

March 22, 1966

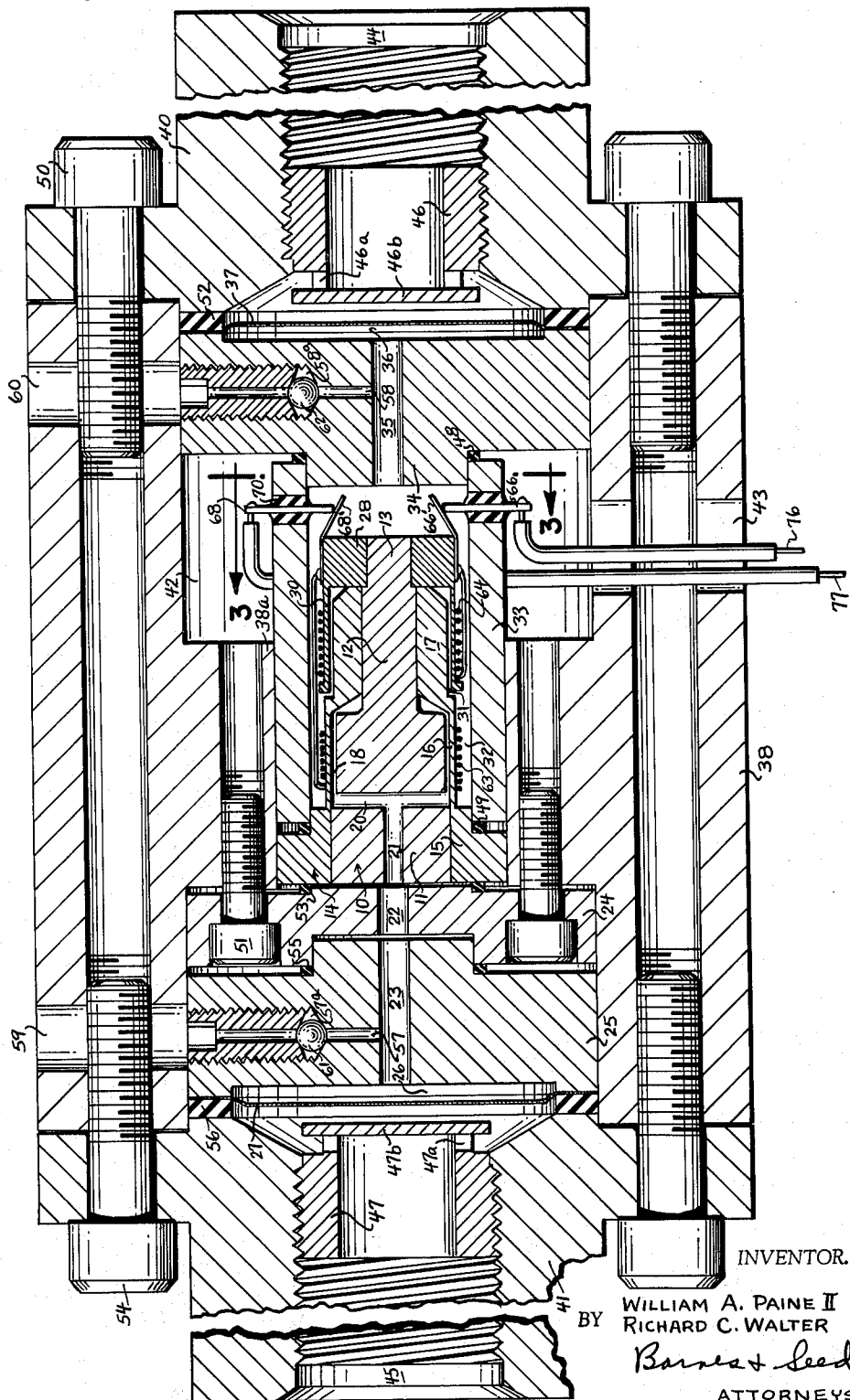
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3,242,448

PRESSURE TRANSDUCER

Filed May 3, 1962

2 Sheets-Sheet 1



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FIG. 2

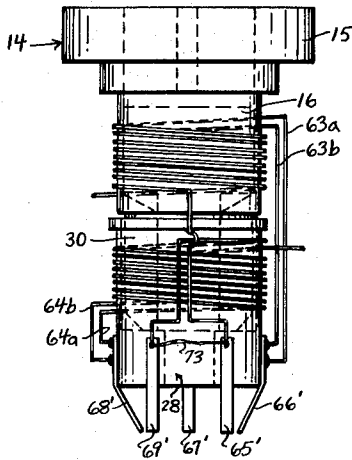


FIG. 3

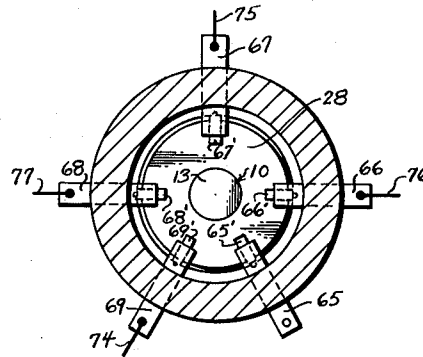
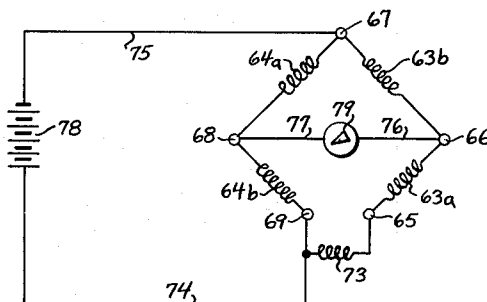


FIG. 4



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PRESSURE TRANSDUCER

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The present invention relates to pressure transducers of the general type in which strain responsive elements are mounted on a tubular pressure diaphragm so as to have varying electrical resistance effecting a recording circuit responsive to deformations of the diaphragm caused by test pressures to which it is subjected.

More particularly, the invention concerns low-volume pressure pickups of the type shown, for example, in United States Patent No. 2,883,503, issued April 21, 1959, and aims to provide a low-volume pressure transducer which gives superior freedom from fluid compliance and inertia effects, and from balance drift due to both static and dynamic temperature changes.

Another object is to provide a superior pressure transducer which is unusually small and compact, light weight, free of moving parts, and relatively economical to produce.

As still another object the invention aims to provide a low-volume pressure transducer which is trouble free of internal contamination and electrical shorts, and which cannot be readily damaged by fast moving particles or sharp objects entering its ports.

With yet additional objects and advantages in view which, with the foregoing, will appear and be understood in the course of the following description and claims, the invention consists in the novel construction and in the adaptation and combination of parts hereinafter described and claimed.

In the accompanying drawings:

FIGURE 1 is a longitudinal sectional view of a pressure transducer embodying the present invention.

FIG. 2 is a side elevational view of the active and passive diaphragms.

FIG. 3 is a transverse sectional view taken as indicated by line 3-3 of FIG. 1; and

FIG. 4 is a typical wiring circuit used with the invention.

Referring to the drawings, it is seen that a central plug 10 is externally stepped providing a primary section 11, a neck section 12, and a head section 13. Sleeved on this plug is a shell member 14 which has a base section 15, an intermediate active diaphragm 16, and a collar section 17. The base and collar sections 15, 17 of the shell member have a snug fit on the foot portion of the primary section 11 and the neck section 12 of the plug, respectively, while the head portion of the primary section is relieved opposite the active diaphragm 16 to provide a low volume pressure chamber 18 therebetween. This chamber is intersected at its foot end by passages 20 radiating in the primary section 11 from a center longitudinal bore 21 which originates at the base of the plug 10.

Bore 21 is in turn aligned with axial through bores 22 and 23 in respective foot and base plates 24-25 to communicate with a foot chamber 26 enclosed by a foot insulating diaphragm 27 which may be stainless steel.

Fitting snugly on the head section 13 of the plug 10 is a hat 28 which is formed with a passive compensating diaphragm 30 having the same transverse cross section as the active diaphragm 16. In this regard, these diaphragms 16, 30 are very thin, in the range of .015 to .025 inch. The brim of the hat 28 is spaced by a gap longitudinally of the head end of the active diaphragm,

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and the step between the latter and the collar section 17 is sufficient to provide a chamber 31 between the collar section and the passive diaphragm 30 which communicates through said gap with an external chamber 32 surrounding the diaphragms 16, 30. This chamber 32 is circumferentially enclosed by a cylinder 33 seated on the base section 15 and receiving at its other end a head plate 34. The latter matches the base plate 25 and has its center bore 35 interconnecting the chamber 32 with a head chamber 36 in turn enclosed by a head insulating diaphragm 37 complementing the foot diaphragm 27. An outside casing 38 and head and foot covers 40-41 complete the housing for the unit. It will be noted that the casing 38 has a central portion 38a sleeved on the foot half of the cylinder 33 and is counter-bored at the ends to receive the foot and base plates 24-25 at the foot end and the head plate 34 at the other end while providing a wiring chamber 42 around the head half of the cylinder 33. This chamber 42 has an access wiring port 43.

The covers 40-41 are longitudinally bored to provide head and foot pressure ports which communicate with the diaphragms 37, 27 via radial ports 46a-47a in cup-shaped baffle members 46-47, respectively. These baffle members are threaded into position with their baffles 46b-47b facing the respective diaphragms to stop fast moving particles or sharp objects entering the port 44-45 from puncturing or deforming the diaphragms.

To seal the chamber 32 the cylinder 33 is provided at its ends with metal gaskets 48-49 which are clamped between the cylinder and the head plate and the cylinder and the base section 15 of the shell member 14 by action of screws 50 and 51, respectively. Screws 50 also clamp the head cover 40 against a sealing gasket 52 for the rim of the head diaphragm 37 while screws 51 also clamp the foot plate 24 against the gasket 53 at the base of the shell member 14. A third set of screws 54 locks the base plate 25 and foot cover 41 in place against sealing gaskets 55-56 while also clamping the rim of the diaphragm 27 between the gasket 56 and the base plate.

For filling the unit with fluid between the diaphragms 27, 37 the base plate 25 and head plate 34 are provided with radial fill passages 57-58 intersecting the bores 23, 25 and registering with fill ports 59-60 in the casing 38. The fill passages are counterbored and threaded at 57a-58a to receive ball and screw valves 61-62.

Before explaining the wiring of the transducer, it should be understood that the plug 10, shell member 14, and hat 13 are formed from the same material so as to have the same expansion coefficient and equal thermal conductivity. This material may be of a suitable aluminum alloy which can be anodized to produce in the case of the diaphragms 16, 30 a hard surface having good electrical insulating properties so that pairs of wire elements 63a-b, 64a-b can be tension wound directly thereon in spaced bi-filar relation. It will also be understood that other materials than aluminum alloy can be used and that the surface upon which the wire elements are to be wound can be treated other than by anodizing to obtain suitable hardness and electrical insulation. The illustrated wound wire elements 63, 64 are of high-resistance strain gage wire and a thin coating of insulating varnish is applied thereon while they are tensioned to assure electrical separation of the turns and to bond them in place and maintain the tension. However, it is to be expressly understood that these wound wire elements are by way of example only, and that other types of strain responsive elements may be mounted on the active and passive diaphragms.

The wire elements 63a-b, 64a-b are electrically connected together in a Wheatstone bridge circuit as shown

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in FIG. 4. For this purpose terminal posts 65-69 are provided which project radially through openings near the head of cylinder 33. These posts are hermetically sealed and electrically insulated as by ceramic or glass heads 70. Because they are so fine, for example, .001 inch diameter, the strain responsive wire elements are not connected directly to the terminal posts but rather are bonded to the anodized surface of the hat 28 and electrically communicate with the posts of respective tabs 65'-69'. In the illustrated embodiment the foot ends of elements 63a-b communicate with terminals 65 and 67, respectively. Also communicating with the terminal 67 is a foot end of element 64a, the head end of the latter along with the head end of element 64b communicating with terminal 68. Element 64b has its foot end communicating with terminal 69. It is essential that the bridge be balanced before loading, i.e. the resistances of elements 63a-b be the same as the combined resistances of elements 64a-b. For this purpose the required length of strain gauge wire to balance the circuit can be applied as a jumper 73 between terminals 65, 69.

Leads 74-77 pass from the terminals through the wiring port 43, leads 74-75 for connecting to a battery 78, and leads 76-77 for connection to an oscillograph or other suitable indicating or recording device 79. Within the transducer the leads 76, 75, 77 are connected to terminal posts 66-68, respectively, and lead 74 is connected to either post 65 or 69 depending upon which half of the Wheatstone bridge required the jumper 73 for balance.

In order to prevent contamination and electrical shorts, the transducer is filled through the ports 59-60 with a suitable inert fluid, such as a silicone fluid or a fluoro chemical fluid, which remains isolated by the diaphragms 27, 37. These diaphragms are metal and are limber enough to cause no pressure drop across themselves when moved by fluid pressure applied through their respective ports 45, 44, or by expansion of the inert fluid due to heat.

Port 45, diaphragm 27, chambers 18 and 26 with their interconnecting passages 20-23, are provided to permit the measuring of the differential pressures. If gage pressure is to be instrumented, all of the structure to the left of the foot plate 24 as viewed in FIG. 1 can be eliminated. In such a case, to make an absolute pressure measuring device, the passage 22 in the foot plate 24 is sealed to provide a static reference point, usually near zero p.s.i. It will be noted that the transducer is adapted to be mounted directly by a nipple threaded into the port 44 on the equipment where the pressure is to be measured.

The clearance in chamber 18 between the principal diaphragm 16 and the plug 10 is made such that when pressure is applied only at port 44, the diaphragm 16 is compressed inward against the plug and becomes supported thereby when full scale pressure is reached. This arrangement prevents collapse and rupturing of the diaphragm under overload conditions.

Since the active and passive diaphragms 16, 30 are identical in structure, balance drift due to static and dynamic temperature changes are almost completely eliminated. The transducer also has minimum fluid compliance and inertia effects therein, because of its small fluid displacement. Accordingly, it has superior sensitivity and output even under varying thermal and vibrational conditions.

It is thought that the invention will have been clearly understood from the foregoing detailed description. Changes in the details of construction will suggest themselves and may be resorted to without departing from the spirit of the invention, wherefore it is our intention that no limitations be implied and that the hereto annexed claims be given a scope fully commensurate with the broadest interpretation to which the employed language admits.

What we claim is:

1. In a pressure transducer, a housing defining a closed fluid chamber, an active diaphragm sensitive to variations

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in fluid pressure mounted in said housing means for loading said active diaphragm by pressurized fluid, a compensating diaphragm matching said active diaphragm in material and transverse cross-section exposed on both of its sides to said fluid so as to be non-responsive to the pressure thereof, means for holding said compensating diaphragm in spaced relation to said active diaphragm, and an electrical circuit including matching strain-responsive elements mounted on said diaphragms.

2. In a pressure transducer, a housing defining a closed fluid chamber, an active tubular diaphragm mounted in said housing, means for loading said active diaphragm by pressurized fluid, a tubular compensating diaphragm matching said active diaphragm in material and transverse cross-section and exposed on both of its sides to said fluid so as to be non-responsive to the pressure thereof, means for holding said compensating diaphragm in spaced relation to said active diaphragm, and matching strain-responsive means mounted on said diaphragms.

3. In a pressure transducer, a housing, an active diaphragm and an isolating diaphragm mounted in said housing and spaced apart from one another said housing having a closed fluid chamber with fluid therein and exposed to one side only of both of said diaphragms, a compensating diaphragm matching said active diaphragm in material and transverse cross-section exposed on both of its sides to the fluid in said chamber so as to be non-responsive to pressure of said fluid, means for holding said compensating diaphragm in spaced relation to said active diaphragm, matching strain-responsive means mounted on said active and compensating diaphragms, and pressurized fluid means exposed to the other side of said isolating diaphragm for loading the isolating diaphragm to thereby responsively load said active diaphragm via the fluid in said chamber.

4. In a pressure transducer, a housing, an active tubular diaphragm and an isolating diaphragm mounted in said housing and spaced apart from one another, said housing having a closed fluid chamber with fluid therein and exposed to one side only of both of said diaphragms, a tubular compensating diaphragm matching said active diaphragm in material and transverse cross-section and exposed on both of its sides to fluid in said chamber so as to be non-responsive to pressure of said fluid, matching strain-responsive means mounted on said active and compensating diaphragms, and a fluid passage in said housing external of said chamber for carrying pressurized fluid to the other side of said isolating diaphragm for loading the isolating diaphragm to thereby responsively load said active diaphragm via the fluid in said chamber.

5. The structure of claim 4 in which baffle means are mounted in said passage adjacent said isolating diaphragm for protecting the latter.

6. In a pressure transducer, a housing, an active diaphragm and two isolating diaphragms mounted in said housing, said isolating diaphragms being spaced from said active diaphragm, and said housing having two closed fluid chambers with fluid therein, one of said chambers being exposed to one side only of said active diaphragm and to one side only of one of said isolating diaphragms, and the other of said chambers being exposed to the other side only of said active diaphragm and to one side only of the other of said isolating diaphragms, a compensating diaphragm matching said active diaphragm in material and transverse cross-section mounted in one of said chambers and having both of its sides exposed to the fluid in such chamber so as to be non-responsive to the pressure of such fluid, matching strain-responsive means mounted on said active and compensating diaphragms, and differential pressure fluid means exposed to the other sides of said isolating diaphragms for differential loading said isolating diaphragms to thereby responsively differentially load said active diaphragm via the fluid in said chambers.

7. In a pressure transducer, a housing, an active tubular diaphragm and two isolating diaphragms mounted in

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said housing, said isolating diaphragms being spaced from said active diaphragm, and said housing having two closed fluid chambers with fluid therein, a first of said chambers being exposed to the outside only of said active diaphragm and to one side only of one of said isolating diaphragms, a compensating tubular diaphragm mounted in said first chamber and having both of its sides exposed to the fluid in said first chamber so as to be non-responsive to the pressure of such fluid, said compensating diaphragm being of the same material and having the same transverse cross-section as said active diaphragm, matching strain-responsive means mounted on the outside of said active and compensating diaphragm, and differential pressure fluid means exposed to the other sides of said isolating diaphragms for differential loading said isolating diaphragms to thereby responsively differentially load said active diaphragm via the fluid in said chambers.

8. The structure of claim 7 in which said housing has a stop in said second chamber for limiting collapse of said active diaphragm under overload conditions.

9. In a pressure transducer, a necked plug member, a stepped shell member having a base section snugly sleeved on said plug member, an intermediate tubular active diaphragm section spaced by a gap from the plug member, and a collar section snugly sleeved on the neck of said plug member, the outer diameter of said collar section being less than the inner diameter of said active diaphragm section, a hat member mounted on said plug member and presenting a tubular compensating diaphragm skirting said collar section in spaced alignment with said active diaphragm, said active and compensating diaphragms being of the same material and having the same transverse cross-section, a housing for said members and providing a fluid pressure chamber exposed to the outside only of said ac-

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tive diaphragm and to both sides of said compensating diaphragm, and matching strain-responsive means on said diaphragms.

10. In a pressure transducer, a necked plug member, a stepped shell member having a base section snugly sleeved on said plug member, an intermediate tubular active diaphragm section spaced by a first fluid pressure chamber from the plug member, and a collar section snugly sleeved on the neck of said plug member, the outer diameter of said collar section being less than the inner diameter of said active diaphragm section, a hat member mounted on said plug member and presenting a tubular compensating diaphragm skirting said collar section in spaced alignment with said active diaphragm, said active and compensating diaphragms being of the same material and having the same transverse cross-section, a housing for said members and providing a second fluid pressure chamber isolated from said first chamber and exposed to the outside of said active diaphragm and to both sides of said compensating diaphragm, and matching strain-responsive means on said diaphragms.

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