Sept. 22, 1964 F. PISCHINGER 3,150,274

PIEZOELECTRIC PRESSURE TRANSDUCER

Filed Sept. 30, 1960

FIG. 1

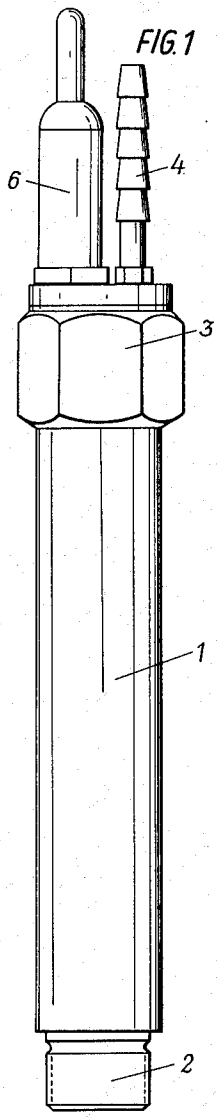


FIG. 2

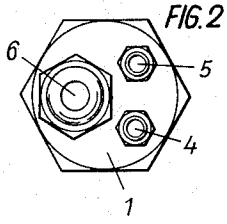


FIG. 3

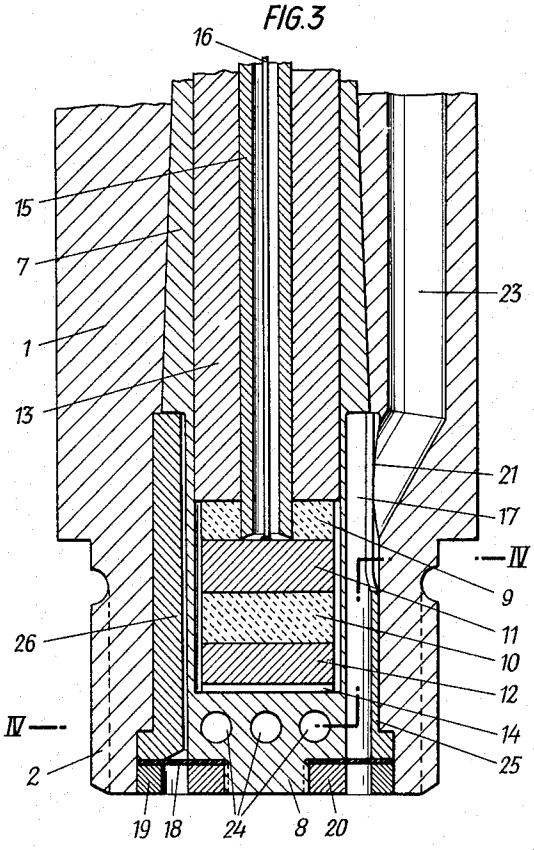
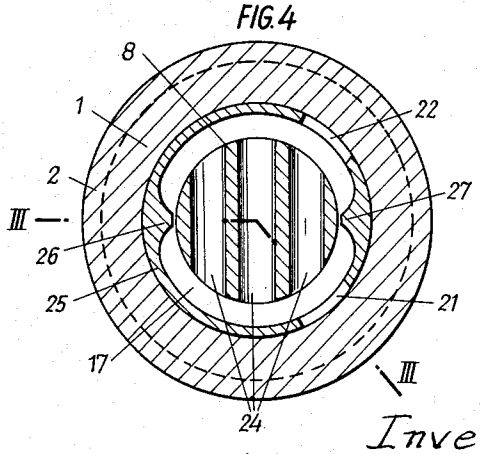


FIG. 4



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PIEZOELECTRIC PRESSURE TRANSDUCER

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2 Claims. (Cl. 310—8.9)

The invention relates to a piezoelectric gauge, in particular for measuring the pressure in the cylinders of internal combustion engines, comprising a casing and a sleeve attached thereto, said sleeve presenting a thin-walled elastic enclosure for the piezoelements at least in the area of the pressure-loaded extremity and being closed at said extremity by a pressure-transfer head, an annular chamber being provided between said sleeve and said casing, said annular chamber being closed by a membrane at the head end and traversed by the coolant entering through an inlet and discharged through an outlet opening.

In conventional appliances of this type, the cooling water is delivered to the annular chamber through a duct, said cooling water flowing around the sleeve and emerging from the annular chamber through a discharge duct located approximately opposite the admission duct. Experience goes to show that precisely such elements of the piezoelectric gauge which attain the highest temperature in operation, that is in particular, the sleeve and the pressure-transfer head are inadequately cooled. As a result, these elements are subject to an excessive thermal stress and the temperature of the quartz crystals generally used as piezoelements is not maintained on a constant level, so that measurements become inaccurate. In addition, it was found that the water which is inadequately entrained by the current, especially in the vicinity of the membrane, will start boiling, thereby causing the membrane to vibrate. These vibrations are transferred to the piezoelements causing errors of measurement such as overlapping of the pressure curve recorded by a cathode ray oscillograph.

The purpose of the invention is to eliminate these drawbacks, the basic idea being to provide for a satisfactory heat evacuation by dissipating the heat already on its way to the piezoelements from the pressure-loaded extremity of the sleeve and in particular, from the head which closes the latter on the pressure side.

The invention consists in providing the head in the area of the annular chamber with at least one through bore extending in transverse relation to the sleeve and serving for the passage of the cooling liquid, and furthermore arranging inside the annular chamber two approximately diametrically opposite projecting ribs extending axially over the entire height of the annular chamber, said ribs originating on the outer surface of the annular chamber and protruding towards the sleeve, the inlet and outlet openings being located at different sides of the projecting ribs. The design according to the invention provides a positive flow of the cooling liquid inside the annular cooling chamber of the piezoelectric gauge, thereby preventing the heat from flowing from the front end of the piezoelectric gauge to the piezoelements. As a result of the considerably improved cooling effect, the piezoelectric efficiency will not be impaired by temperature fluctuations of the piezoelements. The projecting ribs which may extend nearly to the outer surface of the sleeve deflect a substantial portion of the cooling liquid entering the annular chamber through the inlet opening by discharging same through the bores in the pressure-transfer head, thereby keeping the cooling liquid permanently on the move in every section of the annular chamber. This largely eliminates the risk of the cooling liquid starting boiling, particularly in the area of the membrane which closes the

annular chamber. Besides, the piezoelements are located farther inside the piezoelectric gauge, since on account of the provision of bores, the head is of greater length without any noticeable increase of its mass. The coolant used may be either water or a liquid having a higher boiling point than water, such as silicon oil.

It is already known to cool the pressure-loaded extremity of the sleeve of the piezoelectric gauge by means of cooling water in permanent motion. According to that design, the piezoelements are located outside the sleeve, surrounding the latter inside an annular casing encompassed by an external cooling chamber of annular shape. In addition to this external cooling circuit, an internal cooling circuit serves to cool the sleeve, the cooling water being delivered through a pipe extending into the interior of the sleeve nearly to the pressure-loaded extremity of the latter and drained off alongside the walls of the sleeve. However, this arrangement implies a most complicated design of the piezoelectric gauge without improving the cooling effect to any considerable extent, as only a minor portion of the sleeve surface is covered by the cooling water and only a negligible section of the head closing the sleeve at the pressure end comes into contact with the cooling water.

According to another known design it has been proposed to provide the membrane of a capacity-operated piezoelectric gauge with transverse grooves on the underside, a disk pressed against said membrane defining in conjunction with said grooves, ducts for the passage of the coolant. In view of the particular nature of the physical phenomena applied in this design, there are no piezoelements nor is there any element comparable to the pressure-transfer head of the object of the invention. Moreover, no provision has been made for the maintenance of a regular current so that the flow of coolant through the passages defined by the transverse grooves in the membrane is wholly inadequate.

According to a preferred embodiment of the invention, the projecting ribs are formed by a guide sleeve, the outer surface of which adjoins the casing and which extends over the entire height of the annular chamber. The most remarkable feature of this embodiment resides in the fact that it is easy to manufacture. The difficulty of installing and removing the sleeve if the projecting ribs are rigidly attached to the casing is also eliminated.

An embodiment of the invention is illustrated by the accompanying drawing in which

FIGURE 1 shows a front view of the piezoelectric gauge according to the invention,

FIGURE 2 is a plan view of same,

FIGURE 3 is a cross-sectional view of the portion of the piezoelectric gauge containing the piezoelements, on line III—III of FIGURE 4, and

FIGURE 4 is a cross-sectional view on line IV—IV of FIGURE 3, each on an enlarged scale.

The piezoelectric gauge illustrated comprises a cylindrical casing **1**, the lower extremity of which presents a threaded connection **2** suitable for screwing it into the cylinder head of an internal combustion engine for example, whereas its upper extremity presents a hexagon head **3**. The upper extremity of the casing **1** also carries pipes **4** and **5** to be connected to the inlet and discharge ducts for the coolant and a leading-in insulator **6** from which the electrical supply line emerges.

The sleeve **7** is located inside the casing **1** and attached thereto and closed by a pressure-transfer head **8**. In the area of its pressure-loaded extremity the sleeve **7** is thin-walled and elastic and encloses the piezoelements, such as, for example, two quartz crystals **9** and **10**. In the embodiment shown, these are superimposed and connected in opposition, an electrode **11** being provided between them for the purpose of leaking off the positive charges

for instance, whereas the negative charges are allowed to leak off over the body of the piezoelectric gauge. For that purpose an electrode 12 is provided on one side of the quartz crystals and a steel cylinder 13 on the other side, said cylinder being connected to the quartz crystal 9 and serving at the same time to clamp the quartzes down. The electrode 12 adjoining the quartz crystal 10 is conductively connected with the head 8 and consequently also with the body of the piezoelectric gauge via a layer 14 of a soft metal such as aluminum. The purpose of the metal layer is to establish an electric contact with the least possible transfer resistance between the electrode 12 and the head 8. Inside the steel cylinder 13 an insulating tube 15 is located which encloses the electric wire 16 leading from the electrode 11 outside.

Recessed between the thin-walled section of the sleeve enclosing the piezoelectric quartz crystals 9 and 10 and the casing 1 is an annular chamber 17 closed at the head end by a membrane 18 located between the casing 1 and the head 8, said membrane being maintained in position by rings 19 and 20. The upper part of the annular chamber 17 comprises an inlet 21 and an outlet 22 through which the coolant admitted through pipe 4 and discharged through pipe 5 and via channels 23 in the casing 1 flows through the annular chamber 17.

The section of the head 8 located in the area of the annular chamber 17 comprises three through bores 24 extending in transverse relation to the sleeve, for the passage of the cooling liquid from one half of the annular chamber 17 to the other half. In order to get the largest possible amount of cooling liquid to flow through the bores 24, a guide sleeve 25 is provided in the annular chamber, said guide sleeve adjoining with its outer surface the casing 1 and extending over the entire height of the annular chamber 17. The guide sleeve 25 comprises two diametrically opposite projecting ribs 26 and 27 extending in axial direction and protruding towards the thin-walled section of sleeve 7. Between the projecting ribs 26 and 27 on the one hand and the thin-walled section of sleeve 7 on the other hand, only narrow slots are left for the passage of the cooling liquid. Thus a larger or smaller portion of the cooling liquid is allowed to flow through the bores 24 in the head 8, depending on the width of said slots. In order to achieve a greater cooling effect

the projecting ribs 26 and 27 are for example, dimensioned in such a way as to let about 60 percent of the cooling liquid pass through the bores 24.

I claim:

1. A piezoelectric pressure transducer comprising a casing and a sleeve clamped in said casing, piezoelectric elements enclosed in said sleeve, a head closing said sleeve at its pressure-loaded extremity for transferring pressure to said piezoelectric elements, said sleeve being thin-walled and elastic at least in a portion thereof enclosing said piezoelectric elements, a guide sleeve enclosed by said casing and coaxial with and spaced from said first-mentioned sleeve, the space between the sleeves forming an annular chamber surrounding the thin-walled portion of the first-mentioned sleeve, a membrane closing said annular chamber, said guide sleeve having inlet and outlet openings for the admission and discharge of a cooling liquid to and from the annular chamber, said head having a bore traversing said head in the area of the annular chamber and serving for the passage of the cooling liquid, two axially extending and diametrically opposite projecting ribs in the annular chamber, said projecting ribs being integral with the said guide sleeve but freely protruding towards the first-mentioned sleeve and extending over the entire height of the annular chamber, and said inlet and outlet openings being located on opposite sides of the projecting ribs.

2. A piezoelectric gauge as claimed in claim 1, in which a plurality of bores are provided inside the head in parallel relation to each other.

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