A senior engineer of the Kurgan State Inspection Laboratories (LGN), comrade D. D. Kirillov, has appealed to the editorial staff in a letter which raises questions regarding a revision of Instruction No. 166-63 or an improvement in the documentation for instruments of the KSPZ-P and KSMZ-P types from the Chelyabinsk factory "Teplopribor." He points out that in Instruction No. 166-63 there are discrepancies in the technical conditions with respect to rating the operating errors for contacts of the regulator devices that are built into the instruments. The author of the letter enquires as to the permissible norms for the errors when checking these instruments. The article published below by a senior scientific staff member of the All-Union Scientific-Research Institute of the Creamery and Cheese-Making Industry, comrade A. I. Lisenkov, includes among other things an answer to the questions posed. As the editorial staff has reported, the All-Union State Standard Association of the USSR plans to develop during 1975 a testing standard on automatic potentiometers and bridges to replace Instruction Nos. 166-63 and 158-62.

METHOD OF CHECKING AUTOMATIC MEASURING INSTRUMENTS

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Modern industrial automatic potentiometers and bridges, i.e., automatic measuring instruments (AMI), are highly complicated, multifunctional technical equipments. The standard documents now in force [1, 2, 3] do not take account of certain peculiarities of the physical characteristics in AMI's and do not indicate some features in their checking such as checking at a point in the measuring range with due regard for the effect of quantization on the input signal. The question of choosing inspection points in the measuring range of an AMI is answered in these documents without sufficient justifications.

The fundamental questions of the checking procedure are discussed below.

Checking Procedure at a Point in the Measuring Range of an AMI

A general form of block diagram for an AMI is shown in Fig. 1. It contains an input transducer $K_1$ (for example, an input attenuator or a switch for the measuring channels of a multiple-point AMI; many AMI's have no input transducer), a servomechanism $K_o$, and output transducers $K_1, K_2, \ldots, K_n$. The quantity $x$ being measured is fed to $K_1$ which converts it to an input signal $U(x)$ for the servomechanism. The output signal $y_o$ of the servomechanism is converted by the output transducers (AMI) into the output signals $y_1, y_2, \ldots, y_n$, i.e., into an indication, a recording, a voltage, etc.

In accordance with the block diagram, an error $\Delta n$ in any measuring channel of an AMI can be represented by the sum of three errors: that of an input transducer $\Delta K_1$, of the servomechanism $\Delta K_o$, and of an output transducer $\Delta K_i$.

The error $\Delta K_o$ has a decisive significance in the AMI checking procedure. AMI servomechanisms differ from one another in the elements employed for the principal feedback network. A slidewire resistance is the element used for this purpose in the majority of servomechanisms. To visualize the characteristics of $\Delta K_o$, let us consider the operation of a

Fig. 1

servomechanism with a slidewire resistance when checking an AMI such as a potentiometer. We will assume that the system includes only ideal elements and we will ignore velocity feedbacks because the rate of change \( V \) of \( U_x \) during checking is negligible.

The servomechanism is depicted in Fig. 2. It contains a compensating circuit which is represented in the form of \( N \) resistors having each a value \( r \) connected in series (where \( r \) is the resistance of one turn of the slidewire helix) and which is supplied with a stabilized voltage \( U_{sv} \), an amplifier for the uncompensated voltage \( AU \), and a reversing motor \( M \) which is linked to the movable contact on the slidewire resistance \( S \). The output signal \( Y_0 \) of the servomechanism is the displacement of \( S \). Figure 3 shows a graph of the variation in the compensating voltages \( U_c \), in the uncompensated \( AU \), and in \( Y_0 \) as a function of \( U_x \).

It is evident from Fig. 3 that the position of \( S \) corresponding to a point \( K \) in the measuring range remains unchanged \((Y_{OK} = \text{const}) \) during an increase \( \Delta U > 0 \) or a decrease \( \Delta U < 0 \) of \( U_x \) within the limits \( U_r \) (where \( U_r \) is the voltage drop on one turn of the slidewire resistance). Consequently at the \( K \)-th position of \( S \) the input signal of the servomechanism can have a value that lies within the limits

\[
U_{x_i} = U_r (K - 1) + \Delta U_s \\
U_{x_2} = U_r K - \Delta U_s \\
U_{x_3} = U_r (K + 1) - \Delta U_s \\
U_{x_4} = U_r (K - 1) - \Delta U_s
\]

These formulas determine the effect of quantizing the input signal \( U_x \). It is readily shown that from the stability condition for the servomechanism \( \Delta U_s > 0.5 U_r \). Therefore the values of \( U_{x_2} \) and \( U_{x_4} \) are, respectively, the greatest \( U_{x_{\text{max}}} \) and the least \( U_{x_{\text{min}}} \) values of \( U_x \), and the value \( K \) of each measuring channel will correspond to \( x_{i_{\text{max}}} \) and \( x_{i_{\text{min}}} \). Here \( \Delta n_{i_{\text{max}}} \) and \( \Delta n_{i_{\text{min}}} \), the measuring errors of the channel, are defined as

\[
\Delta n_{i_{\text{max}}} = x_{N_i} - x_{i_{\text{max}}} \quad \text{when} \quad \Delta U > 0 \\
\Delta n_{i_{\text{min}}} = x_{N_i} - x_{i_{\text{min}}} \quad \text{when} \quad \Delta U < 0
\]

where \( x_{N_i} \) is the nominal value of \( x \) corresponding to the point being checked in the \( i \)-th channel while \( x_{i_{\text{max}}} \) and \( x_{i_{\text{min}}} \) are the values of \( x \) at the beginning of an output signal step in the \( i \)-th channel (the movement of the indicator, for example) away from the point being checked in an increasing or decreasing direction, i.e., the value of the voltage that starts the servomechanism away from the steady-state position when \( x \) increases or decreases.

The quantization of \( U_x \) by the servomechanism causes the value of the output signal \( y_i \) to change in steps \( y_{r_i} \) which correspond to the change of \( x \) within the limits \( x_r \).

As shown by investigations of type K34 instruments, the position \( y_{ri} \) of the indicator with respect to a scale corresponding to one and the same value of \( x \), the steps \( y_{ri} \) of the indicator, and the corresponding changes in \( x_r \).