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AD NUMBER
AD285343
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19 September 1962

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ITEM OF INTEREST

Prepared by

Aerospace Information Division



CATALOGED BY ASTIA
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SUBJECT: Lunar Temperature Measurements

SOURCE : Chistyakov, Yu. N. Attempt at determining the temperature of separate sectors of the lunar surface. IN: Akademiya nauk SSSR. Komissiya po fizike planet. Izvestiya, no. 2, 1960, 46-54.

Measurements were made in March 1959 of the temperature of separate sectors (1.5' x 1.5') of the lunar surface, using a modified version of the method proposed by Menzel (reference given). A vacuum thermoelement with a sensitivity of 10 v/wt, set in the Newton focus of the 13" reflector of the Abastumani Observatory, was employed for measurements. The thermocurrent was recorded on the M-21/5 galvanometer having a sensitivity of $3 \cdot 10^{-8}$ $\frac{\text{a}\cdot\text{m}}{\text{mm}}$.

The amount of water vapor determining the absorption of planetary heat in the atmosphere was computed with Hann's empirical formula, which relates the amount of water vapor in a column of the atmosphere over 1 cm² of the earth's surface (so-called precipitated water) to the absolute humidity at the surface. It has the form

$$d = 1.7 e_w, \quad (1)$$

where d is the precipitated water (in cm), and e_w is the absolute humidity (in cm). A mean value of $d = 0.5$ cm was obtained.

The temperature T of a lunar spot i is determined by the formula

$$T_1(\alpha) = \frac{T_0}{R^{1/2}} \sqrt{\frac{\text{rad}}{A} \frac{1}{I_{\text{ref}}(\alpha)}} \times \sqrt{\frac{J_1^{\Sigma}(\alpha) - \frac{J_1^{\text{f}}(\alpha)}{\rho} \frac{k(0)}{k(t)}}{\rho_1(\alpha)}}, \quad (2)$$

where α is the phase angle; T_0 is the temperature of an absolutely black body radiating energy equal to the solar constant; R is the distance to the sun; \bar{A}^{rad} is the radiometric albedo value; η is the grayness factor; $I_{(0)}^{\text{ref}}$ is the deviation caused by the total flux without instrument and atmospheric absorption; $J_1^{\text{E}}(\alpha)$ is the deviation of the galvanometer in observations without filter, i.e., the deviation caused by the total flux; $J_1^{\text{F}}(\alpha)$ is the deviation in observation with a filter, i.e., the deviation caused by the reflected flux partially weakened by the filter; $k(t)$ is the factor accounting for change in the sensitivity of the equipment in time; $k(0)$ is the initial sensitivity factor; $\rho_1(\alpha)$ is the transmittance of thermal radiation by the instrument and by the atmosphere. With α at $+17.0^\circ$, the value $\bar{A}^{\text{rad}} = 0.128$; the deviation values $J_1^{\text{E}}(\alpha)$ and $J_1^{\text{F}}(\alpha)$ are determined directly from observations; and $\frac{k(0)}{k(t)} \approx 1$, since the drop in sensitivity of the thermoelement during the 7-day observation period is negligible.

After substituting numerical values, the formula for a temperature takes the form

$$T_1(\alpha) = 88^\circ \sqrt[4]{\frac{J_1^{\text{E}}(\alpha) - \frac{J_1^{\text{ref}}(\alpha)}{p_f}}{\rho_1 \text{atm} + \text{flu}(\alpha)}}, \quad (3)$$

where $\rho_1 \text{atm} + \text{flu}(\alpha)$ is the combined transmittance of thermal radiation by the atmosphere and by the fluorite window of the thermoelement; p_f is the transmittance of reflected radiation by the filter; "ref" stands for "reflected."

Computational results show that the temperature of the subsolar point for a phase angle α of $+17.2^\circ$ is 375° , which coincides with the value arrived at theoretically by Pettit for the full moon. The temperature of seas is about 10° higher than that of the adjacent continents. The ratio of the radicands of formula (3) gives:

$$\frac{J_{\text{con}} - \frac{J_{\text{con}}^{\text{ref}}}{p_f}}{J_{\text{sea}} - \frac{J_{\text{sea}}^{\text{ref}}}{p_f}} \cdot \frac{\rho_{\text{sea}}}{\rho_{\text{con}}} = \frac{E_{\text{con}}^{\text{ir}}}{E_{\text{sea}}^{\text{ir}}} = \frac{J_{\text{con}}^{\text{ir}} \cdot \rho_{\text{sea}}}{J_{\text{sea}}^{\text{ir}} \cdot \rho_{\text{con}}} \quad (4)$$

Here E^{ir} denotes thermal energy (infrared).

Inasmuch as atmospheric conditions do not change substantially during the measurement of two adjacent points, it may be

assumed that $\rho_{con} = \rho_{sea}$, in which case

$$\frac{J_{con}^{ir}}{J_{sea}^{ir}} = \frac{E_{con}^{ir}}{E_{sea}^{ir}} \quad (5)$$

For each pair of computational points $\frac{E_{con}^{ir}}{E_{sea}^{ir}} = 0.93 \pm 0.02$. This

value supports the validity of the equality showing the relationship between the radiometric and visual albedos of points and mean A_0 values, viz.:

$$A^{rad} = \frac{A^{vis}}{A_0^{vis}} A_0^{rad} \quad (6)$$

The ratio of the visual and radiometric albedos of separate points is the same as the ratio of mean albedos over the disk.

The authors believe that their method of measurement and the equipment employed are sufficiently reliable for determining the temperature of selected areas of the lunar surface.