTION

This invention relates to intrusion detection systems and more particularly to an improved perimeter-type intrusion detection system.

A fence mounted coaxial electret cable described in application Ser. No. 111,291, now U.S. Pat. No. 3,763,482 assigned to the assignee of this invention provides a signal to remote monitoring equipment when mechanical vibrations induced in the fence are applied to the cable. Such coaxial electret cable is a coaxial cable in which the dielectric filler between outer and inner conductors is an electret. Signal processing circuits in the monitoring equipment establish certain bandpass, time duration and amplitude criteria for the cable signals which actuate an alarm indicative of an attempted intrusion, such as the climbing of the fence or the severing of the fence with wire cutters. By judicious selection of these criteria, the possibility of alarms from signals generated by wind, falling objects, rain or hail, seismic vibrations, thunder, moving vehicles and the like is greatly reduced so that the so-called "false alarm" rate of this system is within acceptable limits.

In spite of such signal discrimination techniques, however, spurious signals occasionally generated on the cable do meet the established criteria and cause false alarms. This is due in part to a tradeoff between sophistication and cost of the discrimination circuits. Also, the general security requirement of detection systems that all intruder-caused signals produce an alarm dictates a predetermined sensitivity for the system and this increases the likelihood that some spurious signals will get through and affect the false alarm rate.

A desirable feature in such perimeter detection systems is the capability of identifying the nature of an attempted intrusion once it has produced an alarm. For example, it is desirable to know whether the attempted intrusion is the cutting of the fence or the climbing of it so that the correct type of counteraction can be taken. One way to achieve this capability is through deployment of television cameras at strategic locations around the protected perimeter with a monitor and master controls at the remote station. The disadvantage of this approach is high cost, installation difficulties and maintenance problems.

An object of this invention is the provision of a perimeter intrusion detection system in which the automatic alarm circuitry is augmented with means to enable the operator to listen to sounds generated by the condition which produced the alarm.

A further object is the provision of a low-cost technique for reproducing sounds made by a suspected intrusion of the perimeter protected by a coaxial electret cable.

This invention is based on the discovery that electric signals produced on a coaxial electret cable by mechanical vibrations can be converted to sound waves that duplicate the sound pattern of the condition causing the vibrations so that the sound pattern is recognizable by a human operator. Conversion of such signals to sound waves in a loudspeaker or the like provides the operator with an effective tool for immediately verifying the nature of the alarm condition and to further discriminate against spurious signals so as to minimize or eliminate costly time-consuming investigation of false alarms.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of a portion of a chain link fence to which a coaxial electret cable has been connected;

FIG. 2 is an enlarged cut-away portion of coaxial cable of FIG. 1 showing the fence mounted clamp ring;

FIG. 3 is a transverse section taken on line 3—3 of FIG. 2; and

FIG. 4 is a schematic diagram of signal processing and alarm circuits to which the coaxial electret cable is connected and showing the sound reproducing channel embodying this invention.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings, FIG. 1 shows a chain link fence 10 comprising vertical posts 11 secured in the ground G and supporting wire mesh fencing material 12. A coaxial electret cable 14 is secured by clamping rings 15 to the fencing material 12 throughout the entire length of the fence. Cable 14 is connected to a signal processor 16 preferably buried adjacent to the fence and output lines 17 and 18 connect the outputs from the processor to a remote station 19 containing monitoring equipment.

Clamp rings 15 tightly grip the outer surface of cable 14 and hold it against the fencing material so as to couple vibrations from the fence to the cable in such a manner as to produce an electrical signal within the cable. Processor 16 has a predetermined passband preferably of about 200 Hz to 4 kHz so that low frequency disturbances such as wind-induced fence movements which typically generate within the cable signals having a frequency characteristic below 200 Hz do not produce an alarm signal on output line 17. The system therefore is generally capable of discriminating against false alarms from such conditions. Disturbances which produce signals having frequencies within the passband such as severing of fence strands with a wire cutter (approximately 4 kHz), the climbing of the fence by a human, or snagging of clothing by the barbed wire strands do produce an output from processor 16 and provide an indication at station 19 that such compromises of the fence have been attempted.

Cable 14 has a braided sleeve-type outer conductor 20, see FIGS. 2 and 3, covered by an insulating sheath 21 made of polyvinylchloride or the like, an inner conductor 22 and a dielectric filler 23 in the space between the inner and outer conductors. The dielectric filler 23 is conditioned in such a manner that it is an electret polarized in the direction of a unidirectional (dc) electric field applied across inner conductor 22 and outer conductor 20, i.e., radially. These several coaxial layers are tightly formed around the inner conductor and normally are flexible and radially resilient. Clamping rings 15 tightly engage the periphery of the cable and lock it to strands 12a of fencing 12 so that no play exists between the cable and the fence strands at the point of connection. This insures that vibrations induced in the fence are coupled directly to the cable so as to move the outer conductor relative to the inner conductor.

Signal processor 16 in part comprises an ac amplifier 24, see FIG. 4, which places a resistive load between outer and inner conductors, and integrator 25, and a
threshold circuit 26 connected in series. Amplifier 24 has a high gain, preferably about 80 db, and has a pre-determined passband which may be and preferably is about 500–2,000 Hz. The threshold level of circuit 26 is adjustable by a variable resistor 27 to provide further discrimination against unwanted or spurious signals.

The output of circuit 26 is an alarm signal transmitted by line 17 to remote station 19 containing switch 28, the contacts 28a of which connect line 17 to alarm generator 29 such as a bell or flashing light.

In operation, vibrations transmitted to cable 14 on fence 10, for example, by an intruder climbing the fence, are converted to electric signals and are transmitted by cable 14 to processor circuit 16. The automatic alarm circuitry comprising amplifier 24, integrator 25 and threshold circuit 26 produces an output on line 17 if the cable generated signal meets the criteria of this circuit and is passed through switch 28 to cause generator 29 to produce an alarm.

The foregoing automatic alarm circuit and coaxial electret cable are described in application Ser. No. 111,291 and do not per se constitute this invention.

In accordance with this invention, processing circuit 16 includes an audio amplifier 31 whose input is connected by line 32 to the output of amplifier 24. The output of amplifier 31 on line 18, in one embodiment of the invention, is connected through normally open contacts 28b of manually operated switch 28 to a loudspeaker 34. Amplifier 31 amplifies the audio signals on cable 14 and drives speaker 34 when switch 28 is depressed to close contacts 28b. Thus the operator may manually switch the system from its automatic alarm state to its listening state by operation of switch 28.

In operation, the system is normally responsive to signals generated on cable 14 as a result of conditions which qualify as intrusions by bandpass, duration and amplitude criteria of the automatic alarm channel of processor 16. If such a signal is produced so as to activate alarm generator 29, the operator depresses switch 28 to connect the loudspeaker 34 by line 14 to audio amplifier 31. With the switch in this position, the operator may then listen to the sounds generated by the condition which alarmed generator 29. The electrical signals generated on the cable by the condition being monitored are of such quality as to uniquely reproduce the sound created by that condition. For example, the distinctive sounds made by a person climbing fence 12 remote from station 19 are carried by cable 14 as electrical signals to the station where they are reproduced in recognizable form by loudspeaker 34. Such sounds are different from those made by wire cutters on the fence and this difference is clearly recognizable from the sounds produced by the loudspeaker. Similarly, the sounds of rain on the fence are both distinctive and recognizable. With the additional aid of experience and training, the operator is enabled to make an immediate determination from these sounds whether the condition producing them is indeed an intrusion to be investigated as well as the nature of the intrusion or whether it is a spurious condition such as rain, wind, moving vehicle or the like which need not be investigated. The efficiency of the intrusion detection system in terms of minimizing false alarms is thereby greatly increased without complex costly modifications and the additional information available to the operator through aural monitoring of vibrations on the cable further enable him to initiate appropriate counteraction, if any, more intelligently.

In certain applications of the intrusion detection system described herein, such as when a rapidly moving intruder can quickly scale the fence, it is desirable that the system operator be able to listen to the sounds caused by the intruder immediately after the alarm condition is detected. FIG. 4 further illustrates additional circuits by which audio signals on cable 14 may automatically be switched to the loudspeaker 34 after alarm generator 29 is energized.

Alarm generator 29 is connected to a latch circuit 36 by line 37. Latch circuit 36 controls a relay 35 through line 38. Relay 35, when activated, switches audio signals from audio amplifier 31 directly to loudspeaker 34 in a manner similar to the manually operated switch 28. Whenever alarm generator 29 generates an alarm indication latch circuit 36 is triggered, thereby activating relay 35 and causing loudspeaker 34 to emit the sounds caused by the intruder. Latch circuit 36 continues to activate relay 35 regardless of the duration of the output on line 37 of the alarm generator 29, until reset either by a manual control 40 or by an automatic timer, not shown, contained within latch circuit 36. An alternative method of triggering latch circuit 36 is by integrator and threshold circuits similar but separate from integrator 25 and threshold circuit 26. Thus the processing parameters such as bandwidth, duration, and amplitude used to switch audio sounds to the loudspeaker could be different from the parameters used to trigger alarm generator 29. This technique has the advantage of providing the system operator with an indication of suspicious activity which does not meet alarm criteria, but which may be preliminary to an actual intrusion.

What is claimed is:

1. A system for detecting and identifying a source of mechanical vibrations in a solid body comprising a coaxial electret cable, means for mechanically externally coupling to said cable the mechanical vibrations produced in said body by said source whereby electrical signals are generated by said cable, said signals having a frequency in the audio range, an alarm device, a signal processor electrically connected to said cable and having a first output connected to said device and a second output comprising said audio frequency signals, said processor being responsive to certain of said electrical signals having predetermined characteristics for producing said first output for automatically energizing said alarm device, and transducer means electrically connectable to said second output and responsive to said audio frequency signals for converting same into sound waves.

2. The system according to claim 1 with automatic switch means connecting to said transducer means said second output of the processor in response to the energizing of said alarm device by the first output from said processor.

3. The method of detecting targets traversing an area protected by a fence consisting of the steps of tightly mechanically coupling a coaxial electret cable to the body of the fence and causing vibrations produced on the fence by a target to be coupled to said
cable whereby electrical signals are generated by said cable,
automatically actuating an alarm device solely in re-
response to certain of said electrical signals having
parameters characteristic of signals generated by
the target, and
energizing loudspeaker means with all of said electro-
cal signals and aurally verifying the nature of the
source of said vibrations to determine whether the
alarm is true or false.

4. The method according to claim 3 in which said
loudspeaker means is energized after actuation of the
alarm device.

5. The method according to claim 3 in which energy-
ization of said loudspeaker means is independent of the
actuation of the alarm device.

6. The method according to claim 5 in which said en-
ergization of the loudspeaker means is automatic after
actuation of the alarm device and is responsive to all
electrical signals generated by said cable.

7. The method of detecting intrusions of an area pro-
tected by a coaxial electret cable tightly coupled to a
solid body consisting of converting into sound waves
electrical signals generated on said cable by vibrations
transferred to the cable from the body whereby an op-
erator is enabled to aurally determine the nature of the
condition producing said vibrations.

8. In combination,
a solid body capable of transmitting mechanical vi-
brations produced by a condition to be monitored,
a coaxial electret cable,
means for mechanically coupling said cable to said
body whereby said vibrations cause said cable to
generate an electrical signal, and
means responsive to said electrical signal for indicat-
ing the character of the condition being monitored
and comprising transducer means for converting
signals having audio frequencies into sound waves.

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