The equivalent resistance of points B to "ground" and B' to "ground" depends on the conductance of the diode groups D1-D3 and D4-D5. In each group the diode anodes are connected to the corresponding cathodes of the digital display tubes, for instance, to the cathodes of numbers 100 and 99. The first group is connected to the 4th, 3rd and 2nd decades, and the second group to the 3rd and 2nd decades. When the readings of the digital display units are within tolerances (for instance, 998), the anodes of the first diode group are at a high potential (figures 100 do not light). The diodes are conducting, the equivalent resistance at point B is small, the grid of T1 receives a low potential, and a positive voltage difference is fed from its anode to the "and" circuit. The anodes of the second group of diodes have a low potential (figures 99 light). The diodes are blocked, and the equivalent resistance at point B' is large. The grid of T2 receives a high potential and its output does not feed a positive voltage difference to the "and" circuit. When the reading is outside its tolerances (for instance, 989), both at points B and B' there are low potentials and positive voltage differences are fed to the "and" circuit input. The tube indicating the correct operation of the circuit is extinguished. The indicating tube will flash for an incorrect operation of the converter if the self-control circuit is connected to it periodically. The circuit is designed to operate in the range of 90% of the converter error.

The front panel of the digital converter unit carries a potentiometer for setting the zero, another potentiometer for adjusting the nominal value of the signal and a push-button for starting the converter.

The instrument is made in 5 units suitable for rack mounting, consisting of the digital converter unit, the self-control unit, two digital display units, and a supply unit.

An experimental use of the voltmeter-converter has shown that the above units meet the requirements of operation under factory conditions.

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RATIOmeter measuring circuit with HEated RESistor

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We shall assume that a circuit which converts the ratio of two electrical quantities into an electrical current or voltage is a ratiometer measuring circuit. Such a circuit together with a measuring instrument can perform all the functions of a ratiometer. It can be used for measuring frequency, phase and other parameters of electrical circuits, such as resistance, capacitance and inductance. Indicating instruments and automatic recording potentiometers can be used as measuring devices.

A ratiometer measuring circuit with a heated resistor has been developed by the author at the Institute of Electromechanics, and comprises a bridge, one of whose arms consists of an indirectly heated wire-wound resistor Rg (Fig. 1). The bridge supply voltage is U2, and the voltage supplying the heater and the building-out resistor R is U1. The bridge current Iq is sufficiently small to have virtually no effect on the value of the heated resistor.
The resistance of the bridge arms is chosen in such a manner that, in the absence of a current through the heater, voltage $U_{AB}$ is always larger than voltage $U_{AD}$. It is obvious that voltage $U_d$ across the bridge diagonal will first increase for a simultaneous and proportional rise in voltages $U_1$ and $U_2$, will remain virtually constant for a further rise in these voltages, and finally, will decrease to zero, since with a rise in the voltage across the heated resistor $R_3$ the bridge tends to become balanced (Fig. 2). Curves 1, 2, and 3 correspond to three different values of the coefficient of proportionality $k = U_4/U_2$.

The voltage $U_d$ across the bridge diagonal is proportional to the supply voltage but independent of voltages $U_1$ and $U_2$ providing they increase simultaneously and proportionately, which means that voltage $U_d$ is inversely proportional to $U_1$. Hence,

$$U_d = \frac{U_2}{U_1}.$$  \hfill (1)

The above expression holds providing $U' \leq U_1 \leq U''$, since $U_d = \text{const}$ according to Fig. 2 only over a limited range of the variations of $U_1$. At the same time (1) holds for all the values of $U_2$ which do not change the value of the heated resistor.

Let us now analyze the operation of the ratiometer circuit. The relation between the heated resistor $R_3$ and voltage $U_1$ which is applied to the heater and the building-out resistor $R$ has the form [1]

$$R_3 = c + c_1 U_1^n,$$

where $c$ and $c_1$ are constants depending on the construction of the heated resistor and the conditions of its operation; $\alpha$ is a constant depending on the material of the heater and the condition of its operation.

Voltage $U_d$ in the bridge diagonal is

$$U_d = U_2 \frac{R_1 R_4 - R_3 R_2}{M}.$$  \hfill (2)

where

$$M = (R_1 + R_3)(R_4 + R_1) + \frac{R_1 R_3 R_2 + R_1 R_2 R_4 + R_4 R_3 R_1 + R_3 R_2 R_4}{R_d}.$$

Assuming that $U_2 = nU_1$, where $n = 1/k = \text{const}$, let us determine under what conditions we find that $dU_d/dU_1 = 0$.

It will be seen from Fig. 2 that the condition for $dU_d/dU_1 = 0$ corresponds to the operation of the ratiometer circuit in a stabilized voltage condition. In this condition, as in the one obtained in bridge circuits with stabilizing incandescent lamps or current regulator tubes the ratio of the bridge arm resistors $R_3 R_4 / R_1 R_2$ approaches unity. Thus, in the first approximation it is possible in (2) to neglect the relative variation in the denominator $M$ of the fraction as compared with the relative variation of the numerator when both are due to variations in resistor $R_3$.

Assuming that $k = \text{const}$ we have

$$\frac{dU_d}{dU_1} = \frac{n}{M} \left( R_2 R_4 - R_3 R_2 - \alpha R_3 U_1^n \right).$$

By equating the above expression to zero we can find the condition for which $U_d$ will be proportional to the ratio of voltages $U_2/U_1$:

$$R_3 R_4 = R_2 (R_4 + \alpha R_1 U_1^n).$$  \hfill (3)