

## Description

The invention relates to diaphragm pressure transducers.

In pressure transducers of the kind wherein pressure acting on a diaphragm results in a force which is transmitted to a sensor beam, the diaphragm is connected to the sensor beam by a shaft which acts perpendicularly to the diaphragm and to the sensor beam as described for example, in EP—A—2 623 993. The diaphragm is protected against damage due to overpressure conditions by means of an O-ring which contacts the transducer body and seals a fluid filled cavity between the diaphragm and the sensor beam, the incompressible fluid preventing excessive movement of the diaphragm under high differential pressure conditions. As the pressure increases, the O-ring continues to compress until a mechanical stop integral with the connecting shaft contacts the transducer body to prevent overstressing the sensor beam.

In previously proposed constructions the connecting shaft must be very accurately located relative to the diaphragm, and the O-ring and the mechanical stop must be accurately positioned on the shaft. As a result of the extreme accuracy required, even the slightest misalignment can cause the O-ring to fail to seal properly, which can result in damage to the diaphragm. Under extreme conditions of misalignment the O-ring can become extruded between the mechanical stop and the transducer body resulting in seal failure and thus damage to the diaphragm and/or excessive bending and thus overstress the sensor beam and diaphragm assembly.

According to the invention there is provided a diaphragm pressure transducer comprising a body, a sensor beam fixed to the body within a first cavity formed therein, a diaphragm attached to a side of the body over a second cavity in communication with the first cavity, and a shaft assembly connecting the diaphragm and the sensor characterised in that the shaft assembly comprises a first element attached to the sensor beam, a second element attached to the diaphragm and rigidifying material connecting the first and second elements.

The invention thus provides an improved connection between the diaphragm and the sensor.

The rigidifying material connecting the diaphragm and the sensor beam can eliminate misalignment and potential tolerance stack up problems.

The invention is diagrammatically illustrated by way of example with reference to the accompanying drawing, in which:-

Figure 1 is a cross-sectional view of a pressure transducer of previously proposed kind;

Figure 2 is an enlarged cross-sectional view showing a portion of the transducer illustrated in Figure 1; and

Figure 3 is a cross-sectional view of a pressure transducer according to one embodiment of the invention.

Referring the drawings, in which like reference characters designate like or corresponding parts throughout the several views, a pressure transducer 10, comprises a body 12, a sensor 14 fixed to the body 12 within a first cavity 16, a first diaphragm 18 attached at its periphery to the body 12, and a first shaft assembly 20 connecting the first diaphragm 18 and the sensor 14. A second diaphragm 19 is attached to the body 12 opposite the first diaphragm 18, and a second shaft assembly 21 connects the second diaphragm and the sensor 14. The transducer illustrated herein can be of the kind wherein the sensor 14 defines a beam to which strain gauges (not shown) are attached, and wherein bending forces applied to the beam by the diaphragms are proportional to the differential pressure acting on the diaphragms.

Referring particularly to Figures 1 and 2, the shaft assemblies 20 and 21 previously proposed are essentially identical, and only one will be described herein in detail. As shown in Figure 1, the first shaft assembly 20 is a cylindrical member having a first diameter portion 22 which defines an actuating shaft in contact with the sensor beam 14, a second relatively large diameter portion 24 having a channel 26 formed therein to receive an O-ring 28, and a third diameter portion 30 which is attached to the centre of the diaphragm 18. The face of the large diameter portion 24 which is defined by its intersection with the first diameter portion 22 defines a mechanical stop surface 32.

The shaft assembly 20 is received within a second cavity 34 defined by first and second counterbores 36 and 38 respectively formed in the side of the body 12, the diaphragm 18 being received over the counterbore 38. The actuating shaft portion 22 extends through a bore 40 formed in the body, which connects the first and second cavities.

The interconnected cavities 16 and 34 are filled with a fluid. If the differential pressure acting on the right side of the diaphragm 18 exceeds a predetermined level, the O-ring 28 contacts the wall 42 of the cavity 34 thus sealing the cavity, whereby the incompressibility of the fill fluid will resist further movement of the diaphragm. If further excessive force is applied, the stop surface 32 will contact the wall 42 to prevent further movement and possible damage to the sensor.

In the previously proposed construction the shaft assembly 20 must be maintained perpendicular to the diaphragm 18, must meet the diaphragm at the proper height, and be concentric with it. Typical tolerances on the position of the shaft are a 0.50 maximum on perpendicularity,  $\pm 0.05$  mm ( $\pm 0.002$  inches) on height, and  $\pm 0.127$  mm ( $\pm 0.005$  inches) on concentricity. Because there is a large stack-up of dimensions which contribute to the position of the shaft relative to the diaphragm, all dimensions must be held to very close tolerances, which results in high machining and inspection costs. The same is true for the positioning of the O-ring 28 and the mechanical stop

32. Devices of this type have a typical stroke of .10 mm (.004 inches) with three times permissible overrange of .3 mm (.012 in.) and very slight O-ring compression of .076 mm (.003 in.) average. For normal operation of the device, the O-ring should not contact the wall within .127 mm (.005 inches) of motion, and the mechanical stop 32 should contact the wall 42 at a maximum of .3 mm (.012 inches) of motion. This leaves a  $\pm .05$  mm ( $\pm .002$  inch) tolerance on the height position. For a reliable sealing the O-ring should be parallel to its seat within 0.50.

Figure 2 illustrates a possible failure mode of the prior art construction. Assuming a 4.57 mm (.180 inch) diameter O-ring for illustration, with the O-ring being out of parallel with the seat by  $1^\circ$ , when one side of the O-ring 28 is fully compressed and the stop surface 32 contacts the wall 42, the O-ring will not have sufficient compression to seal, resulting in possible damage to the diaphragm if an overpressure condition occurs. There is further danger of the O-ring being extruded into the gap between the stop surface 32 and the wall 42, resulting in damage to the O-ring as well as damage to the diaphragm and possibly to the sensor beam 14.

Referring to Figure 3, in the embodiment of the invention shown the shaft assemblies 120 and 121 are each formed of two parts, a sensor post or stub shaft 122 which is fixed to the sensor beam 14, and an overpressure stop member 124 which includes an extended hollow cylindrical portion 125. The opening of the hollow portion and the length of the stub shaft 122 are dimensioned such that the cylindrical portion surrounds the stub shaft 122 with an annular gap therebetween, and there is a space between the end of the stub shaft and the bottom of the cylinder 125. The space between the stub shaft and the cylinder wall of the stop member 124 is filled with a rigidifying material 126, for example an epoxy.

In the embodiment illustrated, the diaphragms 18 and 19 are attached to the overpressure stop members 124, and the stub shaft 122 is attached to the sensor beam 14. When the transducer is assembled, the diaphragms and the overpressure stops are set relative to the transducer body, thus cutting a dimensional stack-up chain down to three links and allowing the adhesive joints to compensate for fairly broad variations in the positions of the sensor stub shafts.

To take full advantage of the shear strength of the adhesive, the interior wall of the extended portion 125, and the sensor stub shafts 122 can be threaded, thus increasing the area of adhesion.

#### Claims

1. A diaphragm pressure transducer comprising a body (12), a sensor beam (14) fixed to the body (12) within a first cavity (16) formed therein, a diaphragm (18) attached to a side of the body (12) over a second cavity in communication with the first cavity (16), and a shaft assembly (120) connecting the diaphragm (18) and the sensor (14)

characterised in that the shaft assembly (120) comprises a first element (122) attached to the sensor beam (14), a second element (124) attached to the diaphragm (18), and rigidifying material (126) connecting the first (122) and second (124) elements.

2. A pressure transducer according to claim 1 in which the first element comprises a stub shaft (122), and the second element comprises a cylindrical member (124) having a hollow cylindrical portion (125) in surrounding relation to the stub shaft (122), and the rigidifying material (126) is received in the space between the stub shaft (122) and the cylindrical member (124).

3. A pressure transducer according to claim 2, in which the free end of the stub shaft (122) is spaced from the bottom of the hollow cylindrical portion (125) and, a portion of the rigidifying material (126) is received in the space.

4. A pressure transducer according to any one of claims 1 to 3, in which the rigidifying material (126) comprises an epoxy.

#### Patentansprüche

1. Membrandruckwandler mit einem Hauptteil (12), einem Sensorträger (14), welcher an dem Hauptteil (12) innerhalb einer darin ausgebildeten Vertiefung (16) befestigt ist, einer Membran (18), welche an einer Seite des Hauptteiles (12) über einer zweiten Vertiefung angebracht ist, die in Verbindung mit der ersten Vertiefung (16) steht, und mit einem Schaftaufbau (120), welcher die Membran (18) und den Sensor (14) miteinander verbindet, dadurch gekennzeichnet, daß der Schaftaufbau (120) ein erstes Element (122) aufweist, welches an dem Sensorträger (14) angebracht ist, ein zweites Element (124) aufweist, welches an der Membran (18) angebracht ist, und Versteifungsmaterial (126) aufweist, welches das erste (122) und das zweite Element (124) verbindet.

2. Druckwandler nach Anspruch 1, bei welchem das erste Element eine Stummelwelle (122) aufweist, und das zweite Element ein zylindrisches Teil (124) aufweist, das einen hohlen zylindrischen Abschnitt (125) hat, welcher die Stummelwelle (122) umgibt, und wobei das Versteifungsmaterial (126) in dem Raum zwischen der Stummelwelle (122) und dem zylindrischen Teil (124) aufgenommen ist.

3. Druckwandler nach Anspruch 2, wobei das freie Ende der Stummelwelle (122) von dem Grund des hohlen zylindrischen Abschnittes (125) beabstandet ist und wobei ein Teil des Versteifungsmaterials (126) in dem Zwischenraum aufgenommen ist.

4. Druckwandlernach einem der Ansprüche 1 bis 3, wobei das Versteifungsmaterial (126) ein Epoxidharz aufweist.

#### Revendications

1. Capteur de pression à diaphragme comprenant un corps (12), un barreau capteur (14) fixé au

32. Devices of this type have a typical stroke of .10 mm (.004 inches) with three times permissible overrange of .3 mm (.012 in.) and very slight O-ring compression of .076 mm (.003 in.) average. For normal operation of the device, the O-ring should not contact the wall within .127 mm (.005 inches) of motion, and the mechanical stop 32 should contact the wall 42 at a maximum of .3 mm (.012 inches) of motion. This leaves a  $\pm .05$  mm ( $\pm .002$  inch) tolerance on the height position. For a reliable sealing the O-ring should be parallel to its seat within 0.50.

Figure 2 illustrates a possible failure mode of the prior art construction. Assuming a 4.57 mm (.180 inch) diameter O-ring for illustration, with the O-ring being out of parallel with the seat by  $1^\circ$ , when one side of the O-ring 28 is fully compressed and the stop surface 32 contacts the wall 42, the O-ring will not have sufficient compression to seal, resulting in possible damage to the diaphragm if an overpressure condition occurs. There is further danger of the O-ring being extruded into the gap between the stop surface 32 and the wall 42, resulting in damage to the O-ring as well as damage to the diaphragm and possibly to the sensor beam 14.

Referring to Figure 3, in the embodiment of the invention shown the shaft assemblies 120 and 121 are each formed of two parts, a sensor post or stub shaft 122 which is fixed to the sensor beam 14, and an overpressure stop member 124 which includes an extended hollow cylindrical portion 125. The opening of the hollow portion and the length of the stub shaft 122 are dimensioned such that the cylindrical portion surrounds the stub shaft 122 with an annular gap therebetween, and there is a space between the end of the stub shaft and the bottom of the cylinder 125. The space between the stub shaft and the cylinder wall of the stop member 124 is filled with a rigidifying material 126, for example an epoxy.

In the embodiment illustrated, the diaphragms 18 and 19 are attached to the overpressure stop members 124, and the stub shaft 122 is attached to the sensor beam 14. When the transducer is assembled, the diaphragms and the overpressure stops are set relative to the transducer body, thus cutting a dimensional stack-up chain down to three links and allowing the adhesive joints to compensate for fairly broad variations in the positions of the sensor stub shafts.

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characterised in that the shaft assembly (120) comprises a first element (122) attached to the sensor beam (14), a second element (124) attached to the diaphragm (18), and rigidifying material (126) connecting the first (122) and second (124) elements.

2. A pressure transducer according to claim 1 in which the first element comprises a stub shaft (122), and the second element comprises a cylindrical member (124) having a hollow cylindrical portion (125) in surrounding relation to the stub shaft (122), and the rigidifying material (126) is received in the space between the stub shaft (122) and the cylindrical member (124).

3. A pressure transducer according to claim 2, in which the free end of the stub shaft (122) is spaced from the bottom of the hollow cylindrical portion (125) and, a portion of the rigidifying material (126) is received in the space.

4. A pressure transducer according to any one of claims 1 to 3, in which the rigidifying material (126) comprises an epoxy.

#### Patentansprüche

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2. Druckwandler nach Anspruch 1, bei welchem das erste Element eine Stummelwelle (122) aufweist, und das zweite Element ein zylindrisches Teil (124) aufweist, das einen hohlen zylindrischen Abschnitt (125) hat, welcher die Stummelwelle (122) umgibt, und wobei das Versteifungsmaterial (126) in dem Raum zwischen der Stummelwelle (122) und dem zylindrischen Teil (124) aufgenommen ist.

3. Druckwandler nach Anspruch 2, wobei das freie Ende der Stummelwelle (122) von dem Grund des hohlen zylindrischen Abschnittes (125) beabstandet ist und wobei ein Teil des Versteifungsmaterials (126) in dem Zwischenraum aufgenommen ist.

4. Druckwandler nach einem der Ansprüche 1 bis 3, wobei das Versteifungsmaterial (126) ein Epoxidharz aufweist.

#### Revendications

1. Capteur de pression à diaphragme comprenant un corps (12), un barreau capteur (14) fixé au



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corps (12) à l'intérieur d'une première cavité (16) formée dans celui-ci, un diaphragme (18) fixé à un côté du corps (12) sur une seconde cavité en communication avec la première cavité (16), et un ensemble d'arbre (120) reliant le diaphragme (18) et le capteur (14) caractérisé en ce que l'ensemble d'arbre (120) comprend un premier élément (122) fixé au barreau capteur (14), un second élément (124) fixé au diaphragme (18), et un matériau de rigidification (126) reliant le premier (122) et le second (124) élément.

2. Capteur de pression selon la revendication 1, dans lequel le premier élément comprend un tronçon d'arbre (122), et le second élément com-

prend un élément cylindrique (124) comportant une partie cylindrique creuse (125) entourant le tronçon d'arbre (122), et le matériau de rigidification (126) se trouve dans l'espace entre le tronçon d'arbre (122) et l'élément cylindrique (124).

3. Capteur de pression selon la revendication 2, dans lequel l'extrémité libre du tronçon d'arbre (122) est espacée du fond de la partie cylindrique creuse (125) et, une partie du matériau de rigidification (126) se trouve dans l'espace.

4. Capteur de pression selon l'une quelconque des revendications 1 à 3, dans lequel le matériau de rigidification (126) comprend un époxy.

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