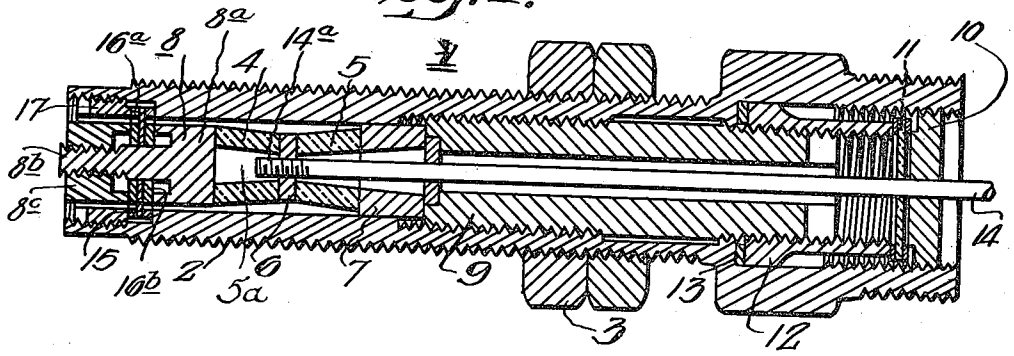
Oct. 8, 1940. G. SWIFT 2,216,966

PIEZOMETER

Filed Jan. 31, 1939

Fig. 1.



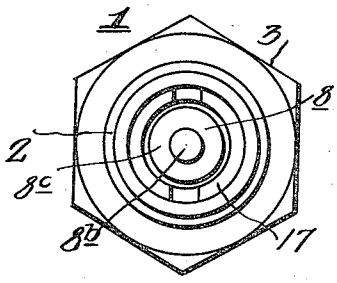


Fig. 2.

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PIEZOMETER

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9 Claims. (Cl. 171—327)

This invention relates to piezometers, i. e., to instruments for translating instantaneous and/or continuously variable pressures into measurable electrical energy by utilization of the piezoelectric properties characteristic of quartz, tourmaline or other crystalline substances.

The principal object of the invention is to provide improvements in piezometers of the general type disclosed in U. S. Patent 2,096,826 to Harold J. Schrader.

The piezometer or pressure pick-up unit of the Schrader patent comprises a pair of parallel connected piezoelectric crystals enclosed in a cylindrical metal casing which is adapted to be inserted in the wall of the engine cylinder or other pressure chamber within which the time-pressure phenomena to be studied occurs. A thin metal diaphragm closes that end of the crystal casing which is presented to the pressure chamber; a metal hemisphere which has its curved surface in contact with the inner surface of the diaphragm and its flat surface in contact with the "bottom" crystal transmits the variable forces at work within the chamber and to which the diaphragm is exposed, to the crystals which convert these mechanical forces into measurable electrical currents of correspondingly varying intensity. The translating efficiency of the crystals is maximum when a clamping force of fixed, but not necessarily critical intensity, is applied thereto as by means of an externally threaded screw which applies a clamping force to the crystals against the restraining force of the diaphragm.

While the Schrader piezometer operates satisfactorily under normal conditions of service, difficulties may arise when it is subject to extremely high conditions of temperature and pressure. By way of example, it has been found that when the diaphragm at the leading or chamber end of the Schrader piezometer is subjected to the direct flames and the pressures of combustion encountered within the cylinders of a high speed Diesel engine, the electrical output of the device may become distorted. This difficulty has been traced to changes in the original clamping force applied to the crystals due to expansion of the said diaphragm. The alteration in the pressure upon the crystal elements due to the effects of temperature change in the diaphragm are of a cyclic nature of a period which usually corresponds to the rate of the explosions within the engine cylinder under test.

Accordingly, a specific object of the present invention is to provide a piezometer wherein the clamping pressure exerted upon the piezoelectric elements remains substantially constant irrespective of constant or cyclic changes in the temperatures to which the device is subjected, whereby substantially undistorted output currents are ensured.

Another and specific object of the invention is to provide a piezometer wherein the electrode surfaces of the piezoelectric elements are subject to substantially the same relative conditions of temperature at all times, whereby fractures due to thermal strains in these crystalline bodies are substantially obviated.

Another specific object of the invention is to provide a piezometer wherein the pressure transfer ratio between the pressure surface and piezoelectric elements is substantially greater than in prior art devices employing hemispherical or similar "point contacts" in the pressure transfer chain.

Still another object of the present invention is to provide a piezometer wherein the natural period of the device and its component parts is such as to permit its useful application in the study of high frequency components of pressure chamber explosions.

Other objects and advantages together with certain details of construction will be apparent and the invention itself will be best understood by reference to the following specification and to the accompanying drawing, wherein—

Figure 1 is a longitudinal sectional view of a piezometer constructed in accordance with the principle of the invention, and

Figure 2 is an elevational view of the leading end of the piezometer of Fig. 1.

In the drawing, 1 designates generally a piezometer or pressure pick-up device having an externally threaded hollow cylindrical casing 2 which is preferably provided with a pair of external clamp nuts 3 for maintaining the device in a threaded bore, provided for the purpose, in the wall of the pressure chamber (not shown) which it is desired to examine. The casing or cylinder 2 contains two quartz piezo-electric crystal elements 4 and 5 separated by an output electrode 6 and maintained under contact between two grounded parts comprising a plug 7 and a piston 8 as by means of a hollow screw 9 which is accessible for adjustment when a seal nut 10 and mica disc 11 at the output end of the cylinder are removed. An internal lock nut 12 which is seated upon a gasket 13 and surrounds the clamping screw 9 maintains the clamping force, applied to the crystals by that screw

through the plug 7, substantially constant. When a pressure is exerted on the piston 8 (as by the ignition of a vapor charge in the chamber or cylinder under test) the crystals 4 and 5 are subject to a compression force and an electrical charge will appear on the electrode faces of each crystal due to their piezoelectric properties.

In the device illustrated, as in the Schrader device, the crystal elements 4 and 5 are each cut in the form of a frustrum of a cone and are mounted with their smaller electrode faces out of contact with the casing 2 so that short circuiting of the electric charges which appear on the faces of opposite polarity is avoided. The output electrode lead comprises a rigid rod 14 which extends from the electrode 6 through a tapered orifice 5a in the "upper" crystal 5 and thence along the central axis of the casing 2. As disclosed by Schrader and shown in the drawing, the conductor 14 passes through the orifice 5a without contacting the portions of the body and surface of crystal 5 in which electric charges of opposite polarity accumulate. This arrangement prevents short circuiting of the faces of opposite polarity by the electrode lead 14. The crystal elements 4 and 5 are connected in parallel; that is to say, they are so cut with respect to their natural or crystallographic axes that the electrical charges which appear on their faces contiguous electrode 6 are additive.

The external shape of the crystals need not be of the described frusto-conical contour provided their diameter adjacent the electrode 6 is less than the internal diameter of the casing and are maintained out of contact with the casing wall as by extending the electrode lead 14 a short distance into the lower crystal, as indicated at 14a.

As previously set forth, the plug 7 and piston 8 are grounded with respect to the casing 2 so that the casing itself constitutes a part of the other necessary electrical connection to the crystals 4 and 5. The conductive connection between the piston 8 and the casing 2 preferably comprises a stainless steel diaphragm 15 mounted between two pairs of copper gaskets 16a, 16b, which ensure a hermetic seal.

The diaphragm 15 is mounted within and spans the bore of the cylinder 2 in a plane remote from its leading or chamber end thereof whereby it is not subject to direct flame nor to the extreme conditions of temperature which may prevail adjacent the extremity of the device. It is thus not subject to that degree of thermal expansion which will produce an appreciable cyclic or permanent change in the clamping force applied to the piezoelectric crystals 4 and 5 by the pressure screw 9.

An externally threaded annulus 17 serves to retain the diaphragm 15 in its position within the casing 2. If desired, the diaphragm may constitute an integral part of the piston 8, in which case it may be in the form of a thin peripheral flange or skirt extending outwardly from the body of the piston. Preferably, however, the diaphragm is in the form of disc 15 having a central orifice, and the piston 8 is of the bipart construction shown in the drawing. The "upper" part 8a of the piston in this case is preferably T-shape in cross section and is mounted with its lateral arm in contact with the gaskets 16b and is thus in pressure transfer relation with the inner surface of the diaphragm. The dependent arm, 8b, of the piston extends through the central orifice in the gaskets and diaphragm. The outer part 8c of the piston is threaded on the dependent arm of the T and comprises a pressure pick-up surface which is presented to the otherwise open end of the cylinder. The inner side of the connection between the pressure pick-up surface 8c is through the gaskets 16a which contact the diaphragm 15 over a major portion of its surface whereby any compression force originating adjacent the end of the casing 2 is evenly transmitted to the lateral or electrode surface of piston 8 both directly through its dependent arm and indirectly through the gaskets and diaphragm.

The diaphragm 15 preferably constitutes the sole support for the piston 8, that is to say, the separable parts of the piston are preferably mounted out of contact with the inner surface of the casing 2 to prevent frictional losses in the transmission of the compression force to the piezoelectric elements 4 and 5. The clearance between the piston and casing walls is very small, say of the order of 10 to 15 mils of an inch, and, in any event, should be narrow enough to inhibit the passage of a flame therethrough.

Since the crystal elements 4 and 5 of the device of the present invention are mounted remote from its leading end, and are separated therefrom by a piston of appreciable length, heat will be transmitted thereto less rapidly and more evenly than in prior art devices wherein the crystals are mounted closely adjacent the end. This arrangement protects the surfaces and bodies of crystals from undue thermal strains which may result in fracturing.

It is known to those familiar with the study of time-pressure phenomena that a single explosion of a vapor charge within a pressure chamber, such as an engine cylinder, usually contains high frequency components. In order to obtain an accurate pressure diagram of such high frequency components, the present invention dictates the use of a piston of a physical length less than one-quarter of the wave length (in the material of which the piston is constituted) of the highest frequency encountered in the chamber with which the device is to be used. By way of example, it has been found that when the piston is constituted of stainless steel and has a length of one-half inch, accurate pressure diagrams may be obtained of components of a frequency up to substantially 100,000 cycles per second.

Other modifications will suggest themselves to those skilled in the art. It is to be understood, therefore, that the foregoing is to be interpreted as illustrative and not in a limiting sense except as required by the prior art and by the spirit of the appended claims.

What is claimed is:

1. A pressure pick-up device, comprising a casing, a piezoelectric element within said casing, a diaphragm mounted within said casing in a plane remote from an end thereof, and means for transmitting a compression force originating adjacent said end of said casing to said piezoelectric element through the plane of said diaphragm.

2. A pressure pick-up device, comprising a hollow cylinder, a piezoelectric element within said cylinder, a diaphragm mounted within the bore of said cylinder in a plane removed from an end thereof, and means comprising a piston extending through the plane of said diaphragm for transmitting a compression force originating adjacent the said end of said cylinder to said piezoelectric element.

3. The invention as set forth in claim 2 and wherein the physical length of said piston is less than one-quarter of the wave length of the high-

est frequency component of said compresion force.

4. A pressure pick-up device, comprising a hollow metal cylinder, a piezoelectric element within said cylinder, a diaphragm mounted within the bore of said cylinder in a plane remote from an end thereof, and means comprising a piston extending through the plane of said diaphragm out of contact with the inner wall of said cylinder for transmitting a compression force originating adjacent the said end of said cylinder to said piezoelectric element, said diaphragm constituting the sole direct support for said piston.

5. The invention as set forth in claim 4 and wherein the space between said piston and the inner wall of said cylinder is sufficiently narrow to inhibit the passage of a flame therethrough.

6. The invention as set forth in claim 4 and wherein said piston constitutes an electrode for said piezoelectric element and said diaphragm constitutes the sole electrical connection between said electrode and said metal cylinder.

7. A pressure pick-up device, comprising a hollow metal cylinder having an open end, a piezoelectric element within said cylinder, a diaphragm mounted within and spanning the bore of said cylinder in a plane remote from said open end, a piston extending through said diaphragm for transmitting a compression force originating adjacent the said open end of said cylinder to said piezoelectric element, said piston comprising a substantially T-shaped member disposed with its lateral arm in pressure transfer relation with the inner surface of said diaphragm and its dependent arm extending through said diaphragm, and a second member comprising a pressure pick-up surface removably secured to said arm and presented to the otherwise open end of said cylinder.

8. The invention as set forth in claim 7 and wherein the inner side of said pressure pick-up surface is mounted in pressure transfer relation with said diaphragm whereby said compression force is transmitted to the lateral arm of said T-shaped member through its dependent arm and through said diaphragm.

9. In a device of the class described, a hollow metal casing, a pair of piezoelectric elements within said casing and having a maximum diameter less than the internal diameter thereof, an electrode interposed between said piezoelectric elements, and a rigid electrode lead extending through one of said piezoelectric elements and at least part way through the other piezoelectric element for maintaining them out of physical contact with said conductive casing.

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