

April 12, 1960

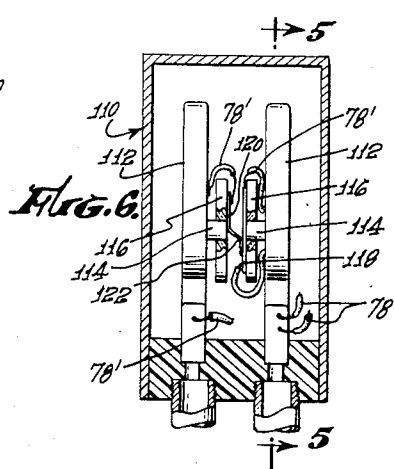
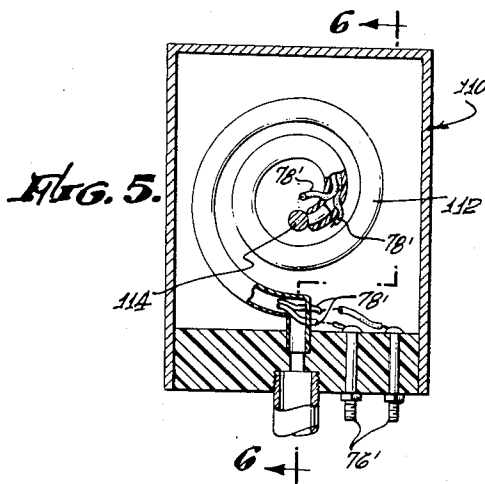
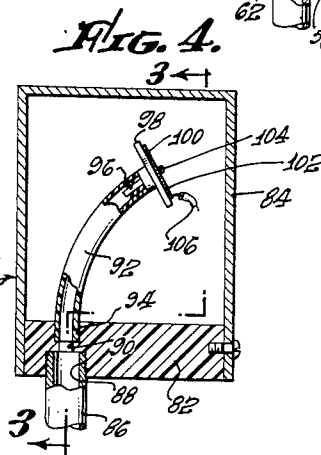
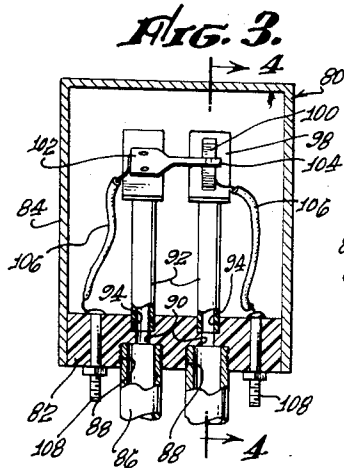
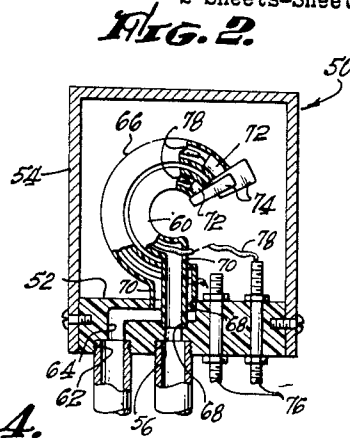
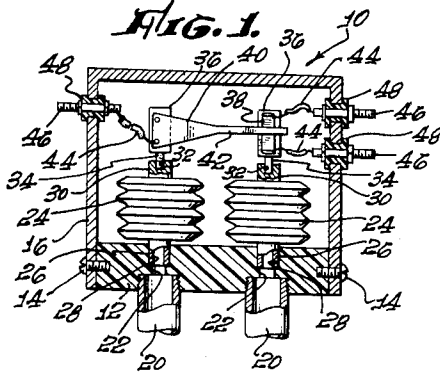
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2,932,807

PRESSURE RESPONSIVE ELECTRICAL INSTRUMENTS

Filed June 14, 1956

2 Sheets-Sheet 1



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PRESSURE RESPONSIVE ELECTRICAL INSTRUMENTS

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FIG. 7.

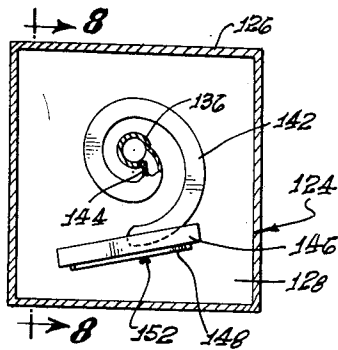


FIG. 8.

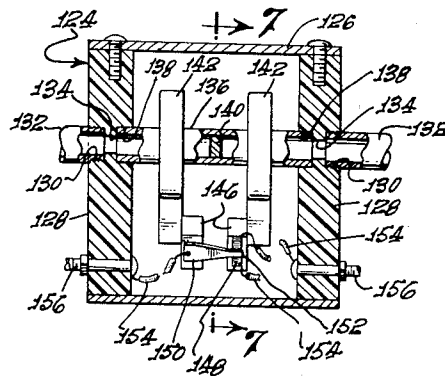


FIG. 9.

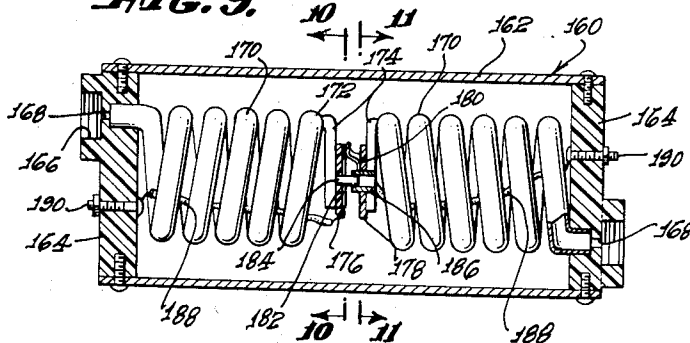


FIG. 10.

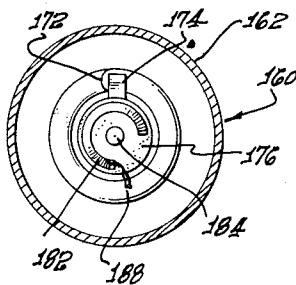
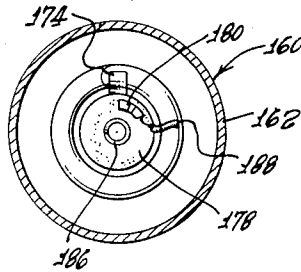


FIG. 11.



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PRESSURE RESPONSIVE ELECTRICAL INSTRUMENTS

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1 Claim. (Cl. 338—40)

This invention relates to new and improved pressure responsive electrical instruments, and especially to electrical potentiometers.

A wide variety of different pressure responsive instruments are manufactured at the present time. In spite of this there is a decided need for pressure responsive instruments which are unaffected by ambient pressure, which are capable of being used to measure the pressures of corrosive gases, which are relatively immune to the effects of shock, vibration and acceleration, and in which the temperature of the instrument does not affect the electrical output obtained.

A broad object of this invention is to provide pressure responsive electrical instruments having all of these qualities combined into a single unit. A more specific object of this invention is to provide electrical instruments in which only a minimum number of operative parts are employed. This latter is interconnected to the cost of such instruments, and to their ease in assembly. The latter is frequently very important since it is difficult to produce inexpensive, effective instruments on a production line basis.

One specific object of this invention is to provide a new type of pressure responsive element having the essential shape of a Bourdon tube, but being formed of non-metallic materials of a corrosion resistant category. Another specific object of this invention is to provide in pressure responsive electrical instruments a new type of electric conductor construction utilized with pressure responsive elements of the variety indicated in the preceding sentence.

Because of the nature of this invention further objects of it will be more fully apparent from the remainder of this description, including the appended claim and the accompanying drawings in which:

Fig. 1 is a side cross sectional view of a pressure responsive potentiometer of this invention;

Fig. 2 is a side cross sectional view of a pressure responsive capacitor of this invention;

Fig. 3 is a side cross sectional view taken along line 3—3 of Fig. 4 of a pressure responsive variable resistor of this invention;

Fig. 4 is a cross sectional view taken at line 4—4 of Fig. 3;

Fig. 5 is a cross sectional view taken at line 5—5 of Fig. 6 of a modified pressure responsive potentiometer of this invention;

Fig. 6 is a cross sectional view taken at line 6—6 of Fig. 5;

Fig. 7 is a cross sectional view taken at line 7—7 of Fig. 8 of another modified potentiometer of this invention;

Fig. 8 is a cross sectional view taken at line 8—8 of Fig. 7;

Fig. 9 is a cross sectional view similar to Fig. 2 of a modified variable resistor of this invention; and

Figs. 10 and 11 are cross sectional views taken at lines 10—10 and 11—11 of Fig. 9, respectively.

In all figures of the drawing like numerals are used

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to designate like parts whenever convenient for purposes of illustration and explanation. It is to be understood that this invention is not limited to pressure responsive electrical instruments having the precise size, shape and configurations shown, inasmuch as the basic features of this invention can be readily incorporated into other instruments of this category having different sizes, shapes and configurations.

In order to understand this invention it may be stated that it broadly concerns pressure responsive electrical instruments having the characteristics briefly indicated in the preceding discussion each of which instruments includes a mounting member, two pressure responsive members each having a fixed end secured to said mounting member and each having a movable end spaced from said mounting member; first and second electrical means carried by said movable ends so that as said movable ends are caused to move in response to pressure changes said means coact together so as to vary an electrical value; and terminal means attached to said electrical means. It may also be stated in essentially summary form that this invention includes Bourdon tube-like pressure responsive elements or means formed of an electrically non-conductive composition.

The actual nature of this invention can be best explained by referring directly to the accompanying drawing. In Fig. 1 there is shown a pressure responsive potentiometer 10 having a non-conductive mounting member or base 12 formed of a phenolic or other similar composition. Attached to this base by means of screws 14 is a metal cover 16 which, if desired, may be termed a housing. Screwed into tapped holes in the bottom of the base 12 are two threaded pipes 20, which are connected to sources of pressure fluid (not shown). The pipes 20 are interconnected by means of passages 22 to the interiors of bellows 24. The bellows 24 are carried upon the base 12 by means of hollow bushings 26 forming a part thereof. These bushings 26 are secured as by the use of a conventional adhesive or equivalent means within enlarged openings 28 communicating with the passages 22.

Each of the bellows 24 is provided at its movable end with a projecting stud 30; each of the studs has a non-round opening 32 formed therein so that correspondingly shaped extensions 34 from non-conductive supports 36 may be secured therein by any desired means such as, for example, an adhesive, screws, or the like. One of the supports 36 carries a conventional resistance element 38 which may be mounted upon it in any desired manner. The other of the support 36 carries a metal electrical contact or wiper 40 having a resilient arm 42 engaging the resistance element 38. The wiper 40 may also be mounted by any convenient method. The supports 36 can be formed of a phenolic or other non-conductive resin, or even of a ceramic composition. Wires 44 lead from the wiper 40 and from the ends of the resistance element 38 to terminals 46 passing through non-conductive rubber or other bushings 48; these bushings in turn pass through openings in the cover 16 as illustrated.

The operation of the potentiometer 10 is considered to be essentially obvious. When fluid under pressure such as, for example, a gas is introduced into either of the pipes 20 one of the bellows 24 is caused to expand moving either the wiper 40 or the resistance element 38. This in turn adjusts these electrical means as they are moved with respect to one another. The mere operation of the potentiometer 10 does not, however, fully indicate its advantages. The electrical means shown are substantially unaffected by ambient pressure from any source. Thus, the cover 16 need not be sealed with respect to the base 12. The electrical mechanism employed in this

unit is isolated from both sources of pressure which may be used to actuate it.

Since the bellows 24 are preferably formed so as to be identical in construction, and so as to be mounted parallel to one another, temperature effects such as the change in the spring rate of these bellows are substantially eliminated. Further, because of the bellows structure employed, the electrical means carried by these bellows move in the same direction, the same rate, etc. when the potentiometer 10 is subjected to acceleration, vibration and/or shock so that any electrical signal obtained is unaffected by such factors.

A similar type of construction is involved in the pressure responsive capacitor 50 shown in Fig. 2. This unit includes a base 52 similar to the base 12 and a cover 54 similar to the cover 16. Within the base 52 there is provided a first threaded opening 56 which is connected by a short passage to the interior of an inner Bourdon tube 60. Another opening 62 similar to the opening 18 is provided within the base 52 so as to be connected by means of a passage 64 with an outer Bourdon tube 66. These two tubes are mounted, as illustrated in this figure, within openings of depressions 68 concentrically located with respect to one another and of different dimension so that straight, cylindrical necks 70 from the tubes 60 and 66 extend from them. These necks 70 are connected with the tubes proper; the movable ends of these tubes remote from the necks 70 are sealed so as to each carry projecting electrical conductors 72. These conductors are preferably utilized so as to carry integrally formed electrodes 74 serving as capacitor electrodes. These electrodes 74 are, of course, spaced from one another.

The construction of the tubes 60 and 66 with this embodiment of the invention is quite important. These tubes are, as illustrated, mounted with respect to one another so that the necks 70 constituting fixed ends of these tubes are held by the base 52, while the movable ends or portions of these tubes extend parallel and concentrically to each other. Thus, with this construction, the electrodes 74 move in synchronism with one another so as to compensate for acceleration, vibration and shock effects as indicated in the preceding discussion. Further, temperature effects resulting from the change in spring rate of the tubes 60 and 66 are eliminated. In order to achieve all of these effects the inner tube 60 should preferably differ in dimension from the outer tube 66 as indicated on the drawing in an amount depending upon the distance between these two tubes since they are both mounted within the same plane.

The material from which the tubes 60 and 66 are constructed is considered to be quite important with this invention. Although these two tubes can be formed of metal and electrodes 74 can be connected to terminals 76 by means of wires such as the wires 44 previously described when these electrodes are electrically insulated from one another, it is preferred to form the tubes 60 and 66 of a non-conductive synthetic "plastic" or resinous material. Suitable materials are various filled phenolic casting resins, polyester styrene copolymers, styrene compositions, epoxy compositions and the like. These compositions can be altered or modified in an infinite variety of ways, and can include various conductive or non-conductive fillers modifying their expansion characteristics. If desired they may be provided with an exterior or interior polyvinyl alcohol or other coating so as to severely restrict their tendency to allow gas to pass through their walls.

Strictly speaking the tubes 60 and 66 are not Bourdon tubes when formed of such materials since Bourdon tubes are frequently defined as having thin metal walls. Hence, they may, if desired, be termed pressure responsive elements. Being non-conductive in nature they form excellent passages for wires 78 which may lead from the conductors 72 out through the necks 70 to the terminals

76. These terminals may, as shown, extend through the base 52. The wires are, with this type of construction sealed where they pass through the necks 70 as by making use of the inherent properties of the non-conductive resins employed. Where one of the necks 70 passes through the other of the necks shown these two necks are preferably sealed together with a resinous material.

If desired, both the tubes 60 and 66 can be formed integrally with one another by various procedures. One of these procedures involves first locating the wires 78 and the conductors 72 in a desired mold corresponding to the shape of the voids within the tubes 60 and 66; casting plaster of Paris into this mold; removing the article formed and placing it in another mold corresponding in shape to the final Bourdon tube construction desired. The final Bourdon tube structure may then be created by filling this final mold with a resinous material of any of the categories indicated, and knocking the plaster of Paris from the final article as through shock treatment or the like.

With the type of structure indicated the wires 78 cannot possibly move during use of the capacitor 70 so as to affect the operation of this instrument. The type of structure of the Bourdon tubes 60 and 66 can obviously be used with a potentiometer such as the one shown in Figure 1, or with other related electrical instruments without major modification. If desired the wires employed may be passed directly through the tube walls. This is advantageous in a potentiometer construction where two wires must be passed through a single tube and where the tube is to be employed with a corrosive material. The wires in this type of construction also reinforce the tube and aid in its operation.

In Figs. 3 and 4 of the drawing there is shown a variable resistor 80 of the invention which incorporates a base 82 similar to the base 12 and a cover 84 similar to the cover 16. Threaded pipes or tubes 86 connecting this resistor 80 to any desired pressure sources are designed to be threaded within openings 88. These openings in turn are connected by means of passages 90 to the interiors of curved Bourdon tubes 92. These tubes are mounted within other openings 94 in the base 82 as by the use of an adhesive or the like. Within the end of each of them remote from the base 82 there is carried a small, handle-like extension 96 projecting from a non-conductive support 98. Positioned on one of these supports in any desired conventional manner is a conventional resistance element 100; positioned upon the other of these supports is a conventional contact member or wiper 102 having an arm 104 resiliently engaging the resistance element 100. The wiper 102 and one end of the resistance element 100 are connected as through use of solder to wires 106 leading to terminals 108 extending through the base 82.

The essential operation of the resistor 80 is similar to the operation of the potentiometer 10; hence it will not be described in detail. It will be noted, however, that the Bourdon tubes 92 employed are of identical construction and are mounted parallel to one another, and that the extensions 96 are sealed within the ends of these tubes. Although it is possible to form the Bourdon tubes 92 of thin metal it has been found preferable to form these tubes and the extensions 96 of a non-conductive material such as any of the materials indicated in discussing the capacitor 50. One particular composition for the tubes 98 which has proved to be favorable because of strength and other considerations is a reinforced fiberglass structure utilizing a polyester-styrene copolymer such as is commonly employed for fishing rods or the like. A thin-walled reinforced wall structure of this category is particularly advantageous because of its ability to flex when subjected to acceleration, shock and/or vibration in order to withstand such treatment. Also, this material, in this type of construction, is very corrosion resistant and, hence, the resistor 80 can be employed

to measure the pressure of corrosive gases or the like. If desired the walls of a Bourdon tube type of structure of this category can be coated with a composition such as polyvinyl alcohol or the like so as to cut down their ability to allow gas to permeate them.

In Figs. 5 and 6 there is shown a pressure responsive potentiometer 110 of the invention which is so similar in construction to the capacitor 50 that the various parts of it will not be described in detail, these parts of an identical nature are designated by the primes of the numerals used in describing the capacitor 50. Within this potentiometer 110 there are employed helical or spiral Bourdon tubes 112 which support at their inner ends small rods 114. These rods are secured to non-conductive, movable supports 116. Upon one of these supports there is secured in any known manner a conventional electrical resistance element 118. Upon the other of the supports there is located in any desired known manner a contact member or wiper 120 having a resilient arm 122 engaging the resistance element 118. Wires 78' are described as previously indicated so as to connect these electrical means to terminals 76'. The potentiometer 110 operates essentially as any of the units discussed previously.

In Figs. 7 and 8 of the drawing there is shown another modified potentiometer 124 having a metallic housing 126 within the ends of which there are held non-conductive mounting members 128 similar to the base 12. Openings 130 in these mounting members are used to place pipes 132 in communication with passages 134 leading to the ends of a hollow tube 136 supported by the two mounting members 128 within aligned openings 138. Appropriate sealing means, such as adhesives are used to prevent leakage.

Within the center of the tube 136 there is located a barrier 140 which is secured to the walls of this member essentially as a blockade so that fluid from pressure either of the pipes 132 can travel into either of two identically shaped helical Bourdon tubes 142. As shown in Fig. 7 these Bourdon tubes are attached to the tube 136 so as to extend through openings 144 formed therein, and the junction of each of the tubes 142 with the tube 136 is sealed. Upon the outer or movable ends of the tubes 142 there are mounted non-conductive blocks 146 as through the use of an adhesive, welding or the like. One of these blocks 146 carries a conventional resistance element 148, and the other carries a movable contact member or wiper 150 having a resilient arm 152 engaging the resistance element 148. The wiper and the resistance element can be attached in any desired manner. Wires 154 extend from the ends of this element and from the wiper 150 to terminals 156 projecting through the mounting members 128.

In the potentiometer 124, as in all preceding units, the pressure responsive members or Bourdon tubes are mounted parallel to one another. In this unit as in all the other units described except the capacitor 50 these pressure responsive members are identical to one another. Hence, with this construction, and the other constructions described, all of the advantages during operation indicated earlier in this specification are obtained.

These same advantages can be obtained with a different type of construction employing two spiral Bourdon tubes each extending in a cylindrical path. This type of construction is illustrated in Figs. 9, 10 and 11 of the accompanying drawing. Here there is shown a variable resistor 160 having a cylindrical housing 162. The ends of this housing are closed by non-conductive caps 164 such as may be formed of a phenolic composition or the like so as to include threaded openings 166 designed to be attached to appropriate pipes or conduits conveying fluid under pressure. Pressure is conveyed from the openings 166 through passages 168 leading to the interiors of two Bourdon tubes 170.

These Bourdon tubes are mounted upon the caps 164

as shown, and are both of a spiral configuration and extend within a cylindrical path; the axes of these paths are coincident with one another. The two Bourdon tubes 170 are preferably identical to one another in dimensions, etc., but they are wound in opposite directions as illustrated in Fig. 9. Upon the end 172 of one of the Bourdon tubes 170 there is secured a short rod 174 as by welding or the like. This rod carries a first non-conductive support 176 formed out of a phenolic resin or the equivalent. Projecting from the ends 172 of the other Bourdon tube 170 is another rod 174 which carries a second non-conductive support 178 of identical construction to the support 176. Mounted by various conventional means such as, for example, an adhesive upon the support 176 is a small resilient metal contact or brush member 180 which is designed to engage an arcuate resistance element 182, such as for example, a printed circuit resistance element located upon the support 176.

From the support 176 there projects a centrally located cylindrical pin 184 which is normally carried within a correspondingly shaped cylinder 186 mounted upon the support 178 in a central location. The pin 184 and the cylinder 186 are, with this construction, capable of sliding within one another so as to accommodate relative movement between the Bourdon tubes 170. As these Bourdon tubes change configuration as a result of pressure changes the brush 180 rotates with respect to the resistance element 182, and/or this resistance element tends to rotate with respect to the brush 180. The precise rotation will be dependent upon the pressure differential within the two Bourdon tubes 170. Undesired movement of the two electrical means employed is prevented by means of the pin 184 and the cylinder 186. Wires 188 are attached to an end of the resistance element 182 and to the brush 180 so as to connect these members to terminals 190 mounted upon the caps 164.

This type of construction may be converted into a potentiometer very easily by using wires leading to both ends of the resistance element 182. It can be converted into a capacitor by placing electrodes on the supports 176 and 178. Obviously the structures at the ends of the Bourdon tubes 170 can be replaced by other equivalent means. The important feature of this construction is that two bilaterally symmetrical spiral Bourdon tubes are utilized to obtain the advantageous results described. Further these two tubes in the structure shown project in the locus of the same cylinder. If desired the Bourdon tubes 170 can be constructed in the same manner as any of the non-conductive Bourdon tube like structures previously indicated.

It is to be understood that, by appropriate modification of essentially an obvious engineering nature, the Bourdon tube or pressure responsive member constructions herein described can be interchanged with one another in different types of electrical instruments. Thus, for example, the instrument 80 can be formed with a capacitor or resistor or the like. All such modifications of this category are to be considered as part of the invention in so far as they are defined by the appended claims. Similarly any modifications involving the use of a gas or liquid, such as a dielectric fluid, within a unit as described in the specification are to be considered as covered by this invention. Also modifications involving one evacuated or sealed pressure responsive member are to be considered as covered by the invention.

Although non-conductive pressure responsive members in the nature of Bourdon tubes have been specifically set forth in this application in conjunction with electrical instruments utilizing two parallel pressure responsive members, it is to be understood that Bourdon tubes of this category can be employed in virtually any type of pressure responsive instrument, even in instruments which are not of an electrical category. The materials indicated for use in these non-conductive pressure responsive

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members are not to be taken as limiting this aspect of the invention since other known non-conductive resins or reinforced or "filled" resin compositions can obviously be used.

I claim:

A differential pressure transducer comprising a base member, a pair of spiral Bourdon tubes mounted side by side and parallel to one another on said base member, means for introducing two different fluid pressures from separate sources into said Bourdon tubes, a resistance element mounted on the free end of one of said Bourdon tubes, and a contact member mounted on the free end of the other Bourdon tube and wiping on said resistance element, said contact member and said resistance element being moved different distances by the different fluid pressures in their respective Bourdon tubes,

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causing said contact member to shift its position with respect to said resistance element and thereby produce an electrical signal that is a function of the differential in said fluid pressures.

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