Centralized temperature control can be achieved in two ways: either by switching into the machine input transformers with various output signal levels which are functionally dependent on the parameter being measured, and by using secondary transformers in the machine to unify the signals; or to unify the output signal by a primary transformer. The first centralized control machines were developed for working directly with primary transformers; such a solution, however, places strict limits on the universality of the machine. Recently, Soviet industry has developed temperature signal transformers with a unified output in constant current type PT-TS, PT-TP. These transformers are basically used in concert with centralized control systems which include linearization devices. More universal type systems have been developed for working with transformers which linearize the signals besides unifying them. The transformer PT-TS-L, whose output current depends linearly on temperature, as well as the transformers PT-TP and PT-TS are constant current amplifiers with high negative feedback. The necessity of amplifying the signal leads to a loss of accuracy and fidelity in the transformers, and to an increase in their mass and overall dimensions. Development of a transformer whose output signal is linearly dependent on temperature but which is free of amplifying devices is a long-term goal related to the advent of digital instruments on lower levels.

One of the possible arrangements of such transformers is shown in Fig. 1. In transformers constructed on the constant current amplification principle, linearization of characteristics is achieved by nonlinear feedback. In the proposed linearizing transformer, an additional nonlinear element is used: two thermal transducers, a platinum resistance thermometer and a platinum-platinorhodium thermocouple. The resistance thermometer is connected up in one arm (R_p) of a bridge arrangement fed by a stabilized source of known electromotive force (e.m.f.) E and internal resistance R_w. As is known, the sensitivity of a bridge falls if the thermometer resistance increases by ΔR; this means that the output voltage of the bridge depends nonlinearly on the variation in the thermometer resistance [1]. Also, the resistance of the platinum thermometer depends on the temperature nonlinearly, and this nonlinearity is similar in nature and sign to that of the bridge arrangement. Therefore the output voltage of the bridge, one of whose arms is the platinum resistance thermometer, is nonlinearly dependent on temperature, and the voltage increment per °C decreases as temperature increases. Since emf increment per °C of the platinum-platinorhodium thermocouple increases as the temperature being measured rises, addition of the emf to the bridge output voltage leads, in principle, to a more linear voltage-temperature relation. The deviation from linearity cannot exceed a fraction of one percent when the appropriate choice of bridge elements is made.

The requirement that the error in the nonlinear arrangement is zero at three points in the range being measured is assumed as a basis for calculating the components of the arrangement.

When the middle and the two ends of the measurement range are chosen as the full compensation points of the nonlinearity error, this requirement can be written as a system of equations for the range 0 to t_n:

\[ E_0 + U_0 = 0; \quad E_0.5 t_n + U_{0.5 t_n} = 0.5 U_{t_n}; \quad E_{t_n} + U_{t_n} = U_{t_n}, \]

where \( E_0, E_{0.5 t_n}, E_{t_n} \) are thermocouple emf's corresponding to the temperatures 0, 0.5 \( t_n \) and \( t_n \); \( U_0, U_{0.5 t_n}, U_{t_n} \) are bridge output voltages corresponding to these temperatures; and \( U_{t_n} \) is the output voltage of the arrangement at the upper end of the measurement range.
The resistance arm of the bridge arrangement is selected so that the first equation of (1) is satisfied. The connecting wires of the thermometer, when added to the bridge arm, influence the measurement; to diminish this influence, it is most expedient to choose the arms \( R_2 \) and \( R_4 \) as equal, and the magnitudes of their resistances as large as possible. Moreover, one must take into account that the sensitivity of the transformer will be better for lower values of the resistance of these arms. For example, if the value of the resistance of the connecting wires is 2.5 \( \Omega \), and its variation for a 10 °C temperature change in the surroundings is 0.1 \( \Omega \), then the arms \( R_2 \) and \( R_4 \) must be chosen as not less than 200 \( \Omega \) to have a maximal allowable error of approximately 0.1%. The arm \( R_5 \) is chosen to fulfill the condition that the output voltage of the arrangement is zero at the temperature corresponding to the lower end of the measurement range. Since the thermocouple emf is zero in this case, and if we introduce the notation

\[
\frac{R_2}{R_0} = \frac{R_4}{R_0} = m, \tag{2}
\]

where \( R_0 \) is the resistance thermometer resistance at 0 °C, we obtain

\[
R_3 = \frac{mR_0 \cdot mR_0}{R_0} = m^2 R_0. \tag{3}
\]

By eliminating the unknown \( U_{tn} \), we transform the second and third equation of (1) into one:

\[
2U'_{0.5t_n} - U'_{tn} = E_{tn} - 2E_{0.5t_n}. \tag{4}
\]

Put

\[
E_{tn} - 2E_{0.5t_n} = \Delta E. \tag{5}
\]

The value \( \Delta E \) can be calculated from (5), if the values \( E_{tn} \) and \( E_{0.5t_n} \) are first determined by thermocouple calibration tables. Thus

\[
2U'_{0.5t_n} - U'_{tn} = \Delta E. \tag{6}
\]

The input voltage \( U' \) of the bridge can be written as the difference of the voltage drops on the arms \( R_1 \) and \( R_4 \):

\[
U' = [E - I(R_W + R_a)]\left(\frac{R_1}{R_1 + R_3} - \frac{R_4}{R_3 + R_4}\right), \tag{7}
\]

where \( R_a \) is the additional resistance; \( I \) is the current flowing in the diagonal power supply;

\[
I = \frac{E}{R_W + R_a + \frac{(R_1 + R_3)(R_3 + R_4)}{R_1 + R_3 + R_4 + R_4}}; \tag{8}
\]

and \( E \) and \( R_W \) are the emf and the internal resistance of the power source.

After some simple mathematics, (7) takes the form

\[
U' = \frac{Em^2 R_0 e}{(R_W + R_a)[e + (1 + m)^2] + mR_0 (1 + m) (e + 1 + m)}, \tag{9}
\]

where \( e = \Delta R/R_0 \) is the relative thermometer resistance increment.

By substituting the expression for the voltage \( U' \) at the temperatures 0.5\( t_n \) and \( t_n \) from (9) into (6) we get

\[
2\epsilon_{0.5t_n} = \frac{E_{0.5t_n} [\epsilon_{0.5t_n} + (1 + m)^2]}{(R_W + R_a) [e_{0.5t_n} + (1 + m)^2] + mR_0 (1 + m) [e_{0.5t_n} + 1 + m]}. \tag{10}
\]