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THE SMITHSONIAN ECLIPSE EXPEDITION OF JUNE 8, 1918

(With Four Plates)

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REPORT OF L. B. ALDRICH

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PREPARATION

Congress having made appropriation for an expedition from the Smithsonian Astrophysical Observatory to observe the total solar eclipse of June 8, 1918, plans were made according to which the director of the Observatory would personally accompany the expedition. But as the time approached, Dr. Abbot found other urgent matters requiring his attention, and though his advice and assistance were available at all times, he placed the expedition in charge of the writer.

It was early decided that a location in western Kansas be chosen, rather than to go farther west, chiefly for the reason that the line of observers would thus be more extended and the probable number of stations favored with good weather increased.

Besides the writer, the expedition included Mr. Andrew Kramer, instrument maker of the Observatory, and Rev. Clarence Woodman, C. S. P., of Berkeley, Cal., a volunteer observer whose large experience materially aided in the success of the expedition. Both Father Woodman and Mr. Kramer had assisted in the eclipse expedition of the Smithsonian Institution under Secretary Langley at Wadesboro, N. C., in 1900.

Because of transportation difficulties incident to the war, a minimum of apparatus was sent from the Institution. As far as possible the equipment was obtained and constructed at the station. Only two medium-sized boxes of apparatus were prepared, and these were taken as personal baggage by the expedition members.

OBJECTS

The objects in view were three-fold:

(1) Measurements with the pyranometer. This included—

(a) Measurements of sky brightness.

(b) Measurements of the total radiation from sun and sky.

(c) Measurements of the outgoing radiation from the earth during totality.

Similar observations for comparison were also planned for another day and at night.

(2) Direct photography of the solar corona, with two cameras of 335 cm. (11 feet) focus and 7.5 cm. (3 inches) aperture.

(3) Observations of the times of contact, and visual observations of the phenomena.

FIELD CONDITIONS

The station chosen was on the central eclipse line, about midway between the towns of Lakin and Hartland, Kansas, both of which are on the main line of the Santa Fé Railroad. Computations by Rev. Woodman gave the location of the station as follows:

Latitude	37°	53′	4″.2	N,
Longitude	101°	17′	51″.3	W.

The altitude at this place is 900 meters (3,000 feet) above sea level, with a mean barometer of 67 cm. (26.7 inches). There is little rainfall, and the land, which is flat and bears few large trees, is chiefly given to the cultivation of alfalfa, watered artificially.

Mr. Aldrich and Mr. Kramer arrived at Hartland on Monday morning, June 3, and were joined there by Rev. Woodman. An eclipse party from the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, under the direction of Dr. S. J. Mauchly, had chosen the same location and were already on the ground when the Smithsonian party arrived. This fact proved of decided value to our expedition, for, being familiar with local conditions, Dr. Mauchly and his party gave us valuable suggestions and assistance. Their interest and help is gratefully acknowledged.

Within a few hundred feet of the station of the Department of Terrestrial Magnetism, and in the same alfalfa field, there stood an unused barn which immediately suggested itself as an excellent windshield for our instruments. Permission to use the barn was given us by Mr. Jacob M. Hoss, lessee of the property. The thanks of the Institution are due him for granting this privilege entirely without charge. It is pleasant to record the universal interest and disposition to help among all with whom we came in contact. Especially we wish to acknowledge the kindness of Mr. and Mrs. P. C. Pittenger, the nearest neighbors, for furnishing two of our party room and board at great inconvenience to themselves.

Our location being settled, necessary equipment was obtained from Lakin by auto truck, and with the help of a local carpenter, the barn was altered to suit our needs, piers erected, and the instruments mounted as rapidly as possible.

From the time we arrived on Monday morning, up to an hour before the eclipse began on Saturday afternoon, the weather was very discouraging. Almost continuous cloudiness existed during this period. Thursday and Friday were completely overcast, with much lightning and thunder. We were unable to obtain any focus plates or to correct the rate of the driving mechanism of the photographic apparatus. Saturday morning, the day of the eclipse, the sky was more densely overcast than ever and the success of the expedition looked hopeless. At noon a few rifts appeared and by an hour before the eclipse began, the cumulus clouds had practically disappeared, leaving the sky covered with streaks of thin cirrus cloud. This condition continued the remainder of the day. While the sky was not ideal for our work, it enabled us to carry out the complete program with success.

APPARATUS

For the radiation work, Pyranometer A. P. O. No. 5 [1] was used. To meet more adequately the eclipse requirements, it was partially rebuilt, as follows: A new thermopile, consisting of four tellurium-platinum thermo-elements, was inserted beneath the blackened manganin strip. (Pyranometer A. P. O. No. 5 is a single-strip type of instrument.) This made it more sensitive than any pyranometer yet constructed, and made easily measurable a radiation absorbed by the strip as small as .0005 calory (per square centimeter per minute). To avoid a small galvanometer drift found in measuring radiation from the sky alone, the sun shade [2] was increased in size so as to shade from direct sun rays the whole copper disk surrounding the absorbing strip. It was also raised to a distance of about 35 centimeters from the strip so as not to intercept too large a sky area.

[1] See Smithsonian Misc. Coll., Vol. 66, No. 7, p. 7.

[2] With the small sun shade, this galvanometer drift occurs in the single-strip type of instrument because, since the cold junctions of the thermopile are buried in the copper disk, part of which is exposed to direct solar radiation during the sky-alone measurements, the temperature of these junctions tends to increase. In the two-strip form of instrument this difficulty is obviated by placing the cold junctions beneath the second absorbing strip. The angular radius for the large shade was 7° 34′, the small strip shade, 3° 10′, and for the sun, 0° 16′. The corresponding solid angles subtended were, for the large shade .0547, small shade .00962, and sun .000068.

The galvanometer was of the D'Arsonval type furnished with the Ångström pyrheliometer and pyrgeometer. It also was modified, first, by adding a lever device giving means for setting the scale zero as desired; second, by removing the iron damping core, thus insuring a definite first swing under all conditions of use. All the pyranometer measurements were made according to the first-swing method described in detail in the paper "On the Use of the Pyranometer" (Smithsonian Misc. Coll., Vol. 66, No. 11).

Weston Milliammeter No. 8,244, reading to 1.5 amperes and previously calibrated at the Bureau of Standards, was used.

As a measure of precaution a duplicate pyranometer, galvanometer, and ammeter were brought from Washington, but by good fortune were not needed.

The pyranometer was mounted outside on a pier about 6 meters west of the shelter which enclosed all the auxiliary apparatus and at an altitude of 1.5 meters above the ground. The absorbing strip was horizontal and was exposed to almost a complete hemisphere of sky, only a small portion of the sky low in the east being cut off by the barn. Inside the barn, the galvanometer was hung on a solid wooden pier, well protected from wind or temperature changes. In front of the galvanometer another pier supported the ammeter, rheostats, and dry cells which furnished the calibrating current, and a dial resistance box. This box was inserted in the galvanometer circuit, enabling the observer at the galvanometer to keep the deflection always of suitable magnitude.

For the photographic work, a portion of the west wall and roof of the barn sufficient to expose the lenses to the sun during the duration of the eclipse was removed and the remainder of the barn was made a better protection by covering cracks with strips of batting. Two tubes of 8 inch (20 cm.) iron stove-pipe, riveted together in lengths 11 feet (335 cm.) long, formed the tubes for the double-barreled camera. These were mounted on a polar axis which itself was supported by two wooden posts embedded in cement and well braced. An arm 8 feet (2.5 meters) long, clamped to the polar axis, extended due west and moved downward over a roller, thus causing the camera tubes to follow the apparent solar motion. The rate of motion was regulated by a clockwork placed on a pier just above the end of the lever arm.

The photographic plates used were 8 by 10 inches (20 x 25 centimeters) Special Red Label brand, made by the Hammer Dry Plate Co.

For the determination of the times of contact, a small telescope of 2 inches (5 centimeters) aperture was mounted just outside the opening in the barn.

ASSIGNMENT OF OBSERVERS

The observers were assigned as follows:

Rev. Woodman,

(1) Determination of times of contacts and general observations with the 2 inch refractor.

(2) Giving of warning signals.

(3) Manipulation of the cap exposing the photographic plates.

Mr. Kramer,

(1) Manipulation of the pyranometer.

(2) Observations of general phenomena.

Mr. Aldrich,

(1) Observing at the galvanometer.

(2) Manipulation of the camera driving mechanism and plate-holder slides.

A number of practise eclipses were carried through on Saturday morning to familiarize each with his duties.

OBSERVATIONS

(1) PYRANOMETER

Observations with the pyranometer both of the brightness of the sky alone and of the total sky and sun, were made on the afternoon of the eclipse beginning at about one o'clock of local summer time and continuing until after ten o'clock at night. These were made about every 15 minutes up to the beginning of the eclipse, their frequency then increasing as totality approached and again decreasing after totality. An observation of the brightness of the sky was made 2 minutes before totality and 15 seconds after totality, and of the total sky and sun 2½ minutes before and 1 minute after. During totality the glass hemisphere covering the pyranometer strip was removed and two determinations made of the outgoing radiation to space. In the course of the observations frequent calibrations were made with heating currents sufficient to give deflections of the same size as those recorded by the exposures to the sky and to the sky and sun. Also, at intervals readings were made of the water vapor pressure with a sling psychrometer.

On the afternoon of June 9, with a sky considerably clearer than June 8, similar though not so frequent observations were made for comparison.

After the work of the expedition was concluded, the pyranometer and ammeter were taken by the writer to the Smithsonian station at Mt. Wilson, Cal., and there comparisons were made with Secondary Pyrheliometer A. P. O. No. IV on the sun alone, for the purpose of determining the constant of the eclipse pyranometer. Five comparisons were made on June 26, and six on June 28, the mean of these giving a value 23.8 as the constant of the eclipse pyranometer when glass covered, and 22.6 with glass off. The computed value of the constant (glass covered) is 25.9. The discrepancy is not surprising when one considers the vicissitudes of the instrument since the computation was made early in 1916. The value 23.8 was adopted in reducing the readings to calories.[1]

NOTE BY C. G. ABBOT.—The value 22.6 stated by Mr. Aldrich as the constant of pyranometer No. 5, as used for nocturnal work, without the glass cover is determined by multiplying the day value, 23.8, by the fractions $\frac{92}{100}$ and $\frac{98}{95}$. The former fraction corrects for removing the hindrance to rays caused by two reflecting surfaces of glass, the latter represents an attempt to take account of the fact that the blackening of the pyranometer strip is less completely absorbing for long wave rays, such as are proper to a body at ordinary terrestrial temperatures, than for sun rays. This latter assumption is quantitatively very uncertain.

Dr. A. K. Ångström has lately published a paper entitled "Determination of the Constants of Pyrgeometers" (Arkiv för Matematik Astronomi och Fysik, K. Svenska Vetenskaps akademien, Band 13, No. 8, 1918). In this paper he explains clearly the methods and results of his recent investigation to fix the scale of the Ångström nocturnal radiation instruments, and gives the constant of Pyrgeometer No. 22, now with the Smithsonian solar constant expedition to Chile as 13.4.

Messrs. Moore and L. H. Abbot of the Chilean expedition made careful comparisons of that pyrgeometer with pyranometer S. I. No. 3, at Hump Mt., N. C., on several nights of 1917 and 1918. They found that if the same conventions adopted by Mr. Aldrich in computing the nocturnal radiation constant of the pyranometer were employed, and if we assume that as so used the pyranometer truly reads in calories, then the constant of Ångström pyrgeometer No. 22 is 9.8. Their value differs by 36 per cent of itself from Angström's, so that Angström's results are therefore much higher than ours.

I call attention to this glaring discrepancy, not intending to imply that the Smithsonian pyranometer scale of nocturnal radiation is right or that Ångström's pyrgeometer scale is wrong, but rather to hinder readers from accepting either scale as yet verified. Nocturnal radiation measurements can-

[1] See Smithsonian Misc. Coll., Vol. 66, No. 7, p. 7.

not, I believe, be put on a sound basis until an instrument for nocturnal radiation is perfected which employs as the radiating and absorbing member a hollow chamber, or so-called "absolutely black body." I believe the discrepancy above mentioned results from the facts that both the radiation and absorption of the sensitive strips of the pyranometer and pyrgeometer, and the radiation and absorption of the terrestrial atmosphere differ widely from being "perfect" for wave lengths exceeding 10 microns.

The reader *should not infer* that it is admitted that the scale of the pyranometer for *daylight* measurements with *glass on* is doubtful. Sunbeams and the brightness of the sky embrace rays almost wholly transmissible by glass, and for which the absorption of lamp black paint is well known. Furthermore, as a check to its computed constant the pyranometer with glass on is calibrated against the pyrheliometer.

In Tables 1A and 1B are summarized the observations of June 8 and June 9. Columns 2 and 3 give the calories of radiant energy reaching a square centimeter of horizontal surface per minute from the whole sky (the sun being shaded), and from the total sky and sun, respectively. Table 1C, showing the brightness of the sky for a typical Mt. Wilson day made with the same pyranometer, is added for comparison. Table 1A also gives the values of the outgoing radiation to space during totality and at night.

Tables 2A and 2B give values of the air mass and corresponding solar radiation in calories per square centimeter of surface normal to the radiation per minute all during the eclipse of June 8, and on the afternoon of June 9. These values are obtained by subtracting the total sky brightness from the total sun and sky brightness and dividing by the cosine of the zenith distance of the sun. Table 2C, giving similar values (obtained by pyrheliometry) for a typical Mt. Wilson day, is added for comparison.

TABLE 1A.—*June 8, 1918*

Hour angle (west)			Sky brightness	Sky and sun	Wet and dry bulb readings	Vapor pressure	Remarks
h.	*m.*	*s.*	(*Calories*)	(*Calories*)	(*F.°*)	(*mm. of mercury*)	
0	14	40	.349	....	....	....	Wind S. E.
	16	50	....	0.556	65.2	13.10	Clouds breaking, especially
	32	25	.388	....	76.0	....	in west. Sun shines in-
	34	25	....	1.597	....	....	termittently.
	40	05	.378	....	....	....	
	41	25	....	1.540	....	....	
	44	15	.381	....	....	....	
	45	05	....	1.556	....	....	
1	12	40	.217	....	....	....	
	13	45	....	1.300	....	....	
	15	45	.232	....	67.8	14.35	Cumulus clouds disappear-
	35	40	.250	....	79.5	....	ing. Strati-cirri devel-
	36	45	....	1.310	....	....	oping over whole sky.
	40	25	.235	....	....	....	
	41	25	....	1.333	....	....	
	46	05	.253	....	....	....	
	47	25	....	1.352	....	....	
2	13	45	.214	....	....	....	
	15	25	....	1.237	....	....	
	17	30	.218	....	68.0	14.17	
	44	20	.250	....	81.0	....	
	46	20	....	1.178	....	....	
3	14	10	.203	....	....	....	
	16	05	....	1.048	....	....	
	17	30	.203	....	68.2	14.30	
	27	50	.215	....	81.1	....	
	29	40	....	.972	....	....	Strati-cirri over whole sky.
	30	55	.214	....	....	....	Cumuli low in west and
	41	55	.195	....	....	....	east.
	44	05	....	.784	....	....	
	46	40	.177	....	....	....	First contact at $3^h\ 35^m\ 52^s$.
	54	55	.154	....	....	....	
	56	50	....	.682	....	....	
	58	0	.136	....	....	....	
4	06	55	.102	....	....	....	
	08	20	....	.502	....	....	
	08	55	.097	....	....	....	
	12	40	.0792	....	....	....	
	13	55	....	.397	....	....	
	15	10	.0742	....	68.7	14.20	
	21	55	.0514	....	81.0	....	
	23	10	....	.245	....	....	
	23	45	.0471	....	....	....	
	28	0	.0340	....	....	....	
	28	50	....	.163	....	....	
	29	35	.0302	....	....	....	
	33	45	.0188	....	....	....	
	34	10	....	.0864	....	....	
	34	45	.0181	....	....	....	
	35	10	.0140	....	....	....	
	40	25	.0031	....	....	....	
	40	55	....	.0167	....	....	
	41	10	.0017	....	....	....	
	43	30	—.145				Glass off. Eclipse total from $4^h\ 43^m\ 19^s$ to $4^h\ 44^m\ 41^s$.
	44	25	—.137				

TABLE 1A.—*June 8, 1918* (Continued)

Hour angle (west)			Sky brightness	Sky and sun	Wet and dry bulb readings	Vapor pressure	Remarks
h.	*m.*	*s.*	(*Calories*)	(*Calories*)	(*F.°*)	(*mm. of mercury*)	
	44	55	.0006	....	....	....	
	45	25	....	.0031	....	....	
4	45	50	.0019	....	....	....	
	49	25	.0088	....	....	....	
	49	55	....	.0305	....	....	
	50	30	.0119	....	....	....	
	55	10	.0283	....	65.0	13.43	
	55	50	....	.0871	74.0	....	
	56	10	.0333	....	....	....	
	59	25	.0493	....	....	....	
	59	55	....	.120	....	....	
5	0	25	.0528	....	....	....	Strati-cirri continue.
	04	50	.0721	....	....	....	
	05	25	....	.161	....	....	
	05	55	.0735	....	....	....	
	13	20	.1028	....	65.7	13.84	
	13	45	....	.268	74.6	....	
	15	25	.1063	....	....	....	
	30	55	.145	....	....	....	
	31	30	....	.324	....	....	
	32	05	.144	....	....	....	
	43	40	.148	....	....	....	
	44	10	....	.298	....	....	
	44	55	.1485	....	....	....	Fourth contact at $5^h\ 45^m\ 49^s$.
6	13	05	.1080	....	....	....	
	15	55	....	.131	65.1	13.58	
	15	55	.1022	....	73.7	....	Thick strati-cirri around horizon (which obscured sun soon after 6.44). Also streaked over whole sky. Very little wind.
	42	40	.0559	....	....	....	
	43	40	....	.0554	....	....	
	44	40	.0512	....	....	....	
							Sun below horizon.
7	20	25	.00371		....	....	Sunset $7^h\ 17^m$.
	21	10	.00295		....	....	
	22	55	.00231		....	....	
	24	25	—.0992		64.0	13.74	Glass off.
	56	30	.00193		69.6	....	Glass on.
	59	0	—.1066		....	....	Glass off.
8	34	30	0		....	....	Glass on.
	37	0	—.0907		....	....	Glass off.
9	19	0	—.0887		62.0	13.31	
					65.2	....	
							Sky apparently clear overhead, but clouds around horizon.

NOTE.—The negative values are the outgoing radiation from the earth to space, in calories per sq. cm. per minute.

TABLE 1B.—*June 9, 1918*

Hour angle (west)			Sky brightness	Sky and sun	Wet and dry bulb readings	Vapor pressure	Remarks
h.	*m.*	*s.*	(*Calories*)	(*Calories*)	(*F.°*)	(*mm. of mercury*)	
0	23	0	.1378	....	....	....	Sky clear except of some cumuli around horizon. Little wind.
	24	50	....	1.587	....	....	
	27	40	.1338	....	71.7	15.22	
	48	45	.1245	....	89.8	....	
	49	35	....	1.462	....	....	
	50	35	.1278	....	....	....	
1	21	25	.1126	....	....	....	
	22	10	....	1.333	....	....	
	23	10	.1142	....	....	....	Cumuli increasing somewhat.
	52	25	.1262	....	....	....	
	52	55	....	1.349	....	....	
	53	35	.1262	....	70.6	13.67	
2	21	0	.1228	....	92.0	....	
	21	35	....	1.223	....	....	
	22	25	.1145	....	....	....	Wind increasing.
3	14	15	.1109	....	....	....	
	14	45	....	1.033	....	....	
	15	45	.1178	....	70.0	13.89	
	45	30	.1145	....	89.0	....	
	46	0	....	0.909	....	....	
	46	45	.1042	....	....	....	
4	23	15	.0924	....	....	....	
	24	0	....	.712	....	....	
	24	45	.0952	....	67.7	12.42	
	36	30	.0895	....	87.0	....	
	39	05	....	.642	....	....	
	39	55	.0905	....	....	....	
5	57	45	.0855	....	67.8	12.85	Considerable cirri over whole sky.
	58	30	....	.311	85.5	....	
	59	25	.0885	....	....	....	

TABLE 1C.—*Mt. Wilson, Cal., Aug. 9, 1918*

Hour angle (west)			Sky brightness	Wet and dry bulb	Vapor pressure	Remarks
h.	*m.*	*s.*	(*Calories*)	(*C.°*)	(*mm. of mercury*)	
2	10	20	.0957	....	....	Some cumuli low in east. A little wind.
	16	0	....	13.8	7.17	
	38	10	.0928	24.8	....	
3	25	40	.0938	....	....	
	31		....	12.8	6.85	
4	18	0	.0826	22.7	....	
	44	50	.0776	....	....	
	49		....	11.2	6.30	
5	14	50	.0671	19.9	....	
	54	50	.0455	....	....	No wind.
6	01		....	9.0	4.33	
	20	50	.0281	19.2	....	
	37	50	.0141	....	....	
	45	05	.0085	....	....	Sun close to horizon.
	54	20	.0026	....	....	Sun below horizon.
7	0		....	6.6	2.41	
				18.3		

TABLE 2A.—*June 8, 1918*

Hour angle (west)			Air mass	Sun alone
h.	*m.*	*s.*	(*Sec. z.*)	(*Calories, normal surface*)
0	34	25	1.045	1.272
	41	25	.049	.217
	45	05	.051	.235
1	13	45	.078	.160
	36	45	.110	.185
	41	25	.117	.217
	47	25	.128	.241
2	15	25	.187	.211
	46	20	.279	.187
3	16	05	.398	.181
	29	40	.468	.112
(1st contact)				
	44	05	1.552	0.928
	56	50	.638	.880
4	08	20	.729	.695
	13	55	.777	.568
	23	10	.864	.3655
	28	50	.924	.2522
	34	10	.983	.1348
	40	55	2.065	.0295
(2d and 3d contacts)				0
	45	25	2.125	.0039
	49	55	.189	.0516
	55	50	.278	.1282
	59	55	.344	.1617
5	05	25	.440	.215
	13	45	.605	.427
	31	30	3.045	.548
	44	10	.467	.520
(4th contact)				
6	13	55	5.160	.129
	43	40	10.00	.019

TABLE 2B.—*June 9, 1918*

Hour angle (west)			Air mass	Sun alone
h.	*m.*	*s.*	(*Sec. z.*)	(*Calories, normal surface*)
0	24	50	1.039	1.508
	49	35	.053	.407
1	22	10	.086	.325
	52	55	.137	.391
2	21	35	.202	.327
3	14	45	.390	.277
	46	0	.560	.248
4	24	0	.868	.154
	39	05	2.068	.141
5	58	30	4.095	0.918

TABLE 2C—*Mt. Wilson, Cal., September 21, 1914**

Hour angle (east)			Air mass	Sun alone	Wet and dry bulb readings	Vapor pressure
h.	*m.*	*s.*		(*Calories, pyr. No. 4*)	(*C.°*)	(*mm. of mercury*)
1	49	50	1.348	1.529	....	....
2	0	0	.381	....	13.2	7.49
	47	50	.606	1.492	22.2	....
	51	0	.625	....	10.9	5.74
3	35	50	2.022	1.419	20.3	....
	42	0	.097	....	10.3	5.92
4	5	50	.47	1.366	18.4	....
	15	0	.97	....	7.1	3.06
	26	50	.97	1.297	17.7	....
	41	50	3.46	1.248	....	....
	52	0	4.00	....	6.2	2.48
	58	50	4.32	1.148	17.1	....
5	11	50	5.34	1.061	....	....
	15	50	5.76	1.027	....	....
	20	0	....	....	8.0 17.2	4.12

* See Smithsonian Misc. Coll., Vol. 65, No. 4, p. 14.

TABLE 3

Place	Altitude	Temperature	Vapor pressure	Nocturnal radiation
	(*Meters*)	(*Centigrade*)	(*mm.*)	(*Calories*)
Bassour, Algeria	1160.	18.8	12.57	.146
Mt. Wilson, Cal.	1730.	18.9	12.37	.143
Indio, Cal.	0.	24.1	10.3	.177
Mousaia Valley, Algeria	540.	19.6	8.0	.174
Lakin, Kan., during totality	900.	about 24.0	13.8	.145 .137
Lakin, Kan.	900.	20.9 18.4	13.7 13.3	.102 .090

(2) PHOTOGRAPHIC

Equal exposures of 70 seconds for each camera were made during totality by Father Woodman. The negatives were kindly developed, with Director Pickering's permission, by Mr. King at Harvard College Observatory. They show evidences of motion caused by the lack of opportunity to rate the driving clock accurately, but exhibit coronal streamers extending at least $2\frac{1}{2}$ solar diameters. These are much shortened in the accompanying reproductions.

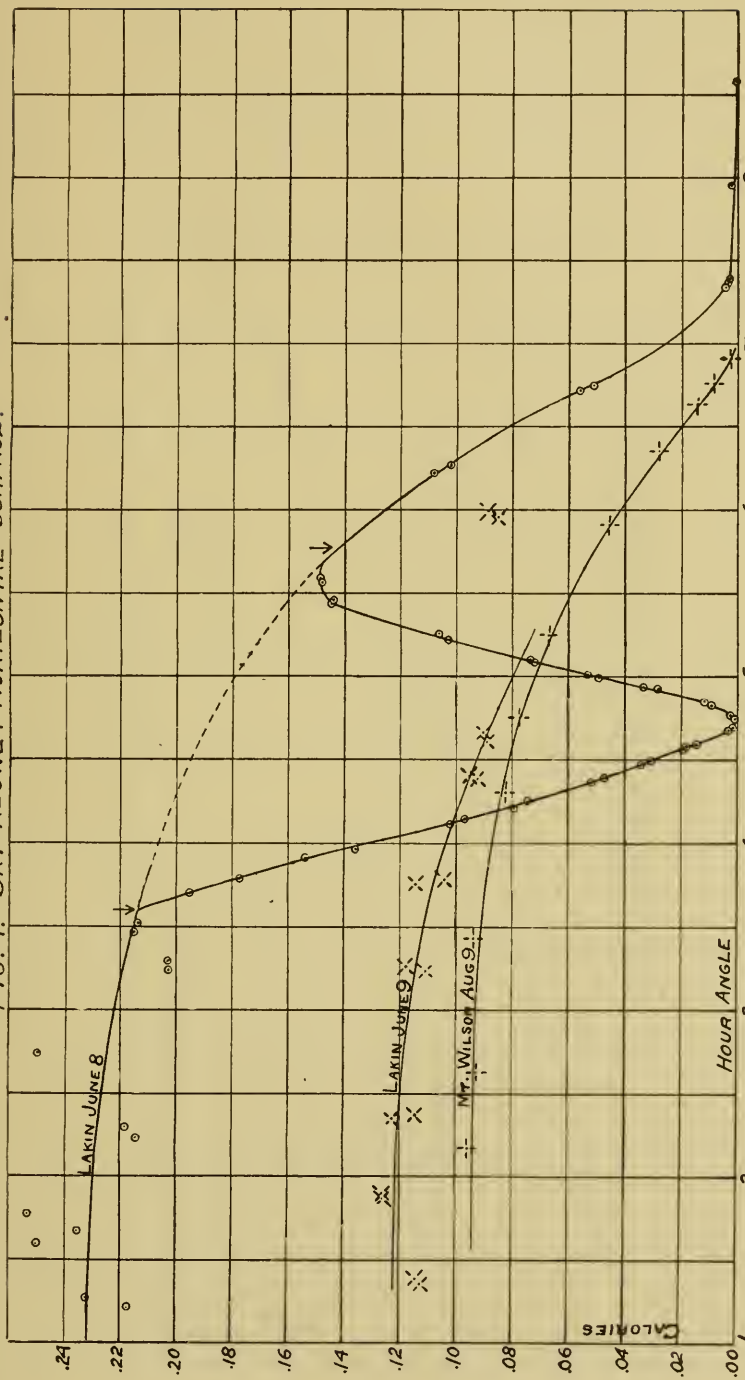
(3) TIMES OF CONTACT

Rev. Woodman obtained an accurate rating of his watch from Western Union noon signals during the week preceding the eclipse and each day comparisons were made with an excellent Hamilton watch of the Smithsonian Institution. The times of contact determined by Rev. Woodman follow:

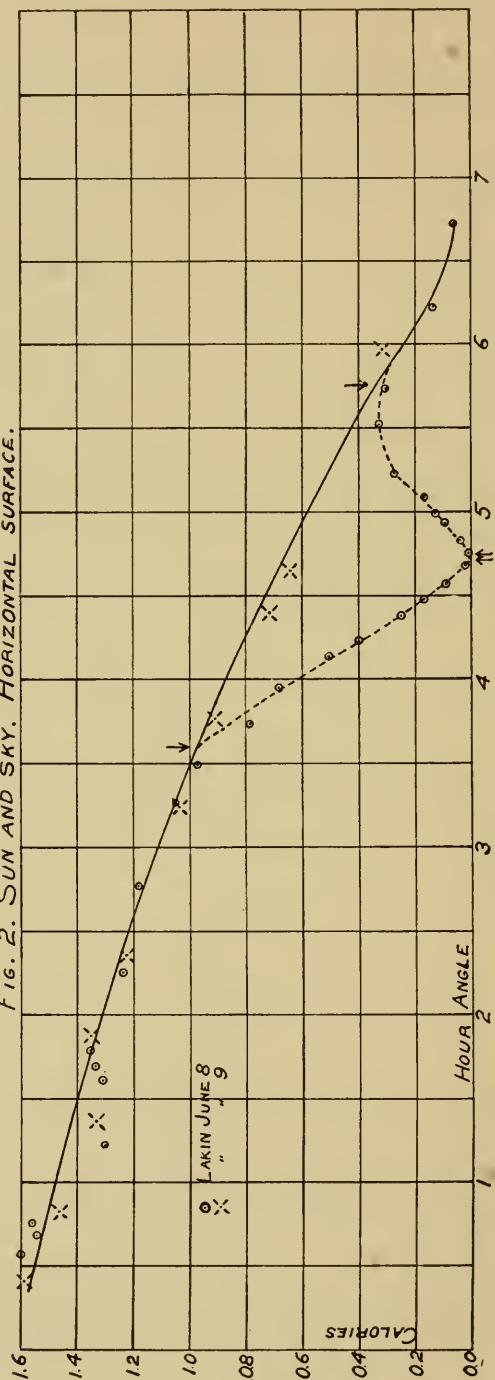
1st contact	$10^h19^m48.^s5$	G. M. T.
2d contact	11 27 15. 1	
3d contact	11 28 37. 3	
4th contact	12 29 45. 4	

(4) GENERAL OBSERVATIONS

The writer obtained only one short look at the total eclipse through a small window in the barn. He was profoundly astonished at the weird grandeur of the sight. Rev. Woodman and Mr. Kramer, both stationed out of doors, were impressed with the unusual darkness which prevailed, it being markedly greater than that which they experienced at Wadesboro, N. C., in 1900. Miss A. L. Loving, of St. Joseph, Mo., a spectator, reported seeing shadow bands distinctly in the direction northeast to southwest.



SKY RADIATION. TOTAL SOLAR ECLIPSE. LAKIN, KAN., JUNE 8, 1918.



SUN AND SKY RADIATION. TOTAL SOLAR ECLIPSE. LAKIN, KAN., JUNE 8, 1918.

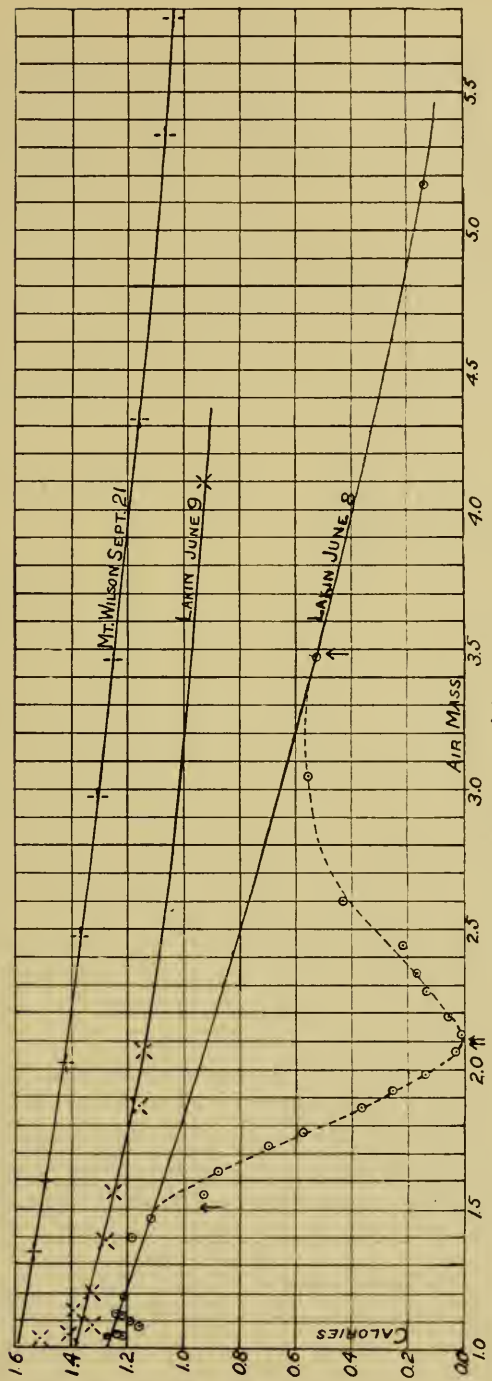


FIG. 3. SUN ALONE. NORMAL SURFACE.

SOLAR RADIATION. TOTAL SOLAR ECLIPSE. LAKIN, KAN., JUNE 8, 1918.

RESULTS

The results summarized in the tables are graphically shown in figures 1, 2, and 3. Figure 1 shows the relation between sky brightness and hour angle, figure 2 the total sun and sky brightness and hour angle, and figure 3 the intensity of solar radiation and air mass (secant of the zenith distance). The intensity of sky brightness on June 8 was nearly double that of June 9 due to the streaks of cirrus cloud which prevailed on the former day. On June 9 the sky was clear and blue during the afternoon up to an hour angle of about five hours. At this time, cirri similar to June 8 spread over the whole sky. This explains the deviation of the last two points on the curve of June 9 (fig. 1). The great deviations in sky brightness early on the afternoon of June 8 arise from the presence of cumulus clouds scattered over the sky. By the time the eclipse began the cumuli had practically disappeared and the values for the remainder of the day yield a surprisingly smooth curve.

It is apparent from these data that the total brightness of the sky during totality was less than that of the twilight one hour after sunset of the same day. From first contact to second during the eclipse the decrease in sky brightness was almost linear. The curves of figures 1 and 2, showing the relationship of sky and total sun and sky brightness to hour angle, are in their general form in agreement with those computed from theoretical considerations by King.[1] However, the ratio of sky brightness at large zenith distances of the sun to that at high sun is much smaller in the observed values than the ratio obtained from King's computed curves. In other words, the falling off of sky brightness as the sun approaches the horizon is considerably more rapid in both the Mt. Wilson and Lakin curves than would be anticipated from his theoretical considerations. It is probable that the presence of clouds low in the west on June 8 behind which the sun set made the after-sunset sky brightness values of that day lower than a clear sky would have shown.

Of the two values of the outgoing radiation to space obtained during totality, the second is smaller than the first, due to the rapid cooling off of the instrument and surrounding air and consequent decrease in temperature difference between the instrument and the space to which it is radiating. This agrees with the values obtained by Ångström[2] at the total eclipse at Åviken, Sweden, in 1914. Both

[1] Phil. Trans. Roy. Soc. London, Series A, 212, p. 429.

[2] "Radiation of the Atmosphere," A. Ångström, Smithsonian Misc. Coll., Vol. 65, No. 3, p. 74.

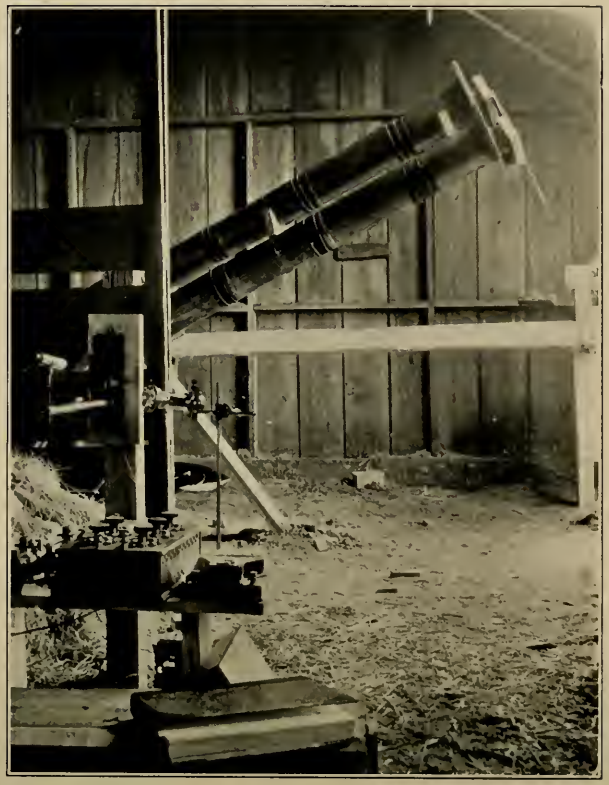
values are considerably in excess of the nocturnal radiation values obtained after dark the night following the eclipse, with humidity and sky conditions nearly identical. This was to be expected because of the higher temperature during totality. So far as can be seen from these values, they uphold the conclusion of Ångström that "the effective temperature radiation during the day follows the same laws as hold for the nocturnal radiation."

Table 3 is appended, showing values of nocturnal radiation found by Ångström with clear skies under varying conditions and comparing them with the Lakin values. That the latter are lower than Ångström's values may be due partly to the veiling effect of the thin cirrus clouds at Lakin, and partly to the difference in scales of nocturnal radiation above noted.

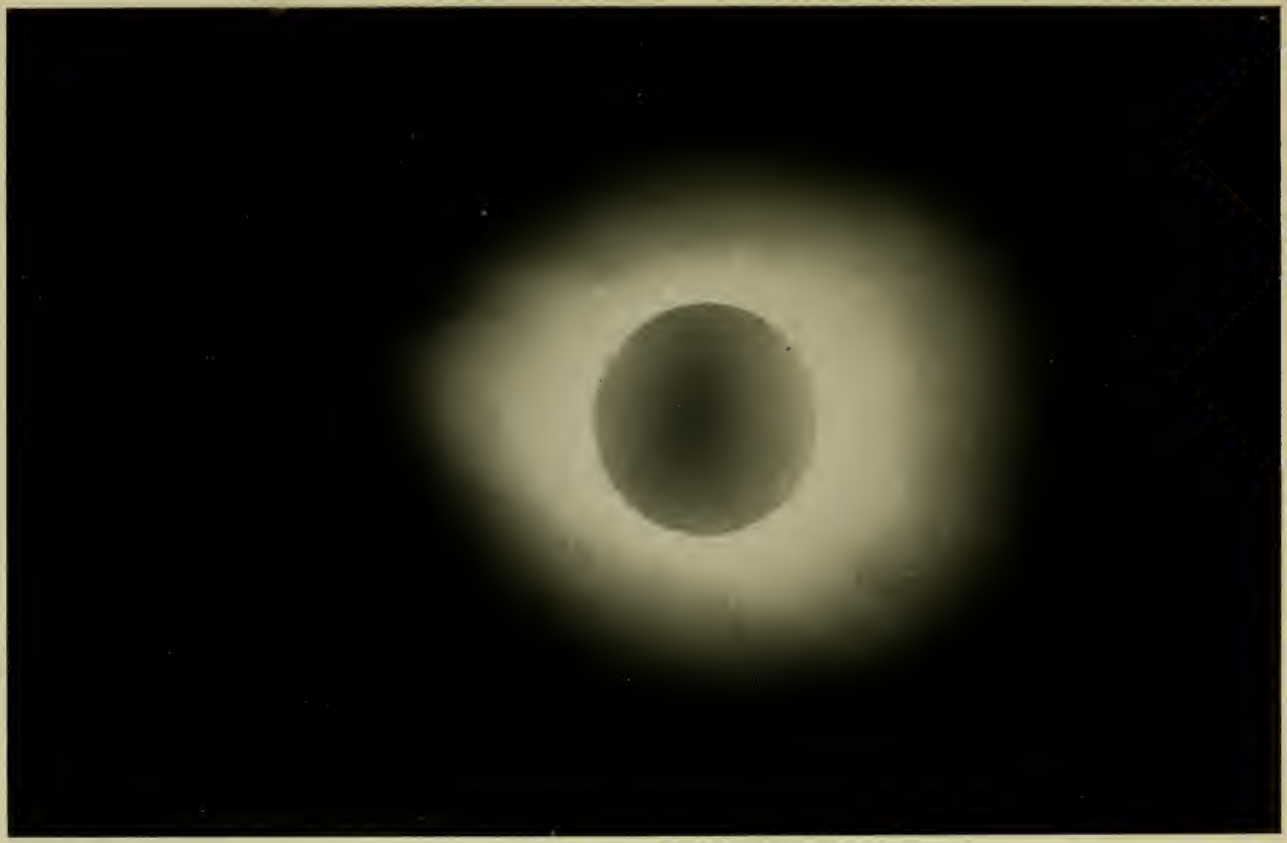
SMITHSONIAN OBSERVING SHELTER NEAR LAKIN, KANSAS.

EXTERIOR OF OBSERVING SHELTER SHOWING POSITION OF PYRANOMETER AND VISUAL TELESCOPE.

VISUAL AND PHOTOGRAPHIC TELESCOPES.



INTERIOR OF OBSERVING SHELTER.



TOTAL SOLAR ECLIPSE OF JUNE 8, 1918. 11-FOOT FOCUS CAMERA EXPOSURE 70 SECONDS. DEVELOPED TO SHOW EXTENSION OF CORONA.

TOTAL SOLAR ECLIPSE OF JUNE 8 1918. 11-FOOT FOCUS CAMERA; EXPOSURE 70 SECONDS. DEVELOPED TO SHOW PROMINENCES AND INNER CORONA.