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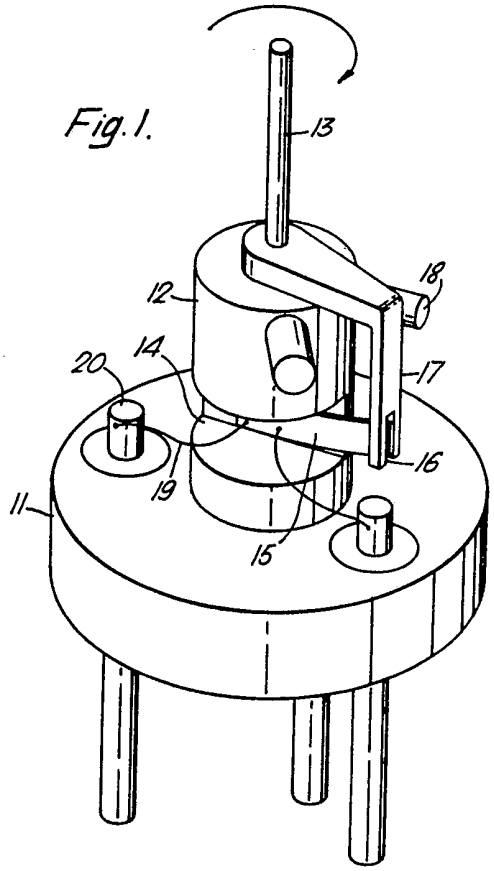
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(54) Piezo-resistive rotation transducer

(57) A transducer responsive to rotational movement comprises a support member (11) on which a shaft (13) is rotatably mounted. Relative movement between the member (11) and the shaft (13) is sensed by flexure of a strip (15) of a single-crystal piezo-resistive material, e.g. silicon. The strip (15) can be connected in a Wheatstone bridge circuit supplying an amplifier. By masking and etching a silicon wafer to include the bridge resistors and amplifier, a plurality of strips can be manufactured. Stops (18) limit flexure of strip (15).

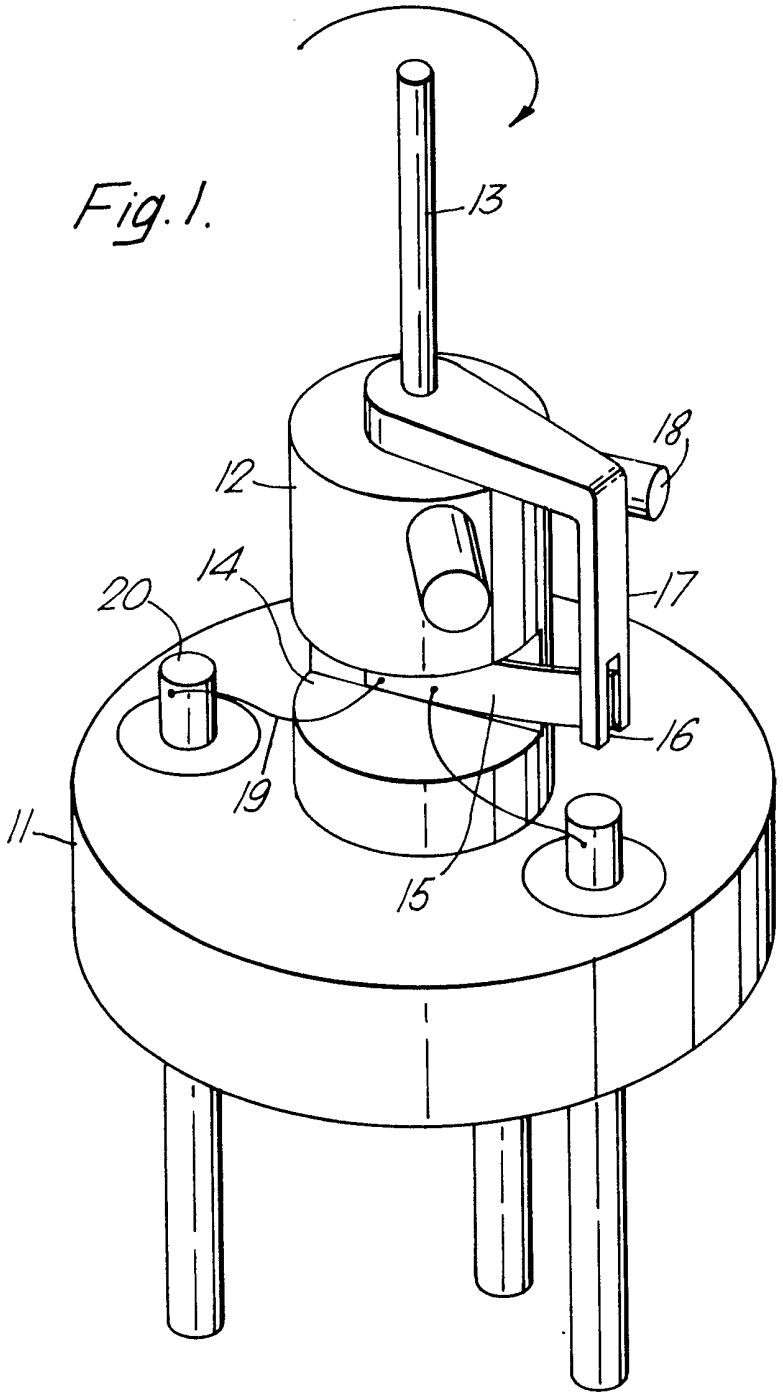
Fig. 1.



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

Fig. 1.



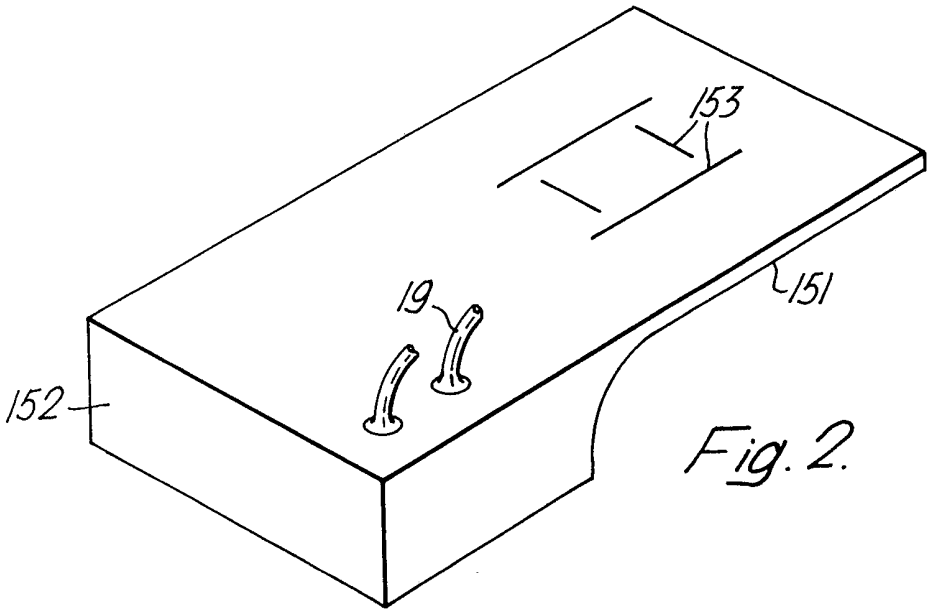
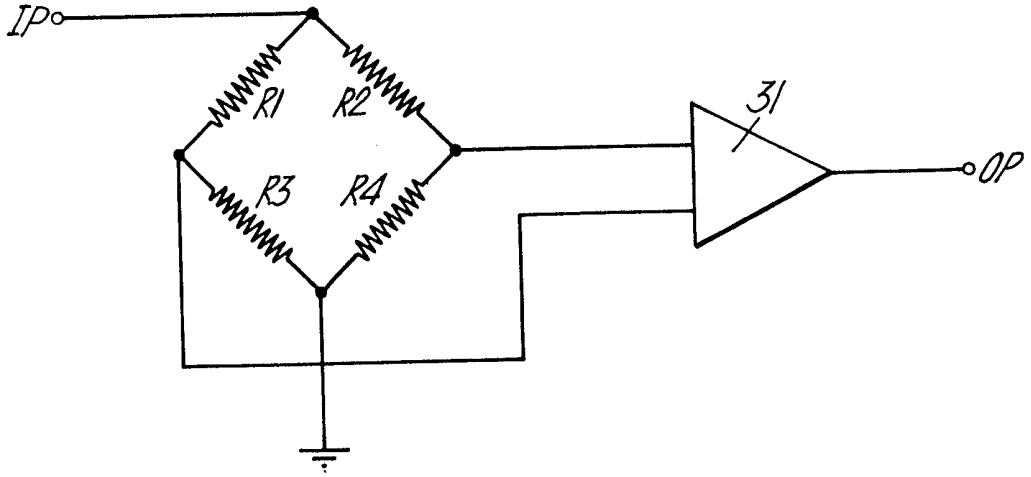


Fig. 2.

Fig. 3.



SPECIFICATION

Transducer

This invention relates to electromechnical transducers, and in particular to a transducer wherein the active element comprises a flexible body of a piezo-resistive material.

According to one aspect of the invention there is provided a transducer for detecting relative rotational movement between first and second bodies, wherein the sensor element of the transducer comprises a flexible strip of a single crystal piezo-resistive material so disposed as to be flexed by the rotational movement.

According to another aspect of the invention there is provided a transducer responsive to rotational movement, including a support member having a shaft rotatably mounted thereon, and a flexible transducer element formed from a single crystal piezo-resistive material, wherein the transducer element is coupled between the shaft and the support member such that relative rotational motion therebetween causes flexure of the element and a corresponding change in its electrical sensitivity.

An embodiment of the invention will now be described with reference to the accompanying drawings wherein:-

Figure 1 is a plan view of a transducer assembly;

Figure 2 shows the transducer element of the assembly of Fig. 1; and

Figure 3 shows the equivalent circuit of the transducer assembly of Fig. 1.

Referring to Fig. 1, the transducer assembly includes a support member 11 having a cylindrical portion 12 extending therefrom and on which a shaft 13 is rotatably mounted. The cylindrical portion 12 has a cut-away portion defining a slot 14 for receiving a transducer element comprising a flexible single crystal strip 15 of a piezo-resistive material. Typically this material is silicon.

The free end of the element 15 engages a slot 16 in a rigid arm 17 mounted on the shaft 13 such that rotation of the shaft causes corresponding bending, and a consequent resistive change, of the element 15. Excessive bending of the element 15 may be prevented by the provision of limit stops 18 against which the arm 17 abuts at the limits of its travel. External connection to the element 15 may be provided via leads 19 which connect to contact pins 20 mounted on the support member 11.

Fig. 2 shows the detail of a transducer element for use in the assembly of Fig. 1. It will be clear that the particular configuration of this element is given by way of example only and that other transducer structures could be employed. As shown in Fig. 2 the element 15 comprises a relatively thin flexible portion 151 supported on and formed integral with a relatively thick support portion 152 whereby the element, in use, is mounted. Flexure of the portion 151 is indicated by changes in the values of an array of piezo-resistors 153 formed e.g. as doped regions in the flexible portion. Electrical coupling between the resistors 153 and the input/output leads 19 may be effected by metallisation or diffusion tracks (not shown). Typically the element 15 also incorporates an amplifier (not shown) whereby the resistance charges in the resistors 153 due to flexure of the portion 151 are amplified to provide an output signal.

Referring now to Fig. 3, the transducer element 15 incorporates a resistor network comprising typically a Wheatstone bridge arrangement of power piezo-resistors R1 to R4. The values of these resistors are such that the bridge is balanced in the unstressed condition of the element 15. Flexure of the element 15 changes the values of the resistors, typically by up to 5%, thus producing a corresponding inbalance of the bridge. This inbalance signal may then be amplified, e.g. by an amplifier 31 preferably formed integral with the element, to provide an output signal indicative of the degree of rotation of the shaft. Preferably all the resistors to R4 of the network are formed on the element 15 thus providing automatic compensation for temperature changes.

Advantageously the transducer element 15 is formed from single crystal silicon, e.g. by masking and selective etching from a silicon wafer. Typically the wafer is processed to form the resistor and, optionally, amplifier regions of the individual elements and is then masked on its front and back faces. The front mask defines the boundaries between the elements and the back mask defines the support regions 152 of these elements. The wafer is then etched first from the back face to define the flexible portions 151 and then from the front to separate the elements. We have found that conventional etches provide a very uniform cast which maintains the thickness tolerance of the flexible portion 151 to within a micron. Finally leads 19 are applied, e.g. by mail head bonding, to contact the device regions of the element and the element is mounted by the portion 152 in a transducer assembly.

The transducer assembly may be employed to provide a remote indication of relative rotation between adjacent bodies. Such an arrangement may be employed, e.g. in an aircraft or a submarine to provide confirmation of the correct degree of movement of a control surface in response to a navigational instruction. Other applications include use as a high quality potentiometer which is substantially wear free.

Whilst silicon is the preferred material, both for its physical and electrical properties, from

the active element of the transducer it will be clear to those skilled in the art that other single crystal piezo-resistive material could also be employed.

CLAIMS

1. A transducer for detecting relative rotational movement between first and second bodies, wherein the sensor element of the transducer comprises a flexible strip of a single crystal piezo-resistive material so disposed as to be flexed by the rotational movement.

2. A transducer responsive to rotational movement, including a support member having a shaft rotatably mounted thereon, and a flexible transducer element formed from a single crystal piezo-resistive material, wherein the transducer element is coupled between the shaft and the support member such that relative rotational motion therebetween causes flexure of the element and a corresponding change in its electrical sensitivity.

3. A transducer as claimed in claim 2, wherein said element is provided with a Wheatstone bridge resistor network.

4. A transducer as claimed in claim 3, wherein said element includes an amplifier for amplifying the output of said bridge network.

5. A transducer as claimed in any one of claims 1 to 4, wherein the element comprises a strip of single crystal silicon.

6. A transducer as claimed in claim 5, wherein the element is formed by masking and etching of a single crystal silicon wafer.

7. A transducer substantially as described herein with reference to the accompanying drawings.

8. A telemetry or control system incorporating a transducer as claimed in any one of claims 1 to 7.

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