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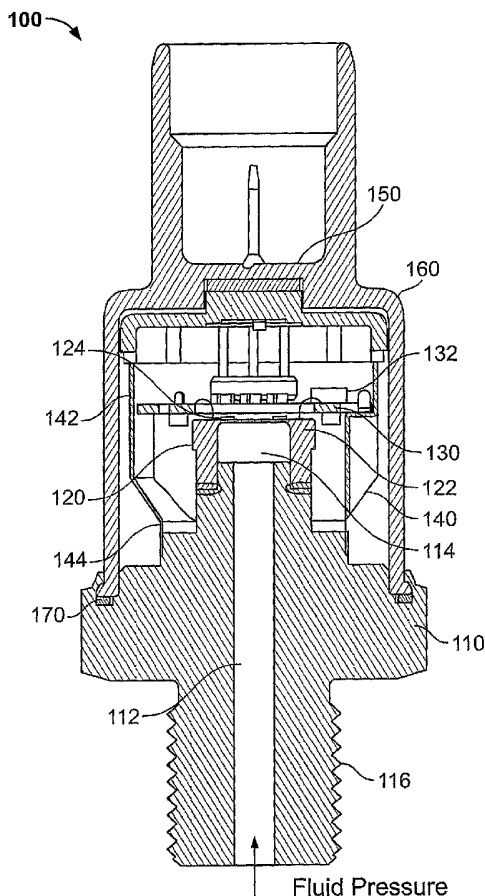
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(54) Title: SYSTEM AND METHOD FOR PRESSURE MEASUREMENT



(57) Abstract: A pressure measurement system may provide ready manufacturing, reliable operation, and/or enhanced performance by using a circuit board housing. In particular implementations, a pressure measurement system 100 includes a pressure inlet joint 110, a pressure detecting component 120, a circuit board 130, and a circuit board housing 140. The pressure detecting component is coupled to the pressure inlet joint, which is adapted to introduce a pressure of a fluid. The circuit board is coupled to the pressure detecting component and is operable to condition an electrical signal from the pressure detecting component. The circuit board housing at least partially encloses the pressure detecting component and is adapted to engage the circuit board. The circuit board housing has a substantially cylindrical shape and includes a larger diameter section 142 and a smaller diameter section 144, the smaller diameter section coupled to the pressure inlet joint, the circuit board located at least in part in the larger diameter section.

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## **SYSTEM AND METHOD FOR PRESSURE MEASUREMENT**

### **REFERENCE TO RELATED APPLICATIONS**

The present application claims the benefit of U.S. Application No. 10/928,024, filed on August 27, 2004, the entire contents of which are hereby  
5 incorporated by reference.

### **FIELD OF THE INVENTION**

The present invention relates to process management and, more specifically, to pressure measurement.

### **BACKGROUND**

10 In the structure of a pressure sensor based on the conventional technology as disclosed, for instance, in Japanese Patent Publication No. 3,440,629, an amplifying circuit board is directly fixed to a body with adhesive, as described on page 4 and shown in Figs. 1-3 of the publication. The adhesive may be a silicone adhesive. A shield member having a feed-through capacitor is placed on the amplifying circuit  
15 board so as to cover the amplifying circuit board, and the shield member is fixed, together with a fixing member, to the body by laser welding or resistance welding techniques so that noise resistance is improved.

In United States Patent No. 5,880,372, a printed circuit board is fixed to a spacer made of an electrically insulating material, such as resin, provided on a  
20 pressure port by soldering techniques, as described on page 2 and shown in Fig. 2A of the patent. An interlock provided on the spacer is engaged to an interlock receiver (hole) provided on the pressure port for positioning in the rotational direction together with a ground log. To improve noise resistance, an electrical connection is achieved by press-fitting a ground line of the printed circuit board from the spacer into a case  
25 ground contact (hole) provided on the pressure port via the ground log. After components on the printed circuit board are assembled, a downward force is loaded by caulking so that the spacer is fixed.

In Japanese Laid-Open Patent Publication No. 2001-208633, the amplifying circuit board is fixed to a terminal base made of resin by soldering, as described on

page 8 and shown in Figs. 1-6 of the publication. The terminal has a plurality of convex sections in the upper side, and the convex sections are engaged with a concave section provided on the plate to be fixed thereto. A shield case is fixed to a terminal base by inserting and caulking an opening peripheral edge thereof into a concave section provided on an external peripheral surface and is electrically connected to an external metallic case via an elastic piece provided on the opening peripheral edge, as shown in Fig. 8 of the publication, for improving the noise resistance.

In Japanese Utility Model Laid-Open Publication No. HEI 6-78836, the amplifying circuit board is fixed by adhesive filled in the groove provided on the case, as described on page 2 and shown on Fig. 2 of the publication. A plate is contacted and electrically connected to the case by caulking via a sub-connector and a connector for improving the noise resistance.

#### SUMMARY

A pressure measurement system may include a housing for a circuit board that conditions the output signal of a pressure detecting component. The housing may provide ease and reliability in manufacturing and use. Furthermore, the housing may provide enhanced performance.

In one general aspect, a pressure measurement system includes a pressure inlet joint, a pressure detecting component, a circuit board, and a circuit board housing. The pressure detecting component is coupled to the pressure inlet joint, which is adapted to introduce a pressure of a fluid. The circuit board is coupled to the pressure detecting component and is operable to condition an electrical signal from the pressure detecting component. The circuit board housing at least partially encloses the pressure detecting component and is adapted to engage the circuit board. Additionally, the circuit board housing has a substantially cylindrical shape and includes a larger diameter section and a smaller diameter section. The smaller diameter section coupled to the pressure inlet joint. The circuit board is located, at least in part, in the larger diameter section.

The circuit board housing may include a number of columns formed substantially parallel to the longitudinal axis of the circuit board housing, each

column including a cover, which may engage the circuit board. The columns may be substantially semi-cylindrical and extend from the smaller diameter section toward the larger diameter section.

In certain implementations, a projection may be formed on the cover of at least one column and be adapted to be coupled to the circuit board, and, in others, a number of projections may be formed on the covers of the columns, the projections being arranged at unequal intervals around the cylinder. One or more projections may be electrically coupled to a ground line of the circuit board and/or to the pressure inlet joint.

The circuit board housing may be coupled to the pressure inlet joint at a number of point by spot welding. In one implementation, at least part of the longitudinal portion of the smaller diameter section engages the pressure inlet joint, and the welds occur in this part.

In particular implementations, the pressure measurement system may include an electrical connector electrically coupled to the circuit board for connection to an external device. The pressure measurement system may also include a second housing at least partially enclosing the circuit board housing, the second housing coupled to the pressure inlet joint.

In another general aspect, a circuit board housing for a pressure measurement system is adapted to at least partially enclose a pressure detecting component and to engage a circuit board, the circuit board housing having a substantially cylindrical shape and comprising a larger diameter section and a smaller diameter section, the smaller diameter section adapted to couple to a pressure inlet joint.

The circuit board housing may include a number of columns formed substantially parallel to the longitudinal axis of the circuit board housing, each column including a cover. The columns may be substantially semi-cylindrical and extend from the smaller diameter section toward the larger diameter section, and the covers of the columns may be adapted to engage with a circuit board. A projection may be formed on the cover of at least one column and be adapted to be coupled to a

circuit board. The projection may also be adapted to be electrically coupled to a ground line of a circuit board.

In yet another general aspect, a pressure measurement system includes a pressure inlet joint, a pressure detecting component, a circuit board, and a circuit board housing. The pressure inlet joint is adapted to introduce a pressure of a fluid, and the pressure detecting component is coupled to the pressure inlet joint. The circuit board is coupled to the pressure detecting component and is operable to amplify an electrical signal from the pressure detecting component. The circuit board housing partially encloses the pressure detecting component and is adapted to engage the circuit board. Also, the circuit board housing has a substantially cylindrical shape and includes a larger diameter section, a smaller diameter section, and a number of substantially semi-cylindrical columns. The smaller diameter section is coupled to the pressure inlet joint at a number of points by spot welding, at least part of the longitudinal portion of the smaller diameter section engaging the pressure inlet joint around the welds. The columns are formed substantially parallel to the longitudinal axis of the circuit board housing and extend from the smaller diameter section toward the larger diameter section. Each column includes an upper cover having a projection formed thereon to couple to the circuit board, the circuit board held on the upper covers of the columns in the larger diameter section by the projections, which are spaced at unequal intervals around the cylinder. At least one projection is also electrically coupled to a ground line of the circuit board and to the pressure inlet joint. The pressure measurement system also includes a housing and an electrical connector. The housing partially encloses the circuit board housing and is coupled to the pressure inlet joint. The electrical connector is electrically coupled to the circuit board for connection to an external device.

Various implementations may have a variety of features. For example, particular implementations may provide a highly reliable pressure sensor having a simple structure that securely holds a signal conditioning circuit board, requires only a few assembly operations, and shows at most minimal change in noise-resistance property over time.

The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

5 Fig. 1 is a cross-sectional view showing an example pressure measurement system.

Fig. 2 is a perspective view showing an example of a circuit board housing for the system in FIG. 1.

Fig. 3 is a side cross-sectional view of the circuit board housing in FIG. 2.

10 Fig. 4 is a top cross-sectional view showing an example of the circuit board housing in FIG. 2 in relationship to a pressure detecting component and a circuit board.

Fig. 5 is a perspective view showing an example of a column section for the circuit board housing in FIG. 2.

15 Fig. 6 is a perspective view showing an example circuit board housing.

Fig. 7 is side cross-sectional view of the circuit board housing in Fig. 6.

Fig. 8 is a side cross-sectional view showing a circuit board housing and a pressure inlet joint coupled by seam welding.

20 Fig. 9 is a side cross-sectional view showing a circuit board housing and a pressure inlet joint coupled by spot welding.

Like reference symbols in the various drawings indicate like elements.

### **DETAILED DESCRIPTION**

A system for pressure measurement may generate an electrical signal representative of the measured pressure. In particular implementations, a system for  
25 pressure measurement may include a pressure detecting component, a pressure inlet joint for introducing a pressure of a fluid, a circuit board for conditioning an electrical signal from the pressure detecting component, a circuit board housing at least partially surrounding the pressure detecting component and adapted to engage the circuit

board, an electrical connector electrically coupled to the circuit board to provide electrical coupling to an external device, and a housing at least partially enclosing the circuit board housing and coupled to the pressure inlet joint. Other implementations, however, may have fewer, additional, and/or a different arrangement of components.

5 Fig. 1 illustrates an example pressure measurement system 100. As illustrated, pressure measurement system 100 is a pressure sensor. Pressure measurement system 100 may measure the pressure of any appropriate fluid (e.g., liquid and/or gas).

Pressure measurement system 100 includes a pressure inlet joint 110, a pressure detecting component 120, and a circuit board 130. Pressure inlet joint 110, which in certain implementations may be a socket, includes a passage 112 that ends in a chamber 114 formed by the pressure inlet joint and pressure detecting component 120. Pressure inlet joint also include threads 116 for securing system 100 to a process for which pressure is to be measured. In particular implementations, pressure inlet joint 110 may be composed of stainless steel having high mechanical strength and corrosion-resistance. Pressure detecting component 120 includes a diaphragm 122, which may have a substantially cylindrical bottom. Diaphragm 122 may be metallic and has a strain gauge 124 formed on a surface opposite of the fluid-inlet side. In particular implementations, strain gauges are provided at a number of locations (e.g., four) to form a bridge circuit and output an electric signal. Pressure detecting component 120 is coupled (e.g., fixed and sealed) to pressure inlet joint 110 (e.g., by welding). Circuit board 130 is electrically coupled to pressure detecting component 120 and conditions signals representative of pressure that the pressure detecting component generates. Circuit board 130 includes various electronic components 132 (e.g., filters, amplifiers, and processors) to condition the pressure-representative signals.

Pressure measurement system 100 also includes a circuit board housing 140 (e.g., a shield case) that engages circuit board 130. As illustrated, circuit board housing 140 is substantially cylindrical and has a larger diameter section 142 and a smaller diameter section 144, the smaller diameter section being coupled to pressure inlet joint 110. Smaller diameter section 144 may be coupled (e.g., by resistance or

30



laser welding) to pressure inlet joint 110 at multiple points. Larger diameter section 142 is adapted to couple to circuit board 130, which will be discussed in more detail below, although not all of the circuit board or its components need to be located in the larger diameter section. Circuit board housing 140 may or may not be vented to the atmosphere. In particular implementations, circuit board housing 140 may be electrically coupled to a ground line of circuit board 130 to provide increased noise resistance for the circuit board.

Pressure measurement system 100 further includes an electrical connector 150, a system housing 160, and a gasket 170. Electrical connector 150 is coupled to system housing 160 and is electrically coupled to circuit board 130. In particular implementations, electrical connector 150 and system housing 160 may be composed of an electrically insulating material. In the illustrated implementation, electrical connector 150 is integral with system housing 160. System housing 160 is also coupled to pressure inlet joint 110 (e.g., by caulking, crimping, or welding). System housing 160, in conjunction with pressure inlet joint 110, encloses circuit board housing 140. Gasket 170 interfaces with system housing 160 and pressure inlet joint 110 for preventing intrusion of moisture and dust from the outside.

In operation, pressure inlet joint 110 is coupled (e.g., screwed and sealed) to a process for which a pressure is to be measured and allows pressure of a fluid to enter passage 112 and arrive at chamber 114. Based on the pressure in chamber 114, diaphragm 122 deforms, and strain gauge 124 senses the pressure as a strain and converts the pressure to an electrical signal, which is conveyed to circuit board 130. Circuit board 130 conditions (e.g., filters and amplifies) the electrical signal, which is then conveyed to electrical connector 150. Electrical connector 150 conveys the signal outside of system housing 160, so that the signal may be provided to a remote device.

FIGs. 2-3 illustrate an example of circuit board housing 140 – circuit board housing 200. Circuit board housing 200 includes a larger diameter section 202 and a smaller diameter section 204. Circuit board housing 200 may be composed of tin-plated soft steel, stainless steel, which may be matched to the pressure inlet joint, soft

steel that may be readily formed, copper-based metal having good electrical characteristics, or any other appropriate material. Smaller diameter section 204 may engage a pressure inlet joint and be coupled thereto at a number of points (e.g., by spot welding).

5           Circuit board housing 200 also includes three column sections 210. Column sections 210 have a substantially semi-circular cross section and extend from smaller diameter section 204 toward larger diameter section 202. The column sections are substantially parallel to the longitudinal axis of the circuit board housing. In other implementations, column sections 210 may have any other appropriate shapes and/or  
10           orientations. Each of column sections 210 includes a cover 212, which each includes a projection 214. Covers 212 can support a circuit board, and one or more of projections 214 may be coupled to the circuit board. Also, one or more of projections 214 may be electrically coupled to a ground line for the circuit board. The electrically-coupled projections may provide part of an electrical path from the circuit  
15           board to the pressure inlet joint. In particular implementations, the circuit board housing may complete the path to the pressure inlet joint, and a ground line of the circuit board may be coupled to a projection via a capacitor and/or a varistor. In particular implementations, the projections are arranged at unequal intervals around the housing.

20           In one mode of operation, a circuit board is installed and supported on covers 212. The circuit board is then coupled to projections 214 (e.g., by engagement or soldering techniques). At least one of the couplings may allow a ground line of the circuit board to be electrically coupled to a projection. When coupling one of  
25           projections 214 to the circuit board, the projection may be pressed against a ground pad on the circuit board and bent thereon for engagement. In certain implementations, however, joint by soldering is preferable because of increased reliability.

FIG. 4 illustrates circuit board housing 200 engaged with a pressure detecting component 410 and a circuit board 420, which may be similar to pressure detecting  
30           component 120 and circuit board 130, respectively, of system 100. As illustrated,

circuit board 420 is coupled to circuit board housing 200, and electrodes of a strain gauge arrangement 412 of pressure detecting component 410 are electrically coupled to electrodes of circuit board 420 by wire bonding 414. Although the pressure detecting component is directly connected to the circuit board by wire bonding in the  
5 illustrated implementation, a configuration may be employed in which the pressure detecting component is connected via a lead frame to the circuit board.

Circuit board 420 also includes an amplifier 422, solder joints 424, a capacitor 426, and an input/output terminal 428. Amplifier 422 may, for example, be an integrated circuit. In operation, an electrical signal that is generated by pressure  
10 detecting component 410 and conditioned (e.g., amplified) by circuit board 420 is provided to input/output terminal 428, from which it may be sent via a relay board to an electrical connector for an external device. Input/output terminal 428 may serve as the basis of an amplified output (e.g., 0-5 Vdc ratiometric, 4-20 mA, and 0-10 Vdc).

This implementation of circuit board housing 140 has a variety of features.  
15 For example, when the circuit board is tightly coupled to the circuit board housing (e.g., by soldering), and the circuit board housing is tightly coupled to a pressure inlet joint with a pressure detecting component fixed thereon, a fixed portion of the circuit board is less susceptible to breaking. This allows a pressure measurement system with high reliability to be obtained. As another example, a ground terminal of the  
20 circuit board may be electrically coupled to a pressure inlet joint via the circuit board housing, which provides good grounding of the circuit board and an improvement in noise resistance. In particular implementations, an AC component superimposed on a DC power supply line can be released to the earth. Also, this electrical coupling may be realized by soldering and welding, increasing the reliability of the coupling and  
25 reducing structural changes that may occur during the passage of time, which allows the noise resistance property to be maintained for a longer period of time. As an additional example, by fixing the circuit board housing to a pressure inlet joint by spot welding, an improvement in strength may be obtained. This increases reliability by providing a pressure measurement system capable of maintaining performance even  
30 in an environment in which vibration or impacts may occur. As a further example, the area for mounting components on the rear surface of the circuit board is increased

because the circuit board is coupled to the circuit board housing in the larger diameter section and the housing does not support the circuit board around its entire periphery. Also, when the component mounting area is secured, a diameter of the circuit board does not have to increase, and, as a result, the diameter of the pressure sensor does not  
5 have to increase. Further, by managing the height of covers 212, the height of the circuit board can readily be managed.

As another example, since column sections 210 are arranged in parallel to the longitudinal axis of the circuit board housing from the smaller diameter section to the larger diameter section, fabrication by press working can readily be performed.  
10 Namely, pressing work in the lateral direction in addition to processing in the vertical direction may be avoided. This may allow not only a less complicated structure of a die, but also easier die maintenance and increased press working speed, not to mention increased construction consistency. The pressing direction can be realized in the longitudinal direction also in the case of the projections, so that the pressure  
15 measurement system can be readily manufactured. Easing processing operations results in the circuit board housing being produced as a low cost member.

As an additional example, the circuit board is coupled to the pressure inlet joint through a circuit board housing, which may be securely coupled to the pressure inlet joint. This may provide proper positioning of the circuit board, especially in the  
20 rotational direction, and a more lasting coupling, especially in high static or dynamic heat and/or load environments. If a circuit board loses its coupling to a pressure inlet port, disconnection of a wire electrically coupling the circuit board to a pressure detecting component may occur.

As a further example, the circuit board housing may be made of an electrically  
25 conductive material. This may improve the reliability of the circuit board housing and/or the interface between the circuit board housing and the pressure inlet joint by lessening the difference between thermal coefficients of expansion.

FIG. 5 illustrates an example column section 500. Column section 500 is one  
30 example of column sections 210 for circuit board housing 200. As with column sections 210, column section 500 includes a cover 510 and a projection 512.

Projection 512 is formed by cutting cover 510 and bending the cut portion. In other implementations, a projection may be formed by raising the cover with a form like a ball by a burring processing.

Figs. 6-7 illustrate another example circuit board housing 600. Circuit board housing 600 includes a smaller diameter section 610 and a larger diameter section 620. A circuit board is held on a step 630 between the larger diameter section and the smaller diameter section. A projection 632 for coupling (e.g., by soldering) to a ground line of a circuit board may be provided according to the necessity. Smaller diameter section 610 may be engaged with a pressure inlet joint at multiple points and coupled thereto by spot welding (e.g., resistance welding or laser welding).

Fig. 8 illustrates a conventional technique for coupling a circuit board housing 800 and a pressure inlet joint 810. Circuit board housing 800 and pressure inlet joint 810 may be similar to circuit board housing 140 and pressure inlet joint 110 of system 100.

As illustrated, circuit board housing 800 and a pressure inlet joint 810 are coupled to each other by using seam welding, along a weld portion 830. A clearance is provided between circuit board housing 800 and pressure inlet joint 810. But when welding is performed in the weld portion 830 in this state, a force  $F$  in the lateral direction results in the stress being received by weld portion 830. Generally, a circuit board housing does not require high strength and, therefore, is commonly made with an iron plate with a thickness of approximately 0.5 mm or below by using press working techniques. Thus, the welded portion is integrated relatively weakly, and, as a result, the welded portion may easily break when a force  $F$  is loaded thereto.

FIG. 9 illustrates another technique for coupling a circuit board housing 800 and a pressure inlet joint 810. As illustrated, circuit board housing 800 and pressure inlet joint 810 are coupled to each other by using spot welding, at a number of weld sections 840 (only one of which is shown). When spot welding is performed at the welding sections 840, circuit board housing 800 deforms slightly inward at the sections. Because of this feature, when a force  $F$  is applied to the circuit board

housing, the section as a whole receives the force, so the stress is not concentrated at the welded section. This may result in the weld sections resisting breakage.

A number of implementations of the invention have been described, and a number of other implementations have been mentioned or suggested. Nevertheless, it  
5 will be understood that various additions, deletions, substitutions, and/or modifications may be made while still achieving pressure measurement. For these reasons, the invention is to be measured by the scope of the appended claims, which may include one or more of the implementations.

**CLAIMS**

1. A pressure measurement system, the system comprising:  
a pressure inlet joint adapted to introduce a pressure of a fluid;  
a pressure detecting component coupled to the pressure inlet joint;  
5 a circuit board coupled to the pressure detecting component and operable to  
condition an electrical signal from the pressure detecting component; and  
a circuit board housing at least partially enclosing the pressure detecting  
component and adapted to engage the circuit board, the circuit board housing having a  
substantially cylindrical shape and comprising a larger diameter section and a smaller  
10 diameter section, the smaller diameter section coupled to the pressure inlet joint, the  
circuit board located at least in part in the larger diameter section.
2. The pressure measurement system according to claim 1, wherein the  
circuit board housing comprises a plurality of columns formed substantially parallel to  
the longitudinal axis of the circuit board housing, each column including a cover, the  
15 circuit board engaged with the covers of the columns.
3. The pressure measurement system according to claim 2, wherein the  
columns are substantially semi-cylindrical and extend from the smaller diameter  
section toward the larger diameter section.
4. The pressure measurement system according to claim 2, wherein a  
20 projection is formed on the cover of at least one column, the projection adapted to be  
coupled to the circuit board.
5. The pressure measurement system according to claim 4, wherein a  
plurality of projections are formed on the covers of the columns, the projections being  
arranged at unequal intervals around the cylinder.
- 25 6. The pressure measurement system according to claim 4, wherein the  
projection is electrically coupled to a ground line of the circuit board.
7. The pressure measurement system according to claim 6, wherein the  
projection is electrically coupled to the pressure inlet joint.

8. The pressure measurement system according to claim 1, further comprising an electrical connector electrically coupled to the circuit board for connection to an external device.

9. The pressure measurement system according to claim 1, wherein the  
5 smaller diameter section of the circuit board housing is coupled to the pressure inlet joint at a plurality of points by spot welding.

10. The pressure measurement system according to claim 9, wherein at least part of the longitudinal portion of the smaller diameter section engages the pressure inlet joint, and the welds occur in this part.

10 11. The pressure measurement system according to claim 1, further comprising a second housing at least partially enclosing the circuit board housing, the second housing coupled to the pressure inlet joint.

12. A circuit board housing for a pressure measurement system, the circuit board housing adapted to at least partially enclose a pressure detecting component and  
15 to engage a circuit board, the circuit board housing having a substantially cylindrical shape and comprising a larger diameter section and a smaller diameter section, the smaller diameter section adapted to couple to a pressure inlet joint.

13. The circuit board housing according to claim 12, wherein the circuit board housing comprises a plurality of columns formed substantially parallel to the  
20 longitudinal axis of the circuit board housing, each column including a cover, the covers of the columns adapted to engage with a circuit board.

14. The circuit board housing according to claim 13, wherein the columns are substantially semi-cylindrical and extend from the smaller diameter section toward the larger diameter section.

25 15. The circuit board housing according to claim 13, wherein a projection is formed on the cover of at least one column, the projection adapted to be coupled to a circuit board.



16. The circuit board housing according to claim 15, wherein a plurality of projections are formed on the covers of the columns, the projections being arranged at unequal intervals around the cylinder.

17. The circuit board housing according to claim 15, wherein the  
5 projection is adapted to be electrically coupled to a ground line of a circuit board.

18. The circuit board housing according to claim 12, wherein the smaller diameter section is adapted to be coupled to a pressure inlet joint at a plurality of points by spot welding.

19. The circuit board housing according to claim 18, wherein at least part  
10 of the longitudinal portion of the smaller diameter section is adapted to engage a pressure inlet joint around the weld points.

20. A pressure measurement system comprising:

a pressure inlet joint adapted to introduce a pressure of a fluid;

a pressure detecting component coupled to the pressure inlet joint;

15 a circuit board coupled to the pressure detecting component and operable to amplify an electrical signal from the pressure detecting component;

a circuit board housing partially enclosing the pressure detecting component and adapted to engage the circuit board, the circuit board housing having a substantially cylindrical shape and comprising:

20 a larger diameter section,

a smaller diameter section, the smaller diameter section coupled to the pressure inlet joint at a plurality of points by spot welding, at least part of the longitudinal portion of the smaller diameter section engaging the pressure inlet joint around the welds, and

25 a plurality of substantially semi-cylindrical columns formed substantially parallel to the longitudinal axis of the circuit board housing and extending from the smaller diameter section toward the larger diameter section, each column including an upper cover having a projection formed thereon to couple to the

circuit board, the projections spaced at unequal intervals around the cylinder, the circuit board held on the upper covers of the columns in the larger diameter section by the projections, at least one of the projections electrically coupled to a ground line of the circuit board and to the pressure inlet joint;

- 5 a housing partially enclosing the circuit board housing, the housing coupled to the pressure inlet joint; and

an electrical connector electrically coupled to the circuit board for connection to an external device.

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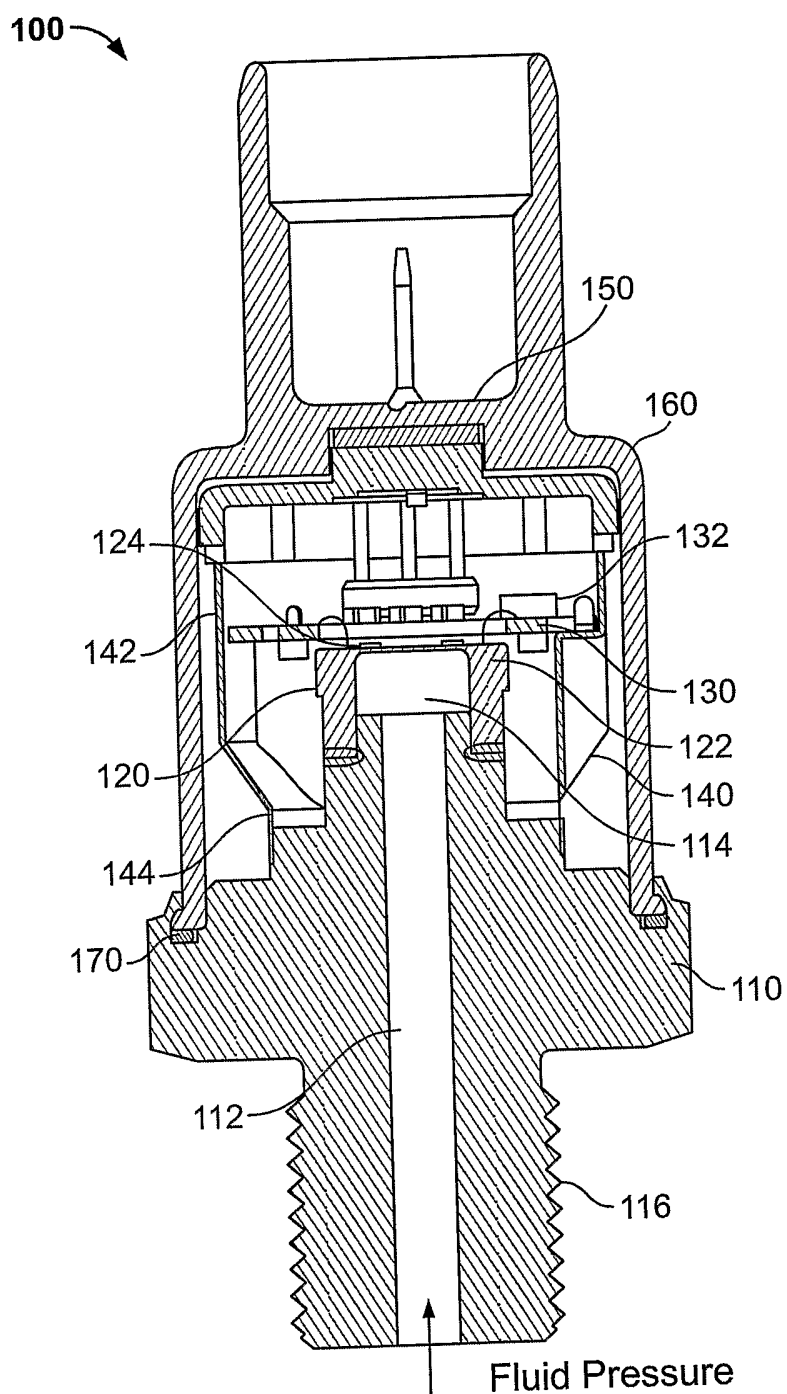


FIG. 1

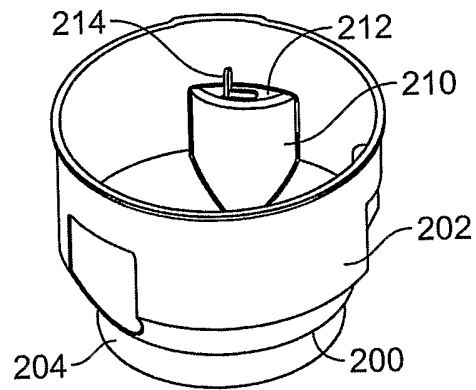


FIG. 2

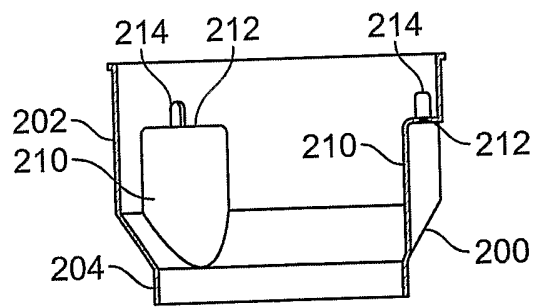


FIG. 3

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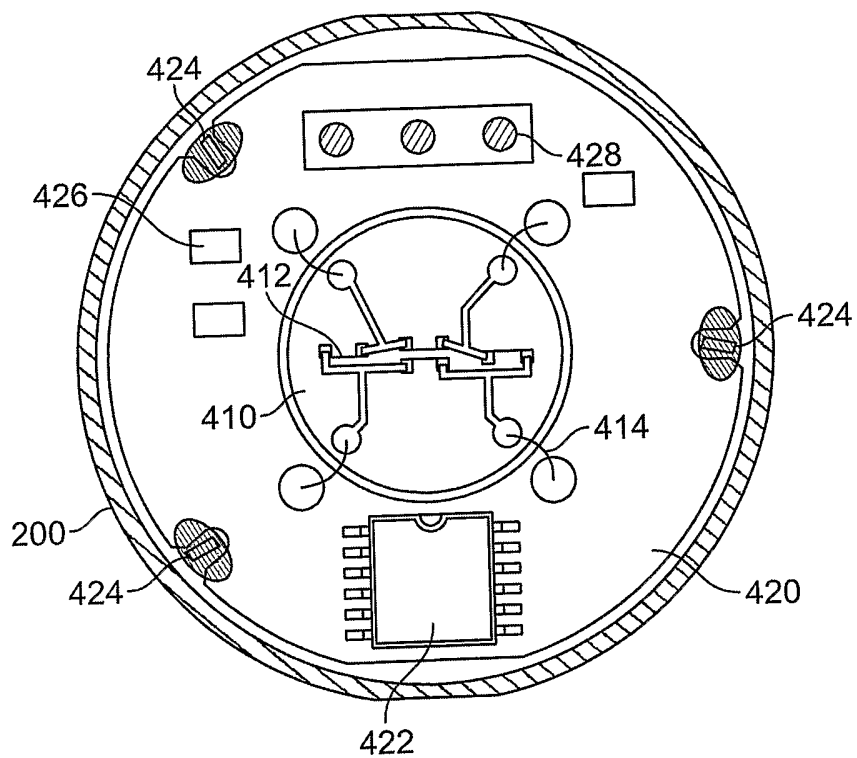


FIG. 4

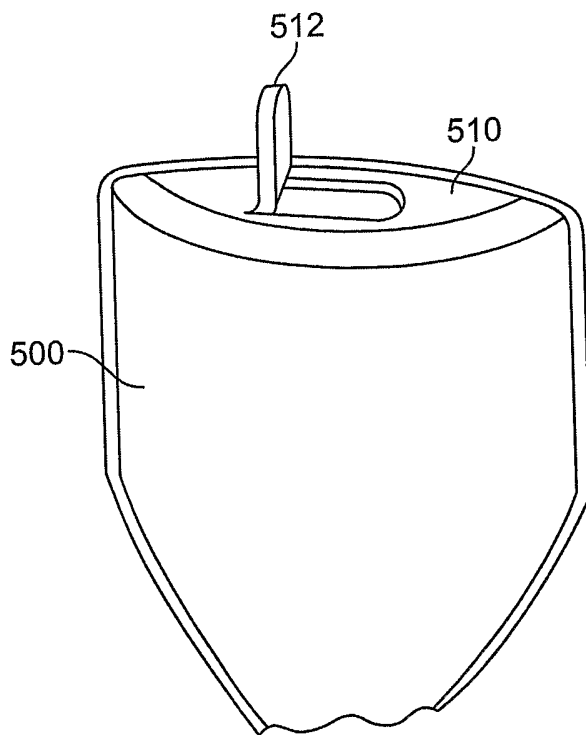


FIG. 5

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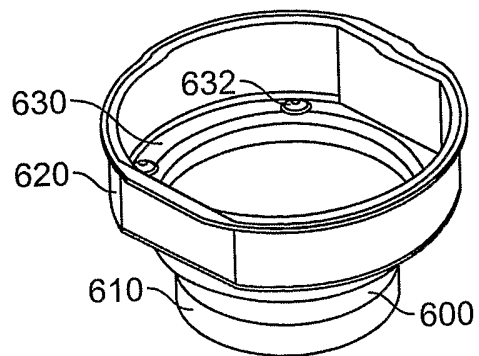


FIG. 6

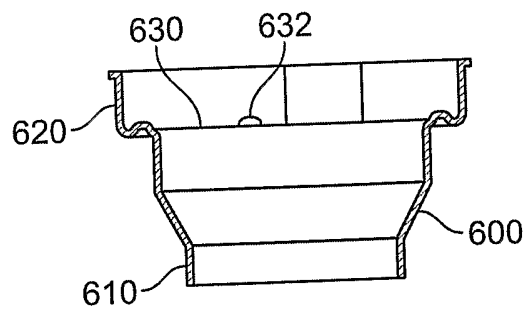
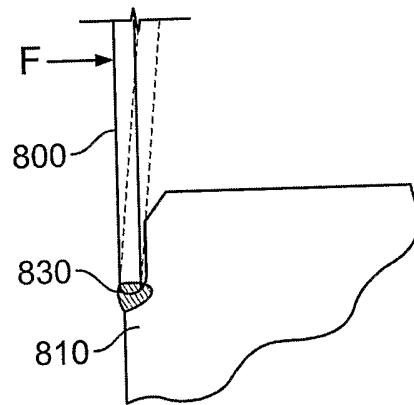
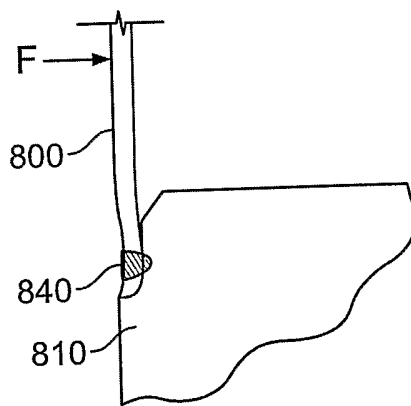


FIG. 7



**FIG. 8**  
**(Prior Art)**



**FIG. 9**

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/JP2005/030297

**A. CLASSIFICATION OF SUBJECT MATTER**  
 G01L9/00      G01L19/14

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**  
 Minimum documentation searched (classification system followed by classification symbols)  
 G01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)  
 EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 211 496 A (NAGANO KEIKI CO., LTD) 5 June 2002 (2002-06-05)	1, 12
Y	abstract; figure 25	2-11, 13-19
A	paragraph '0002! - paragraph '0010! -----	20
Y	EP 1 382 953 A (TEXAS INSTRUMENTS INCORPORATED) 21 January 2004 (2004-01-21) abstract; figures 8a-12 paragraph '0031! - paragraph '0038! -----	2-11, 13-19
Y	EP 0 995 979 A (ENDRESS + HAUSER GMBH + CO; ENDRESS + HAUSER GMBH + CO.KG) 26 April 2000 (2000-04-26) abstract; figures 6,7 paragraph '0028! - paragraph '0029! -----	2-11, 13-19

Further documents are listed in the continuation of box C.       Patent family members are listed in annex.

\* Special categories of cited documents:

<p>*A* document defining the general state of the art which is not considered to be of particular relevance</p> <p>*E* earlier document but published on or after the international filing date</p> <p>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>*O* document referring to an oral disclosure, use, exhibition or other means</p> <p>*P* document published prior to the international filing date but later than the priority date claimed</p>	<p>*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>*&amp;* document member of the same patent family</p>
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Date of the actual completion of the international search  <b>2 December 2005</b>	Date of mailing of the international search report  <b>14/12/2005</b>
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International Application No  
PCT/US2005/030297

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EP 1382953	A	21-01-2004	JP	2004101515 A	02-04-2004
EP 0995979	A	26-04-2000	DE	59809098 D1	28-08-2003