Equipment for Field Geotechnic Investigation of Soils

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Problems of field investigations of structural properties of soils have an important practical significance for various types of construction. At the present time in the USSR and in the USA there are several different methods for the solution of these problems. In the United States and the West European countries various instruments and methods based on penetrometers of relatively small size are used for field investigations.

In the USSR there are two methods of soil investigations utilizing pits and bore holes. The first method utilizes loading by presses and platforms of relatively large size, many exceeding the size of the penetrometers used in the United States and West Europe. In the second method, establishment of carrying capacity of soils is carried out on the basis of definite physical and mechanical properties of soils obtained from undisturbed samples.

My remarks are directed to the second method. In this connection I shall permit myself briefly to acquaint you with some of the instruments developed by me which have been manufactured and used in the USSR and other countries during the past eight years. The techniques of using these instruments are described in a book, "Investigations of Soils Under Field Conditions" and the corresponding officially approved specifications.

In the Southern Building Research Institute YUZHNII there have been developed Litvinov Type-9 field laboratories for accelerated tests of the building properties of soils directly on the site. The laboratories are in serial production now and are widely used both in the USSR and in other countries. They are portable sets of equipment conveniently operated and handled by one man and can replace the complicated and bulky equipment of stationary field laboratories. The equipment has been thoroughly tested both in laboratories and on the site by research and productive institutions and has been used with success.

The equipment of these field laboratories permits the determination of the physical and mechanical properties of soils to be made with a high degree of accuracy by drawing conclusions from experimental data based on parallel field tests of hundreds of soil block samples rather than on testing a limited number of samples as is usually done. The time required for taking undisturbed samples and making accelerated determinations of their basic physical properties has been reduced to one-tenth of that required for other generally employed methods and apparatus. The expenses involved in carrying out research work are thus considerably reduced and the rate at which it is done is greatly increased.

The field laboratories which are contained in two hand cases weighing eight and 12 kgs each and are equipped with a drying cabinet (1.5 kgs weight) and a device for shear tests of soil weighing 6 kgs *(Figs. 1, 2)*. The equipment also includes devices and apparatus of special design that permit determinations of all the building properties of soils required by the codes.

Here are some examples of the use of this equipment:

(a) Selection of undisturbed soil block samples of natural moisture content from holes and pits by using the devices shown *(Figs. 3, 4)*. These block samples are then used to determine the basic physical properties of the soil and tested for filtration, compressive properties, shear, etc.

(b) Determination of various soil characteristics: dry volume-weight, wet volume-weight, moisture content; porosity, density, and permeability under various loadings; plasticity, consistency, granulometricity, angles of the slope of repose of sandy soils *(Fig. 5)*, swelling, relative modulus of compression, structural cohesion, shearing cohesion of plastic clayey and silty soils, etc.

(c) Determination of the compressive properties by the usual or accelerated method in a consolidometer *(Fig. 6)* or

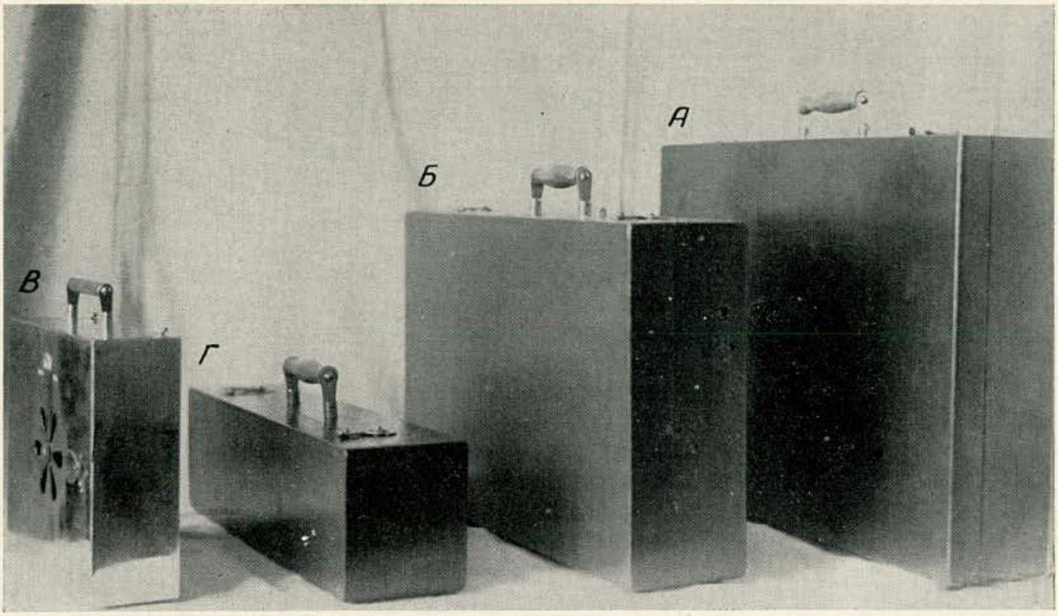

FIGURE 1

General view of the Litvinov Type-9 field laboratory developed in YUZHNII: A. Main set of equipment; B. compression device; C. field drying oven; D. shear test device.

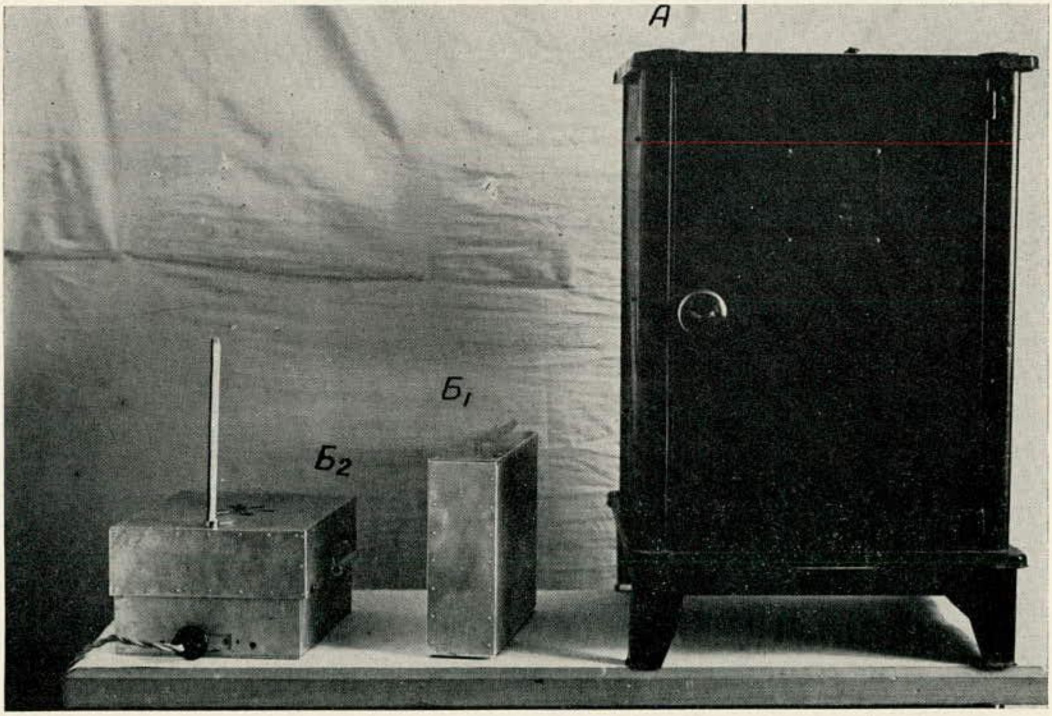

FIGURE 2

Drying oven. A. Standard oven for laboratory work; B-1. oven for Type-9 field laboratory ready for shipment; B-2. oven in working condition.

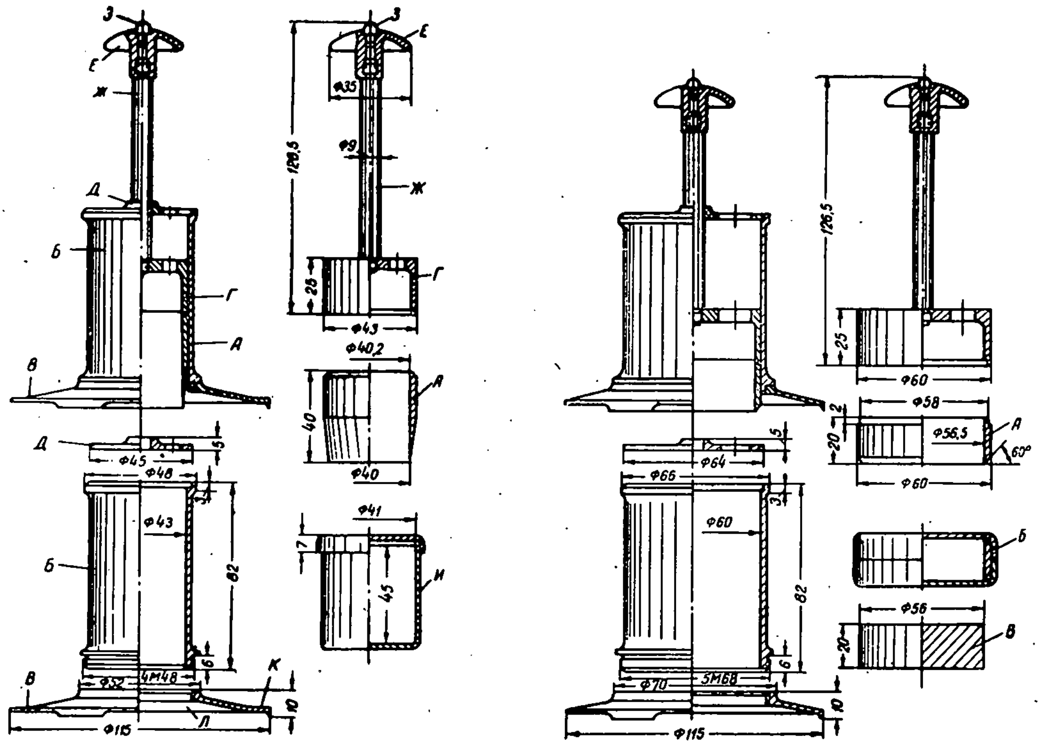

FIGURE 3
Type-9 field laboratory devices used in collection of undisturbed soil samples for determination of the basic physical, compressive, sedimentary, filtration and shear properties.

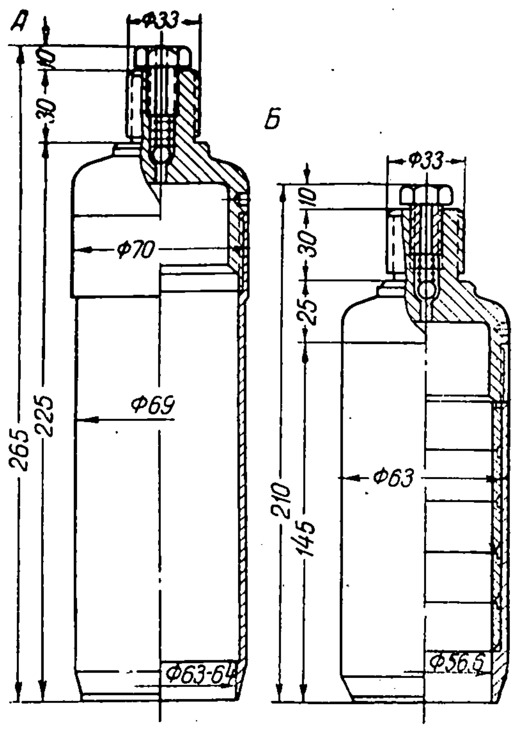

FIGURE 4
Soil sample transporters D-1 and D-2.

another device *(Figs. 7, 8)* by means of which pressure is applied uniformly on all sides of the block sample.

(d) Determination of the structural properties of loess soils, the coefficients of settlement after wetting *(Fig. 6)* and the size of possible settlements after wetting.

(e) Field investigation of the shear properties of soils by means of a special device *(Figs. 9, 10, 11)*.

(f) Determination of the critical pressure on the soil in accordance with the codes and technical requirements.

(g) Calculation of the possible settlement of the footings of various buildings and structures.

This equipment ensures proper control of the quality of different earthwork in the construction of soil dams, embankments, dikes, canals, fills and other structures involving the use of soils *(Fig. 12)*.

The drying of soil samples is carried out in a collapsible oven of special design (see Figure 2) weighing only 1.5 kg and having dimensions very convenient for transporta-

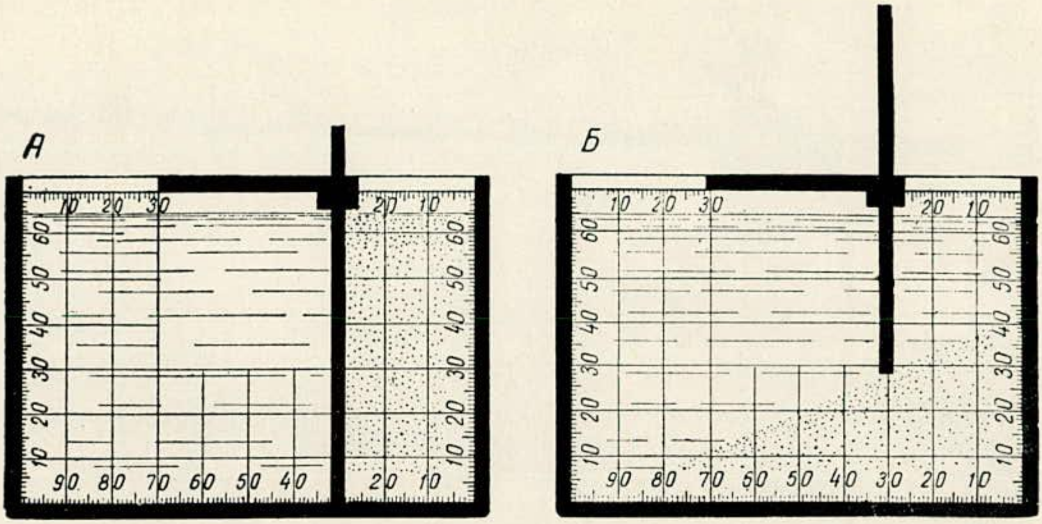

FIGURE 5
Type-9 field laboratory device for determining the angle of repose of sand.

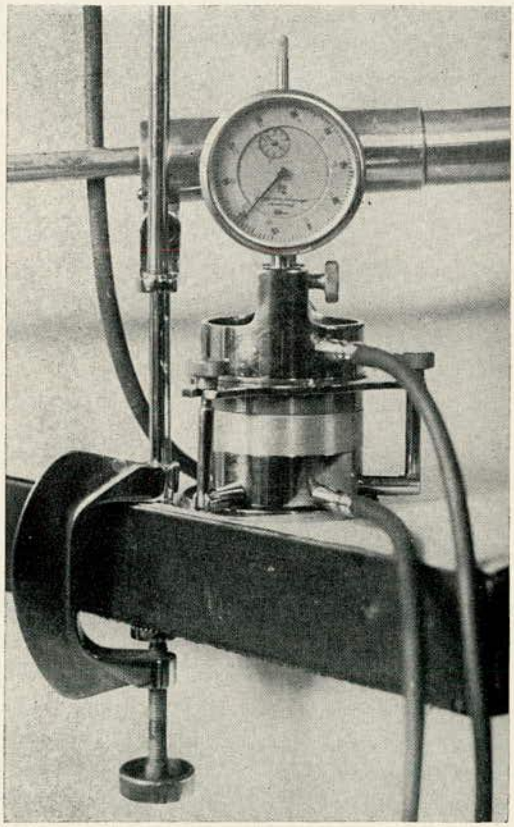

FIGURE 6
Compression device of Type-9 field laboratory in working condition.

tion; the height of the oven when folded is 7 cm. The oven allows 50 samples of soil to be dried simultaneously on the site at different circuit voltages and with automatic temperature regulation.

The high accuracy of operation is due to some constructional features of the sampling equipment (shape of sampling tube, guides, smooth operation of the lever arrangement for pressing the sampling tube into the soil, etc.). It is also due to the fact that the determination of the volume weight and the preliminary weighing for determining the natural moisture content are carried out directly on the site, avoiding a number of intermediate operations that are necessary with the usual method and which exert an undesirable effect on the change of the natural condition of the soil samples by introducing additional errors.

In comparing the degrees of accuracy and the time required with different methods of control sampling of block samples of the same undisturbed soil, it has been found that the maximum difference between such parallel (control) determinations of the volume weight varies within limits:

(a) 2 to 6 per cent for the method of large cylinders (D = 125 mm).

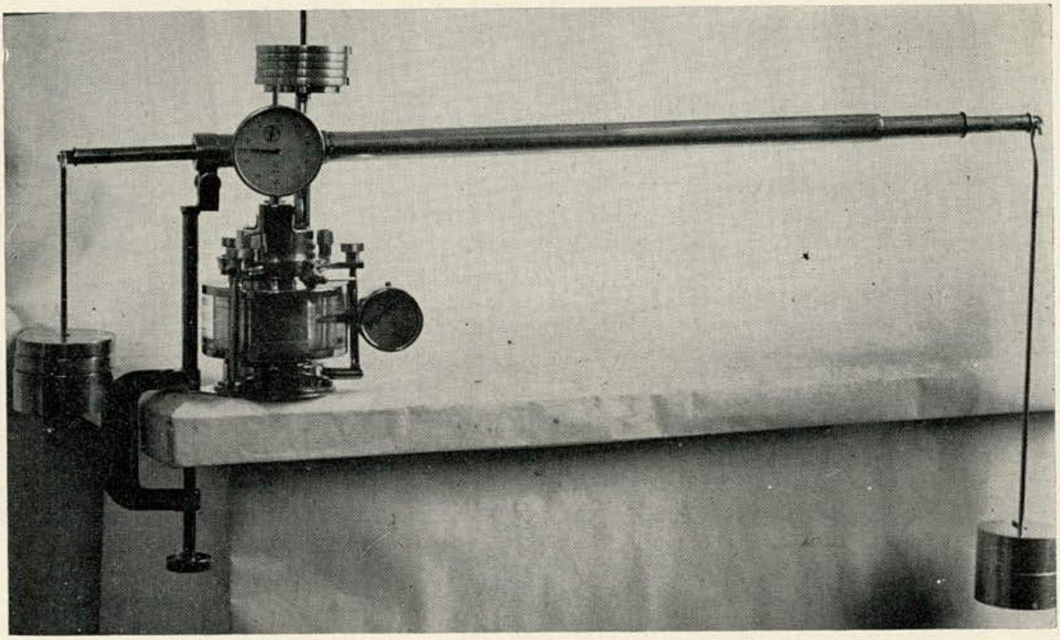

FIGURE 7
General view of device for field investigation of soils when sample is subjected to compression on all sides (Type-9 field laboratory).

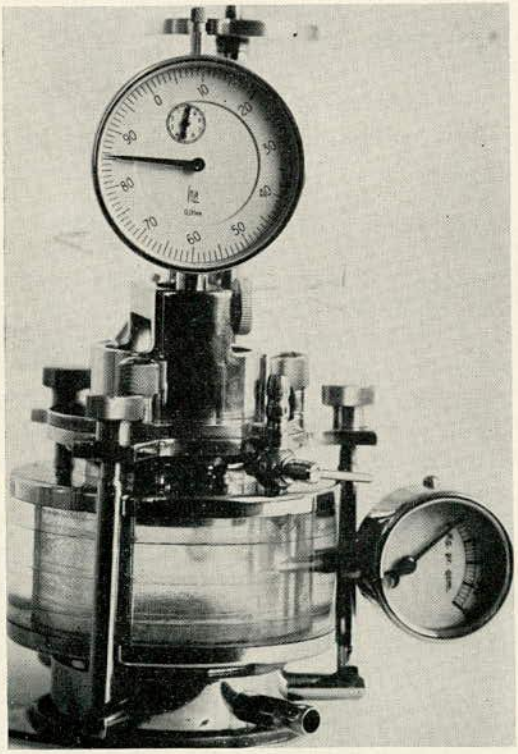

FIGURE 8
Working part of device shown in Fig. 7.

(b) 5 to 10 per cent for the mercury displacement method.

(c) 0.5 to 1 per cent in using the field laboratory equipment.

The time required for the selection and packing of soil block samples with undisturbed structure and the determination of volume weight is:

(a) 190 to 200 minutes for the method of large cylinders.

(b) 90 to 110 minutes for the mercury displacement method.

(c) 8 to 10 minutes using the field laboratory equipment.

Some data on the economical efficiency achieved by using this equipment will be given here. The cost of selection of one soil block sample by the conventional methods varies between 25.5 and 62 roubles, while using the field laboratory equipment would reduce the cost to but one rouble. Hence, if 20 block samples a day are taken, i.e., when the equipment is made use of only to 20-25 per cent of its full efficiency, the cost of soil sampling work would be reduced 500 roubles in one day, or 125,000 roubles during a year.

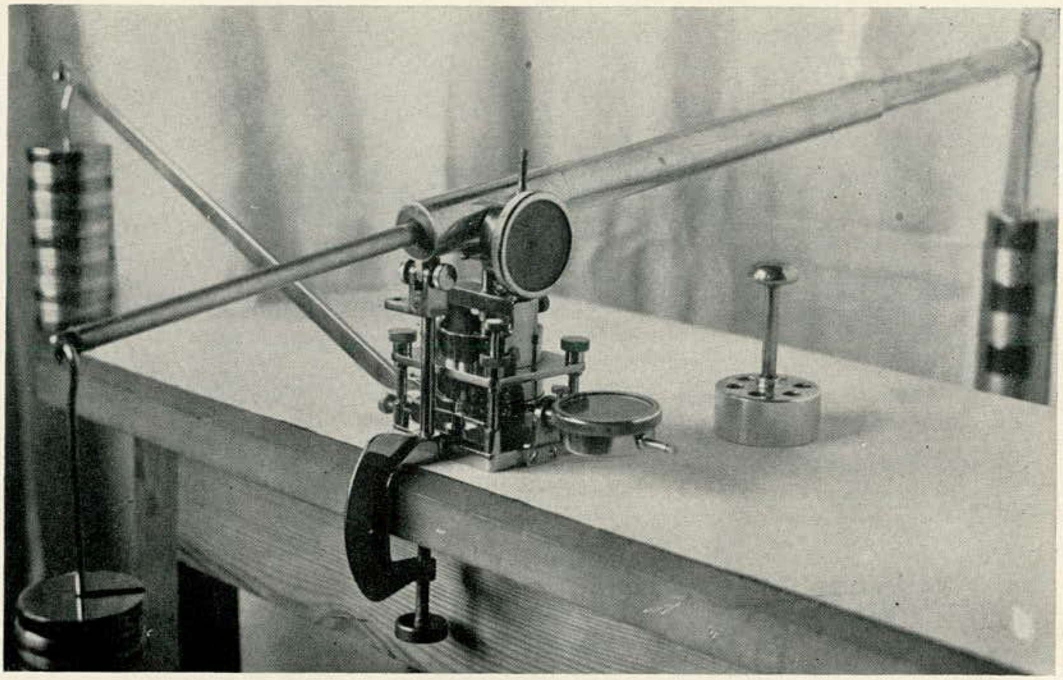

FIGURE 9
General view of device for field shear tests of soils (Type-9 field laboratory).

The determination of the basic physical properties of soil samples of undisturbed structure and natural moisture content by means of a field laboratory is actually reduced to simple operations: sampling blocks of soil and weighing them before and after drying. The other basic physical properties of the soil (volume, weight, natural moisture content, porosity, coefficients of porosity, density) are further determined by very simple mathematical computations.

The compressive properties of cohesive soils, the granulometric composition and density of loose soils, different factors characterizing the moisture content, and other characteristics are determined by means of devices specially designed for work on the site and contained in the field laboratory equipment. The work is carried out following the procedure described in a manual on the use of field laboratories.*

A special device for shear tests of soils directly on the site has been developed by the author and included in the Type-9 field laboratory as an integral part of the equipment. (See Figures 9, 10, 11.)

The device is of the single-shear type. The main feature of the device is the plane which separates the stationary part of the tube with the soil from the movable part and in which shearing of the soil sample is effected. This plane is not designed parallel to the line of motion of the movable part as in other equipment, but at a small angle α which never exceeds several degrees. The gap which automatically forms during the horizontal motion of the movable part of the device widens while the test is being carried out. In this manner it is possible to eliminate completely the sliding friction of the metal. At the same time any possibility is here avoided of wedge action by particles of sandy soil which considerably increases the accuracy of testing.

Another device has been developed to be used with the Type-9 field laboratory for accelerated control of the quality of soil compaction in different earthworks. This device, which has been thoroughly tested in laboratory work and in field investigations,

* I. M. Litvinov, Field Investigation of Soils, Second Edition, Revised, Coal Mining Publishing House (UGLETEKHISDAT), 1954.

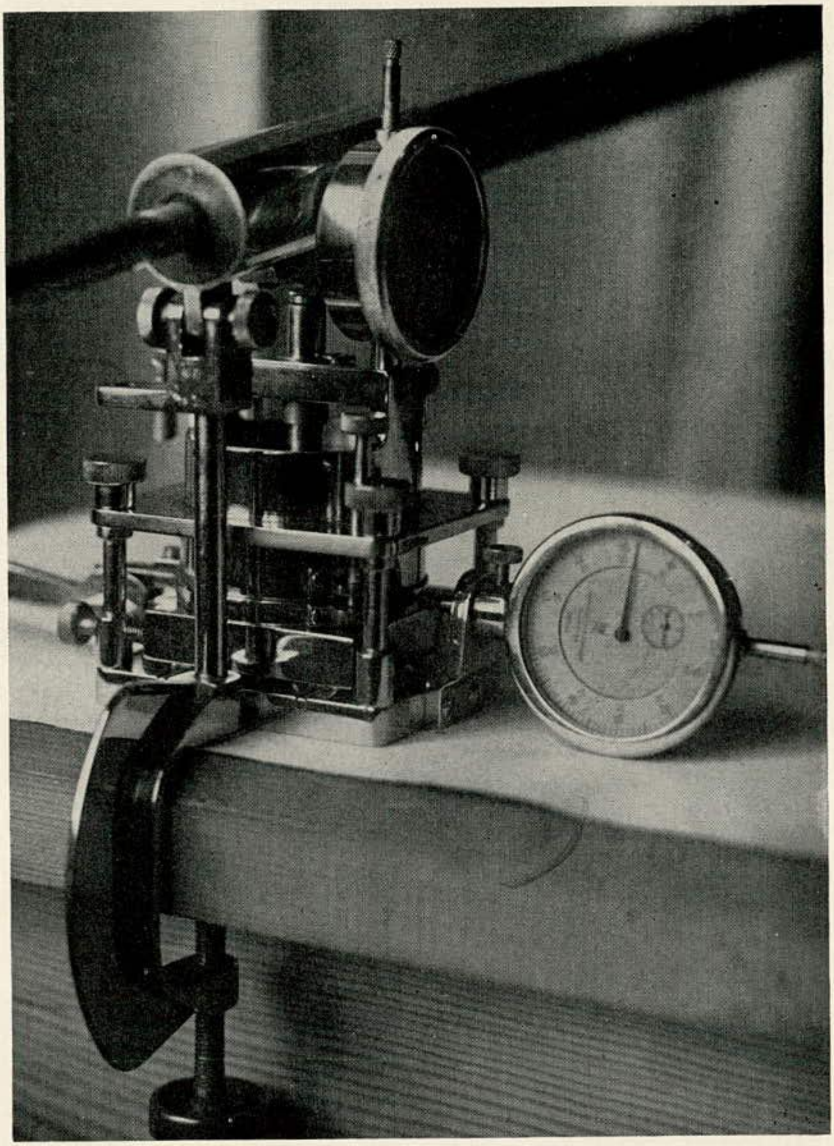

FIGURE 10
Working part of the device shown in Fig. 9.

can be used with success in hydraulic engineering, road construction, etc. The volume weight, moisture content, porosity and other physical soil characteristics can be determined quickly and with high accuracy and without preliminary drying out of the samples. In addition, the device permits the specific weight of the solid phase of soil to be determined directly in the field, with very high accuracy just as it could be done in stationary laboratories.

The operation of the device is based on the hydrostatical weighing of soil samples in water. The total weight of the device with case is 2.2 kg.

The author has also developed a set of vibrational equipment of original design for accelerated and dynamical investigations of soils, which can be used for the determination of the compressive properties, shear strength and density. The main part of the equipment is a high-frequency vibrator

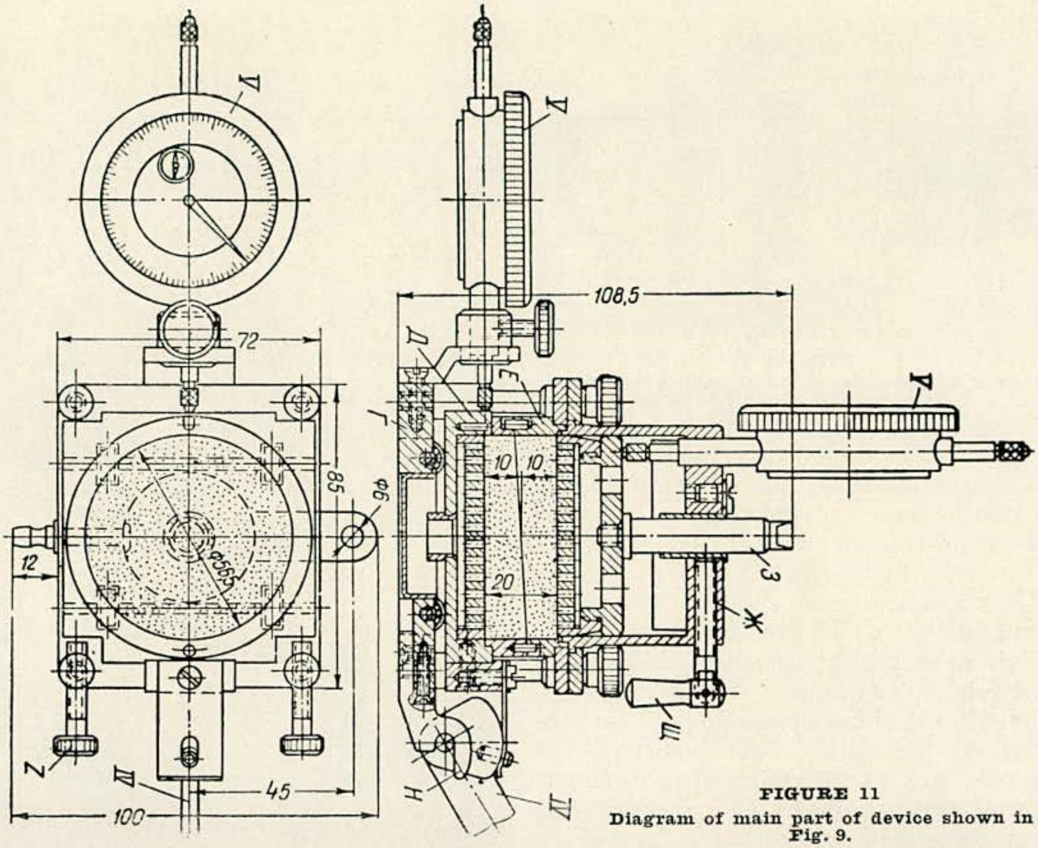

FIGURE 11
Diagram of main part of device shown in Fig. 9.

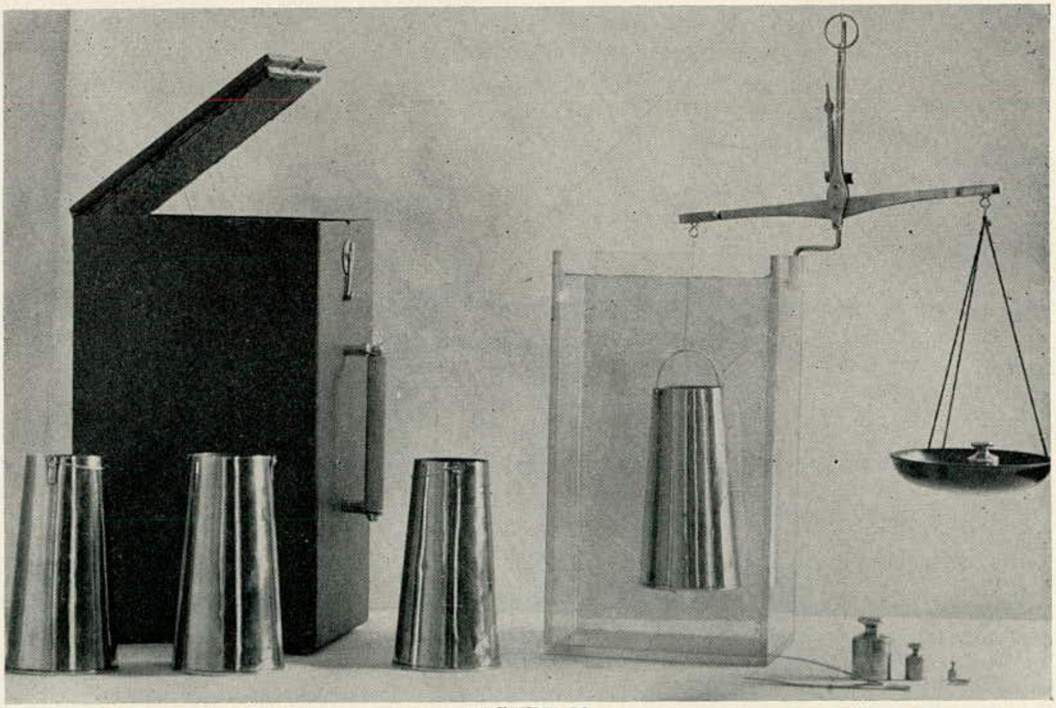

FIGURE 12
View of device for accelerated quality control of soil consolidation in earthworks.

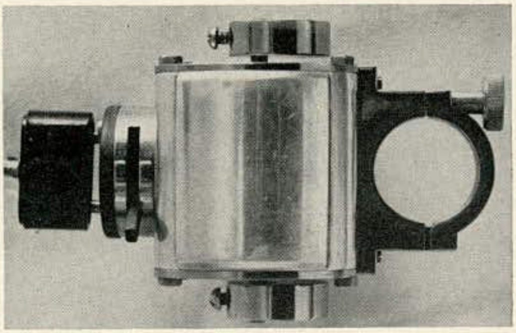

FIGURE 13
View of Type-9-B set of vibrational equipment for compression and shear test devices.

(Figs. 13, 14), mounted on the loading lever of the compression device. Through the loading lever vibrations of given direction, frequency and amplitude are induced by the vibrator in the loaded member.

The weight and size of the counterweights symmetrically mounted along the motor shaft, as well as the amplitude of vibration, are determined in such a manner that, after the settlement has been stabilized for any stage of the statical load applied to the sample, starting the vibrator and its subsequent operation during a given interval of time do not cause additional increase in the settlement. The vibrational equipment is also applicable to dynamical investigation of soils.

The field laboratories are widely used for the investigation of the building properties of soils in housing, civil engineering, industrial building, road and railway construction, hydraulic engineering, etc., in many countries. These devices are of special value in regions remote from the stationary well-equipped laboratories.

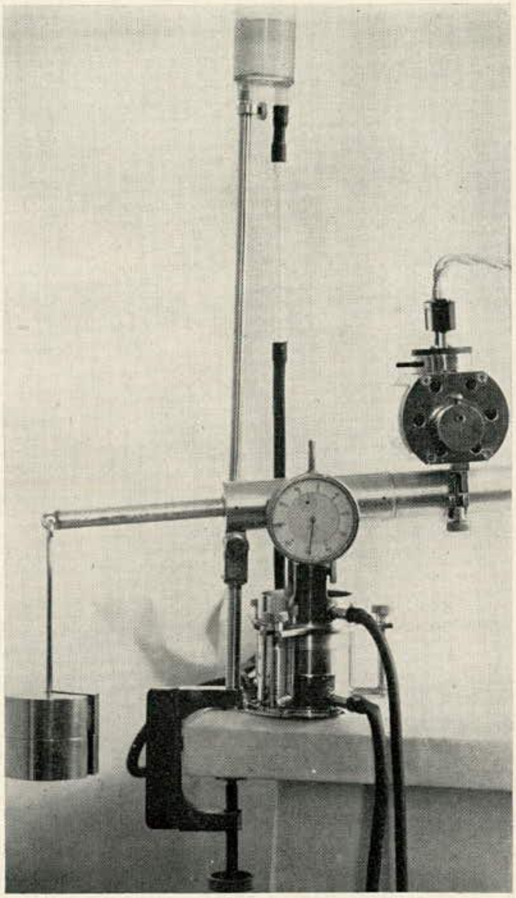

FIGURE 14
Type-9-B set of vibrational equipment during compression tests.

Use of the Vibratory Method for Sinking Piles and Pile Shells in Bridge Construction in the USSR

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The following vibratory drivers were used during the past six to eight years in the bridge building practice of the USSR for sinking piles and pile shells:

VIBRATORY DRIVER VP-1 *(Fig. 1)*

This is a mechanism of single frequency action which has the following structural parts:

1. The body of the vibratory machine consisting of a steel box with outside guide rollers and with loops at the upper corners for raising the vibrator.
2. Four working shafts connected to the body of the vibrator by bearings; eccentric weights are attached to these shafts.
3. A system of cylindrical gears which transmit the rotational movement of the electromotor to the working shafts.