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(56) Documents cited **GB A 2020027** **GB 1508348** **GB 0933089** **GB 0897972**
(58) Field of search **G1J** **G1K**
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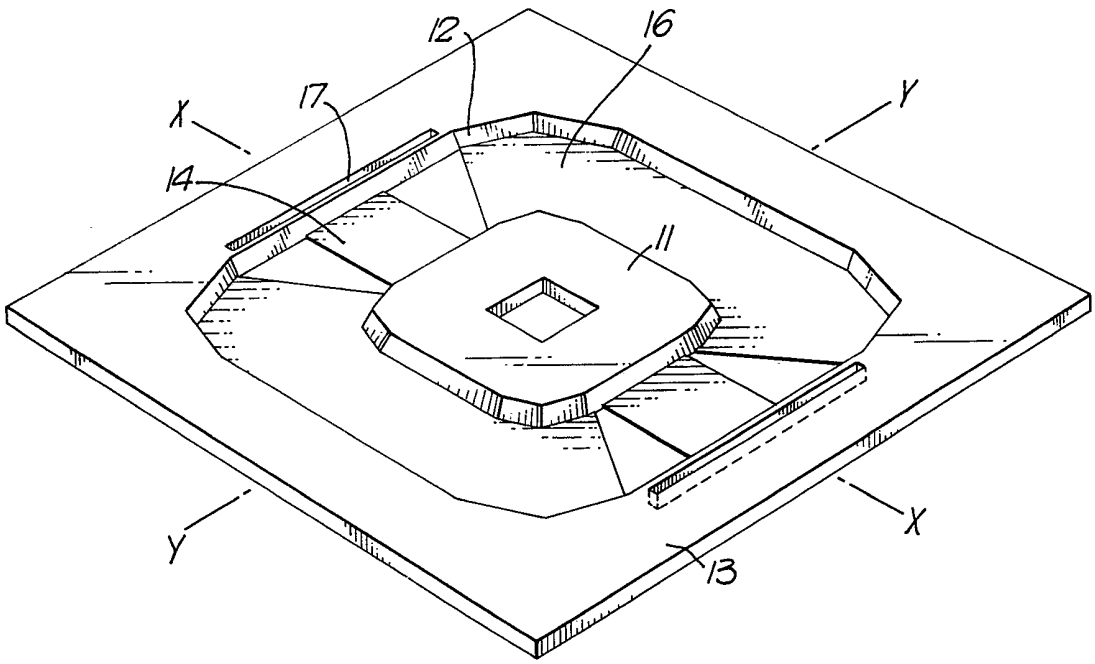
(54) **Accelerometer device**

(57) An accelerometer or seisometer element comprises a moveable body 11 mounted via two symmetrically disposed elastic beams 14 in an opening in a support body 13. Movement of the body is confined to a single direction by the provision of an elastic membrane 16 between the two bodies 11 and 13. Slots 17 are provided to reduce the stiffness of the coupling of beams 14. Element 11 has an opening to accomodate a seismic mass (31, Figure 3 not shown). Strain gauges (15, Figure 2 not shown) are provided to measure movement of element 11. The arrangement may be located in an evacuated housing, or one containing an inert atmosphere.

The element may be formed as an integral structure by selective etching of a silicon body doped with boron.

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.

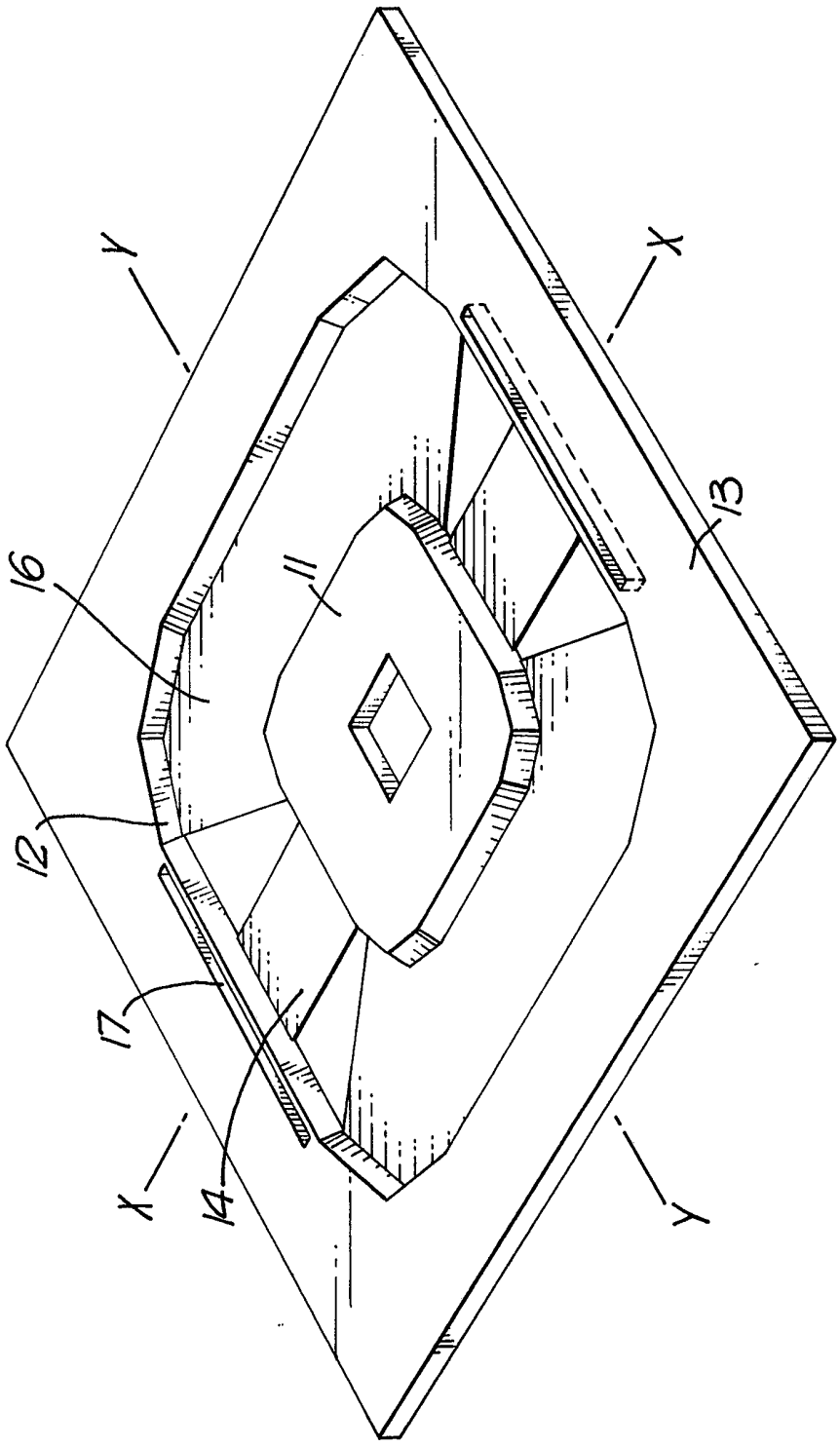

Fig. 1.

Fig. 2.

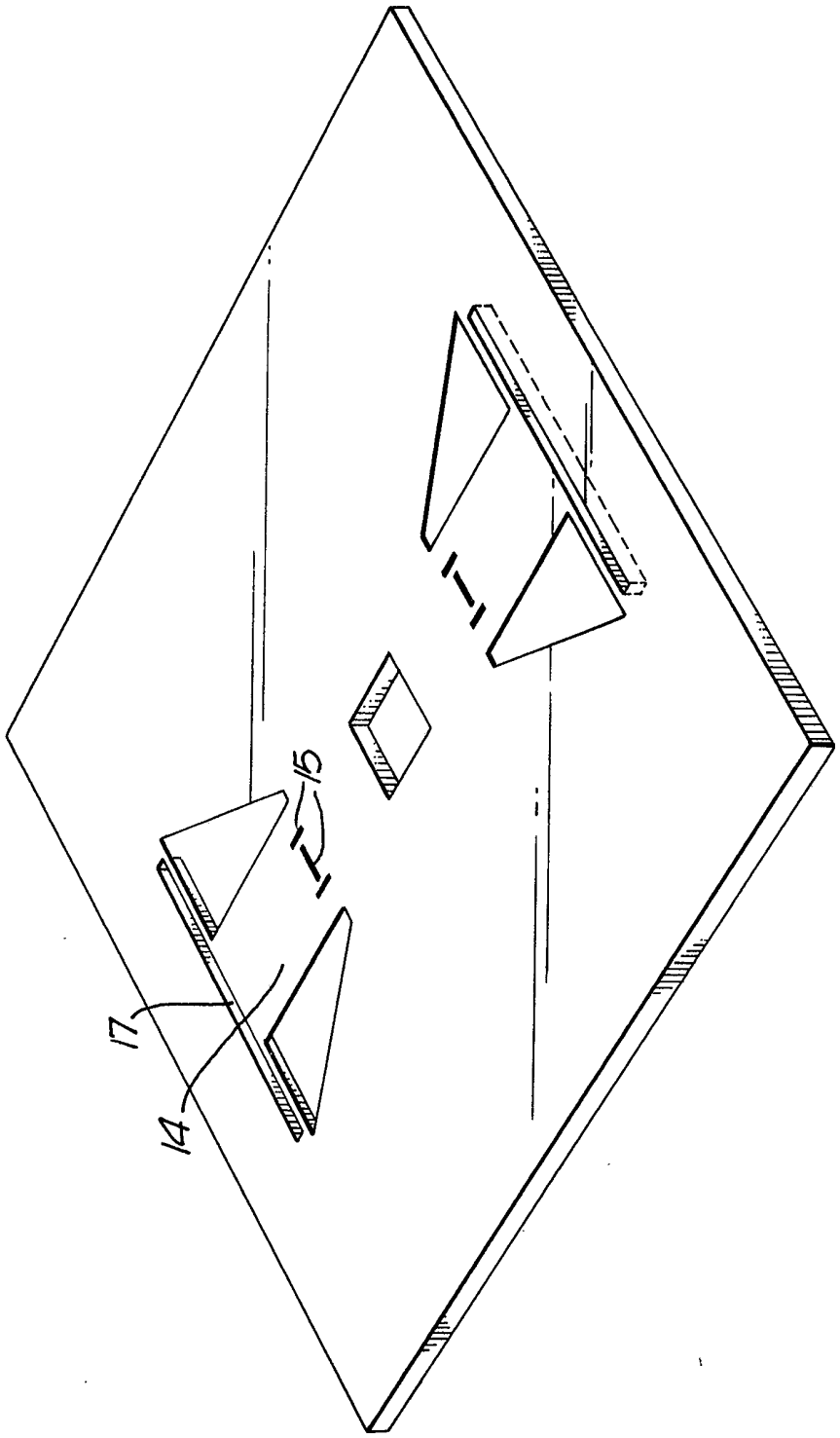

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Fig. 3.

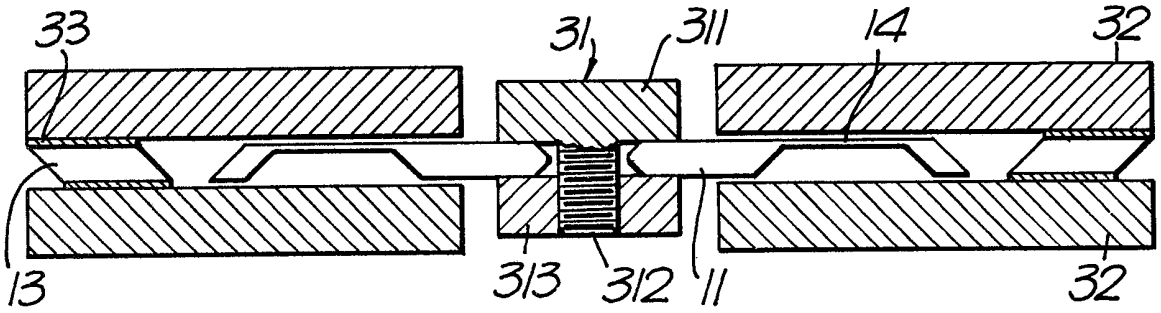
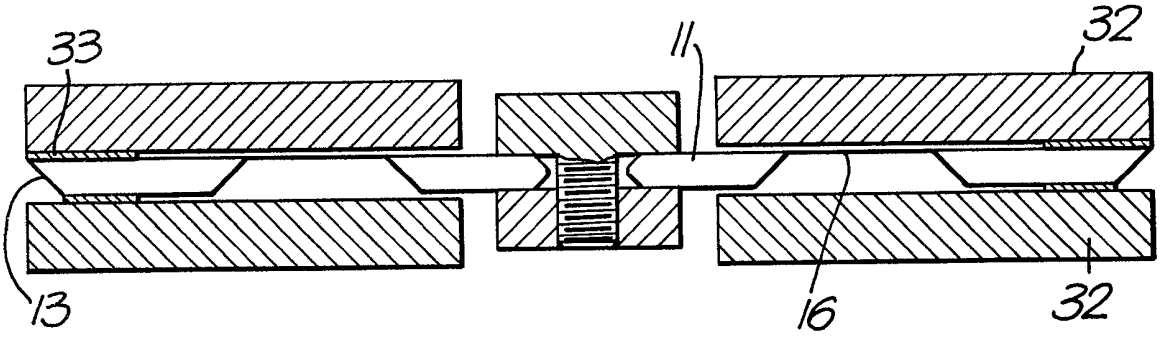


Fig. 4.



SPECIFICATION

Accelerometer device

This invention relates to accelerometer or seismometer devices and to methods of fabricating such devices.

According to the invention there is provided an accelerometer or seismometer element, including a rigid laminar body having an opening therein, and a movable body supported in said opening via first and second symmetrically disposed elastic beams mounted on or integral with the laminar body, wherein the movable body is coupled to the laminar body via an elastic membrance extending over at least a portion of the opening whereby movement of the movable body in a plane parallel to that of the laminar body is inhibited.

Advantageously the element is formed as an integral structure by selective etching of a body of resilient material, e.g. silicon.

In a preferred embodiment the laminar body is provided with slots adjacent the coupling points of the elastic beams to the body. This provides a degree of mechanical decoupling and avoids excessive stiffness of the arrangement.

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

Figure 1 is a plan view of the accelerometer or seisometer element:

Figure 2 is a view of the underside of the element of Figure 1; and

Figures 3 and *4* show two sectional views of the element of Figures 1 and 2 supported in a mounting frame.

Referring to Figures 1 and 2, the accelerometer or seisometer element includes a moveable element 11 supported in an opening 12 in a laminar body 13 via two symmetrically disposed elastic beams 14. Movement of the element 11 relative to the plane of the body 13 is detected by strain gauges 15 disposed on the beams 14.

Movement of the element 11 in directions parallel to the plane of the supporting body 13 is inhibited by an elastic membrane 16 whereby the element 11 is coupled to the body 13. This ensures that oscillation of the movable element 11 in response to an accelerating force is confined to a single mode in a direction perpendicular to the plane of the body 13. The arrangement is thus responsive only to that component of an accelerating force that is in a direction normal to the plane of the arrangement. Advantageously the element 11 has an opening whereby a loading seismic mass 31 (Figure 3) may be attached to the element to enhance sensitivity and to reduce the resonant frequency.

Advantageously the body 13 is provided with slots 17 adjacent the regions at which the beams 14 are attached to the body 13. This provides a degree of mechanical decoupling between the beams 14 and the body 13 and by reducing the stiffness of the coupling, provides enhanced sensitivity of the arrangement to an accelerating force.

Figures 3 and 4 show cross-sectional views of the element of Figures 1 and 2 mounted between a pair of rigid support frame members 32 and provided with a loading mass 31 In Figure 3 the section is taken along the plane X-X of Figure 1, and in Figure 4 along the plane Y-Y of Figure 1. As shown in Figures 3 and 4 the loading mass is of two-part construction and comprises a body portion 311 having a threaded boss 312 which boss protrudes through the opening in the movable element 11 and receives a lock nut 313. Typically the body portion 13 of the element is secured to the frame members 32 by frit bonds 33.

The frame members 32 are spaced such that the elastic beams 14 are free to move therebetween, the frame members providing a limit stop against excessive deflection of the beams 14. Typically the maximum displacement of the beams 14 is from 10 to 20 microns.

Advantageously the arrangement shown in Figures 3 and 4 is mounted in a sealed housing (not shown) which may be evacuated or filled with an inert gas.

In a preferred embodiment the element of Figures 1 to 4 is formed as an integral structure by selectively etching a body of single crystal silicon.

Typically a silicon body is selectively doped with boron to a level of at least 4×10^{19} atoms/cc in certain regions that will ultimately comprise the finished device. The wafer is then etched e.g. with a mixture of catechol, ethylene diamine and water or a mixture of potassium hydroxide, isopropyl alcohol and water. Such etch compositions have been found to be chemically selective when employed with boron doped silicon. There is an abrupt change in etch rate from that normal for undoped silicon to substantially zero at a boron doped interface so that the configuration of unetched regions is defined precisely by their boron doping profiles. Typically a single crystal silicon body is doped with boron through a mask in those areas where etching is not required and is then subjected to the etching treatment to remove only the undoped material. In some cases a plurality of masking, doping and etching stages will be required. Such techniques are more fully described in our published specification No. 1 211 496 (J.C. Greenwood 6). In a modification of the process some parts of the silicon body are prevented from etching by boron doping. Other parts are protected from the etch by resistant layers typically of silicon dioxide or silicon nitride.

Although only a single device is shown in Figure 1 it will be clear to those skilled in the art that a plurality of such devices may be fabricated simultaneously e.g. on a single semiconductor wafer, the wafer subsequently being subdivided by conventional techniques to form the individual devices.

CLAIMS

1. An accelerometer or seisometer element, including a rigid laminar body having an opening therein, and a movable body supported in said opening via first and second symmetrically disposed elastic beams mounted on or integral with the laminar body, wherein the movable body is coupled to the laminar body via an elastic membrance

extending over at least a portion of the opening whereby movement of the movable body in a plane parallel to that of the laminar body is inhibited.

2. An element as claimed in claim 1, and comprising an integral structure formed from an elastic material.

3. An element as claimed in claim 2, wherein the elastic material is single crystal silicon.

4. An element as claimed in claim 1, 2 or 3, wherein openings are provided in the laminar body adjacent the elastic beams whereby mechanical coupling between the two bodies is reduced.

5. An element as claimed in any one of claims 1 to 4, wherein strain gauges are provided on said beams.

6. An element as claimed in any one of claims 1 to 5, wherein said movable body has an opening for receiving a loading mass.

7. An accelerometer or seisometer element substantially as described herein with reference to the accompanying drawings.

8. An accelerometer or seisometer incorporating an element as claimed in any one of claims 1 to 7.

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