Stray voltages as well as the thermal emf are present at the input of instruments which are used for measuring temperature by means of thermocouples. The appearance of these voltages is due to the effect on the measuring circuit of external conditions (the existence of electromagnetic fields, potential differences between grounding points, leakages, etc.). The methods and means for reducing the noise level at the input of an instrument are described in [1, 2, 4]. However, cases exist in practice when the noise level due to external electromagnetic fields and potential differences between grounding points is so large that the required results cannot be obtained by normal precautions (grounding, twisting of conductors, screening, utilization of filters). Such cases comprise temperature measurements above 1000°C in heavy electrical heating installations [3], temperature measurements in the presence of high noise levels, etc. Sufficiently precise temperature measurements can be obtained in these cases by adopting special precautionary measures which either supplement or replace existing arrangements.

This article describes the testing of a device for reducing the noise level at the input of a measuring instrument. The objective of this article is to show the possibility of measuring thermal emfs under conditions for which the noise level cannot be reduced by normal precautionary methods.

A schematic representation of the effect of noise due to external magnetic fields and potential differences between the grounding points of the instrument and the thermocouple are shown in Fig. 1.

The voltage drop across the instrument’s input impedance is equal to

\[
\dot{U}_1 = \frac{\dot{U}_{ns}^* (Z_1 + Z_2) Z_1 + \dot{U}_{ns}^* Z_1 Z_2 + \dot{U}_{ns}^* Z_1 (2Z_4 + Z_2)}{(Z_1 + Z_1 + Z_2) (Z_2 + Z_2) - Z_2^2}.
\]

Thus, with the knowledge of the experimental or calculated values of noise levels \(\dot{U}_{ns}^*\), \(\dot{U}_{ns}^*\), and \(\dot{U}_{ns}^*\), it is possible to evaluate by means of (1) the noise level at the input of the measuring instrument.
The main sources of noise under production conditions consist of external electromagnetic fields and potential differences between the grounding points of the instrument and the thermocouple. Measurements of the noise induced in measuring circuits and of the noise due to potential differences between the earthing points have shown that the stray currents and voltages are, as a rule, of a harmonic nature. The level of noise produced by the potential differences between earthing points can exceed considerably the level of the thermal emf. Figure 2 shows an oscillogram of noise voltage variations (curve 1) measured on the thermal electrodes of a platinum-platinorhodium thermocouple. Curve 2 shows variations in the supply voltage of the heating device whose power amounts to 17.5 kW. It will be seen from the oscillograms that the noise level attains 0.23 V. The high noise level may in many instances preclude temperature measurements by means of thermocouples. Moreover, it was found in practice that it is impossible by normal protection methods to reduce the noise level due to a difference in potentials between grounding points.

It is known [2] that in order to reduce noise it is possible to use at the measuring instrument's input a balanced bridge circuit (Fig. 3) whose arms are formed by the thermocouple electrode impedances (Z₁, Z₂) and the instrument input impedances (Z₃, Z₄).

Only currents due to the thermal emf will flow in the measuring diagonal of such a bridge circuit with appropriate values of the instrument input impedances Z₃, Z₄ > Z₁, Z₂. However, under actual operating conditions the resistance of the thermocouple electrodes (impedances Z₁ and Z₂) changes by different amounts for the same temperature increments, i.e.,

\[ r_1 = r_{01} (1 + \alpha_1 \Delta t); \quad r_2 = r_{02} (1 + \alpha_2 \Delta t), \]

where \( r_{01} \) is the resistance of the first electrode (for instance, the alumel electrode) at the initial temperature; \( r_{02} \) is the resistance of the second electrode (for instance, the chromel electrode) at the initial temperature; \( \alpha_1 \) is the resistance temperature coefficient of the first electrode; \( \alpha_2 \) is the resistance temperature coefficient of the second electrode; \( \Delta t = t - t_0 \) is the difference between the measured and the initial temperatures.

It is obvious from the above that the circuit in Fig. 3 will only be balanced for a single value of the measured temperature. At all other temperatures the circuit will be close to a balanced condition, but a current due to the difference of potentials will flow through the measuring diagonal. Table 1 shows the values of the output voltage in a bridge circuit whose arms were made up of MSR resistance boxes, two of which were used for simulating variations in the resistances of chromel-alumel electrodes heated up to 1000°C. It was assumed that the electrodes were 10 m long with a diameter of 0.5 mm. The resistances of the other two boxes were set at 4000 and 8000 Ω.

Before measurements the circuit was balanced, and then arm resistances \( R_1 \) and \( R_2 \) were changed according to the resistance variations of chromel-alumel electrodes. The alternating voltage was measured on a V3-6 millivoltmeter. It will be seen from Table 1 that, when the electrodes are heated up to 1000°C, the noise voltage at the input of the measuring instrument amounts to 5-50% of the measured quantity for variations in the difference between the ground potentials of the instrument and the thermocouple of 1 to 10 V.

The alternating voltage at the output of the balanced bridge circuit can be reduced by inserting at the input of the measuring instrument a compensation filter. Figure 4 shows the schematic of a device based on the application of a compensated-bridge method for reducing the noise level at the instrument input. It has been shown above that an alternating current flows through the measuring diagonal when the electrodes are heated. This current flows through the secondary winding \( W_2 \) of the filter choke and induces a magnetic flux in the opposite direction to that