The flows and quantities of fluids are measured at present by means of various methods and instruments. Moreover, new methods are also being developed. Despite this, in many instances it is as yet impossible to select a suitable measuring device. One of the reasons for this condition consists of the insufficient standardization and normalization of existing methods and means for measuring flows. Moreover, we do not refer to a limited standardization which often amounts to typification, but a genuine, profound standardization suitable for ensuring a considerable expansion of a given measuring method's application field. Such a standardization can be based, naturally, only on the results of a profound and purposeful scientific research work. Let us examine the basic scientific problems which arise in standardizing methods and instruments for measuring flows.

1. Flowmeters with a Variable Pressure Drop

Basic instruments for measuring the flows of liquids, gases, and vapors comprise at present flowmeters which consist of constricting devices placed in the pipeline and a differential manometer which is used for measuring the pressure difference produced by the constricting device.

The normalization of differential manometers with respect to selecting their types and classes and limiting pressure drops and static pressures is relatively simple and is applied to a considerable extent, although certain problems, such as the advisability of normalizing errors with respect to the pressure drop or the flow, still remain unsolved.

Constricting Devices. The standardization of constricting devices is much more complicated. In this case, in addition to a substantiated selection of the type of the device it is also necessary to conduct extensive experimental work for determining the discharge coefficient $c_f$ of these devices. It is necessary to find the relationship of this coefficient not only to modulus $m$ of the constricting device [$m = (d/D)^2$, where $d$ and $D$ are the diameters of the constricting device and the pipeline], but also to find the Reynolds number $Re$, or more precisely to establish the range of $Re$ numbers, within which $c_f$ remains constant.

It is known that up to 1966 the ISO recommended to standardize only a single type of diaphragm and two types of nozzles. According to this recommendation the "Rules 28-64" standardized the so-called "normal diaphragm" and "normal nozzle." Another type of nozzle, the so-called "elliptical nozzle," has not been adopted in European countries. However, the basic experiments in evaluating the flow factors of a normal diaphragm and a normal nozzle were made over 35 years ago, and since then constricting devices have been widely adopted in many countries. Thus, in our country certain regulating documents for normal diaphragms were issued long before "Rules 28-64." These documents included "norms" VTI of 1932, "Rules 169" of 1939, and "Rules 27-54" of 1954.

In subsequent years these rules and norms were only slightly amended and supplemented. At the same time the demands regarding the measuring equipment increased continuously. Necessity arose for measuring the flows of dust-laden gases, fluid flows with small $Re$ numbers, flows in small-diameter pipelines, and in many other cases. In order to meet the above-mentioned and other requirements many new types of constricting devices were produced, including segmented diaphragms for dust-laden and polluted gases, "quarter-circle" and "half-circle" nozzles for double diaphragms, double-bevel diaphragms for small $Re$ numbers, and various flowmeter pipes with a small residual loss of pressure. These constricting devices are being used on a fairly wide scale. However, to date not a single one of them has been standardized, which undoubtedly impedes their wide application. However, some of these devices, for instance, segmented diaphragms and "quarter circle" nozzles have been thoroughly investigated, and their normalization is absolutely necessary. It is possible that for this purpose it will be necessary to carry out a few more additional tests of small proportions. Considerably more extensive investigations are required for standardizing flowmeter pipes, especially of new types, including those of the Doll and double-nozzle types which provide the best power efficiency of all the known constricting devices. Moreover, flowmeter pipes of old designs including Venturi

tubes and nozzles, require additional research. Thus, although Venturi nozzles are included in "Rules 28-64," they have an excessively large root-mean-square discharge coefficient error as compared with normal nozzles; and Venturi tubes have not been normalized at all in our country, despite the fact that they have been used for a very long time.

Unfortunately our metrology and instrument making lag in the field of developing and investigating new types of constricting devices. This lagging must be overcome if we want to use on a wide scale new constricting devices and develop our norms and standard specifications on the basis of the results of our investigations without waiting for similar norms to be developed abroad. It is only under such conditions that we shall be able to lead in this important field of measurement technology.

It is especially important to deal with the standardization of constricting devices for pipelines smaller than 50 mm in diameter. It is known that the smaller the diameter of a pipeline the greater is the effect of its surface roughness on the discharge coefficient. This is one of the reasons why "Rules 28-64" specify normal diaphragms and nozzles for pipes with a diameter not less than 50 mm. Moreover, in diaphragms with a small-diameter hole the effect of the edge sharpness on the value of \( \alpha \) increases considerably. All these considerations are the reasons for the widely-held opinion that it is inadvisable to standardize constricting devices for small-diameter pipes. However, we can hardly agree with this opinion. In order to eliminate the effect of variable surface roughness it is necessary to normalize in addition to the constricting devices also the adjacent segments of pipes. In small-diameter pipes the segments will not be long. These segments should be made from rustproof materials and supplied together with the constricting device which should be selected so as to eliminate the error due to the bluntness of the diaphragm's input edge. Investigations in this respect would solve the important questions of standardizing constricting devices for small-diameter pipes.

**Measurement of Pulsating Flows.** Variable pressure-difference flowmeters can be used for measuring pulsating flows of liquids, gases, and vapors, provided that the pulsations are first smoothed out by means of appropriate filters. Hodgeson's number or criterion are often used to characterize the latter. However, they do not take into account the specific properties of gases described by the adiabatic index \( \gamma \), and they cannot be used for computing multisectional gas filters. Owing to the work carried out at the VNIIM [1], a generalized criterion for smoothing out pulsations has been established, from which Hodgeson's number can be derived as a particular case for \( \gamma = 1 \). Moreover, formulas have been obtained in this work for computing not only single-section but also two- and three-sectional gas filters. The necessity of using the results of this work in compiling norms for measuring pulsating flows has been previously indicated in [2]. In complete agreement with the above we should like to note, however, that it is desirable to carry out certain additional research in order to clarify the possibility of resonance conditions arising in pipelines as well as the effect of the constricting device shape on the precision in measuring pulsating flows.

**Pressure-Head Devices** are used above all for measuring local flow velocities. They are in fact converters of velocity to a pressure difference which is then measured by a differential manometer. However, pressure-head devices can also be used for measuring flows, if the ratio between the measured and mean velocities is known. A classical pressure-head device consists of a combination of a Pitot tube with a pipe which serves to pick out static pressure. At present these devices are not standardized and the correction factor to the theoretical formula which related the dynamic head with the pressure difference produced by it is evaluated experimentally for each pressure-head tube by means of a wind tunnel or a rotational machine. Nevertheless, it is possible to assert on the basis of the considerable experimental material obtained at the VNIIM that by observing certain geometrical proportions the correction factor of the tube remains sufficiently constant and equal to unity. From the above it is possible to arrive at the conclusion of the advisability and necessity for standardizing pressurehead tubes. This will simplify and facilitate their manufacture and application, thus extending the field of their utilization.

The pressure-head devices comprise in addition to the tubes also pressure-head amplifiers which combine microconstricting devices: for instance, Venturi microtubes with a Pitot pressure-head tube. Such devices produce a pressure difference which is many times higher than that produced by an ordinary pressure-head tube, which in many cases is very important. The task of standardizing such pressure-head amplifiers is pressing, but it requires considerable preparatory work, since the pressure-head amplifiers have been studied very little.

2. **Circumfluent-System Flowmeters**

Flowmeters of this system are based on the tested substance flowing round a given object (float, piston, disc, etc.), whose displacement is measured as a function of the flow. In compensated flowmeters of the circumfluent system the displacement of the body is negligibly small and, therefore, the measured quantity consists of the countering force which compensates the dynamic pressure of the flow on the body. The best known specimens of such