ATMOSPHERIC PRESSURE MEASUREMENT BY MEANS OF VARIATION OF BOILING POINT OF WATER

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For the purpose of estimating the ventilating pressure in tunnels, atmospheric pressure of several locations in tunnels were measured by using a well-known barometer. But there are some difficulties in getting the accuracy of measurements.

This paper deals with a measuring device of atmospheric pressure based on variation of boilib points of water. Such devices already have been studied, but never have we heard of its utilization. It is the reason why the temperature of boiling points is depended on the position where the temperature sensor is placed. So the authors made an attempt to use the float on which the temperature sensor is attached. In this way, temperature of the sensor could be kept more steable than that without the float. As the results, it was found that the variation of the atmospheric pressure, about 2 mmAq, could be measured by using this device.

1. Introduction

Supposing the atmospheric pressure can be measured accurately between two points in a tunnel, an estimate of pressure drop in it may be got from that measuring results. For this reason, measuring devices of various makes were studied and designed. This paper presents a measuring device of atmospheric pressure based on variation of boiling points, sometimes also called a thermobarometer or a hipsometer. This is constructed of a vacuum bottle, an electric heater, and an accurate thermometer. Pure water is continuously boiled by using this heater and boiling points of water is measured by the accurate thermometer, as the atmospheric pressure is related to boiling points. Trying this

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method, it is found that the several difficulties take place, such as the temperature varies with localities in the bottle. In order to solve these problems, a float on which the temperature sensor is attached is floated on the top of the water, and the distance from the sensor to the water surface may thus be kept constant.

2. Preliminary experiments

Temperature t of boiling points of pure water is related to the atmospheric pressure p, and this relation is given by a following equation,

$$t(°C)=100.00+0.0376(p-760)-0.000023(p-760)^2$$

Atmospheric pressure may, therefore, be estimated from the temperature of boiling points of water.

Schematic of preliminary examination is as shown in Fig.1. The water in the vacuum bottle is heated with the electric heater F. Electric power of 10W is supplied to this heater for supporting the water at a temperature of boiling points. B is a cork stopper coated with sylicon which has a small bore for leaking the vapor. D is a Beckman thermometer. A valve of this thermometer is moved up and down in the bottle, and the temperature is read against the several localities in it. Results obtained are as shown in Fig.2. From the results, evidently, deviation of positions of the thermometer valve above the water surface, about 2 cm, causes a variation of temperature, 0.05 °C, if the pressure is kept constant.

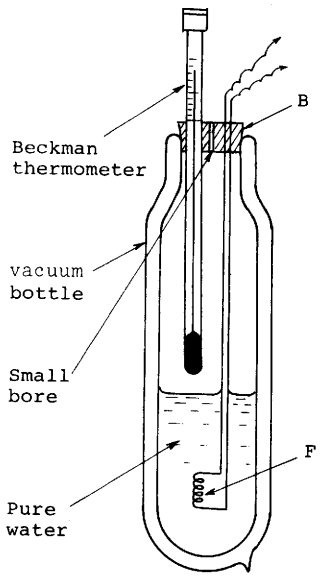

Fig. 1 device of preliminaly examination

3. Measuring device

From the results mentioned above, it is found that the height of the sensor above the water surface must be kept constant. For this purpose, special shaped float with a thermister for measuring temperature is used. Schematic of the construction is as in Fig.3. The thermister R_1 is mounted to inside of a glass tube, and an end of which is formed into funnel shape. These are installed on the doughnut

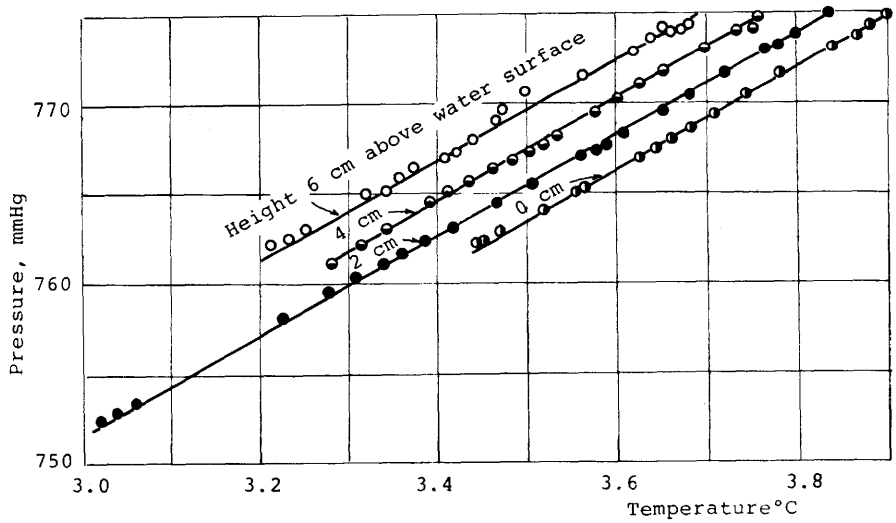

Fig.2 Variation of indicating temperature due to deviation of positions of the thermometer valve above the water surface

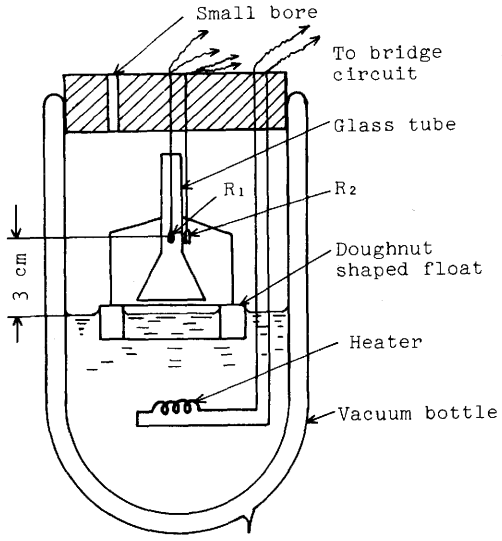

Fig.3 Measuring device

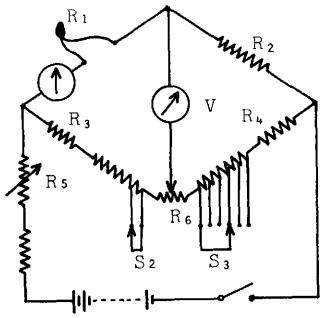

Fig.4 Temperature measuring circuit

shaped float which is made of thin cupper plate. Height of the thermister above the water surface, about 3 cm, may thus be kept constant. Consequently, vaporous temperature around the thermister becomes stable. Atmospheric pressure is, therefore, estimated from the measured temperature. For the temperature compensation, manganine resister R_2 is attached near the location of the thermister R_1. F is a heater for supporting the water at a boiling point. Fig.4 shows a

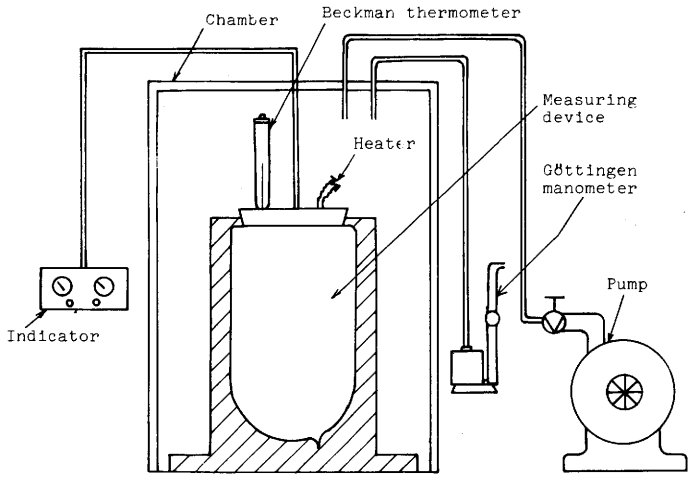

Fig.5 Experimental apparatus for test of the measuring device

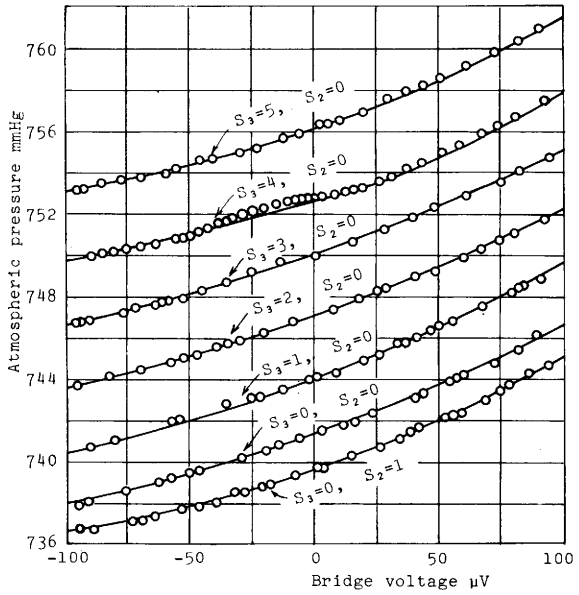

Fig.6 Relation between atmospheric pressure and bridge voltage

measuring circuit of the temperature. R_1 and R_2 are respectively the thermister of thermister constant 3281°K and the manganine resister of 205Ω. R_3 and R_4 are manganine resisters of 3KΩ. Resistance of them, compared with R_1 and R_2 are made large so that they become as small input current of the bridge as possible. S_2 and S_3 are range switches. R_5 is a variable resister of 100Ω for current adjustment. Current through the thermister R_5 is adjusted to 1 mA by using this

resister R_5. V is a valve voltmeter for measuring an unbalance voltage of the bridge.

4. Experimental results and conclusion

At the time of measurement, water temperature in the bottle is supported at boiling points with the heater F, and after that the resister R_6 and R_5 are adjusted in order to balance the bridge and correct the current to the appointed value. When the atmospheric pressure varies, reading of the V is varied with the pressure, and this reading is compared with a Fortin's barometer. Following experiment is also carried out on relation between the pressure and the reading of V. That is, all measuring devices are installed in a chamber which is made of an acrylic acid resin plate, and the pressure in the chamber is varied compulsory with a pump or suction pump. Difference between the inside and outside pressure (atmospheric pressure) of the chamber measured with a Göttingen manometer. These are shown in Fig.5 and results obtained are shown in Fig.6. Enterd numbers in the figure corresponding to S_2 and S_3 indicate the positions of dials of range switches. For example, one step of the switch is equivalent to increase and decrease of 4Ω.

This device is able to measure the range from 736 to 760 mmHg. Measuring ranges may easily be magnified by using multi-stage change-over switches in stead of the above switches, S_2 and S_3. Sensitiveness of this device is of the order of 3.6 μV per 2mmAq. This is not strictly connected with the practical use, but further improvement of the device may bring us possibility of practical use.

ACKNOWLEDGEMENT

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