VARILATIONS DUE TO AMBIENT TEMPERATURE IN THE FIXED DIMENSIONS OF A PROCESS CONTROL INSTRUMENT CAN HAVE EITHER A QUASISTATIC OR A DYNAMIC NATURE, DEPENDING ON THE AMBIENT TEMPERATURE RATE OF CHANGE. IN THE FIRST INSTANCE, VARIATIONS IN THE FIXED Dimension ARISE DUE TO SLOW CHANGES OF THE AMBIENT TEMPERATURE, SO THAT ALL THE PARTS OF AN EXTERNAL GAUGE ACQUIRE THE SAME TEMPERATURE AND THE VARIATION CAN BE CALCULATED FROM THE FORMULA

$$\Delta l = a \Delta T,$$

WHERE $\alpha$ IS THE LINEAR EXPANSION COEFFICIENT OF THE EXTERNAL GAUGE MEASUREMENT COMPONENTS, $l$ IS THE COMPONENTS' EFFECTIVE LENGTH, $\Delta T$ IS THE DIFFERENCE BETWEEN THE TEMPERATURES AT WHICH THE GAUGE WAS SET AND THE MEASUREMENTS WERE MADE.

THE COMPUTATION OF THE FIXED DIMENSION'S DYNAMIC VARIATIONS IS RATHER DIFFICULT, SINCE IT AMOUNTS BASICALLY TO CALCULATING THE TEMPERATURE FIELDS OF THE GAUGE COMPONENTS.

HOWEVER, FOR CERTAIN CASES (FOR A SMALL NUMBER OF GAUGE COMPONENTS AND THEIR SIMPLE SHAPES) IT IS POSSIBLE TO MAKE THIS CALCULATION, WITH A PRECISION SUFFICIENT FOR PRACTICAL PURPOSES, FROM THE FORMULA

$$\Delta l = \sum_i I_i \Theta_i (t) - T_0,$$

WHERE $\Theta_i$ IS THE LINEAR EXPANSION COEFFICIENT OF A MEASURING COMPONENT, $I_i$ IS THE COMPONENT'S LENGTH, $\Theta_i$ IS THE "EFFECTIVE" TEMPERATURE AT THE INSTANT OF MEASUREMENT, $T_0$ IS THE TEMPERATURE AT WHICH THE GAUGE WAS SET.

IT IS KNOWN FROM THE THERMAL INERTIA THEORY [1] THAT THE RELATIONSHIP BETWEEN THE TEMPERATURES OF A BODY $\Theta (t)$ AND A MEDIUM $T_m$ CAN BE REPRESENTED AS

$$T_m (t) - \Theta (t) = [T_m (t) - \Theta (t_0)] e^{-m (t-t_0)} - e^{-mt} \int_{t_0}^t e^{mt} \frac{\partial T_m (t)}{\partial t} dt,$$

WHERE $t_0$ IS THE INITIAL INSTANT, $m$ IS THE THERMAL INERTIA CONSTANT OF THE BODY.

IF THE AMBIENT TEMPERATURE CHANGES LINEARLY OR EXponentially with an initial condition of $T_m (t_0) = \Theta (t_0)$, then the above formula becomes much simpler and assumes the form

$$T_m (t) - \Theta (t) = -\frac{k}{m}.$$

FOR A LINEAR VARIATION OF THE AMBIENT TEMPERATURE AT A CONSTANT RATE WE FIND THAT $k = \frac{\partial T_m}{\partial t}$.

FOR AN EXPONENTIAL VARIATION OF THE AMBIENT TEMPERATURE $T_m (t) = T_m \text{stb} e^{-kt}$ and the formula assumes the form

$$\Theta (t) = T_m (t) + \frac{k T_m \text{stb}}{m - k} e^{-kt} [e^{m-k} t - 1].$$

AN ADDITIONAL CASE SHOULD BE MENTIONED, WHEN THE AMBIENT TEMPERATURE HAS ATTAINED THE GIVEN VALUE AND COME EQUAL TO $T_{\text{stb}}$. THE BODY TEMPERATURE WILL THEN CHANGE ACCORDING TO THE "SIMPLE COOLING (HEATING)" CONDITION.
The above relationships can be used for determining the external-gauge fixed dimension's variations for a heating and cooling cycle of the surrounding medium.

The fixed dimension variations over a linear segment of ambient temperature changes are also linear. Over the exponential section of ambient temperature variations the fixed dimension of the gauge varies according to a law of the type

\[ \Theta(t) = T_{stb} (1 - e^{-nt}) \]

(5)

where \( a_1, a_2, \ldots, b_1, b_2 \) are constants which depend on the inertial properties of the external-gauge dimensional components, initial and final temperatures, the length of components in the dimensional chain, etc.

Depending on the signs of constants \( a \) and \( b \), the function can be either monotonically variable, or it can have one or more extrema at which it changes its sign.

For a theoretical analysis of the fixed dimension variations it is necessary to know the thermal inertia constants of the main components of the gauge. The computation of these constants is possible only for a limited number of simple cases.

The thermal inertia constants of the main components of the gauge and the temperature variations of its fixed dimensions can be determined experimentally according to the following technique.

The process control instrument's measuring gauge which is connected to the reading device is set for measuring the dimension of a quartz cylinder. The gauge is set to its operating position in a thermostat which provides it with a given heating and cooling program.

Various parts of the gauge are connected to thermal transducers which serve to measure the temperature of the gauge components for varying air and thermostat temperatures.

The general schematic of the equipment is shown in Fig. 1. Process control gauge 1 is fixed on a shock-absorbing bracket to a stand. The measured quartz cylinder 2 is mounted on a separate bracket. The air in thermostat 3 is heated with a separate high-power element 4. The air is heated uniformly by stirring it with fan 5 inside the cabinet. The gauge is protected by screen 6 from direct heating by the element. The air temperature inside the cabinet is controlled with electrical-contact thermometer 7 which operates the heater through relay 8. The heating condition of the cabinet is varied by regulating the heater supply voltage through autotransformer 9, and its cooling condition by adjusting the rotation speed of the fan and opening the air-exchange hatches. The air temperature in the cabinet is controlled with an error of the order of 0.025°C by means of electrical thermometer 10, which has a small time constant (not exceeding 5 sec) and is located near the gauge. Moreover, laboratory thermometer 11 with a scale value of 0.2°C is placed in the zone of the gauge, thus providing an additional control of the air.