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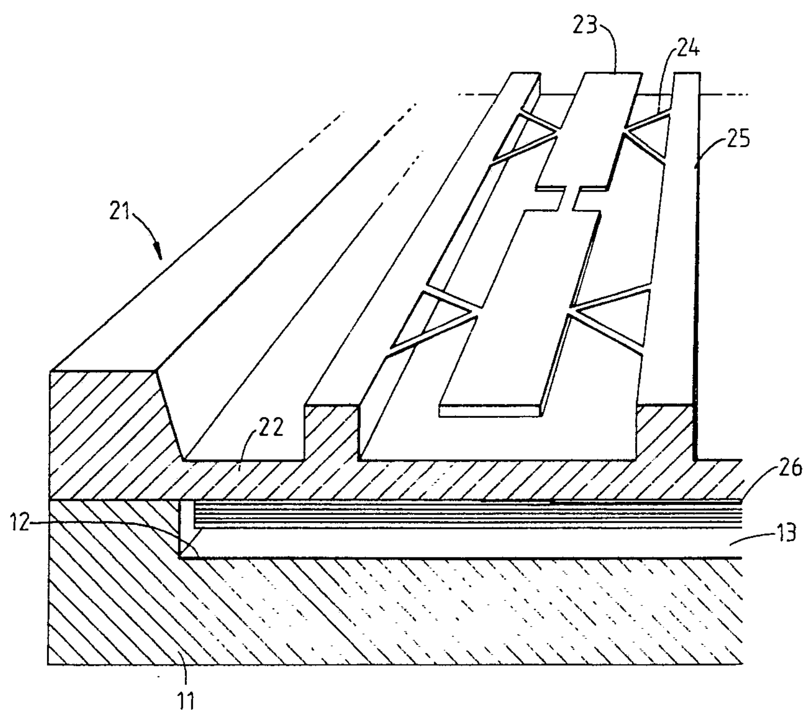
(56) Documents cited
GB 2197069 A GB 2185106 A GB 2161931 A
GB 2019567 A EP 0244086 A EP 0161533 A
US 4541731 A

(58) Field of search
UK CL (Edition J) G1G GPU GPW
INT CL⁴ G01K

(54) Resonantly vibrating temperature sensor

(57) A temperature sensor, e.g. for well logging applications, comprises a strain responsive resonator element 23 coupled to a flexible diaphragm 22. Distortion of the diaphragm, e.g. by differential expansion of a material layer 26 applied thereto, in response to a temperature change causes a corresponding change in the tension in filaments 24 and hence in the resonant frequency. In another arrangement, the layer 26 is omitted and the cavity 13 is filled with argon. The element 23 is driven and sensed optically.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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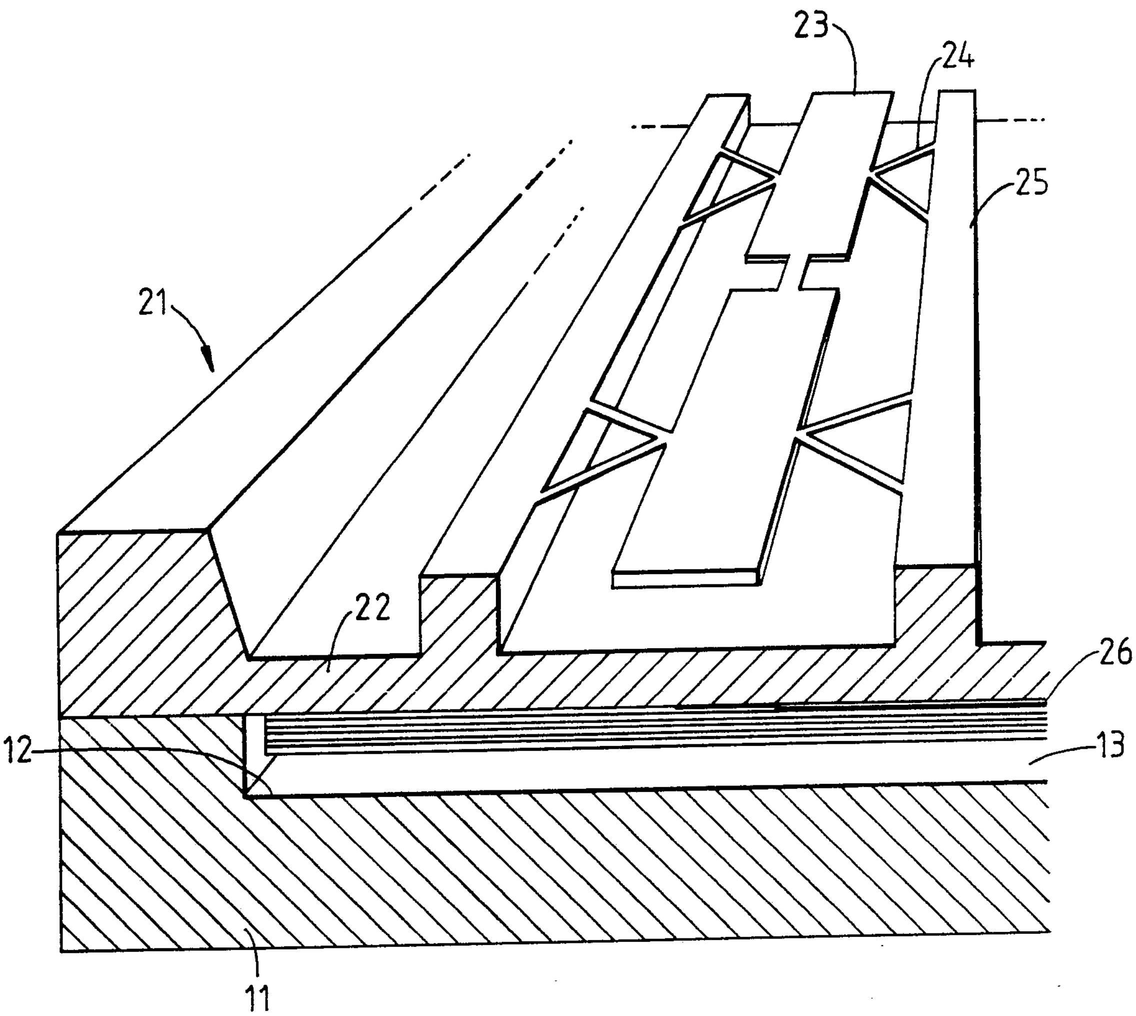
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TEMPERATURE SENSOR.

This invention relates to temperature sensors, e.g. for well logging applications.

According to the invention there is provided a temperature sensor, including a rigid thermally conductive body which, in use, is exposed to the temperature to be measured, a strain responsive transducer disposed on the rigid body and means associated with the body and transducer whereby a strain corresponding to the temperature of the body is applied to the transducer.

According to the invention there is further provided a temperature sensor, including a rigid thermally conductive body which, in use, is exposed to the temperature to be measured, a depression formed in a major surface of said body, a strain responsive transducer having a flexible diaphragm secured to said major surface over said depression so as to define a sealed cavity, said transducer having a resonator supported on said diaphragm and having a resonant frequency determined by strain applied to the resonator by flexure of the diaphragm, and means disposed in said cavity whereby said diaphragm is displaced in correspondence with the temperature of the body thereby determining the frequency of the resonator.

An embodiment of the invention will now be described with reference to the accompanying drawing in which the single figure is a schematic sectional view of a temperature sensor.

Referring to the drawing, the temperature sensor includes a rigid thermally conductive body 11 which, in use, is exposed to an enviroment whose temperature is to be determined. The body 11 supports a strain - responsive structure 21, the body and transducer being bonded together by an adhesive or by brazing. The body 11 has a depression 12 whereby a sealed cavity 13 is defined between the body 11 and the transducer 21. The cavity 13 may be evacuatated.

The transducer 21 includes a flexible diagram 22 forming one wall of the cavity 13. This diaphragm supports a resonator structure 23 via taut filaments 24 extending from support members 25. In use the resonator structure 23 is maintained in a state of oscillation at a resonant frequency determined by the moment of inertia of the resonator and the tension in the filaments 24. Advantageously the transducer is formed as an integral structure from a body of single crystal silicon.

The transducer diaphragm face adjacent the cavity 13 is coated with a layer or film 26 of a material whose thermal coefficient of expansion is significantly different from that of silicon. In use, temperature changes of the body 11 result in differential thermal expansion of the silicon diaphragm and the layer 26. This distorts the diaphragm thus causing a change in the tension of the filaments 24 and a corresponding charge in the resonant frequency of the structure 23. The resonator structure may be driven and interrogated optically via a fibre link (not shown) from a remote station to provide a measure of the temperature of the body 11. The construction and operation of a suitable transducer is described in our specification

No. 2, 189, 601 A. It will however be appreciated that other forms of transducers may be employed.

In an alternative arrangement the layer 26 may be dispensed with and the cavity 13 filled with an inert gas such as argon. The gas pressure within the cavity 13 is proportional to the temperature of the body 11. Thus, changes in temperature of the body 11 causes changes in gas pressure and corresponding changes in displacement of the diaphragm 22. As before this causes corresponding changes in the resonator frequency.

The temperature sensor described herein may be used in well logging applications. It may also be employed in other hazardous enviroments where remote sensing is required.

CLAIMS.

1. A temperature sensor, including a rigid thermally conductive body which, in use, is exposed to the temperature to be measured, a strain responsive transducer disposed on the rigid body and means associated with the body and transducer whereby a strain corresponding to the temperature of the body is applied to the transducer.

2. A temperature sensor, including a rigid thermally conductive body which, in use, is exposed to the temperature to be measured, a depression formed in a major surface of said body, a strain responsive transducer having a flexible diaphragm secured to said major surface over said depression so as to define a sealed cavity, said transducer having a resonator supported on said diaphragm and having a resonant frequency determined by strain applied to the resonator by flexure of the diaphragm, and means disposed in said cavity whereby said diaphragm is displaced in correspondence with the temperature of the body thereby determining the frequency of the resonator.

3. A temperature sensor, including a rigid thermally conductive body which, in use, is exposed to the temperature to be measured, a depression formed in a major surface of the body, a strain responsive transducer having a flexible diaphragm secured to the major surface over said depression so as to define a sealed cavity, which cavity is evacuated, a layer applied to said diaphragm of a material whose thermal coefficient of expansion is significantly different from that of the diaphragm whereby to distort the diaphragm by differential thermal expansion therebetween, and a resonator supported on the diaphragm and having a resonant frequency determined by strain applied to the resonator by thermal distortion of the diaphragm.

4. A temperature sensor substantially as described herein with reference to and as shown in the

accompanying drawings.

5. Well logging apparatus provided with one or more sensors as claimed in any one of claims 1 to 4.

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