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GROUNDMETER-PENETROMETER USED ON THE ALS "L U N A - 13"

by

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SUMMARY

The groundmeter-penetrometer of the automatic lunar station "LUNA-13" is described and account is given on its operation after the soft landing of the probe on the lunar surface on 24 December 1966. Evaluation is made of the precision of the analysis of the strength of lunar surface as a function of the lunar microrelief.

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The groundmeter-penetrometer, illustrated in the plate (Fig.1) was installed on the automatic lunar station "LUNA-13" with the view of estimating the solidity of lunar ground; it constitutes a mechanical device of which the description follows.

It consists first of all of a frame made of plastic material, of which the lower part forms an annular stamp with external diameter of 12.0 cm and internal diameter of 7.15 cm. The upper, cylindrical part of the body serves as a guide for a titanium indentor. The latter has a conical lower part, while its upper part is cylindrical. The cone's sharpening angle is 103°, and its maximum diameter is 35 mm. The indentor may put downward to a depth of 5 cm.

The cylindrical part of the indentor serves as the frame of a solid-fuel jet engine with nozzle directed upward. An electro-pyrotechnical device for engine starting is located directly behind the shear of the nozzle, which is ejected by pressure of powder gases upon wear and tear.

(*) GRUNTOMEP-PENETROMETR AVTOMATICHESKOY STANTSII "LUNA-13"

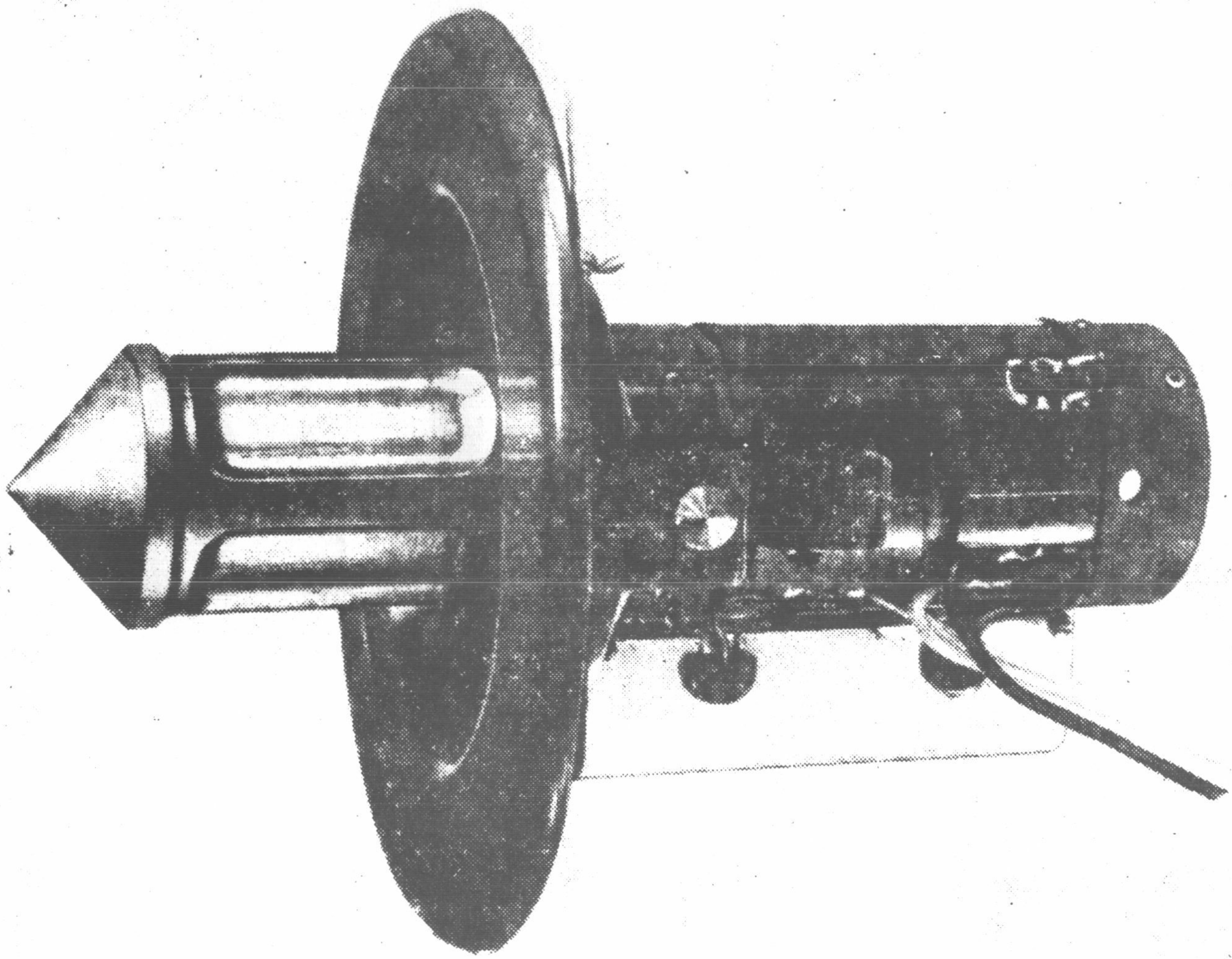

Fig.1

At the same time the top of device's frame is ejected, whereupon the wires of electrical circuits of the launcher are being cut, the spherical lock linking the indentor with the frame is freed thus giving the former the possibility to shift downward.

The duration of engine action in terrestrial conditions is of 0.6 - 1 sec. and the average pull is 5 to 7 kg.

The cylindrical part of the indentor has a protrusion shifting in a vertical slot of the frame and connected with the cursor of the potentiometer which measures the magnitude of indentor's shift relative to the frame of the device. When operating in friable dust-like soils, the indentor may sink deeper than 5 cm. At the same time it catches by its protuberance the frame of the device and pushes into the soil its annular stamp. The sinking depth of the latter may be approximately judged by the phototelevision pictures.

The estimate of mechanical properties by means of the groundmeter-penetrometer is conducted after the device has been brought to the surface of the soil with the aid of a peculiar "five-membered" bearing-out mechanism. The command for device's engine starting is given after station's lobe antennas opened up, the bearing out mechanism operated and the zero reading has been taken from the potentiometer.

After engine operation has ceased the indentor remains in the position reached at that moment of time. The alternate interrogation of the potentiometer by station's telemetry allows the determination of the penetration depth of the indentor, while subsequent interrogations refine this figure and track the indentor shifts on account of various external actions. The precision of measurements constitutes $\pm$ 0.03 cm.

The dimensions of penetrometer's cone and the operational effort of the engine were so chosen that the cone could noticeably sink in most of friable and porous solid formations that may be encountered on the surface of the Moon, except, however, very strong lavas. The sinking of the cylindrical part of the device is possible in the presence of granular soils and, finally, the annular stamp may be pressed only into the surface of weakest, loose granular soils and friable dust-like materials.

14 various materials were used for the ground calibration of the device, among which were porous basaltic and andesite-basaltic lavas, foam concrete and foam glass, quartz sand, granite gruss, kermesite gravel, "agloporitous"* sand, bulged perlite sand and others. The volumetric weight of the materials varied from 1.95 to 0.16 g/cm^3 — and the aggregate state - from hard through friable and dust-like. The calibration tests were conducted on large blocks of hard materials and in cylindrical tanks of 60 cm and diameter and depth and filled with granular and dust-like materials. The indentor pressing was realized by engine's motive power and for control by statistical loading.

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* [no equivalent word was found in any specialized and earth's science dictionaries].

As a result of calibration a table was obtained for indentor sinking depths together with the frame for each of the investigated material; it was subsequently utilized for deciphering the data obtained from the Moon.

Additionally to these experiments realized in terrestrial conditions, a series of experiments were carried out in a vacuum-chamber with discharge of 25 - 37 mm Hg; it has shown that the engine's traction pull then increases, as an average, by 8.5%; special experiments for ascertaining the influence of the gravitation acceleration on the depth of indentor pressing into granular soils.

Such experiments were conducted in the cabin of an aircraft flying along a trajectory over which an acceleration was maintained equal to lunar gravitational acceleration, i. e. 1.66 m/sec^2. The indentor was pressed into two different granular soils with the aid of a spiral spring, the penetration depth being registered by a mechanical recorder. The comparison of the penetration depth under these conditions with that obtained by the same method on Earth allowed us to establish that the decrease of the gravitation acceleration by 6 times vs that on Earth, led, as an average, to indentor sinking increase by 70 percent.

The groundmeter-penetrometer was applied for the study of lunar surface soils on 24 December 1966 at 2106 hours Moscow time, after soft-landing of ALS LUNA-13. The initial penetration depth was found to be 4.5 cm. Subsequently it varied from 4.17 to 4.33 mm, apparently as a consequence of temperature deformations of the extension mechanism and of station's frame.

When extending the indentor by 4.5 cm, that is, less than 5 cm, its protuberance could not carry along the device's frame and, consequently, the annular stamp did not sink into the soil under the action of the traction force of the indentor.

Taking into account the increase of traction force in vacuum and the increase of sinking at lunar gravitation acceleration, the penetration depth of the indentor into the same soil in terrestrial conditions must constitute about 2.6 cm. In accord with the calibration tests this could have taken place in two cases: at device's operation in a quick quartz sand with volumetric weight no higher than 1.52 g/cm^3 or in a light granular material — of the porous clay filler type or "agloporitous"sand with volumetric weight of about 0.77 g/cm^3, chara cterized by feeble cohesions between grains. Inasmuch as the presence in the uppermost layer of the lunar surface of materials with volumetric weight greater than 1.5 g/cm^3 is considered little probable, one should apparently recognize as more reliable the existence of a layer of weakly-coherent light granular material, of which the thickness under groundmeter-penetrometer would constitute no less than 5 cm.

The above data refer to the case of device's operation on a smooth surface. Inasmuch as nuermous stones and craterlets are encountered on the Moon's surface, a distortion of the results of measurements on account pf device's bending and formation of gaps under it is possible. Analysis of this question, utilizing the data on lunar microrelief presented in the work [1], has shown that the probability of an unsuccessful from the standpoint of precision experiment of the surface relief surveyed LUNA-9 constitutes about nearly 30%. In the place of landing of LUNA-13 the surface was somewhat smoother, so that the probability of having obtained more reliable results is in this case higher.

***** T H E E N D *****

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REFERENCE

[1]. PERVYYE PANORAMY LUNNOY POVERKHNOSTI, Izd-vo "NAUKA", 1966. (FIRST PANORAMAS OF THE LUNAR SURFACE). (ST—LPS—10503/sp)

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