A Strain Gauge Transducer for Measuring Physiological Pressures

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Introduction

STRAIN gauge transducers are commonly used for measuring blood pressure and other physiological pressures. Uptil now most of these transducers were only manufactured abroad. This paper is to report the development of a pressure transducer carried out by us from indigenous components.

Construction

Figure 1 depicts the construction of the pressure transducer. The transducer has a flat steel diaphragm held at its periphery, dividing it into two main parts which may be called the fluid chamber and the gauge chamber. The fluid chamber is enclosed by a transparent plastic dome and has one inlet and one outlet and is leak proof. The gauge chamber has a strain gauge cemented on the diaphragm and connected to one of the arms of a d.c. fed Wheatstone's bridge. The strain gauge used by us was of the semiconductor type consisting of a p-type silicon bar 3 mm × 0.2 mm × 0.03 mm and of resistivity of 0.01 ohm-cm with its long side oriented in the crystallographic 111 direction. The strain gauge was mounted on the diaphragm eccentrically, i.e., at a place between the centre of the diaphragm and its periphery, the length of the strain gauge being oriented along the diameter of the diaphragm. In this setting of the strain gauge, whenever the diaphragm sags due to pressure applied on it from the fluid chamber side, the strain gauge experiences a mechanical shear strain, for which the strain gauge has the maximum change of electrical resistance for a given strain.

Indigenous Strain Gauge Transducer
Fig. 1

It may be mentioned that in the conventional transducers developed abroad, resistance type strain gauges have almost been universally used. The diaphragms in these transducers have been of the corrugated type for obtaining greater deflection of

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the diaphragm for the pressures applied. For the use of the silicon gauges which are, in general, two orders of magnitude more sensitive than the resistance gauges, the corrugated diaphragm is not necessary.

The fluid chamber of the transducer has to have special constructional features. The plastic dome is transparent as transparency is required to check the presence of any air bubble getting entrapped in the air chamber during the process of filling the fluid. In practice, the fluid chamber is flushed enough with saline to remove all air bubbles from the chamber. The inlet and outlet points have been so constructed that glass syringes or cannulae can be fitted to them. Accordingly, Luer-lock terminals were used for this purpose.

Electrical System

Figure 2 describes the electrical set-up for the transducer. The Wheatstone's bridge has parallel resistances for obtaining a fine balance. The unbalanced voltage is amplified by a standard strain gauge d. c. amplifier having sufficient frequency response (above 1 KHz) for correctly measuring blood pressure variations, which can be depicted either on an oscilloscope or a fast recorder.

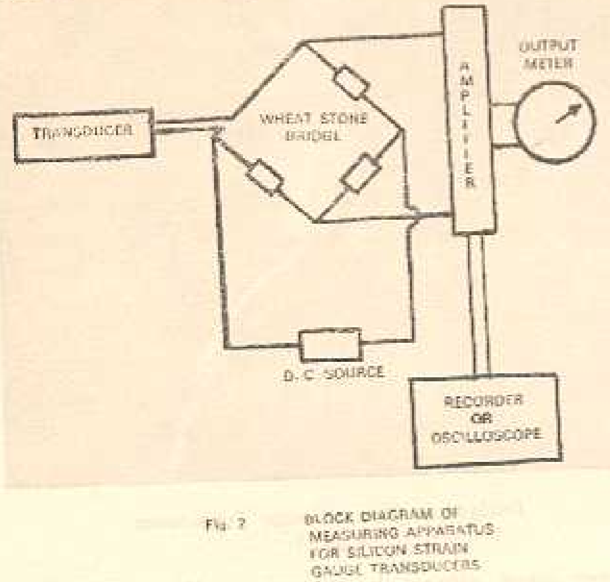


Fig. 2 BLOCK DIAGRAM OF MEASURING APPARATUS FOR SILICON STRAIN GAUGE TRANSDUCERS

Operational Principle and Requirements

The operation of the transducer depends on the fact that when the blood pressure is transmitted (by means of a cannula or otherwise) to the fluid (saline) in the fluid chamber, the diaphragm is elastically bent under this pressure, thus producing a mechanical shear to the strain gauge. To be able to record the blood pressure variations faithfully by means of the electrical output, the transducer response should be linear for pressure ranges which are likely to be reached in the investigation and the frequency response of the transducer system should be high enough (above 100 Hz).

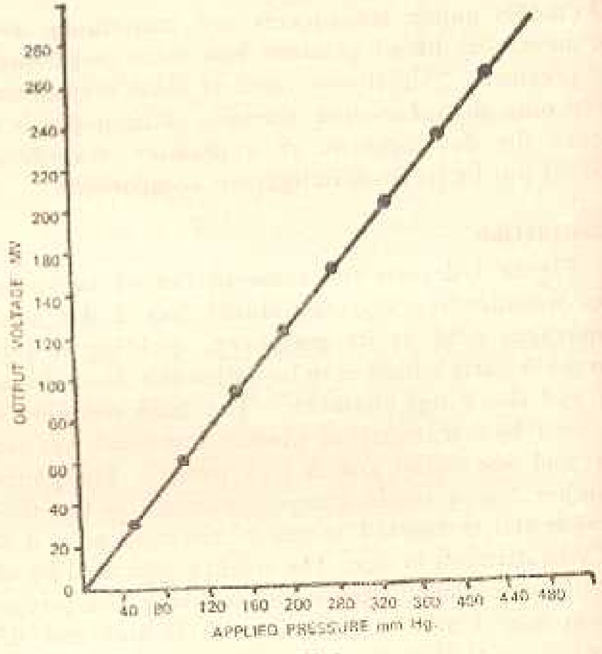
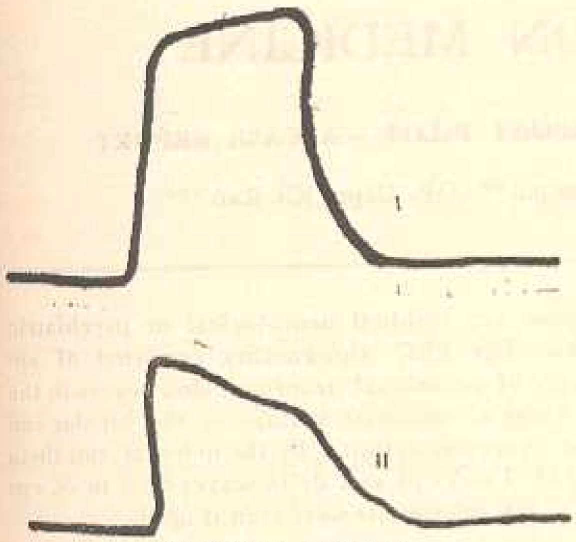


FIG. 3

Performance Tests

Linearity Test : Figure 3 depicts relation between the pressure applied to the diaphragm by an air blower (measured by a mercury manometer) and the corresponding electrical output. The graph obtained is linear.

Frequency Response : The frequency response of our transducer was compared with that of the imported unit under identical conditions. The air pressure applied to the transducers was suddenly released. Figure 4 depicts the graphical response of the two transducers (indigenous and imported) as obtained on the output recorder. It can be seen that the indigenous transducer is similar in general



FREQUENCY RESPONSE
From I INDIGENEOUS TRANSDUCER
II IMPORTED TRANSDUCER
Fig. 4

operation to the imported unit and is even better in frequency response.

The frequency response of the transducer is a function of the mass of the fluid in the fluid chamber, the frequency of the diaphragm and the diameter and length of the cannula (or catheter) used in the system. Thus, the frequency response can be raised still further if so desired by reducing the volume of the fluid chamber and the radius of the diaphragm. In the transducer developed by us, all these constructional modifications can be done easily.

Conclusion

An indigenous blood pressure transducer has been made which is linear and has satisfactory frequency response. All the parts of the transducer are indigenously available. The cost of the single unit will not be more than Rs. 300/- compared to about 200 dollars in foreign exchange required for the imported unit.

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