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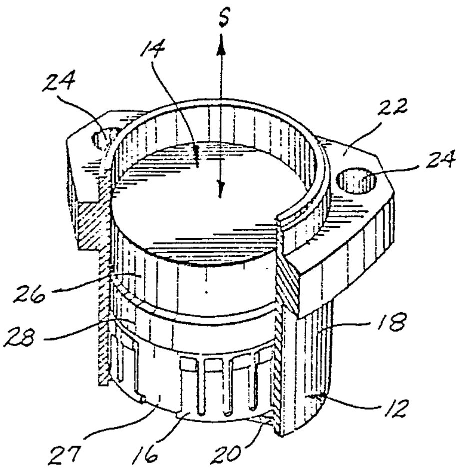
(54) Title: MOUNTING SYSTEM FOR PRECISION TRANSDUCER

(57) Abstract

Most prior mounting systems for accelerometers have been non-compliant and have therefore resulted in stress being applied to the transducer due to differential thermal expansion. This limitation is overcome by the mounting system of the present invention that is adapted to support a precision transducer (14) in spaced alignment with a supporting case (12). The mounting system comprises a plurality of mounting elements (30), each mounting element having a first end (34), a second end (32) and a resilient intermediate portion (36). The first end is connected to the transducer, and the second end is connected to the case. The first ends of adjacent mounting elements are preferably joined to one another by bridge sections (38) to form a continuous mounting ring (16), and the second ends of adjacent mounting elements are preferably separated by gaps (56). At least the first ends and bridge sections are composed of a substance that has a coefficient of thermal expansion approximately equal to the coefficient of thermal expansion of the transducer. Each intermediate portion is adapted to provide a low resistance to relative movement between the transducer and case in a radial direction, and a high resistance to relative movement in other directions. The mounting system therefore securely mounts the transducer against rotation and overall translation, while being compliant with respect to differential thermal expansion.



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MOUNTING SYSTEM FOR PRECISION TRANSDUCER

Technical Field

The present invention relates to mounting systems for precision transducers and, in particular, to a stress-free mounting system for a transducer such as an accelerometer.

Background of the Invention

It is often necessary to isolate a precision transducer from external stress. Such stress may be caused by mechanical distortion of the case or other structure to which the transducer is mounted, or by differential thermal expansion or contraction between the transducer and the case. Isolation from external stress can in principle be achieved by using a compliant mounting system. However, a compliant mounting system will not in general provide precise and stable alignment of the transducer with respect to its case. For many transducers, such alignment is critical for achieving proper operation. A compliant mounting system may also result in unwanted mechanical oscillation of the transducer when the case is exposed to vibration.

One type of precision transducer that is especially susceptible to external stress is an accelerometer. An accelerometer is an example of an instrument that must not be allowed to change position or vibrate with respect to its case. One prior accelerometer mounting technique has been to connect the accelerometer to the case by means of a metal ring or by means of a structural adhesive such as an epoxy resin. These prior noncompliant mounting techniques result in stress being transmitted to the accelerometer due to differential thermal expansion between the accelerometer and the mounting ring and case. These prior techniques also transmit stress to the accelerometer when the case is subjected to mechanical distortion. Distortion can be induced by mounting the case to a surrounding support, or by differential thermal expansion between the case and the support. All such stresses may affect the output of a precision accelerometer, and may result in reduced stability. The temperature induced stresses also may lead to increased variation of accelerometer output with temperature, and may create thermally induced errors in the accelerometer output.

Summary of the Invention

The present invention provides a mounting system for a precision transducer such as an accelerometer. The mounting system is compliant to differential volumetric expansion but rigid against rotation or translation of the transducer with respect to the case.

In one preferred embodiment, the mounting system of the present invention is adapted to support a precision transducer in spaced alignment with a supporting case. The mounting system comprises a plurality of mounting means, each mounting means having first and second ends and a resilient intermediate portion. The first end of each mounting means is connected to the transducer, and the second end of each mounting means is connected to the case. The first ends of adjacent mounting means are preferably joined to one another by bridge sections to form a mounting ring having a continuous, inwardly facing mounting surface, and the second ends of adjacent mounting means are preferably separated by gaps. At least the first ends and bridge sections are composed of a substance that has a coefficient of thermal expansion approximately equal to the coefficient of thermal expansion of the transducer. The intermediate portion of each mounting means is adapted to provide a low resistance to relative movement between the transducer and the case in a radial direction, and a high resistance to relative movement between the transducer and case in directions normal to the radial direction. Differential thermal expansion between the transducer and the case therefore does not apply stress to the transducer, or cause misalignment between the transducer and the case.

Brief Description of the Drawings

FIGURE 1 is a perspective view of an accelerometer mounted in a case by the mounting system of the present invention;

FIGURE 2 is a perspective view of the mounting ring of FIGURE 1;

FIGURE 3 is a cross-sectional view showing the connection of one mounting element between the transducer and the case;

FIGURE 4 is a side-elevational view of a portion of the mounting ring.

Detailed Description of the Invention

FIGURE 1 shows an accelerometer mounted by means of the mounting system of the present invention. The accelerometer of FIGURE 1 includes case 12, transducer 14 and mounting ring 16. Case 12 includes cylindrical sidewall 18, bottom wall 20 and flange 22. Flange 22 includes mounting holes 24 that are used to mount the case and accelerometer to a supporting structure.

Transducer 12 has a cylindrical overall shape and comprises excitation rings 26 and 27 joined by bellyband 28. The transducer is adapted to respond to accelerations along sensitive axis S by producing an electrical signal that indicates the direction and magnitude of such acceleration. The transducer is mounted to the case at excitation ring 27 by mounting ring 16. As described below, the mounting ring provides precise and stable alignment of the transducer, such that the transducer is not free to undergo translational or rotational movement with respect to the case. However, the mounting ring does permit differential radial or volumetric thermal expansion or contraction between the transducer and the case, and also serves to isolate the transducer from stresses that would otherwise result from distortion of the case. Distortion of the case may be caused by mounting the flange to a surface that is not perfectly flat, or by differential thermal expansion between the flange and the support.

Mounting ring 16 is illustrated in greater detail in FIGURE 2. The mounting ring comprises a plurality of mounting elements 30, each mounting element comprising upper end 32 and lower end 34 joined by resilient beam 36. As described below, the upper ends of the mounting elements are attached to the case, and the lower ends are attached to the transducer. The lower end of each mounting element is joined to the lower ends of adjacent mounting elements by bridge sections 38. The bridge sections thereby join the mounting elements into a single, cylindrical mounting ring, as illustrated in FIGURE 2. It is not required for the practice of the present invention that the mounting elements be joined to one another by bridge sections 38. However the use of bridge sections is preferred because it significantly facilitates manufacturing and assembly of the accelerometers.

FIGURES 3 and 4 illustrate further details of the mounting elements and of the connection between the mounting elements and the transducer and case. As best illustrated in FIGURE 3, upper end 32 of mounting element 30 includes pad 40 that includes outwardly facing surface 42. Surface 42 preferably has a cylindrical contour that matches the contour of the adjacent inner wall of sidewall 18 of case 12. Pad 40 is joined to sidewall 18 by adhesive layer 44. A suitable material for adhesive layer 44 is a structural adhesive such as an epoxy resin. Lower end 34 of mounting element 30 includes inwardly projecting flange 46, flange 46 having a cylindrical inner surface 48 that has a contour that matches the contour of the adjacent outer surface of excitation ring 27 of transducer 14. The cross sections of bridge sections 38

(FIGURE 4) may be similar to the cross sections of flanges 46, such that the bridge sections together with the lower ends of the mounting elements form a ring having a continuous, cylindrical inner surface. The radius of such inner surface is dimensioned to match the radius of the adjacent outer surface of excitation ring 27. The mounting ring is joined to the excitation ring by a process, such as welding or brazing, that produces a rigid and integral bond between the mounting ring and the transducer. FIGURE 3 illustrates the use of weld joint 50 to create the bond between flange 46 and excitation ring 27. The point of attachment of the transducer to the mounting ring is preferably spaced as far as possible from flange 22 of case 12, in order to minimize the transmission of stress from the flange to the transducer.

It is an important aspect of the present invention that the mounting ring is attached to the transducer in such a way that minimal stress is produced when the transducer and mounting ring undergo thermal expansion or contraction. This result is achieved by fabricating at least lower ends 34 and bridge sections 38 from a material that has a coefficient of thermal expansion approximately equal to the coefficient of thermal expansion of the transducer, and in particular of excitation ring 27. An intervening layer of material between the mounting ring and the transducer (e.g., an adhesive layer) should generally not be used unless the intervening layer has a coefficient of thermal expansion approximately equal to that of the transducer and mounting ring. Similarly, where a welding or brazing process is used to join the mounting ring to the transducer, any filler metal or brazing material used should have a coefficient of thermal expansion matched to the coefficient of thermal expansion of the transducer and mounting ring. In a preferred embodiment, mounting ring 16 is entirely fabricated from a metal identical to the metal forming excitation ring 27, and is welded to excitation ring 27 without the use of a filler metal. Because of its low coefficient of thermal expansion, Invar, a 36% nickel-iron alloy, is a particularly suitable metal with which to form excitation ring 27 and mounting ring 16.

In general, it will not be practical to match the coefficient of thermal expansion of the mounting ring to the coefficient of thermal expansion of case 12 or adhesive layer 44. Upper ends 32 of mounting elements 30 are therefore preferably not abutting or joined to one another, but are instead spaced apart by gaps 56 (FIGURE 4). Such gaps eliminate or greatly reduce the high hoop stress that would otherwise occur due to differential thermal expan sion or contraction between the mounting ring and the adhesive layer and case. Similar gaps are not required between lower ends 34 of mounting elements 30, because the coefficient of thermal expansion of the mounting ring is matched to that of the excitation ring to which the mounting ring is attached.

Each beam 36 is dimensioned such that the beam has a compliant axis oriented in the radial direction indicated by arrows 52 and 54 of FIGURE 3. The compliant axis of each beam preferably intersects the centerline of the transducer. However, the beam is dimensioned such that it is rigid in directions normal to arrows 52 and 54, i.e, along the length L of the beam and in the directions into and out of the plane of the drawing in FIGURE 3. Differential radial or volumetric thermal expansion (or contraction) between the transducer, mounting ring and case therefore results in differential movement between the transducer and case along the compliant axes of the beams. The beams therefore flex to take up the differential movement without transmitting significant stress to the transducer. However, the rigidity of beams 36 normal to their compliant axes results in a mounting system in which the transducer is not free to rotate or to undergo overall translational movement with respect to the case.

The required compliant characteristics of beam 36 are preferably achieved by making the width W and length L of each beam substantially greater than the thickness T of that beam. The width W of each beam must, of course, be limited (with respect to the circumference of the mounting ring) such that each beam is essentially planar and compliant in a radial direction. In general, width-to-thickness ratios between about 10:1 and 20:1 are most suitable, although other ratios may be used, depending on the nature of the transducer and the mounting ring materials. One preferred mounting ring comprises 24 mounting elements, the beam of each mounting element having a length-to-thickness ratio of about 21:1, and a width-to-thickness ratio of about 12:1. The distance between adjacent mounting elements, i.e., the width of gaps 56, should be large enough to avoid interference between the beams due to thermal expansion or seismic inputs. Referring to FIGURE 3, the distances that pad 40 and flange 46 extend from the plane of beam 36 should similarly be large enough to avoid interference between the beams and the transducer and case.

While the preferred embodiments of the invention have been illustrated and described, it should be understood that variations will be apparent to those skilled in the art. Accordingly, the invention is not to be limited to the specific embodiments illustrated and described, and the true scope and spirit of the invention are to be determined by reference to the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A mounting system for supporting a precision transducer in spaced alignment with a supporting case, the mounting system comprising a plurality of mounting means, each mounting means having first and second ends and a resilient intermediate portion, the first end of each mounting means being connected to the transducer, the second end of each mounting means being connected to the case, at least the first end being composed of a substance that has a coefficient of thermal expansion approximately equal to the coefficient of thermal expansion of the transducer, the intermediate portion of each mounting means being adapted to provide a low resistance to relative movement between the transducer and case in a radial direction and a high resistance to relative movement between the transducer and case in directions normal to the radial direction, whereby differential thermal expansion or contraction between the transducer and case do not stress the transducer or cause misalignment between the transducer and the case.

2. The mounting system of Claim 1, wherein the first ends of adjacent mounting means are joined to one another by means of bridge sections, such that the mounting means and bridge sections form a continuous, mounting ring, the bridge sections being composed of a substance having a coefficient of thermal expansion approximately equal to the coefficient of thermal expansion of the transducer.

3. The mounting system of Claim 2, wherein each intermediate portion comprises a beam having one compliant axis and two noncompliant axes normal to each other and to the compliant axis, each beam having its compliant axis oriented in the radial direction.

4. The mounting system of Claim 3, wherein the transducer is generally cylindrical in shape, wherein the compliant axis of each beam intersects the centerline of the transducer, and wherein the length dimension of each beam is aligned with the cylindrical axis of the transducer.

5. The mounting system of Claim 4, wherein the first ends and the bridge sections form a continuous, cylindrical, inwardly facing mounting

surface, and wherein the mounting ring is connected to the transducer at said mounting surface.

6. The mounting system of Claim 5, wherein the transducer includes a cylindrical mounting section, wherein the mounting ring is connected to the transducer at said mounting section, and wherein the mounting section and the mounting ring are composed of the same substance.

7. The mounting system of Claim 6, wherein said substance is Invar.

8. The mounting system of Claim 6, wherein the mounting ring is connected to the mounting section by welding.

9. The mounting system of Claim 3, wherein the width and length of each beam are substantially greater than the thickness of the beam such that the compliant axis of the beam corresponds to the thickness dimension, and wherein the thickness dimension of the beam is aligned with the radial direction, whereby the beam has a relatively small resistance to differential thermal expansion between the transducer and the case, and a high resistance to overall translation and rotation of the transducer with respect to the case.

10. The mounting system of Claim 2, wherein the second ends of adjacent mounting means are separated from one another by gaps.

11. The mounting system of Claim 10, wherein the second end of each mounting means is connected to the case by means of an adhesive.

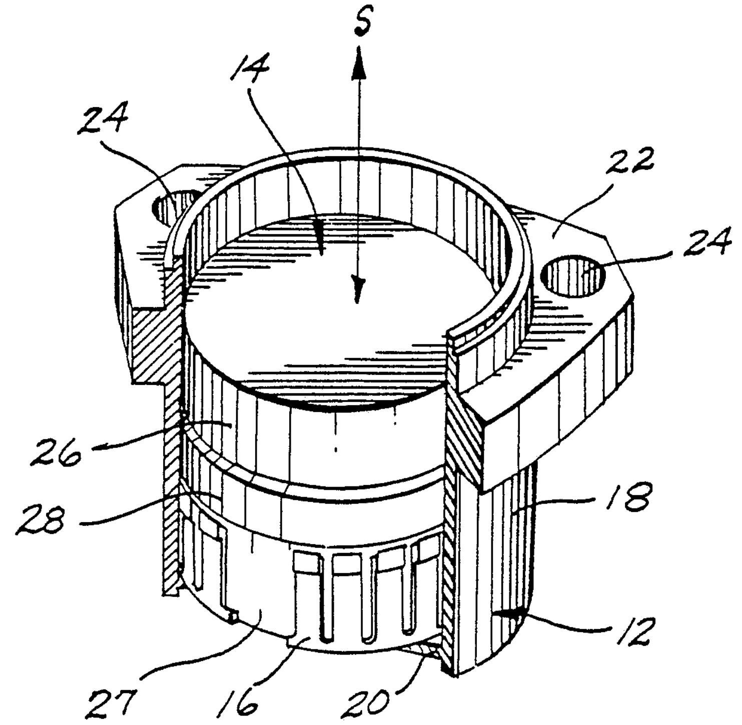

Fig. 1.

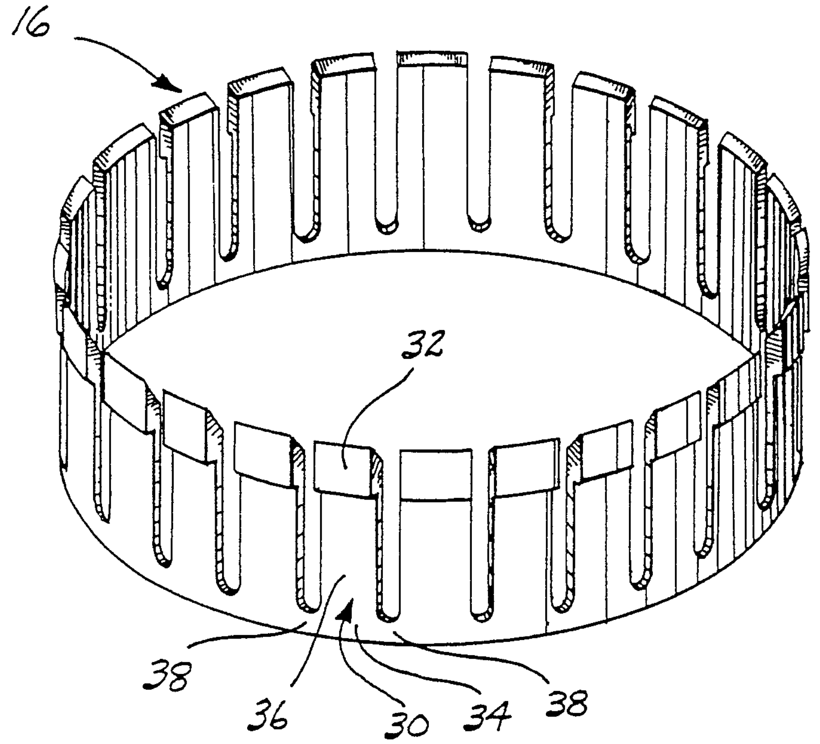

Fig. 2.

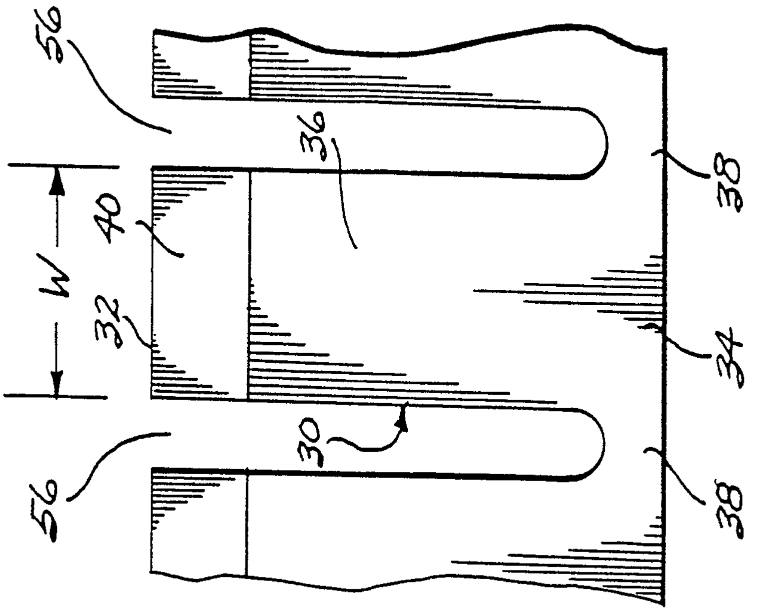
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Fig. 4.

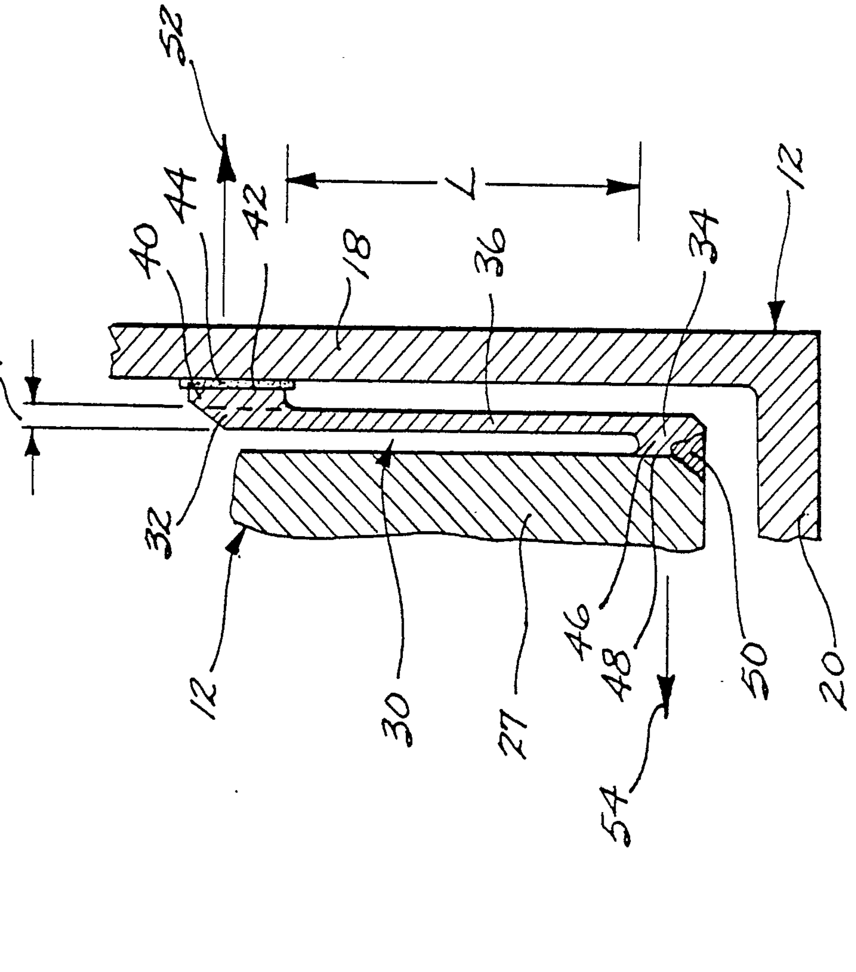
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Fig. 3.

INTERNATIONAL SEARCH REPORT

International Application No PCT/US85/02362

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL.[4] G01P 1/00

U.S. CL. 73/493; 248/1

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	73/493, 497, 517R 248/1, 27.3, DIG 1 310/346, 347, 353

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	US, A, 3,601,343, 24 August 1971, Sivaslian.	1-11
A	US, A, 4,190,782, 26 February 1980, Guess.	
X	US, A, 4,266,157, 05 May 1981, Peters.	1

* Special categories of cited documents: [15]

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IV. CERTIFICATION

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