

Surveyor's Shots Provide Clincher

1966

Photos Prove Moon Walks To Be Safe, UW Man Says

By WILLIAM WITT
(State Journal Staff Writer)

Photographs from Surveyor 1 coupled with other information from Earth definitely show that man can travel on the surface of the Moon, Prof. Heinz H. Lettau, University of Wisconsin meteorologist, said Thursday.

The latest photographs are interpreted as further proof that the surface does not exhibit a substantial dust layer which might endanger a manned landing, he said.

And Luna 9 in February established the fact that the surface had the necessary bearing strength to support a spacecraft.

Man Can Walk on Moon

Lettau said that the weight distributed on each of the feet of Surveyor was roughly comparable to that of a man in a space suit.

"I will flatly say that man can travel on the surface of the moon, and that a man walking on the surface will be in no danger of sinking in below an extremely thin crust," he said.

He described the crust as no more than an inch thick, and said that it might be something like walking on a snow layer that crunched underfoot.

Beneath this crust is porous material and solid volcanic rock after only a few inches, he said.

Mathematical Analysis

Lettau based his observations, after viewing initial surveyor photographs, on a mathematical analysis which he made of radiation measurements of the lunar surface.

The data consisted of microwave and infrared "soundings" of the Moon coinciding with varying depths.

Lettau's analysis provided a description of the surface which is borne out remarkably well by observations of Luna 9 and Surveyor.

He is one of many scientists working along similar lines in attempting to interpret this type of radiation data, he stressed.

His analysis is in contrast to



HEINZ H. LETTAU

estimates by other authorities, who have described a surface ranging from the consistency of lava to one hidden under 15 feet of dust.

He said that the great differences in descriptions came about mainly because some experts restricted their discussions severely by basing conclusions solely on visual impressions from photographs.

Referring to his own studies, he said, "Some significant information on the physical structure of the lunar surface can be derived from measurements of thermal radiation at various wavelengths."

Information from future satellites and lunar probes must be coupled with the impressive amount of information available from telescopic and other equipment on Earth he said.

Surveyor's Photos Better

Comparing Surveyor and Luna 9 photographs, he said that Surveyor's are in a much more favorable situation because the horizon was limited for Luna 9 since it had landed in a crater.

"Our pictures are much better than the Russians because their first pictures were distorted."

He said that the sophistication of the two systems could be com-

pared by noting that the Surveyor camera could be positioned and focused and that the Luna 9 camera was fixed.

The changing length of shadows from rocks and irregularities on the surface as they are photographed over 12 days' time also will provide invaluable information on height determination and other factors, he noted.

How long will it take to analyze the photographs and other data? It depends on the purpose of the analyses, he said. The photographs will be used over and over again by scientists studying difference aspects.

But the basic interest is in the mechanical strength of the surface, he said. This will provide answers to questions on future lunar craft, such as how wide the track of a mobile vehicle should be for maximum efficiency and safety.

When queried, he said he had reservations about the scientific necessity for a manned Moon shot.

"What can man do that a perfected robot couldn't?" he asked.

But he said he still thought "the tremendous human experience and drama" of landing a man was worth the effort.

Wisconsin State Journal

(1966 Interview)

OVER!

Old Moon Theories Have Been Blasted

By JOSEPH L. MYLER

WASHINGTON (UPI)—The dire forecasts turned out to be wrong. But before the Apollo 11 astronauts landed and walked on the moon, nobody could say certainly that none would prove to be right.

According to the horror stories, the moon—the strange inconstant, fickle, untrustworthy, deceptive, tricky (and other adjectives meaning the same things) moon—was capable of inflicting all manner of reprisals against any earthlings arrogant enough to violate its mystery.

Space engineers were, of course, familiar with the demonstrable perils of space flight. These involved the rockets which—if the astronauts were to come safely home—had to burn precisely as ordered, the cabin and spacesuit life support systems which had to work, the communications that must not fail, the parachutes that had to open on time.

But there also were the unknown or only vaguely surmised perils of physical contact with treacherous Luna.

Scientists of considerable consequence had predicted, for the best of reasons, that human

beings seeking to rend the moon's veil would die either in flame or dust.

The dusty death theories were largely destroyed by the Surveyors. The wonderful unmanned creatures landed softly on the moon, photographed its surface, and sent back word that there was no danger that a manned spacecraft would sink out of sight in moon dust.

But that did not remove the possibility that Luna had another kind of dust menace in her repertoire of dooms. Suppose moon dust over the eons had acquired an electrical charge opposite to that of Earth's. An Earthman, in that case, would be greeted on arrival by a fountain of leaping dust grains which—since electrical opposites attract—would quickly smother him.

The Surveyors also appeared to rule out that disaster. Only a part of their vitals was coated by dust, according to the pictures. Only a part.

So was it not possible that some dust might do some damage, perhaps settling on the astronauts' visors and blinding them in their attempts to get back to the safety of their landing craft?

And would the landing craft

itself be safe from moon dust? This dust, never having known contact with Oxygen, might well explode into flame inside the LEM when for the first time it encountered the reactive gas so common and so necessary to life on Earth.

Might not a meteorite puncture a space suit? Might not a solar flare fatally irradiate the space men?

Such horrors seemed possible before the fact. But they didn't happen. Nor did the horrors about the astronauts' ability to walk, think, and function on the low gravity moon.

The astronauts said moon walking was "easy", even "fun".

Learned men had forecast that human beings in the exotic moon environment would lose their ability to judge distances and would become victim to fantastical optical illusions which might do them in. This didn't happen either.

The more likely perils—the chance of landing in a crater, the chance of rocket or communications or parachute failures—remained. This made the Apollo 11 voyage one of the most daring in history, even if the horror stories did turn out to be fiction.

SATURDAY, JULY 26, 1969

Moon Walk Verifies UW Man's Prediction

In 1966, Prof. Heinz H. Lettau, University of Wisconsin meteorologist, predicted from instrumental calculating and photographs that man could safely travel on the surface of the Moon.

He said that the Moon's crust was no more than an inch thick, and that walking on it would be like walking on a snow layer that crunched underfoot.

Beneath, he said three years ago, was solid volcanic rock.

THE APOLLO 11 Moon walk proved him correct.

"I was pleased as punch," Prof. Lettau said Friday, "when I saw Armstrong hitting pretty hard on his boot to get it in."

Lettau is waiting, however, for a more detailed study of the Moon-collected material for final proof of his theories.

But the information was correct "from the evidence that you and I saw on the television," the professor said.

"Fantastic," he said of the Moon trip, "it was really a fantastic achievement of modern technology."

"IT WAS NOT a scientific necessity," he said, re-affirming his 1966 statement, "but it was a necessity of human endeavor."

Lettau had made his observations of the Moon on a mathematical analysis which he made of radiation measurements of the lunar surface.

The data consisted of micro-wave and infrared "soundings"



PROF. HEINZ LETTAU

of the Moon coinciding with various depths.

Lettau's observations were verified by data collected from Luna 9 and Surveyor satellites.

IN 1966, Lettau asked, "What can man do that a perfected robot couldn't?"

Friday, he summarized his feelings about the Moon landing in one repeated word: "Fantastic!"

Climatology of Planet Without Atmosphere (Lunar Type, $F = \epsilon \sigma T_o^4 + S_o$)

1. Insolation $SW \downarrow / I_o = \sin \varphi \sin \delta + \cos \varphi \cos \delta \cos nt$, for positive values only.
Albedo(a) can be constant, or a prescribed function solar zenith angle (or t).
Forcing Function $(1-a)SW \downarrow = \bar{F} = F + \sum \Delta_i F \cos int$, by Fourier expansion.

2. Model assumptions for calculating Response Functions:

2.1 Submedium: Assume $\bar{S}_o = 0$ for longest period (or smallest n) considered.

Tentatively, assume homogeneous conduction so that $\psi_i = \nu \sqrt{n_i}$, $\chi_i = \text{const} = 45 \text{ Deg}$

2.2 $LW \uparrow$: Consider empirical value of emissivity ϵ . If submedium has a small ν -value, linearization may be permissible only to obtain a first-order approximation; an iteration method can be used to obtain higher-order approximations, according to the following scheme:

Approximation	Initial Relations	Generated Relations
First-Order	$T_o^I = \sqrt[4]{F/\epsilon \sigma}$ $\Gamma_i^I = \Gamma^I = 4 F / T_o^I$ $\xi_i^I = \text{arc tan } 0.71 \psi_i / (\Gamma^I + 0.71 \psi_i)$ $Z_i^I = \Gamma^I \cos \xi_i^I + \psi_i \cos(45 - \xi_i^I)$	$T_o^I = \bar{T}_o^I + \sum (\Delta_i F / Z_i^I) \cos(int - \xi_i)$ $S_o^I = \sum (\psi_i \Delta_i F / Z_i^I) \cos(int + 45 - \xi_i)$
Second-Order	$T_o^{II} = \sqrt[4]{(F - S_o^I) / \epsilon \sigma} = T_o^{II}(t)$ $T_o^{II} = \bar{T}_o^{II} + \sum \Delta_i T_o^{II} \cos(int - \xi_i^{II})$ $Z_i^{II} = \Delta_i F / \Delta_i T_o^{II}$	(to be expanded in Fourier-series) $S_o^{II} = \sum (\psi_i \Delta_i F / Z_i^{II}) \cos(int + 45 - \xi_i)$

Third-Order, and higher orders . . . to be continued until S_o^{xx+1} generated agrees with S_o^{xx} used to generate it.

4. Application: Lunar Climatology

4.1 For brevity, consider lunar equator, and zero-value of sun's declination.

Astronomical observations suggest that the moon's albedo depends on solar elevation angle so that $a = 0.073(\cos nt)^{3/2}$. Basic lunation cycle $n = 246 \cdot 10^{-8} \text{ sec}^{-1}$. Solar constant = 1.94 ly/min = 32.3 mly/sec. Employing 8 equally-spaced ordinate values, Fourier expansion yields

$$F = 9.20 + 15.15 \cos nt + 7.40 \cos 2nt - 0.15 \cos 3nt - 1.60 \cos 4nt \text{ (mly/sec)}$$

4.2 Response: Assume $\epsilon = 1.0$. For ν take 1.6 (as for very porous matter), than 14 (as for dry sand), than 45 (as for solid basalt), all in mly/deg per $\sqrt{\text{sec}}$.

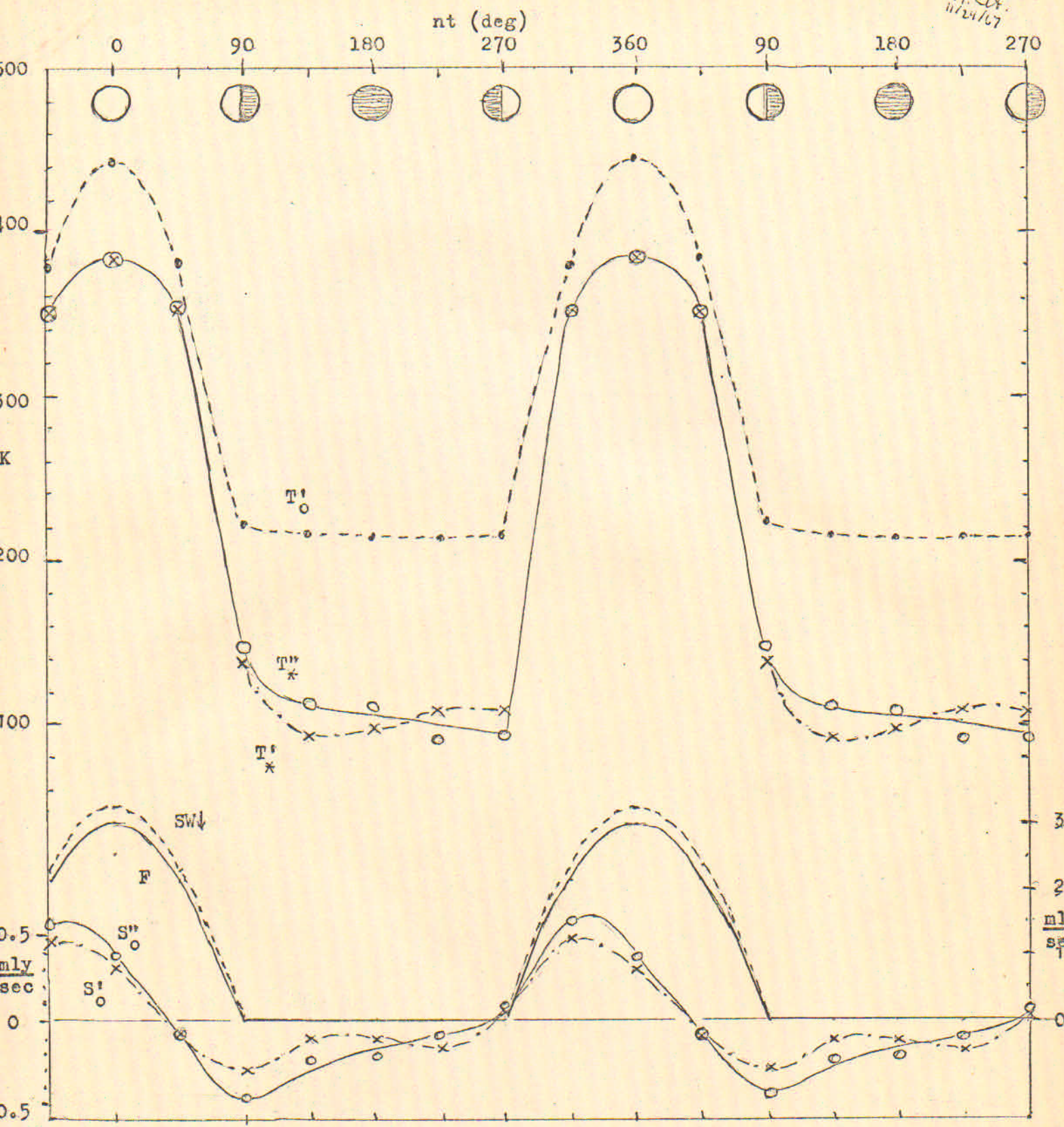
4.3 Summary of parameters and amplitudes calculated for $i = 1$ to 4, $\nu = 1.6$ only

i	F	ψ	Γ_i^I	Z_i^I	ξ_i^I	T_o^I	S_o^I	T_o^{II}	Z_i^{II}	S_o^{II}
1	15.15	0.0026	0.1286	0.1305	0.8	116	0.30	160	0.0965	0.41
2	7.40	0.0035	0.1286	0.1311	1.1	56	0.20	59	0.1280	0.20
3	-0.15	0.0044	0.1286	0.1318	1.3	-1	-0.01	-21	0.0104	0.00
4	-1.60	0.0050	0.1286	0.1322	1.5	-12	-0.06	-24	0.0704	-0.11

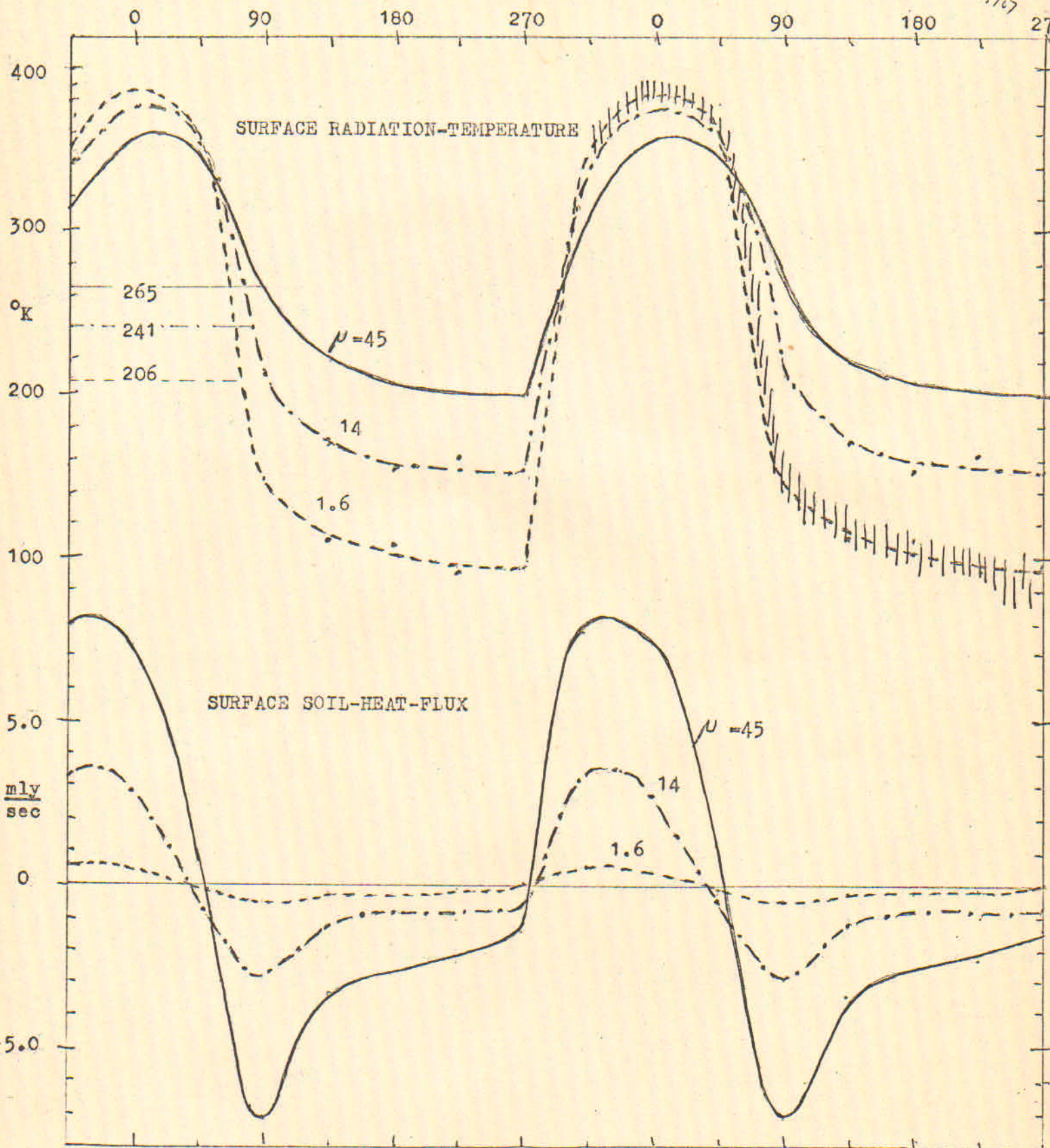
4.4 Fourier Synthesis of Response Functions - Iteration for $\nu = 1.6$ only.

nt (Deg)	0	45	90	135	180	225	270	315	Ave
F(mly/sec)	30.0	21.6	0.2	0	0	0	0.2	21.6	9.2
$\nu = 1.6$ T_o^I (°K)	445	353	221	217	215	213	215	379	256
S_o^I (mly/sec)	0.31	-0.09	-0.30	-0.11	-0.13	-0.19	0.02	0.49	0
T_o^{II} (°K)	383	354	138	94	98	108	107	353	204
S_o^{II} (mly/sec)	0.36	-0.05	-0.50	-0.19	-0.24	-0.07	0.06	0.13	0
T_o^{III} (°K)	383	354	148	112	111	91	94	351	206
$\nu = 14$ S_o^I	2.8	-0.4	-2.8	-1.2	-0.8	-1.0	(x)	3.4	0
T_o^{II}	374	356	212	172	155	164	(x)	341	241
$\nu = 45$ S_o^I	7.4	1.1	-7.1	-3.3	-2.6	-2.3	(x)	8.1	0
T_o^{II}	358	349	267	221	208	202	(x)	316	265

H. Oet.
11/24/67



LUNAR-SURFACE CLIMATONOMY . Example for the following parameterization: (1) Forcing Function: $SW\downarrow = 32.3 \cos nt$, for $-90^\circ \leq nt \leq 90^\circ$; albedo $a = 0.073 \cos^{3/2} nt$; lunation cycle $n = 2.46 \cdot 10^{-6} \text{ sec}^{-1}$. Plotted above are $SW\downarrow$, and $F = SW\downarrow - SW\uparrow$, in mly/sec. (2) Response: Homogeneous conductor with low thermal admittance $\nu = 1.6 \frac{\text{mly}}{\text{deg} \cdot \text{sec}}$ and $\epsilon = 1.0$. T'_0 = zero-order approximation calculated with $\Gamma'_0 = 4 \bar{F}^{3/4} (\epsilon \epsilon)^{-1/4} = \text{const}$; the same Γ'_0 yields first-order approx. of S'_0 which, in turn, produces $T''_0 = [(F - S'_0)/\epsilon]^{1/4}$ = first-order approx. of radiation temperature. Fourier analysis of T''_0 yields improved (variable) T^*_0 which is used to calculate second-order approximations S''_0 and T''^*_0 (as shown above).
Roubin



LUNAR-SURFACE CLIMATONOMY -- Lunation Cycle - Parameterization of Forc. Funct. as before. For calculation of response, emissivity was assumed to equal unity; cycles of surface radiation temperature (in deg K) and surface-soil-heat-flux (in mly/sec) were calculated assuming homogeneous conduction in the lunar crust and three different values of thermal admittance (ν , in mly/sec per $\sqrt{\text{sec}}$). Hatched "band" at upper right indicates observed temperatures (from infra-red measurements) as summarized in NASA TM X-53499 (August 1966)