United States Patent

[11] **3,591,861**

[72] Inventor **Hans Conrad Sonderegger**
Sulz-Rickenbach, Switzerland

[21] Appl. No. **728,082**
[22] Filed **May 9, 1968**
[45] Patented **July 6, 1971**
[73] Assignee **Messrs Kistler Instrument AG**
Winterthur, Switzerland
[32] Priority **June 16, 1964**
[33] **Switzerland**
[31] **7859/64**
Continuation of application Ser. No. 462,196, June 8, 1965.

[54] PIEZOELECTRIC MEASUREMENT

6 Claims, 12 Drawing Figs.

[52] **U.S. Cl.** **310/8.1,** 310/9.7, 310/8.6
[51] **Int. Cl.** **H01v 7/00**
[50] **Field of Search** 340/10; 310/8.0, 8.1, 8.2, 8.4

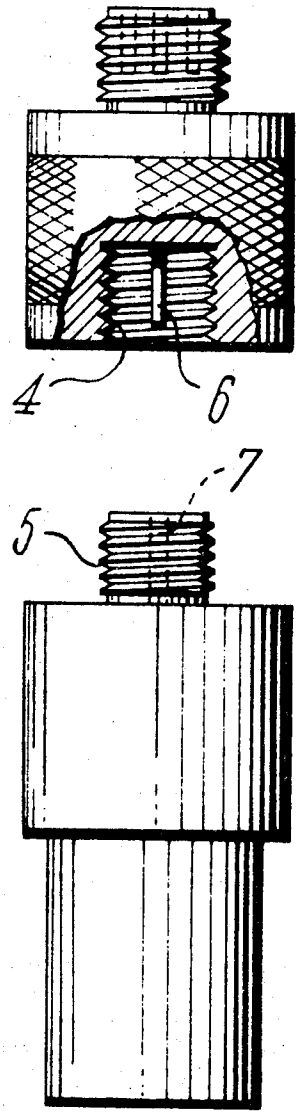
[56] **References Cited**

UNITED STATES PATENTS

2,479,264	8/1949	Rosenberg	310/9.1
2,757,475	8/1956	Pankove	310/8.2
2,783,449	2/1957	Loofbourrow	340/10
3,051,927	8/1962	Mazzagatti	340/10
3,054,982	9/1962	Kieser	340/10
3,359,441	12/1967	Orlacchio	310/8.4
2,988,728	6/1961	Marlow	340/10
3,051,927	8/1962	Mazzagatti	340/10
3,054,982	9/1962	Kieser	340/10
3,123,798	3/1964	Holloway	340/10
3,170,076	2/1965	Wing	310/8.4
3,241,373	3/1966	Ricketts	73/503
3,249,913	5/1966	Smyth	340/10
3,356,868	12/1967	Cother	310/8.4
3,389,276	6/1968	Gradin	310/9.1

Primary Examiner—J. D. Miller
Attorney—Craig, Antonelli, Stewart & Hill

ABSTRACT: This invention relates to a piezoelectric assembly having a amplifier and a piezoelectric transducer of similar dimensions coupled together with a mechanical connector.



PATENTED JUL 6 1971

3,591,861

SHEET 1 OF 2

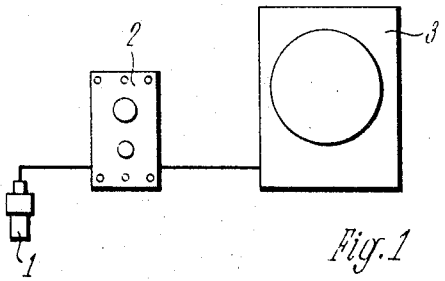


Fig. 1

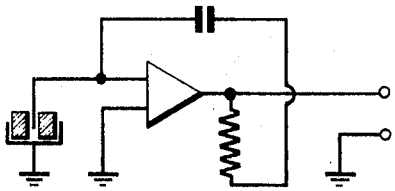


Fig. 2

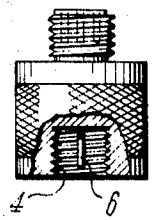


Fig. 3

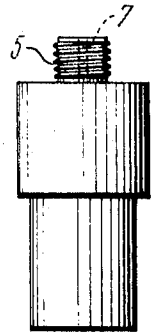


Fig. 4

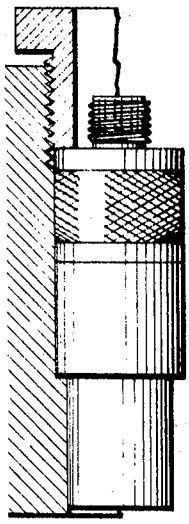


Fig. 5

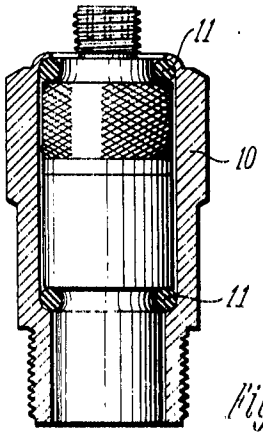


Fig. 6

INVENTOR
HANS CONRAD SONDEREGGER

BY Dicke & Craig
ATTORNEYS

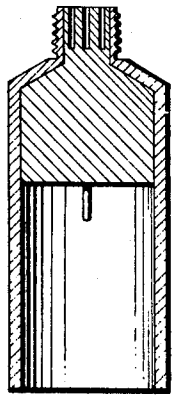


Fig.7

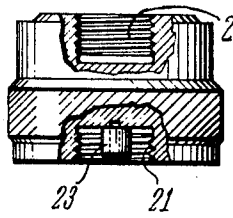


Fig.10

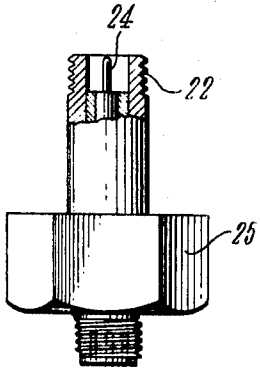


Fig.11

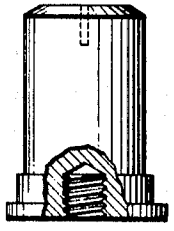


Fig.8

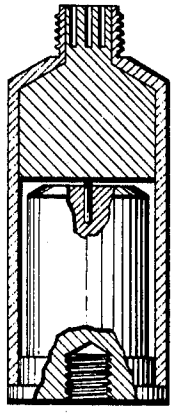


Fig.9

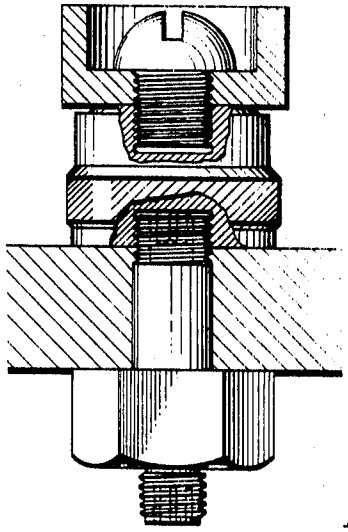


Fig.12

INVENTOR

HANS CONRAD SONDEREGGER

BY Dicke & Craig

ATTORNEYS

PIEZOELECTRIC MEASUREMENT

This application is a continuation of Ser. No. 462,196 filed June 8, 1965.

The present invention relates to a piezoelectric measurement transducer with amplifier.

In piezo measurements it is known to provide a measuring channel consisting of a piezoelectric transducer, a cable connecting the transducer to the measurement amplifier and a further cable connecting the measurement amplifier to an evaluating device. The cable connections between the individual devices such as the transducer, the amplifier and the evaluating appliance may vary between several cm. and 100 m. or so. It is known however, that the cable connection between a piezoelectric transducer and its amplifier is limited in length due to the fact that the cable capacity has a certain value and influences the degree of amplification and the upper measurement frequency. In general therefore the length of cable between the transducer and its amplifier must be kept as short as possible.

In many cases especially with measurements in locations, in which explosions are liable to occur, or in the case of strongly vibrating objects, a relatively long connection between the transducer and the amplifier is at present inevitable.

These and other difficulties are overcome by the features of the invention. The piezoamplifiers available on the market today employ an electrometer tube in the input stage which provides an input resistance of more than 10^{13} ohm. The remainder of the amplifier is then completely transistorized. By using an electrometer tube, however, the present amplifiers are very sensitive to vibration so that in all cases they must be mounted in such manner that they are insulated from the transducer for sound and vibration. As a result of recent further developments in transistors, however such transistors are now available which can be used in place of electrometer tubes. In particular "field-effect" and "MOST" transistors have inherent resistances of 10^{14} to 10^{16} ohm. With such components completely transistorized amplifiers can be produced, i.e., amplifiers can be constructed which consist only of transistors that do not use any tubes.

The object of the invention is to provide such a measurement amplifier arranged no longer as usual between the transducer and the evaluating apparatus, but which corresponding to the shape of the transducer, can be screwed directly to or fitted directly upon the transducer so that the transducer and the amplifier form an integral unit which can however be detached when required. By reason of the fact that transistors are now used, the measurement amplifier is not responsive to acceleration even up to high *g* numbers so that it can be placed directly on the transducer.

The features of the present invention will be described hereinafter by way of example and with reference to the accompanying drawings in which:

FIG. 1 shows the normal system for a measuring channel provided with cable connections,

FIG. 2 shows a block diagram of an amplifier with capacitive feedback,

FIG. 3 shows a miniature completely transistorized measurement amplifier,

FIG. 4 shows a piezoelectric transducer for pressure measurements,

FIG. 5 shows the complete assembly of transducer and amplifier,

FIG. 6 shows a complete unit consisting of transistor and amplifier in a sound insulating casing,

FIG. 7 shows the casing of a piezoelectric acceleration device with a built-in measurement amplifier,

FIG. 8 shows a piezoelectric transducer element,

FIG. 9 shows a composite unit consisting of a piezoacceleration transducer and a measurement amplifier,

FIG. 10 shows a piezoforce transducer,

FIG. 11 shows an assembly screw with a measurement amplifier in the screw head, and

FIG. 12 shows an assembled unit consisting of a piezoforce transducer with an amplifier located in the fastening screw.

According to the invention the amplifier is miniaturized in a conventional manner that it can be inserted in a metal casing which in turn represents one component of the transducer. This arrangement will be explained hereinafter in the case of transducers intended for pressure, acceleration and force effects.

FIG. 1 shows the usual arrangement of a measuring channel for the piezoelectric measurements having a transducer 1 and an amplifier 2 in accordance with the basic diagram of FIG. 2. An evaluating apparatus is represented on FIG. 1 as a meter 3. Coaxial cable connections are provided between the elements 1, 2 and 3. The miniaturized measurement amplifier shown in FIG. 3 is inserted in vacuumtight manner in a metal casing the same diameter as the transducer shown in FIG. 4. One end is provided with a screw thread 4 for receiving a threaded part 5 of the transducer while the contact pin 6 fits into a corresponding socket 7 in the transducer. Commercially available coaxial connectors may be used for this connection to the transducer. The two units of FIGS. 3 and 4 can be joined together in a hermetically sealed manner by means of a sealing medium and may be built together as shown in FIG. 5 to form a transducer/amplifier unit for use at any desired measurement point. For shock wave and sound pressure wave measurements it is desirable to mount the transducer/amplifier unit in a casing 10 by means of two O-ring seals 11 to form a completely sound insulating unit, as shown in FIG. 6.

One example of the application for acceleration measurements is shown in FIGS. 7, 8 and 9 where FIG. 7 shows the casing of the acceleration transducer with an amplifier built into the upper part thereof in a conventional manner. The piezoelectric transducer element (FIG. 8) is fitted into this casing and can be connected with the amplifier by means of a contact pin and socket. The finished unit shown in FIG. 9 has again the same diameter as a normal type of acceleration transducer.

A further example of application for force measurement is shown in FIGS. 10, 11 and 12. The piezoelectric force measurement cell shown in FIG. 10 comprises at one end a screw thread 20 for connection to the force-transmitting member. At the other side there is provided a screw thread 21 which fits with the screw thread of a hollow screw by means of which the measuring cell is mounted on its support. The electric signal is taken off centrally by means of the sleeve 23 and the contact pin 24. The mounting screw shown in FIG. 11 is in the form of a hollow screw and the measurement amplifier is fitted into the screw head 25. FIG. 12 shows the complete unit assembled and screwed down.

This form of construction provides mechanically coupled units which are suitable for pressure, force and acceleration measurement and can be separated at any time into the transducer and amplifier components, an arrangement which considerably facilitates production and servicing problems.

I claim:

1. A piezoelectric assembly consisting of two parts adapted to be assembled into a hermetically sealed unit having substantially the same structural dimensions as standard piezoelectric transducers presently used, comprising a piezoelectric transducer means having a casing and forming one of said two parts, an amplifier unit forming the other of said two parts and including fully transistorized miniature amplifier means and a metal casing hermetically sealing said amplifier means, said transducer having an output adapted to be connected to an input of said amplifier means, and readily separable mechanical connecting means for assembling said amplifier means with said transducer means by directly connecting with each other said casings to form said hermetically sealed unit while simultaneously providing an operative connection between said output and said input.

2. A piezoelectric assembly according to claim 1 wherein said amplifier means is so constructed that it has substantially the same external configuration as a standard pressure trans-

ducer and is adapted to be directly connected thereto by said mechanical connecting means to enable installation directly at the measuring place.

3. A piezoelectric assembly according to claim 2, wherein said amplifier means is directly pressed on said transducer means.

4. A piezoelectric assembly according to claim 2, wherein said amplifier means is threadably connected with said transducer means.

5. A piezoelectric assembly according to claim 1, wherein said amplifier means is assembled in the metal casing in such a manner as to enable installation therein of the piezoelectric transducer means.

6. A piezoelectric transducer-amplifier combination essentially consisting of a piezoelectric measuring element and a fully transistorized amplifier, characterized in that the piezoelectric measuring element is constituted by a separate measurement transducer of standard design as readily available in the market and built into a hermetically sealed housing that includes at one of its end faces a first connecting portion of standard design for establishing an electrical connection, in that the amplifier is a miniature amplifier having diametric dimensions corresponding to the transducer of a standard design and also built into a hermetically sealed housing that includes at one of its end faces a second connection portion of a standard design fitting with said first connecting portion and at its opposite end face a third connecting portion also of standard design and similar to said first connecting portion, and in that said measurement transducer and said amplifier are mechanically and electrically connected with each other by said first and second connecting portions in such a way that the combination of transducer and amplifier can be mechanically connected into one integral solid unit and that the combination can be readily separated at any time in order to enable exchange of one of the components for service reasons and that either the transducer alone or the combination of both transducer and amplifier can be mounted in the same measurement location, one of said first and second connecting portions forming in effect a connecting socket and the other a fitting connecting plug, and in that a hollow screw member includes a screw head which forms the housing containing the amplifier, the transducer being mounted by means of said screw member.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,591,861 Dated July 6, 1971

Inventor(s) Hans Conrad Sonderegger

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title Page, left column, line 6, which now reads:

"Assignee Messrs Kistler Instrument AG"

should read as follows:

--Assignee Kistler Instrumente AG--

Signed and sealed this 5th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

USCOMM-DC 60376-P69
☆ U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334