April 11, 1967 J. C. SANCHEZ 3,314,035

SEMICONDUCTOR POTENTIOMETER

Filed Sept. 4, 1964

FIG. 1a.

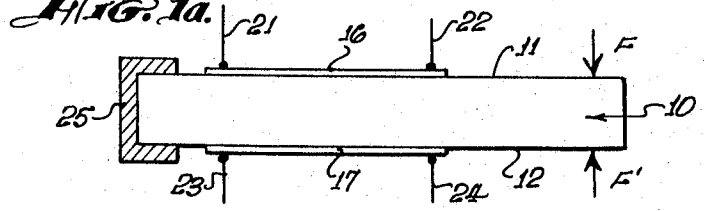



FIG. 1b.

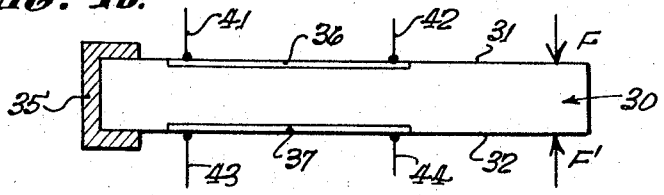



FIG. 2.

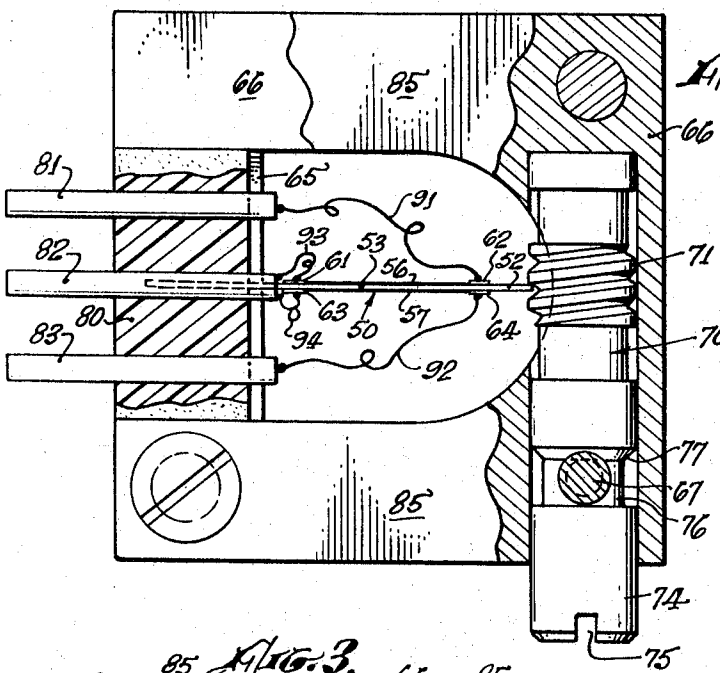



FIG. 4.

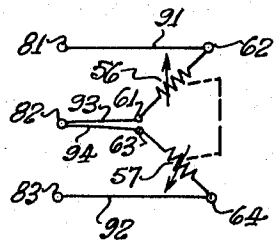



FIG. 3.

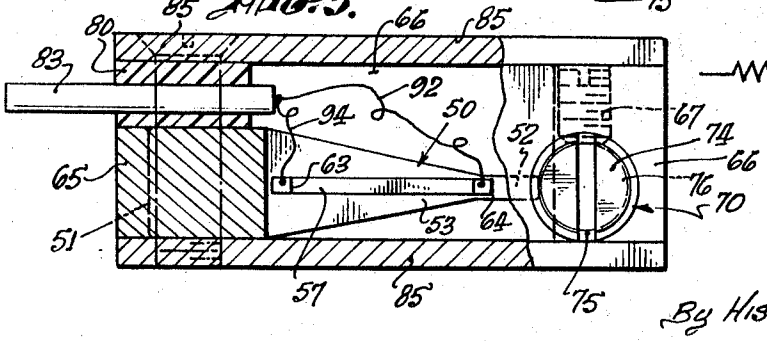
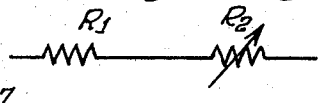



FIG. 5.




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United States Patent Office 3,314,035 Patented Apr. 11, 1967



3,314,035

# SEMICONDUCTOR POTENTIOMETER

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Filed Sept. 4, 1964, Ser. No. 394,553
2 Claims. (Cl. 338—68)

This invention relates to variable resistance devices and more particularly to improved variable resistance device structures utilizing piezoresistive elements.

Present art variable resistance devices commonly employ an electrical contact which is movable in response to an applied force, the movement being along a resistance path defined on the surface of a resistance body. One typical type of resistance body consists of a length of resistance wire spirally wound on a supporting form, movement of the electrical contact changing the effective resistance in single-turn increments. Another typical type utilizes a carbon composition body, movement of the electrical contact providing a continuous variation in effective resistance. The adjusting force which causes movement of the electrical contact to cause variation in the effective resistance of such devices may be either manually or mechanically applied.

However, such prior art variable resistance device structures are not without their attendant disadvantages. The resistance resolution of the wire-wound types is limited by the number of turns of wire and the available space. Both the wire-wound and composition types offer poor resistance to vibration, and an increase in contact pressure to overcome vibrational effects results in high frictional forces which render the devices more sensitive to wear. Furthermore, the presence of dust or other particulate material between the sliding contact and the resistance body increases wear and results in high electrical noise, varying contact resistance, and even complete opening of the contact. All of these aforementioned disadvantageous characteristics have an adverse effect on device reliability, particularly in aircraft and missile applications where impact and high-G forces are commonly encountered. Due to the limited available space for electronic equipment in aircraft and missiles, such applications present the additional requirements that the variable resistance devices must also be extremely compact. Thus, there is a present need for extremely compact and highly reliable variable resistance devices, such as trimming potentiometers, for example.

The present invention is predicated upon the discovery that the application of a controllably variably stress to a piezoresistive element will provide an improved variable resistance device which has no movable electrical contact, thereby resulting in lower electrical noise and less frictional wear together with obviation of the other enumerated disadvantageous characteristics of present art variable resistance devices.

The name given to a change in resistivity caused by applied stress is the piezoresistance effect. All materials probably exhibit the piezoresistance effect to some degree. Although the typical prior art use of piezoresistive elements is in strain gauge applications, a thin rod or bar of any material exhibiting a sufficient piezoresistance effect can be used as a variable resistance, variations in resistance being caused by changes in an applied stress. Prior art piezoresistive elements typically have been fabricated from wire, convoluted so that a sufficient length of wire can be used to provide a usable sensitivity without forming too bulky a device. Recently the use of semiconductor elements have been adopted due to their pronounced piezoresistive effect, thereby enabling a great increase in device sensitivity.

Young's modulus relates the change in stress to the strain by the equation $E=S/e$, where S represents stress and $e$ represents strain. $e$ in the above equation is the longitudinal strain resulting from simple longitudinal stress, S, assuming no stress in the transverse direction. The fractional change in resistivity due to a stress S is $\Delta\rho/\rho=\pi S$, where $\pi$ is the longitudinal piezoresistance coefficient and where $\rho$ represents the resistivity of the material. Thus, $\Delta\rho/\rho=\pi eE$. This can be written as $Me$, where M is defined as $\pi E$. In a crystalline material, such as silicon for example, both $\pi$ and M vary with direction.



Since the resistance, R, of a rod of any material$=\rho L/A$, where L is the length of the rod and A its cross-sectional area, it can be shown for a simple case that

$$\Delta R/R=(1+2\delta+M)e$$

$\delta$ denotes Poisson's ratio; i.e., the ratio of the magnitude of transverse strain to longitudinal strain resulting from the postulated simple stress S. In the above equation, the first term on the right expresses the resistance change due to change in length; the second term is due to the change in area; and the third term is due to the resistivity change.

It is known that semiconductor materials exhibit a piezoresistive effect and semiconductor crystals of certain crystallographic orientations exhibit extremely high percentage resistance changes for a given applied stress. The pronounced piezoresistive effect of semiconductor crystals has rendered properly oriented semiconductor crystal bodies extremely useful as strain-electric transducing elements, percentage resistance changes on the order of one hundred times that of prior art wire or foil elements being easily attainable. The use of semiconductor crystals as unbonded strain-electric transducing elements provides the additional advantage of freedom from hysteresis. Due to these operational advantages, semiconductor crystals are presently preferred for use as the piezoresistive elements forming the resistance bodies in the present invention devices. However, it is to be understood that any other type of piezoresistance element can be used.

The term "active impurity" is used herein to denote those impurities which affect the electrical rectification characteristics of semiconductor materials, as distinguished from other impurities which have no appreciable effect upon these characteristics. Active impurities are ordinarily classified as "donor impurities," such as phosphorous, arsenic and antimony or "acceptor impurities," such as boron, aluminum, gallium and indium.

In the semiconductor art, a region of semiconductor material containing an excess of free electrons is considered to be an N type region, while a P type region is one containing an excess of acceptor impurities, resulting in a deficiency of electrons, or stated differently, an excess of holes. In an intrinsic region (I region), the holes and the electrons are in balance and hence the region cannot be said to be of either N type or P type conductivity. When considering a semiconductor body having a plurality of regions of the same conductivity type but of different active impurity concentration, a reference system utilizing (+) and (−) symbols appended to the conductivity type designating letter is in common use to enable convenient designation of doping levels relative to the active impurity concentration of an arbitrarily chosen region. For example, in a semiconductor crystal body having three P type regions, one of the regions being of a higher active impurity concentration than the chosen reference region and the other region being of a lower active impurity concentration than the chosen reference region, the reference region is designated as the P region, the more highly doped region being designated the $P^+$ region and the more lightly doped region being designated the $P^-$ region. Similarly, in a semi-

conductor crystal body having two N type conductivity regions of differing active impurity concentration, one of the regions may be designated an N region and the other region designated an $N^+$ region.

When a continuous solid specimen of crystal semiconductor material has an N type region adjacent to a P type region, the boundary between them is termed a PN (or NP) junction. The term "junction" as used herein is intended to include the boundary between an N region and an $N^+$ region, and that between a P region and a $P^+$ region, as well as any other combination of P, N, I, $P^+$, $N^+$, $P^-$ and $N^-$ which result in an electrical conductivity barrier between any two such adjoining regions. The use of piezoresistive elements formed of semiconductor bodies containing certain junction configurations has been found to provide additional advantages, as will be hereinbelow explained.

Accordingly, it is an object of the present invention to provide improved variable resistance device structures.

It is also an object of the present invention to provide improved variable resistance device structures which have no movable electrical contact.

It is another object of the present invention to provide improved variable resistance device structures utilizing resistance bodies fabricated from piezoresistive elements.

It is a further object of the present invention to provide compact and highly reliable variable resistance device structures utilizing resistance bodies fabricated from piezoresistive elements.

It is still another object of the present invention to provide improved resistance device structures, the resistances of which are continuously variable.

It is a still further object of the present invention to provide improved variable resistance device structures which are relatively insensitive to vibration.

It is also an object of the present invention to provide improved variable resistance device structures which are free from the high frictional forces of a movable electrical contact and the wear resulting therefrom.

The objects of the present invention are accomplished through the use of a piezoresistive element as a resistance body, controlled variation in a stress applied to the piezoresistive element resulting in controlled variation of its resistance. Various structural embodiments are suitable for application of this present invention concept. For example, the piezoresistive element can be supported as a beam which is loaded by a selectively adjustable force. In a hereinbelow illustrated embodiment, a unitary semiconductor crystal body is supported as a cantilever beam which is point-loaded at its free end by an adjusting screw.

The novel features which are believed to be characteristic of this invention, both as to its organization and method of operation, together with further objects and advantages thereof will be better understood from the following description considered in connection with the accompanying drawings, in which a presently preferred embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

In the drawings:

FIGURE 1*a* is an elevation view, partly in section, showing piezoresistive elements bonded to a beam which is supported at one end and adapted for deflection by point-loading of its free end;

FIGURE 1*b* is an elevation view, partly in section, showing the piezoresistive elements as an integral part of the cantilever beam;

FIGURE 2 is a plan view, showing a practical embodiment of the variable resistance device suitable for use with the instrumented beams of FIGURES 1*a* and 1*b*, the cover plate of the device being removed;

FIGURE 3 is a view taken along the line 3—3 of FIGURE 2;



FIGURE 4 is a schematic diagram of the variable resistance device of FIGURE 2; and,

FIGURE 5 is an equivalent circuit diagram of the variable resistance device of FIGURE 2.

Turning now to the drawing, in FIGURE 1*a* there is shown a solid-state resistance body in accordance with the present invention concepts, comprising a pair of piezoresistive elements bonded to a beam. The resistance body includes an elongate beam **10** secured at one of its ends as a cantilever beam and having respective upper and lower surfaces **11** and **12**. Bonded to the upper surface **11** of the beam **10** is a first elongate piezoresistive element **16**, while bonded to the lower surface **12** of the beam **10** is another elongate piezoresistive element **17**. The piezoresistive elements **16** and **17** are preferably unitary silicon crystals although, as indicated hereinabove, any type of piezoresistive element can be used. In this illustrated embodiment, both of the piezoresistive elements **16** and **17** should have the same type of resistance change characteristics. For example, if the resistance of the element **16** increases when the element is subjected to tension and decreases when the element is subjected to compression, then the element **17** must also be of a type exhibiting an increase in resistance upon being subjected to tension and a decrease in resistance upon being subjected to compression.

The beam **10** can be fabricated of metal, plastic or any suitable material capable of sufficient deflection, within its elastic limits, to provide a usable resistance change in the piezoresistive elements bonded thereto. It is presently preferred to utilize a semiconductor crystal body for the beam **10** to obtain the additional advantage of freedom hysteresis. The piezoresistive elements **16** and **17** are bonded to the respective upper and lower surfaces of the beam **10** by suitable means, such as epoxy cement. If the beam **10** is fabricated from an electrically conductive material, then an insulating layer, such as a sheet of paper or plastic, should be interposed between the piezoresistive elements and the beam. Piezoresistive elements for use as bonded strain gauges are commercially available, the piezoresistive elements being mounted on an insulating carrier member. Such strain gauge elements are readily adaptable for use in the bonded beam configuration of FIGURE 1*a*.

An ohmic contact is provided near each end of the piezoresistive element **16**, an electrical lead **22** being bonded to the other ohmic contact. The piezoresistive element **17** is provided with similar ohmic contacts at either end and with electrical leads **23** and **24** attached thereto, as shown. Ohmic contact to the semiconductor crystals can be established conveniently through the use of masking and metalizing techniques.

The beam **10** is cantilever supported at one of its ends by a support structure. The neutral axis of the composite device consisting of the beam **10** with the piezoresistive elements **16** and **17** bonded thereto is completely contained within the beam **10**. The resistance of the piezoresistive elements **16** and **17** can be changed by point-loading of the cantilever beam at its free end by a force F or F′ applied thereto. The deflection of the beam as a result of an applied force will result in equal but opposite forces acting on either side of the neutral axis of the beam. When subjected to the downwardly directed force F, illustrated in FIGURE 1*a*, the piezoresistive element **16** will be subjected to tension while the piezoresistive element **17** will be subjected to compression.

In FIGURE 1*b* of the drawing, there is shown a solid-state resistance body formed from a unitary semiconductor crystal **30** having an upper surface **31** and lower surface **32**. The crystal **30** is rigidly secured at one of its ends by a mounting clamp **35**, thus being cantilevered and adapted for deflection by application of a force F or F′ applied thereto at its free end. An elongate resistance region **36** is formed in the upper surface **31** of the crystal beam **30** by diffusion of active impurity atoms into the parent crystal body, the diffused active impurity atoms

being of the opposite conductivity type from the semiconductor material of the parent crystal body. A similar resistance region **37** is formed by the diffusion of active impurity atoms into the lower surface **32** of the crystal beam **30**. Since the resistance regions **36** and **37** are of the opposite conductivity type from the parent material of the crystal beam **30**, these surface regions will be electrically isolated from the remainder of the crystal body by the junctions formed at the boundaries between them. In the operation of the ordinary PN junction semiconductor device, current carriers move from region to region across the PN junction. Use of the PN junction semiconductor device in the present invention results in the movement of current carriers only within single regions, the high impedance barriers formed by the PN junctions serving to electrically isolate the different regions of the semiconductor body, there being no significant movement of carriers across the PN junctions.

More particularly, the resistance body of FIGURE 1*b* comprises a unitary semiconductor crystal, preferably silicon, in which an intermediate first region of one conductivity type electrically isolates second and third regions of the other conductivity type, the second and third regions being integrally formed in the crystal body. The second and third regions are spaced apart by the first region and electrically isolated one from the other by means of the high impedance barriers provided by the junctions formed at the boundaries between the first and second regions and between the first and third regions. The surface regions of the body are so arranged that elastic strain of the body will subject the second and third regions which form the resistance elements to strains which are translated to changes in the electrical resistances of these second and third regions. The electrical resistances of the second and third regions are separately measurable, due to their electrical isolation, although such regions form integral parts of the body subjected to strain-inducing stresses.

Any member, such as a beam, plate or the like, strained by bending, for example, will have a neutral axis with equal but opposite forces acting on either side of the neutral axis. In a conventional unitary body of semiconductor or other material, these equal but opposite forces will neutralize the overall change in the electrical resistance of the body. However, by the provision of integral surface regions in the body, which surface regions are electrically isolated from each other and from the remainder of the body, the change in electrical resistance in each of the surface regions can be detected. Thus, although the surface regions are subjected to strain as an integral part of the body, the electrical resistance of each region is determinable as an electrically isolated part of the body. A resistance body of the type illustrated in FIGURE 1*b* can be fabricated from a single unitary semiconductor crystal, using the method disclosed in U.S. Letters Patent 3,049,685, entitled, "Electrical Strain Transducer," issued August 14, 1962, to William V. Wright, Jr.

It is known that P type silicon of a [111] crystallographic orientation and N type silicon of a [100] crystallographic orientation exhibit extremely high percentage resistance changes with applied stress. It is also known that P type silicon exhibits a positive resistance change characteristic under applied stress, while N type silicon exhibits a negative resistance change characteristic under applied stress. Thus, if it is desired to provide a device of FIGURE 1*b* characterized by an extremely high percentage resistance change characteristic, the surface regions **36** and **37** should either be P type silicon of a [111] crystallographic orientation or N type silicon of a [100] crystallographic orientation. If, for example, P type surface regions are desired the crystal body **30** may be fabricated of a N type silicon of a [111] crystallographic orientation. Thus, upon completion of a diffusion operation which creates the P type surface regions **36** and **37** forming the resistance elements of the device, these resistance elements will be of the desired pronounced piezoresistive effect. Similarly, if the device of FIGURE 1*b* is formed by diffusing N type surface regions into a P type silicon crystal, the P type starting crystal should be of the [100] crystallograpic orientation to provide the desired high percentage resistance change per unit stress. Of course, various other crystallographic orientations may be chosen in accordance with the resistance change characteristic desired.

Ohmic contacts are provided at each end of the elongate resistance region **36**, an electrical lead **41** being bonded to one of the ohmic contacts and an electrical lead **42** being bonded to the other ohmic contact. Similarly, ohmic contacts are provided near each end of the elongate resistance region **37**, electrical leads **43** and **44** being bonded to these ohmic contacts.

In FIGURES 2 and 3 of the drawing there are depicted various views of a presently preferred embodiment of the complete present invention variable resistance device, using the unitary cantilever beam resistance structure of the type shown in FIGURE 1*b*, it being understood, however, that the bonded type of resistance element depicted in FIGURE 1*a* could be substituted therefor.

A thin, silicon crystal beam **50** is utilized, the beam being of an irregular shape having a large rectangular end section **51** and a small rectangular end section **52** separated by a tapered section **53**. Elongate rectangular surface regions **56** and **57** are formed by diffusion of active impurity atoms into opposite sides of corresponding portions of the central section **53**, the active impurity atoms being of the opposite conductivity type from the parent crystal material. Ohmic contacts **61** and **62** are provided at opposite ends of the surface region **56** and ohmic contacts **63** and **64** provided at opposite ends of the surface region **57**. The large rectangular end section **51** of the crystal beam is rigidly secured within a rectangular support block **65** of a suitable insulating material, such as plastic. The support block **65** is secured in the open end of a U-shaped hollowed-out portion in a body block **66** which forms the device housing, the crystal beam **50** projecting into the U-shaped opening.

An adjusting screw **70** is rotatably mounted within a suitable aperture in the body block **66**. The screw **70** is provided with a circumferentially threaded portion **71**, a part of which projects into the U-shaped opening in the body block **66**, the tip of the small end portion **52** of the crystal beam being engaged with the threads as can best be seen in FIGURE 2. The adjusting screw **70** is provided with a head section **74** of enlarged dimeter, a portion of the head section projecting from the body block **66**. A transverse slot **75** in the projecting end of the head section allows selective rotation of the screw by screwdriver or other suitable implement.

A reduced diameter neck portion **76** is cut into the head section **74** and includes a tapered wall surface **77** for engagement with the rounded end of a stop pin **67** so that the stop pin **67** will prevent axial movement of the adjusting screw while permitting rotational movement of the adjusting screw.

Mounted atop the support block **65** is a rectangular mounting block **80** through which extend three electrode pins **81**, **82**, and **83**. The upper surface of the mounting block **80** coincides with the upper surface of the body block **66** so that a cover plate **85** (see FIGURE 3) may be sealed thereto to completely enclose the crystal beam. The blocks **65**, **66** and **80**, together with the cover plate **85** are fabricated from an insulating material, such as plastic for example, and can be united in a compact and rigid assemblage by a suitable adhesive substance such as epoxy cement.

A whisker lead **91** has one of its ends bonded to the ohmic contact **62** and its other end bonded to the end of the electrode pin **81** projecting into the U-shaped opening. A whisker lead **92** similarly electrically interconnects the ohmic contact **64** to the electrode pin **83**. Whisker leads

93 and 94 connect the respective ohmic contacts 61 and 63 with the electrode pin 82.

Upon rotation of the adjusting screw 70 the free end of the crystal beam 50 will be deflected, the direction of deflection depending upon the direction of rotation of the screw. In the illustrated embodiment, the adjusting screw 70 is provided with the slot 75 for screwdriver adjustment. Alternatively, the projecting head section 74 of the adjusting screw could be coupled to other means of rotation, such an an adjusting knob. Rotation of the screw provides controllable variation of the beam loading and hence selective variation of resistance.

The embodiment of FIGURES 2 and 3 is assembled in such a manner that the crystal beam 50 is in an undeflected position at approximately the mid range of the screw threads so that the beam will be deflected in one direction near one extreme of the normal range of adjustment of the screw and deflected in the other direction near the other extreme of the screw adjustment.

In practice, the length of the crystal beam 50 can be conveniently on the order of one quarter inch or less and the body block 66 fabricated from a cubical block one half inch or less on a side. The thickness dimension of the crystal beam can conveniently be about 0.005 to 0.020 inch, the screw pitch being about 0.015 to 0.100 inch. The extremely small size of the device practically eliminates all mechanical resonance effects and provides an extremely compact package.

Turning now to FIGURE 4 of the drawing, there is shown a schematic diagram of the variable resistance device of FIGURES 2 and 3, the surface regions 56 and 57 forming the resistance elements being depicted by the schematic symbol identifying a variable resistance. When the adjusting screw is turned in such a manner so as to cause deflection of the crystal beam 50 toward the electrode pin 81, the surface region 56 forming one of the piezoresistive elements will be subjected to compression while the surface region 57 forming the other piezoresistive element will be subjected to tension. Conversely, when the crystal beam is deflected toward the electrode pin 83, the piezoresistive element formed by the surface region 56 will be subjected to tension while the piezoresistive element formed by the surface region 57 will be subjected to compression. Thus, bending of the beam will cause an increase in the resistance of one of the piezoresistive elements with a corresponding decrease in the resistance of the other piezoresistive element, thereby resulting in a relatively wide range of resistance adjustment together with a relatively constant value of total series resistance.

In FIGURE 5 of the drawing there is shown the equivalent circuit diagram of a piezoresistive element, the circuit diagram including a fixed resistance $R_1$ in series with a variable resistance $R_2$. The resistance $R_1$ indicates the minimum resistance of the element and the resistance $R_2$ indicates the range of resistance variation of the element. Under normal conditions a crystalbeam type of piezoresistive element may be strained to produce about a plus or minus 50% change in resistance per unit resistance. Thus, the resistance of a 1000 ohm element (1000 ohms being the element resistance with the beam in an unstressed condition) may be varied from about five hundred ohms to about fifteen hundred ohms while still providing reliable operation. Under such exemplary conditions, in the equivalent circuit diagram of FIGURE 5 the fixed resistance $R_1$ would be 500 ohms and the variable resistance $R_2$ would be 0–1000 ohms. As a practical matter, piezoresistive elements can be fabricated anywhere within the range of from 10 ohms to about 10,000 ohms, these elements being reliably variable plus or minus 50% about their nominal resistance values. Other types of piezoresistive elements are available within the range of from about 1 ohm to about 1 megohm with various resistance change characteristics.

A further advantage of the illustrated embodiment, wherein resistance elements are positioned on opposite sides of the neutral axis of a cantilever beam subjected to strain, is that temperature effects will be eliminated when the piezoresistive elements are of the same resistance characteristics because the temperature variation of both of the bridge arms (see FIGURE 4) will be identical. Those skilled in the art will, of course, appreciate that a pair of piezoresistive elements of opposite resistance change characteristics may be utilized, both of the elements being mounted on the same surface of the beam and hence both subjected to the same type of strain. If a series rheostat function is desired, only one resistance element need be utilized.

Although the hereinabove illustrated embodiment utilizes an end-loaded cantilever beam type of structure, various other structural embodiments for the application of a controllably variable stress to a piezoresistive element are suitable. For example, a piezoresistive element disposed on a center-loaded beam supported at its ends could be utilized. Or, an elongate piezoresistive element, such as a wire or foil type for example, could be secured to a volute spring or to a coil spring, the innermost end of the spring being secured and the outermost free end of the spring controllably moved to vary the spring tension. Various other suitable embodiments will become apparent to those skilled in the art.

Thus there has been described novel variable resistance device structures in which there are no moving electrical contacts, thereby providing a significant improvement in the art. The elimination of moving electrical contacts in variable resistance devices not only insures that the variable resistance elements are permanently maintained in the circuit but also eliminates the problems of variable contact resistance and frictional wear. Although any type of piezoresistive element can be utilized in the application of the present invention concepts, it is presently preferred to utilize unitary semiconductor crystal elements to obtain the additional advantages of freedom from hysteresis and various resistance change characteristics for the same material depending upon selection of the crystallographic orientation. Thus, although the invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made by way only of an example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed. For example, although the illustrated embodiment utilizes point-loading of a beam, other types of loadings as well as other types of piezoresistive element supports may be utilized. Furthermore, the controllably variable stressing of the piezoresistive element need not be derived from a manually applied force, but may be derived from a mechanically applied force or from a pressure, for example.

What is claimed is:

1. A potentiometer device comprising:

(a) a support structure consisting of a substantially rectangular body block defining an elongate slot therein, and a support block of electrical insulating material mounted to said body block within said slot and extending across the open end of said slot;

(b) an elongate unitary crystal semiconductor body of a predetermined conductivity type defining a large end section and a small end section separated by a tapered intermediate section, said semiconductor body being ridigly secured at its large end to said support block and extending into said slot, whereby said semiconductor body is supported as a cantilever beam, said semiconductor body further defining first and second surface regions in said intermediate tapered section on opposing sides of the beam neutral axis, each of said first and second surface regions being of the conductivity type opposite to said predetermined conductivity type and having the same type of resistance change characteristic, a semi-

conductor barrier junction electrically isolating each of said surface regions from the remainder of the semiconductor body, each of said surface regions having spaced apart ohmic contacts thereon for establishing electrical connection thereto;

(c) adjustable screw means rotatably mounted within said body block and having an elongate circumferential threaded portion extending partially into said slot substantially perpendicular to said semiconductor body adjacent its small end section and with the tip of said small end section engaged with the threads of said screw means for controllably deflecting the crystal beam upon rotation of the screw means; and

(e) first, second and third terminal pins mounted to said support block and extending into said slot, flexible wire means electrically connecting said first terminal pin to one of the ohmic contacts on said first surface region, said second terminal pin to one of the ohmic contacts on said second surface region, and said third terminal pin to the other ohmic contact of each of said first and second surface regions.

2. The potentiometer device defined in claim 1, wherein said screw means further defines a reduced diameter intermediate portion within said body block, said potentiometer device further including a stop pin fixedly mounted within said body block and receptively engaged with the reduced diameter portion of said screw means to prevent axial movement of said screw means upon rotation thereof.




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