TRANSDUCER WITH A FLEXIBLE SENSOR ELEMENT FOR MEASUREMENT OF MECHANICAL VALUES

This application is a continuation application of application Ser. No. 107,315, filed Dec. 26, 1979, which in turn is a continuation of Ser. No. 927,929, filed July 25, 1978, both of which are now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to a transducer with a flexible sensor element for measurement of mechanical values.

DESCRIPTION OF THE PRIOR ART

Transducers with a flexible sensor element are known in the form of strain gauges. Strain gauges usually are attached on the body to be measured mainly by means of an adhesive. Forces acting on the body and deforming it cause a corresponding stretch of the strain gauge, the stretch being measurable due to a change in the electrical resistance of the strain gauge wires. Such strain gauges have a number of advantageous properties, for instance, flexibility and small mass, and they are well suitable for both static and dynamic measurements. However, an arrangement is necessary which guarantees a reproducible initial tension of the strain gauge. In cases where the initial tension is subject to greater variations caused by mounting, thermal expansion or the like, the necessary adjustment of the expensive measuring bridge needs additional activities. Such additional work can never be avoided when the dynamic stretches to be measured are in the order of 10^{-5} and lower. The mentioned difficulties happen to all strain gauges in which their physical properties are used to measure variations of length and which depend on the absolute value of the length. Due to mentioned disadvantages, strain gauges are a not satisfactory solution for a broad range of measuring problems.

In many cases of measurement of mechanical values, for instance pressure, forces, and acceleration, often piezoelectric transducers are used. This type of transducer has advantageous properties, e.g., direct measurement of relative variations from any given ground level, compression sensitivity, and simple electronic processing of the charge signals. The known piezoelectric transducers have discs or pins of monocrystals or ceramics as piezoelectric sensors which are to be hold under compressive initial tension by a special device. The initial tension is necessary for transmission of measured outer forces or pressures to the sensor. With acceleration and vibration transducers the initial tension must be chosen sufficiently high that the seismic mass is pressed against the sensor on the whole measuring range. This necessary initial tension and the necessary rigid abutment cause an arrangement having a big mass.

Common pressure transducers are pressed against the measuring point by means of a membrane connected to a pressure transmission plate. This results in limitations in the sensitivity and the dynamic measuring range of the transducer. The compact, fixed outer shape of this transducer type limits its use for measuring problems where simple mounting and adaptability to present geometric situations is required. In addition, the relatively great mass and the resulting strongly limited dynamic resolution capacity of such transducers are often very disadvantageous.

Some typical measuring problems for which common piezoelectric transducers are not satisfactory are for example: dynamic measurement of low pressure differences between two measuring chambers, measuring of passing shock waves in fluids, high-sensitive acceleration transducers of light weight, dynamic measurement of flow velocity of fluids, and measurement of high frequency vibrations of two bodies relatively to each other.

SUMMARY OF THE INVENTION

The present invention avoids the mentioned disadvantages and consists in that at least one flexible piezoelectric sensor element is provided for piezoelectric or capacitive measurement, the opposite surfaces of the sensor element being at least partially connected to "electrically leading" contact surfaces.

The design of a transducer according to the invention enables simultaneous use of the advantageous properties of strain gauges—flexibility, little mass and therefore high temporal resolution, stretchability and stretch sensitivity—and of the advantageous properties of piezoelectric sensors—direct measurement of relative variations from any given ground level (floating zero point), compression, sensitivity, simple electronic processing of the charge signals—, whereby the disadvantages of both transducer principles are avoided.

The piezoelectric film which is advantageously chosen only a few μ thick forms the dielectric of a compacitor, the "electrically leading" surfaces being used as the capacitor electrodes. The sensor element therefore can be used also for capacitive measurement of pressure distribution. This is an essential advantage because static or quasi-static and low frequent processes which cannot be measured piezoelectrically due to the limited insulation resistance, can be measured capacitively. The use of a flexible, piezoelectric film as a sensor element in a pressure transducer allows for the first time the application of one and the same transducer alternatively for piezoelectric or capacitive measurement of pressure distribution without the necessity of additional mounting expenditure.

There are known a number of flexible dielectrics in the form of foils or films, most of which may be considered as electrets in the sense that they posses a semi-permanent electric polarisation, the outer field of which is compensated by also semi-permanent surface charges. Such piezoelectrics show a longitudinal piezoelectric effect in the direction of the Z-axis (axes according to the IRE-convention) and transversal piezoelectric effects in the direction of the X- or Y-axis, respectively. Some known piezoelectrics are for instance Polyvinylidene-Fluoride (PVDF), Polyvinyl-Fluoride (PVF), Polyvinyl-Chloride (PVC), Polyacrylonitrile (PAN). Polymethyl-Methocylate (PMMA), fluorinized Ethylene-Propylene (FEP). Polystyrene Polyethylene (PE) and its Terephthalate, Polycarbonate, Polysulfone and Nylon.

Besides the advantage of the possibility of piezoelectric and capacitive measurement of stretches, the use of a piezoelectric electret according to the invention has the further advantage in that elastic cross-contraction in Z-direction an amplification of the piezoelectric and capacitive stretch sensitivity is obtained. Enlargement of a pipe further may be measured by means of a transducer according to the invention also by the longitudinal piezo effect if the sensor element is so attached that the pipe stretch exerts pressure perpendicular to the