MECHANICAL MEASUREMENTS

REFERENCE 1st GRADE LEVER-TYPE DYNAMOMETER

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For evaluating the errors and consistency in transmitting a force from a 2nd grade reference stationary equipment by means of a 3rd grade reference dynamometer we carried out the following tests: three 3rd grade reference dynamometers, which were previously carefully tested on a 2nd grade installation at the VNIIM (All-Union Scientific Research Institute of Metrology) for their consistency, were calibrated on stationary 2nd grade equipment in Moscow, Sverdlovsk and Novosibirsk. The calibration data obtained for the same dynamometer on various instruments differed from each other by up to 2%, and the quadratic mean errors of the dynamometer calibration data obtained on various instruments exceed tens of times the error obtained by the VNIIM. These measurements once again confirmed the pressing necessity of producing 1st grade dynamometers.

Fig. 1. The unequal arm lever systems [1] studied by us made it possible to design portable equipment with a gear ratio of the order of 25,000 and a limiting measuring error not exceeding ± 0,05% of the measured value.

The kinematic chain of the proposed lever-type dynamometer consists of a combination of unequal arm levers of the first and second order with total gear ratio 25,000. The set of the first three levers, mounted in a separate box, has a nominal gear ratio of 500 with measuring limits of 100 to 1,000 kg-wt; a set of four levers has a nominal gear ratio of 2,500 with a range of 500 to 5,000 kg-wt; the aggregate of all the seven levers makes up a portable instrument of a lever type with a nominal gear ratio of 25,000 and a range of 1,000 to 50,000 kg-wt.

Repeated tests of these instruments consisted in evaluating the error of the dynamometer by loading it directly with reference weights.

The data thus obtained showed that the limiting relative error of the lever system with a gear ratio of 500 did not exceed 0,003% at its top limit (1,000 kg-wt), i.e., it was possible to determine a weight of 1,000 kg with a limiting error of ± 30 g, and a weight of 5,000 kg with a limiting error of ± 500 g.

This error of the lever systems under investigation makes it possible to assert that they can be successfully used for measuring weights from 100 to 5,000 kg and even higher with an accuracy satisfactory for metrological purposes.

Since the above instruments are of a portable type, additional tests were made in order to discover the effect of their dismantling, reassembly and adjustment on the value of the error.
The instruments were repeatedly dismantled, reassembled and transported and after readjustment used for a series of measurements of various loads [2]. By means of these measurements we determined the quadratic mean error of the lever system's gear ratio due both to the measuring procedure and to the reassembly and adjustment of the instruments. The data thus obtained were subjected to a dispersive analysis.

The total quadratic mean error due both to the measurement procedure and the adjustment of the instrument is determined by the formula

$$\sigma_Y = \sqrt{\sigma^2 + S^2_1}$$

The values of $\sigma_{ij}$ for the corresponding loads are shown in the table.

The data given in the table show that it is impossible to ignore the effect of assembling and adjusting (a new instrument), since the value of $\sigma^2$ is of the same order as that of $S^2_1$. The last column shows the quadratic mean deviations which depend both on the measurement errors and the errors of adjustment.

The tests carried out on the multilever portable instruments lead to the following conclusions: the dismantling, reassembly and adjustment of the instrument introduce into the total error an additional component which must be taken into account, and whose value is of the order of 0.01%; the quadratic mean error due to the measuring process only is of the order of 0.002-0.007%.

The above multilever instruments were used as grade 1 dynamometers for checking grade 2 dynamometers.

Figure 1 shows the schematic of a lever-type dynamometer with a top measuring limit of 50,000 kg-wt connected to a grade 2 hydraulic instrument of the M. K. Zhokhkovski system for the purpose of determining its metrological characteristics.