No. 35 IMPROVED TEST FOR NO_2 ON MARS

by JAMES V. MARSHALL*

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ABSTRACT

On the basis of new laboratory tests and microphotometer traces of Mt. Wilson coudé spectra, an upper limit of 8 micron-atm of NO_2 in a vertical column of the Mars atmosphere has been derived. This is two orders of magnitude less than the previous limit and appears to remove empirical arguments for the presence of this gas in the (normal) Martian atmosphere.

Following the announcements by Kiess *et al* (1960, 1963) of their detection of NO_2 in Martian spectra taken in 1956 and 1960–61, several authors have disputed these claims and have set upper limits on the presence of NO_2 in the Mars atmosphere. Sinton and Strong (1960) obtained $<$ 50 mm atm for the planet using the 10 μ region; Sinton (1961a, 1961b) from the 3.34 μ band set the upper limit at 4 mm atm and later 2 mm atm; Kiess *et al* (1963) stated that their plates in the region 0.61–0.63 μ indicate the presence of the gas in the amount of about 1 mm atm; while Spinrad (1963) from the 0.57–0.60 μ region derived 1 mm atm as an upper limit.

Rev. G. T. Sill and the author have photographed the entire NO_2 absorption spectrum between 0.35–1.2 μ with various dispersions averaging about 5Å/mm, with the author continuing the program after Rev. Sill's departure on August 8. The plates discussed here were made more recently. The laboratory runs are absorption spectra with both an incandescent light (0.35–1.2 μ) and the sun as a source (regions of special interest from 0.40–0.46 μ).

The NO_2 absorptions in the blue and violet are the strongest in the accessible photographic region and therefore this paper deals with these bands only. A reproduction of the 4300–4500Å interval, containing the strongest NO_2 bands of the entire region examined, is found in Figure 1; the amount used was about 2 mm atm. A solar spectrum is added for comparison purposes. It is noted that much weaker NO_2 absorptions will be detectable. Reference is made to a low-dispersion absorption spectrum, 4200–4800Å, by Pearse and Gaydon (1950).

The NO_2 band centered on 4482Å occurs in a region of the solar spectrum that is fairly free from prominent Fraunhofer lines. For this reason the interval 4475–4495Å was selected for further analysis. Figure 2 shows two microphotometer traces; *above,* ⅛ mm atm of NO_2, *below,* the solar spectrum recorded through 1 mm atm of NO_2. Figure 3 is similar to Figure 2, *below,* except that the amount of NO_2 is ⅛ mm atm. (The cell used was 2 mm long, the pressure 1/16 atm.) The depression near 4482Å is now considerably reduced, but still visible as indi-

*The laboratory program here described was begun jointly by Mr. Marshall and Rev. Godfrey T. Sill, O. Carm, about July 1, 1964 and continued until Rev. Sill's departure on August 8. Mr. Marshall then continued the program alone, and the results reported here are largely his.

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cated by the straight envelopes drawn in both figures.

Figures 4 and 5 show microphotometer traces for two of seven Mt. Wilson spectra of Mars, loaned to this Laboratory, courtesy of Dr. Babcock. Their dispersion is 2.84Å/mm, and that of the laboratory comparison spectra 5Å/mm. The microphotometer tracings of comparable scale were made by using different scan rates. The record shown in Figure 5 was of a somewhat lighter exposure than that of Figure 4. Approximate intensity scales were derived from comparisons with the *Photometric Atlas of the Solar Spectrum* (Minnaert *et al,* 1940), making allowance for the moderate difference in spectral resolution. These scales are intended only for purposes of orientation and rough calibration.

Comparison of Figures 4 and 5 with Figure 3 establishes at once the extraordinary sensitivity of an NO_2 test in this spectral region. The upper limit that could be present on Mars at the time of the two 1956 Mt. Wilson plates mentioned is, at most, 1/5 of the amount present in Figure 3, or 25 micron-atmospheres. The upper limit in a vertical column of the Martian atmosphere is therefore $25/\pi = 8$ micron-atmospheres.

In addition, a number of other Mt. Wilson spectra of Mars have been examined visually. Plates Ce 39 (Oct. 16, 1926), Ce 73 (March 24, 1927), Ce 10654a (Aug. 24, 1956), Ce 10657 (Aug. 25, 1956), Ce 10658 (Aug. 26, 1956) were borrowed for study in Tucson, in addition to Ce 10655 and Ce 10662, reproduced in Figures 4 and 5. Several other plates were examined during a visit to the Mt. Wilson Observatory office on August 25, 1964. The plates examined with the microphotometer are considered representative of the available collection. The previous position tests of NO_2 two orders of magnitude greater than the upper limit set here are therefore not supported.

The question as to whether the 4482Å band might be temperature-sensitive and therefore of much-reduced intensity on Mars ($T \simeq 200°K$ vs. 295°K in the laboratory) has been discussed by Dr. Kuiper and Dr. Herzberg. Dr. Herzberg concluded that temperature effects on the 4482 NO_2 band would be small; work on the classification of the photographic spectrum of NO_2 is currently in progress in his laboratory.

Acknowledgments. I am indebted to Dr. G. P. Kuiper for his aid in the preparation of this article, to the Mt. Wilson Observatory for the loan of the Mars spectra, and to the Kitt Peak National Observatory for the use of the microphotometer. I have benefited from inspection of a prepublication copy of a review article by Drs. Carl Sagan, Philip T. Hanst, and Andrew T. Young.

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Note added in proof. After the above was written the author had the opportunity to visit Dr. Kiess at his laboratory and inspect his original spectra. The author was unable to detect visually the 4480Å band of NO_2 on the Kiess spectra. The author is indebted to Dr. Kiess for his courteous reception and for the opportunity to review his material.

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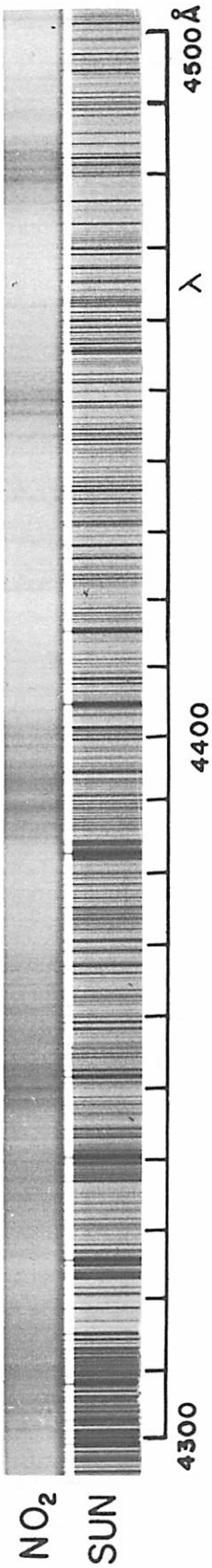

Fig. 1. The Spectrum of NO_2, 4300–4500Å, with solar comparison.

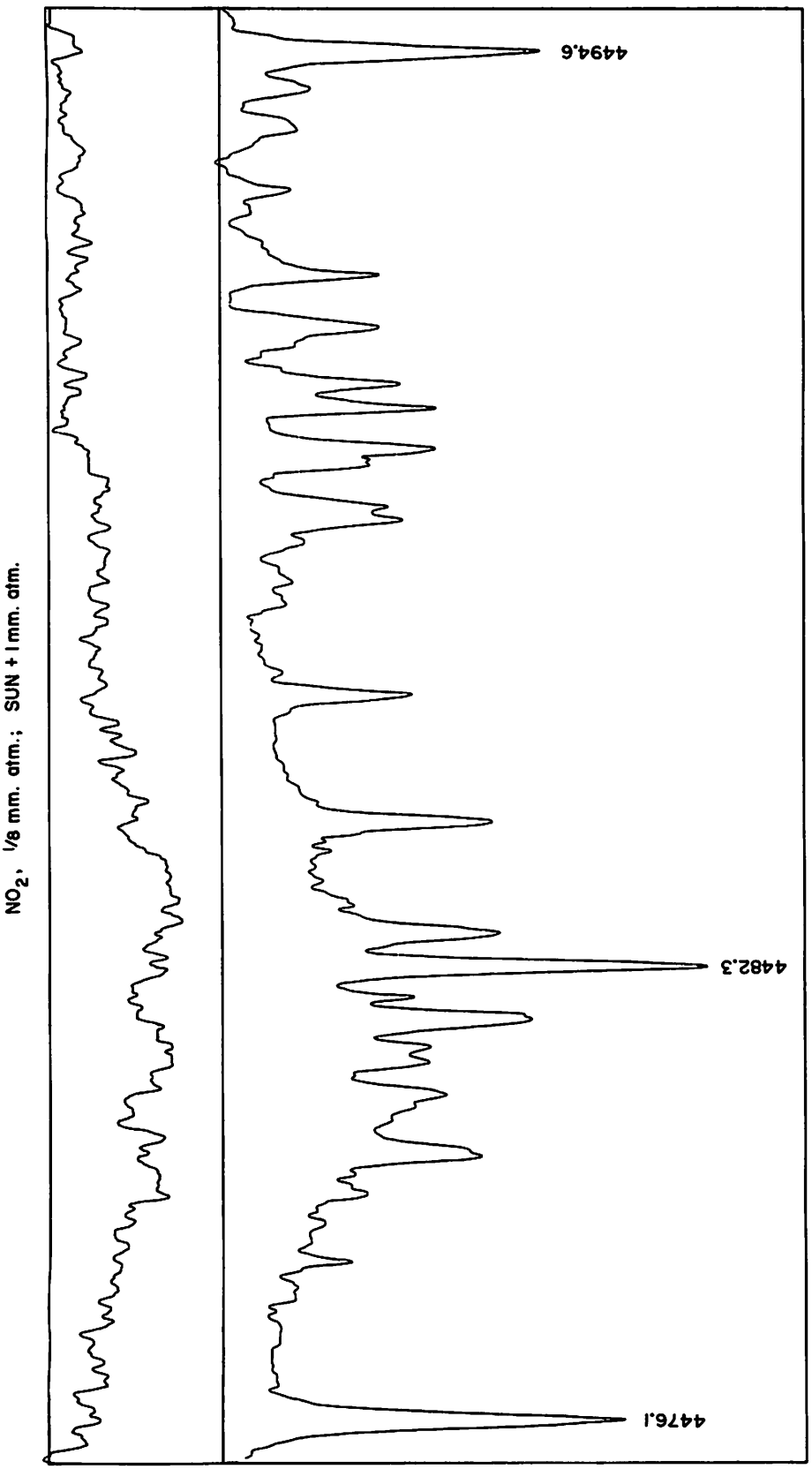

Fig. 2. Microphotometer tracings of spectra, 4475–4495Å. *Above:* NO_2 ⅛ mm atm; *below*, Sun + 1 mm atm of NO_2. Undisturbed continuum indicated by straight line on top.

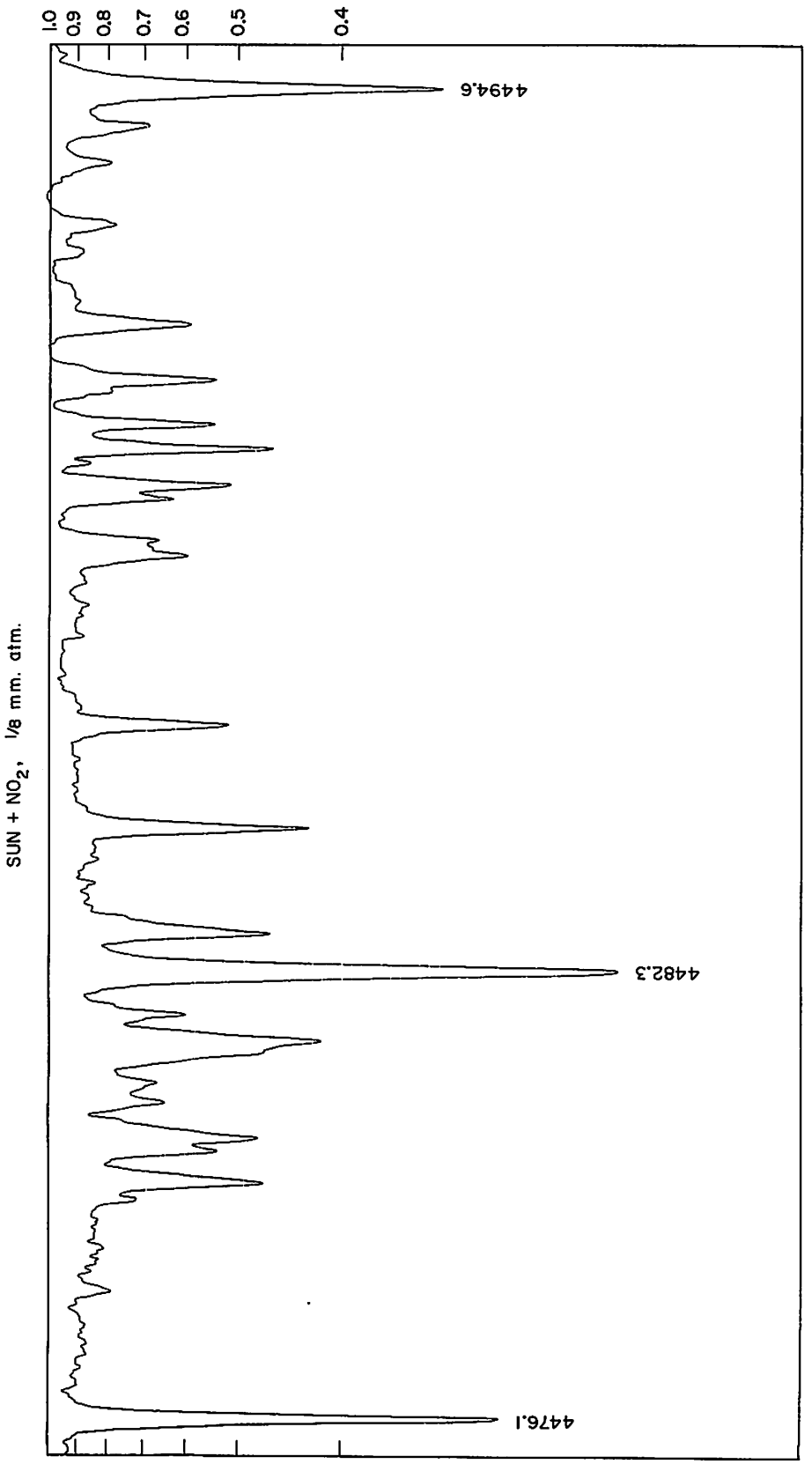

Fig. 3. Microphotometer tracing of spectrum, 4475–4495Å of Sun + ⅛ mm atm of NO_2, cf. Fig. 2.

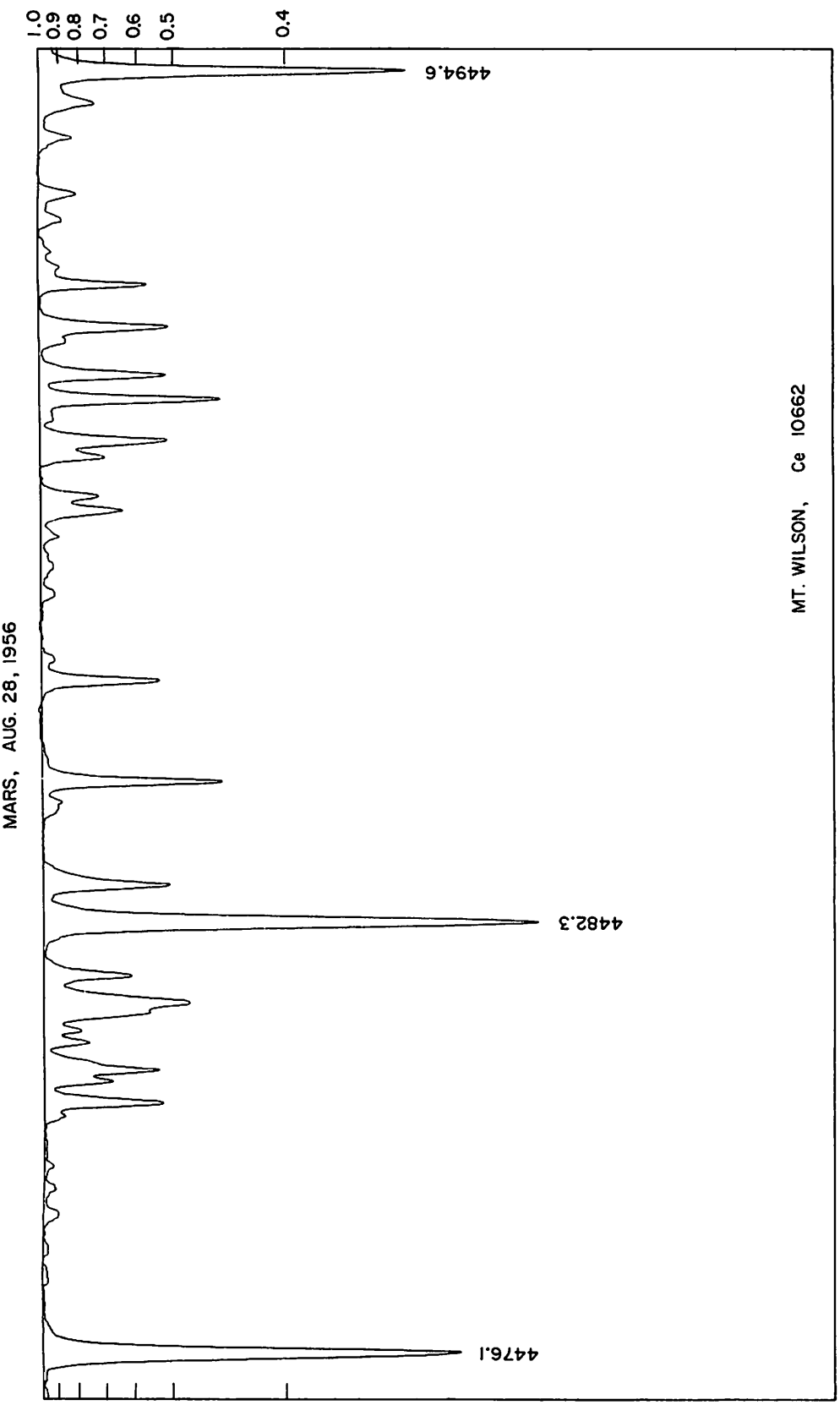

Fig. 4. Microphotometer tracing of Mars spectrum, August 28, 1956 (Mt. Wilson plate Ce 10662) 4475–4495A. Undisturbed continuum indicated by straight line on top. Approximate intensity scale at right.

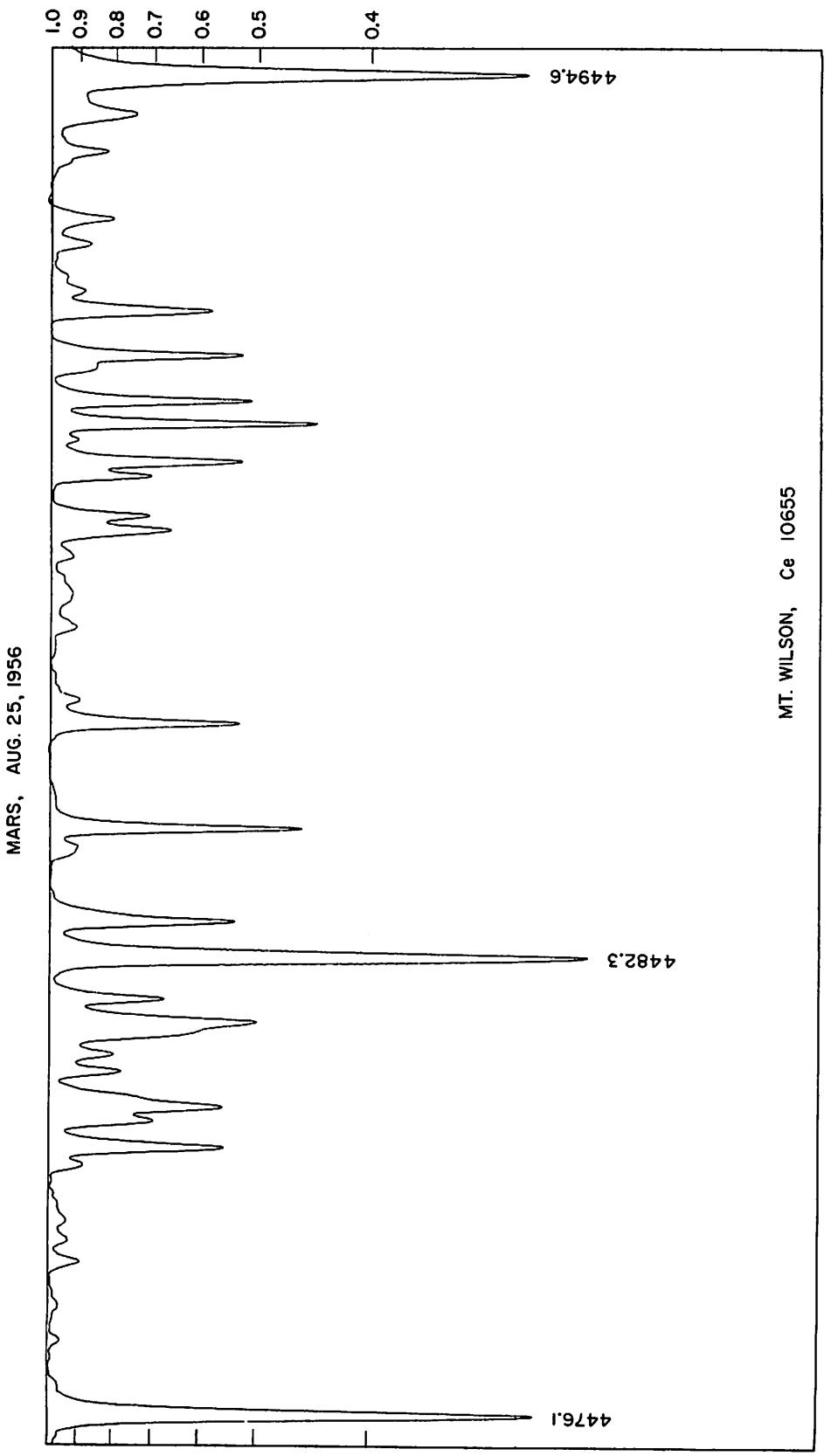

Fig. 5. Microphotometer tracing of Mars spectrum, August 25, 1956 (Mt. Wilson plate Ce 10655).

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