GOST 11606-65 [1] has established the following accuracy classes for spring-type dial indicators for technological scales: 0.1; 0.2; 0.25; 0.4; 0.5; 1. Domestic industry has introduced and is manufacturing all the enumerated accuracy classes with the exclusion of 0.1. Industrial models of spring-type indicators of this class suitable for mass production have still not been created by us, though some foreign firms, for example Avery (England), have produced such indicators over the course of the past few years and have done so with sufficiently stable characteristics.

In the USSR wide use is made of indicators having quadrant force meters in accordance with GOST 9483-60 [2]. These indicators satisfy the requirements of class 0.1, though their design complexity and a number of use deficiencies (low reliability under conditions of vibration and shaking, the complexity of alignment and constant adjustment, etc.) limit their use under the severe conditions of the metallurgical, coal, cement, and other branches of industry, especially on moving weighing devices.

By virtue of what has been said above it is clear that the national economy has a present need for highly accurate spring-type indicators free of the deficiencies found in quadrant indicators. However, investigations made at the Scientific-Research and Design Institute for Testing Machines, Instruments, and Measurement Means for Mass (NIKIMP) [3, 4] and the Special Design Bureau for Means for Measuring Mass (OKB SIM) have shown that using generally accepted design solutions in domestic developments it is possible, in the best case, to attain a basic spring-type indicator error of up to 0.1% of the greatest measurement limit, but only under conditions of individual manufacture, i.e., with manual adjustment and especially careful instrument alignment. To attain, in this manner, any acceptable accuracy reserve necessary for compensation of errors introduced by the lever system, thereby obtaining from the scales in the set an accuracy corresponding to class 0.1 in accordance with GOST 13712-68 [5], is not practicable.

An analysis of the errors of spring-type indicators has shown that a considerable obstacle to the increase in accuracy is the presence in the indicator of a large number of transmission and support elements (levers, ball joints, a pullrod, springs, rack and rod transmissions, etc.). Increases in accuracy by improving a spring-type force meter are difficult, because this involved considerable complication of the technology of spring manufacture. Consequently, it is necessary to strive for maximum simplification of indicator kinematics.

The OKB SIM has proposed an instrument [6] differing from the well-known designs in that it achieves an increase in accuracy with a load-receiving rod joined to the pointer axle by means of a reducer made in the form of two drums of different diameter connected to each other with flexible ribbons placed symmetrically relative to the drum axis and mutually balanced.

Figure 1 shows the schematic of this instrument. The load is conducted to the indicator through force-receiving rod 1, which is connected by means of a flexible ribbon 3 to drum 2. The latter is connected by means of flexible ribbon 4 to the spring-type force meter 5 having a stiffness regulator 13. Drum 6 is attached to the same shaft as drum 2 and drum 6 is connected by means of flexible ribbons 7 and 8 to drum 9 located on the axle of pointer 10. The results of the weighing are read out on dial 11.
Spring elements 12 put the ribbons under tension. During reciprocating motion of load-receiving rod 1 ribbon 7 unwinds and ribbon 8 winds onto drum 9 and vice versa. Mutually balanced flexible ribbons ensure accurate rotations of the pointer axle proportional to the angle of rotation of drum 6, i.e., the applied load.

In using such a spring-type indicator, as will be evident from the calculations shown below, weighing accuracy will correspond to class 0.1 with sufficient reserve.

**Basic Design Data for the Instrument.**

1. Maximum forces on rod 1: a) useful $P_u \approx 50 \text{ N}^*$; b) tare $P_t = 25 \text{ N}$ [1].
2. Spring of force meter 5: a) average diameter $D_0 = 55 \text{ mm}$; b) diameter of the wire $d = 5 \text{ mm}$; c) material, steel 50 KhFA GOST 2052-53; d) hardness HRC = 49-51; e) stress in the working turns under total force:

$$\tau = \frac{8kP_D}{\pi d^3} = 8.8 \cdot 10^7 \text{ Pa},$$

where

$$e = \frac{D_0}{d} = 11; \quad k = \frac{4C+2}{4C-3} = 1.045; \quad P = P_u + P_t = 75 \text{ N}.$$

3. Diameters of drums 2, 6, and 9, respectively: $D_1 = 45-0.017 \text{ mm}$; $D_2 = 320-0.035 \text{ mm}$; $D_3 = 80-0.02 \text{ mm}$.

4. Force ribbons 3 and 4 are made in conformity with GOST 2614-65 [7]: a) strength, 1P; b) material, steel 13kh! GOST 8950-63 with a peak strength of $\sigma_p = (130-160) \times 10^5 \text{ Pa}$; c) thickness $t_{rf} = 0.1 - 0.01 \text{ mm}$; d) width $b_{rf} = 10 \text{ mm}$; e) force required for gap recovery when winding onto drum 2 [8]:

$$P_{tf} = \frac{b_{rf}t_{rf}^2}{6} \frac{\sigma_p}{D_1} = 1.2 \text{ N},$$

which is ensured with a tare force of $P_t > P_{tf}$.

5. Ribbons 7 and 8 transmitting motion to pointer 10: a) strength, material, and peak strength same as for the force ribbons; b) thickness $t_{rt} = 0.05-0.008 \text{ mm}$; d) force required for gap recovery when winding onto drum 9: $P_{rt}^*$. *This value of useful force is determined by a mass of weights on the rod equal to 5 kg.*