LITERATURE CITED


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FLOW-RATE METER WITH RADIOACTIVE PICKUP UNIT

N. S. Korshunov and M. V. Khatskevich

The use of radioactive isotopes makes it possible to construct measurement instruments which have a number of important advantages [1]-[3].

Interesting results have been obtained with the use of radioactive cobalt, in conjunction with an ordinary rotation-type meter [4], in carrying out remote flow-rate measurements on small flows of gases and liquids.

At present rotation type meters are widely used in remote flow-rate measurements; these instruments employ electromagnetic-induction units. It has been shown in practice that instruments of this type are not suitable for measuring small flow-rates (from 0.2 up to 2 liters/hr). Moreover, the sensitivity of these devices is poor and can be increased only by the introduction of complicated electronic circuits and good stabilization. It is not always feasible to make the rotation tube of the instrument of a non-magnetic material nor to make it structurally complicated. These shortcomings can be avoided in a radioactive remote flow-rate meter (RRFM).

A schematic diagram of the device is shown in Fig. 1. A gamma source is placed on a float in the flow-tube. The position of the float is determined by the difference current in a differential ionization chamber connected, for example, to an SP amplifier. The amplifier scale is calibrated in flow-rate units. As desired, the signal from the dc amplifier can be fed to an automatic recorder or to a control system.

The radiation source is Co^{60} in the form of a metal wire 0.7-0.8 mm in diameter. The source intensity is of the order of 2-5 μ curies. A piece of this wire is placed on a teflon float. The rotation tube can be fabricated from any material which meets the engineering requirements.

The construction of the differential ionization chamber is shown in Fig. 2. The chamber consists of four coaxial cylinders and is filled with air at atmospheric pressure. Cylinder 1 is the collector; cylinder 2 is the high-voltage electrode and is cut in two; a voltage of 200 volts, but of opposite sign, is applied to each half at 3; cylinders 4 and 5 are the walls of the chamber.

The inner cylinder contains the rotation tube, which is held in place by rubber gaskets. The collector and high-voltage electrodes are supported by plexiglas insulators 6. All outputs from the electrodes also come through the insulators. Ring 7 is a guard ring and braces the insulator 6; it is connected to a frame screw 8.

The frame of the chamber is fastened to the two supports 9 by collars 10. The chamber can be moved vertically by the lead screw 11 and crank 12, thus making it possible to vary the flow-rate range.

The mathematical relation between the differential current in the chamber and the position of the radioactive float is given by the following expression:

* See C. B. Translation.
Fig. 1. Schematic diagram of the radioactive flow-rate meter.

\[ \Delta I = 2eK \left[ R \left( \tan^{-1} \frac{H-Z}{R} + 2 \tan^{-1} \frac{Z}{R} - \tan^{-1} \frac{H+Z}{R} \right) \right. \]
\[ - \left. R \left( \tan^{-1} \frac{H-Z}{r} + 2 \tan^{-1} \frac{Z}{r} - \tan^{-1} \frac{H+Z}{r} \right) \right] \]
\[ - \frac{1}{2} \left[ (H-Z) \ln \frac{(H-Z)^{3} + r^{3}}{(H-Z)^{3} + H^{3}} + 2Z \ln \frac{Z^{3} + r^{3}}{Z^{3} + H^{3}} \right. \]
\[ \left. - (H+Z) \ln \frac{(H+Z)^{3} + r^{3}}{(H+Z)^{3} + H^{3}} \right] \]

where \( K \) is a proportionality factor.

The remaining terms in the formula are obvious from Fig. 3. Analysis shows that when \( Z = 0, \Delta I = 0 \), that is to say, the chamber current vanishes when the \( \gamma \)-active float is at the center of the chamber. The function \( f(Z) \) is an odd function, that is, \( f(-Z) = -f(Z) \); consequently the differential-current curve is symmetric about the origin.

Fig. 2. Construction of the chamber of the flow-rate meter.
1, 2) electrodes; 3) inputs; 4, 5) cylinders; 6) insulator; 7) ring; 8) screw; 9) support; 10) collar; 11) lead screw; 12) crank.