The Ultraviolet Spectrum of the Sun from V-2 Rockets*

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Spectra of the sun have been obtained from V-2 rockets at heights up to 155 km. A grating spectrograph was used giving a dispersion of 34A/mm. The ultraviolet spectrum of the sun obtained extends down to λ2300A, and traces are evident as far as λ2230A. A tentative list of identified lines is given. The MgII resonance doublet at λ2800A is observed to have emission centers in both absorption components. The intensity of this emission is estimated as about 10 percent that of the adjacent continuum.

I. INTRODUCTION

ONE of the outstanding developments of World War II was the German V-2 rocket. The great loads it can carry (payload 2000 pounds), its relatively small acceleration while rising (about 5 g maximum) and the great altitudes it can attain make it an excellent vehicle for certain types of high altitude research.** The study of the ultraviolet spectrum of the sun, practically free from absorption in the earth's atmosphere, is one of these.

Further essentials to this type of research[1] are techniques for post-flight recovery of photographic film, for the telemetering of data from the rocket in flight, and for radar and theodolite tracking of the rocket.

The first attempt of this laboratory to obtain the spectrum of the sun from German V-2 rockets was made in October 1946. The spectrograph used then was one containing lithium fluoride lenses and prism. It was built for us by the Bausch and Lomb Optical Company. This attempt resulted in failure due to a light leak into the cassette of the spectrograph which fogged the film. This leak was caused by the shock of terminal impact of the warhead of the rocket with the ground.

To avoid some difficulties that were experienced with lithium fluoride lenses and prisms, we have subsequently used reflecting concave grating spectrographs. More nearly shock proof cassettes have been provided.

Two flights have been successful in obtaining sun spectrograms. These were on April 1, 1947, and July 29, 1947. These flights will be referred to as Flights A and B, respectively, in this report.

Flight A took place at noon approximately; and Flight B, while it was planned for sunset firing in order to obtain more detail of atmospheric absorption,[2] actually took place a little after sunrise of a following day.

Since after an initial period of roll-stabilized and nearly vertical flight, the rocket rolls and tumbles, it is necessary to devise some means of directing sunlight into the spectrograph during such angular motion of the rocket. Front reflecting surfaces were used for shining the sunlight into the slits of the spectrograph in both Flights A and B. Because there was little absorbing medium in the path of light from the sun to the spectrograph at the heights at which most of the sun spectrograms were taken and because all reflecting surfaces, mirrors, and gratings were front-aluminized and ultraviolet sensitive film was used, the light intensity and the ultraviolet limit reached should be limited only by the strength of the incident solar radiation. These ideal conditions, however, were not realized in practice. For aside from the decreasing reflecting power of aluminum toward shorter wave-lengths, the parallel decrease of the iron comparison spectrum and the solar spectrum in the region of λ2300A, Figs. 2, 3, and other data indicate a rapid decrease in film sensitivity be-

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** For description of the V-2, see H. S. Siefert, M. M. Mills, and M. Summerfield, Am. J. Phys. **15**, 1, 121, 255 (1947) and J. M. J. Kooy and J. W. H. Uytenbogaart, *Ballistics of the Future* (Technical Publishing Company, H. Stam, Haarlem, Holland, 1946).

[1] L. W. Fraser, R. P. Petersen, H. E. Tatel, and J. A. Van Allen, Phys. Rev. **72**, 173 (1947).

[2] J. J. Hopfield, "U.V. absorption of air," Astrophys. J. **104**, 208 (1946).

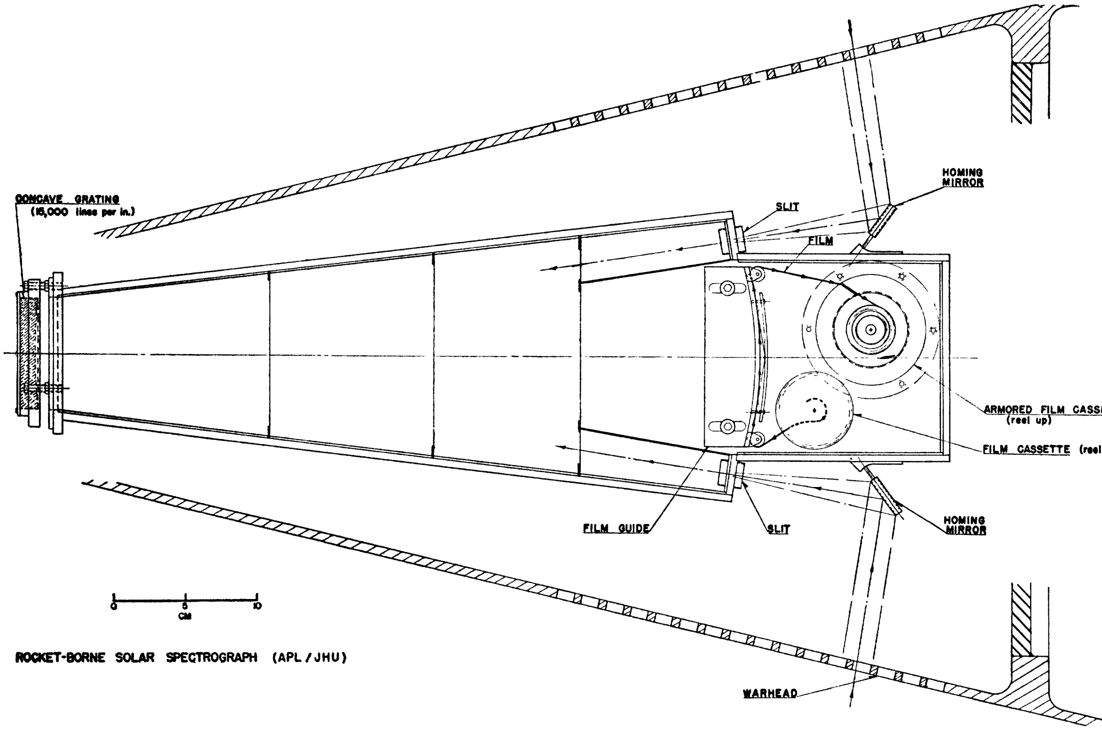

FIG. 1.

ginning at this point and extending to shorter wave-lengths.

Spectrograms of the sun using the V-2 rocket have also been obtained by a group at the Naval Research Laboratory[3,4]

II. SUN SPECTROGRAPHS

The sun spectrographs used in flights of April 1 and July 29 were alike in most details except for the illuminating devices used and the slits. It is the newer one which is shown in detail in the drawing Fig. 1. In this figure, the spectrograph is shown drawn to scale and in place in the nose of the rocket. Some of the special features of this spectrograph are the following: The spectrograph employed two slits, one on each side of the normal to the grating in order to use either side of the rocket which chanced to face the sun while the rocket was in rolling flight. One of these slits was slightly above and the other slightly below the Rowland circle of the grating, so that the two spectra obtained ran in opposite directions and side by side with a few millimeters space between them.

The slit jaws were made of hardened steel, and were fixed into threaded (40 threads per inch) tubes which could be screwed in and out for focusing the instrument. The slits were 0.025 mm wide and masked down to a 2-mm length. The grating was mounted on push-pull screws and the film cassette was movable. The final focusing was done by adjusting all three to give the best results.

The body of the spectrograph was made of $\frac{1}{4}$-in. aluminum plates fitted together with step lap joints and held by screws. The interior surfaces of the spectrograph and all light baffles were sandblasted and then painted a dull black to reduce light reflection. The spectrograph was fitted with a light trapped vent which permitted the air pressure in the spectrograph to be at approximately the ambient pressure at all times.

The grating was made at the Department of Physics, Johns Hopkins University. It was ruled on aluminized glass, with 15,000 lines/inch and had a radius of curvature of 50 cm. The rulings happened to be shaped to give much greater in-

[3] W. A. Baum, F. S. Johnson, J. J. Oberly, C. C. Rockwood, C. V. Strain, and R. Tausey, Phys. Rev. **70**, 781 (1946).

[4] E. Durand, J. J. Oberly, and R. Tausey, Phys. Rev. **71**, 827 (1947).

tensity in the spectrum from one side than from the other.

The spectra were photographed on 35-mm Eastman spectroscopic film, Type 103a–0, which is sensitive to the ultraviolet. The film platen and the film cassettes with the reel-off and reel-up spools are shown in Fig. 1. The armored film cassette (reel-up) was turned from a block of cold-rolled steel. It had a wall thickness of 1.8 cm, and provided with a screw cap of the same thickness. The entrance slot for the film was faced with black velvet to keep out the light. The reel-up spool was driven by a 24-v d.c. motor powered with batteries. The film change took less than 1 second.

The series of exposures was controlled by a switch, operated by a cam driven by a separate motor, which started automatically at rocket take-off. The cam was designed to make a series of 14 exposures of 5 seconds each during the rocket's powered flight while it was roll-stabilized, followed by a series of five exposures of 55 seconds each over the rest of the flight.

Shutters, operated by solenoids in parallel with this motor, shut off the light while the film was being changed. The warhead was blown off during the descent of the rocket thus reducing the landing speed from about 5000 feet per second, in which case all records are destroyed, to the order of two to three hundred feet per second. The film in the reel-up cassette was recovered in excellent condition.

TABLE I. Heights of exposures.

Spectrum no.	Flight	Altitude (km) Initial	Final	Weighted mean	Figure
A1	April 1	38	96	80	7
A2	April 1	103	123	115	
B1	July 29	64	116	95	
B2	July 29	116	148	135	
B3	July 29	148	159	155	
B4	July 29	159	148	155	6
B5	July 29	149	118	135	2, 3, 4, 5

III. ILLUMINATION

The sunlight was made diffuse by reflection from rough patterned glass in the spectrograph of April 1 and was directed into the spectrograph by plane mirrors before the slits. A sun "homing" device was used with the spectrograph of July 29. It was designed for sunset or sunrise firing and utilized a partially diffusing mirror before each slit. These mirrors consisted of two corrugated cylindrical concave mirrors placed back to back with their axes parallel and with the corrugations forming arcs of the cylinder normal to the plane of the incident and reflected light. The corrugated mirrors stretched the sun's image into a line about 5 mm wide and about 60° long in the plane of the paper (Fig. 1). The length of this beam, therefore, should compensate for a 30° tumble of the rocket. The mirrors rotated about shafts nearly coincident with the central elements of the cylinders. The shafts made angles of 45° downward from the axis of the rocket. The photoelectrically controlled rotation of these

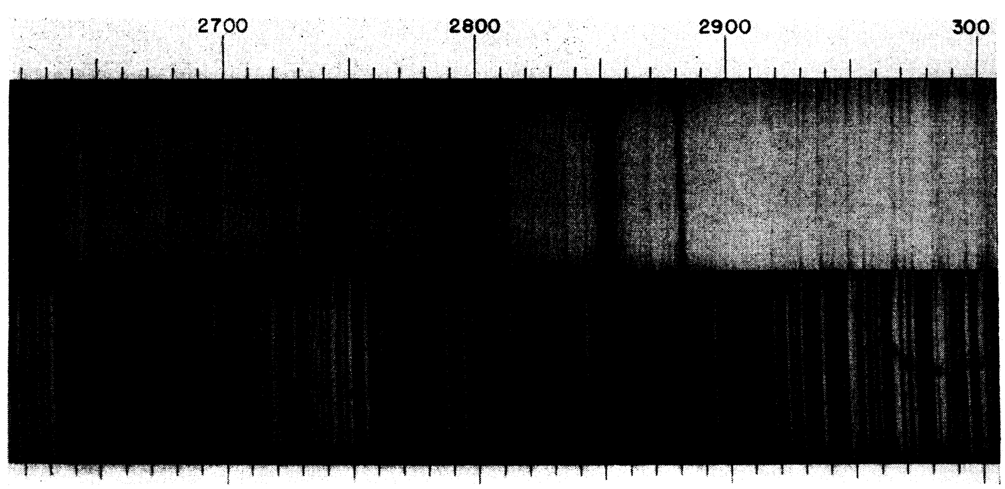

FIG. 2.

mirrors about their axes brought about by this light streak falling between the two midget photo-cells which were placed just above and below each slit constituted the control for the homing about this degree of freedom. This control was such that when the two photocells were equally illuminated by the light streak falling across them and the slit between them, the mechanism was in balance and the streak remained on the slit. When the spectrograph turned away from the sun, the motors turned the mirrors continuously in "hunting" until the sunlight returned. Independent homing systems were used for each slit.

As already mentioned, solenoid-operated shutters cut off the light while the film was being changed. A second pair of photo-cells near each slit was connected to a channel of the telemetering system and the time of illumination of the slits was recorded at the ground station. The voltage across the film drive motor, already mentioned, was also fed into the telemetering system. One could deduce the exposure of the various spectrograms from these combined records.

Because a single large hole in the side of the warhead for admitting the sunlight might be destructive to the mirror mechanism on account of the strong slip stream of the rocket, an array of $\frac{1}{2}$-inch holes with about 50 percent over-all efficiency was used for admitting the sunlight to homing mirrors (see Fig. 1).

IV. RESULTS

The V-2 rocket with the spectrograph which was designed for vertical exposure was fired at 1:10 P.M. M.S.T. on April 1, 1947. The V-2 rocket with the spectrograph designed for horizontal exposure was fired a little after sunrise, 5:55 A.M., M.S.T. on July 29, 1947. The strong side of the grating in spectrograph B had been oriented for a sunset firing. However, trouble with other apparatus in the rocket changed the program to the above time so that the weak side of the grating now faced the sun while the rocket was in roll-stabilized vertical flight. Furthermore, the telemetering record shows that the "homer" on the sunrise side failed for the early part of the flight so that the spectra intended to measure the stratification of ozone and other absorbing gases of the earth's atmosphere were missed.

The height limits and the weighted mean heights of each exposure are given in Table I. This table lists the two spectra taken in the flight of April 1 and the five taken on July 29. The altitude data of Table I were calculated from the telemetered signals in connection with the trajectory as established by optical theodolite and radar tracking.

The spectra appearing in Figs. 2 and 3 show the sun spectrum above and the corresponding iron spectrum below it. The iron spectrum was made with the rocket spectrograph on separate film before the spectrograph was mounted in the rocket. The iron spectrum was then matched

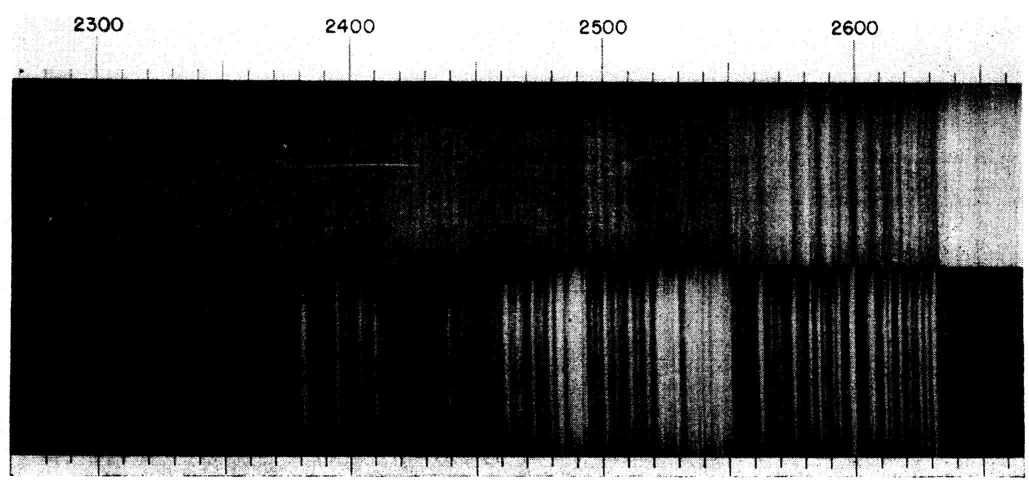

FIG. 3.

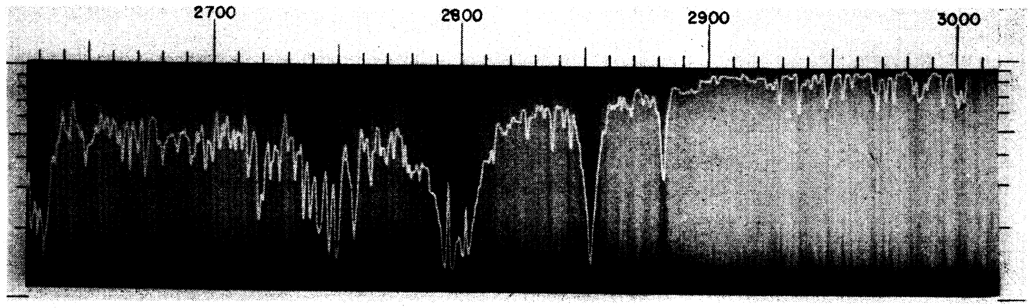

FIG. 4.

with Fraunhofer spectrum of the sun in the enlargement and the two mounted side by side. It is seen from these spectra that the iron spectrum is a dominant one in the sun in the region λ2300–3000A.

The spectra in Figs. 4 and 5 are the same sun spectrum pictures as those of Figs. 2 and 3, but with the microphotometer curve of intensity projected upon the spectra. It was not easily possible to position the intensity curves exactly on the spectrograms chiefly on account of the kind of recording microphotometer used. The slight shifts that exist, however, will cause the reader no confusion in the correlation of the curve and the features of the sun spectrum. The curves are uncalibrated traces, and the scales at the ends are arbitrary logarithmic scales, with the bottom lines marking the background intensity and top lines marking zero intensity.

The spectrum appearing in Fig. 6 shows the washed-out features resulting from underexposure in some parts, yet shows more details in parts where the spectra of Figs. 2 and 4 are overexposed. A comparison of the spectrum of Fig. 6 with those of Figs. 4 and 5 indicates a greater exposure in future flights will extend the sun spectrum and fill in more detail in the region λ2300–2600A. Such greater exposure is contemplated for succeeding "shoots" when "homing" in two degrees of freedom will be provided.

The spectra shown in Fig. 7 were taken on the April 1 "shoot." They do not have as good resolution as the other spectra and are shown only for comparison purposes.

Three sets of sensitometric exposures were made on film cut from the same roll as that used for the sun spectra. These exposures were made using a medium quartz spectrograph, a quartz mercury arc, and a step sector photometer. One of these sets was placed in the reel-up cassette of the rocket spectrograph; another was placed in a strong cylinder and bolted inside the warhead of the rocket; while the third set was held in storage at WSPG in New Mexico. On recovery of the film after the firing of the rocket, all film was processed together. Sets 1 and 2, therefore, had the same thermal, mechanical, and chemical history as the film of the sun spectrum except that the sensitometric exposures were made a few days earlier. The appearance of the background of all the developed films shows them to be alike.

Table II gives a preliminary list of identified

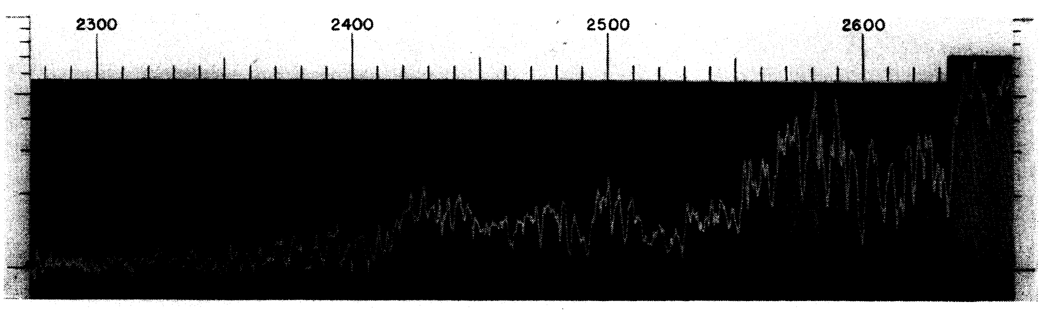

FIG. 5.

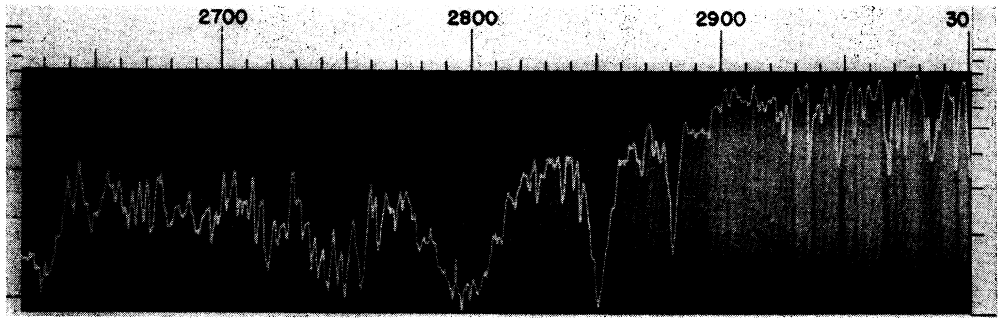

FIG. 6.

lines. As there was no provision for a comparison spectrum, a rough calibration of wave-lengths was made by matching the laboratory spectrum of iron against the solar spectrum. Further precision was attained by using internal standards of chosen iron lines of the solar spectrum. These were selected from among the least blended iron lines as indicated by a table of multiplets kindly furnished to us by Dr. C. M. Sitterly of the National Bureau of Standards. Because of blending, the scatter is large, so that wave-lengths are given to only 0.1A. All unidentified lines and lines identified as blends of several weak ones have been omitted from this preliminary table. The spectrum studied thus far extends to only λ2500A. The study of the lines on the short wave-length side of λ2500A is in progress.

One of the prominent features of the spectrum is the MgII doublet (3^2S-3^2P) at λ2796–λ2803A. This doublet is analagous to the H and K Fraunhofer lines of the solar spectrum due to CaII. The MgII lines are so wide that they overlap, yet each has an emission core located at the center of the line to within the limits of error of measurement. The intensity of the emission is estimated as about 10 percent of the neighboring continuum. A similar but weaker structure had already been observed in the CaII, H, and K Fraunhofer lines and is prominent in the *M*-type stars. An emission core of this type is possible for lines that show strongly in absorption such as the H and K lines due to CaII and which at the same time show strongly in emission in the flash spectrum which originated in the chromosphere of the sun. Solar eclipse data show that such is the case of the H and K lines, and may also be expected in the MgII lines λ2796, λ2803A when the flash spectrum of the sun is observed in this region. The origin of these emission cores is obviously in the high temperature luminous clouds which make up such features as the chromosphere and promi-

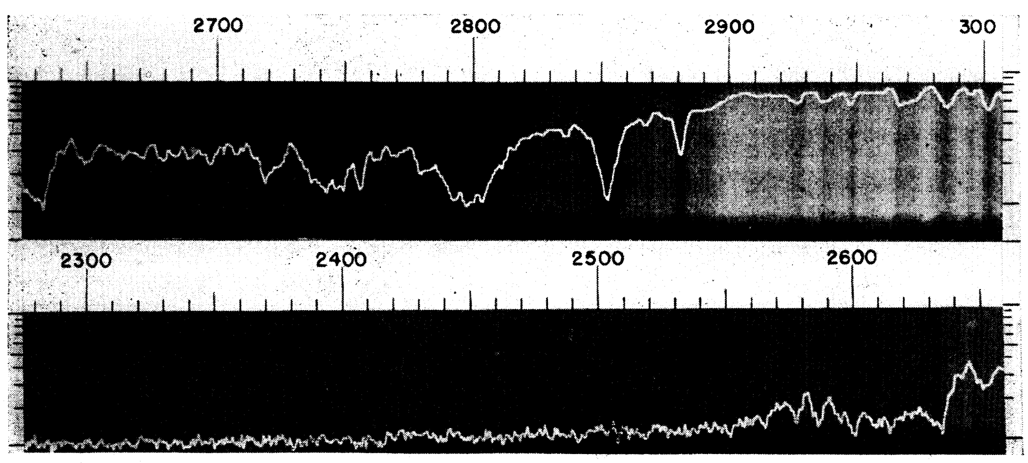

FIG. 7.

TABLE II. List of identified lines.

Wave-Length (A)	Identification		
2501.5	FeI	2501.13	$a^5D_4-x^5D_3^\circ$
	FeII	03.32	$a^4G_{11/2}-z^2H_{11/2}^\circ$
03.7	FeII	03.56	$a^4H_{9/2}-z^4I_{9/2}^\circ$
	FeII	03.87	$b^2G_{9/2}-x^2G_{9/2}^\circ$
06.7	SiI	06.89	$3p^2\,{}^3P_1-4s\,{}^3P_2^\circ$
10.7	FeI	10.83	$a^5D_3-x^5D_2^\circ$
11.7	FeII	11.76	$a^4F_{7/2}-z^4I_{9/2}^\circ$
14.0	SiI	14.32	$3p^2\,{}^3P_0-4s\,{}^3P_1^\circ$
16.3	SiI	16.11	$3p^2\,{}^3P_2-4s\,{}^3P_2^\circ$
19.0	SiI	19.20	$3p^2\,{}^3P_1-4s\,{}^3P_1^\circ$
23.6	FeI	22.84	$a^5D_4-x^5D_4^\circ$
	SiI	24.11	$3p^2\,{}^3P_1-4s\,{}^3P_0^\circ$
28.5	SiI	28.51	$3p^2\,{}^3P_2-4s\,{}^3P_1^\circ$
32.2	SiI	32.38	$3p^2\,{}^1S-5s\,{}^1P_1^\circ$
36.2	FeI	35.60	$a^5D_0-x^5D_1^\circ$
	FeII	36.67	$b^2H_{11/2}-x^4G_{11/2}^\circ$
40.9	FeII	40.67	$b^2D_{5/2}-w^2F_{7/2}^\circ$; $b^4F_{7/2}-y^4F_{9/2}^\circ$
	FeI	40.97	$a^5D_1-x^5D_2^\circ$
	FeII	41.10	$b^4F_{7/2}-y^4F_{5/2}^\circ$
45.6	FeI	45.97	$a^5D_2-x^5D_3^\circ$
	FeII	46.67	$b^4F_{7/2}-y^4F_{7/2}^\circ$
53.0	PI	53.28	$3p^3\,{}^2P_{1/2}^\circ-4s\,{}^2P_{1/2}$
55.2	PI	54.93	$3p^3\,{}^2P_{3/2}^\circ-4s\,{}^2P_{1/2}$
63.0	FeII	62.53	$a^4D_{7/2}-z^4P_{5/2}^\circ$
	FeII	63.47	$a^4D_{5/2}-z^4P_{3/2}^\circ$
67.6	FeII	66.90	$a^4D_{3/2}-z^4P_{1/2}^\circ$
	SiI	68.63	$3p^2\,{}^1S-5s\,{}^3P_1^\circ$
76.2	SiI	77.13	$3p^2\,{}^1S-4d\,{}^3D_1^\circ$
	FeII	77.92	$a^4D_{1/2}-z^4P_{1/2}^\circ$
82.3	FeII	82.58	$a^4D_{3/2}-z^4P_{3/2}^\circ$
85.6	FeII	85.87	$a^6D_{9/2}-z^6D_{7/2}^\circ$
91.2	FeII	91.54	$a^4D_{5/2}-z^4P_{5/2}^\circ$
93.7	NaI	93.82	$3^2S_{1/2}-7^2P_{3/2}^\circ$
	NaI	93.92	$3^2S_{1/2}-7^2P_{1/2}^\circ$
99.3	FeII	98.36	$a^6D_{7/2}-z^6D_{5/2}^\circ$
	FeII	99.39	$a^6D_{9/2}-z^6D_{9/2}^\circ$
2606.6	FeI	2606.83	$a^5F_4-x^5G_5^\circ$
	FeII	07.08	$a^6D_{5/2}-z^6D_{3/2}^\circ$
11.2	FeII	11.87	$a^6D_{7/2}-z^6D_{7/2}^\circ$
14.0	FeII	13.82	$a^6D_{3/2}-z^6D_{1/2}^\circ$
17.7	FeII	17.61	$a^6D_{5/2}-z^6D_{5/2}^\circ$
20.0	FeII	19.07	$b^4F_{9/2}-z^4G_{9/2}^\circ$
21.6	FeII	21.67	$a^6D_{1/2}-z^6D_{1/2}^\circ$
23.6	FeII	23.72	$b^4F_{5/2}-z^4G_{5/2}^\circ$
25.6	FeII	25.66	$a^6D_{7/2}-z^6D_{9/2}^\circ$
28.3	FeII	28.29	$a^6D_{1/2}-z^6D_{3/2}^\circ$
31.8	FeII	31.05	$a^6D_{3/2}-z^6D_{5/2}^\circ$
	FeII	31.32	$a^6D_{5/2}-z^6D_{7/2}^\circ$
64.1	FeII	64.66	$a^2F_{7/2}-y^2G_{9/2}^\circ$
66.5	FeII	66.63	$a^2F_{5/2}-y^2G_{7/2}^\circ$
80.7	NaI	80.33	$3^2S_{1/2}-6^2P_{3/2}^\circ$
	NaI	80.44	$3^2S_{1/2}-6^2P_{1/2}^\circ$
92.7	FeII	92.60	$b^2G_{9/2}-y^2H_{11/2}^\circ$
2702.1	VII	2702.18	$a^5D_3-z^3D_3^\circ$
03.5	FeII	03.98	$a^2F_{7/2}-z^2F_{7/2}^\circ$
06.8	VII	06.17	$a^5D_3-z^5F_4^\circ$
	VII	06.70	$a^5D_2-z^3D_2^\circ$
11.6	FeII	11.84	$a^4G_{11/2}-z^2I_{13/2}^\circ$
14.8	FeII	14.41	$a^4D_{7/2}-z^4D_{5/2}^\circ$
16.0	FeII	16.21	$a^2F_{3/2}-z^2F_{5/2}^\circ$
19.1	FeI	19.02	$a^5D_4-y^5P_3^\circ$
21.0	FeI	20.90	$a^5D_3-y^5P_2^\circ$
23.7	FeI	23.57	$a^5D_2-y^5P_1^\circ$
27.8	FeII	27.38	$a^4G_{11/2}-z^2G_{9/2}^\circ$
	FeII	27.54	$a^4D_{5/2}-z^4D_{3/2}^\circ$
30.8	FeII	30.87	$a^4D_{3/2}-z^4F_{3/2}^\circ$
33.8	FeI	33.58	$a^5F_5-w^5D_4^\circ$
37.2	FeI	37.31	$a^5D_1-y^5P_1^\circ$
39.8	FeII	39.54	$a^4D_{7/2}-z^4D_{7/2}^\circ$
42.3	FeI	42.26	$a^5F_3-w^5D_2^\circ$
	FeI	42.40	$a^5D_2-y^5P_2^\circ$
43.9	FeI	44.06	$a^5D_0-y^5P_1^\circ$
	FeII	46.49	$a^4D_{3/2}-z^4F_{5/2}^\circ$
46.7	FeII	46.98	$a^4D_{5/2}-z^4D_{5/2}^\circ$
	FeI	46.98	$a^5F_5-z^5H_6^\circ$
49.9	FeI	50.14	$a^5D_3-y^5P_3^\circ$
56.6	FeI	56.32	$a^5D_1-y^5P_2^\circ$
	FeII	68.94	$a^4D_{3/2}-z^4D_{5/2}^\circ$
69.3	FeII	69.15	$a^4G_{7/2}-z^4G_{9/2}^\circ$
	FeII	69.35	$a^4G_{11/2}-z^4I_{13/2}^\circ$; $b^2D_{5/2}-w^4F_{7/2}^\circ$
79.9	MgI	blend	$3p\,{}^3P^\circ-p^2\,{}^3P$
83.5	FeII	83.69	$b^2H_{11/2}-z^2G_{9/2}^\circ$
95.9	MgII	95.52	$3^2S_{1/2}-3^2P_{3/2}^\circ$
2802.9	MgII	2802.69	$3^2S_{1/2}-3^2P_{1/2}^\circ$
13.3	FeI	13.29	$a^5F_4-y^5G_5^\circ$
	TiII	28.15	$z^4G_{11/2}^\circ-e^4H_{13/2}$
28.3	TiII	28.89	$z^4G_{9/2}^\circ-e^4H_{9/2}$; $z^4G_{5/2}^\circ-e^4G_{5/2}$
32.3	FeI	32.44	$a^5F_3-y^5G_4^\circ$
36.0	FeII	35.72	$b^2P_{3/2}-z^4G_{5/2}^\circ$
38.3	FeI	38.12	$a^5F_2-y^5G_2^\circ$
52.2	MgI	52.12	$3s^1S_0-3p^1P_1^\circ$
58.8	FeI	58.90	$a^5D_1-z^5G_2^\circ$
73.2	FeII	73.40	$b^2G_{7/2}-z^2H_{5/2}^\circ$
76.6	FeII	75.34	$a^2F_{7/2}-z^2G_{9/2}^\circ$
	FeII	76.80	$a^2F_{7/2}-y^4F_{7/2}^\circ$
81.7	SiI	81.59	$3p^2\,{}^1D_2-3p4s\,{}^1P_1^\circ$
98.2	VI	99.21	$a^4F_{5/2}-v^4D_{7/2}^\circ$
	VI	99.60	$a^4F_{3/2}-v^4D_{1/2}^\circ$
2910.5	VII	2910.00	$a^5F_2-z^3D_2^\circ$
	VII	10.38	$a^5F_1-z^3D_1^\circ$
20.6	VII	20.37	$a^5F_2-z^5F_3^\circ$
23.7	VI	23.63	$a^4F_{9/2}-v^4D_{7/2}^\circ$
	VII	24.63	$a^5F_4-z^5F_4^\circ$
26.5	FeII	26.58	$a^4D_{7/2}-z^6F_{9/2}^\circ$
28.7	MgII	28.62	$3\,{}^2P_{1/2}^\circ-4\,{}^2S_{1/2}$
	FeII	29.00	$a^5D_3-y^5F_2^\circ$
33.0	MnII	33.05	$4s\,{}^5S_2-4p\,{}^5P_1^\circ$
37.0	MgII	36.49	$3\,{}^2P_{3/2}^\circ-4\,{}^2S_{1/2}$
	FeI	37.50	$a^5D_4-y^5F_4^\circ$
39.4	MnII	39.31	$4s\,{}^5S_2-4p\,{}^5P_2^\circ$
	FeII	39.50	$a^4D_{5/2}-z^6F_{3/2}^\circ$
41.5	FeI	41.34	$a^5D_2-y^5F_1^\circ$
44.6	FeII	44.39	$a^4P_{3/2}-z^4P_{1/2}^\circ$
	VII	44.57	$a^5F_4-z^5F_3^\circ$

TABLE II.—(*Continued.*)

Wave-Length (A)	Identification		
47.9	FeII	47.66	$a^4P_{5/2}-z^4P_{3/2}^{\circ}$
	FeI	47.88	$a^5D_3-y^5F_3^{\circ}$
49.4	FeII	49.18	$b^2G_{9/2}-z^2F_{7/2}^{\circ}$
	MnII	49.21	$4s\ ^5S_2-4p\ ^5P_3^{\circ}$
	FeI	50.24	$a^5P_3-5^{\circ}$
54.0	FeII	53.77	$a^4D_{5/2}-z^6F_{7/2}^{\circ}$
	FeI	53.94	$a^5D_2-y^5F_2^{\circ}$
57.3	FeI	57.36	$a^5D_1-y^5F_1^{\circ}$
59.9	FeII	59.60	$a^2F_{7/2}-z^2D_{5/2}^{\circ}$
61.4	FeII	61.27	$a^4D_{3/2}-z^6F_{1/2}^{\circ}$
65.3	FeI	65.26	$a^5D_0-y^5F_1^{\circ}$
66.8	FeI	66.90	$a^5D_4-y^5F_5^{\circ}$
70.3	FeI	70.11	$a^5D_1-y^5F_2^{\circ}$; $a^5D_2-z^3P_2^{\circ}$
	SiI	70.35	$3p^2\ ^1D_2-3p4s\ ^3P_2^{\circ}$
	FeII	70.51	$a^4D_{3/2}-z^6F_{5/2}^{\circ}$
73.2	FeI	73.13	$a^5D_2-y^5F_3^{\circ}$
	FeI	73.27	$a^5D_3-y^5F_4^{\circ}$
76.2	FeI	76.12	$a^3P_2-u^3D_3^{\circ}$
	VII	76.20	$a^5P_1-y^5P_2^{\circ}$
	VII	76.52	$a^5P_2-y^5D_3^{\circ}$
79.1	FeII	79.34	$a^4D_{1/2}-z^6F_{3/2}^{\circ}$
81.4	FeI	81.44	$a^5D_3-z^3P_2^{\circ}$
83.6	FeI	83.57	$a^5D_4-y^5D_3^{\circ}$
84.8	FeII	84.83	$a^4P_{5/2}-z^4P_{5/2}^{\circ}$
85.8	FeII	85.55	$a^4P_{1/2}-z^4P_{3/2}^{\circ}$
	CrI	85.86	$a^5D_2-y^5D_2^{\circ}$
	CrI	86.00	$a^5D_3-y^5D_3^{\circ}$
	CrI	86.47	$a^5D_4-y^5D_4^{\circ}$
87.6	FeI	87.29	$a^5F_4-x^5F_3^{\circ}$
	SiI	87.65	$3p^2\ ^1D_2-3p4s\ ^3P_1^{\circ}$
94.5	FeI	94.42	$a^5D_3-y^5D_3^{\circ}$
	FeI	94.50	$a^5D_0-z^3P_1^{\circ}$
99.5	FeI	99.51	$a^5F_5-x^5F_5^{\circ}$
3000.8	FeI	3000.95	$a^5D_2-y^5D_1^{\circ}$

nences above the cooler reversing layer of the sun.

From a preliminary examination of the microphotometer traces, it is obvious that a determination of the blackbody curve will be difficult. There are a number of sudden drops in intensity such as those near λ2630A, λ2550A, and λ2410A due to multiplets of iron. There are step-wise drops of intensity such as one at λ2950A that might originate in band absorption in the reversing layer of the sun. Another feature of interest is the several bright "windows" that are seen in the spectrum of the sun. Two such are bright lines near λ2638A and λ2643A. The simplest hypothesis is that such windows represent the true intensity of the continuum of the sun and that others will be found when one uses sufficient resolution and exposure to resolve the narrow plateaus of the continuum from the canyons, the Fraunhofer lines. It appears at present that even these windows are less bright than those corresponding to a solar temperature of 5500°K. One should also look into the possibility of the origin of such "bright" lines in the spectrum of iron, calcium, and other elements known to exist in a highly ionized state in the solar corona. There are no systematic differences among exposures B1 to B5 of Table I showing that atomspheric absorption in all of them is small.

To photograph much more of the ultraviolet spectrum of the sun is our desire for future rocket flights, when sufficient exposure is obtained by complete homing on the sun. An important extension would be the Lyman series of hydrogen beginning at λ1215A. This series like the Balmer series so prominent in total eclipses, should be strong in the layer of the sun just outside the reversing layer.

In writing this report, the authors feel that they are only the spokesmen of the people and organizations that made the experiments possible. Among these organizations are the Army Ordnance Group at White Sands Proving Ground, Las Cruces, New Mexico, the General Electric Company through its representatives at White Sands, and the Department of Physics at Johns Hopkins which made the gratings.

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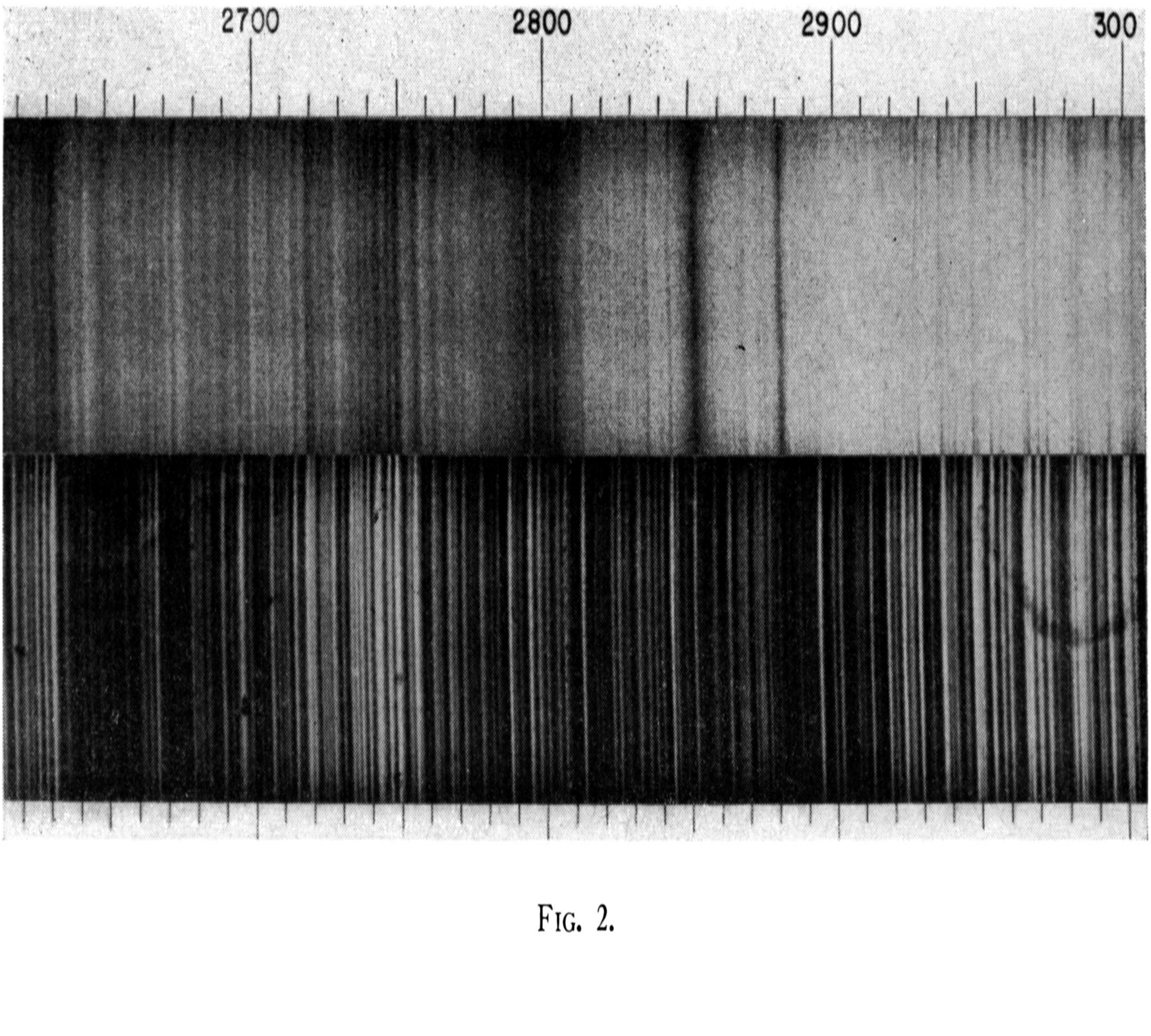

Fig. 2.

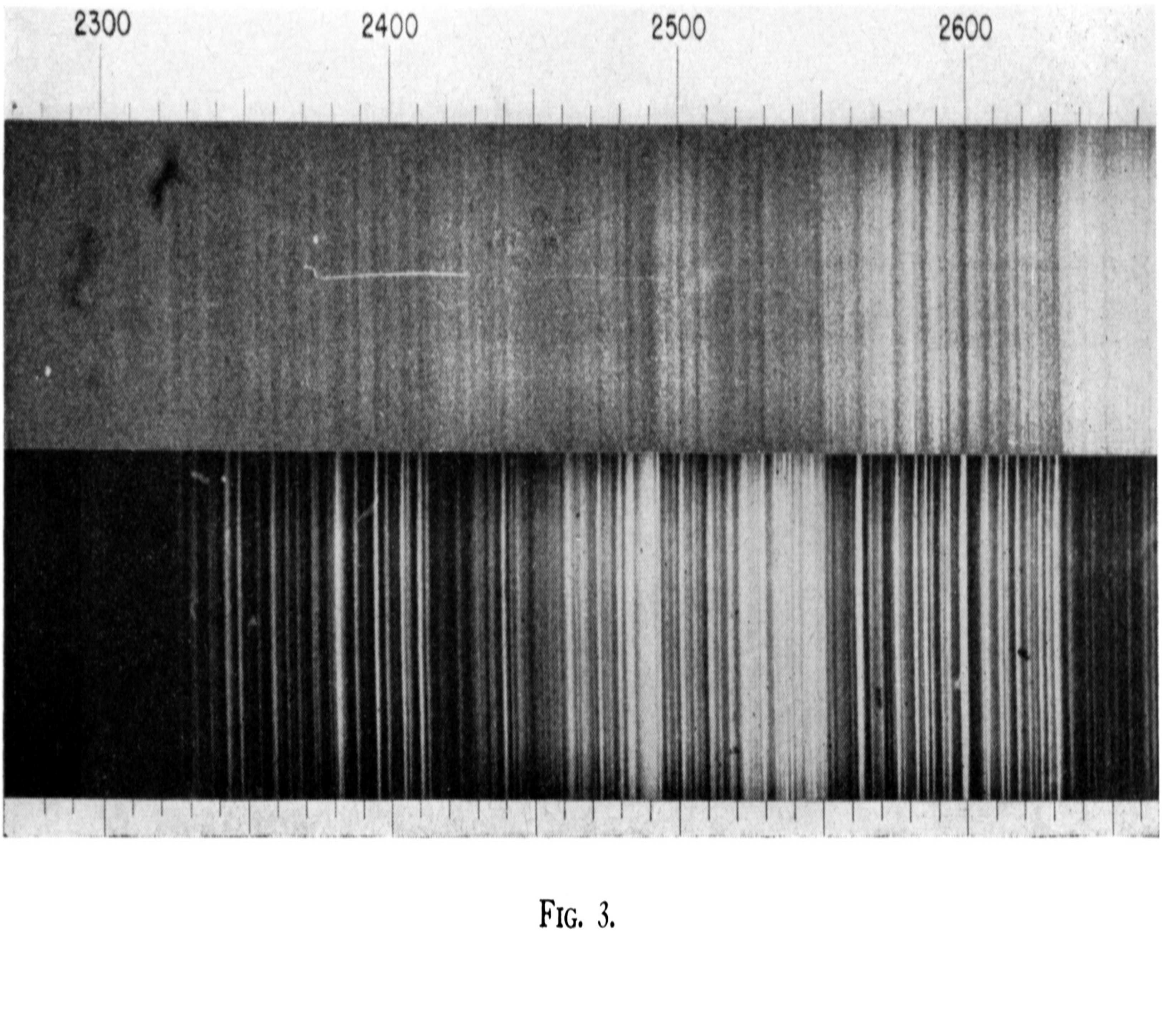

FIG. 3.

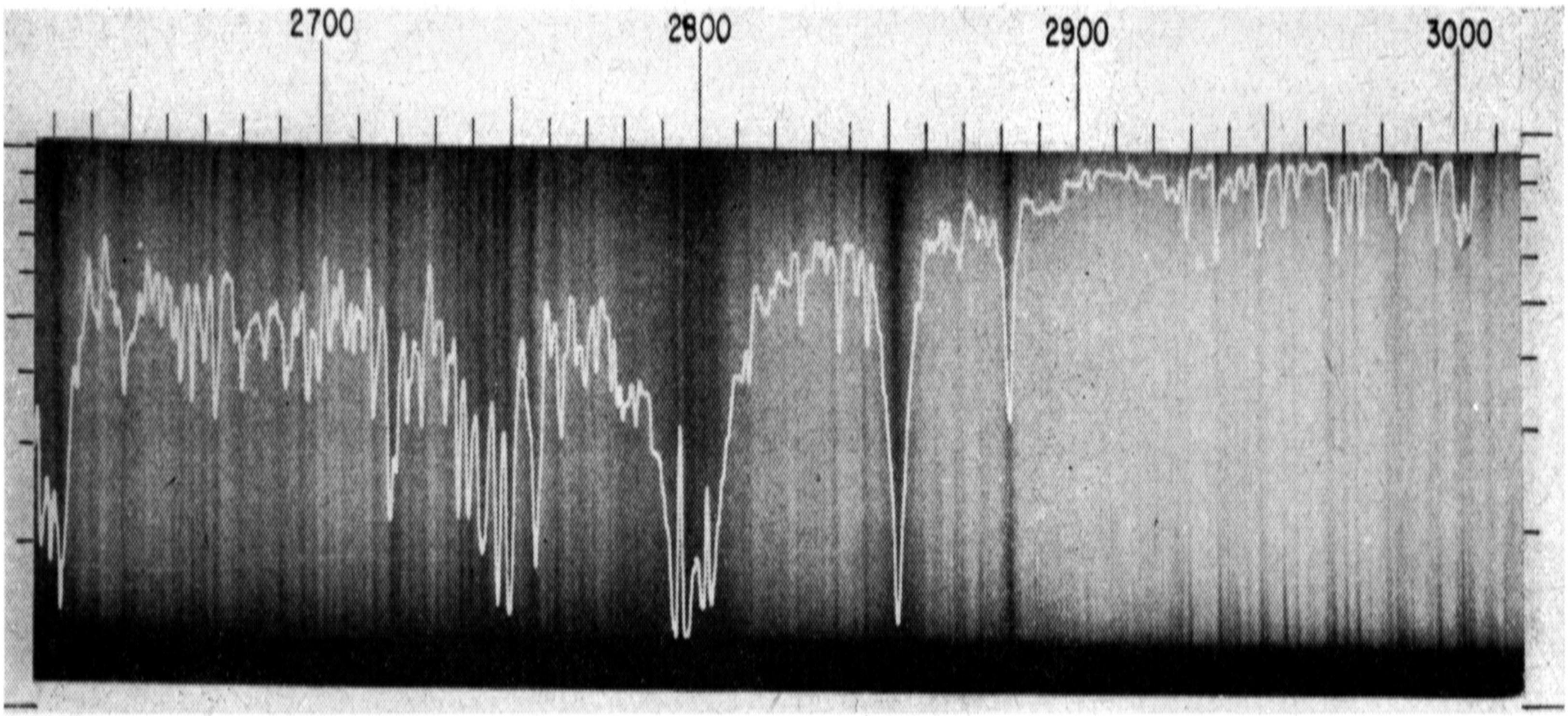

FIG. 4.

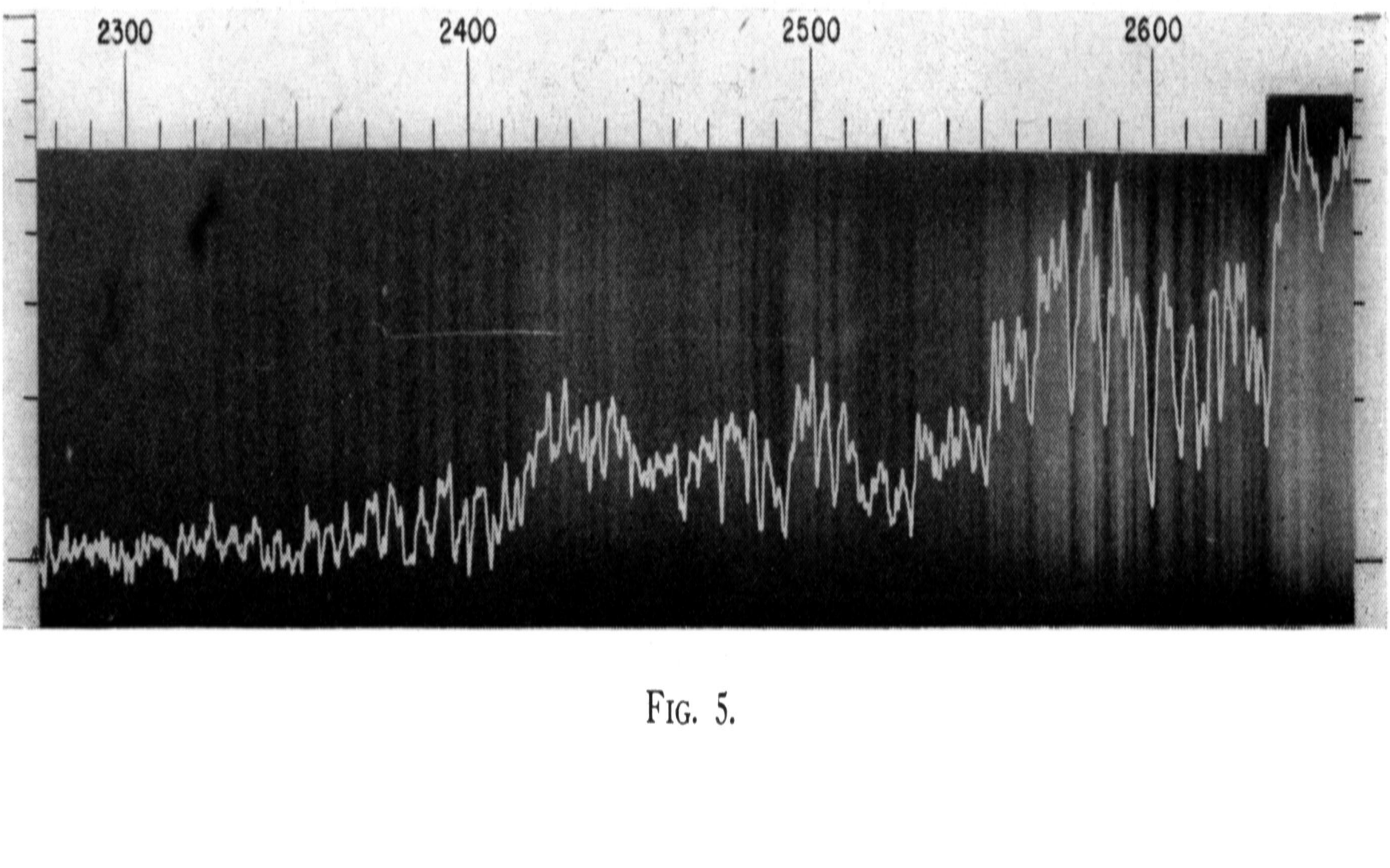

FIG. 5.

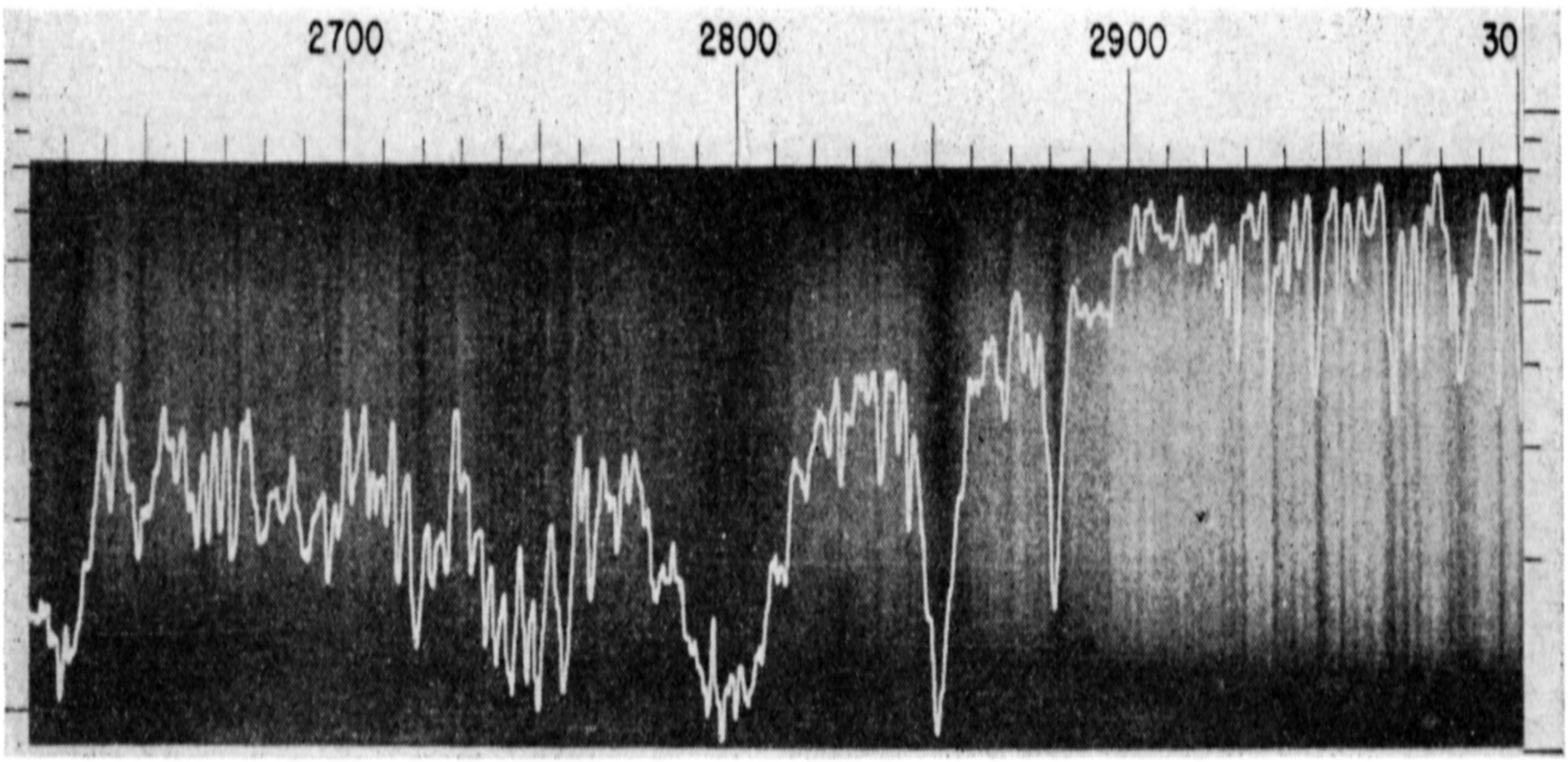

FIG. 6.

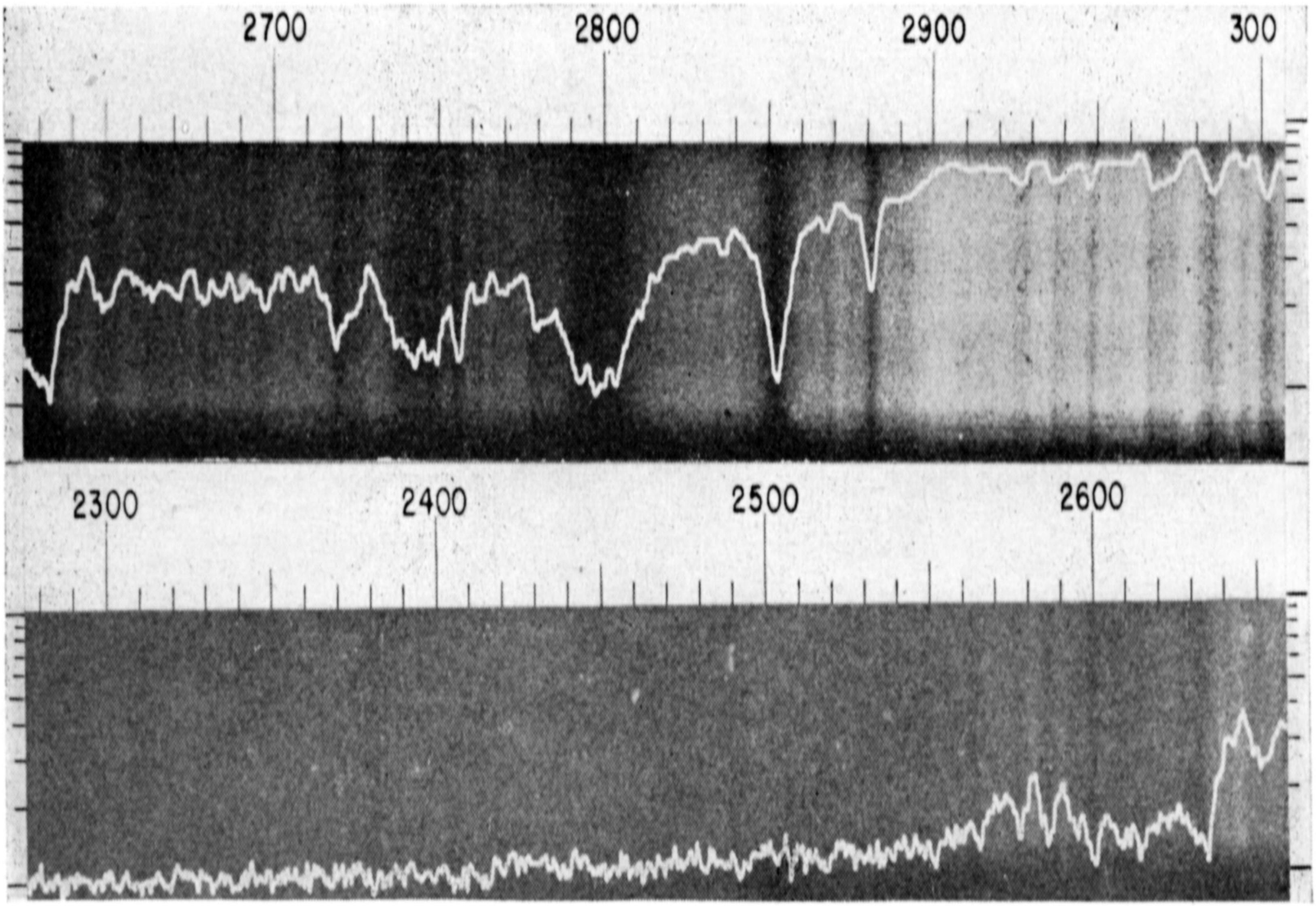

FIG. 7.