United States Patent [19]

Skujins, Jr.

[11] **3,868,667**

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[54] **INTRUDER DETECTION SYSTEM EMBODYING A BIMORPH TRANSDUCER**

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

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[21] Appl. No.: **241,646**

[52] **U.S. Cl.** ..... **340/272**, 73/DIG. 4, 310/8.6, 340/261, 340/258 B

[51] **Int. Cl.** **G08b 13/20**, H01h 35/34

[58] **Field of Search** ..... 340/38, 258, 261, 272, 340/409; 310/9.7, 9.8, 8.6, 8.5, 9.6; 137/81; 73/407 R, 407 PR, DIG. 4

[56] **References Cited**

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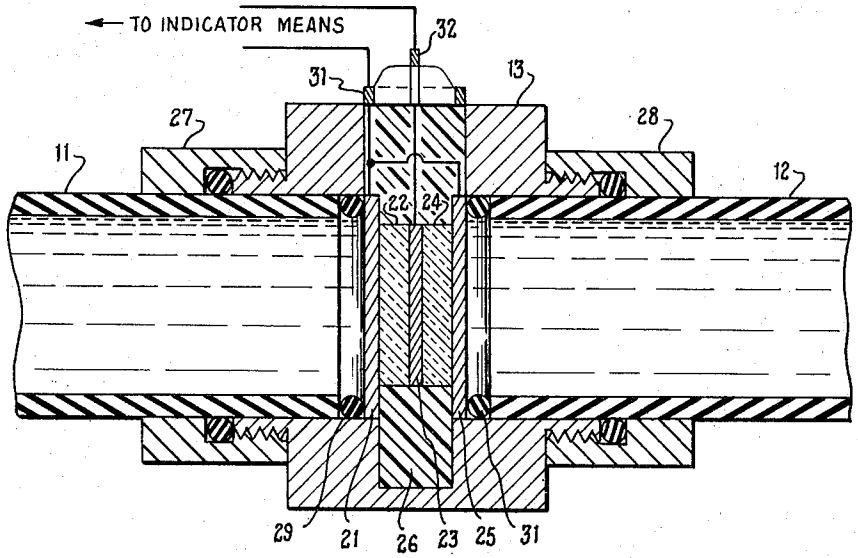
[57] **ABSTRACT**

The disclosed invention is an intruder detection system wherein the piezoelectric transducer responsive to two distinctive pressure signals comprises a hydrostatically balanced, two terminal bimorph assembly.

6 Claims, 2 Drawing Figures



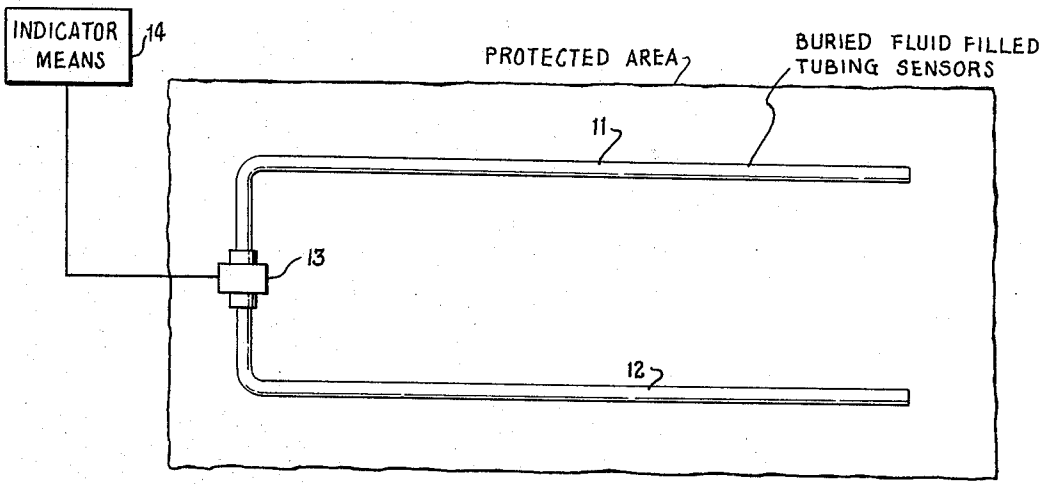
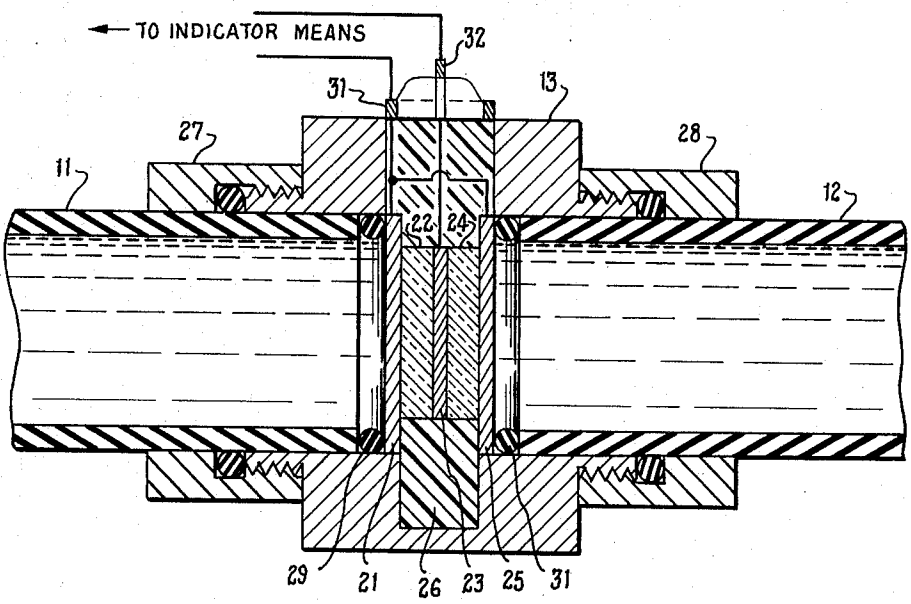

INDICATOR MEANS
14
PROTECTED AREA
BURIED FLUID FILLED TUBING SENSORS
11
13
12

Fig. 1


TO INDICATOR MEANS
32
31
13
27
28
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24
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Fig. 2

INTRUDER DETECTION SYSTEM EMBODYING A BIMORPH TRANSDUCER

GOVERNMENT RIGHTS IN THE INVENTION

The invention described herein may be manufactured, used and licensed by or for the Government of the United States without the payment of any royalty thereon.

BACKGROUND OF THE INVENTION

This invention is especially useful in buried sensor applications wherein the sensors are discretely placed and each sensor is responsive to absolute pressure disturbances produced by movement of an intruder in the immediate area of the sensors. Prior art balanced pressure intrusion detection systems of the type disclosed in the U.S. Pat. No. 3,438,021 to Nelkin, et al, for example, incorporate two separately functioning transducers each having an output responsive to an absolute pressure change. The two electrical output signals are combined to obtain the desired differential signal in a relatively complex electrical circuitry. It will be appreciated that in processing of the electrical signals, the electrical balance of the sensor channels is particularly critical and that the manufacture of such precise electronic circuitry is especially tedious and expensive. Moreover, the electrical balance may be subject to ambient conditions necessitating special environmental controls which may present an intolerable requirement in some circumstances. In addition, it is recognized that the useful life of balanced electronic equipment is limited by the performance of an assembly of components and that individual components in such assembly may deteriorate in service at different rates. In remote unattended applications, deterioration of an electronic component may disturb the essential balance condition and render the detection system effectively inoperative. In the absence of balance sensing means, the system may become unbalanced either by natural or deliberate action and thus disabled without notice to monitoring personnel.

It is an object of this invention to provide an intrusion detection system which places minimum reliance on electronic circuitry.

It is another object of this invention to provide a substantially tamper proof intrusion detection system which utilizes a relatively low cost pressure sensing transducer means which is impervious to moisture and may be buried in the ground.

It is further object of this invention to provide a long life, intrusion detection system which is suitable for relatively low ssignal level and low frequency applications approaching 0.01 Hz.

Other objects of the invention will become apparent upon a more comprehensive understanding of the invention for which reference is had to the following description of a preferred embodiment and the drawings wherein:

FIG. 1 exemplary depicts the minimum electronics pressure sensing detection system of the present invention.

FIG. 2 is a cross-sectional view of the two terminal piezoelectric transducer utilized in the embodiment of FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

FIG. 1 illustrates the system of this invention in a relatively basic intrusion detection application. In this embodiment, two fluid-filled tubes **11** and **12** are shallow buried, in like manner, in spaced parallel relation and in a traverse direction with respect anticipated direction of pedestrian or vehicular intrusion. The fluid-filled tubes **11** and **12** serve as pressure disturbance sensing elements in the system of this invention and moving intruders create pressure disturbances in each sensing element effectively simultaneously but of differing magnitude. The magnitude, of course, is dependent upon the distance of the intruder from the sensing elements and numerous environmental considerations.

The buried fluid-filled sensing elements **11** and **12** are connected to a unique transducer means **13,** shown in more detail in FIG. **2,** in such a manner that the magnitudes of the infrasonic signals in each sensing element are effectively compared and an electrical output is generated having the frequency of the sensed infrasonic signal and a magnitude representative of the difference in magnitudes of the sensed infrasonic signals. In accordance with the invention, the output of the transducer means **13** is connected to a relatively simple alarm or indicator means **14** which may be above ground, as shown, and is responsive to signals of selected frequency and magnitude. Obviously, the system of this invention may be adapted or modified in accordance with standard practice in buried balanced pressure detection systems to improve reliability or any other significant characteristic of the system.

FIG. **2** is a cross-sectional showing of the unique flexure mode transducer means **13** in the embodiment of FIG. **1.** It will be appreciated that the flexible members of the transducer means **13** normally are relatively thin and that the thickness of such flexible members has been exaggerated in the showing of FIG. **2** merely for purposes of clarity of illustration. In FIG. **2,** the sensing elements **11** and **12** are connected to a two terminal bimorph structure consisting of metallic disc **21,** piezoelectric crystal **22,** metallic disc **23,** piezoelectric crystal **24** and metallic disc **25.** In accordance with the invention, the metallic discs **21** and **25** are electrically connected in parallel to terminal **31** of the indicator means **14** and metallic disc **23** is electrically connected to terminal **32** of the indicator means **14.**

The piezoelectric crystals **22** and **24,** which may be barium titanate or the like, should be substantially identical in flexural characteristics and preferably are of the same size and configuration, normally circular. In actual practice, the crystals **22** and **24** are mechanically and electrically bonded to their respective metallic discs by a plastic resin or the like. A metallic mesh, not shown, may be disposed between each piezoelectric crystal and its respective metallic disc and imbedded in the plastic resin which serves to bond, if desired. Such metallic mesh is not essential to the invention but serves to insure electrical contact and to mechanically cushion the piezoelectric crystal structure.

In the event the diameter of the piezoelectric crystals **22** and **24** is less than the inner diameter of the sensing elements **11** and **12,** the spacing between the metallic discs **21** and **25** may be filled with a resilient potting compound, as shown at **26.** It is important to the sensitivity of the flexural transducer assembly, of course,

that the potting compound be not only impervious to the fluid in the sensing elements **11** and **12** but sufficiently resilient to permit relatively free flexure of the crystals **22** and **24.** Uniform consistancy of the potting compound is essential, of course, as discontinuities might disturb the flexure mode. It has been found that circular piezoelectric crystal elements and a center metallic disc of like diameter are relatively easy to assemble in a bimorph arrangement which meets essential requirements and such configuration and symmetry is preferred in the axial disposition shown in FIG. **2.**

It will be appreciated that the hydraulic tubing sensors **11** and **12** may be attached to the transducer means **13** by any conventional hose line fitting, for example threaded fittings as shown at **27** and **28.** It has been found desirable to minimize the possibility of damage during installation, and to mechanically isolate the transducer means during the detection operation, to employ resilient O rings as shown at **29** and **31.**

It is understood that the balanced pressure system of this invention is not restricted to the specifically illustrated embodiment and that various modifications, including alternative hydraulic tubing placments may be resorted to without departing from the purview of this disclosure.

I claim:

1. A system for detecting penetration of a restricted area by an intruder comprising:

first and second substantially identical fluid-filled elongated tubular chambers adapted for ground burial, said elongated chambers adapted to generate representative internal pressures in response to external pressures of the variety produced by movement of intruders in the vicinity of said elongated chambers when buried:

piezoelectric transducer means having first and second pressure sensitive inputs and a single electrical signal output, said piezoelectric transducer means being a planar dual crystal element bimorph structure wherein said first and second pressure sensitive inputs incorporate substantially identical planar crystal elements adapted for like flexure action, said bimorph structure adapted to produce an output signal potential when one crystal expands and the other contracts in response to an instantaneous pressure differential at said first and second pressure sensitive inputs; said first and second tubular chambers mechanically and hydraulically connected to said first and second pressure sensitive inputs such that the full surface area of one side of each respective planar crystal element is subject to said representative internal pressures within its respective tubular chamber;

an indicator means electrically connected to said electrical signal output of said piezoelectric transducer means and adapted to produce an indication in response to said instantaneous pressure differential.

2. A system as defined in claim **1** wherein said electrical signal output of said transducer means is a two terminal output and the electrical signal is measured thereacross, and wherein said dual crystal bimorph structure comprises first and second planar crystal elements cemented in fact to face relation with a first flexible metallic surface therebetween electrically connected to one terminal of said electrical signal output, plus second and third flexible metallic surfaces afixed to the outward facing planar surfaces of said bimorph structure and electrically connected in parallel to the second terminal of said electrical signal output, each of said outward facing planar surfaces of said bimorph structure disposed in relation to a respective elongated sensor to react to fluid pressure deviations therein.

3. A system as defined in claim **2** wherein said flexible metallic surfaces have a thickness substantially less than the thickness of said planar crystal elements such that the flexural characteristics of said dual crystal bimorph structure are essentially determined by the flexural characteristics of said planar crystal elements.

4. A system as defined in claim **3** wherein each of said flexible metallic surfaces and said planar crystal elements have a circular disc configuration.

5. A system as defined in claim **4** wherein each of said flexible metallic surfaces and said planar crystal elements has substantially the same size circular disc configuration and said metallic surfaces and said crystal elements are disposed and alligned in a substantially symmetrical sandwich arrangement.

6. A system as defined in claim **5** wherein said circular disc configuration is a circle.

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