of an increase and a decrease in q. As an example of this consider Fig. 11 ($\alpha = 37°$), from which, according to Eq. (1), it follows that $q = 1.33$. The graphs relating to the continents, in which $(\epsilon)_{max} = \alpha$, are in fairly good agreement with Lambert's law with respect to curvature also.

It would be incorrect, however, to extend this conclusion to observations of Mars during periods (e.g., September 1956), when the atmosphere of the planet is a poor transmitter even of red and infrared rays, since this may affect the steepness of the curves of brightness distribution over the disk. Moreover, photometrically homogeneous regions of the continents and seas of Mars are not always located on its visible disk along the intensity equator. The images best suited for studying the law of reflection of light from the continents of the planet are those we obtained in 1954.† Here $\phi_{♂}^{c} < 15°$‡ and the equatorial regions of the continents lie on the intensity equator. Owing to this the 1954 observations can be used to obtain a very accurate red-light brightness distribution along the intensity equator on the continents of Mars.

The corresponding curves, obtained as a result of photometric measurements of images of Mars made with MF-2 and MF-4 photometers, are given in Fig. 16 for phase angles $\alpha = 5, 21, 39$, and 40°.

† If we consider only observations made in 1954 and 1956.
‡ $\phi_{♂}^{c}$ is the latitude of the visible center of Mars.

Observations made in 1956 (in the absence of turbidity in the Martian atmosphere) are more suitable for studying the seas of Mars, since during the observation period $\phi_{♂}^{c} \approx 20°$ and a continuous region of sea could be observed fairly frequently at the intensity equator.

For the seas of Mars $(\epsilon)_{max}$ is systematically greater than α. According to the data of Fig. 12, Eq. (1) gives $q = 0.60$.

All the foregoing data confirm our earlier conclusion with respect to the roughness of the continents and seas of Mars, and we now have a firmer basis for our opinion that the distribution of brightness on the continents and seas of the planet is not the same.

References

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Reviewer's Comments

The abstract itself is fairly clear in expressing the intent of the paper. There may be some portions of the paper which have been translated too literally. The word "smoothness" in the title is somewhat vague in connection with the substance of this paper. Presumably, Dr. Koval′ had in mind the texture of the material (rock or soil, or dust, and vegetation cover) on the solid surface. Also, the concept of seas of water has long been abandoned; the Latin "maria" should have been used, just as we refer to the maria on the moon—simply the dark regions.

The term "intensity equator" will probably confuse many readers. The intensity equator is defined by the great circle arc passing through the sub-earth and sub-solar points with the longitude measured from the sub-earth point. It may even run at right angles to the Martian geographic equator, as it would at times close to opposition time. In Sec. 1, Koval′ assumes that "the atmosphere of Mars on the measurements in red and infrared light can evidently be neglected, we must conclude . . . . " We are not sure that it can be completely ignored because of instances of thin, low-level haze (possibly composed of very fine dust particles in suspension) which appears to settle out in a few days. We observed some instances of this in 1954, but it was of course nothing like the severity of the great obscuration of 1956, which Koval′ states would unreliably affect his red and infrared observations. Anyway, in order to minimize the effects of the Martian atmosphere, the near infrared is the best obtainable within the spectral range of photography.

Limb haze is nearly always present in the visual region, and it is highly variable from night to night, indeed from hour to hour, in intensity, width, and geographic position. Color changes in the maria further complicate the situation. We observed the color of Sabaeus Sinus and Meridiani Sinus change from blue-green as of June 11 to reddish-purple by June 20, 1954. How seriously such color changes in the visual range would affect the infrared contrast values between maria and "continent," we do not know.

Dr. Koval has made some very interesting and significant observations of Mars. We have studied other articles of his in past issues of Astronomicheskii Zhurnal with much interest He ends his paper without venturing interpretation of the results of these observations. We would like to express a probable interpretation. Dr. Koval′'s findings indicate that the maria of Mars are different from the "continents" or deserts, since the maria do not appear to follow Lambert's Law. This may be interpreted as due to either a different kind of rock (such as rough lava flows) or to some kind of vegetation. Perhaps the first possibility (lava flow material) can be eliminated by the following argument.

Since the shapes of the maria on Mars are quite angular, unlike the circular maria on the moon, this indicates to the reviewer an entirely different origin for the Martian maria. We have observed many canals to be continuations of the "coast lines" of the maria on to the "continents" or deserts, and lead to the small circular dark "oases," from which the canals originate. The maria appear to be graben blocks of the Martian crust, that is, they may represent sections of the crust that sank between deep fractures (faulting). Since the deserts are light colored and appear to consist of rhyolite, or felsite, they probably represent the original sialic crust of lighter rocks like that on the Earth's continents. This type of rock, being less dense than the denser ferro-magnesian rocks, would be expected to rise to the uppermost levels in the crust of any terrestrial type of planet. Since there are no vestiges of a water erosional pattern on Mars, by which sediments could be deposited on the lower levels, namely, the maria, then the maria very likely consist of the same light colored and less dense rock of the desert areas. Mars was never subjected to the strong tidal deformation suffered by the Earth and Moon, because its two satellites are tiny and Mars is farther from the Sun. This very important factor seems to have been overlooked in comparing the features of Mars to those of the Moon and Earth.

It is apparent then that the areas occupied by the Martian maria have been covered with some different substance, such as vegetation and the remains of vegetation. Another one of Koval′'s findings is very interesting. His observations indicate greater atmospheric clarity over the maria, despite their deeper level in the Martian atmosphere. This suggests that vegetative cover is capable of reducing the amount of dust haze that the winds can pick up. Koval's results then lend support to the idea of vegetation on Mars, as is indicated by Sinton's spectrographic studies at the Lowell Observatory. The character of the seasonal and secular changes in the maria also support the interpretation of vegetation.

In conclusion:

1) The paper does reveal a considerable amount of Russian work.

2) Dr. Koval's paper is in need of some further elucidation for a mixed audience of American readers; especially a fuller explanation of the parameters of some of the graphs is needed. But even without it, the paper is worthy of acceptance.

3) This Russian paper certainly meets the requirement for originality.

4) Contrast measurements between maria and deserts have been made by others, but the author's method of analysis is clever and useful.

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Linear Theory of Three-Layered Shells with a Stiff Core

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THE object of this paper is a study of the general equilibrium equations of a three-layer shell with a stiff core in an orthogonal system of curvilinear coordinates. In the course of the analysis, the oscillations of an infinitely long three-layered cylindrical shell are considered also.

In deriving the equations the following assumptions are made. The faces and the core are made of different orthotropic materials, the orthotropic axes being mutually parallel. All the layers are of constant thickness. The core is incompressible in the transverse direction, and therefore the deflections of the middle surfaces of the faces will be the same. Displacements in the middle surfaces of the layers of the shell will be different for each of the layers. The usual Kirchhoff-Love hypotheses are assumed to hold for the faces, whereas for the core we shall establish a linear displacement law with respect to thickness. The expressions employed for the angles of inclination of the normal to the middle surface are more refined than in the theory of shallow shells.[1] It is assumed that the deformations always remain elastic.

First, we shall derive equilibrium equations for a shell of arbitrary shape acted upon by an arbitrary load and arbitrarily heated with respect to the thickness and over its surface. It is further assumed that the core is stiff, that is, capable of withstanding not only transverse shear but also loads parallel to its middle surface. A variational expression is given for the potential energy of the shell. This yields a system of equilibrium equations and the boundary conditions. As an example, equilibrium equations in terms of displacements are presented for a cylindrical shell.

Finally, equations are derived for the free oscillations of an infinitely long cylindrical shell, the core of which will withstand only transverse shear. An equation for determining the natural frequencies of the shell is derived also.

General Equations of the Problem

1. Displacements and Strains

As our surface of reference, we shall take the middle surface of the core. We shall assume that after deformation a rectilinear element of the core, normal to the thickness, is not distorted but remains straight. Then (see Fig. 1) the displacements in a surface equidistant from the middle surface will have the following form:

In the upper face ($c/2 \leqq z \leqq c/2 + t$):

$$u = u_1 + \left(z - \frac{c+t}{2}\right)\psi_1$$
$$v = v_1 + \left(z - \frac{c+t}{1}\right)\psi_2 \tag{1.1}$$

In the lower face [$-(c/2) - t \leqq z \leqq -(c/2)$]:

$$u = u_2 + \left(z + \frac{c+t}{2}\right)\psi_1$$
$$v = v_2 + \left(z + \frac{c+t}{2}\right)\psi_2 \tag{1.2}$$

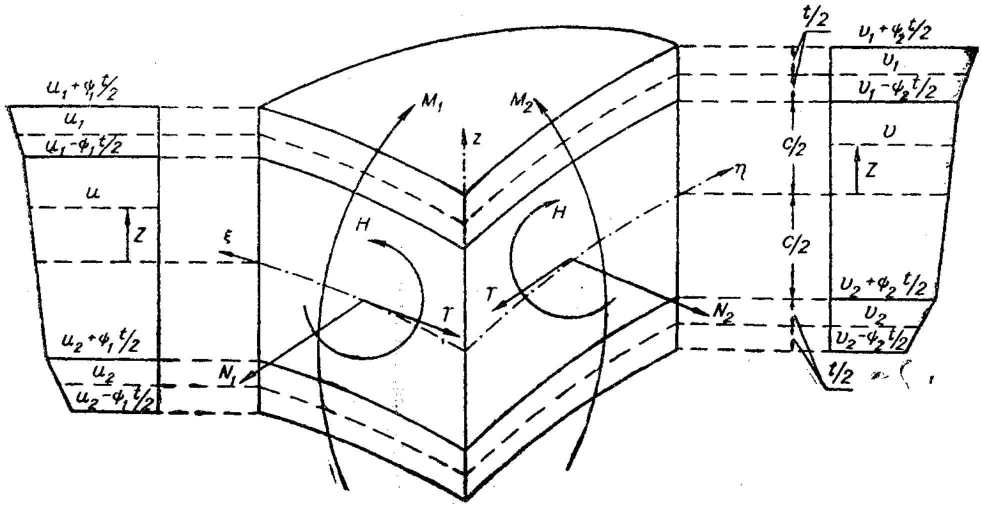

Fig. 1

Translated from Izvestiia Sibirskogo Otdeleniia Akademii Nauk SSSR (Bulletin of the Academy of Sciences of the USSR, Siberian Branch), No. 3, 12–24 (1962). Translated by Faraday Translations, New York.