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PRESSURE MEASURING DEVICE WITH ELECTRICAL INDICATOR

ALBRECHT HASSE

TRANSLATION FROM THE GERMAN

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By

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Denver, Colorado

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Translator's Note

This is a first draft translation. A careful revision has not been felt justified at this time.

E. N. Wilsey,

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PRESSURE MEASURING DEVICE WITH ELECTRIC INDICATION

By Dr. Albrecht Hasse

(Translated by E. F. Wilsey)

Construction of the Pressure Meter.

Pressure measurements with a piezometer or a Bourdon tube, for example, the aneroid barometer, have the disadvantage that they can measure only relatively slow pressure variations; also, they respond only to large changes of the outer air pressure. Piezometer readings are difficult to determine; the reading of the piezometer height allows only an arbitrary accuracy. Devices employing the Bourdon action work satisfactorily only in a definite pressure range. An extension of this range can only be accomplished at the expense of accuracy.

These considerations led to the design of a pressure measuring device which avoids all of these defects. The arrangement is based on the principle of the Bourdon-tube and is an airtight closed cell with a small interior pressure (see figure 1). The new device differs essentially from earlier arrangements in that it reproduces the deflection of the diaphragm electrically instead of by levers. The two flanges, a, clamp together with the two diaphragms, b, the two mica washers, d, and a metal plate c, so that two airtight compartments are formed. Since the metal plate, c, is insulated from both membranes, b, by means of the mica rings, the whole comprises a condenser whose plates are b and c. An external pressure acting on the apparatus causes both diaphragms to deflect inward or outward as the case may be. The capacity of the condenser varies according to the formula:

$$C = \frac{1}{36 \pi 10^{11}} \frac{EF}{a} \text{ Farad}$$

in which

a = the thickness of the dielectric in cm.
F = the area of the planes in cm^2.
E = the dielectric constant

In order to measure the existing capacity of the condenser different procedures may be followed. It has seemed unsatisfactory to use equal currents because of the insulation difficulties. In this case the condenser is inserted in an oscillating circuit. If two circuits each containing inductance and capacitance are so tuned to one another that they are approximately in resonance, then when one of these is detuned, the plate current varies with the change in the capacitance within certain limits. This in turn corresponds to the pressure change. This is the method known as the "half-resonance curve".[1] The smaller the capacity of the condenser, the greater will

[1] Schnauffer, K. Z VDI, Bd. 74, 1930, p. 1066

be the proportionate changes in the capacity of the condenser. In this way the measuring range of the apparatus can be widely varied.

The wiring diagram consists essentially of two circuits, a transmitting circuit and a receiving circuit with one tube in each. These circuits are loosely coupled by inductance. One circuit contains a variable condenser, the other the measuring condenser. An ammeter placed in the plate circuit of the receiver indicates the variation of the capacitance. This simple design requires only two tubes and two plate batteries.

An essentially simpler arrangement than this uses one tube which acts both as an oscillator and receiver. Circuit I (see fig. 2) contains the pressure measuring device along with three additional capacitances, b_1, b_2, b_3, all of which can be connected in parallel at will. The loose coupling is effected by the coils c_1 to c_4 which can likewise be connected in parallel by the switch. Circuit II lies between the filament and grid of the tube, g. The milliammeter, h, indicates the existing capacity.

Manipulation of the Device.

The sensitivity of the arrangement depends on the size of the measuring condenser. The greatest sensitivity is attained only with the proper condenser. To tune the circuit the proper coil must be connected by the switch. If a small change in capacitance falls outside the range of resonance, the range of measurement is proportionately small. The range may be increased by retuning by means of a variable condenser, e. A change in pressure to any final pressure can be measured with considerable accuracy. The greater the variation in pressure, the more the sensitivity is decreased because of the necessity of connecting condensers in parallel. However, it is possible to separate this change into several parts measuring each part individually with sensitive connections.

The influence of the air pressure affects only the zero of the apparatus and then only in case the measuring compartments are actually not airtight. This situation may affect its use as an altimeter or deep sea sounding device. A reading may be corrected by the addition of a condenser and the comparison with a standard barometer.

For the most delicate measurements additional directions are necessary. The more sensitive the ammeter, the smaller is the range of measurement. In order to go outside this range it is necessary to compensate any constant reading of the ammeter and to measure only the change in the current which corresponds to the change in pressure. In the light of my own experience with a compensator, I put an electron tube in the plate current circuit. The grid potential of this tube can be altered with a potentiometer and hence the plate current can be varied widely and with the proportionate accuracy. If the constant plate current is compensated, an oscillograph may be used to measure the pressure variations, since the current change is of the order of 1×10^{-3} amperes for a 1/100 mm. change in pressure head. This is large enough for a good deflection on an oscillograph.

Since the sensitivity of the apparatus depends, on the one hand, on the capacity of the condenser and, on the other, on the sensitivity of the ammeter, it is possible to choose a suitable ammeter and compensator and also a proportionally large condenser without the sensitivity suffering too much. However, with this arrangement the range of pressure is necessarily limited.

Use

There are many applications of this measuring device. In its simplest form it serves the purpose of a device requiring an adjustable sensitivity and pressure range with which rapid changes of pressure can be measured. Since the motion of the diaphragm is very small (about 1/100 to 1/1000 mm), the diaphragm may be considered to be without mass and for that reason, the device can successfully record pressure events of 1/1000 seconds duration. The measuring cell may be made very small (diameter from 2 to 3 mm.).

As an altimeter or sounding device, a cell apparatus is used whose sensitivity is dependent on the range of measurement. An altimeter in aviation is desirable if it operates with the greatest possible accuracy in the neighborhood of the ground and at the same time possesses a range sufficient for all elevations. Ordinary pressure measuring devices are unsatisfactory in that they have but one range which when widened decreases the accuracy of the readings. It is unlikely that a device can be designed which has a greater measuring range and flexibility than this electric device. As soon as the limits of one range of measurements are exceeded, a new range may be switched on automatically or by hand. Suppose, for example, an aeroplane is approaching the ground, then the range, 0 to 250 meters, will be switched on so that each meter difference of elevation will be indicated. Greater elevations are taken care of by ranges, say from 0 to 2,500 and 0 to 10,000 meters. In order to measure small differences at high elevations, the compensator is easily connected and the range of measurement of the electric apparatus consequently altered.