XR 3,582,692

United States

[11] 3,582,692

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[73] Assignee **U.S. Research Corporation**
Washington, D.C.

[54] RESILIENTLY SUPPORTED SENSING TRANSDUCER

4 Claims, 16 Drawing Figs.

[52] **U.S. Cl.** **310/8.5,** 310/8.1, 310/9.1, 310/9.2, 340/261, 340/272, 340/274, 340/278, 340/279, 340/280
[51] **Int. Cl.** **H02v 7/00,** H02r 17/00
[50] **Field of Search** 310/8.0, 8.3, 8.5, 9.1, 8.2, 9.2, 9.7; 248/304, 301, 497; 340/278, 279, 280, 261, 274, 272; 317/246

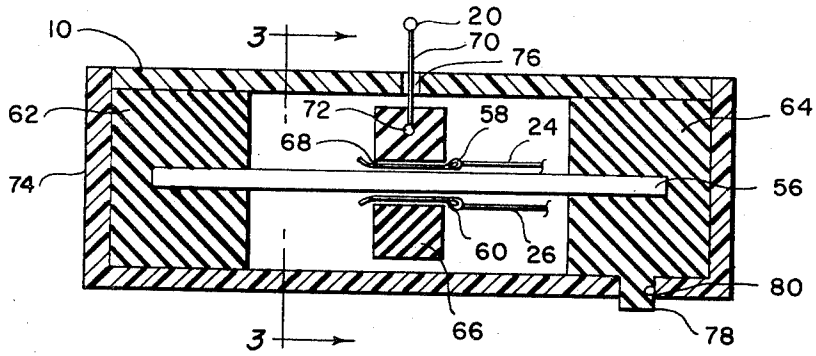
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ABSTRACT: An improved sensing transducer is provided which may be used to provide a signal in response to a change in an external pressure. The transducer is particularly effective when connected to a circuit with an alarm so that it may be used as a security device. The sensing transducer has a piezoelectric element, a pair of electrodes positioned on opposite sides of the element to pick up current from a voltage created across the element in response to mechanical stress upon the element, a supporting means connected to the element for supporting at least a portion of the element against movement, and an actuator means connected to the element for applying pressure to at least a portion of the element to create a stress in the element in response to the change in pressure to be sensed.



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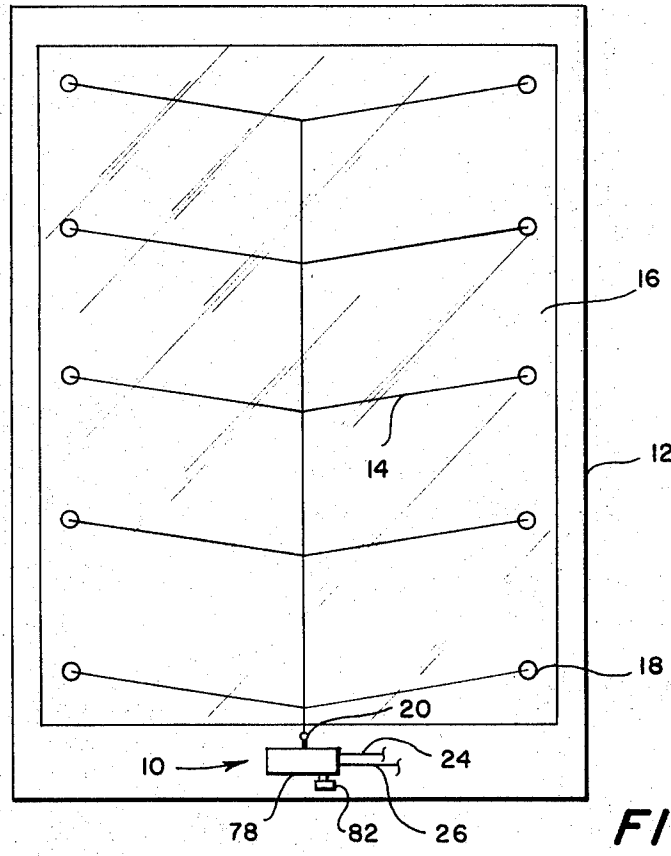


FIG. 1

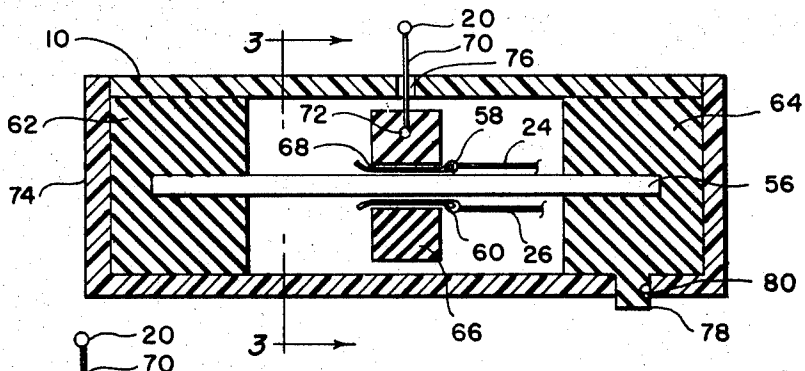


FIG. 2

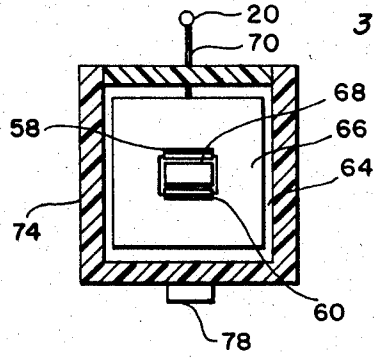


FIG. 3

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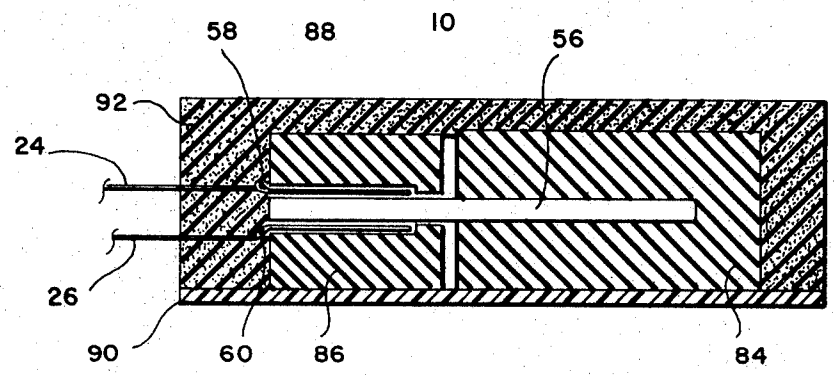


FIG. 4

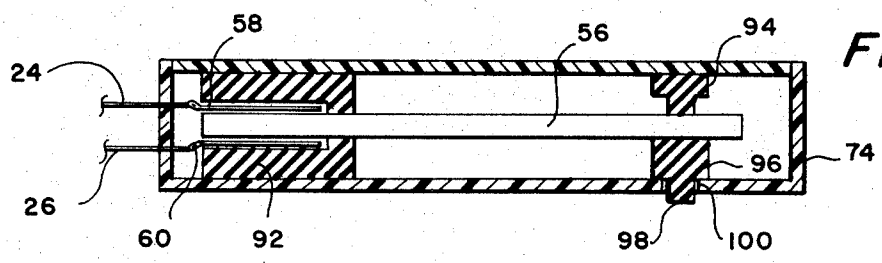


FIG. 5

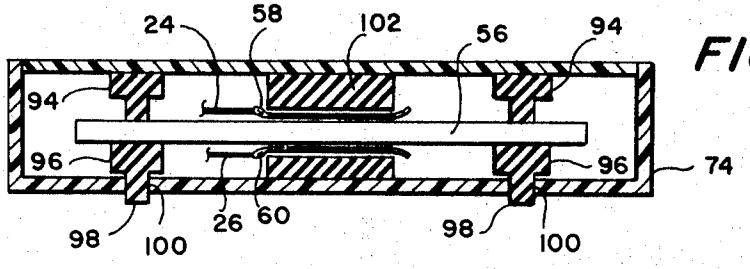


FIG. 6

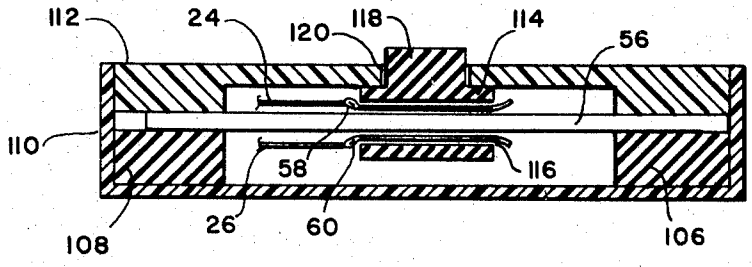


FIG. 7

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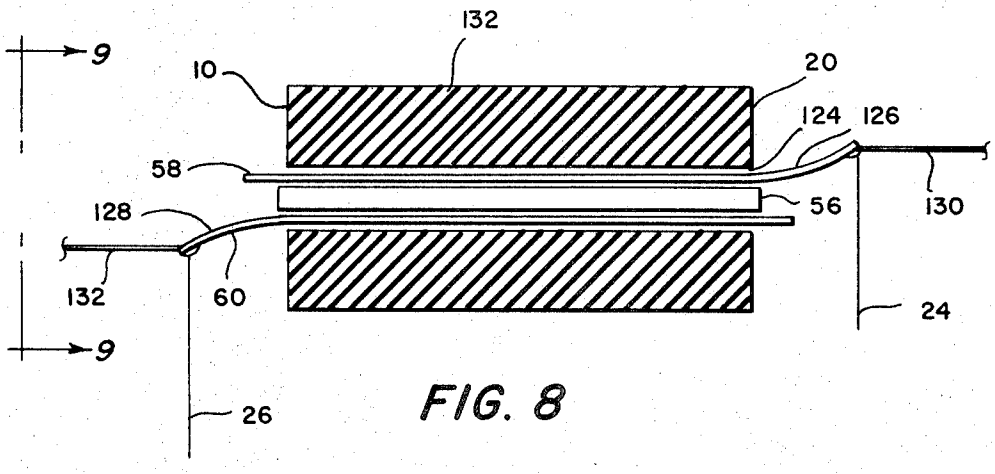


FIG. 8

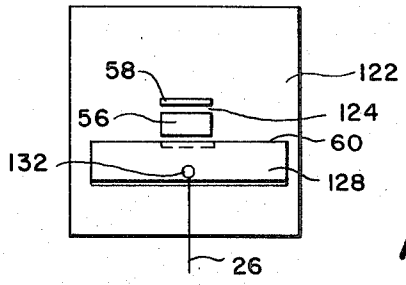


FIG. 9

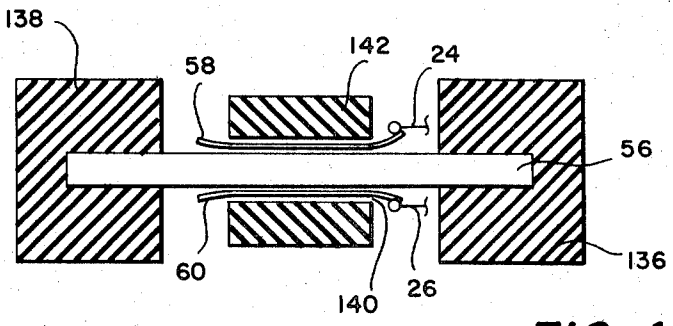


FIG. 10

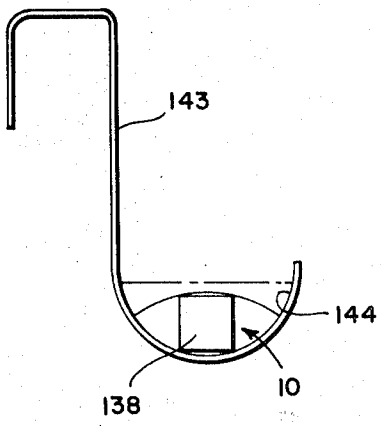


FIG. 11

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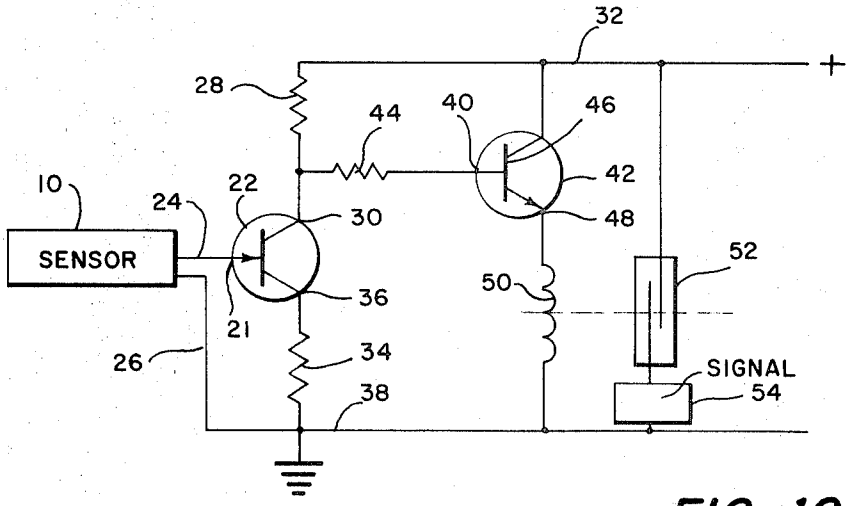


FIG. 12

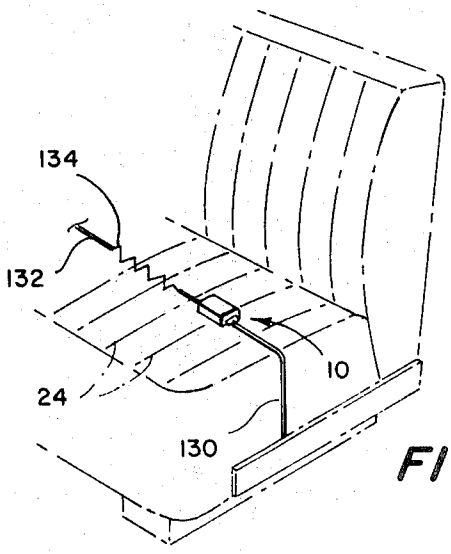


FIG. 14

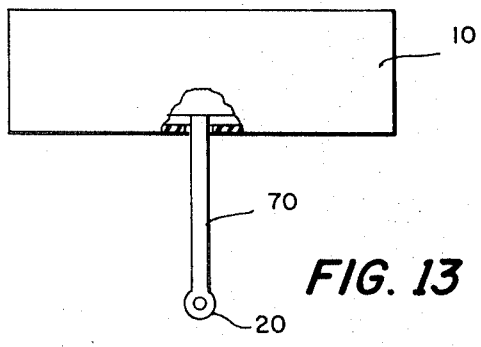


FIG. 13

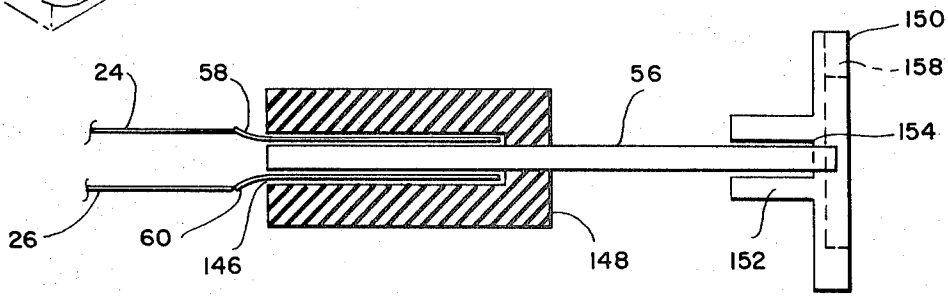


FIG. 15

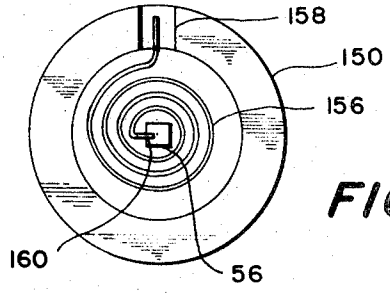


FIG. 16

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RESILIENTLY SUPPORTED SENSING TRANSDUCER

This invention relates to sensing transducers and more particularly to piezoelectric transducers.

The sensing transducers of this invention are of particular utility when used with trigger circuits as a part of a security system. The system may be used for protecting against the theft of objects, such as works of art, museum pieces, and displays; they may be used to provide a warning when an intruder has opened or broken a window or has illegally entered a building, automobile, or the like.

The sensing transducers of this invention may also be used in conjunction with a security system connected to a cash register or the like to provide a warning when unauthorized persons have attempted to remove money from the cash register.

The uses of the sensing transducers of this invention are not limited to security situations, but also include informational systems such as where the signal from the transducer provides information concerning the presence of a person seated in a certain chair or the like.

Many additional uses will become readily apparent to those skilled in the art without departing from the spirit or scope of this invention.

Sensing transducers have been used in the past for security systems and the like. However, the prior art transducers have not been capable of detecting very small pressure changes which are frequently encountered when a vandal removes a small item from a large exhibit, as for example, a hat or other piece of clothing from a mannequin, or an article from a table containing several articles. Thus, there is a need for a reliable sensing transducer which can sense very light pressure changes and at the same time is of rugged construction and can withstand heavy loads.

It is therefore a primary object of this invention to provide a new and improved sensing transducer.

It is a further object of this invention to provide a new and improved sensing transducer which can be used in conjunction with a warning circuit for actuating a signal as a part of a security device or the like.

Additional objects and advantages of the invention will be set forth in part in the description which follows and in part will be obvious from the description or may be learned by practice of the invention, the objects and advantages being realized and attained by the means of the instrumentalities and combinations particularly pointed out in the appended claims.

To achieve the foregoing objects and in accordance with the purpose of the invention as embodied and broadly described herein, the sensing transducer of this invention comprises; a piezoelectric element, a pair of electrodes positioned on opposite sides of the element to pick up current from a voltage created across the element due to a change in mechanical stress upon the element, supporting means for supporting a portion of the element against movement, and actuator means operatively connected to the element for applying pressure to the element to create a stress in the element in response to the change in pressure to be sensed.

Preferably, the electrodes are positioned either between a portion of the actuator means and the element or between a portion of the supporting means and the element.

In one embodiment of the invention, the electrodes each have at least one end curved out of the plane of the main portion of the electrode and connecting means are connected to the curved ends of the electrode for applying pressure to the end of the electrodes to cause the electrodes to act as the actuator means, by applying pressure to the element to create a mechanical stress upon the element.

The invention consists in the novel parts, constructions, arrangements, combinations, and improvements shown and described.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory but are not restrictive of the invention.

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate preferred embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

FIG. 1 is a front elevation of a sensing transducer constructed in accordance with this invention shown in conjunction with a security system for a window;

FIG. 2 is a front elevation partially in section of the sensing transducer illustrated in FIG. 1;

FIG. 3 is a vertical section taken along line 3–3 of FIG. 2;

FIG. 4 is a front elevation partially in section of another embodiment of the sensing transducer constructed in accordance with the teachings of this invention;

FIG. 5 is a front elevation partially in section of another embodiment of a sensing transducer constructed in accordance with the teachings of this invention;

FIG. 6 is a front elevation partially in section of another embodiment of a sensing transducer constructed in accordance with the teachings of this invention;

FIG. 7 is a front elevation partially in section of another embodiment of a sensing transducer constructed in accordance with the teachings of this invention;

FIG. 8 is a front elevation partially in section of another embodiment of a sensing transducer constructed in accordance with the teachings of this invention;

FIG. 9 is an end elevation of the sensing transducer of FIG. 8;

FIG. 10 is a front elevation partially in section of another transducer constructed in accordance with the teachings of this invention;

FIG. 11 is an end elevation of a picture hook having the sensing transducer of FIG. 10 mounted therein;

FIG. 12 is a circuit schematic diagram illustrating a typical connection for the sensing transducers of this invention to a warning circuit operating an alarm device;

FIG. 13 is a front elevation partially in section of a sensing transducer constructed in accordance with the teachings of this invention which may be used as a hanger;

FIG. 14 is a partial perspective view of an automobile seat illustrating the connection of the sensing transducer illustrated in FIG. 8 to the automobile seat;

FIG. 15 is a front elevation partially in section of a sensing transducer constructed in accordance with the teachings of this invention, and

FIG. 16 is a right end elevation of the sensing transducer of FIG. 15.

Referring first to the embodiment illustrated in FIGS. 1—3, it may be seen that the sensing transducer, generally 10, is mounted on a window, generally 12. Hair-thin break wires 14 are mounted on glass 16 by means of adapters 18 and are connected through a common wire to a connector 20 on sensing transducer 10.

Sensing transducer 10 is connected by conductors 24 and 26 to a suitable warning circuit, a typical example of which is illustrated in FIG. 12. Referring to FIG. 12, it may be seen that the sensing transducer 10 is connected to the gate electrode 21 of a unijunction transistor, generally 22 by conductor 24. Conductor 26 connects sensing transducer 10 to a ground. Unijunction transistor 22 is connected across a power supply by the means of a biasing resistor 28 connected between the conduction electrode 30 and a supply conductor 32 and by a biasing resistor 34 connected between the conduction electrode 36 of unijunction transistor 22 and a grounded (or negative) supply conductor 38.

A connection is made from the conduction electrode 30 of unijunction transistor 22 to the base electrode 40 of semiconductor transistor, generally 42, through a biasing resistor 44. Transistor 42 is connected by its collector electrode 46 to the positive power supply conductor 32 and is connected by its emitter electrode 48 through a magnetic coil 50 to the grounded supply conductor 38. Magnetic coil 50 is physically constructed so as to be in close proximity to a vibrating reed switch 52. Vibrating reed switch 52 is connected to supply conductor 32 on one end and to a signal device 54 on its other end. Signal device 54 is in turn connected to grounded supply conductor 38.

Describing now the operation of the circuit illustrated in FIG. 12, it is assumed that the initial conditions are such that the sensing transducer 10 has no output. Accordingly, unijunction transistor 22 will conduct a leakage current of predetermined value through its electrodes 30 and 36. This leakage current serves to initially bias the semiconductor-switching transistor 42 into a state wherein little or no current will flow from the supply conductor 32 through the collector-emitter path 46—48, and the magnetic coil 50, to grounded conductor 38. Thus, the magnetic field produced by magnetic coil 50, if any, will not be sufficient to actuate vibrating reed switch 52 and signal 54 will remain deenergized.

When a change in pressure is sensed by such sensing transducer 10, as will be described in more detail hereinafter, a current impulse is carried by conductor 24 to gate electrode 21 of the unijunction transistor 22. The biasing level of unijunction transistor 22 is, accordingly, adjusted so that current flow through the conduction electrodes 30 and 36 of the unijunction transistor 22 decreases by a predetermined amount. This decrease in current flow effects a decrease in voltage drop across resistor 28, thus increasing the voltage appearing in the conduction electrode 30 of the unijunction transistor 22. This increased voltage is in turn applied to the base electrode 40 of transistor 42 through biasing resistor 44, thus changing the biasing conditions for transistor 42. Transistor 42 will then conduct an increased amount of current through its collector-emitter path 46—48 causing an increased amount of current to flow through magnetic coil 50 which produces a magnetic field of sufficient strength to initially actuate vibrating reed switch 52 and consequently energize signal device 54.

Other circuits may be used in conjunction with the sensing transducers of this invention without departing from the spirit and scope of the invention. The presently described and illustrated circuitry is for purposes of explanation and other acceptable circuits will become apparent to those skilled in the art.

For example, magnetic coil 50 could be placed in the collector circuit rather than the emitter circuit as described. Additionally, the biasing resistor 44 connected to base electrode 40 of transistor 42 could be eliminated or a variable resistor could be substituted therefor as desired. Another modification could include changing transistor 42 schematically designated as a NPN transistor to a PNP transistor with obvious changes being made in biasing such as connection of the base electrode 40 to the conduction electrode 36 of unijunction transistor 22. Transistor 42 could also be a solid-state trigger unit as, for example, a SCR (Silicon-Controlled Rectifier).

Although it is necessary that the signal from the sensing transducer be received by a highly sensitive device such as a unijunction transistor, other suitable devices such as an N channel MOS-FET (Metal Oxide Semiconductor-Field Effect Transistor), a P channel MOS-FET, or a photo-FET could also be used. Signal 54 may be a light, bell, or any suitable means.

Having described generally the use of a sensing transducer of this invention, we will now refer to the inventive sensing transducer itself.

Referring to FIGS. 2—3, it may be seen that the sensing transducer includes a piezoelectric element 56, a pair of electrodes 58 and 60 positioned on opposite sides of element 56 to pick up current from voltages created across element 56 when changes in mechanical stress occur in element 56.

The sensing transducer of this invention also includes supporting means for supporting a portion of the element against movement, and actuator means operatively connected to the element for applying pressure to create a stress in the element in response to the pressure to be sensed. As here embodied, the supporting means is comprised of rubber blocks 62 and 64 positioned at the ends of piezoelectric element 56 which is illustrated as being elongated and rectangular in shape. As here embodied, the actuator means comprises a rubber holder 66 having a central slot 68 extending therethrough. Piezoelectric element 56 with electrodes 58 and 60 adjacent thereto are mounted in slot 68 of rubber holder 66.

It is to be noted that although for purposes of clarity it appears that the electrodes are spaced from element 56 in each of the embodiments illustrated, the slots in the rubber blocks which hold the electrodes and the piezoelectric element are tight fitting with the electrodes being firmly pressed against the sides of the element so that the rubber blocks hold both the element and the electrodes in proper alignment.

Two conductors corresponding to conductors 24 and 26 in FIGS. 1 and 12 are connected to electrodes 58 and 60. Conductors 24 and 26 pass out of shell 74 in an appropriate place, as for example, by passing through rubber block 64 and the end of housing 74 as illustrated in FIG. 1. As here embodied, sensing transducer 10 also includes a housing and connecting means extending through an opening in the housing to connect the actuator means to the item in which the change in pressure is to be sensed.

The housing here embodied consists of a plastic shell 74 surrounding the other components of the transducer. As here embodied, the connecting means comprises a wire 70 fastened to a slot 72 in holder 66 and extending through an opening 76 in housing 74, and connector 20 attached to the end of wire 70.

This embodiment of the sensing transducer also includes a second actuator means. As here embodied, the right-hand support which is rubber block 64 has a protrusion 78 extending from its lower end through an opening 80 in housing 74. Protrusion 78 thus may transmit pressure from outside of the housing through rubber block 64 to one end of element 56. Since element 56 is held stationary by rubber block 62, this pressure creates a stress on the element.

The operation of the sensing transducer illustrated in FIGS. 2—3 will now be described in conjunction with the window security system illustrated in FIG. 1. It is to be understood, however, that the transducer of FIGS. 2—3 may be used many different ways as well as that illustrated in FIG. 1. Connector 20 is fastened to hair-thin break wires 14 with a slight tension which is transferred through wire 70 to rubber holder 66, which in turn applies pressure on element 56. Since rubber blocks 62 and 64 hold the element relatively stationary at its ends, this pressure creates a stress on element 56.

This initial stress will create voltage across element 56 and a current impulse is picked up by electrodes 58 and 60 and carried by conductors 24 and 26 which are connected to the warning circuit such as that illustrated in FIG. 12. The power to the warning circuit will be cut off when the transducer is initially loaded to prevent a signal at that time.

If an intruder or an unauthorized person breaks glass 16 of window 12, hair-thin break wires 14 will also be broken causing a change in the tension on wire 70 and hence in the tension on holder 66 which in turn changes the stress on piezoelectric element 56. The change in stress on element 56 creates a current impulse which is picked up by electrodes 58 and 60 and carried by conductors 24 and 26 to the warning circuit shown in FIG. 12 which operates as described above to cause a signal to issue from signal device 54.

Because of the sensitivity of the transducer, the breaking of even one of hair-thin break wires 14 with the resultant change in tension of the group of wires on wire 70 will result in a signal from signal device 54.

The second actuator means, protrusion 78, is utilized to provide a warning if the window is opened without breaking the glass. This warning is accomplished by the use of a wedge-shaped abutment 82 mounted on the window casement. When the window is pivoted to the closed position, abutment 82 creates a pressure on protrusion 78 which in turn is transmitted through rubber block 64 to the end of piezoelectric element 56 creating a stress in the element. As described above, the initial stress will cause a signal in the warning circuit unless it is shut off at the time of loading. When the window is pivoted to the open position, protrusion 78 passes out of contact with wedge 82 relieving the pressure on protrusion 78, thereby changing the stress on element 56. This change in stress creates a voltage across element 56 and a current impulse is picked up by electrodes 58 and 60.

Any type of standard piezoelectric element may be utilized in the sensing transducer of this invention. One particularly effective element is manufactured by Clevite of Bedford, Ohio, under the name of PZT-5H-BIMORPH.

It should be noted that for the purposes of illustration and explanation the size of the sensing transducer units has been greatly magnified. These units can be made extremely small and are typically less than three-fourths inch long, less than one-fourth inch deep and less than one-fourth inch wide. The exact size and shape of the unit used will depend in most cases on the function for which the unit is to be used. The most desirable size and shape will be easily determined by those skilled in the art from the description set forth in the specification.

In discussing the other embodiments of the sensing transducer of this invention, the parts which are similar or identical to the parts illustrated in FIGS. 1 and 2 will be given the same number.

Referring now to the embodiment illustrated in FIG. 4, it may be seen that the piezoelectric element 56 is mounted at one end in a rubber block 84 and at the other end in a rubber block 86. Blocks 84 and 86 cover substantially the entire length of element 56 with a slight gap between the two blocks. Electrodes 58 and 60 are mounted on opposite sides of element 57 in a slot 88 in block 86.

In this embodiment sensing transducer 10 includes a housing made up of a plastic base 90 and a flexible cover 92 which may be rubber or other suitable material. Conductors 24 and 26 which are connected to electrodes 58 and 60 extend through the housing to be connected to appropriate circuitry as described above.

As here embodied, pressure is applied to the flexible portion 92 of the housing to create a stress in element 56. If the pressure is applied to the right-hand end of the sensing transducer, then block 84 will act as the actuator means and block 86 will act as the supporting means. If pressure is applied to the left-hand end of the sensing transducer, block 86 will act as the actuator means and block 84 will act as the supporting means.

This particular sensing transducer is useful where an article may be placed on one end of the transducer and it is desired to sense the removal of this article or a portion of the article.

As may be readily seen, when the article is initially set on one end of the transducer, its pressure will be transmitted through the flexible housing and the associated rubber block to the element 56 creating a stress on the element. When the article or a portion of the article is removed, the amount of pressure acting on the element 56 will be changed thus changing the stress in element 56 and creating an impulse of current which is picked up and carried by electrodes 58 and 60 through conductors 24 and 26 to the appropriate circuitry for providing a signal.

Referring now to the embodiment illustrated in FIG. 5, piezoelectric element 56 is mounted at its left end in a supporting means which is a rubber block 93. Electrodes 58 and 60 are mounted on opposite sides of element 56 between blocks 93 and element 56. The actuator means is comprised of a pair of resilient T-shaped elements 94 which in this instance are rubber. As here embodied, the transducer also includes a housing made up of a plastic shell 74. As may be seen, T 94 has its upper surface resting against the undersurface of shell 74 and its lower surface resting on element 56.

T 96 has its upper surface resting against element 56 and its lower end extending, as a protrusion 98, through a slot 100 in shell 74. The purpose of the T shape of T 94 is so a firm abutment will be achieved between the inside surface of shell 74 and T 94 while at the same time not providing too strong a force acting on the upper surface of element 56 at the place where T 96 must apply sufficient pressure to bend element 56. For this same reason, T 94 is desirably made of a softer rubber than block 93.

In the operation of this embodiment, an article is placed on the upper surface of shell 74 which creates pressure on protrusion 98 of T 96. This pressure is transmitted through T 96 to element 56. Since element 56 is held stationary by block 93 a stress is created in element 56. When the object or a portion of the object is removed, the pressure on protrusion 98 and hence the stress on piezoelectric element 56 is changed creating an impulse which is picked up by electrodes 58 and 60 and transmitted through conductors 24 and 26 to appropriate circuitry to supply a signal.

Referring to the embodiment illustrated in FIG. 6, it may be seen that element 56 is mounted on two substantially identical actuator means, one located near each end of the element, and supporting means located between the two actuator means. As here embodied, the transducer is mounted in a housing consisting of a plastic shell 74. The two actuator means are comprised of two upper resilient T's 94 having their upper surfaces supported against the inner surface of shell 74 and their lower surfaces abutting element 56. The actuator means further includes two lower T's 96 having their upper surfaces abutting element 56 with their lower ends extending as protrusions 98 through slots 100 in shell 74.

As here embodied, the supporting means is comprised of a block 102 which is here made of rubber and has a longitudinal slot 104 in which are mounted element 56 and electrodes 58 and 60. Preferably, T's 94 are made of a softer rubber than block 102 so that element 56 will be bent when pressure is applied to T's 96 since T's 94 will be compressed but block 102 will not.

Here again, conductors 24 and 26 pass out of the shell 74 through appropriate openings to a suitable circuit such as that illustrated in FIG. 12.

In operation, an article is placed on the upper surface of shell 74. The weight of the article creates a pressure on protrusion 98 of lower T's 96. This pressure in turn is transmitted to element 56 and tends to force the ends of the element upwardly while the center of the element 56 is held stationary by rubber block 102. This action creates a stress in element 56. When the article or a portion of the article is removed the pressure acting on T's 96 is decreased thus decreasing the pressure acting on element 56 and thereby changing the stress in element 56. The change in stress creates a current impulse which is picked up by electrodes 58 and 60 and carried to the warning circuit through conductors 24 and 26.

Referring now to the embodiment illustrated in FIG. 7, the sensing transducer has two rubber block-supporting means 106 and 108 located at the ends of element 56. In this embodiment, the transducer includes a housing which is made of a plastic cup 110 and a plastic top 112. The housing is made in two parts so that the element may be placed on supporting means 106 and 108 and then the top placed on top of the element. The top 112 is secured to the sides of cup 110 so that top 112 does not create pressures on element 56.

As here embodied, the actuator means is comprised of a rubber holder 114 having a longitudinal slot 116 extending therethrough. Element 56 and electrodes 58 and 60 are mounted in slot 116 with the two electrodes being on opposite sides of element 56. Holder 114 includes a protrusion 118 extending upwardly through a slot 120 in plastic top 112 of the housing.

The operation of the sensing transducer of FIG. 7 is as follows. An article is placed on the top of the transducer with at least a portion of the article resting on protrusion 118 of holder 114. The weight of the article creates a pressure on protrusion 118 which in turn is transmitted through holder 114 to element 56. Since element 56 is supported by blocks 106 and 108 at its ends, this pressure at the midpoint tends to bow element 56 and creates a stress in the element. When the article or a portion of the article is removed, the pressure on protrusion 118 and hence on element 56 is reduced thereby reducing the stress in element 56. This change in stress in element 56 creates an impulse of current which is picked up by electrodes 58 and 60 and conducted to the appropriate circuit through conductors 24 and 26.

Referring now to the embodiment of the sensing transducer illustrated in FIGS. 8, 9, and 14, it may be seen that piezoelec-

tric element **56** is mounted between a pair of electrodes **58** and **60**. The electrodes and the piezoelectric element are mounted in a slot **124** in a supporting means which in this embodiment is a rubber block **122**. Electrodes **58** and **60** are connected to conductors **24** and **26** which are in turn connected to a suitable warning circuit such as that illustrated in FIG. **12**. Electrodes **58** and **60** have curved ends **126** and **128** which are connected to connecting means which in this case are wires **130** and **132**, respectively.

In operation of this sensing transducer, wires **130** and **132** are connected across an article on which pressure is to be sensed. An example of such an element is illustrated in FIG. **14** where the transducer is mounted underneath the seat cover on the seat of an automobile with wires **130** and **132** extending across the width of the seat. A spring coil **134** is connected to wire **132** to limit the amount of pressure which can be applied to electrodes **58** and **60**. When someone sits on the seat in the automobile, the weight of the person causes the wires to stretch coil spring **134** applying pressure to the ends of electrodes **58** and **60**. Since the ends of electrodes **58** and **60** are curved, the electrodes tend to pivot within slot **124** and block **122**. This pivoting of the electrodes applies pressure to piezoelectric element **56** creating a stress in the element. The stress in turn creates a current impulse in electrodes **58** and **60** which is carried to a suitable warning circuit through conductors **24** and **26**.

As may be best seen in FIG. **9**, the curved ends **126** and **128** of electrodes **58** and **60** are wider than the remaining portion of the electrode. This additional width provides an increased area for the connection of the wires **130** and **132** to the end of the electrodes.

Referring now to the embodiment illustrated in FIGS. **10** and **11**, it may be seen that the sensing transducer is comprised of a piezoelectric element **56** mounted in actuator means which as here embodied comprises two rubber blocks **136** and **138**. A pair of electrodes **58** and **60** are mounted on opposite sides of element **56** in a slot **140** of supporting means, rubber block **142**.

Conductors **24** and **26** connect electrodes **58** and **60** to an appropriate warning circuit such as that illustrated in FIG. **12**. As may be seen in FIG. **11**, this embodiment of the sensing transducer of this invention is particularly useful in conjunction with hook **143** for pictures or the like.

After the transducer is placed in the base of the hook, the base area of the hook is filled with flexible material **144** such as plastic or the like, which acts as a housing for the transducer.

In use of the picture hook-sensing transducer combination, the hook is placed on the wall and a picture or the like is hung on the hook with the picture wire resting on rubber blocks **136** and **138** of the sensing transducer in the base of hook **143**. The weight of the picture will cause pressure to be exerted by the picture wire on the outer edges of the rubber blocks **136** and **138**. The pressure is transmitted through blocks to element **56** and tends to bow element **56** creating a stress.

If the picture or a portion of the picture is removed from the hook, the amount of pressure being exerted on blocks **136** and **138** will be reduced causing a reduced pressure on the ends of piezoelectric element **56**. This reduced pressure reduces the stress in element **56**. The change in stress in element **56** creates a current impulse which is picked up by electrodes **58** and **60** and carried through conductors **24** and **26** to the warning circuit.

FIG. **13** illustrates another type of sensing transducer-hook combination, utilizing a sensing transducer like that illustrated in FIGS. **2** and **3**.

The sensing transducer is mounted on the wall in an inverted position as compared with the position of the element illustrated in FIGS. **2** and **3**. Wire **70** and connector **20** are made strong enough to hold a hook or the like connected to a picture or other article. In this embodiment, protrusion **78** of rubber block **64** is not needed and has been omitted.

In the embodiment illustrated in FIGS. **15** and **16**, piezoelectric element **56** is mounted in a slot **146** in a supporting means which is in this case a rubber block **148**. Electrodes **58** and **60** are mounted on opposite sides of element **56** in slot **146** and are connected to conductors **24** and **26** which are connected in turn to a warning circuit such as that illustrated in FIG. **12**.

In accordance with the invention, actuator means is provided on one end of element **56**. As here embodied, the actuator means includes a turning means or disc **150** which has an inwardly extending stem **152**. Disc **150** has a longitudinal slot **154** extending through its center and the end of element **56** is positioned in the slot. Disc **150** is free to revolve on element **56**. As best seen in FIG. **16**, a spiral spring **156** is mounted in disc **150** with one end of spring **156** being connected to an adapter **158** on disc **150** and the other end of spring **156** being connected to a slot **160** in element **56**.

This embodiment of the sensing transducer is particularly useful in providing a security system for a cash register or the like.

Specifically, disc **150** may be connected by appropriate means to the holddown lever which holds bills in their place in the cash drawer of the cash register. When the holddown lever is pivoted into position on top of the bills, disc **150** is turned creating a tension in spiral spring **156**, which tends to twist the end of element **56**. This force on the end of element **56** creates a stress in element **56** which causes an initial current impulse in electrodes **58** and **60**. As explained above, the warning circuit desirably is disconnected during this initial loading of the system.

With the system in operation, if bills are removed from under the lever or if the lever is lifted to permit removal of a stack of bills, disc **150** will be turned creating a change in tension on spring **156**. The change in tension on spring **156** causes a change in the stress on element **56**. The changes in stress on element **56** create a signal which is picked up by electrodes **58** and **60** and carried by conductors **24** and **26** to the warning circuit thus providing a signal or warning that the bills are removed.

This system may be coupled with a circuit whereby an authorized person can remove bills without causing a warning signal by pushing a button or the like to disengage the warning circuitry. In such a system, the sensing transducer may be left on constantly and will provide a signal any time any unauthorized person removes bills from the cash register drawer.

In accordance with the invention a new and improved sensing transducer has been provided which is extremely sensitive and durable and which may be used in security systems or the like.

It will be apparent to those skilled in the art that many modifications and variations could be made in the sensing transducer without departing from the scope or spirit of this invention.

The invention in its broader aspects is not limited to the specific details shown and described but departures may be made from such details within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

What I claim is:

1. An improved sensing transducer for sensing changes in mechanical pressure and supplying a signal in response to the change in pressure comprising:

a. a piezoelectric element;

b. a pair of electrodes positioned on opposite sides of said element to pick up current from a voltage created across said element due to mechanical stress upon said element;

c. supporting means for supporting a portion of said element against movement;

d. resilient actuator means connected to said element for applying pressure to said element to create the stress in said element in response to the change in pressure to be sensed; and

e. a housing;

f. said supporting means comprising at least two supports, one mounted at each end of said element with at least one of said supports being resilient and having a protrusion extending out of said housing to provide a second actuator means which operates by transmitting pressure from outside of said housing through said support to one end of said element to create a stress on said element.

2. An improved sensing transducer for sensing changes in mechanical pressure and supplying a signal in response to the change in pressure comprising:

a. an elongated piezoelectric element;

b. a pair of electrodes positioned on opposite sides of said element to pick up current from a voltage created across said element due to mechanical stress upon said element;

c. supporting means for supporting a portion of said element against movement; and

d. resilient actuator means connected to said element for applying pressure to said element to create a stress in said element in response to the change in pressure to be sensed, said actuator means comprising two substantially identical actuator means, one located at each end of said element and said support means located between said two actuator means.

3. An improved sensing transducer for sensing changes in mechanical pressure and supplying a signal in response to the change in pressure comprising:

a. a piezoelectric element;

b. a pair of electrodes positioned on opposite sides of said element to pick up current from a voltage created across the element due to mechanical stress upon said element;

c. supporting means for supporting a portion of said element

against movement; and

d. resilient actuator means connected to said element for applying pressure to said element to create a stress on said element in response to the change in pressure to be sensed;

e. said support means being located at one end of said element and said actuator means being located at the other end of said element;

f. said actuator means including turning means which may be twisted to impart stress to said element and a coil spring for transmitting stress from said turning means to said element.

4. A picture hook for use in a security device to protect an object suspended on the hook from unauthorized removal, which comprises:

a hook having a base portion for receiving a wire on which an object is supported; and

a sensing transducer located in said base portion of said hook and having a piezoelectric element for detecting small changes in mechanical pressure and providing a voltage due to stress of said element;

said sensing transducer including:

actuator means including a pair of blocks in which opposite ends of said piezoelectric element are mounted;

supporting means located between said blocks and having a slot for receiving said element; and

a pair of electrodes mounted on opposite sides of said element and located in said slot for sensing a voltage created across said element due to stress of said element.