TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY H. R. MORGAN FROM THE NEGATIVES.

PUBLICATIONS

OF THE

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SECOND SERIES.

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SUPERINTENDENT.

Rear-Admiral Asa Walker, U. S. N.

ASTRONOMICAL DEPARTMENT.

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ERRATA.

VOLUME IV, APPENDIX II—SECOND SERIES.

PAGE E 17, argument, eleventh column: For ° ″ read ° ′.

VOLUME IV, APPENDIX IV—SECOND SERIES.

Most of the following changes are due to information received since this appendix was put in plate:
PAGE G 8, in Table for the Conversion of Time,
fifth line, second column: For $+10^{h}\ 20^{m}\ 59^{s}$ read $+10^{h}\ 30^{m}\ 0^{s}$
third column: For $+\ 5\ \ 20\ \ 59$ read $+\ 5\ \ 30\ \ 0$
twenty-fourth line, second column: For $+4^{h}\ 23^{m}\ 40^{s}$ read $+4^{h}\ 23^{m}\ 15^{s}$
third column: For $-0\ \ 36\ \ 20$ read $-0\ \ 36\ \ 45$
PAGE G 12, second line from bottom of page, second column: For Madras read Greenwich.
third column: For $+10^{h}\ 20^{m}\ 59^{s}.1$ read $+10^{h}\ 30^{m}\ 0^{s}$
fourth column: For $+\ 5\ \ 20\ \ 59.1$ read $+\ 5\ \ 30\ \ 0$
PAGE G 13, forty-first line, third column: For $+4^{h}\ 23^{m}\ 39^{s}.5$ read $+4^{h}\ 23^{m}\ 15^{s}.3$
fourth column: For $-0\ \ 36\ \ 20.5$ read $-0\ \ 36\ \ 44.7$
PAGE G 15, twentieth line: For meridan read meridian.
PAGE G 17, under British Empire—India add:

The Indian Government has officially adopted standard time of the meridian of longitude 82° 30′ east from Greenwich for the Indian peninsula, beginning January 1, 1906. In Burma standard time of the meridian of longitude 97° 30′ east from Greenwich has been adopted by the Telegraph Administration.

Opposite Indian peninsula, insert in third column $+10^{h}\ 30^{m}\ 0^{s}$
in fourth column $+\ 5\ \ 30\ \ 0$
Opposite Burma, insert in third column $+11^{h}\ 30^{m}\ 0^{s}$
in fourth column $+\ 6\ \ 30\ \ 0$

PAGE G 22, under Portugal: For the entire paragraph read:

Standard time is in use throughout Portugal and is based upon the meridian of Lisbon Observatory (9° 11′ 10″). It is established by the Royal Observatory in the Royal Park (Tapada) at Lisbon, and from there sent by telegraph to every telegraphic station throughout Portugal. Clocks on railway platforms are five minutes behind standard time, while clocks outside of stations are true. The adoption of Western European time (Greenwich mean time) is expected soon.

first line, third column: For $+4^{h}\ 23^{m}\ 39^{s}.5$ read $+4^{h}\ 23^{m}\ 15^{s}.3$
fourth column: For $-0\ \ 36\ \ 20.5$ read $-0\ \ 36\ \ 44.7$
PAGE G 28, twenty-sixth line: For Manilla read Manila.

PAGE G 7, in Table for the Conversion of Time, China
PAGE G 9, second paragraph
PAGE G 13, China (east coast)
PAGE G 18, China
Correct in accordance with the following quotation:

"The Central Government of China has made no authoritative statement in regard to the adoption of Zone Time. But, by the joint action of the Imperial Telegraph Administration, the Imperial Maritime Customs, the Imperial Postal and Railway Services, Zone Time, using the Greenwich Meridian as a datum, has practically been adopted all over the Empire.

"The idea of Zone Time in certain of the Ports in China was initiated by the Zikawei Observatory, and it came fully into operation on the 1st of August, 1905."

APPENDIX I.

TOTAL SOLAR ECLIPSES

OF

MAY 28, 1900, and MAY 17, 1901.

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TOTAL SOLAR ECLIPSE OF MAY 28, 1900.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901.

LIST OF PLATES.

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[a] The original drawing was lost at the office of the engraver before the plate was made

TOTAL SOLAR ECLIPSE

OF

MAY 28, 1900.

INTRODUCTORY REMARKS.

The observation of the total solar eclipse of May 28, 1900, by the Naval Observatory was rendered possible by an appropriation of $5,000 contained in an act making appropriations to supply urgent deficiencies, approved February 19, 1900.

The arrangements for the observation of this eclipse were made by Prof. of Math. S. J. BROWN, U. S. N., then Astronomical Director, acting under the authority of the then Superintendent, Capt. C. H. DAVIS, U. S. N. Several scientists not connected with the Observatory were consulted regarding the preparations, some of whose suggestions in regard to methods and the construction of apparatus were adopted.

In equipping two stations on the central line—one in North Carolina and one in Georgia—the intention was merely to duplicate the work so as to lessen the danger arising from cloudy weather. Most of the spectroscopic work of the Georgia station was located at a point near the northern limit of totality so as to secure as long an exposure as possible on the reversing layer.

The general plan of observation included a determination of the longitude of each station by exchange of telegraphic signals with the Naval Observatory and a determination of the latitude by TALCOTT'S method. Longitude signals were also exchanged between the Naval Observatory at Washington and the eclipse station of Prof. ORMOND STONE, of the University of Virginia, at Winnsboro, S. C. The observations at Washington were made with the 9-inch transit circle by Mr. E. A. BOEGER, the details of which may be found in Publications of the United States Naval Observatory, Second Series, Volume IV, Part 1.

The instruments were shipped from Washington on the Seaboard Air Line Railroad in two freight-cars, one for the North Carolina station and the other for the Georgia station.

In response to the request contained in the Supplement to the American Ephemeris, 1900, numerous reports of observations made during the total solar eclipse of May 28, 1900, have been received, and from these have been selected the miscellaneous reports that form a part of this appendix.

REPORT

OF THE

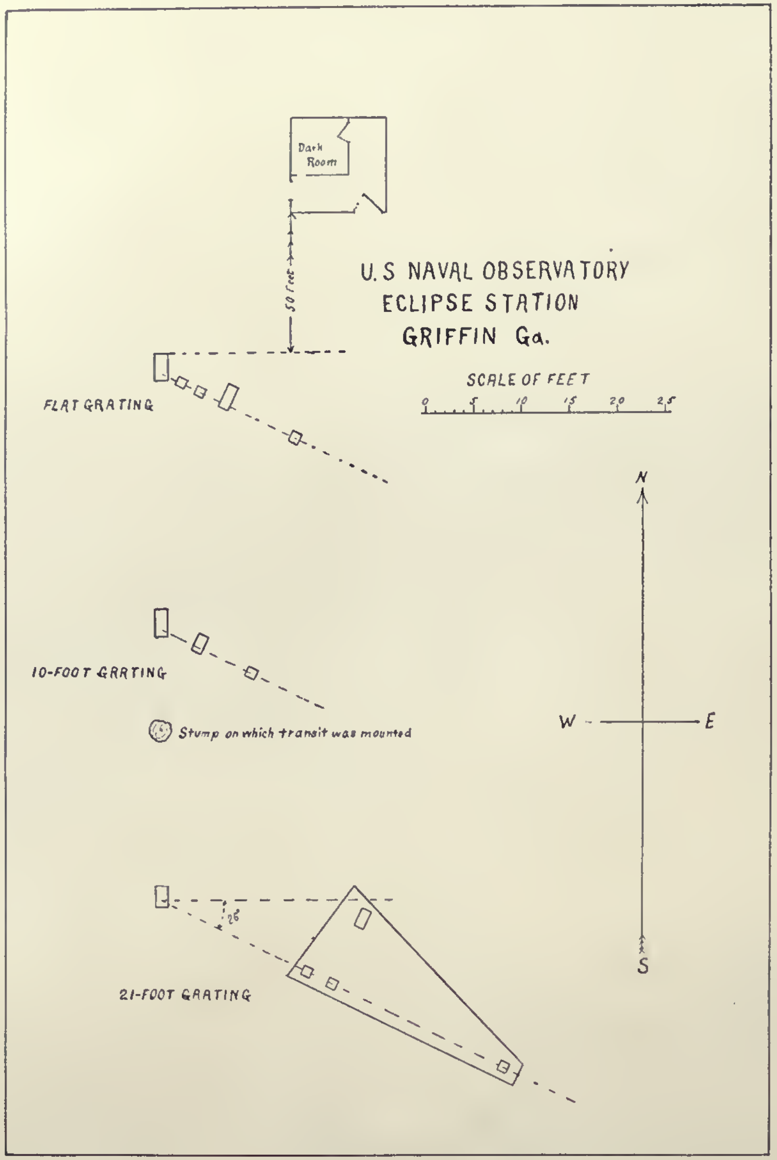
U. S. NAVAL OBSERVATORY ECLIPSE EXPEDITION

TO OBSERVE THE

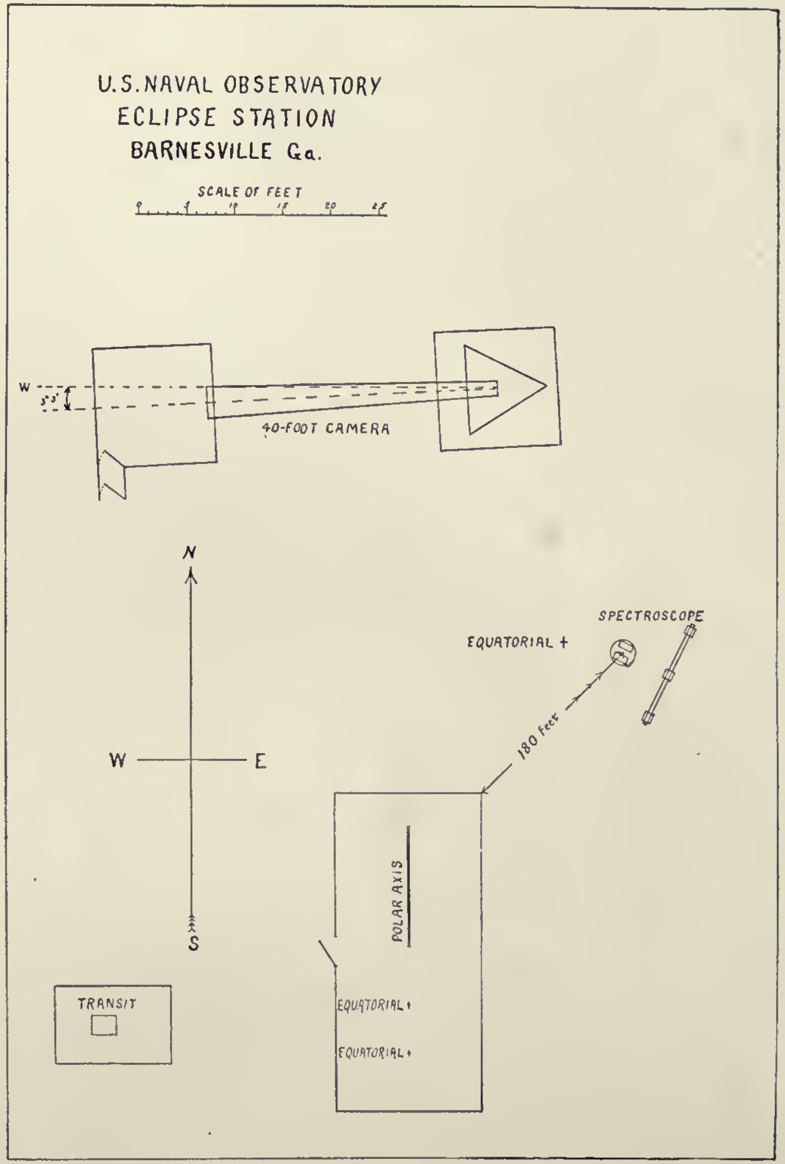
TOTAL SOLAR ECLIPSE OF MAY 28, 1900,

AT

BARNESVILLE AND GRIFFIN, GEORGIA.



Drawn by W. W. Dinwiddie.



Drawn by W. W. Dinwiddie.

GENERAL REPORT

OF THE

BARNESVILLE AND GRIFFIN STATIONS.

Professor of Mathematics MILTON UPDEGRAFF, U. S. N., in charge.

On April 23 the Astronomical Director of the U. S. Naval Observatory informed Prof. of Math. MILTON UPDEGRAFF, U. S. N., who up to this time had had but little to do with the eclipse preparations, that he would be called upon to take charge of the eclipse stations at Barnesville and Griffin, Ga.

Professor BROWN had already visited Barnesville, in order to inform himself with reference to the local conditions there, and it was soon decided to select some point near that town for the main station, and also a point near Griffin, 20 miles north of Barnesville, as the place for spectroscopic work, which could be done best near the edge of the shadow belt on account of the longer exposure of the gases which are only slightly elevated above the photosphere of the Sun.

Professor UPDEGRAFF was to select the locations of the stations at Barnesville and Griffin, and to have charge of the work at these two places. The station at Griffin was to be located from 2 to 4 miles inside the edge of the shadow path.

Assistant Astronomers G. A. HILL and F. B. LITTELL and Photographer G. H. PETERS had been detailed to assist in preparing for and observing the eclipse, and G. F. COULON, an employee of the Observatory, to aid in mechanical work and in packing and unpacking instruments.

It was Mr. HILL'S special duty to make the determinations of latitude and longitude. For this purpose he was provided with a combined zenith telescope and transit instrument, STACKPOLE No. 1502.

Mr. LITTELL was to make the astronomical adjustments of the 40-foot camera and polar axis.

Mr. PETERS was to focus the photographic instruments and do the photographic work.

The work of these gentlemen, however, was not strictly confined to the specific lines stated above.

GRIFFIN STATION.

Griffin is a thriving town of 7,000 inhabitants. It has several large cotton mills, and is surrounded by a cotton-growing region.

Professor UPDEGRAFF and Mr. HILL, leaving Washington on May 1, arrived at Griffin on May 2, about 6 p. m. That night was cloudy, but they succeeded in getting the latitude within a few seconds by sextant observations of the altitude of α Ursæ Minoris. During the next day they set up the transit instrument, and that night secured fairly accurate observations for time and latitude. Comparisons at the railway station of the chronometer, NEGUS No. 1295, with the noon signals from Washington gave the longitude. The approximate coordinates of the place of observation, within a few hundred feet of the Central of Georgia Railway station in Griffin, thus determined, are

Latitude $=+33^\circ 15' 10''$.
Longitude $=0^h 28^m 46^s.6$ west from Washington.

These results showed, by reference to the map of the shadow path published by the American Ephemeris and Nautical Almanac, that in order to locate the station sufficiently near to the edge of the shadow path it would be necessary to go a mile or two farther to the north or northwest. It was found on inquiry that the Georgia State Experiment Station is located in that direction from Griffin and at about the required distance. While preparing to drive out to examine the grounds Col. R. J. REDDING, the director of the experiment station, called at the hotel, accompanied by Prof. A. L. QUAINTANCE, one of the scientific staff of the station. These gentlemen kindly offered to assist in every way possible. On examination of the ground a site for the station was selected in a cornfield near the farmhouse of Mr. J. B. STOREY, about three-fourths of a mile northwest of the buildings of the Experiment Station. Within 30 yards was an old redoubt or earthwork, which had been thrown up during the latter days of the civil war to resist the advance of General SHERMAN'S army. It is an elevated spot, and although but little higher than the ground in the immediate neighborhood, it commands a fine view of the country for 15 or 20 miles around.

In the meantime Mr. LITTELL and Mr. PETERS had arrived from Washington. The instruments were removed to the station from Griffin, and Mr. HILL and Mr. LITTELL commenced the work of determining the latitude and longitude.

On May 8, Mr. LITTELL went to Barnesville, while Mr. HILL remained until May 19.

During his stay at Griffin, Mr. HILL not only determined the latitude and longitude, but also at the same time superintended the location and erection of the piers for the various instruments and the construction of the dark room for the use of the observers at that station. Thirteen brick piers were built for the spectroscopic work. Five of these were for the use of Prof. HENRY CREW and his assistant, Doctor TATNALL, both of the Northwestern University, at Evanston, Ill. Three were for Mr. L. E. JEWELL of Johns Hopkins University and his assistant, Dr. S. A. MITCHELL, of Columbia University. The five remaining piers were for Dr. W. J. HUMPHREYS and his assistant, Mr. W. W. DINWIDDIE, both of the University of Virginia.

The instruments are described in the individual reports.

Professor UPDEGRAFF visited the station from time to time during the progress of the work, and was at all times in communication by telephone with Mr. HILL.

By May 19, with the exception of Mr. JEWELL who arrived on May 24, all of

THE POLAR AXIS SHED AT BARNESVILLE, GA.

Photographed by G. H. Peters.

the party who were to observe the eclipse there had arrived and were engaged in preparing for the day of the eclipse. Accommodations for all were provided in the homes of Colonel REDDING and others of the staff of the Georgia Experiment Station, whose kind helpfulness during the entire stay in Georgia is gratefully remembered.

BARNESVILLE STATION.

On the evening of May 5, Professor UPDEGRAFF and Mr. PETERS left Griffin for Barnesville. They were met in Griffin by Mr. OTIS A. MURPHY, a member of the Barnesville Board of Trade, and Mr. ER LASHÉ, editor of the Barnesville Gazette, who accompanied them to Barnesville. The party was met at the station by the mayor, Mr. J. L. KENNEDY, and several of the board of aldermen, who welcomed the eclipse expedition to the city and offered to help the members in their work.

Barnesville was found to be a pleasant town of 3,000 inhabitants, situated in a beautiful agricultural region on the line of the Central of Georgia Railway between Atlanta and Macon. The Magnolia Inn became the headquarters of the party during its stay. On the following morning Messrs. MURPHY and LASHÉ came to the hotel with carriages and drove the party about the environs of Barnesville in search of the best place for the station. The first place visited was an eminence known as Reservoir Hill, about 1½ miles slightly east of north of the city. This hill is about 165 feet higher than the town. The reservoir of the city waterworks is situated on its summit, a point which on a clear day commands a magnificent view of the country for 20 or 30 miles in all directions. Some of the outlying foothills of the Blue Ridge Mountains are visible toward the west, points on which the advancing shadow of the Moon might be seen perhaps 15 or 20 seconds before its arrival. The people of Barnesville had already decided by common consent that Reservoir Hill was the best place for the station, its elevation being regarded as the controlling factor.

But in the time at our disposal convenience of location was of great importance. There were no accommodations by way of board and lodging near Reservoir Hill, and we were not provided with a camping outfit. In view of the shortness of the time it seemed advisable to choose a more accessible location for the station. After visiting several other places, it was decided to locate on a rocky and wooded hill about one-half of a mile east of the town and 35 feet higher, in an inclosed field on the farm of Mr. P. F. MATTHEWS. This hill is of the form known as a hog's back, running from northeast to southwest. It commands a good view toward the east and is higher than any other ground within a mile or so. The trees covering the ground are chiefly pine and oak with rather thick underbrush. While sufficient to afford shade and protection from the wind, the larger trees were not so thick as to obscure the horizon too much. The surface of the ground is strewn with rocks and bowlders of burrstone, so called from its being used, on account of its flinty character, to make the burrs or grinding stones of gristmills. A place was easily found which was reasonably level, with an abrupt slope to the northwest, near by, which would be convenient in mounting the tube of the 40-foot camera. The situation was rather secluded, free from dust, smoke, and harmful radiation from bare ground, had a good horizon toward the east, and was easily accessible. It was, in fact, an ideal place for the station, except, perhaps, that there might have been some advantage in a greater elevation.

Mr. MURPHY obtained the consent of Mr. MATTHEWS, the owner, for the use of the ground. The brush was cleared away that day, and a meridian line laid down that night by observations of α Ursæ Minoris with an engineer's transit instrument which we had carried with us. On the following day the ground was laid out for the scaffold and dark room for the 40-foot camera, for the shed for the polar axis, and for the observing tent for the transit instrument. Capt. A. O. BENNETT, of Barnesville, a contractor, was engaged to provide materials and erect the buildings. He did the work rapidly and well, and for a moderate price.

The polar axis shed fronted east, was 15 by 33 feet on the ground, and built of pine boards. The eastern slope of the roof was longer than the western. The former was covered with a large piece of canvas and the latter with boards covered with tar paper. This shed was to contain the two 5-inch equatorial telescopes, CLARK No. 858 and CLARK No. 863, as well as the polar axis.

The scaffold and tripod of the 40-foot camera were both 18 feet high, the former 12.5 feet square on the ground, while the feet of the latter made an equilateral triangle 9.5 feet on a side. They were built of pine timbers and were strongly braced and guyed with telegraph wire. The tripod was within the scaffold and was for the support of the 40-foot camera lens while the scaffold was for the support of the 40-foot camera tube.

The altitude of the Sun at mid-totality on May 28 had been computed to be 37° 17′ and the azimuth 3° 3′ north of east. The focal length of this camera is 39.0 feet. In order that the tube should be elevated to the correct altitude, it was necessary that the top of the tripod should be 23.5 feet higher than the center of the plate-holder and 31 feet distant in a direction 3° 3′ north of east. Five and one-half feet in the height of the scaffold were saved by the slope of the hill, and this diminished height gave greater freedom from wind shake.

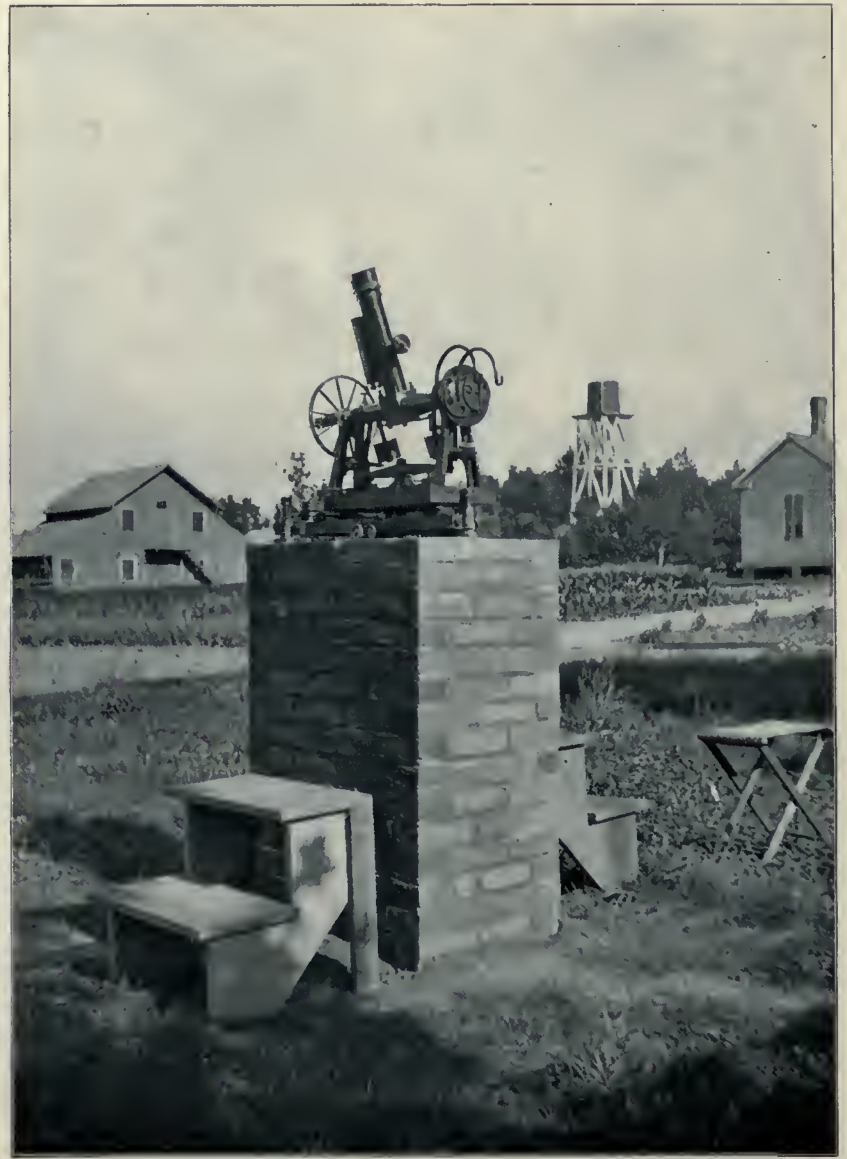
Mr. LITTELL came from Griffin on May 8, leaving Mr. HILL to continue his work alone.

On May 9 Prof. H. C. LORD, of the Ohio State University, Columbus, Ohio, who had been invited to become a member of the eclipse party, arrived at Barnesville, and chose a location about 180 feet northeast of our buildings. He furnished the greater part of his instrumental outfit. Brick piers were erected for him, and everything possible was done to facilitate his work. He in turn rendered us valuable assistance.

The freight car arrived from Washington on May 9. The polar axis shed was ready to be used as a shelter for freight, and the car was unloaded and its contents hauled to the station on the morning of May 10, and from that time the work of setting up and adjusting the instruments was pushed forward as rapidly as possible. Numerous difficulties were encountered in adjusting the polar axis and the tube of the 40-foot camera in their proper positions. We were fortunate, however, in having good weather and hearty cooperation on the part of all who could in any way promote the success of the expedition. There was much to contend with in the faulty construction of the polar axis and the slide for the plate-holder of the 40-foot camera.

THE 40-FOOT CAMERA AT BARNESVILLE, GA.

Photographed by G. H. Peters.



THE COMBINED ZENITH TELESCOPE AND TRANSIT INSTRUMENT, STACKPOLE NO. 1502.

Photographed by W. W. Dinwiddie.

The former was lacking in rigidity, although its supports were firm, and it was rather heavily built of 2-inch pine planks. But the chief cause of this trouble was lack of stiffness in the long arm, consisting simply of a 2-inch gas-pipe 10 feet long, by means of which it was moved by the clepsydra in hour angle. This difficulty was partially, but by no means wholly, overcome by strengthening this arm with a truss of telegraph wire. The two clepsydras, furnished for driving the polar axis and the plate-holder of the 40-foot camera, gave a great deal of trouble. They were, however, finally made to work fairly well, principally through the skill of Mr. T. C. SCHNEIDER, an expert mechanic from Johns Hopkins University, who joined the party at Barnesville on May 18.

On May 18 Prof. of Math. S. J. BROWN, U. S. N., Astronomical Director of the Naval Observatory, arrived in Barnesville, accompanied by Mr. C. A. POST, of New York, a volunteer member of our party. Without relieving Professor UPDEGRAFF of his duties as the officer in charge of the station, Professor BROWN took part in the work of preparing for the eclipse. He remained until May 27, when he went to the Griffin station to observe the eclipse from that point.

Mr. HILL came to Barnesville from Griffin on May 19, bringing his longitude and latitude outfit with him, and proceeded to determine the position of the station. The Western Union Telegraph Company ran a loop to the station so that signals could be exchanged with Washington for longitude. The results of Mr. HILL'S observations are appended in a separate report.

On May 24 Prof. of Math. J. R. EASTMAN, U. S. N. (Retired) a member of our party and a veteran eclipse observer, arrived. Professor EASTMAN gave us the benefit of his large experience and aided us materially in the work.

On May 25 Prof. of Math. T. J. J. SEE, U. S. N., arrived in Barnesville from Washington, accompanied by Prof. J. N. HART, of the University of Maine, Orono, Me.

Prof. OTIS ASHMORE, of Savannah, Ga., a volunteer member of our party, arrived on May 26.

The reports of these gentlemen are appended.

Besides our own party there were two other parties of astronomers who came to observe the eclipse in Barnesville. One was in charge of Prof. C. L. DOOLITTLE, of the University of Pennsylvania, and the other was in charge of Prof. M. B. SNYDER, of the Philadelphia Observatory.

About May 22 two Dutch astronomers, Doctor WILTERDINK, of Leyden, and Doctor NIJLAND, of Utrecht, visited the stations at Barnesville and Griffin. They went from Barnesville to Thomaston, Ga., and observed the eclipse from that point.

EQUIPMENT AT BARNESVILLE.

The 40-foot camera.—The lens selected for use at the Barnesville station was one of those made by CLARK for the Transit of Venus Expedition in 1874. It is of 5 inches aperture, and its focal length, as determined at the Naval Observatory before leaving for Barnesville, is 467.6 inches at 67° Fahrenheit. This determination was made by photographic trails of α Bootis on inclined plates.

The lens was mounted on a lens board with flange and collimating screws, the board itself being capable of adjustment vertically, horizontally, and with respect to the angle of elevation. This board was secured to the top of the inner scaffold and was joined to the tube of the 40-foot camera by a flexible connection of black cloth.

The tube consisted of a gas-pipe frame 18 inches square at its upper end and 36 inches square at its lower end. In the middle of each section of the frame were wooden braces, and additional rigidity was given to the whole by diagonal wires tightened by turn-buckles and acting as trusses.

This frame carried a white canvas tube lined with black cloth and furnished with several black cloth diaphragms to intercept stray or reflected light.

The dark room was a frame structure 12 feet square, with an ell 3 feet square at the southwest corner in which were double doors, permitting entrance at any time without the admission of light. The dark room was covered outside with building paper to insure its being light proof.

The supporting frame of the plate-carriage rested on brick piers insulated from the floor. Conveniently at hand in the northeast and southeast corners of the room shelves were built. On one shelf the plates to be used for the eclipse were stored, and after exposure they were transferred to the other.

The plate-carriage was made by Mr. G. N. SAEGMULLER according to designs of Mr. PETERS. It consisted of two strong castings of aluminum for the top and bottom, with a central bolt acting as a pivot in the upper one and two bolts acting in slots at each side of the bottom one. These allowed a small change of position angle to the plate for final adjustment. Two strong steel bars were bolted through these castings, forming the sides of the carriage. Into these bars the steel guide rails were set in a planed groove. These rails were about 18 inches apart and shaped to follow the curvature of the path of the Sun's image in the focal plane. The plate-carrying part of the device was of wood, and so arranged that 14 by 17 plates would rest upon three brass ledges.

The carriage had three wheels running on the rails above described and in the same plane. On one side were two, one at each end, and on the other side one in the middle. The single wheel was provided with a spring which kept all the wheels firmly pressed against the tracks. When this apparatus was tested the motion of the carriage was found to be somewhat irregular, owing to unevenness in the finish of the rails, but this was satisfactorily remedied by Mr. T. C. SCHNEIDER.

The carriage was designed to fall by its own weight, but its rate of motion was controlled by a clepsydra. This was arranged so that the piston moved upward parallel to the downward motion of the plate-carriage, to which it was connected by a wire passing over a simple pulley. The clepsydra had a micrometer valve for regulating its rate. It had also a stop-cock, so that after the micrometer was properly regulated it was only necessary to turn on the stop-cock to set the carriage in motion at the proper speed.

The plate-carriage was fastened firmly upon an inclined framework of heavy scantling, which in turn rested upon the three brick piers. This framework was about 2 feet back from the end of the tube, leaving sufficient room for manipulating the plates. The inclination was such that the carriage would move parallel to the focal plane.

The position of the focal plane was determined approximately by measuring the proper distance from the lens with a steel tapeline. This approximation was corrected by examination of the Sun's image on a screen through blue glass and afterwards by photographic trails of β Herculis made on an inclined plate. As satisfactory trails could not be obtained with the plate stationary, the plate was run at half speed, and then trails of β Herculis and several other stars were obtained on the same plate.

The lens and plate were collimated with respect to each other by reflected images of a small flame. The glass side of a dry plate was used on the plate-carriage for this purpose.

The position of the Sun's image on the plate for the day of the eclipse was determined from observations of its image on preceding days, proper allowance being made for the Sun's motion in declination in the intervening interval.

Exposures during the eclipse were made by means of a flap shutter, constructed principally of sheet-iron. This was attached to the end of the gas-pipe frame, which projected a few inches beyond the lens. The sheet-iron flap was hinged at the top to a piece of the same material about 18 inches square, covering the end of the tube and containing a 7-inch circular aperture with its center on the line of sight. Connected with the flap was an arm with a leverage of about 6 inches. This was set at an angle to give the best results, and was connected to the dark room by a wire passing through screw eyes as guides. A small coil spring was arranged so as to be extended when the shutter was opened and served to give additional impetus when it was closed. A pull upon the wire from the dark room served to open the shutter, and the weight of the flap and the action of the spring closed it promptly at the end of each exposure. This shutter was constructed principally at the shop of a tinsmith in Barnesville, and its performance was excellent.

The polar axis.—The polar axis was about 11 feet long, the cross-section being a square about 1 foot on a side. It was constructed of pine boards and at each end were axes arranged to turn in roller bearings. A low triangular frame resting on a bed of cement carried the lower end and received the thrust. A large tripod with legs extending down to bed rock a few feet below the surface of the ground carried the upper end. The axis was put in adjustment so as to point to the celestial pole and motion for following was given by a clepsydra connected with the axis by a gas-pipe arm about 10 feet long.

Upon the axis were mounted five cameras.

(1) A camera of 80 inches focal length, using a 6-inch telescope objective and photographic corrector, the property of Mr. C. A. POST, of Bayport, N. Y. This was focused by star trails.

(2) A camera of 104 inches focal length using a 6-inch telescope objective with a color screen consisting of a cell filled with a solution of picrate of copper, recommended by Mr. JEWELL. This screen cuts off both ends of the spectrum. This was to be used with CRAMER isochromatic instantaneous plates, with which there should not be a great loss in rapidity. This was focused visually on sun-spots.

(3) A camera known as 6.A. DALLMEYER of 33 inches focal length and 6 inches aperture focused by star trails.

(4) A camera, 4.B. DALLMEYER, of 17 inches focal length and 4 inches aperture focused by star trails.

(5) A camera, 3.C. DALLMEYER, of 9½ inches focal length, and 3½ inches aperture, which was used with a color screen and plates similar to those used on (2), and which was focused visually upon stars.

The equatorial telescopes.—Two 5-inch equatorials, CLARK No. 858 and CLARK No. 863, originally constructed for the use of the Transit of Venus Expedition in 1874, were set up for visual observation of the chromosphere, prominences, corona, etc. These equatorials are portable and are adjustable to any latitude, and each is furnished with divided circles and clock-motion. The clock-motion is regulated by a BOND spring governor. They have solar eyepieces and graduated shade-glasses.

A 6-inch equatorial belonging to Professor ASHMORE, and described in his report, was used by him in observing the contacts and the corona.

The spectrograph.—The prism spectrograph used by Professor LORD is described in his report.

On Saturday night, May 26, the preparations for observing the eclipse were almost complete. The tube of the large 40-foot camera had been directed to that point in the sky where the Sun would be at the time of totality, and the plate-holder had been adjusted in the focal plane of the lens and in such a position that the Sun's image would fall on the center of the plate. The polar axis had been adjusted parallel to the axis of the Earth and the five cameras, already described, which were mounted on it had been adjusted in focus and direction. The clepsydras of both the polar axis and the 40-foot camera had been made to work fairly well and to run at the proper rate. The two 5-inch equatorials, CLARK No. 858 and CLARK No. 863, which were set up in the polar-axis shed, had been put in adjustment and all the numerous mechanical fixtures had been put in readiness.

ASSIGNMENTS FOR ECLIPSE DAY.

The duties of the various members of the party on the day of the eclipse were arranged as follows:

Professor EASTMAN to observe the corona with the 5-inch equatorial, CLARK No. 863.

Professor SEE to observe the coming of the shadow and to draw the corona, together with Professor HART, at their station on Reservoir Hill, using a 4-inch comet seeker.

Professor UPDEGRAFF to observe the corona with the 5-inch equatorial, CLARK No. 858, to observe the times of second and third contacts, and to give the signal at beginning of totality for commencing work with the photographic instruments.

Mr. HILL to point the long focus finding telescope on the polar axis, and to give the signals for uncapping the cameras when all jar or movement which had been communicated to the axis by the drawing of the slides of the plate-holders had subsided. Also to observe with the 5-inch equatorial, CLARK No. 858, the times of first and fourth contacts.

Mr. LITTELL to take charge of the manipulation of the cameras on the polar axis, and to give the signals for drawing slides, and capping and regulating the times of exposure. At the invitation of Professor EASTMAN he was also to observe the first and fourth contacts with the 5-inch equatorial, CLARK No. 863.

Mr. PETERS, assisted by Mr. SCHNEIDER, to make the exposures in the dark room of the 40-foot camera.

Mr. COULON to operate the clepsydra of the polar axis.

Mr. POST to manipulate the plate-holder of his 80-inch camera, which was mounted on the polar axis.

Prof. J. M. POUND, of Gordon Institute, Barnesville, to manipulate the plate-holder of the 104-inch camera with color screen, also mounted on the polar axis.

Messrs. WILLIAM TURNER, HAL RIVIERE, and RALPH GRAVES, students of Gordon Institute, to manipulate the plate-holders of the cameras on the polar axis, and Messrs. JOHN CORNELL, C. HIGHTOWER, JACK HODGE, and FORRESTER BUCKNER, also students of Gordon Institute, to do service in capping and uncapping the cameras on the polar axis. The capping was accomplished by interposing light-weight opaque screens between the objectives and the Sun during the intervals between exposures.

Prof. FRANK OLIPHANT, of Gordon Institute, to count seconds during totality.

Prof. H. S. BRADLEY, of Emory College, Oxford, Ga., to record from the chronometer face the times of Professor UPDEGRAFF'S signals for beginning and ending of totality.

Prof. J. HARRIS CHAPPELL, of Milledgeville, Ga., and Dr. WILLIAM F. AIKEN, of Savannah, Ga., desiring to observe visually and to photograph, if possible, the shadow bands as projected on horizontal and vertical surfaces, were assigned a position on the grounds of the station near the scaffold of the 40-foot camera.

Professor LORD to occupy himself with his own instrument, which was mounted 180 feet northeast of the other buildings of the station.

Professor ASHMORE set up his 6-inch equatorial on the grounds, and made preparations to observe the corona and also the times of the contacts.

The grounds were roped in, and Professor POUND kindly allowed his battalion of cadets, under the command of Col. J. Q. NASH, to form a cordon around the grounds of the station, at a distance of 100 feet or more, to give the observers freedom from the intrusion of sightseers. This precaution proved to be necessary, since on the day of the eclipse several thousand persons came to Barnesville on excursion trains from the cities of Atlanta and Macon, and the large white tube of the 40-foot camera, which was visible from the town, rising above the trees surrounding the station, proved to be a center of attraction.

Several hundred people observed from the summit of Reservoir Hill, which offered the finest possible advantages for a spectacular view of the phenomena of the eclipse.

Mr. JULIAN HARRIS, managing editor of the Atlanta Constitution, with an artist and a photographer, were given places on the grounds of the station. They secured good pictures, several photographs, and a drawing of the corona.

For several days before May 28 we had practice drills in the manipulation of the polar axis and the 40-foot camera. The final drill took place on Sunday morning, after which all hands rested in preparation for the work of the following day.

Sunday, May 27, was beautifully clear, and the local weather conditions gave promise of continued clear skies. During the evening the sky continued clear until 11 p. m., when there was a hazy-looking cloud low down on the southeastern horizon.

ECLIPSE DAY.

On rising Monday morning at 4 a. m. the sky was thinly but completely overcast. When the Sun rose at 5 a m. it was hidden by clouds, but the sky showed some signs of clearing and every preparation was made for making the observations. As the Sun rose higher the clouds seemed to gather about it, while the rest of the sky was comparatively clear. But as the time for the first contact approached the clouds disappeared from the immediate neighborhood of the Sun, the seeing became beautifully steady, and the contact was successfully observed by Mr. HILL, Mr. LITTELL, and Professor ASHMORE. The final touches of our preparations were now made with great enthusiasm as the obscuration of the Sun progressed with clear, though slightly whitish, sky, with a light west wind, together with falling temperature and with crescent-shaped images of the Sun cast by the foliage of the trees. As totality approached, the usual yellowish light settled upon the landscape and the air grew slightly chilly. Every man stood at his post. Professor UPDEGRAFF, with a shade-glass over the eyepiece of his telescope, observed the rapidly narrowing crescent of light, and as the BAILEY'S Beads appeared and vanished gave the signal, "Now—go," for work to commence. For a few brief seconds comparative darkness prevailed, the corona and prominences appeared, while the count of the timekeeper, the commands of Mr. HILL and Mr. LITTELL, and the rattle of the slides of the plate-holders on the polar axis, and the clicking of the mysterious machinery in the observing tent of Professor LORD, continued for a few brief seconds, when suddenly the sunlight broke out and all was over.

During totality Professor UPDEGRAFF did not leave his telescope, but attempted to receive as good an impression of the corona as possible as viewed through the instrument. He looked carefully for details in the equatorial regions of the corona for perhaps one solar diameter from the Sun, but saw none. The delicate filamentary structure of the two large pink-colored prominences on the western limb was more distinctly seen than is shown perhaps on any photograph in existence. The phenomenon known as BAILEY'S Beads was seen both at the beginning and at the ending of totality.

The colors of the corona and prominences were very brilliant and delicate, but no words could be found to do justice to the general beauty of the phenomenon.

The sudden bursting forth of the sunlight at third contact was particularly noted by Mr. HILL, as he had been led to expect a gradual return of the light from the description given by TROUVELOT of the total solar eclipse of July 29, 1878.

Visual observations of shadow bands were made by Dr. WM. F. AIKEN, of Savannah, Ga., and are described in his report. He attempted to photograph them but failed to get any impression on his plates. Prof. J. HARRIS CHAPPELL, of Milledgeville, Ga., cooperated with Doctor AIKEN, and his report also is appended.

The last contact was observed by Mr. HILL and Mr. LITTELL, and half an hour afterwards the sky was covered with cumulus clouds. Our program had been carried out perfectly, except that the loss of one second in the counting during totality had caused the flashing of the last set of plates on the polar axis, and the last plate on the 40-foot camera. Twenty photographs had been secured on the polar axis, and four on the 40-foot camera. Drawings of the corona had been secured by Professor

EASTMAN, Professor SEE, Professor ASHMORE, and Professor HART. Observations of shadow bands had been made by Doctor AIKEN and Professor CHAPPELL. Professor LORD had succeeded in photographing the flash spectrum at both the beginning and the ending of totality.

Immediately after the observation of last contact a telegram was sent to Capt. C. H. DAVIS, U. S. N., Superintendent of the Naval Observatory, announcing the successful outcome of the observations. Then the dismounting and packing of the instruments was begun. That afternoon or the following day all members of the party, except Professor UPDEGRAFF, left Barnesville for their homes. He remained until the afternoon of May 30 for the final settlement of business affairs, when he left Barnesville for Griffin, and saw that the instruments and apparatus there were ready for shipment.

Contacts Observed at Barnesville.

[Greenwich Mean Time.]

Observer.	I	II	III	IV
	h m s	h m s	h m s	h m s
UPDEGRAFF	. .. .	1 38 35.1	1 39 58.1	. .. .
HILL	0 31 50.6	. .. .	. .. .	2 56 14.3
LITTELL	0 32 (0.1)*	. .. .	. .. .	2 56 14.1
ASHMORE	0 31 48.4	1 38 33.4	1 40 (1.4)§	2 56 (10.4)
Mean	0 31 49.5	1 38 34.2	1 39 58.1	2 56 14.2
Computed	0 31 51.1	1 38 41.9	1 40 5.3	2 56 16.4
O—C...............	— 1.6	— 7.7	— 7.2	— 2.2

* Several seconds late.

§ Uncertain by 3 seconds.

ACKNOWLEDGMENTS.

Our thanks are due in general to the citizens of Barnesville and Griffin for the intelligent and generous aid given by all who could in any way promote the success of the expedition. The following are among those whose services deserve specific mention:

Hon. J. L. KENNEDY, mayor of Barnesville; Hon. W. D. DAVIS, mayor of Griffin, and the members of the city councils of both these municipalities, for aid and courtesies extended to us.

Mr. OTIS A. MURPHY, a business man of Barnesville, and Mr. ER LASHÉ, editor of the Barnesville Gazette, for aid in various ways, and especially for conducting Professor UPDEGRAFF and Mr. PETERS about in search of a site for the station.

Mr. P. F. MATTHEWS, of Barnesville, for the use of his land on which the station was situated.

Mr. GEO. E. HUGELY, cashier of the New South Savings Bank, for the loan of one tent.

Prof. J. M. POUND, president, and Prof. F. OLIPHANT, vice-president, of Gordon Institute of Barnesville, for numerous favors and courtesies, and for aid which they personally rendered on the day of the eclipse.

Col. J. Q. NASH, commandant of cadets of Gordon Institute, for his services in forming a guard about the station on the day of the eclipse.

Capt. A. O. BENNETT, contractor in Barnesville, for the faithful and efficient manner in which he did the work of erecting the buildings at the station.

Mr. and Mrs. MATTHEW GRACE and Mr. J. A. BLALOCK, of the Magnolia Inn, Barnesville, for kind and courteous treatment during our stay at that hostelry.

Col. R. J. REDDING, director of the Georgia State Experiment Station, near Griffin, and Mrs. REDDING, for their kind hospitality and aid which they rendered in many ways.

Judge C. L. BARTLETT, M. C., of Macon, Ga., for information and letters of introduction to citizens of Barnesville and Griffin, given to Professor UPDEGRAFF before leaving Washington.

Messrs. R. A. and J. W. STAFFORD, W. B. SMITH, J. W. HIGHTOWER, and Dr. J. P. THURMAN for aid and courtesies extended in various ways.

LONGITUDE AND LATITUDE WORK AT BARNESVILLE AND GRIFFIN.

The latitude and longitude of three points in or near Griffin were determined with sufficient accuracy for the purpose by Mr. HILL, using a 2.5-inch combined zenith telescope and transit instrument, STACKPOLE No. 1502, and a break-circuit sidereal chronometer, NEGUS No. 1295. The latitudes were determined by TALCOTT'S method, and the longitude by comparison of the chronometer with telegraphic noon signals from Washington.

The approximate determination of the coordinates of a point in the town of Griffin, made immediately upon our arrival, has been described above.

At the eclipse station, 2½ miles northwest of Griffin, Mr. HILL made observations on three nights for latitude and time, carrying his chronometer to the railway station in Griffin each day for comparison with the Washington noon signals. There being no time to build a suitable pier for the transit instrument, the stump of an oak tree was used as a pier, but proved not to be well adapted to the purpose. Notwithstanding these unfavorable circumstances an approximation to the latitude and longitude was secured which showed that, according to the data of the American Ephemeris, the station was between 2 and 3 miles within the northern limit of the shadow path.

It seemed desirable, however, to determine the longitude of the station more accurately, and to this end a brick pier for the transit instrument was built on the lawn in the rear of the office of the director of the Experiment Station, and within a few feet of the telephone, by means of which the chronometer might be compared with the railway time signals. It was intended to connect the eclipse station with this point by means of a survey.

Mr. HILL made observations for latitude and longitude at this place on four nights, and made daily comparisons of his chronometer with the railway time signals from the Naval Observatory. All the time observations at this place were made by the eye and ear method.

The observations for latitude and longitude at the eclipse station at Barnesville were made with better facilities for accurate work. A telegraph wire was run out to the station from the Western Union Telegraph office at Barnesville, and a chronograph and the services of a telegraph operator were provided. A brick pier of suitable size had been built, and a canvas tent, with a board floor especially designed for transit work in the field, was erected over the pier. Observations for time and latitude, and exchange of signals with the Naval Observatory, were made by Mr. HILL on four nights.

The difference in altitude between the railroad at the depot and the eclipse station as measured by Mr. HILL and Mr. LITTELL is 35.9 feet. Applying this to the altitude of Barnesville as given in GANNETT'S Dictionary of Altitudes, the altitude 911 feet was obtained for the eclipse station.

The results of these determinations of latitude and longitude are given in Mr. HILL'S report, which is appended, but for convenience of reference they are inserted here, together with the elevations as far as the latter are known.

Situation.	Latitude.			Longitude.			Elevation.
	°	′	″	h	m	s	ft.
Barnesville Eclipse Station....................	+33	3	25.0	5	36	35.05	911
Griffin Eclipse Station........................	33	16	27.6	5	37	9.8	1020 approx.
Georgia Agricultural Experiment Station......	+33	15	55.0	5	37	8.0	1000 approx.

REPORT OF ASSISTANT ASTRONOMER G. A. HILL.

THE LONGITUDE AND LATITUDE OF BARNESVILLE AND GRIFFIN.

The instrument used was the combined zenith telescope and transit instrument, STACKPOLE No. 1502, with an aperture of 2½ inches and a focal length of about 30 inches. It is provided with a striding level and also a latitude level.

The value of one revolution of the zenith distance micrometer screw is 68″.455. There are three zenith distance threads, designated as A, B, and C, of which A is the one nearest the head.

The recorded micrometer reading always corresponds to the position of thread B. When the star is observed on thread A the recorded reading must be increased by $15^{r}.039$; when observed on thread C the recorded reading must be decreased by $14^{r}.890$.

The timepiece used in the longitude work was a break-circuit sidereal chronometer, NEGUS No. 1295.

Time Observations at First Station, Griffin, Ga.

[Observer, G. A. HILL.]

Date.	Clamp.	Name.	T			Aa+Bb+Cc	ΔT
1900			h	m	s	s	s
May 4	W.	ν Ursæ Majoris	11	13	13.7	− 0.8	−5.3
		λ Draconis	11	25	30.9	+ 6.9	[−5.4]
		β Virginis	11	45	41.0	− 3.4	−5.6
	W.	ο Virginis	12	0	18.3	− 2.9	−5.6
	E.	4 Draconis	12	7	20.5	+21.7	[−5.6]
		η Virginis	12	14	58.9	− 2.8	−5.8
		20 Comæ Berenices	12	24	51.4	− 0.9	−5.6
	E.	β Canum Venaticorum	12	29	6.7	+ 1.4	−5.3

Time Observations at Eclipse Station, Griffin, Ga.

[Observer, G. A. Hill.]

Date.	Clamp.	Name.	T			Aa+Bb+Cc	ΔT
1900			h	m	s	s	s
May 5	W.	α Ursæ Minoris s. p.	13	23	41.7	-88.5	[-10.2]
	E.	α Ursæ Minoris s. p.	13	24	20.8	-127.6	[-10.2]
		η Bootis	13	50	8.4	+0.4	-10.3
		τ Virginis	13	56	47.2	-0.3	-10.3
	E.	α Bootis	14	11	18.3	+0.5	-9.7
6	W.	γ Virginis	12	36	48.0	+0.4	-9.8
	E.	α Ursæ Minoris s. p.	13	21	34.0	+38.7	[-9.3]
	W.	α Ursæ Minoris s. p.	13	20	57.9	+75.1	[-9.6]
		ζ Virginis	13	29	48.3	+0.8	-10.1
		τ Bootis	13	42	42.8	+0.4	-9.5
	W.	η Bootis	13	50	7.5	+0.4	-9.4
7	E.	υ Leonis	11	31	56.8	+4.4	-8.8
		β Leonis	11	45	36.7	+4.3	-9.1
	E.	α Ursæ Minoris s. p.	13	17	40.0	+272.4	[-8.6]
	W.	α Ursæ Minoris s. p.	13	17	17.6	+294.9	[-8.7]

Time Observations at Georgia Agricultural Experiment Station, Griffin, Ga.

[Observer, G. A. Hill.]

Date.	Clamp.	Name.	T			Aa+Bb+Cc	ΔT
1900			h	m	s	s	s
May 14	W.	ν Ursæ Majoris	11	13	11.88	-0.32	-3.99
		υ Leonis	11	32	1.28	-4.78	-4.15
		β Virginis	11	45	40.40	-4.44	-4.08
	W.	δ Corvi	12	24	55.36	-6.72	-4.22
	E.	α Ursæ Minoris s. p.	13	27	45.30	-333.22	[-3.86]
	W.	α Ursæ Minoris s. p.	13	27	20.20	-307.94	[-4.04]
15	W.	ν Ursæ Majoris	11	13	12.06	-0.45	-4.19
		υ Leonis	11	32	1.22	-4.46	-4.37
		β Virginis	11	45	40.38	-4.09	-4.41
	W.	δ Corvi	12	24	54.82	-6.05	-4.38
	E.	α Ursæ Minoris s. p.	13	27	28.27	-314.81	[-4.46]
	W.	α Ursæ Minoris s. p.	13	27	11.25	-297.97	[-4.28]
16	W.	ν Ursæ Majoris	11	13	11.68	-0.59	-3.69
		υ Leonis	11	32	0.86	-4.81	-3.66
		β Virginis	11	45	39.65	-4.53	[-3.25]*
	W.	δ Corvi	12	24	54.68	-6.64	-3.56
	E.	α Ursæ Minoris s. p.	13	27	18.60	-305.24	[-3.62]
	W.	α Ursæ Minoris s. p.	13	27	0.75	-287.46	[-3.55]
17	W.	ν Ursæ Majoris	11	13	11.16	-0.96	-2.82
		υ Leonis	11	32	0.74	-5.23	[-3.14]*
	W.	δ Corvi	12	24	54.30	-7.03	-2.89
	E.	α Ursæ Minoris s. p.	13	27	29.27	-315.75	[-3.06]
	W.	α Ursæ Minoris s. p.	13	27	10.25	-297.03	[-2.76]

* Only three threads and discordant.

Time Observations at Eclipse Station Barnesville, Ga.

[Observer, G. A. HILL.]

Date.	Clamp.	Name.	T			Aa+Bb+Cc	ΔT
1900			h	m	s	s	s
May 21	E.	κ Draconis	12	28	44.08	+0.27	[+32.11]
		γ Virginis	12	36	6.78	−0.33	+32.13
		31 Comæ Berenices	12	46	20.80	−0.27	+32.04
		α Canum Venaticorum	12	50	52.02	−0.21	+32.16
	E.	ε Virginis	12	56	43.22	−0.32	+31.99
	W.	4 Ursæ Minoris	14	8	44.90	−0.97	[+32.46]
		ρ Bootis	14	27	2.90	−0.63	+32.07
		μ Virginis	14	37	19.34	−0.67	+32.08
		ε Bootis	14	39	8.78	−0.63	+32.18
	W.	β Bootis	14	57	42.50	−0.61	+31.99
22	W.	κ Draconis	12	28	42.52	−0.58	[+34.55]
		γ Virginis	12	36	5.18	−0.25	+33.61
		31 Comæ Berenices	12	46	19.28	−0.25	+33.53
		α Canum Venaticorum	12	50	50.60	−0.26	+33.62
	W.	ε Virginis	12	56	41.58	−0.26	+33.57
24	W.	4 Ursæ Minoris	14	8	42.20	+0.77	[+35.42]
		ρ Bootis	14	26	59.06	−0.18	+35.45
		μ Virginis	14	37	15.68	−0.46	+35.54
		ε Bootis	14	40	5.08	−0.21	+35.46
		Piazzi XIV, 221	14	50	57.86	−0.23	+35.63
	W.	β Bootis	14	57	38.86	−0.27	+35.30
	E.	β Coronæ Borealis	15	23	9.80	+0.29	+35.44
		α Coronæ Borealis	15	29	54.62	+0.39	+35.41
		α Serpentis	15	38	47.20	+1.34	+35.36
		β Serpentis	15	41	1.12	+0.76	+35.66
		ζ Ursæ Minoris	15	47	16.60	−10.35	[+35.46]
	E.	τ Herculis	16	16	13.06	−1.31	+35.49
25	E.	κ Draconis	12	28	44.86	−5.05	[+36.54]
		γ Virginis	12	35	59.92	+1.97	+36.63
		31 Comæ Berenices	12	46	15.34	+0.62	+36.57
		α Canum Venaticorum	12	50	47.48	−0.03	+36.47
	E.	ε Virginis	12	56	36.74	+1.50	+36.63
	W.	4 Ursæ Minoris	14	8	49.80	−10.96	[+39.48]
		ρ Bootis	14	26	57.24	+0.51	+36.58
		μ Virginis	14	37	11.88	+2.36	+36.52
		ε Bootis	14	40	2.94	+0.78	+36.60
	W.	β Bootis	14	57	37.42	−0.10	+36.56

Adopted Chronometer Corrections.

Date.	Sidereal Time.	Corr.	Station.
1900	h	s	
May 5	13.99	−10.1	Eclipse Station, Griffin.
6	13.42	− 9.7	
7	11.64	− 9.0	
14	11.73	− 4.11	Georgia Agricultural Experiment Station.
15	11.73	− 4.34	
16	11.72	− 3.64	
17	11.82	− 2.86	
21	12.792	+32.080	Eclipse Station, Barnesville.
21	14.670	+32.080	
22	12.790	+33.582	
24	14.710	+35.476	
24	15.698	+35.472	
25	12.790	+36.575	
25	14.670	+36.565	

Comparison of Sidereal Chronometer, Negus No. 1295, with Noon Signal from Washington, D. C.

Date.	Place.	Face of Chronometer.			Corr. for Noon Signal.	Corrected Face of Chronometer.			Washington Sid. Time of Mean Noon, 75th Meridian.			Δλ+Chron. Corr.		Daily Rate.
1900		h	m	s	s	h	m	s	h	m	s	m	s	s
May 5	Griffin, Ga..........	2	15	27.3	+0.1	2	15	27.4	2	44	9.7	+28	42.3	+1.65
7	Experiment, Ga.....	2	23	17.2	0.0	2	23	17.2	2	52	2.8	+28	45.6	−1.0
8	Griffin, Ga..........	2	27	14.8	0.0	2	27	14.8	2	55	59.4	+28	44.6	+0.6
9	Griffin, Ga.........	2	31	10.5	+0.2	2	31	10.7	2	59	55.9	+28	45.2	+1.9
10	Experiment, Ga.....	2	35	5.0	+0.4	2	35	5.4	3	3	52.5	+28	47.1	−0.6
11	Experiment, Ga.....	2	39	2.6	−0.1	2	39	2.5	3	7	49.0	+28	46.5	0.0
12	Experiment, Ga.....	2	42	59.3	−0.2	2	42	59.1	3	11	45.6	+28	46.5	+0.6
14	Experiment, Ga.....	2	50	51.0	0.0	2	50	51.0	3	19	38.7	+28	47.7	+0.6
15	Experiment, Ga.....	2	54	47.2	−0.2	2	54	47.0	3	23	35.3	+28	48.3	+0.2
16	Experiment, Ga.....	2	58	43.5	−0.2	2	58	43.3	3	27	31.8	+28	48.5	+0.3
17	Experiment, Ga.....	3	2	39.8	−0.2	3	2	39.6	3	31	28.4	+28	48.8	+0.1
18	Experiment, Ga.....	3	6	35.8	+0.2	3	6	36.0	3	35	24.9	+28	48.9	+0.3
19	Experiment, Ga.....	3	10	31.8	+0.5	3	10	32.3	3	39	21.5	+28	49.2	+0.55
21	Barnesville, Ga	3	18	24.3	0.0	3	18	24.3	3	47	14.6	+28	50.3	+1.3
22	Barnesville, Ga	3	22	19.8	−0.2	3	22	19.6	3	51	11.2	+28	51.6	+1.3
23	Barnesville, Ga	3	26	14.8	0.0	3	26	14.8	3	55	7.7	+28	52.9	+0.9
24	Barnesville, Ga	3	30	10.5	0.0	3	30	10.5	3	59	4.3	+28	53.8	+1.2
25	Barnesville, Ga	3	34	5.7	+0.1	3	34	5.8	4	3	0.8	+28	·55.0	+1.6
26	Barnesville, Ga	3	38	30.8	0.0	3	38	30.8	4	6	57.4	+28	56.6	+0.95
28	Griffin, Ga..........	3	45	52.0	0.0	3	45	52.0	4	14	50.5	+28	58.5	+0.9
29	Barnesville, Ga	3	49	47.5	+0.1	3	49	47.6	4	18	47.0	+28	59.4	

Longitude of Eclipse Station, Griffin, Ga.

[Determined by comparison of chronometer, NEGUS No. 1295, with noon signals from Washington.]

Date.	May 5.	May 6.	May 7.
	h m s	h m s	h m s
Chronometer slow of Washington sidereal time	0 28 43.1	0 28 44.6	0 28 45.2
Chronometer fast of local sidereal time	10.1	9.7	9.0
Longitude from Washington	+0 28 53.2 *	+0 28 54.3	+0 28 54.2

* The determination of May 5 has been given one-half weight.

	h	m	s
Longitude of Eclipse Station, Griffin, Ga., west from Washington	0	28	54.0
Longitude of Eclipse Station, Griffin, Ga., west from Greenwich	5	37	9.8

Longitude of Georgia Agricultural Experiment Station, Experiment, Ga.

[Determined by comparison of chronometer, NEGUS No. 1295, with noon signals from Washington.]

Date.	May 14.	May 15.	May 16.	May 17.
	h m s	h m s	h m s	h m s
Chronometer slow of Washington sidereal time	0 28 47.9	0 28 48.4	0 28 48.6	0 28 48.8
Chronometer fast of local sidereal time.	4.1	4.3	3.6	2.9
Longitude from Washington	+0 28 52.0	+0 28 52.7	+0 28 52.2	+0 28 51.7

	h	m	s
Longitude of Georgia Agricultural Experiment Station west from Washington	0	28	52.2
Longitude of Georgia Agricultural Experiment Station west from Greenwich	5	37	8.0

Longitude Exchange between Washington and Barnesville.

Date.	Signals from—	Epoch of Signals.		Difference of Clocks Δ_1	Clock Correction.			$\Delta\lambda$	Double Transmission Time.	Mean $\Delta\lambda$.
		Washington T_e	Barnesville T_w		Washington ΔT_e	Barnesville ΔT_w	$\Delta T_e - \Delta T_w$			
1900		h m	h m	m s	s	s	s	m s	s	m s
May 21.4	Washington	14 5.4	13 36.2	29 8.994	−17.720	+32.072	−49.792	28 19.202	0.230	28 19.317
	Barnesville	13 51.9	13 22.7	29 9.195	−17.706	+32.057	−49.763	28 19.432		
22.4	Washington	13 46.2	13 17.1	29 10.899	−18.026	+33.601	−51.627	28 19.272	0.144	28 19.344
	Barnesville	13 42.5	13 13.3	29 11.036	−18.022	+33.598	−51.620	28 19.416		
25.3	Washington	13 58.0	13 28.7	29 14.657	−18.848	+36.558	−55.406	28 19.251	0.229	28 19.366
	Barnesville	13 55.2	13 25.9	29 14.884	−18.848	+36.556	−55.404	28 19.480		

	h	m	s
Mean	0	28	19.342
Longitude of 9-inch transit circle, east from center of clock room			0.069
Longitude of Barnesville, west from center of clock room, Naval Observatory	0	28	19.273
Longitude of Washington, west from Greenwich	5	8	15.78
Longitude of Barnesville, west from Greenwich	5	36	35.05

Latitude Observations at Eclipse Station, Griffin, Ga.

[Observer, G. A. HILL.]

Date.	Star.		Micrometer Reading.	Declination.			Level Correction.	Latitude.			v
1900			r	°	′	″	″	°	′	″	″
May 5.6	α Canum Venaticorum.	N.	18.905 C	+38	51	20.9					
	43 Comæ Berenices	S.	25.127 A	+28	22	54.4	+0.8	+33	16	30.1	+2.5
5.6	α Canum Venaticorum.	N.	18.905 C	+38	51	20.9					
	B. A. C. 4390........	S.	13.386 A	+28	9	28.1	+0.8	+33	16	29.6	+2.0
6.3	ψ Ursæ Majoris	N.	34.292 B	+45	2	22.4					
	δ Leonis	S.	25.928 C	+21	4	5.7	−1.0	+33	16	29.1	+1.5
6.3	ο Virginis	S.	19.018 A	+ 9	17	1.8					
	δ Ursæ Majoris	N.	16.970 B	+57	35	13.2	+2.1	+33	16	24.6	−3.0
6.3	α Canum Venaticorum.	N.	24.840 C	+38	51	21.1					
	B. A. C. 4390........	S.	19.349 A	+28	9	28.3	−1.5	+33	16	26.5	−1.1
6.3	α Canum Venaticorum.	N.	24.840 C	+38	51	21.1					
	43 Comæ Berenices	S.	31.099 A	+28	22	54.6	−2.4	+33	16	26.5	−1.1
6.3	α Bootis	S.	20.572 B	+19	41	57.2					
	λ Bootis	N.	21.630 A	+46	32	40.8	−0.5	+33	16	29.7	+2.1
7.3	ψ Ursæ Majoris	N.	20.021 A	+45	2	22.6					
	δ Leonis	S.	26.629 C	+21	4	5.8	−4.9	+33	16	27.7	+0.1
7.3	ο Virginis	S.	29.683 A	+ 9	17	1.9					
	δ Ursæ Majoris	N.	27.732 B	+57	25	13.4	+0.9	+33	16	26.8	−0.8
7.3	α Canum Venaticorum.	N.	18.931 C	+38	51	21.3					
	B. A. C. 4390........	S.	28.485 B	+28	9	28.5	−1.1	+33	16	26.9	−0.7
7.3	α Canum Venaticorum.	N.	18.931 C	+38	51	21.3					
	43 Comæ Berenices	S.	25.240 A	+28	22	54.8	−1.3	+33	16	26.0	−1.6

Latitude of Eclipse Station, Griffin, Ga.. +33° 16′ 27″.6.

Latitude Observations at the Georgia Agricultural Experiment Station, Griffin, Ga.

[Observer, G. A. Hill.]

Date.	Star.		Micrometer Reading.	Declination.			Level Correction.	Latitude.			v
1900			r	°	′	″	″	°	′	″	″
May 14.3	ψ Ursæ Majoris	N.	28.090 C	+45	2	23.4					
	δ Leonis	S.	20.379 A	+21	4	6.5	+0.8	+33	15	56.4	+1.4
14.3	ο Virginis	S.	19.550 A	+ 9	17	2.5					
	δ Ursæ Majoris	N.	16.551 B	+57	35	14.8	+2.5	+33	15	53.5	−1.5
14.3	α Canum Venaticorum	N.	22.560 C	+38	51	22.7					
	B. A. C. 4390	S.	18.115 A	+28	9	29.8	+0.4	+33	15	54.1	−0.9
14.3	α Canum Venaticorum	N.	22.560 C	+38	51	22.7					
	43 Comæ Berenices	S.	29.941 A	+28	22	56.0	+0.4	+33	15	52.4	−2.6
14.3	τ Virginis	S.	32.640 C	+ 2	1	26.3					
	α Draconis	N.	35.880 B	+64	51	9.0	−0.4	+33	15	56.4	+1.4
15.3	ψ Ursæ Majoris	N.	27.038 C	+45	2	23.6					
	δ Leonis	S.	19.270 A	+21	4	6.6	+0.6	+33	15	54.4	−0.6
15.3	ο Virginis	S.	17.331 B	+ 9	17	2.6					
	δ Ursæ Majoris	N.	20.285 A	+57	35	15.0	+1.2	+33	15	53.9	−1.1
15.3	α Canum Venaticorum	N.	23.138 C	+38	51	22.9					
	B. A. C. 4390	S.	18.655 A	+28	9	29.9	+1.2	+33	15	56.5	+1.5
15.3	α Canum Venaticorum	N.	23.138 C	+38	51	22.9					
	43 Comæ Berenices	S.	30.492 A	+28	22	56.2	+1.2	+33	15	54.3	−0.7
16.3	ο Virginis	S.	22.500 C	+ 9	17	2.6					
	δ Ursæ Majoris	N.	25.522 B	+57	35	15.2	−0.4	+33	15	54.2	−0.8
16.3	α Canum Venaticorum	N.	23.602 C	+38	51	23.1					
	B. A. C. 4390	S.	19.170 A	+28	9	30.1	+1.7	+33	15	55.4	+0.4
16.3	α Canum Venaticorum	N.	23.602 C	+38	51	23.1					
	43 Comæ Berenices	S.	30.930 A	+28	22	56.4	+0.9	+33	15	55.0	0.0
17.3	ψ Ursæ Majoris	N.	22.029 A	+45	2	23.8					
	δ Leonis	S.	29.722 C	+21	4	6.7	−1.1	+33	15	55.4	+0.4
17.3	ο Virginis	S.	31.909 C	+ 9	17	2.7					
	δ Ursæ Majoris	N.	19.929 A	+57	35	15.4	+2.3	+33	15	56.8	+1.8
17.3	α Canum Venaticorum	N.	23.198 C	+38	51	23.3					
	B. A. C. 4390	S.	18.732 A	+28	9	30.2	+0.8	+33	15	55.7	+0.7
17.3	α Canum Venaticorum	N.	23.198 C	+38	51	23.3					
	43 Comæ Berenices	S.	30.488 A	+28	22	56.6	+0.8	+33	15	56.4	+1.4

Latitude of the Georgia Agricultural Experiment Station.............................. +33° 15′ 55″.0.

Latitude Observations at Eclipse Station, Barnesville, Ga.

[Observer, G. A. HILL.]

Date.	Star.		Micrometer Reading.	Declination.			Level Correction.	Latitude.			v
1900			r	°	′	″	″	°	′	″	″
May 21. 3	ψ Ursæ Majoris	N.	26. 112 A	+45	2	24. 9					
	δ Leonis..............	S.	26. 423 A	+21	4	6. 8	−0. 2	+33	3	26. 3	+1. 3
21. 3	o Virginis............	S.	24. 402 A	+ 9	17	3. 2					
	δ Ursæ Majoris	N.	14. 421 C	+57	35	16. 0	+0. 3	+33	3	23. 4	−1. 6
26. 3	B. A. C. 4260	S.	28. 190 C	+21	36	35. 3					
	B. A. C. 4282	N.	19. 463 C	+44	38	57. 8	+2. 4	+33	3	24. 4	−0. 6
26. 3	Groombridge 1994 ...	N.	23. 098 C	+41	14	55. 4					
	B. A. C. 4526	S.	23. 320 C	+24	51	49. 1	−3. 0	+33	3	26. 8	+1. 8
26. 3	B. A. C. 4741	N.	28. 243 C	+46	32	46. 6					
	B. A. C. 4785	S.	33. 890 C	+19	40	25. 8	+2. 1	+33	3	25. 0	0. 0
26. 3	B. A. C. 4958	N.	21. 596 C	+40	47	0. 3					
	B. A. C. 4981	S.	25. 419 C	+25	15	23. 2	+2. 2	+33	3	24. 8	−0. 2
27. 3	B. A. C. 4169	S.	19. 600 C	+26	23	55. 7					
	B. A. C. 4188	N.	27. 059 C	+39	34	19. 9	+4. 0	+33	3	27. 1	+2. 1
27. 3	Groombridge 1994 ...	N.	18. 295 A	+41	14	55. 5					
	B. A. C. 4526	S.	18. 192 A	+24	51	49. 2	+4. 0	+33	3	22. 8	−2. 2
27. 3	B. A. C. 4741	N.	26. 890 C	+46	32	46. 8					
	B. A. C. 4785	S.	21. 248 C	+19	40	26. 0	+1. 2	+33	3	24. 5	−0. 5
27. 3	B. A. C. 4958	N.	19. 109 A	+40	47	0. 6					
	B. A. C. 4981	S.	30. 301 B	+25	15	23. 4	+1. 4	+33	3	25. 1	+0. 1

Latitude of Eclipse Station, Barnesville, Ga.................................. .... +33° 3′ 25″.0.

REPORT OF PHOTOGRAPHER G. H. PETERS.

A DISCUSSION OF THE CORONAL PHOTOGRAPHS

THE PROMINENCES AND INNER CORONA.

The discussion of the prominences and inner corona is based upon a study of the negatives obtained with the 40-foot camera at Barnesville, Ga.

Four plates were exposed with this instrument during the eclipse. The last plate was, unfortunately, exposed just after third contact, and the short exposure given, together with the reappearance of the Sun, rendered it valueless, though some of the corona shows faintly upon it.

The diameter of the lunar image as measured on Negative No. 1 is 4.36 inches; the corresponding value of the diameter of the Sun's photosphere would consequently be 4.28 inches, from the data given in the American Ephemeris.

Owing to the smallness of the difference in the apparent diameters of these bodies there is only a slight concealment of the features in the neighborhood of the Sun. This negative shows prominences on both the eastern and western sides of the Moon, together with a large amount of chromosphere on the northeastern limb. The greatest elevation of the chromosphere above the Moon's limb, neglecting the heights of the prominences, is 22″.

THE PROMINENCES.

The position angle of the Sun's north pole at the time of this eclipse is taken as 17° west of north. In the case of the larger prominences the position angles and latitudes of both edges are given, which will serve to indicate their angular width and consequent dimensions.

Beginning at the north pole of the Sun and proceeding in the direction of the increase of position angles, the prominences as shown on the negative are located as follows:

P. A. 64° 0′
Lat. + 9° 0′

A Y-shaped prominence, its base visible to the chromosphere, and extending to a height of about 65″. The arms curve over at the top, the southern arm being apparently projected upon the prominence at position angle 67° 30′, and in connection with it producing an arch-like formation. From differences in the characteristics of these two objects, it is probable that they are two separate prominences.

P. A. 67° 30′
Lat. + 5° 30′
A round-top prominence, wide at the base and inclined slightly toward the north, the end meeting the southern arm of the prominence above noted.

P. A. 75° 0′
Lat. — 2° 0′
A small and comparatively faint prominence, which projects directly outward and is connected at the base with the one at position angle 76° 30′ described below.

P. A. 76° 30′
Lat. — 3° 30′
A long and narrow prominence, rising obliquely in a sinuous line to an altitude of 50″. It is inclined toward the south at an angle of about 45° to the Moon's limb. Two pendants, looped together and having forms resembling a horseshoe, project downward from about the middle.

P. A. 84° 0′
Lat. —11° 0′
A faint prominence, but slightly more intense than the coronal rays, rising to the height of about 50″. To this elevation the prominence rises almost perpendicularly, but at its upper limit a faint cloud-like branch extends nearly horizontally toward the north.

P. A. 87° 30′
Lat. —14° 30′
A long, narrow prominence leaning slightly toward the south.

P. A. 104° 0′
Lat. —31° 0′
A broad, round-top prominence, of slight elevation and of great intensity, rising from the chromosphere, and about 15″ in width.

P. A. 119° 30′
Lat. —46° 30′
An intense prominence, about the same width as the above, and rising to a height of 21″. Its top curves over slightly to the north, and ends with a pointed tip. The chromosphere on Negative No. 1 disappears behind the Moon's limb at about this point.

P. A. 127° 0′
Lat. —54° 0′
A small prominence with rounded top, that is partly hidden at its base by the Moon, which here covers the chromosphere.

P. A. 135° 0′
Lat. —62° 0′
A small, round-top prominence just showing above the Moon's limb.

P. A. 212° 0′
to 216° 0′
Lat. —41° 0′
to —37° 0′
This was the largest and most conspicuous prominence visible at this eclipse. It rose to an elevation of 97″ above the Moon's limb, and was 72″ wide where it emerged. Its form on the negative is roughly quadrilateral, with the exception of a small tongue-like projection, which is emitted from the middle of the upper part and curves slightly to the west.

This prominence presents considerable detail in structure, together with some complexity. In its central parts is seen a slender and apparently somewhat spiral emissive jet, whose top is recognized in the tongue mentioned above. This latter feature reaches the greatest elevation found in the prominence, and on either side of this central jet prominence matter is apparently falling back to the Sun. Comparatively vacant spaces are found on both sides of this emissive jet, extending from the Moon's limb upward to over half the entire elevation of the prominence. In the southern part of the prominence, near the edge, another rift extends upward for about half its height. From the northern part a jet branches off, and after reaching an elevation about as great as the rest of the prominence, curves over sharply and descends until hidden behind the Moon's limb. A comparison of photographs taken at this and other stations along the belt of totality shows that a considerable change of form took place in this prominence during the time required for the passage of the shadow from one station to another. In the later photographs this prominence loses its rectangular outline, and appears as if composed of numerous tongues of flame, having on the whole an irregular oval outline.

P. A. 225° 0′
Lat. −28° 0′
A long and curved prominence, shooting out obliquely from behind the Moon's limb in the direction of the large prominence described above. It narrows gradually as it recedes from the Sun, and at first curves slightly over and then upward near its end, where it is quite pointed. Beneath it and apparently of the same general origin is another thin prominence formation. This also extends toward the large prominence obliquely, its end curving up and nearly meeting the end of the first-mentioned part of this feature.

P. A. 232° 0′
to 238° 30′
Lat. −21° 0′
to −14° 30′
A large triangular-shaped prominence, with the base of the triangle in contact with the limb. The west side of this prominence rises almost perpendicularly to an elevation of 42″. The hypothenuse descends to the Moon's limb from the apex in a series of steps which are somewhat irregular. It exhibits considerable structural detail, mostly radial and divergent. From the top of the apex a shoot or tongue of prominence matter of slight extent projects outward. This prominence also shows considerable change of form in comparing Negative No. 1 with those taken at other stations.

P. A. 305° 0′
Lat. +52° 0′
A thick horn-like prominence of slight elevation, with rounded top, curving considerably toward the north.

P. A. 307° 30′
Lat. +54° 30′
A prominence of slight elevation with rounded top, just appearing above the Moon's limb.

P. A. 308° 30′
Lat. +55° 30′
A short thick prominence of the horn variety, curving slightly toward the north.

It is likely that these last three separate elevations from their proximity and general characteristics together form a single or connected prominence. A considerable space above the chromosphere on this side of the Sun is covered by the Moon on this negative, thus hiding the bases of these prominences.

THE INNER CORONA.

The longest streamers of the inner corona, as shown on Negative No. 1, are seen extending to a distance of 0.7 of an inch beyond the Moon's limb, corresponding in angular measurement on the scale of the photographic image to a little over 4′.5.

The inner corona, while exhibiting considerable detail, contains no marked features. In general, it is of the striated type, consisting principally of long, narrow rays, in some places interlaced, proceeding outward at small angles with the vertical.

Where the polar rays change to those of the equatorial type, the coronal rays are greatly curved, and tend to follow in their outer parts a direction nearly parallel to the equatorial plane. In the equatorial regions there is some tendency for these rays to cluster into wings, but none of these are prominent features of the inner corona.

It will thus be seen that the corona at this eclipse is typical of the sun-spot minimum period, to which epoch it corresponds.

While the prominences are quite numerous, and several of large dimensions, the hood and arch formations of coronal matter over them are absent on this occasion. No evidence of even a tendency to this form of corona is found, which is so conspicuous a feature on the large-scale photographs of short exposure in many eclipses.

The polar rays.—The aggregations of the coronal rays about either pole are pronounced in type, while the lines of demarkation between them and the equatorial systems are quite distinct.

Those surrounding the north pole extend over an arc of 41°, or from position angle 323° to position angle 4°. They extend in latitude from 70° on the west side of the Sun over the north pole to latitude 69° on the east side. The south polar rays lie between position angles 132° and 189°, and in latitude extend from 59° on the east side over the south pole to 64° on the west side, covering an arc of 57°.

It will be seen from the results of these measurements that there is but a slight displacement in the symmetrical distribution of the polar rays from the poles of rotation. Inasmuch as there is necessarily some uncertainty as to the precise line of demarkation between the polar and equatorial rays, the polar rays may be considered as being situated almost symmetrically about the poles respectively.

The south polar rays are somewhat longer than those opposite, and are somewhat more numerous, while the rifts dividing the several pencils of rays are less pronounced there than at the north pole. The north polar rays, on the contrary, are separated into distinct bundles of streamers by these rifts, with fairly sharp outlines, those on the western side of the pole being in general of greater width. All of these northern rays are of quite similar intensity, but of varying dimensions, and many of the rifts between them are nearly devoid of coronal matter and extend almost to the Moon's limb, which here covers the chromosphere to a less extent than at the south pole. The change from the polar to the equatorial form of streamers is more sudden and strongly marked in the northern than in the southern hemisphere.

To the east of the north pole, adjoining the equatorial streamers, the polar rays become less well defined and somewhat blended, though still retaining their typical appearance. In this locality they also exhibit a considerable inclination toward the east, and in the direction of the equatorial plane. They are here also more pointed than the polar rays in general, being quite wide and intense at the base, but tapering rapidly as they extend outward from the Sun.

The chromosphere disappears behind the Moon's limb on Negative No. 1 about where the north polar rays on the eastern side begin, but small elevations in the chromosphere can be seen above the edge of the Moon extending beyond the pole. These elevations are hardly large enough to be classed as prominences—at least they can not be recognized as such on the scale upon which the image is found. Thirteen objects can be counted in this region, and in nearly every case a polar ray is seen to emanate from each. These elevations are probably not due to the halation effect of chromospheric light shining through a valley on the lunar limb, as their height precludes that hypothesis, and as there is but little indentation on the limb at their bases.

At the southern pole of course these elevations are not visible, as the Moon's limb completely covers the chromosphere in that region.

The equatorial regions.—On the eastern side of the Sun the inner corona, with some exceptions, is quite regular in its formation, and, though presenting much detail, this is mostly of a fine variety and to a great extent of the striated and filamentary type. Several small wings, however, of slight extent and intensity are noted, especially in the northeast and southeast quadrants near the polar rays. In the northeast quadrant there appears on Negative No. 1 a series of small coronal wings of great curvature, which arch over toward the south. The first of these consists of two arching wings rising one above the other, while to the south of these is a single arching wing, which overlaps the inner one of the pair first mentioned. From this same region also three longer wings shoot out, having but slight curvature and diminishing rapidly in intensity and narrowing toward the ends. From the southern edge of these curved and arching streamers to the prominence at position angle 64° the corona consists of fine rays, closely associated and blending together, with no distinctive features.

Beginning at the above prominence, and extending southward to about position angle 80°, three small rays are seen, which are, however, considerably mixed with faint diffused coronal matter.

There next comes a region showing but little detail, which is of about the same extent as the preceding, ending at a space of slight width in the corona filled with faint nebulous matter.

From position angle 95°, adjoining the above space and extending to position angle 106°, there is a broad brush of coronal rays which proceeds farther outward, as shown on Negative No. 1, than any other feature. It has the appearance of a wing, though not a pointed one, and the coronal detail here consists of fine striated and nearly parallel rays, curving northward or toward the equatorial regions, as they recede from the Sun.

Extending from the base of the above wing to the southern polar rays is another large wing, the inner parts of which are quite intense. Its center lies over the prominence at position angle 119° 30′, above which its inner portions have a dome-shaped aspect, though not of the arch-type formation. A faint pointed ray of coronal matter projects outward at its extremity to a considerable distance.

On the western side of the Sun the inner corona presents much more detail than upon the opposite side. Omitting the region of the south polar rays, which has been previously described, and still continuing in the direction of increase of position angles, the equatorial features on this side may be catalogued as follows:

Adjoining the polar rays are three wings whose combined bases reach to the great prominence extending from position angle 212° to position angle 216°. These features are blended together on Negative No. 1 at their bases, but gradually separate as they extend farther away from the Sun. The first of these wings, adjoining those of the polar type, is quite long and narrow, gradually tapering toward the end, and though nearly straight has quite an inclination toward the north. In this wing two strong rays, somewhat of the polar type, are observed, which, although appearing to be an integral part of it, may perhaps be projected on it by perspective.

The middle wing is quite broad at its base and quite extensive, curving over slightly in an equatorial direction, and ending in a double filament of faint coronal matter. In the northern part of its base, and projected upon it, is a small ray inclined toward the south and tapering rapidly with the end curving upward.

Between this middle wing and the large prominence, and adjoining the latter, is a short brush-like wing which narrows slightly for a short distance and then gradually widens. The sides extend farther out than the middle part as bright objects, though the space between them and somewhat beyond is filled with faint nebulous matter.

Rising from the large prominence above mentioned, extending from position angle 212° to position angle 216°, are three quite long, bright, narrow rays which seem to have an intimate connection with this prominence. One of these rays apparently originates at the tongue-shaped projection at the summit of the prominence, and the other two in the upper regions of this object on either side of it. The one rising at the summit, and that which springs from the southern part of this prominence, are projected almost directly away from the Sun, although approaching each other somewhat as they recede. The ray extending from the northern side of this prominence is somewhat broader than the others and is double at its base. It has an inclination toward the north and a slight curvature in that direction, considerably more than the other coronal rays in its vicinity, and gradually tapers toward the end. This difference in curvature and inclination probably shows that while the corona in general emanates from the lower chromospheric levels, the rays in question originate at a considerable altitude in the large prominence and are affected by its conditions. These rays proceeding from this prominence have a close connection with it.

Between the above large prominence and the large triangular one extending from position angle 232° to position angle 238° 30′, and also over this latter prominence, the corona is considerably agitated. The rays here are long and have an upward curvature, being inclined at their bases toward the first-mentioned large prominence. They are divided into somewhat narrow filaments, tapering gradually as they recede from the Sun. In this region are four conspicuous rays, whose curvature at the base is in the same direction as the others, but which, as they ascend, gradually bend over in the opposite direction. The lines of curvature assumed by these latter rays are somewhat parabolic in form. Above the large triangular prominence is a broad ray shooting directly out from it, doubling as it proceeds, and showing some delicate structure in its lower parts. Beginning at the northern or perpendicular side of this triangular prominence and extending for a distance of about 5° is a comparatively vacant place or gap in the corona. Within this gap some fine detail is perceptible, which is quite faint and somewhat mottled in appearance. On the side toward this prominence the edge of the gap, though irregular in outline, extends almost directly away from the Sun, while on the opposite side it is still more irregular. Over the prominences in this region there is no indication of an arch formation, although the coronal rays exhibit considerable curvature.

Between this gap and the equator, on the west side of the Sun, is a complex wing made up of several rays. At the southern end of this aggregation near the equator is a double streamer extending outward beyond the average elevation of coronal matter as photographed on Negative No. 1.

Adjoining the equator in the northern hemisphere is another very similar wing separated from the one above mentioned by a region of comparative scarcity of coronal matter, located at the equator and extending a short distance on either side of it. In this wing the coronal matter appears to diverge to some extent from either side of the stronger middle ray and at an elevation of about 1′.5 above the Moon's limb two lateral rays shoot out diagonally from the strongest ray of the streamer in opposite directions, extending to a distance of about 2′ on each side of it. At the northern side of this wing is another small wing branching off from it and cutting across the diagonal ray on the same side. Beyond this wing a partial gap occurs in the corona filled with faint nebulous matter, in the midst of which a narrow and comparatively bright ray is visible, with a slight curvature in a northerly direction.

Between this gap and the group of prominences extending from position angle 305° to position angle 308° 30′ there are three small wings having a small amount of curvature toward the south, which curvature increases as the north polar regions are approached. Of these three wings the one nearest the equator is pointed at the end while the other two separate into two narrow streamers, which division is especially prominent in the case of the middle one.

Extending from the prominence at 308° 30′ to the north polar rays are seen three distinct streamers. The first two curve over in an equatorial direction, while the other, close to the polar rays, is nearly straight, but is projected at about the same inclination as the polar rays adjoining and is divided at the end into two narrow rays.

Numerous minor details of the inner corona have necessarily been omitted from this report relating mostly to minutiæ of the streamers. This for the reason that, for the most part, they are somewhat inconspicuous features, and also because to be intelligently available they must be seen on the negatives.

THE OUTER CORONA.

The discussion of the outer corona is based upon a study of the negatives obtained with the instruments mounted on the polar axes at Barnesville, Ga., and Pinehurst, N. C.

The orientation of the plates which contain the impressions of the outer corona has been accomplished by reference to the place occupied by the planet Mercury. The image of this planet is found photographed, together with the corona, upon the plates taken with several of the portrait lenses. The apparent position angle with respect to the Moon's center for mid-totality at the Barnesville station has been taken as 268°.

The outer corona at this eclipse presents, in general, a wedge or hatchet-shaped appearance, which form is due to the three large and bright equatorial wings, which are the main features of the outer coronal extensions. Two of the three wings are thrown off from the western side of the Sun at the middle latitudes, and are somewhat divergent and pointed at the ends. The space between them, however, and extending for some distance out into space, is filled with coronal matter, mostly in the form of streamers. The other conspicuous wing, mentioned above, emanates on the eastern side of the Sun and is nearly opposite the first two. In length it has about the same extent as the others, and several smaller, though considerable, streamers lie between it and the poles on either side.

The foregoing summary of the appearance of the outer corona will serve to indicate its general features.

The polar rays.—The polar rays extend on some of the negatives of 20 seconds exposure taken with the DALLMEYER portrait lenses to a distance of about 1½ times the diameter of the Moon, at each of the polar regions. On the negative with the same length of exposure, taken with the 104-inch camera and color screen, using CRAMER isochromatic instantaneous plates, they extend to over 1¼ lunar diameters.

A comparison of the different negatives of about the same relative length of exposure shows that where the isochromatic plates and color screens were employed the polar rays have a greater proportional extension than on the double-coated unstained plates. This is probably due to the color value of the rays at these polar regions of the corona compared with the equatorial streamers, and would seem to indicate some differences in their constitution which might be shown in the spectrum.

Commencing the description of the outer corona with the north polar rays, at their juncture with the equatorial streamers on the west side of the Sun, the first distinctive ray of this classification is quite intense. It is composed of a bundle of long fine filaments branching out diagonally from the Sun and curving over slightly away from the pole. It is separated from the typical equatorial streamers by a gap which, while very narrow at its base, widens out considerably as it becomes more distant from the Sun. About the north polar regions the other typical polar rays with some exceptions, which will be noted, are very similar in structure to the one just described. They gradually, however, become straighter as the pole is approached, resuming their curvature away from the pole when it has been passed. Between each pair of these distinctive bundles of rays is a sensible, and at times a considerable gap, while the bundles themselves vary somewhat in relative width. By a careful examination of the best negatives, the separate structural filaments composing these bundles of rays may be seen. They can be traced from within a short distance of the lunar limb to an extent which is limited only by their fading into invisibility on the negative. These individual filaments on the negative taken with the 104-inch camera and color screen, of 20 seconds exposure, where they have the best general definition, have a diameter of from 5″ to 10″. It is likely that they may be still more finely divided, as these angular values correspond to from 2,250 to 4,500 miles, respectively, on the Sun. In some parts of this region these filamental rays stand out separately on the photograph on the background of the sky, so that an estimate of their diameter is easily made. Some of the filaments on the same negative congregate into large and intense bundles, while in other parts they are less densely associated, and in some cases are to be seen apparently single. It seems likely that these polar rays are built up of single filaments originating in the same vicinity, and to some extent augmented by other filaments lying nearly in the same line of sight; for it must be remembered in studying these negatives that the coronal wings, streamers, and rays, while apparently emerging from the edge of the seemingly flat lunar disk, are in all cases bodies of three dimensions and are ejected from all parts of the Sun.

Among the exceptions to the typical polar rays in this region is a small group on the western side of the north pole and lying close to the equatorial type of streamers. Here there is a short extent which, while of the polar type, is very much condensed, and emerging obliquely has considerable curvature. While the individual rays composing this group lie close together, they are quite evenly distributed and may be seen in most places separated from each other. There are in this region two remarkably dark rays. One is situated near the eastern side of this group and follows the course of the polar rays in its vicinity. It can not be traced quite to the lunar limb, but can be followed to within about 20″ of it. The other ray of this description is the more conspicuous of the two. It begins at the western side of the above group, where the polar rays change to streamers of the equatorial type. It can be traced from near the limb of the Moon to as far as the rays in this locality can be seen. Throughout its whole extent it is quite dark, and in comparison with the background of the sky shows but little, if any, photographic action. On a transparency made from this negative it is apparently even darker than the sky in some parts, though this effect may be due to contrast with the surrounding coronal rays.

The southern polar rays have somewhat different characteristics from those surrounding the opposite pole and show a less equal distribution throughout this entire region. They also exhibit more complexity of arrangement, combined with a somewhat greater length, and are more intense on the western than on the eastern side of the Sun. Over this entire region they are more numerous, while the bundles of filaments have a somewhat greater breadth than those at the opposite pole. They may be divided into three general groups which differ from each other to some extent, and are separated from one another by darker spaces or gaps. In the composition of these groups fine wisp-like rays can be seen, forming by their aggregation the broader streamers of the polar type.

On the eastern side of the south pole and beginning in the vicinity of 6° from it, with an extent of about 22° toward the equatorial streamers on the same side, are four broad composite rays of the polar type. That nearest the equatorial streamers is greatly curved, bending over to below the line of projection of the equatorial rays. It can even be traced inside this latter region, which is not extremely dense in coronal matter, where it retains its curvature and distinctive features. The two adjoining rays in this group are broad and double, the easterly one conspicuously so. The remaining south polar ray of this group, the one nearest the pole, consists of three parts, a rather intense ray, flanked by two fainter ones on either side of it, which separate gradually as they proceed outward.

Covering the southern pole and with an extent of about 12° is a broad brush of coronal matter projecting directly away from the Sun. But little curvature of these rays is exhibited, even at the edge of this group, on account of their proximity to the pole. Near the middle is a narrow gap, and on either side of it may be seen the numerous filaments composing these rays, which, taken together, form this brush.

On the western side of the south pole, extending from a gap at the edge of the brush just described, to the equatorial streamers on the same side are three noticeable groups of rays. The first ray adjacent to those near the pole has quite a similar aspect, being of a brush-like formation. It is inclined considerably toward the west at its place of emission, and has but slight curvature. This brush of rays together with those surrounding the pole are longer and more brilliant, as a whole, than any of the others in either of the polar regions. On the negative of 20 seconds exposure, taken with the 104-inch camera at Barnesville, they extend from the limb to a distance of about two-thirds the diameter of the Moon. On the negative obtained at the Pinehurst station with the VOIGTLAENDER lens, exposed during nearly the whole of totality, they extend to a distance of 1¼ times the lunar diameter. There is visible on each of these negatives an indication of photographic action on the sensitive films beyond the limits specified, but so faint that the coronal structure is lost on the plates at about the above distances.

The two remaining south polar rays on the western side show a gradual though slight curvature. The first of these is somewhat fainter than those just described, while the other has about the same intensity but is somewhat broader. From this latter a fainter ray is noticed branching off at a distance of about 10′ from the Moon's limb. The appearance suggests, but can not be determined with certainty even by consulting our other negatives, that it may be a separate ray originating in about the same line of sight, but having greater curvature.

The equatorial regions.—In connection with some of the more interesting features, the relationship between the extensions of the corona and their inner parts is traced back to the inner regions as found on Negative No. 1 of 2 seconds exposure obtained with the 40-foot camera at the Barnesville station.

Most of the finer detail of the outer corona is found on the excellent negative taken with the 104-inch camera and color screen, using CRAMER isochromatic instantaneous plates, which has been before mentioned. The negatives made with the other instruments, mounted on the polar axes, show a less amount of fine detail, though in some cases a greater extension of the coronal streamers. This finer detail is due to some extent to the scale of the image given by the 104-inch camera, which is about 0.9 of an inch for the diameter of the Moon, and also considerably to the processes employed.

The comparatively short duration of totality at this eclipse occasioned a sky of unusual brightness, and several negatives of long exposure taken with the quick-working portrait lenses are considerably darkened by the skylight. This, by preventing contrast between the corona and the background, obliterates the extreme coronal extensions on these plates.

Beginning the description of the equatorial streamers in the northeast quadrant, there are four conspicuous ones in the space extending from the polar rays to the base of the large equatorial wing on the same side. The first two of these are quite intense at their bases, but suddenly diminish in intensity after reaching a distance of about 5′ from the Moon. The second of these is much longer than the first, extending outward with slight curvature toward the south to a traceable distance on this negative of about 20′. Next to these, and the third of this series, is a remarkably long, intense, and narrower streamer extending out to about 1¼ lunar diameters, curving a little toward the equator. It fades away gradually toward the end, and commencing at about the middle widens out somewhat. The last of this series is separated from the one just mentioned by a slight gap extending nearly to the Moon's limb, where this streamer broadens out. It is quite long, extending about a half degree from the Moon with a slightly greater degree of curvature in the same direction than the others. An examination of Negative No. 1, taken with the 40-foot camera at Barnesville and showing the chromosphere in this region, exhibits but slight irregularities on the chromospheric limb in this locality. This would indicate that the prominences have but little to do with the formation of these streamers, if it were certain that the latter emanated from, at, or near the visible limb. This, however, is uncertain, and is hardly possible; while the probabilities are that we are generally looking at the streamers obliquely to some extent. The differences in shape and appearance of the streamers projected apparently in the same vicinity, but having quite different curvatures, would be explained by these circumstances.

The next feature of the outer corona is the great wing on the eastern side, extending from the above streamer to just south of the equator. This wing narrows rapidly as it proceeds outward, and is composed of four broad streamers considerably blended together. Toward the end but two of these streamers remain visible, the outlying ones having disappeared, the remaining pair having the appearance of a double streamer, both in intensity and direction. The general direction in which this wing points is about position angle 65°, or opposite to the general trend of one of the great wings on the western side, which is at 245°.

Lying close to the great wing on the eastern side of the Sun and south of it is a pair of streamers curving toward it. The one next to the great wing is the longer of the two and curves more gently, while the other with greater curvature is apparently composed of long, fine filaments.

Next in order is a long pair of streamers very similar in appearance, traceable to a distance of 1.3 diameters of the Moon. They occupy about the corresponding latitude on this side of the Sun, as the single and remarkably long streamer in the opposite hemisphere. They decrease rapidly in intensity and width for about 10′ from the limb, and on the shorter exposed negatives are seen to be built up of striated filaments. They also seem to originate in the neighborhood of the prominence at 104°, and apparently in the chromosphere on either side of it. In direction they are nearly parallel to each other, and extend about parallel to the equator, though with a slight curvature toward it.

The next streamer between the above pair and the south polar rays is made up of a large number of thin filaments and is quite broad and practically double. The composing filaments resemble those which make up the bundles of rays at either pole. There is no decided separation or gap dividing this streamer, but the part nearest the polar rays is somewhat fainter than the other, though of about the same extent. The southern edge of the streamer is projected in nearly a straight line, curving over slightly, however, for a short distance at its place of emission. The other edge is somewhat more indefinite and blends with its companion streamer. Its inner parts are rather intense owing to the crowding of the filaments composing them, but diminish rapidly in intensity, after which they gradually fade away. The companion streamer is even more intense at its base, and seems to originate in nearly the same locality as the former, and though its filamentary texture is apparent, it is not so evident as in the former case. The place of their emanation is in the region of the prominence at position angle 119° 30′, and has an extent of about 0°.75 on the negative of 20 seconds exposure taken with the 104-inch camera.

Beginning in the southwest quadrant at the junction of the polar rays with the equatorial streamers, the first feature is the extensive wing in this locality, which shows considerable detail in its structure. It is situated, in part, over the two great prominences extending from position angle 212° to position angle 238° 30′. These great prominences are apparently the cause of a considerable disturbance in the direction of some of the streamers in the corona at this position. The southern edge of this great wing adjoining the polar rays is sharply defined, and for a short distance curves in the same direction that they do. As this wing lengthens the edge becomes straighter and toward the end the curvature is reversed. It disappears gradually without coming to a point, and can be traced outward on the negative of 20 seconds exposure, taken with the 104-inch camera, for about 1°.5, while on some of those made with the DALLMEYER lenses it can be followed for upward of 2°. The inner parts of this wing near the edge are composed of long streamers which show a curvature similar to that predominating at the southern edge described. Two of these streamers originating near this southern edge are nearly parallel throughout their entire course. They exhibit, however, a much greater degree of curvature than the southern edge of the wing and deviate from the course pursued by the latter and again return to it. The path followed is very similar in direction to that of the streamers emerging from the region surrounding the great prominences, and they are apparently affected by the same disturbing causes. In at least three places they appear to be connected by faint bridges of coronal matter, giving them a somewhat mottled appearance. This, so far as can be determined, is the sole instance of a like formation in the corona at this eclipse. The streamer next to these originates at nearly the same place, but north of this latter pair, and follows closely in nearly the same curves, but gradually diverging from them. The curvature is more accentuated as it reverses, and from this point on approaches the other gradually. Up to the position of turning it is much brighter than the others, but here drops off suddenly in intensity, after which it continues with about the same brilliancy as theirs.

In the description of the inner corona three bright rays were noted (see page D 40) as being emitted from the upper regions of the great prominence extending from position angle 212° to position angle 216°. Two of these objects, emerging from the southern part of and at the top of this prominence, respectively, blend together into a single long and bright streamer, whose course is quite irregular, though its general direction is almost directly outward. It apparently ends in the long, curved streamer described above, the curvature of the latter bringing them into contact. The other ray emitted from the western side of this prominence maintains a steady though not a greatly curved course toward the north and develops into a streamer of about the same brilliancy as its companion. Between the streamers from this large prominence the corona is composed of striated matter which seems to branch out from these streamers in their outward course.

The region between the great prominence just mentioned and the large prominence extending from position angle 232° to position angle 238° 30′ is filled with nearly parallel filaments of coronal matter. These take the form of a long, narrow wing, which bends over toward the north at first, and finally takes on a reverse curve, turning slightly to the south. The whole contour forms a delicate compound curve which can be traced outward to a distance of 40′ from the limb.

A long, pointed wing extending from position angle 238° 30′ to the equator is next found. The middle part is quite intense and rather broad at its base, narrowing rapidly at first as it recedes from the Sun, and then gradually to its extremity, where it can be traced on the long exposure negatives to a distance of about a half degree. It is composed of filament-like streamers which appear to be curved toward the axial line, which is itself straight, those on the sides being shorter and less intense than the middle part of the wing. On the opposite side of the equator, in northern latitude, another and very similar wing is situated, joined to the former at its base by an intense mass of striated coronal matter. It is of greater length and less pointed than the one just described, and the coronal matter composing it is apparently repelled somewhat on either side from the brighter central streamer seen in it. Between these two wings are two long streamers originating near the base of the northern one, and drawing together at the ends.

The outer corona extending from the wing described above and north of the equator to the great wing in the northwest quadrant consists of two long pairs of faint streamers involved at their bases in nebulosity. In the southern pair the component streamers approach each other, especially toward the end, the curvature being quite irregular. The northern pair proceeds almost directly outward, curving slightly to the south near its extremity.

The remaining wing in this northwest quadrant is the great one adjoining the polar rays. Its northern outline is clear cut and, bending over, follows nearly the curvature of the polar rays in its vicinity, the curvature becoming gradually less as it extends outward. At a distance of about half a degree from its origin the northern edge of this wing gradually straightens and, finally reversing its curvature, continues in that direction till it disappears on the negatives. This is the wing which points in the direction of the planet Mercury, at position angle 268°. Near its northern edge are seen two long, narrow streamers of the polar type, but which are apparently connected with the great wing. They are separated from it somewhat and from each other, but follow nearly the same lines of curvature as its northern edge. The great wing covers an extent of 13° in this quadrant at its base. It tapers rapidly at first on account of the curvature of its northern edge, and then less rapidly as the curve straightens and reverses and ends in a long, narrow streamer. It extends on the negatives of long exposure about 3½ lunar diameters to the planet Mercury. The southern edge of this wing is nearly straight but not so well defined as the northern one. The inner parts show little detailed structure, and that of a faint striated character.

The above description of the outer corona is the result of careful examination of the different negatives, and of positive copies of some of them. It was in some cases impossible to decide with certainty, even after tracing the course of the different features from the short exposure negatives, with which of the streamers they should be included. As most of these finer details are necessarily lost in the process of reproducing these photographs, those wishing to make an exact study of the corona of this eclipse should resort to direct copies on glass of the original negatives.

Exposure Times, Plates Used, and Results for the Barnesville Cameras.

THE 40-FOOT CAMERA.

Kind of Plate.	No. of Negative.	Length of Exposure.	Result.	Remarks.
SEED double coated, 27 G. E. outer and 23 inner emulsion.	1	2 seconds....	Inner corona and chromosphere on eastern side and prominences.	A shorter exposure would have brought out the inner features better.
	2	10 seconds...	Inner corona extended	Striated structure of corona shown well. No prominences.
	3	35 seconds...	Middle corona	Considerable extent of polar rays, striated equatorial wings and streamers.
	4	½ second....	Sun out. Prominences and corona faintly.	Streaks on negative extending from solar cusps.

THE 104-INCH CAMERA.

CRAMER isochromatic instantaneous.	1	2 seconds....	Inner corona..............	Shows slight movement of camera.
	2	5 seconds....	Inner corona..............	Perfectly sharp.
	3	5 seconds....	Middle and inner corona ...	Fairly sharp.
	4	20 seconds...	Outer corona..............	A fine photograph of the corona. Sun reappeared just before capping lens.

THE 80-INCH CAMERA.

SEED 23............	1	2 seconds....	Inner corona..............	
	2	5 seconds....	Inner corona..............	Plate broken in plate-holder across image.
	3	5 seconds....	Middle corona	
	4	20 seconds...	Outer corona..............	Extension and development limited by sky light and reappearance of the Sun.

Exposure Times, Plates Used, and Results for the Barnesville Cameras—Continued.

THE 33-INCH CAMERA.

Kind of Plate.	No. of Negative.	Length of Exposure.	Result.	Remarks.
SEED double coated, 27 G. E. outer and 23 inner emulsion.	1	2 seconds....	Corona as a whole..........	
	2	5 seconds....	Extension of outer corona ..	
	3	5 seconds....	Outer corona	
	4	20 seconds ..	About the same as Negative No. 1, but not as well.	

THE 17-INCH CAMERA.

Kind of Plate.	No. of Negative.	Length of Exposure.	Result.	Remarks.
SEED double coated, 27 G. E. outer and 23 inner emulsion.	1	2 seconds....	Extension of outer corona ..	
	2	5 seconds....	Extension of outer corona ..	
	3	5 seconds....	Extension of outer corona ..	
	4	20 seconds...	Extension of outer corona ..	

THE 9.5-INCH CAMERA.

Kind of Plate.	No. of Negative.	Length of Exposure.	Result.	Remarks.
CRAMER isochromatic instantaneous.	1	2 seconds....	Extension of outer corona ..	
	2	5 seconds....	Extension of outer corona ..	
	3	5 seconds....	Extension of outer corona ..	
	4	20 seconds...	Extension of outer corona ..	

THE BARNESVILLE SPECTROGRAPH AS SET UP AT COLUMBUS, OHIO.
Photographed by H. C. Lord.

THE PRISM SPECTROGRAPH AT BARNESVILLE, GA.
Photographed by H. C. Lord.

REPORT OF PROFESSOR H. C. LORD.

A DISCUSSION OF THE BARNESVILLE SPECTROGRAMS.

INTRODUCTION.

Early in the winter of 1900, Professor Brown wrote me, asking if I would care to join the Naval Observatory eclipse party, and asking me to suggest any line of investigation that had occurred to me. I wrote that I would like to try for the flash spectrum in the visual portion of the spectrum on orthochromatic plates; and I thought it probable that the trustees of the Ohio State University would allow the large stellar spectrograph of the Emerson McMillin Observatory, together with an excellent 4-inch Clark objective, to be used for this purpose. He replied that if I could secure these instruments I might consider myself a member of their party, and that the Government would bear the expense of fitting these instruments for work in the field, together with my own expenses down and back and while at the station.

My reasons for confining myself to the visual spectrum were that while this apparatus was highly efficient for the lower regions it was ill adapted for the upper regions of the spectrum, and further, in the past, observers of the flash had confined their attentions to the violet end of the spectrum.

APPARATUS.

A tube carrying a 4-inch Clark objective of 1,486 millimeters focal length was fitted to the spectroscopic breech-piece of the 12-inch telescope of the Emerson McMillin Observatory, the combination forming a complete telespectrograph, so far as objective, tube, and spectrograph were concerned, but minus the mounting. To supply this, a large cast-iron ring was made into which the breech-piece fitted just as it does to the tail-piece of the 12-inch. This ring carried two trunnions at the extremities of a diameter, which in turn fitted into boxes clamped to a vertical wooden framework heavily braced. Light was fed to the 4-inch objective by an excellent coelostat furnished by the Naval Observatory. The axes of these trunnions were set at right angles to the Moon's path across the eclipsed Sun, and the ring carrying the spectroscope and objective was capable of a slight rotation, given by a short screw, about this axis. Thus by a slight motion the observer was enabled to point the instrument accurately from the edge of the Sun at second contact to that at third, during totality. The whole apparatus was carried on a triangular framework of wood. The vertex of the triangle was pivoted under the center of the coelostat mirror, and the triangle could be rotated in azimuth about this point, enabling the Sun to be observed for a number of days preceding the eclipse, for purposes of adjustment. The arrangement of this apparatus is well shown in PLATE VI, a photograph of the instrument as it was set up and tested at the Emerson McMillin Observatory before it was shipped south. It should be stated that this wooden stand was not sent south, but a similar one was built in the field of somewhat heavier material.

The spectrograph was the two-prism spectroscope of the Emerson McMillin Observatory, and is fully described in the Astrophysical Journal, Volume IV, page 50.

The constants of this instrument are as follows:

Collimator focus, 383 mm.
Collimator effective aperture, 25.8 mm.
Camera focus, 375 mm.
Camera effective aperture, 25.8 mm.
Two 60° extra dense flint prisms.

The camera was provided with a movable plate-holder designed and built by myself in the instrument shop of the Emerson McMillin Observatory especially for this eclipse. On the end of the camera was clamped a rigid bed-plate 10 inches long and 4 inches wide. This carried a sliding piece mounted on ⅜-inch bicycle balls, which traveled in two ways. Directly over these ways two wheels, 1½ inches in diameter, were pressed against the sliding piece by spiral springs fastened to the boxes on the end of the wheel shaft. Thus a very accurate and at the same time easy motion was secured at right angles to the spectrum. This allowed four photographs ⅜ of an inch wide and 1⅞ inches long, leaving ¼ of an inch between them. From the bed-plate projected a diaphragm having the above aperture and nearly in contact with the photographic plate. This prevented portions of the plate not directly opposite the diaphragm from being fogged by diffused light. On the sliding piece was placed an ordinary double plate-holder. The end of the sliding piece carried a toothed projection, into which fitted a catch operated by a small piston fitting a brass cylinder. A rubber bulb, such as is used for any camera shutter, was used to operate it. The slide of the plate-holder being drawn, a portion of the plate ⅜ of an inch by 1⅞ inches was exposed. Pressing the bulb caused the plate to move ¾ of an inch, thus bringing the unexposed portion opposite the diaphragm. Releasing the pressure on the bulb caused a similar shift, and a second pressure made the final change. Four photographs could be taken on one plate with an interval of not over one-fourth of a second between them, the length of exposure being at the command of the observer. During totality the plate-holder was changed and the carriage reset for a second four. To prevent jar, an adjustable brace was carried from the end of the camera to the solid framework of the stand. This effectually prevented any shake, as not the slightest evidence of tremors was detected on the negatives, even though in one instance the plate was shifted without capping the instrument.

In front of the 4-inch objective was a single sliding shutter closed by a spring and opened by pulling a string held in the hand of the observer. Thus, holding the bulb in one hand he could shift the plate, and pulling the string with the other he could make the exposure, which might be long or short, as desired. This shutter was satisfactory for the flash and exposures during totality, but was far from rapid enough for exposures made preceding totality. One-fourth of a second was about the shortest exposure possible.

The tests on the apparatus at Columbus, Ohio, showed that the brace was needed, which had not been designed and was built only after these preliminary trials showed it to be necessary.

To determine the time at which the exposures were to be made, I fastened a 60° dense flint prism in front of the observing telescope of the spectroscope which I had taken to Barnesville to use in adjusting, and mounted this as an objective prism on a rough alt-azimuth stand built in the field. This prism and observing telescope were taken to determine the focus of the collimator and camera by SCHUSTER'S method. This showed the entire process of the flash most beautifully, and in my judgment could not have been improved. Thus I did not need to take my eye from the telescope until all four exposures had been made and it became necessary to change plates and reset the carriage during totality. I could see exactly what I was trying to photograph. At the actual time of the eclipse the slit-plate of the two-prism spectroscope was removed, the image of the solar crescent formed by the 4-inch objective at the principal focus acting as the source of light, the instrument being pointed by means of the light reflected from the front face of the first prism as is done in taking stellar spectrograms, using the Potsdam method of following.

This spectroscope is provided with three millimeter scales; one gives the focus of the camera, one of the collimator, and one the distance of the collimator objective from the 4-inch objective. The eyepiece of the Potsdam device was provided with two cross wires at right angles, one being placed parallel to the slit so that the solar crescent could be brought accurately to the point ordinarily occupied by the slit. PLATE VII shows the instrument as set up at Barnesville, Ga.

RECORD OF ADJUSTMENTS PRECEDING ECLIPSE.

I left Columbus the morning of May 9, the apparatus having been shipped a day or so earlier, arriving at Barnesville on the evening of May 10, and found on the following morning everything in the express office. Work was at once begun on building piers, a new framework, etc., and on May 17 the first observations were made for adjustment. The instrument was pointed on the Sun and the following record entered in my notebook:

Barnesville, Ga., May 17, 1900: Adjusting apparatus; marked setting frame north side center piece at $9^{h}\ 12^{m}$, $\varDelta T = -1^{m}\ 48^{s}$.

From this I was enabled to complete the setting of the triangular frame, which would be proper for α Bootis, which star I expected to use for final adjustment of focus, and found that the index arm should be moved $\frac{11}{16}$ of an inch farther south.

In order to determine the setting for focus of the several scales, namely, that for collimator, camera, and 4-inch objective, the following observations were made:

Barnesville, May 17, 1900: Observations for collimation of different lenses. Visual No. 3 in collimator.

Focus of Collimator.

Line	B	D	b	F	H_γ
	mm	mm	mm	mm	mm
	14.0	13.2	13.0	13.6	13.5
	13.5	13.0	13.1	12.9	13.8
	13.5	13.0	13.0	13.2	14.0
Mean	13.7	13.1	13.0	13.2	13.8

SCHUSTER'S method was employed, using the 60° flint prism and visual objective No. 4 in the observing telescope. These points were plotted on cross-section paper and a smooth curve, the color curve of the collimator objective, drawn through them. From this curve the setting 13.1 for the *b*'s was read off and adopted as the setting of the collimator objective, as being about the middle point of the portion of the spectrum I expected to photograph. In order to find the color curve of the 4-inch, it became necessary to determine that of the observing telescope with the collimator set at 13.1. Accordingly the following observations were made:

May 17, 1900: Observations for collimation of different lenses. Visual No. 4 in observing telescope with Visual No. 3 at 13.1.

Focus of Observing Telescope.

Line	B	D	b	F	H_γ
	° ′	° ′	° ′	° ′	° ′
Deviation	55 5	56 0	57 6	57 47	59 22
	mm	mm	mm	mm	mm
	20.0	19.9	19.3	19.3	20.2
	20.6	19.2	19.0	19.0	19.3
	19.5	19.1	19.0	19.3	20.7
Mean	20.0	19.4	19.1	19.2	20.1

Plotting these, the settings could be read off and the color curve of the 4-inch determined. For this purpose the following observations were made on the Sun's limb: May 17, 1900: Color curve of 4-inch.

Observations on Sun's limb.

Focus of 4-inch Objective.

Line	B	D	b	F	H_γ	Deviation 58° 40′
	mm	mm	mm	mm	mm	mm
	35.0	34.5	36.6	33.0	38.8	39.2
	36.1	35.1	34.8	32.3	39.0	37.8
	37.0	33.4	32.3	35.8	36.5	39.1
	34.5	36.5	35.0	36.5	37.2	35.3
	36.5	33.5	34.5	34.0	38.8	38.0
Mean	35.8	34.6	34.8	34.3	38.1	37.9

Plotting these observations and drawing a smooth curve through them, I found that the setting for *b* was about 35, but such observations are very uncertain and liable to large constant errors. They were only preliminary, as I had determined to find the exact focus by observations of α Bootis, both visually and photographically. Accordingly the following observations were made on α Bootis:

May 19, 1900: Observing telescope set at 19.1. α Bootis for focus of 4-inch.

38.3
38.3
37.5
38.1
38.1

Mean...... 38.1

Setting the scale of the 4-inch at 38.1, the lens Photographic Camera was placed in the camera and the following observations made on α Bootis:

3.8
3.5
4.3
4.3
4.0

Mean...... 4.0

In both cases the observation consisted simply in racking the collimator or camera in and out until the star's spectrum was linear; the camera being provided with a special eyepiece for that purpose, and the slit of course being wide open. In order to determine the focus of the camera more accurately, the following observations were made visually on the Sun:

May 21, 1900: Camera focused on Sun. Lens Photographic Camera in camera.

$\lambda = \frac{F+b}{2}$. 4.5
4.8
5.1
5.1
4.7

Mean...... 4.9

In order to test this still further the following photographs were taken of the solar spectrum:

May 22, 1900: Test photographs for camera on the Sun. Collimator 13.1, 4-inch focus 38.1.

Photograph No. 1, Camera set at 3—3.5—4—4.5
Photograph No. 2, Camera set at 5—4.5—4—3.5
Photograph No. 3, Camera set at 3—4 —5—6
Photograph No. 4, Camera set at 3—4 —5—6

From these plates the setting 4.0 was adopted as the focus of the camera. To accurately determine the focus of the 4-inch the following photographs were taken of α Bootis. The slit was set perpendicular to the star's drift, so that irregular driving of the coelostat mirror would not tend to broaden the spectrum, the slit being wide open.

May 24, 1900: α Bootis for focus, camera at 4.

Negative No.	4-inch Focus.	Order of Exposure.
1	40.0	1 2 3 4 5
2	39.0	4 and 5 close.
3	38.0	
4	37.0	
5	36.0	

May 26, 1900:

Negative No.	4-inch Focus.	Order of Exposure.
1	36	3 and 4 close. Plate run backward.
2	37	
3	38	37 best, but go by ½ mm. to-night.
4	39	

From these I adopted 37.5 as the setting of the 4-inch. Instead of repeating these photographs I made four exposures with the slit set parallel to the stars' drift. These negatives, though considerably under-exposed, are full of lines and quite sharp. Everything was then deemed in satisfactory adjustment.

From this time until the day preceding the eclipse regular rehearsals were kept up. For two days I kept time on myself for each part of the work.

ECLIPSE DAY.

With the string which operated the exposing shutter in one hand and the bulb which shifted the plates in the other, I watched the spectrum through the objective prism spectroscope. At six and one-half minutes before totality the dark H_β line was faintly shown. Three minutes later numerous lines began to appear. Shortly before totality H_β was brilliantly reversed and exposure No. 1 was made. The spectrum then rapidly narrowed and No. 2 snap, about ⅓ of a second exposure, was made. The spectrum continued to narrow until it suddenly broke up into a number of bright strips extending the length of the spectrum. With this came the flash and No. 3 was exposed. I had intended at this point to leave the shutter open until the flash disappeared, but habit was stronger than purpose and I involuntarily made a snap shot at this point; I instantly remembered myself and again opened the shutter so I feel safe in saying that I did not lose over ⅓ of a second by this mistake. It is, however, in my judgment, rather fortunate that this accident happened, as it throws some light on the duration of the flash.

Negative No. 6 had full exposure on the flash, and yet does not show much greater exposure than No. 3, which would tend to show that the duration of the flash was considerably under one second.

The appearance of the flash itself was very peculiar, though the entire appearance was excessively short. My notes, made at the time, say, "Could not have been over one second." It was not fixed while it lasted, for the lines seemed to twinkle. It were as if one whose back was turned to one of those signs made by incandescent lights which are kept going out and lighting up again by a motor, the motor being speeded up, were to whirl about on his heel and note the appearance of the sight as it flashed past him. As soon as the flash disappeared exposure No. 4 was made for about three seconds. As the slide was arranged for only four exposures the plate-holder was changed, the slide set, and the instrument pointed to the point of third contact. So intent had I been on watching the spectrum through the objective prism that I had been oblivious to the count, and fearing I was late, I listened and heard 33–34 with a sense of great relief. I at once opened the 4-inch, thus exposing Negative No. 5, and turned to look at the corona which I watched until 60 was called. When I turned back to the objective prism I was at once struck with the great brilliancy of the H_β line which showed several well-marked prominences, and I felt it was time the plate was shifted without closing the 4-inch. This exposure was continued until the flash was well developed and as long as I dared. The objective was then capped and the plate shifted, but I made a double shift at this point, so that I had but one plate left to expose after the third contact. This exposure was made almost immediately following the flash; was about ⅓ of a second duration, and is No. 8 on my list, No. 7 being a blank. The plates were taken to Columbus for development.

DESCRIPTION OF NEGATIVES.

The most noticeable feature common to all was the great amount of continuous spectrum. This was certainly not due to light leaking through the apparatus, as this point had not only been carefully tested, but portions of the plate between the exposures showed not the faintest trace of fog. Negative No. 1 was much over-exposed, but showed, in addition to a number of the dark FRAUNHOFER lines, the *F* line brilliantly reversed on the edges and dark in the center. The dark *F* fades into the bright one, but the lines do not butt against each other but overlap, so that for a considerable extent the bright and dark lines are seen side by side like the pieces of a spliced rod, except that the prolongation of the dark line does not pass through the center but to one side of the bright line. The same thing is shown in a few of the other lines but is not nearly so well marked. Negative No. 2 shows a number of bright lines bordering a continuous over-exposed spectrum containing only a very few dark lines. D_3 is bright, clear across the spectrum. Negative No. 3 is the flash extending from D to H_γ. Negative No. 4 shows only a very few bright lines. Negative No. 5 the same. Negative No. 6 is the flash at third contact. Negative No. 8 shows quite a number of bright lines bordering the continuous spectrum, which, as in Negative No. 2, shows almost no dark lines but a number of light and dark streaks running the length of the spectrum. Negatives No. 3 and No. 6 are reproduced in PLATES LIX and LX.

MEASUREMENT OF NEGATIVES NO. 3 AND NO. 6.

For the measurement of these two negatives the following plan was adopted:

The two lines $\lambda=3197.56$ and $\lambda=5188.78$ were selected on account of their great sharpness as zero lines, and the zero of the plate was taken as the mean of the micrometer settings on the two lines. The instrument used was a ZEISS comparator No. 10. This instrument consists of two micrometer microscopes mounted on a stand. Under the microscopes is a sliding plate, upon one end of which and under one of the microscopes is fastened a scale graduated upon silver to fifths of a millimeter. On the other end of the sliding plate and under the second microscope is a plate which has a small motion parallel to the motion of the first plate. This carries the negative, which can therefore be moved accurately a small amount parallel to the scale, so that any given line can be brought to a particular setting. The plate and scale can then be simultaneously moved parallel to the scale for its entire length, thus bringing in succession all the lines of the negative under the wire of the plate microscope.

As the work was actually carried out the plate micrometer was kept at zero, the bisections being made by means of the slow motion which moves the sliding plate of the instrument, and the division on the scale was then bisected by the scale microscope. The scale reading M corresponding to any line is given by the equation,

$$M=S+m+\Delta+me,$$

where S is the scale reading, m the micrometer reading, Δ the division error, and e the error of runs. The micrometer head is divided into 100 parts, and two revolutions correspond to one division on the scale; thus the minimum reading of the instrument is 0.0001 of a millimeter. The error of runs is 0.0011 of a millimeter. Thus the maximum value of me is 0.0002 of a millimeter. The magnifying power used was approximately 20 diameters.

In the use to which this instrument is put at the Emerson McMillin Observatory there is no occasion to have the absolute values of Δ, it being only necessary to have a scale of equal parts. To determine these errors the scale readings 40 and 60 were adopted as correct. A second scale was ordered from ZEISS, and the division errors determined by a method slightly modified from that given by Doctor GILL in Monthly Notices of the Royal Astronomical Society, Volume XLIX, page 105. This work was done from February, 1897, to January, 1898, and required a total of 9,044 pointings. The space 40 to 60 was divided into ten equal parts on eight different days, and each 2-millimeter space was then divided into ten equal parts on three different days, the agreement of the several days' work being very satisfactory, the maximum difference between two values for any one line being 0.0009 of a millimeter, and this occurs but once. The values are given in TABLE I.

Negatives No. 3 and No. 6 were taken so nearly at the instant of the interior contacts that the continuous spectrum is reduced to a few narrow streaks which, when examined closely with a low power eyepiece, are seen to be full of bright lines, and when examined under the measuring engine lose all appearance of a continuous spectrum and appear singly as streaks of maximum density of the bright lines. They serve, however, as an easy means of adjusting the plate parallel to the scale, it only being necessary to make a spot of dust in the eyepiece follow the streak as the plate is moved rapidly from end to end. As the instrument at Barnesville was set for the mean position angle of the two contacts, the tangents to the solar crescents at the points where they are crossed by these streaks are not at right angles to the direction of the streak, and it would be difficult to make an accurate pointing were the micrometer wire set perpendicular to the direction of motion of the plate under the microscope. This difficulty was entirely avoided by rotating the plate micrometer until the wire was tangent to the curved lines at the point where they are crossed by the streak; with this precaution I think almost if not quite as accurate pointings can be made as if the lines were straight.

Each negative was measured two different times, with an independent estimate of the intensity and character of the lines. From a preliminary determination of the probable error of pointing on a sharp line it was found that this was about of the same magnitude as the larger division errors, and while it seemed almost unnecessary to take them into account, yet to be on the safe side it was done, where the definition was at its best. In order to do this it was necessary to shift the plate, the measurements being carried on in two positions. In the first position the first zero line was at *M* 47.51, and in the second position at *M* 60.00 approximately. This enabled corrections for division error to be applied as far as $\lambda=4549.78$. The following program of measurement was adopted:

First three pointings were made on each of the zero lines, then three on each of the lines to be measured, except in those cases where the lines were either groups or very indefinite in character. In these cases but a single pointing was made, and in all such cases the wave-lengths are carried out only to the nearest ÅNGSTRÖM unit. At the close of each set of measurements three more pointings were made on each of the zero lines. Thus a means was given whereby not only could the two positions of the plate be reduced to the first position, but the several days' work could be reduced to a common zero point, and any change in the position of the plate during measurement could be detected. The reading of the scale for the point midway between these lines was taken as 47.438 that of the first day's work; and the correction to be applied to the measures for any other day's work is given by

$$47.438-\tfrac{1}{2}\,(M_1+M_2),$$

where M_1 and M_2 are the readings on the zero lines. The micrometer was read to 0.0001 of a millimeter, and after taking the means and applying the corrections Δ and *me*, the ten thousandths of a millimeter were dropped as being meaningless. These averages were made in duplicate. The measurements and their preliminary adjustments are given in TABLE II.

DISCUSSION OF MEASUREMENTS.

The measurements thus obtained are given in columns 5 and 8, TABLE II. From an examination of these figures it is at once evident that there was a progressive difference in the measurements of corresponding lines on the photographs of the flash at the two contacts. This was due to two causes. First, in shifting the instrument during totality it was impossible to bring the solar crescent to exactly the same point on the focal plane of the collimator. An effect therefore would be produced exactly similar to a slight shift of the slit parallel to itself. Second, should the several lines be at different elevations it is evident that the high-level lines would be shifted relatively to the low-level lines too far towards the violet on one plate and too far towards the red on the other. In order to test if there was any such displacement, seventy-one low-level lines were selected from the two negatives, No. 3 and No. 6, and the differences $M_3 - M_6$ were plotted on cross-section paper. It at once became evident that the discordances followed a well-marked law, and that they could be represented by a straight line about as well as by any other form of curve. Accordingly a straight line was passed through these points by the method of least squares, and the following equation deduced:

$$\Delta M_3 = M_6 - M_3 = +\overset{\text{mm}}{0.0016} - \overset{\text{mm}}{0.00256}\ (M_3 - 47.0),$$

where M_3 is the measured scale reading of any line on Negative No. 3.

The value of this correction is given in column 6, TABLE II. Column 7 gives the measured scale reading of Negative No. 3 thus reduced to the basis of Negative No. 6, and column 9 the mean of the two measurements. As the correction was based solely on low-level lines—that is, short lines—it is evident that were the long lines at any considerable elevation the amount of this elevation would show in the difference $M_3 - M_6$ after the measurements of Negative No. 3 had been corrected by the above formula. I give in TABLE III this difference for all lines having an elevation (length) greater than 4.

Assuming that the difference in column $M_3 - M_6$ corresponds to a difference of elevation of the substance emitting the given line and that the stratum was of uniform brilliancy, it is evident that the elevation of its upper limit would be given by the expression

$$E = 206264 \times 450 \times \frac{f_1 (M_3 - M_6)}{1000 f_2 F} = 64\ (M_3 - M_6),$$

where $E =$ elevation in miles, $f_1 = 383$ millimeters focal length of collimator, $f_2 = 375$ millimeters focal length of camera, and $F = 1486$ millimeters focal length of image lens. This, of course, would only be exact for minimum deviation, but would be sufficiently accurate for the extent of spectrum covered by these negatives. Upon this assumption I have computed the elevations given in TABLE III. Of the three negative values found two are so small as to be easily accounted for by accidental errors of observation, while the third is near the limit of the negative and is so badly out of focus as to render the measurements very uncertain.

Of the four lines whose elevation comes out greater than 1,000 miles one is F. The two at 4713.67 and 4471.83 are given by YOUNG as due to cerium, and the remaining one at 5015.80 as due to titanium. The behavior of this latter line is, however, very peculiar and is similar to that of the line at 4686.28. Both of these lines on the two negatives show much more markedly at the horns of the crescent than at the vertex where they seem to disappear almost entirely, so much so in fact that it was impossible to actually set the micrometer wire upon them at that point, and the measurements were made by estimating the distance from a close companion. This peculiarity is shared by no other lines found on either negative and is clearly marked for both these lines on each negative. I feel therefore that these two lines must be common to some substance, and that they are not due to a substance which shows other lines on the photographs.

Since the above was written Prof. E. B. FROST has called my attention to the close agreement of three of these lines with those found by RUNGE and PASCHEN in the spectrum of cleveite gas. The line 4713.67, with an intensity of 4, agrees with the mean of 4713.252 and 4713.475, intensities 3 and < 1, respectively, within the limit of error of my wave-lengths; 4471.83, intensity 10, agrees with the mean of 4471.646 and 4471.858, intensities 6 and < 1, respectively; and 5015.80, intensity 2, with 5015.732, intensity 6. The first two belong to the second and first subordinate series of helium proper, respectively, the last to the principal series of the lighter constituent. This explanation would be very satisfactory were it not for the line at 4686.28, which is not found by these observers in cleveite gas, nor by KAYSER in the spectrum of argon. ROWLAND gives a line at 4686.40 with an intensity 3 as due to nickel, but this line in its behavior is so exactly like that at 5015.80, and so radically different from all the others, that I can not believe it is due to nickel. In a paper entitled The New Series in the Spectrum of Hydrogen, Astrophysical Journal, Volume VI, page 236, RYDBERG deduces from his formulæ a line at 4687.88, concerning which he says:

> These conclusions are confirmed in every respect, if we consider the spectra of stars of the fifth type. * * * As we see, all the known lines of hydrogen are surpassed in intensity by the line 4688, which corresponds almost exactly to the computed value 4687.88, and which we can, with full certainty, indicate as the first line of the hydrogen spectrum, being at once the first term of the principal and of the sharp series.

The line 4686.28 may well be this hydrogen line; the difference in wave-length, 1.6 ÅNGSTRÖM units, is somewhat large, but the peculiar character of the line made measurements rather uncertain. Its intensity is, however, much less than that of the other hydrogen lines, being certainly not over one-tenth that of either H_β or H_γ.

The low value of these elevations appears to be somewhat surprising. Even if the stratum, which gives rise to these radiations at greater elevations is not of uniform intensity, but much brighter on the inner side, it would hardly seem that the center of density should come very much nearer the level of the shorter crescents, and in that case the crescent should appear sharp on the inner edge and hazy on the outer, a condition of affairs which is by no means markedly in evidence. Furthermore, the elevations are in a great many cases but a very small fraction of the width of the line, thus indicating that the high level (long) lines, while being shifted bodily by a small amount relatively to the low level (short) lines, have nevertheless been broadened on each side of this shifted position by a much greater amount. If this be true, the explanation is not at once apparent, at least to me. That the shift above is real, and an approximation at least to the true amount, is confirmed by Negative No. 1, exposed several seconds before totality. Here the dark and bright *F* lines are seen side by side and evidently overlapping, but not superimposed. A number of other lines are found both bright and dark, but only in the case of *F* was the definition good enough to enable even an approximation to a measurement. The value found in this case was 0.033 of a millimeter, or 2,112 miles as the distance between the centers, or 4224 from the outer edge of the high level stratum. But these lines nearly overlapped, as both the bright and dark *F* lines fined down where they came together, thus tending to greatly increase the measured elevation. I have given this discussion thus fully for I can see no instrumental cause that would cause this shift, and am at a loss to understand why it is not greater in amount. I can only say that I have given the facts as they have been observed, absolutely without bias, as I was ignorant until all the computations had been finished as to whether this shift corresponded to a low or high elevation.

DETERMINATION OF WAVE-LENGTHS.

For the determination of wave-lengths the following plan was adopted. Three normal places were formed from the measurements given in column 9, TABLE II. For the first normal place D_1, D_2, and D_3 were used; for the second b_1, b_2, and $\frac{b_3+b_4}{2}$; for the third *F*. From these the following normal places were found:

For $M=59.900$ $\lambda=5888.35$
$M=47.000$ $\lambda=5173.95$
$M=38.680$ $\lambda=4861.50$

From these a CORNU-HARTMANN interpolation formula was computed, giving the following equation:

$$\lambda=2697.89-\frac{[5.1542630]}{M-104.610}$$

With this formula the list of normal lines given in TABLE IV were identified with lines in YOUNG'S list of chromospheric lines as revised by FROST in SCHEINER'S Astronomical Spectroscopy. The first column gives the number, the second the intensity, the third the adopted λ, the sixth the value of M computed by the above formula, the seventh the observed value of M being the mean of Negative No. 6 and Negative No. 3 reduced as above to Negative No. 6, the eighth $C-O$, the ninth, tenth, and eleventh are from YOUNG'S list of chromospheric lines. The remaining columns explain themselves. I think this table explains the values of the adopted wave-lengths. In adopting these values while adhering to no rule but trusting rather to my judgment as to what seemed the most probable value from the material at my command yet I was guided by the following considerations. Where two lines were found too close to be resolved on my negatives and of equal or nearly equal intensity as given by KAYSER and RUNGE in the arc spectrum their mean wave-length was adopted, while if their intensities were markedly different that of the brighter one was used. In every case ROWLAND'S value of λ was employed. Though these adopted wave-lengths may be slightly in error, yet I do not believe they will be so changed as to appreciably alter the wave-length computed from them as normal lines even though they may change quite appreciably the constants of the CORNU-

Hartmann formula. D_3 and F were rejected from this second list of normal lines as being far too wide for accurate measurement. From these 28 residuals corrections to c and m of the Cornu-Hartmann formula, together with their weights and probable errors, were computed by the method of least squares and the final values found were

$$\lambda = (2695.60 \pm 0.64) - \frac{(142857 \pm 79)}{M - (104.637 \pm 0.018)},$$

while the probable error of an observation of M whose weight is unity came out 0.0022 of a millimeter corresponding to a probable error of 0.04 at m 20, 0.07 at m 40, and 0.16 at m 60.

With this equation the wave-lengths of the normal lines were computed and are given in column 4, Table IV, and the residuals $C\text{–}O$ in column 5. The average probable error of a single wave-length deduced from these residuals comes out 0.09 of an Ångström unit.

With this same equation the final wave-lengths given in Table II were computed. These were first computed directly with seven-place logarithms and checked by computing a table for every millimeter of M from 20 to 60 and interpolating, using second differences, and are I think free from any errors of computation. I have carried these wave-lengths out to the hundredths of an Ångström unit, not because I think the hundredths are of real significance, but, except in the case of very broad lines, such as D, F, and H_γ, and in cases of lines classed as very hazy, I believe the tenths are, and it was as easy to carry out the computations to the hundredths as to be certain of having the tenths correct. The normal lines were not extended beyond 4549.78, as above this point the want of definition due to the nonachromatic properties of the instrument employed became very marked. But I computed their wave-lengths, as one does not feel inclined to throw away any material secured at the time of an eclipse, even if not of very great value.

I had hoped to be able to determine the elevations of these lines by measuring the arc of their crescents, but it soon became evident that measurements of this character would be valueless, since the irregularities of the Moon's surface were so large in proportion to the elevations that lines frequently appeared, disappeared, and reappeared again several times. I decided, therefore, to divide the lines into five classes and denote their elevations on a scale of from 1 to 5, 1 being the shortest and 5 being the longest.

I have added three columns to Table II, giving all lines in Young's list of chromospheric lines which are certainly found on my negatives, and, in addition, those lines of Young's list which, though near the lines of my negative, yet seem so far away as to render the identification doubtful. The remaining 89 lines are certainly not present in Young's list, while a number of the lines given in Young's list are not found on my negatives. Further than this I have made no attempt at identification, as my library facilities are far too limited to justify me in such an attempt. Furthermore, it is the object of this report to present the facts observed rather than to discuss them.

Table I.

M	*Δ*	*M*	*Δ*	*M*	*Δ*	*M*	*Δ*	*M*	*Δ*
	mm		mm		mm		mm		mm
40.0	0.0000	44.2	+0.0004	48.2	+0.0012	52.2	+0.0020	56.2	+0.0007
40.2	+0.0018	44.4	+0.0004	48.4	+0.0005	52.4	+0.0012	56.4	−0.0001
40.4	+0.0009	44.6	+0.0007	48.6	+0.0007	52.6	+0.0015	56.6	+0.0004
40.6	+0.0010	44.8	+0.0002	48.8	−0.0001	52.8	+0.0013	56.8	0.0000
40.8	+0.0010	45.0	0.0000	49.0	+0.0004	53.0	+0.0006	57.0	+0.0008
41.0	0.0000	45.2	+0.0012	49.2	+0.0007	53.2	−0.0008	57.2	+0.0010
41.2	+0.0011	45.4	0.0000	49.4	+0.0003	53.4	−0.0011	57.4	−0.0004
41.4	−0.0001	45.6	+0.0014	49.6	+0.0010	53.6	−0.0002	57.6	+0.0014
41.6	+0.0004	45.8	+0.0003	49.8	+0.0005	53.8	−0.0011	57.8	+0.0006
41.8	+0.0004	46.0	+0.0008	50.0	+0.0014	54.0	+0.0009	58.0	0.0000
42.0	+0.0006	46.2	+0.0021	50.2	+0.0018	54.2	+0.0014	58.2	+0.0001
42.2	+0.0005	46.4	+0.0015	50.4	+0.0009	54.4	+0.0007	58.4	−0.0006
42.4	+0.0017	46.6	+0.0008	50.6	+0.0013	54.6	+0.0006	58.6	−0.0003
42.6	+0.0003	46.8	+0.0003	50.8	+0.0014	54.8	+0.0006	58.8	−0.0003
42.8	+0.0005	47.0	+0.0004	51.0	+0.0020	55.0	+0.0002	59.0	−0.0007
43.0	+0.0012	47.2	+0.0006	51.2	+0.0019	55.2	+0.0009	59.2	+0.0001
43.2	+0.0015	47.4	+0.0005	51.4	+0.0012	55.4	+0.0006	59.4	+0.0006
43.4	+0.0010	47.6	+0.0001	51.6	+0.0004	55.6	+0.0008	59.6	−0.0007
43.6	+0.0007	47.8	+0.0003	51.8	0.0000	55.8	0.0000	59.8	−0.0001
43.8	+0.0015	48.0	−0.0005	52.0	+0.0021	56.0	0.0000	60.0	0.0000
44.0	+0.0011								

Table II.

Note.—In the column "Character," *S* indicates sharp; *H*, hazy; *B*, broad; *BG*, broad group; *V²H*, very, very hazy, and similarly for *V³H*; *? H*, doubtful, hazy line; *SB*, sharp band; *BHG*, broad, hazy group; *BPD*, broad, probably double; *W*, wide; *RSVH*, sharp on red side, hazy on violet.

No.	Int.	Elev.	Character	M_3	ΔM_3	$M_3 + \Delta M_3$	M_6	Mean.	Computed Wave-length.	Young's Chrom. Lines.		
										λ	F	B
1 D_1*	4	4½	S-H-HR-H	60.034	−.032	60.002	60.002	60.002	5896.16	5896.16	25	2-10
2 D_2*	4	4½	S-S-H-S	59.950	−.032	59.918	59.914	59.916	5890.00	5890.18	25	2-10
3 D_3	10	5	S-HR-HR-S	59.780	−.031	59.749	59.746	59.748	5878.05	5876.0	100	90
4	1	1	?H-VH	......	.....	......	59.410	59.410	5854.27	5853.90	8	2
5	1	1	Hazy group..........	57.25	−.02	57.23	57.24	57.24	5710.	5709.62	1	1
6	1	1	Hazy group..........	......	.....	......	56.86	56.86	5686.	5688.43	2	1
7	1	1	?H-H	56.527	−.023	56.504	.....	56.504	5663.56	5662.75	15	2
8	1	1	Very large and broad ?H	......	.....	......	56.478	56.478	5661.96	....	...	....
9	1	1	S-S-S-S.............	56.436	−.022	56.414	56.415	56.414	5658.02	5658.10	8	3
10	1	1	S-S	56.160	−.022	56.138	......	56.138	5641.17	5641.66	1	1
11	1	1	VBH-?H	......	.....	......	55.870	55.870	5624.98	5624.77	2	1
12	1	1	H-H-S-S............	55.732	−.022	55.710	55.714	55.712	5615.52	5615.88	2	1
13	1	1	HG-HG-HG-H	55.50	.....	......	55.494	55.494	5602.57	....	...	....
14	1	1	S-S	......	.....	......	55.350	55.350	5594.07	....	...	....
15	1	1	HPD-BH-HPD-H ...	55.269	−.020	55.249	55.248	55.248	5588.09	5588.98	2	2
16	1	1	H-H	......	.....	......	54.992	54.992	5573.17	....	...	....

*Normal lines.

TABLE II—Continued.

No.	Int.	Elev.	Character.	M_3	ΔM_3	$M_3+\Delta M_3$	M_6	Mean.	Computed Wave-length.	YOUNG'S Chrom. Lines.		
										λ	F	B
17	1	1	H-H	.....	.....	......	54.933	54.933	5569.76	....	...	....
18*	2	2	S-S-S-S	54.348	—.017	54.331	54.328	54.330	5535.30	5535.07	50	12
19	2	3	S-H-H-B	54.208	—.017	54.191	54.198	54.194	5527.65	5528.64	40	5
20	1	1	H-H-S-S	53.830	—.016	53.814	53.821	53.818	5506.69	5507.00	2	1
21	1	1	H-H-S-H	53.740	—.016	53.724	53.727	53.726	5501.62	5501.69	2	1
22	1	1	H-H-H-S	53.666	—.015	53.651	53.644	53.648	5497.32	5497.73	2	1
23	2	1	S-S-S-S	53.288	—.014	53.274	53.272	53.273	5476.86	5477.13	1	1
24	1	1	H-H-S-S	53.024	—.014	53.010	53.010	53.010	5462.70	5463.49	1	1
25*	3	2½	S-S-S-S	52.894	—.014	52.880	52.883	52.882	5455.86	5455.83	10	4
26*	2	2½	S-S-S-S	52.731	—.013	52.718	52.716	52.717	5447.08	5447.13	10	4
27	2	2	S-S-S-S	52.496	—.012	52.484	52.481	52.482	5434.69	5434.74	2	2
28*	2	2	S-S-S-S	52.400	—.012	52.388	52.384	52.386	5429.65	5429.9	8	3
29	1	1	S-S-S-S	52.308	—.012	52.296	52.300	52.298	5425.06	5425.4	25	6
30	1	1	S-S-H-?H	52.198	—.012	52.186	52.183	52.184	5419.12	5419.0	5	2
31	1	1	H-S-H-S	52.116	—.012	52.104	52.106	52.105	5415.03	5415.42	2	2
32	1	1	S-S-S-S	52.020	—.011	52.009	52.006	52.008	5410.02	5410.0	2	2
33	2	2	S-S-S-S	51.936	—.011	51.925	51.927	51.926	5405.79	5405.99	2	1
34	1	1	S-?S	......	.....	......	51.896	51.896	5404.25	5404.1	5	3
35	1	2	S-S-S-S	51.772	—.011	51.761	51.761	51.761	5397.34	5397.35	4	2
36	1	1	?H-S	......	.....	......	51.686	51.686	5393.51	5393.38	2	1
37	1	1	HG-HG-HG-BG	51.46	—.01	51.45	51.44	51.44	5381.	5381.2	3	2
38	3	2½	S-S-S-S	51.262	—.009	51.253	51.250	51.252	5371.58	5371.69	10	3
39	2	2	H-H-V^2H	51.090	—.009	51.081	51.077	51.079	5362.92	5363.01	20	5-10
40	1	1	H-H-S-S	50.906	—.008	50.898	50.887	50.892	5353.65	5353.59	2	2
41	1	1	H-H	50.820	—.008	50.812	......	50.812	5349.70	....	...	....
42	1	1	H-S-S-S	50.748	—.008	50.740	50.736	50.738	5346.06	5346.0	1	1
43	1	1	S-S-S-S	50.644	—.008	50.636	50.632	50.634	5340.95	5341.3	2	1
44	1	1	S-S-S-S	50.558	—.007	50.551	50.549	50.550	5336.84	5336.9	5	2
45*	4	3½	S-S-S-S	50.382	—.007	50.375	50.375	50.375	5328.33	5328.7 5328.2	3	2
46	1	1	H-H	......	.....	......	50.290	50.290	5324.21	5325.4	2	2
47	4	3½	S-S-S-S	50.146	—.006	50.140	50.135	50.138	5316.88	5316.79	100	2-20
48	1	1	H-??H	49.939	—.006	49.933	......	49.933	5307.05	....	...	....
49	1	1	H-H-S-H	49.841	—.006	49.835	49.835	49.835	5302.38	.. ....	...	....
50	1	1	H-H-B and H-H	49.742	—.005	49.737	49.746	49.742	5297.97	....	...	....
51	2	1	Note HV-H-H	49.450	—.005	49.445	49.444	49.444	5283.92	5284.2	10	2-6
52	1	1	?H-H	......	.....	......	49.390	49.390	5281.39	....	...	....
53*	4	3½	S-S-S-S	49.284	—.004	49.280	49.276	49.278	5276.16	5276.21	10	10
54*	5	3½	S-S-S-S	49.153	—.004	49.149	49.144	49.146	5270.02	5270.50	5	2
55	1	1	Band	49.08	.00	49.08	49.07	49.08	5267.	5266.73	5	2
56	1	1		48.96	.00	48.96	48.96	48.96	5261.	5260.5	1	1
57	1	1	S-S-S-H	48.820	—.003	48.817	48.822	48.820	5254.98	5255.1 5255.2	1	1
58	1	1	H-S-S-S	48.730	—.003	48.727	48.724	48.726	5250.68	5249.8	3	1
59	1	1	S-S-S-S	48.638	—.002	48.636	48.651	48.644	5246.94	5247.8	2	1

* Normal lines.

TABLE II—Continued.

No.	Int.	Elev.	Character.	M_3	ΔM_3	$M_3 + \Delta M_3$	M_6	Mean.	Computed Wave-length.	YOUNG'S Chrom. Lines.		
										λ	F	B
60	2	3	H–SB–S–S	48.364	–.002	48.362	48.374	48.368	5234.42	5234.8	10	10
61	1	1	S–S	......	.....	......	48.334	48.334	5232.89	5233.12	1	2
62	1	1	S–S–S–S	48.206	–.001	48.205	48.199	48.202	5226.95	5226.7	5	5
63	3	4	H–H–H–V^2H	47.963	–.001	47.962	47.959	47.960	5216.15	5216.5	3	2
64*	3	4	S–S–H–S	47.796	.000	47.796	47.788	47.792	5208.70	5208.8 5208.6	4	5
65*	1	1	B–Probably double	47.723	.000	47.723	47.714	47.718	5205.43	5205.9	1	2
66	1	1	S–S–S–S	47.540	.000	47.540	47.538	47.539	5197.56	5197.8	15	10
67	1	1	H–S	......	.....	......	47.487	47.487	5195.29	5195.1	2	2
68	1	1	S–S–H–S	47.414	+.001	47.415	47.413	47.414	5192.10	....	...	....
69	1	1	S–S–S–S	47.337	+.001	47.338	47.338	47.338	5188.78	5189.0	10	5
70 b_1*	8	5	S–S–S–S	47.232	+.001	47.233	47.230	47.232	5184.18	5183.79	50	35
71 b_2*	5	5	S–S–S–S	46.979	+.002	46.981	46.974	46.978	5173.22	5172.87	50	30
72 b_3*	5	4	S–S	46.866	+.002	46.868	46.883	46.865	5169.14	5169.22	40	25
73 b_4*	5	4	S–S				46.842		5167.39	5167.57	20	10
74	1	1	?H–??H	......	.....	......	46.717	46.717	5162.05	5161?	1	1
75	1	1	H–VH–H–H	46.531	+.003	46.534	46.527	46.530	5154.12	5153.5	2	2
76	1	1	?Hazy–V^2 doubtful V–VH	46.456	+.003	46.459	46.459	46.459	5151.12	5151.03	1	1
77	1	1	?H–?H	......	.....	......	46.388	46.388	5148.12	5149.2	2	2
78	1	1	H–H–S–H	46.248	+.003	46.251	46.258	46.254	5142.49	5143.04	2	1
79	1	1	S–S–S–H	46.178	+.004	46.182	46.181	46.182	5139.48	....	...	....
80	1	1	H–?H	......	.....	......	46.116	46.116	5136.72	....	...	....
81	1	1	H–H–S–VH	45.928	+.004	45.932	45.931	45.932	5129.07	5129.8	1	1
82	1	1	H–H	45.789	+.005	45.794	......	45.794	5123.36	5123.5	2	2
83	1	1	S–S–S–S	45.478	+.005	45.483	45.482	45.482	5110.56	5112.3	2	2
84	1	1	S–S–S	45.398	+.006	45.404	45.408	45.406	5107.46	5107.8	1	1
85	1	1	H–H	45.180	.....	......	45.24	45.24	5101.	5098.8	1	1
86	1	1					45.14	45.14	5097.	5097.18	1	1
87	1	1	S–S–S–S	44.902	+.007	44.909	44.912	44.910	5087.43	5087.6	2	1
88	1	1	S–S–H–H	44.798	+.007	44.805	44.807	44.806	5083.28	5084.3	1	1
89	1	1	H–H–H–H	44.706	+.007	44.713	44.716	44.714	5079.61	5079.0	1	2
90	1	1	?H–S–S	44.583	+.008	44.591	44.590	44.590	5074.69	....	...	....
91	1	1	H–?H–S–H	44.516	+.008	44.524	44.530	44.527	5072.19	....	...	....
92	1	1	H–H–VH	44.437	+.008	44.445	44.439	44.442	5068.84	....	...	....
93	1	1	H–H–S–H	44.324	+.008	44.332	44.337	44.334	5064.59	....	...	....
94	1	1	G	......	.....	......	44.21	44.21	5060.	....	...	....
95	1	1	BHG	44.02	+.01	44.03	......	44.03	5053.	....	...	....
96	1	1	....	43.89	+.01	43.90	......	43.90	5048.	5048.2	2	2
97	2	1	....	......	.....	......	44.000	44.000	5051.54	....	...	....
98	2	1	H–H–S–S	43.724	+.010	43.734	43.739	43.736	5041.33	5041.80	2	2
99	1	1	H–H–S–S	43.574	+.010	43.584	43.588	43.586	5035.56	....	...	....
100	2	1½	S–S–S–H	43.460	+.011	43.471	43.472	43.472	5031.20	5031.3	4	3
101	1	1	S–S	......	.....	......	43.376	43.376	5027.54	....	...	....
102*	5	4½	S–S–S–S	43.132	+.012	43.144	43.139	43.142	5018.67	5018.5	30	15

* Normal lines.

TABLE II—Continued.

No.	Int.	Elev.	Character.	M_3	ΔM_3	$M_3 + \Delta M_3$	M_6	Mean.	Computed Wave-length.	YOUNG'S Chrom. Lines.		
										λ	F	B
103	2	4½	Note	43.064	+.012	43.076	43.056	43.066	5015.80	5015.9	30	10
104	1	1	?H-V^3H	......	.....	......	43.034	43.034	5014.59	....	...	....
105	1	1	S-S	42.987	+.012	42.999	......	42.999	5013.28	....	...	....
106	1	1	S-S-H-S	42.943	+.012	42.955	42.968	42.962	5011.89	... ...	...	....
107	1	1	BH-BH-HG-BG	42.796	+.012	42.808	42.81	42.808	5006.12	....	...	....
108	1	1	BHG-BHG	42.64	......	......	42.71	42.71	5002.	....	...	....
109	1	1	......				42.61	42.61	4999.	....	...	....
110	1	1	H-VH-S-S	42.462	+.013	42.475	42.477	42.476	4993.78	4994.32	2	1
111	1	1	S-VH-S-H	42.378	+.013	42.391	42.400	42.396	4990.83	....	...	....
112	1	1	Hazy group	42.15	+.01	42.16	42.18	42.17	4982.	....	...	....
113*	3	3½	S-S-S-S	41.466	+.016	41.482	41.480	41.481	4957.57	4957.48	1	2
114	1	1	Hazy	......	.....	......	41.165	41.165	4946.31	....	...	....
115	1	1	H-H-VH-H	40.937	+.017	40.954	40.958	40.956	4938.92	....	...	....
116*	5	4	S-S-S-S.	40.806	+ 017	40.823	40.820	40.822	4934.21	4934.2	30	5
117*	5	4	S-S-S-S	40.514	+.018	40.532	40.534	40.533	4924.12	4924.11	40	10
118	1	1	S-S with shading	......	.....	......	40.432	40.432	4920.61	4919.18	20	5
119	1	4	Note	......	.....	......	40.390	40.390	4919.16	4919.1	20	3
120	1	1	S-H	......	.....	......	40.238	40.238	4913.91	4912.3	3	2
121	1	1	HB-BG	40.12	+.019	40.14	40.140	40.140	4910.54	....	...	....
122	1	1	V^2H-V^2H-S-S	39.921	+.020	39.941	39.920	39.930	4903.35	....	...	....
123	1	1	S-S	......	.....	......	39.960	39.960	4904.37	....	...	....
124*	2	1½	S-S-S-S	39.814	+.020	39.834	39.832	39.833	4900.05	4900.31	30	6
125	2	2	S-S-H-S	39.552	+.020	39.572	39.574	39.573	4891.24	....	...	....
126*	2	2	S-S-H-H	39.328	+.021	39.349	39.351	39.350	4883.74	4883.9	10	4
127	1	1	HG-H-S-S	39.142	+.021	39.163	39.190	39.176	4877.92	....	...	....
128	2	1	SB-H-H-H	38.968	+.022	38.990	38.989	38.990	4871.74	4870.4	5	1
129 F	20	5	S-S-VBS-S	38.668	+.023	38.691	38.669	38.680	4861.51	4861.50	100	80
130	1	1	G on 3-S-S	38.45	+.02	38.47	38.488	38.488	4855.22	4855.5	5	2
131	1	1	S-H-BH-V^2H	38.255	+.024	38.279	38.276	38.278	4848.39	4848.7	3	2
132*	2	3½	S-BPD-BH-H	37.489	+.026	37.515	37.517	37.516	4823.95	4824.33	10	2
133	1	1	H-H	......	.....	......	37.102	37.102	4810.90	....	...	....
134*	2	3½	H-B-S-S	36.891	+.027	36.918	36.918	36.918	4805.16	4805.25	3	1
135	1	1	S-S	......	.....	......	36.712	36.712	4798.76	....	...	....
136	1	1	S-S	......	.....	......	36.412	36.412	4789.51	....	...	....
137	1	1	S-S	......	.....	......	36.316	36.316	4786.52	....	...	...
138	1	1	H-H-S-S	36.184	+.029	36.213	36.216	36.214	4783.45	....	...	....
139	1	1	H-H-S-S	36.078	+.029	36.107	36.102	36.104	4780.10	4779.7	3	2
140	1	1	S-?S	......	.....	......	35.969	35.969	4776.00	....	...	....
141	1	1	Wide group	......	.....	......	35.86	35.86	4773.	....	...	....
142	1	1	H-H	......	.....	......	35.646	35.646	4766.26	....	...	....
143	2	1	BG-HWG	35.52	.....	......	35.60	35.60	4765.	....	...	....
144							35.49	35.49	4762.	....	...	....
145	1	1	S-V^3H-H-H	35.206	+.032	35.238	35.236	35.237	4754.06	....	...	....
146	1	1	S-H	......	.....	......	34.952	34.952	4745.64	....	...	....

No. 103 is very peculiar, being much more intense at the horns than at the vertex of crescent. Vertex too faint to be bisected, set by estimating distance at horns from near companion.

*Normal lines.

TABLE II—Continued.

No.	Int.	Elev.	Character.	M_3	ΔM_3	$M_3+\Delta M_3$	M_6	Mean.	Computed Wave-length.	Young's Chrom. Lines.		
										λ	F	B
147	1	1	W-H	......	.....	......	34.651	34.651	4736.82	....	...	....
148	1	1	H-H-S-S	34.434	+.034	34.468	34.477	34.472	4731.62	4731.7	1	1
149	1	1	?H-H	.....	.....	......	34.342	34.342	4727.85	....	...	....
150	1	1	VH-V^2H	......	.....	......	34.147	34.147	4722.23	....	...	....
151	4	5	S-S-HW-SSR	33.820	+.036	33.856	33.840	33.848	4713.67	4713.4	2	2
152	1	1	Wide group	33.62	+.04	33.66	33.73	33.73	4710.	....	...	....
153	1	1					33.60	33.60	4707.	....	...	....
154	1	1	H-H-S-S	33.442	+.036	33.478	33.472	33.475	4703.09	....	...	....
155	1	1	VH-H	......	.....	......	33.338	33.338	4699.23	....	...	....
156	1	1	S-H	......	.....	......	33.064	33.064	4691.56	....	...	....
157	1	4½	Note	32.840	+.038	32.878	32.870	32.874	4686.28	....	...	....
158	1	1	S-H-S-S	32.694	+.038	32.732	32.725	32.728	4682.24	....	...	....
159	2	1	H-H-S-S	32.260	+.039	32.299	32.306	32.302	4670.54	....	...	....
160	2	1	H-H-H-H	32.134	+.039	32.173	32.180	32.176	4667.10	4667.5	3	1
161	1	...	Broad group	......	.....	......	32.02	32.02	4663.	4664.2	2	1
162	1	1	H-S-H-VH	31.768	+.040	31.808	31.804	31.806	4657.09	4657.1	2	1
163	1	1	H-V^2H	......	.....	......	31.712	31.712	4654.56	....	...	....
164	2	1	H-H-S-BH	31.575	+.041	31.616	31.610	31.613	4651.90	....	...	....
165	2	1	H-S^2R-S^2R-V^2H	31.359	+.042	31.401	31.404	31.402	4646.27	....	...	....
166	1	1	?H-?H	......	.....	......	31.074	31.074	4637.57	......	...	....
167	1	1	H-V^2H-S-H	30.910	+.043	30.953	30.948	30.950	4634.30	....	...	....
168*	4	3	S-S-S-S	30.722	+.043	30.765	30.767	30.766	4629.47	4629.52	15	18
169	1	1	H-V^2H	......	.....	......	30.652	30.652	4626.49	....	...	....
170	1	1	S-H	......	.....	......	30.438	30.438	4620.92	4621.1	1	1
171	1	1	H-S^2R-H-H	30.318	+.044	30.362	30.370	30.366	4619.05	....	...	....
172	1	1	H-H-BH-BVH	30.219	+.045	30.264	30.258	30.261	4616.34	....	...	....
173	1	1	BH-V^2H	......	.....	......	30.152	30.152	4613.53	....	...	....
174	1	1	H-??V^2H ?	......	.....	......	30.068	30.068	4611.37	....	...	....
175	1	1	H-VH	......	....	......	29.736	29.736	4602.88	....	...	....
176	1	1	H-H-BH-BH	29.608	+.046	29.654	29.644	29.649	4600.67	....	...	....
177	1	2	H-H-S-S	29.192	+.047	29.239	29.230	29.234	4590.18	4590.13	1	1
178	1	1	H-H-S-H	29.116	+.047	29.163	29.160	29.162	4588.37	4588.38	2	2
179	4	4	RSVH-S-S-S	28.940	+.048	28.988	28.982	28.985	4583.94	4584.1	15	6
180	1	1	S-H	......	.....	......	28.836	28.836	4580.23	....	...	....
181	1	1	S-S-H-H	28.634	+.048	28.682	28.686	28.684	4576.46	4576.6	4	2
182*	5	4½	S-S-S-S	28.464	+.049	28.513	28.505	28.509	4572.14	4572.16	10	4
183*	4	4½	S-S-S-S	28.130	+.050	28.180	28.174	28.177	4563.99	4563.94	10	5
184	1	3	S-S-S-H	27.918	+.050	27.968	27.962	27.965	4558.82	4558.9	8	1
185	1	1	S-S	27.805	+.051	27.856	......	27.856	4556.18	4556.2	10	5
186	5	4½	S-S-S-S	27.726	+.051	27.777	27.771	27.774	4554.19	4554.21	10	5
187*	5	4½	S-S-S-S	27.541	+.051	27.592	27.590	27.591	4549.78	4549.8	10	8
188		1	Broad group	......	.....	......	27.44	27.44	4546.	....	...	....
189							27.34	27.34	4544.	....	...	....

No. 157 is very peculiar, being much more intense at the horns than at the vertex of crescent. Vertex too faint to be bisected, set by estimating distance at horns from near companion.

* Normal lines.

TABLE II—Continued.

No.	Int.	Elev.	Character.	M_3	ΔM_3	$M_3+\Delta M_3$	M_6	Mean.	Computed Wave-length.	Young's Chrom. Lines.		
										λ	F	B
190		1	Broad group	......	.....	......	27.26	27.26	4542.	....	...	....
191							indefinite		....	4540.0	2	1
192*	5	4½	S-S-S-S............	26.887	+.053	26.940	26.932	26.936	4534.15	4534.2	5	5
193	1	1	VH-V^{2}H	......	.....	......	26.806	26.806	4531.08	....	...	....
194	1	1	H-V^{2}H..............	......	.....	......	26.712	26.712	4528.86	....	...	....
195	2	2½	S-S-S-H	26.400	+.054	26.454	26.452	26.453	4522.79	4522.9	3	3
196	1	1	H-H-H-VH	26.286	+.054	26.340	26.348	26.344	4520.25	....	...	....
197	2	1½	H-H-H-V^{2}H	26.080	+.055	26.135	26.136	26.136	4515.41	4514.5	2	1
198	2	1½	H-H-H-V^{2}H	25.777	+.056	25.833	25.831	25.832	4508.39	4506.9	2	1
199*	5	4½	S-S-S-H	25.472	+.057	25.529	25.525	25.527	4501.40	4501.44	15	6
200	1	1	BH-V^{2}H	......	.....	......	25.336	25.336	4497.05	....	...	....
201	1	1	H-V^{3}H..............	......	.....	......	25.217	25.217	4494.35	....	...	....
202	1	1	H-V^{3}H..............	......	.....	......	25.082	25.082	4491.30	4491.5	20	8
203	1	1	Broad group	25.06	+.06	25.12	......	25.12	4492.	....	...	....
204	1	1		24.88	+.06	24.94	......	24.94	4488.	....	...	....
205	1	1	BH-V^{2}H	......	.....	......	24.993	24.993	4489.29	4490.2	15	3
206	1	1	V^{2}H-G-BH-V^{2}H.....	24.608	+.059	24.667	24.674	24.670	4482.05	4481.7	5	2
207	1	1	H-V^{2}H..............	......	.....	......	24.396	24.396	4475.95	....	...	....
208	10	5	S-S-H-H...........	24.160	+.060	24.220	24.200	24.210	4471.83	4471.8	100	25
209	5	4½	S-S-H-H...........	24.006	+.060	24.066	24.060	24.063	4468.59	4469.5	20	5
210	1	1	S-V^{2}H	......	.....	......	23.878	23.878	4464.53	....	...	....
211	1	1	V^{2}H-V^{2}HG-H-V^{2}H ..	23.682	+.060	23.742	23.736	23.739	4461.49	....	...	....
212	1	2	V^{2}H-H-VH-V^{2}H	23.369	+.062	23.431	23.428	23.430	4454.77	....	...	....
213	1	2	V^{2}H-V^{3}H-VH-V^{2}H ..	23.165	+.062	23.227	23.238	23.232	4450.50	....	...	....
214	5	4½	H-VH-H-VH	22.862	+.063	22.925	22.924	22.924	4443.88	4443.5	10	2
215	1	1	BH-V^{2}H-VH-V^{2}H...	22.450	+.064	22.514	22.515	22.514	4435.15	4434.0	1	1
216	1	1	V^{2}H-VH-VH-V^{2}H...	22.074	+.065	22.139	22.138	22.138	4427.22	4426.6	2	3
217	1	1	V^{2}H-V^{2}H-G........	21.834	+.066	21.900	21.90	21.900	4422.24	....	...	....
218	4	2½	V^{2}H-V^{2}H-VH-V^{3}H ..	21.617	+.066	21.683	21.678	21.680	4417.66	4419.0	2	1
219	3	2½	V^{2}H-V^{2}H-VH-V^{3}H ..	21.488	+.067	21.555	21.554	21.554	4415.05	4415.30	1	1
220			Hazy group..........	......	.....	......	21.22	21.22	4408.	4408.6	1	1
221	1	1	V^{2}H-V^{2}H	21.146	+.068	21.214	......	21.214	4408.04	4408.6	1	1
222	2	3½	V^{2}H-V^{2}H-VH-V^{3}H ..	20.975	+.068	21.043	21.052	21.048	4404.64	4404.93	1	1
223	3	3½	V^{3}H-V^{3}H-VH-V^{3}H ..	20.737	+.069	20.806	20.822	20.814	4399.87	4398.9	1	1
224	5	4½	V^{2}H-V^{2}H-VH-V^{2}H ..	20.495	+.069	20.564	20.574	20.569	4394.90	4395.2	15	3
225	3	3½	V^{2}H-V^{2}H-VH-V^{3}H ..	19.924	+.071	19.995	20.003	19.999	4383.46	4383.72	1	1
226	3	3½	V^{3}H-V^{2}H-V^{2}H-V^{3}H .	19.480	+.072	19.552	19.562	19.557	4374.69	4374.8	8	3
227	1	1	V^{2}H-V^{4}H	......	.....	......	18.74	18.74	4359.	4359.78	1	1
228	2	1	V^{2}H-V^{4}H	......	.....	......	18.36	18.36	4351.	4352.4	3	1
229 H_γ	15	5	VBSH-V^{5}H	......	.....	......	17.79	17.79	4340.	4340.66	100	65

* Normal lines.

TABLE III.

No.	λ	M_6	M_3	M_3-M_6	E in Miles.
1 D_1	5896.16	60.002	60.002	0.000	0
2 D_2	5890.00	54.914	59.918	+0.004	+ 256
3 D_3	5878.05	59.746	59.749	+0.003	+ 192
45	5328.33	50.375	50.375	0.000	0
47	5316.88	50.135	50.140	+0.005	+ 320
53	5276.16	49.276	49.280	+0.004	+ 256
54	5270.02	49.144	49.149	+0.005	+ 320
62	5226.95	48.199	48.205	+0.006	+ 384
64	5208.70	47.788	47.796	+0.008	+ 512
65	5205.43	47.714	47.723	+0.009	+ 576
70	5184.18	47.230	47.233	+0.003	+ 192
71	5173.22	46.974	46.981	+0.007	+ 448
½(72+73)	5168.26	46.862	46.868	+0.006	+ 384
102	5018.67	43.139	43.144	+0.005	+ 320
103	5015.80	43.056	43.076	+0.020	+1280
113	4957.57	41.480	41.482	+0.002	+ 128
116	4934.21	40.820	40.823	+0.003	+ 192
117	4924.12	40.534	40.532	−0.002	− 128
129 F	4861.51	38.669	38.691	+0.022	+1408
132	4823.95	37.517	37.515	−0.002	− 128
134	4805.16	36.918	36.918	0.000	0
151	4713.67	33.840	33.856	+0.016	+1024
157	4686.28	32.870	32.878	+0.008	+ 512
179	4583.94	28.982	28.988	+0.006	+ 384
182	4572.14	28.505	28.513	+0.008	+ 512
183	4563.96	28.174	28.180	+0.006	+ 384
186	4554.19	27.771	27.777	+0.006	+ 384
187	4549.78	27.590	27.592	+0.002	+ 128
192	4534.15	26.932	26.940	+0.008	+ 512
199	4501.40	25.525	25.529	+0.004	+ 256
208	4471.83	24.200	24.220	+0.020	+1280
209	4468.59	24.060	24.066	+0.006	+ 384
214	4443.88	22.924	22.925	+0.001	+ 64
224	4394.90	20.574	20.564	−0.010	− 640

TABLE IV.

No.	Int.	Adopted λ.	Computed λ.	C—O	Computed M.	Observed M.	C—O	Young's Chrom. Lines.		
								λ	F	B
1 D_1	4	5896.16	5896.16	0.00	60.009	60.002	+0.007	....	50	30
2 D_2	4	5890.19	5890.00	−0.19	59.925	59.916	+0.009	....	50	30
18	2	5535.35	5535.30	−0.05	54.337	54.330	+0.007	5535.07	50	12
25	3	5455.83	5455.86	+0.03	52.888	52.882	+0.006	5455.83	10	4
26	2	5447.13	5447.08	−0.05	52.724	52.717	+0.007	5447.13	10	4
28	2	5429.91	5429.65	−0.26	52.397	52.386	+0.011	5429.9	8	3
45	4	5328.47	5328.33	−0.14	50.383	50.375	+0.008	5328.7 5328.2	3 3	2 2
53	4	5276.21	5276.16	−0.05	49.284	49.278	+0.006	5276.21	10	10
54	5	5270.14	5270.02	−0.12	49.154	49.146	+0.008	5270.5 5269.72	5 10	2 2
64	3	5208.69	5208.70	+0.01	47.797	47.792	+0.005	5208.8 5208.6	4	5
65	1	5205.50	5205.43	−0.07	47.724	47.718	+0.006	5205.9	4	5
70 b_1	8	5183.79	5184.18	+0.39	47.228	47.232	−0.004	....	50	35
71 b_2	5	5172.86	5173.22	+0.36	46.974	46.978	−0.004	....	50	30
$\frac{72+73}{2}$ $\frac{1}{2}(b_3+b_4)$	5	5168.36	5168.37	+0.01	46.869	46.865	+0.004	....	40 20	25 10
102	5	5018.63	5018.67	+0.04	43.144	43.142	+0.002	5018.5	30	15
113	3	4957.63	4957.57	−0.06	41.485	41.481	+0.004	4957.48	1	2
116	5	4934.24	4934.21	−0.03	40.824	40.822	+0.002	4934.2	30	5
117	5	4924.11	4924.12	+0.01	40.534	40.533	+0.001	4924.11	40	10
124	2	4900.10	4900.05	−0.05	39.835	39.833	+0.002	4900.31	30	6
126	2	4883.87	4883.74	−0.13	39.355	39.350	+0.005	4883.9	10	4
132	2	4824.01	4823.95	−0.06	37.517	37.516	+0.001	4824.33	10	2
134	2	4805.28	4805.16	−0.12	36.921	36.918	+0.003	4805.25	3	1
168	4	4629.52	4629.47	−0.05	30.762	30.766	−0.004	4629.52	15	18
182	5	4572.16	4572.14	−0.02	28.502	28.509	−0.007	4572.16	10	4
183	4	4563.94	4563.96	+0.02	28.167	28.176	−0.009	4563.94	10	5
187	5	4549.72	4549.78	+0.06	27.579	27.591	−0.012	4549.8	10	8
192	5	4534.14	4534.15	+0.01	26.926	26.936	−0.010	4534.2	5	5
199	5	4501.44	4501.40	−0.04	25.518	25.527	−0.009	4501.44	15	6

TABLE IV—Continued.

No.	ROWLAND'S Intense Lines.									AYSER and RUNGE'S Fe_2 Lines.						HASSELBERG'S *Ti* Lines.			
	λ	I.	Ele.	λ	I.	Ele.	λ	I.	Ele.	λ	I.	λ	I.	λ	I.	λ	I.	λ	I.
1 D_1	5896.16	..	....	....	..	....	....	..	....	....	..	....	..	....	..	....	..	....	..
2 D_2	5890.19	..	....	....	..	....	....	..	....	....	..	....	..	....	..	....	..	....	..
18	5535.06	2	*Fe*	5.64	2	*Fe*	....	..	....	5.52	4	4.87	6	....	..	....	..	....	..
25	5455.83	4	*Fe*	5.67	2	*Fe?*	....	..	....	7.72	5	5.80	1	4.53	6	....	..	....	..
26	5446.80	2	*Ti*	7.13	6*d?*	*Fe*	....	..	....	7.05	1	....	..	....	..	6.80	2	....	..
28	5429.91	6*d?*	*Fe*	....	..	....	....	..	....	9.74	1	9.10	6	....	..	9.37	2.3	....	..
45	5328.24	8*d?*	*Fe*	8.70	2	*Fe*	....	..	....	8.15	1	8.50	2	8.94	6	....	..	....	..
53	5275.93	1	*Cr*	6.17	3	*Fe?*	6.24	2	*Cr*	6.19	6	....	..	....	..	....	..	....	..
54	5269.72	8*d?*	*Fe*	0.56	4	*Fe*	....	..	....	9.65	1	0.43	1	....	..	....	..	....	..
64	5208.60	5	*Cr*	8.78	2	*Fe*	....	..	....	....	..	....	..	....	..	....	..	....	..
65	5204.77	3	*Fe*	4.68	5	*Cr*	6.22	5	*Cr, Ti*	....	..	....	..	....	..	....	..	....	..
70 b_1	5183.79	..	....	....	..	....	....	..	....	....	..	....	..	....	..	....	..	....	..
71 b_2	5172.86	..	....	....	..	....	....	..	....	....	..	....	..	....	..	....	..	....	..
$\frac{72+73}{2}$ $\frac{1}{2}(b_3+b_4)$	5168.36	..	....	....	..	....	....	..	....	....	..	....	..	....	..	....	..	....	..
102	5018.63	4	*Fe*	8.46	1	*Ni*	....	..	....	8.53	4	....	..	....	..	....	..	....	..
113	4957.48	5	*Fe*	7.78	8	*Fe*	....	..	....	7.80	2	7.43	3	....	..	....	..	....	..
116	4934.21	3	*Ba*	4.28	4	*Ba*	....	..	....	....	..	....	..	....	..	....	..	....	..
117	4924.11	5	*Fe*	4.96	3	....	....	..	....	4.00	6	4.89	5	....	..	....	..	....	..
124	4900.10	2	*Ti, La*	0.30	2	*Y?*	....	..	....	....	..	....	..	....	..	0.08	3	....	..
126	4883.87	2	*Yt*	....	..	....	....	..	....	....	..	....	..	....	..	....	..	....	..
132	4823.70	5	*Mn*	4.32	3	*Fe*	....	..	....	3.63	4	4.27	6	....	..	....	..	....	..
134	4805.'28	3	....	5.61	0	*Ti*	....	..	....	....	..	....	..	....	..	5.25	1.2	5.56	2.3
168	4629.52	6	*Ti, Co*	....	..	....	....	..	....	....	..	....	..	....	..	....	..	....	..
182	4572.16	6	*Ti*	....	..	....	....	..	....	....	..	....	..	....	..	2.15	3	....	..
183	4563.94	4	*Ti*	....	..	....	....	..	....	....	..	....	..	....	..	3.60	1.2	3.94	2.3
187	4549.64	2	*Fe*	9.81	6*d?*	*Ti, Co*	....	..	....	....	..	....	..	....	..	....	..	....	..
192	4534.14	6	*Ti, Co*	....	..	....	....	..	....	....	..	....	..	....	..	....	..	....	..
199	4501.44	5	*Ti*	....	..	....	....	..	....	....	..	....	..	....	..	....	..	....	..

Note.—The identifications and wave-lengths of the lines in TABLE IV are taken from the following sources: A Preliminary Table of Solar Spectrum Wave-lengths, by HENRY A. ROWLAND; Über die Spectren der Elemente, von H. KAYSER und C. RUNGE, 1888; and Researches on the Arc Spectra of the Métals, by B. HASSELBERG, Astrophysical Journal, Vol. IV, p. 212.

REPORT OF PROF. OF MATH. J. R. EASTMAN, U. S. N. (RETIRED).

After a conference at the Naval Observatory, I left Washington on May 22, reaching Barnesville on the morning of May 24. I reported immediately to Prof. of Math. MILTON UPDEGRAFF, U. S. N., in charge of the U. S. Naval Observatory station.

On learning the general plan for conducting the observations I immediately made the necessary arrangements for studying visually the character of that portion of the corona near the supposed boundary between the *inner* and *outer* divisions. An equatorial telescope, CLARK No. 863, with a 5-inch objective, used in 1874 and 1882 to observe the transits of Venus, was reserved for this purpose, and as soon as this instrument was adjusted I rendered such assistance as I could in the preparations for observing other phenomena on the morning of the 28th. When I reached Barnesville the weather had been unfavorable for several days, with easterly winds and clouds, but on the morning of the 27th the wind had shifted to the west and the sky was nearly clear. Up to the evening of the 26th there had been one group of small sun-spots near the center of the Sun's disk, showing no appreciable change for several days. At 11 a. m. on the 27th a second group, nearly as large as the first, had appeared near the first, and for two hours considerable change in the outlines of the larger spots was noticeable. By 5 p. m. all apparent variation in these spots had ceased and did not appear again before the eclipse. On the morning of the 28th the sky was almost cloudless, and the few clouds in sight did not appear near the Sun. At the time of first contact I counted aloud the seconds from the chronometer to enable Assistant Astronomer LITTELL to observe that phenomenon with my telescope.

The observations of sun-spots and contacts were made with a diagonal eyepiece, but my observations of the corona were made with a direct-vision eyepiece giving a power of 96. At the beginning of totality I looked at the corona without the aid of a telescope for about five seconds, in order to get a general view of its form, and found it the most brilliant that I have ever seen. The color seemed to be a pure white without any blue or yellow tints. I then looked at it with the small finder of the telescope for about eight seconds. During the remainder of the time I used the 5-inch objective with the full aperture.

I first examined that portion of the corona, about 8′ wide, lying next the Moon; then I studied the next section, which for convenience I will call the middle corona, both east and west of the Moon; and then the outer, or east and west, extensions of the corona; and finally took a hasty sweeping view of the corona from the eastern to the western limit and back to the western limb of the Moon just as totality ended.

For convenience I retain the terms inner, middle, and outer corona, though there was really no place beyond the Moon's limb where one could draw the boundary line of any section.

The inner corona is described best, perhaps, as nebulous. It presented no appearance of being built up of rays, beams, or zones of light, and at equal distances from the Moon's limb, on the east and west sides, the density seemed to be the same. Within about 8′ of the Moon's limb the density did not seem to vary, but beyond that point to the extreme limits of the east and west extensions the density of the nebulous matter appeared to diminish quite rapidly. I saw no evidence of motion in any part of the corona.

With the aid of the very rapid sketches made during and immediately after the total phase, the accompanying drawing, PLATE XXXIX, was made with crayon on black enameled cloth with a slightly roughened surface.

The general form and extension of the corona on the east and west sides of the Sun represent fairly well what was seen, except that the outline of the short extension or spur on the east side is a little too sharply defined, perhaps, in the drawing.

The curved rays on the north and south sides represent in a conventional way what was incidentally seen while shifting the view from the east to the west extensions of the corona, and should not be considered as showing accurately either forms or positions.

Just before the end of the total phase a long range of solar prominences, covering a space of at least 15° along the Sun's limb, was very conspicuous about the point where the Sun's light burst out. In the eclipses of 1869, 1870, and 1878 these prominences were a dark or cardinal red, but in this eclipse the color was decidedly a light pink. As I saw these objects only long enough to note their color, without attempting to study their form or location, I did not introduce them into the drawing.

At the end of totality I finished my notes and sketches, and at the close of the eclipse again counted the seconds from the chronometer to enable Assistant Astronomers HILL and LITTELL to observe the last contact.

In this connection I wish to express my appreciation of the courtesy of Prof. of Math. S. J. BROWN, U. S. N., in charge of the Naval Observatory parties, of Prof. of Math. MILTON UPDEGRAFF, U. S. N., chief of the party, and also of all the members of the Observatory party at Barnesville.

To the courtesy of Capt. C. H. DAVIS, U. S. N., Superintendent of the Naval Observatory, I am greatly indebted for the opportunity to observe this very interesting eclipse under favorable circumstances.

REPORT OF PROF. OF MATH. T. J. J. SEE, U. S. N.

Having been occupied with satellite observations until May 24, I reached Barnesville, Ga., in accordance with orders of the Department, on May 25. The next two days were occupied with studies of the eclipse preparations, and with arrangements for observations on May 28. It was arranged that Prof. J. N. HART, of the University of Maine, who was a guest of the Naval Observatory party, and the writer should be assigned to Reservoir Hill, the highest station in all the surrounding country, standing 165 feet above the town and situated some 2 miles northeast of it. From this elevated point we were to watch the approach of the shadow and signal the main body of observers when totality should be expected, in order that by an appropriate warning they might give their apparatus the diurnal motion, so that the whole time of totality could be utilized in photographic work.

Accordingly, a set of signals being agreed upon, we reached the southwest corner of the reservoir before 6 a. m. and set up and adjusted the 4-inch comet seeker, with which visual observations were to be made on the outer corona. As the eclipse came on, a concourse of some five hundred people surrounded the reservoir, but were kept from our reservation by the stretching of ropes and by a guard of cadets, who had been assigned to us by courtesy of the Gordon Institute. The temperature of the air began to increase as usual early in the morning, but when the Moon covered about half the Sun's disk it began to grow cool, at first slowly, at length very rapidly, as totality approached; the change was so marked as to be very uncomfortable, and was accompanied by a chilly wind from the southwest, as if an "eclipse wind" preceded the shadow. The fall in temperature was so rapid that it is difficult to construct any thermometer which would respond to the descent of the temperature before it again rose after totality; but being accustomed to estimate changes of temperature in the Observatory dome at all seasons of the year, I concluded that the effective change was about 18° Fahrenheit. This estimate is conservative, and will approximate the truth very closely.

As the time of totality approached, the writer prepared to give the signal agreed upon, and at length when the shadow was seen coming swiftly over the whitened hills some 20 miles to the southwest, the signal of waving a large navy flag was made and distinctly seen by several persons at the main eclipse station about twenty seconds before totality. As the shadow sped across the distant hills it was clearly seen that the edge of the darkness was not sharp and sudden, but faded away gradually, the sunlight being separated from totality by a hazy band from 1 to 2 miles in width. The approach of the darkness was an awe-inspiring spectacle, and was observed by the crowd in rapt silence. The twilight circle about the shadow was probably due to the unusual brightness of the lower corona, which rendered the whole eclipse rather light, so that the fine lines of a drawing could be seen perfectly in the midst of totality.

The accompanying study, PLATE XL, was made from three hasty sketches traced during the eclipse, the work being done with crayon on crayon paper. It was finished at the hotel in Barnesville on our return to town a few hours after the eclipse. Care was exercised to retain the features of the original sketches unimpaired, and it is believed that this study gives a very satisfactory view of the corona as it appeared to the naked eye or in a small telescope.

The falling off in brightness toward the outer limit of the corona was remarkable; in fact, the fading away of the corona was indefinite. It extended almost to Mercury, as seen with the naked eye, and perhaps a little beyond it, as seen in the comet seeker.

The color was a delicate silvery white, almost exactly like that of the sky near the Sun on a clear dry day, when there is little dust or vapor to diffuse the Sun's light. The polar streamers were conspicuous, but less so than the main equatorial wings. The prominences were recognized and clearly seen to be of faint rose or pinkish color, but the observer was too occupied to locate them accurately, and in the drawing, referred to above, these features were afterwards added from the photographs.

REPORT OF PROFESSOR J. N. HART.

I was stationed with Professor SEE upon Reservoir Hill, an elevation to the westward of the Naval Observatory station and somewhat higher. Our location gave a clear view of the country toward the southwest for several miles. Not having prepared to do any instrumental work, I planned to get as good an idea as possible of the general phenomena of the eclipse—in particular, to watch the approach of the shadow and to make a sketch of the corona, PLATE XLI.

The coming of the shadow was much less clearly defined than I had anticipated. As the Moon crept gradually upon the face of the Sun the light faded away by degrees, and no instant could be assigned when the sunlight disappeared.

About a minute before the computed time of totality I turned toward the western horizon and with watch in hand called out the time to Professor SEE, who was also watching for the shadow, and who was to signal its approach to the observers at the Observatory station by waving a flag. I was provided with a lighted lantern, which I was to wave if the darkness were sufficient to render the flag invisible. But when the shadow first appeared sweeping over the hills the light with us was still so considerable that the lantern signal seemed unnecessary and likely to be invisible from the station.

Instead of the dark wall or cylinder of shade, of which I have read in connection with earlier eclipses, the shadow seemed to me not so very different from that of an exceptionally dark thundercloud. It was not distinct enough so that I could tell definitely when it reached us, and I was still watching it when the people about us, who had been watching the diminishing crescent, began to exclaim: "The corona! The corona!" I then began to sketch the outlines of the corona as it appeared to my unaided eye, working with white chalk upon blue paper, in accordance with the suggestions in the Supplement to the American Ephemeris. I estimated that the equatorial streamers extended two and a half to three diameters from the Sun's limb in each direction. The western streamer was forked at its extremity and quite symmetrical; the eastern was much narrower, with a bright stripe along its middle. There was a short streamer toward the southeast corresponding to one of the forks of the western streamer.

The color of the corona was pearly white, the inner portion intensely brilliant, the outer portion grayish, and fading away very gradually at the east and west, while the north and south edges of the equatorial streamers were much more clearly defined.

The polar rays were very prominent and distinctly curved. I made no attempt to count the separate polar streamers.

During the last third of totality Professor SEE very kindly gave me the use of the 4-inch comet seeker, with which he had been studying the corona. While using it I gave my attention almost entirely to the polar rays. I estimated that they extended to a distance of one-half or two-thirds of a solar diameter from the Sun's limb. They were brighter than the equatorial streamers, very distinctly curved, and symmetrically arranged. I saw no prominences, probably because I did not think to look for them especially.

The eclipse was much lighter than I had expected, all near objects being distinctly visible during totality.

Before totality there seemed to be a marked fall in the temperature. At the time of first contact the wind was not more than a gentle breeze, but before second contact it had become quite fresh, and one felt that an overcoat would be comfortable.

While the coming on of darkness was very gradual, the return of sunlight seemed almost instantaneous.

REPORT OF PROFESSOR OTIS ASHMORE.

I joined the Naval Observatory party, in charge of Professor UPDEGRAFF, at Barnesville, Ga., on the morning of May 26, was assigned to a position upon the grounds, and immediately prepared for the work I had in view. After consultation and agreement this work was as follows:

First. To observe and time the contacts.

Second. To make a crayon sketch of the corona.

Third. To make special telescopic observations of the solar prominences and other phenomena on the preceding limb of the Moon, the following limb having been assigned to Professor EASTMAN.

Fourth. To note in a general way such other phenomena as might incidentally present themselves.

A series of observations upon the shadow bands, made at my suggestion, was undertaken by Dr. WM. F. AIKEN, of Savannah, Ga., and Prof. J. HARRIS CHAPPELL, of Milledgeville, Ga., whose reports are herewith attached. A report on the shadow bands made by CASSIUS E. GILLETTE, captain, Corps of Engineers, Savannah, Ga., is also submitted. The intelligence and skill of these gentlemen entitle their observations to special consideration.

The telescope used in my own observations was a 6-inch CLARK equatorial, made in 1896, with a focal length of 85 inches. The power used was 73, and the field covered was 38′. For convenience a HERSCHEL diagonal eyepiece was used, and spider lines were placed at the focus to mark the exact points of contact. Throughout the entire observations the full aperture of the object-glass was used, and with evident advantage.

A very convenient and effective sunshade for the eyepiece was made by smoking a strip of glass 1 inch wide and 7 inches long, diminishing the depth of shade from one end to the other, and by covering it with a similar glass strip separated from the first by a thin cardboard mat. A circular piece of cardboard 6 inches in diameter, to represent the Sun's disk and to indicate the exact point of contact, was slipped over the eyepiece and adjusted to the correct computed position. This was found to be a very valuable attachment in determining the exact position of first contact, a matter of no small importance where the inversion of the image of the telescope is still further complicated by the optical somersaults of a diagonal eyepiece.

The telescope was mounted upon a heavy tripod with equatorial bearings, with a hand-screw movement in right ascension, but not in declination. It may be added that the quality of the telescope is most excellent, and the images throughout the entire series of observations were remarkably sharp, steady, and distinct.

A steady and substantial drawing table, improvised from an old box top, was placed immediately under the eye end of the telescope, and slightly inclined for convenience in writing and drawing. All apparatus and drawing material needed were carefully arranged upon this table, with a view of utilizing every moment of time during totality. A barrel turned upon end served as a very convenient seat.

Mr. HILL had placed at my disposal a chronometer, NEGUS No. 1802, which was located about 3 feet to my right, and read by Prof. J. L. BEESON, of Milledgeville, Ga., who was previously drilled in noting observations. This chronometer had been carefully rated by Mr. HILL and compared with the time signals on the day of the eclipse. The computed times of contact had been previously made and furnished to me by Mr. LITTELL. The skies were clear, the air almost still, and all the conditions were very favorable for the best results from the observations.

About one minute before the first contact the telescope was focused sharply upon the limb of the Sun and the spider lines were adjusted to that position of the limb where the first contact was expected to occur. At $7^h\ 22^m\ 50^s$ by the face reading of my chronometer a slight black indentation was observed on the Sun's limb exactly at the point expected. "Time" was called, and it was immediately recorded by Professor BEESON. For a moment there was a doubt, but the next second confirmed the observation, as the sharp black edge of the Moon began to cut its way unmistakably across the bright surface of the Sun. The advancing limb of the Moon reminded me of the edge of a dull razor seen under a microscope, but inky black even to its very circumference, without a vestige of light to indicate atmospheric refraction on the Moon's surface.

Just before the first contact I strained my vision to the utmost to observe, if possible, the dark limb of the Moon projected upon the bright corona before it reached the Sun, but not the slightest evidence of the Moon's presence was observed before it suddenly impinged upon the solar disk. The size and power of the telescope used and the remarkably fine definition and steadiness of the image, I think, were very favorable for observing these features.

During the time from the first to the second contact nothing of special note fell under my observation. I had prepared to make a crayon sketch of the corona upon a plan not heretofore pursued, and the results attained warrant me, I think, in giving a brief description of it, in order that future observers may utilize the method and improve upon it. All the suggestions heretofore given concerning sketches of the corona advise the use of a circle of 1½ inches in diameter to represent the Sun. After some practice with drawings upon this scale I became convinced that the scale was too small for the best results. The ratio of error in the use of the pencil or crayon is much greater in a small drawing than in a large one, besides, the blending effect, which I had learned by experience is best produced by the fingers, could be attained with much more satisfaction in a larger drawing. So I adopted a circle 4 inches in diameter, drawn upon blackboard paper such as is commonly used for school purposes. This was smoothly stretched upon a large drawing board and placed upon the table immediately under the eye end of the telescope. As the duration of totality was short—only 83 seconds—I sought to utilize every moment of the precious time. A heavy ring of crayon about one-half of an inch wide was drawn around the 4-inch circle, to be quickly modified into the corona by blending with the fingers at the proper time. Much practice had shown that but little other crayon would be needed, and that quite accurate and satisfactory results could be attained in a very short time. Thus prepared, the second contact and the attendant phenomena were awaited with perfect composure.

A few minutes before totality the landscape, which had gradually assumed a peculiar gloomy aspect, now appeared ominous and ghastly. Glancing toward the west, where the view was unobstructed for many miles, the coming shadow, but not sharply defined, could be seen, turbid and black, extending downward from the sky and enveloping the landscape in a death-like gloom. As my special work, however, was not with this feature, I now turned my eye to the telescope and caught the bright crescent of the receding Sun some seconds before totality. The second contact was noted with distinctness at $8^h\ 29^m\ 35^s$.

Just at totality, and possibly a few moments before, the solar prominences burst suddenly into view, and the corona also appeared, extending much beyond the field of my telescope. The prominences were visible only near the equatorial region, and extended probably not more than 25 degrees along the solar disk. Most of them were pointed like little tongues of flame, which reminded me of the tips of camel's-hair brushes used by artists when dipped in red paint. Some of these were inclined considerably from the perpendicular to the Sun's surface, and some appeared as masses with blunt tops.

One prominence, much larger than the rest, was observed extending in mass far out from the Sun. The accompanying drawing, PLATE XLII, indicates fairly well the position and number of these prominences as they appeared to me.* Their color was not a deep red, but rather a deep rose or pink. The phenomenon of BAILEY'S Beads was scarcely noticeable or at least not to the extent which I had expected.

A few seconds before totality the sunshade before the eyepiece of the telescope was removed and the prominences observed with the unprotected eye. I was struck with the great brightness of the last bits of the retreating Sun as they shook their bright colors defiantly above the black parapets of the vanquishing Moon. I now spent a few seconds in a naked-eye view of the corona. There it stood, a glorious object of indescribable, majestic beauty suspended in the heavens, with wings extending along the ecliptic. Its color was that of burnished silver, blending uniformly and fading gradually into space. The upper or western wing was fish-tail in shape with a curving reentrant angle, while the lower or eastern wing was more pointed and arrow-shaped. A distinct spur or streamer extended downward and almost radially for more than one diameter of the Sun. The upper streamers were longer than the lower, extending about four diameters from the Sun.

One very marked feature of the corona attracted my attention more than any other, and that was the curve in the long upper streamer not far from the north polar region. My drawing shows this as I saw it. This to me was significant, and I marked it with special interest and fidelity.

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*By comparison with the photographs these prominences seem to have been erroneously located on the drawing, undoubtedly due to the fact that the corona was drawn from naked-eye observations and the prominences located from the telescopic view.—Editors.

I now turned to my drawing board and rapidly blended the ring of crayon previously prepared into the coronal appendage as I saw it, using additional crayon occasionally when required for the streamers. This was done during totality, when I could compare my drawing with the actual object. A glance at the Sun during totality through a small pair of opera glasses proved unsatisfactory, as the light seemed too intense.

An examination of the corona was now made with the telescope to observe its structure and extent. The telescope revealed but little apparent structure, but the substances of the corona seemed to be nearly uniform in character. The inner corona was very bright, but there was no sharp boundary between this and that which extended beyond. As my telescope could not be easily moved in declination the polar streamers could not be well observed; they were unmistakably present, however, and showed the usual curved shapes.

The third contact was rapidly approaching, and a glance at the following limb of the Moon revealed a long row of solar prominences extending some 35 or 40 degrees along the equatorial limb of the Sun. These prominences were similar to those seen on the opposite limb, but more numerous and extensive. None of them, however, were as large as the largest one seen at the second contact.

My attention was occupied in observing one of these prominences when the flash came suddenly, and I called "Time," with a probable error of three seconds. With the flash the corona disappeared as suddenly as it had come into view, and nothing further of special interest was noted till the fourth contact, which occurred under most favorable conditions for observation at $9^h\ 47^m\ 12^s$, both Professor Beeson and Professor Pound reading the chronometer.

During totality the planet Mercury was distinctly seen near the Sun, and I was surprised at its brilliancy. Two or three stars were seen incidentally, though I was engaged with other observations. The light during totality is difficult to estimate. I had no difficulty in making notes or in reading the chronometer. I think that ordinary newspaper print could have been read, but this was about the limit.

The following tabulated statement shows the observations of the four contacts. The error of the chronometer used, Negus No. 1802, was carefully computed, both by Mr. Hill and myself, to be $+0^h\ 8^m\ 58^s.4$.

Contact.	Position Angle.	Observed Time.						Computed Time.		
		Negus No. 1802, Face Reading.			Greenwich Mean Time.			Greenwich Mean Time.		
	°	h	m	s	h	m	s	h	m	s
I	256	7	22	50	0	31	48.4	0	31	51.1
II	65	8	29	35	1	38	33.4	1	38	41.9
III	267	8	31	3±3	1	40	1.4*	1	40	5.3
IV	76	9	47	12	2	56	10.4	2	56	16.4

*Uncertain by 3^s.

Accompanying this report is my original crayon sketch, which I submit at your request. I also send a photograph of the sketch which I had made in Savannah, Ga. The faint transverse striation in the photograph is due to one of those unwelcome tricks of photography by which things invisible to the natural eye are sometimes brought into view. The striations represent brush marks upon the drawing paper quite unnoticeable in the original sketch.*

My thanks are due to Prof. S. J. BROWN, Prof. MILTON UPDEGRAFF, and others for various courtesies extended to me during my visit at Barnesville.

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* PLATE XLII is a reproduction from a glass positive by Mr. G. H. PETERS of Professor ASHMORE'S original drawing.—Editors.

REPORT OF WM. F. AIKEN, M. D.

The shadow bands were very apparent, both immediately before and after the total phase of the eclipse. They were caught upon a white canvas screen attached to the frame serving as a wind-break about the structure supporting the objective, or eastern end of the 40-foot camera. The base line of the screen ran exactly north and south; it faced to the east and slightly upward, inasmuch as the frame inclined toward the west at an angle of about 15°. At its base, extending over the ground toward the east, was attached a wide stretch of sheeting, resembling in its arrangement a photographer's floor-ground. This nearly horizontal extension was designed to show the motion of the bands at a considerable angle as compared with the upright screen. Both parts of the screen displayed prominent marks, indicating dimensions in several directions to facilitate measurements both ocular and photographic.

The shadow bands appeared as distinctly contrasted but elusively outlined and vaguely spindle-shaped markings arrayed in seemingly straight ranks, which ranks moved rapidly in a direction at right angles to their length, marching across the upright screen from above and from the left of the observer, standing with his back to the eclipsed Sun. In other words, they move diagonally downward and northward. The long axis of each spindle-shaped or ripple-shaped marking pointed roughly toward the North Star. Each ripple appeared to be from 1 to perhaps 3 feet long and from 1 to 3 or possibly 4 inches across. They resembled lighter and darker shades of smoke, showing absolutely no trace of color, only the varying tints of a monochrome gray. They chased each other across the screen like wind ripples flowing over a large flag. Their vagueness of outline, together with the neutral color and rapid flowing motion, to say nothing of the mental tension of the observer, made any more accurate estimation of their exact size quite out of the question. Owing to the necessarily rapid handling of the camera no opportunity occurred for the writer to note the appearances on the horizontal sheet.

REPORT OF PROFESSOR J. HARRIS CHAPPELL.

A snow-white canvas sheet was stretched on an upright frame 7 feet wide and 16 feet high set facing due east. I watched this sheet very closely for 7 minutes immediately preceding totality, but I saw no bands during that time. I saw none during totality. About 70 or 80 seconds after totality, or third contact, the bands very suddenly made their appearance. They were faint, dark, and shadow-like, about an inch and a half wide and an inch apart, plainly visible, but not clearly defined. They ran rapidly across the sheet with a tremulous motion, as if chasing each other, much like the wavelets created by throwing a pebble in a still pond of water, only the movement was much more rapid. It was very noticeable that these shadow bands crossed the sheet in a diagonal direction—from the upper north side to the lower south side. If the sheet had been lying flat on the ground instead of standing up vertically, the movement would have been from northwest to southeast.

I can not estimate, except by mere guesswork, the velocity with which the bands moved, but I should say, at a venture, about 5 feet a second. The exhibition lasted not more than 8 seconds, when the bands vanished from the sheet with the same suddenness with which they had made their appearance. The whole phenomenon had been as "illusive as a dream, as fleeting as a shadow."

REPORT OF CAPT. CASSIUS E. GILLETTE, U. S. A.

It should be stated that not expecting to see the eclipse from the central line of totality, I made no preparations for any observations whatever, and thinking that all points of scientific interest were covered by the Government observers at the nearby station, I made no special effort to observe any particular phenomena, had made no studies of what to expect to see, and made no observations with any special reference to time, rate, direction, or other elements of accuracy in the matter. However, the appearance of the corona and the shadow bands were the most interesting phenomena that came under my notice.

The point where I was standing during the period of totality was in the wagon road directly down the hill from the Naval Observatory station. This road was of the color of white sand for a width of 8 or 9 feet, and its direction, as I remember it, was such that looking down the road I almost exactly faced the Sun. Just before and just after totality the so-called shadow bands were plainly visible on the road. There is no possible doubt of their being real shadows. They were almost as distinct as the circular shadows seen under the arc lights in the city streets. Without having made special observations of the point I should say that the shadows were of about the same degree of density throughout their entire appearance, the background upon which they were cast growing gradually darker until the moment of totality, when they entirely disappeared.

As I saw them, the term "shadow bands" would be rather misleading. The idea of bands would not have occurred to me in describing them. They were quite suggestive of ripples on the water. They were of irregular shapes, but each one had a decidedly long axis, and all of these axes were parallel to each other. The different shadows, I should say, were from 2 to 8 inches in width and from 8 inches to 2½ feet in length, with the widest part perhaps irregularly located but generally near one end. Their direction of motion was straight down the road toward the Sun. Their axes, curiously enough, made an angle of about 45 degrees with the road, the forward end of each shadow being to my left as I faced the Sun.

Doctor AIKEN thinks that the banded shape of the shadows, together with the narrow streak of white on the road, misled me as to the direction of their motion; that they really moved diagonally across the road and at right angles to their axes. While, as I say, I was not making scientific observations of the matter, it does not seem possible that I could be mistaken in this particular as to what I saw, because it struck me as a most peculiar thing about the eclipse that these shadows should be so traveling in this bias direction. They lasted a sufficient time, both before and after totality, so that there was plenty of time for an erroneous impression as to their direction to be corrected, and I changed from looking at the shadows to looking at the corona once or twice during each period of their existence, and, as the road was four or five times as wide as the length of any particular shadow, I can not think I was mistaken in their direction of travel.

Their rate of progress is hard to estimate; I should say somewhere between 2 and 5 feet per second. While these figures do not indicate a very rapid speed, yet the trembling motion of the shadows gave the impression that they were hurrying down the road toward the Sun, and at the same time, possibly caused by the weird stillness and peculiar luminous darkness at the time, there was a majesty about their movement that gave the impression of a mighty sweep of something high in the air.

Whether the trembling nature of the movement was caused by each shadow moving forward by short jerks, with stops between, or whether there was a movement backward, or whether each shadow only moved a little way and disappeared, its place being taken by others, I can not say, but I am inclined to think the last the correct supposition. The sketch, PLATE LXXIX, gives something of an idea as to how they would have appeared had it been possible to get an instantaneous photograph of them.

REPORT OF PROFESSOR HENRY CREW.

Accepting the courteous invitation of the Astronomical Director to cooperate with the Naval Observatory staff in the observation of the solar eclipse of May 28, 1900, I went to Griffin, Ga., on May 10. Mr. G. A. HILL was already there, and Dr. R. R. TATNALL joined us on May 16.

The eighteen days after my arrival were spent in assisting in the erection of piers, tents, dark room, etc., in assembling mountings for plane and concave gratings, and in adjusting coelostats, spectrographs, etc.

Doctor TATNALL and I used a slit spectrograph, made up of the ROWLAND 10-foot concave grating belonging to the Northwestern University, in a mounting the general design of which is that described by WATERHOUSE in Memorie della Società degli Spettroscopisti Italiani, Volume XVIII, pages 14–16. The details of this mounting were planned by Mr. L. E. JEWELL, who very kindly supervised its construction in Baltimore. Considered as a portable mounting, the arrangement proved to be a very satisfactory one.

The solar image was furnished by a transit-of-Venus coelostat and a superb 3.5-inch quartz lens, both sent from the Naval Observatory. Each of these instruments proved to be eminently satisfactory in every particular.

Facing the spectrograph and looking along the incident beam the entire instrument was rotated in a clockwise direction about the incident beam through an angle of 36° from the horizontal, thus making the slit tangent to the solar image at a point about midway between the points of second and third contact. The slit was approximately one-thirtieth of a millimeter in width. The first order spectrum was employed for photographic purposes, the second order for simultaneous visual observations. Two plates, each 1 by 12 inches, placed end to end, making a strip 24 inches long and covering the region between $\lambda 6000$ and $\lambda 3000$ were employed for each exposure. The plate-holder was made to carry five such strips; it was also provided with a curved back so that the plates were bent to the proper radius. Only CRAMER isochromatic instantaneous plates, on thin crystal glass, were used.

By the afternoon of the 27th, everything was in satisfactory adjustment, as tested both by visual and photographic observations. On the morning of the 28th the following program was carried out:

PROGRAM.

7.25 a. m.—Put plates in holder, about half of them, on the advice of Mr. JEWELL, having been previously backed with WINSON & NEWTON'S water-color lampblack.

7.35 a. m.—Put plate-holder in spectrograph.

Ten seconds before computed time of second contact.—Exposed plates No. 1 and No. 2 for FRAUNHOFER comparison spectrum. Duration of exposure, 2 seconds.

THE 10-FOOT CONCAVE GRATING SLIT SPECTROGRAPH AT GRIFFIN, GA.

Photographed by W. W. Dinwiddie.

THE PLANE GRATING OBJECTIVE SPECTROGRAPH AT GRIFFIN, GA.

Photographed by W. W. Dinwiddie.

At Jewell's signal "Go," first flash.—Exposed plates No. 3 and No. 4 for 13 seconds.

At fifteenth second of totality, as indicated by timekeeper.—Exposed plates No. 5 and No. 6. Duration of exposure 26 seconds, closing with Jewell's signal "Stop."

Immediately after third contact.—Exposed plates No. 7 and No. 8 for Fraunhofer comparison spectrum. Duration of exposure 4 seconds.

While I carried out this program Dr. Tatnall shifted the plate-holder and adjusted the image of the crescent on the slit.

WEATHER.

During the morning of the 28th the horizon was filled with long and slender clouds. For some minutes before second contact a thin white cloud covered the region round about the Sun. For some minutes after totality this cloud was still about the Sun. An hour after totality the sky was covered with cumulus clouds.

DEVELOPMENT OF PLATES.

During the evening of the day of the eclipse Mr. Jewell very kindly developed most of the plates; on the following morning I developed the remainder. We were greatly disappointed to find all of these plates very much underexposed, the following lines appearing:

Negative No. 1, $\lambda 4500$ to $\lambda 3000$, exposed for 2 seconds just before second contact, shows, $H_\gamma - 4340$, $H_\delta - 4101$ (?), $H_\varepsilon - 3970$, $H - 3968$, $K - 3933$, $H_\eta - 3835$, and possibly $H_\zeta - 3889$, all bright in a spectrum which is otherwise the ordinary Fraunhofer spectrum.

Negative No. 2, $\lambda 6000$ to $\lambda 4500$, exposure same as No. 1, shows only a faint Fraunhofer spectrum.

Negative No. 3, $\lambda 4500$ to $\lambda 3000$, exposed during first 13 seconds of totality, shows H and K bright, and nothing else.

Negative No. 4, $\lambda 6000$ to $\lambda 4500$, exposure same as No. 3, perfectly blank.

Negative No. 5, $\lambda 4500$ to $\lambda 3000$, exposed during last 26 seconds of totality, shows H_γ, H_δ, H_ε, H, and K bright, and nothing else.

Negative No. 6, $\lambda 6000$ to $\lambda 4500$, exposure same as No. 5, shows H_β bright, and nothing else.

Negative No. 7, $\lambda 4500$ to $\lambda 3000$, exposed for 4 seconds immediately after second flash, shows H and K beautifully doubly reversed, otherwise the ordinary Fraunhofer spectrum.

Negative No. 8, $\lambda 6000$ to $\lambda 4500$, exposure same as No. 7, shows only the ordinary Fraunhofer spectrum.

CAUSES OF FAILURE.

Among the causes of our failure to secure a good photograph of the bright line spectrum of the reversing layer I reckon the following, which are placed in what appears to me to be the order of their importance.

(1) An underestimate of the intensity of radiation from the eclipsed Sun.

(2) An underestimate of the effect of astigmatism in the curved grating. A point source at the slit of our instrument gives a spectrum band one-eighth of an inch wide in the order employed on this occasion. The circular crescent crossing a slit one-thirtieth of a millimeter wide is practically a point source.

(3) An exposure of two plates instead of one during totality was more than was justified by our dispersion and slit-width.

(4) A slit considerably wider than one-thirtieth of a millimeter might have been used and still have given better wave-length determinations than any hitherto published for the flash spectrum.

(5) I saw no bright line spectrum at third contact. This may have been due to imperfect following, and if so, would partly explain the paucity of lines on negatives No. 5 and No. 6.

(6) The light veil of cloud about the Sun. The effect of this appears to me very difficult to estimate.

(7) The difference between computed and observed time of second contact.

SUGGESTIONS FOR USE IN FUTURE ECLIPSES.

I. Provide a silvering solution ready to mix, or an additional silvered mirror.

II. For parties located near the edge of the shadow, one man should give his entire attention to keeping the crescent on the slit. Doctor TATNALL says he found it impossible to shift the plate-holder for each new exposure and at the same time follow a crescent which was all the while rapidly changing its position angle. In our case the crescent shifted through 60 degrees of position angle in 39 seconds.

III. In attempting to detect the first appearance of the bright line spectrum—the so-called flash—one should use a dispersion much less than that employed by me, viz, the second order of a 10-foot concave grating. Observing in the *b* group, I saw only one bright line, and it made its appearance gradually, not instantly.

No slit spectroscope, not even one employing a prism, or first order grating, would be so reliable as the field glass provided with an objective grating.

IV. The use of the concave grating without a slit which has been suggested to me independently by Mr. JEWELL and by Prof. GEO. E. HALE, ought to be thoroughly tested with an electric spark, or some bright line source, in the focus of a large collimator.

V. I am inclined to prefer the use of a dark room, such as that employed by Doctor HUMPHREYS at our station, instead of a portable dark box, as a mounting for any concave grating of over 5 feet curvature.

The placing of slit, grating, and plate-holder on three independent piers diminishes greatly the weight to be transported, allows one to make his adjustments independently and with the assurance that they will remain; in short, it allows the work to be done under ordinary laboratory conditions, which, other things being equal, is an eminently desirable result.

In conclusion, I beg to express my heartiest thanks for the courteous consideration which I have received at the hands of Professor BROWN and his colleague, Professor UPDEGRAFF. A very large factor in the pleasure and profit of our stay in Georgia was the cordial hospitality extended to all our party by Colonel and Mrs. REDDING and their colleagues at the Georgia Agricultural Experiment Station.

THE 21-FOOT CONCAVE GRATING SLIT SPECTROGRAPH AT GRIFFIN, GA.

Photographed by W. W. Dinwiddie.

THE 21-FOOT CONCAVE GRATING SLIT SPECTROGRAPH (INTERIOR VIEW) AT GRIFFIN, GA.

Photographed by W. W. Dinwiddie.

REPORT OF W. J. HUMPHREYS, PH. D.

On the invitation of Prof. of Math. S. J. BROWN, U. S. N., at that time Astronomical Director of the U. S. Naval Observatory, I became a member of the party stationed at Griffin, Ga., to observe the total eclipse of the Sun of May 28, 1900.

The apparatus at my disposal consisted of a large ROWLAND concave grating of 21.5 feet radius, loaned by the University of Virginia, a quartz lens, and a coelostat. After due consideration it was decided to mount the spectrograph according to the well-known ROWLAND method; that is, with the slit, camera, and middle of grating on the circumference of a circle whose diameter, normal at one end to the center of the camera and at the other to the grating, is equal to the radius of curvature of the ruled surface. It was further decided to work in the ultra-violet of the second order, because of the exceeding brilliancy of this particular grating in that region.

The optical train, taken in order, consisted of the silver-on-glass mirror of the coelostat, the quartz condensing lens, a slit, the grating, and finally the camera. The central ray of light from the mirror to the grating was horizontal, but the plane determined by this line and the middle of the camera, normal, of course, to the slit and rulings on the grating, was so inclined to the horizon that the image of the disappearing crescent would be approximately parallel to the slit. To secure steadiness the coelostat, lens, slit, grating, and camera were mounted on independent brick piers, and, except the coelostat, all were inclosed in a light-tight shed. A lens, clamped in position close beside the camera and focused on the hydrogen *F* in the second order, enabled the observer to decide when the image was on the slit in such a manner as to give this line most brilliantly. It was hoped that by this means a fair knowledge might be had of the light reaching the camera, and that with this knowledge more intelligent manipulation could be made during the progress of the eclipse. It is only fair, however, to state that, owing to the fact that hydrogen appears much higher in the solar atmosphere than most other substances, and the further fact that the condensing lens necessarily produced chromatic aberration, the hydrogen *F* might have appeared, even in its brightest condition, while the light from most of the flash lines fell to one side of the slit.

Close in front of the camera, but suspended from the roof of the shed, and thus free from the camera and its pier, was a drop shutter so arranged that the observer had it under perfect control with one hand, and by it could quickly admit light to the photographic plate or cut it off. The observer also had control with his other hand, by means of a lever that moved the condensing lens, of the position of the image on the slit. He was therefore able to watch continuously the hydrogen *F*, and with one hand, by means of the control lever, to keep it at its maximum brilliancy, while with the other hand he could manipulate the camera shutter according to any prearranged program, or in accordance with his own judgment, based on the intensity of the light and on the time signals given outside the camera house.

Despite some unfavorable weather, everything was in perfect order and working nicely the morning of the eclipse. In all the work of mounting and adjusting, and in making the observations, I was ably assisted by Mr. W. W. DINWIDDIE.

The program was arranged with the view of obtaining three or more negatives, but though the exposure was promptly begun at the signal "Go," owing to the faintness of the light during the whole of the short period of totality, no change of plates was made, it being thought better to get one plate fairly exposed than several with but little on them.

For a minute, or possibly longer, before totality the hydrogen *F* began to appear as a bright line, but it did not flash out instantly as a bright line and remain so till the end and then suddenly change back again to a dark line, but came and went irregularly for some seconds, with the intervals of darkness becoming shorter and the darkness less pronounced till it became a steady bright line. During this interval the ends of the line did not come and go in exactly the same places; they seemed somewhat split or shattered. After totality the same phenomena were repeated, but in the reverse order.

The exposure was made on a narrow strip along the middle of a SEED gilt edge plate, 20 inches long, and after totality this middle portion was protected and the sides exposed to bright sunlight, for a very brief interval, to secure a comparison FRAUNHOFER spectrum of about the same intensity as that of the flash lines.

The plate was developed by Mr. L. E. JEWELL, but gave no lines. The cause of failure was the feebleness of the spectrum, and this was conditioned by several combining circumstances. Thin wispy clouds undoubtedly reduced the light to some extent, and very much of that which reached the mirror was not reflected. The ultra-violet was being worked with, and silver is a very poor reflector in this part of the spectrum. Also the diameter and focus of the quartz lens were such that only a small fraction of the reflected light could reach the ruled suface of the grating. And finally the chromatic aberration of this lens made it impossible to keep the slit simultaneously well covered with a wide range of the spectrum.

Under these circumstances, as we now know, success could not reasonably have been expected, but when the experiments were made their failure was not so clearly a foregone conclusion. Thus the exceeding feebleness with which silver reflects much of the ultra-violet was not known to me at that time, and indeed the first and so far only careful quantitative measurements of its reflective power for a wide range of the spectrum, including the ultra-violet, had not then been made. As to the lens, while it was perfectly evident that its size and focal length left much to be desired, it was nevertheless the best quartz lens available, and since the work was to be done in the ultra-violet, glass could not be used. In the light, however, of our present knowledge it would have been much better to have worked with longer wave-lengths which are strongly reflected by silver, and in this case a glass lens would have been quite as good as one of quartz. The two great losses of light, the one due to imperfect reflection, the other to an unsuitable lens, could thus have been avoided.

It does not seem probable, however, that a grating mounted according to the ROWLAND method and used with a slit can, even under the most favorable circumstances, yield nearly as many flash lines as may be obtained with a prism or a concave grating used directly without lens or slit. But several problems other than the number of flash lines and their probable FRAUNHOFER counterparts present themselves in connection with eclipse spectra, and some of the most important of these could be answered nearly as well with a few as with many lines, but in any case provided only that the focusing was known to be perfect, and some means was at hand for determining absolute wave-lengths.

For the solution of all such problems, among them the line of sight motion of polar streamers, pressure shifts, anomalous dispersion, and the possible doubling of lines, the concave grating mounted according to the above plan seems to be peculiarly adapted. Such a mounting is easily made and perfect focusing can readily be obtained. Besides a comparison arc spectrum may be secured on each plate exposed. Negatives of this nature would be of the utmost value even though the flash lines were comparatively few in number.

It would be well in using a spectrograph of this kind to avoid the chromatic aberration of lenses entirely and to form the image on the slit by means of suitable reflectors. It might also be best to use silver reflectors and to avoid that part of the ultra-violet of wave-length shorter than λ3600.

Direct grating and prism spectrographs should be used, if possible, without reflectors of any kind, but when a reflector is used it should consist of magnalium for the ultra-violet and of silver for light of longer wave-lengths.

REPORT OF MR. L. E. JEWELL.

Having been invited by Prof. of Math. S. J. Brown, U. S. N., the Astronomical Director of the Naval Observatory, to become a member of the U. S. Naval Observatory eclipse expedition, I arrived at Experiment, Ga., from Pinehurst, N. C., on the morning of May 23, 1900, having been delayed by the adjusting of the spectroscopic instruments at the last-named place. As it was raining at the time, I went to Barnesville with Professor Brown and returned to Experiment Thursday morning. I found that the spectrograph which Doctor Mitchell and I were to use was partly set up, but no adjustments had as yet been attempted. During Thursday, Friday, and Saturday it was cloudy most of the time, the small amount of sunshine available giving scarcely any chance for adjusting the instrument until late Saturday afternoon, when the Sun was too low to use the coelostat to advantage.

The lens was found to be not properly centered and considerable time Sunday morning had to be used in collimating the quartz lens. This having been completed, the adjustments were pushed ahead as rapidly as possible. The collimator used for focusing proved to be unsatisfactory and gave much trouble, so that Sunday afternoon found the objective grating spectrograph approximately, but not satisfactorily, adjusted. The coelostat had also required considerable adjusting.

Monday morning, before the eclipse became total, was spent in perfecting adjustments, so that Doctor Mitchell and I had no time for practice, and we were obliged to trust to what we believed was a thorough understanding with each other. This arrangement proved to be satisfactory so far as carrying out the program agreed upon was concerned, but an error of the makers in the construction of some details of the camera was responsible for an accident which, unknown at the time to either of us, prevented light from reaching the grating during totality. Had we had any time for preliminary practice the source of trouble would have been discovered and corrected, but as the camera was not finished until we left Baltimore and had to be sent after we left, there was no chance for testing the apparatus until we had it set up and adjusted, which was not accomplished until twenty-five minutes before second contact.

Our program as laid out by us was for Doctor Mitchell to attend to the coelostat, the changing of the plates, etc., while I stationed myself at the other end of the camera box where there was a convenient place for the chronograph key and a good outlook for observing the spectrum with a small objective grating held in my hand. Mr. J. H. Drewry, of Griffin, Ga., had kindly consented to watch for the approach of the Moon's shadow and was stationed about 50 or 60 yards to the west of the eclipse station upon the old breastworks at the top of the hill. He was to give us warning of the approach of the shadow. After careful study of the subject I had arranged the following program:

PROGRAM OF EXPOSURES.

No. 1. One short exposure to be made 5 or 6 seconds before totality for the FRAUNHOFER line crescents.

No. 2. One exposure for the flash, beginning at the signal (the word "Go") by which I was to announce the beginning of totality for the convenience of the other observers. The exposure was to last for 5 or 6 seconds.

No. 3. A long exposure of 20 or 25 seconds at mid-totality for the coronal and the higher chromospheric lines.

No. 4. An exposure of from 5 to 10 seconds, ending just at third contact for the flash spectrum at the end of totality.

No. 5. A short exposure for the FRAUNHOFER crescents as soon after the end of totality as possible.

I was also to give the signal for the beginning of totality (the word "Go") and the end of totality (the word "Stop") for the benefit of the others. Prof. S. J. BROWN, observing near at hand with a 5-inch telescope, also called out the beginning of totality, our signals coinciding exactly. I also was to make the exposures for the objective grating spectrograph with a LOW shutter worked by a bulb held in my hand, and to record the times of the exposures by knocking against the key of the chronograph with the back of my hand. In the meantime I was to observe the changes in the spectrum by the aid of the small objective grating held in my left hand, and to keep track of the count of the seconds by Prof. A. L. QUAINTANCE.

The program as agreed upon was carried out except that exposure No. 2, instead of stopping at the fifth or sixth second, was continued to the eighth, as the medium strength lines of the chromospheric spectrum continued visible for a longer time than had been estimated. Also exposure No. 4, which was to end at third contact, was not ended quite soon enough. I was watching the brightening of the spectrum lines, and the photosphere broke out a moment before I could realize it and give the signal, "Stop." The delay, however, was not over a second, and probably less.

In the eye observations made for the purpose of gauging the exposures, use was made of a form of direct-vision spectroscope designed for the purpose. It was composed of one set of lenses from a pair of field-glasses, combined with a 1¼-inch plane grating of 15,000 lines to the inch and a 1¼-inch plane speculum metal mirror. Its performance was entirely satisfactory, and the view of the flash spectrum obtained was about perfect and very beautiful. As the spectrum was too bright for comfort in the green, yellow, and red portions when observations were begun, my attention was confined to the blue and blue green.

About 2 or 2½ minutes before second contact the *F* line showed as a bright point at the lower edge of the FRAUNHOFER spectrum, and about 1½ minutes before second contact it showed as a bright point at the upper edge of the spectrum. About 5 seconds before second contact the mountains of the Moon began to cut across the FRAUNHOFER crescents and exposure No. 1 was made. Then I called out, "Get ready;" and just about 2 or 2½ seconds later Mr. DREWRY called out, "The shadow is coming." The FRAUNHOFER spectrum had narrowed down to a narrow band and many of the more prominent chromospheric lines had begun to show at the edge of the spectrum band; 2 or 3 seconds later the spectrum band disappeared and

I called out, "Go," just as the small lines appeared as bright lines. There was a very great deal of difference in the length of different arcs, and the phenomenon was not a suddenly appearing one at all, although taking place within about 1 or 2 seconds. The large arcs appeared first and the shorter ones just as the FRAUNHOFER band gave place to a continuous spectrum strip. This continuous spectrum lasted probably not over a second, and as it disappeared the whole spectrum band was filled with bright arcs, many of them very short, while the *F* line showed as a very long brilliant arc. The shortest arcs lasted but 2 or 3 seconds, and then gradually disappeared; the arcs of medium length lasted somewhat longer, while the *F* line and the other hydrogen lines showed brightly, and a few others faintly throughout the duration of totality, the *F* line at mid-totality showing about two-thirds or three-fourths of a complete ring.

Exposure No. 2 was continued until the eighth second was called; then the plate was changed and Exposure No. 3 began, ending at the twenty-ninth or thirtieth second. Then the plate was changed again and continued until the fortieth second was counted, when I called "Stop," and then added "Over" in a louder voice. Exposure No. 5 was made immediately afterwards.

TIME OF CONTACTS.

The third contact occurred just about at the count of the fortieth second, and certainly not over about half a second before. The length of totality was thus about 2 seconds, or at least between 1 and 2 seconds, longer than the 38 seconds duration that had been computed. Unfortunately, the accident referred to had, unknown to either of us, prevented light from reaching the grating during totality, and also the chronograph had failed to record most of my signals, although their sound was distinctly heard as I made them.

My recollection of the time of contacts agrees quite well with those of Professor QUAINTANCE and Doctor TATNALL. The former, after the eclipse was over, gave me the scheme that had been used in counting, as follows:

The computed time of second contact by the chronometer was $1^h38^m19^s$. He called out the times as follows:

10 minutes before totality,
5 minutes before totality,
3 minutes before totality,
1 minute before totality,
30 seconds before totality,
20 seconds before totality,
15 seconds before totality,

and then began counting every second, intending to stop 5 seconds before the estimated time of second contact.

The signal "Go" for the beginning of totality was given immediately after the count of 10 seconds, so that the count 1 was given in place of 9, and occurred so as to fit in perfectly with the regularity of the count, so that it must have come immediately after the count of 10 seconds.

Every second was then counted up to the fortieth, when the signal for the end of totality, "Stop," was given, and immediately afterwards the call "Over," in a louder tone. This would make the second contact occur at $1^h38^m9^s$, and the third contact $1^h38^m49^s$ by the chronometer.

Doctor TATNALL says that the signal for second contact (the word "Go") was given at $38^m50^s \pm 0^s.5$ by his watch, and that his watch read 39^m when the chronometer read $38^m21^s.5$. This would make the time of second contact by the chronometer $1^h38^m11^s.5 \pm 0^s.5$. By the noon signal from Washington on May 28 the chronometer was $52^s.8$ slow, making the time of second contact $1^h39^m4^s.3$ according to Doctor TATNALL. According to Professor QUAINTANCE it would be $1^h39^m1^s.8$, or perhaps more nearly $1^h39^m2^s$..

The estimated time of $1^h38^m19^s$ by the chronometer was based upon the rate which the chronometer had had for several days, but evidently it had changed its rate between noon of May 27 and May 28.

In the afternoon after the eclipse Mr. DREWRY and I made a bicycle trip along the line of the Central of Georgia Railroad to locate, as well as we could, the northern edge of the eclipse path. Careful inquiry of many persons who had observed the eclipse determined, with practical certainty, that the eclipse was just total at the post-office at Sunnyside, some 150 feet west of the railroad tracks and station; while at Mr. J. T. DORSEY'S store, about 80 feet north of the post-office, the eclipse was not quite total. The apparent lack of totality may have been due however to the appearance of the brilliant prominences observed. At the post-office totality was estimated to have lasted only 1 or 2 seconds.

REPORT

OF THE

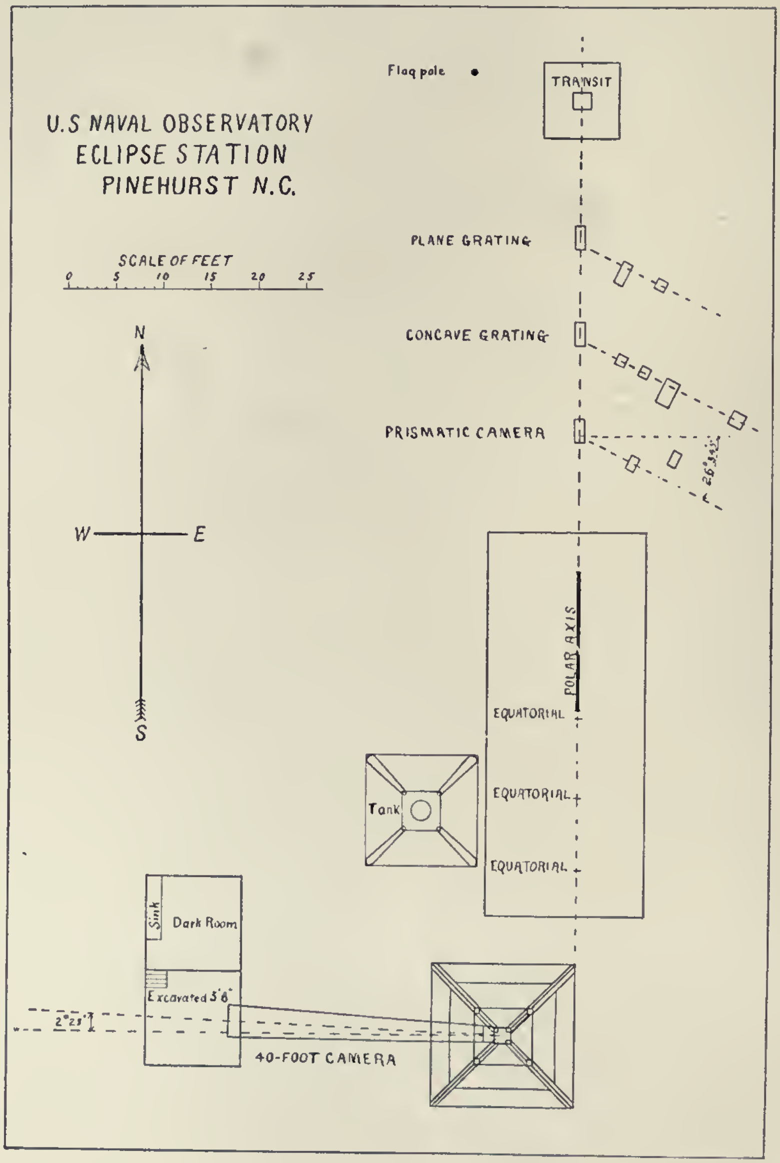
U. S. NAVAL OBSERVATORY ECLIPSE EXPEDITION

TO OBSERVE THE

TOTAL SOLAR ECLIPSE OF MAY 28, 1900,

AT

PINEHURST, NORTH CAROLINA.



Drawn by W. W. Dinwiddie.

GENERAL REPORT OF THE PINEHURST STATION.

Professor of Mathematics A. N. Skinner, U. S. N., in charge.

It having been decided to select a place for observation in the vicinity of Southern Pines, N. C., an examination of this region covering two days was made by Professor Skinner in April, 1900. This led to the selection of Pinehurst, some 6 miles west of Southern Pines, as the location for the station.

Pinehurst is a winter resort, comprising numerous cottages and hotels owned and controlled by Mr. James W. Tufts, of Boston, Mass., who very courteously extended an invitation to the Naval Observatory to locate an eclipse observing station on his property. The season is over and the hotels are generally closed by May 1, but through the good offices of the general manager, Mr. C. D. Benbow, Mr. J. M. Robinson, one of the hotel keepers, was induced to keep open the Lenox for our entertainment.

On May 3, Prof. of Math. A. N. Skinner, U. S. N., and Assistant Astronomer Theo I. King arrived at Pinehurst to begin preparations for observing the eclipse. A plot of ground about 800 feet southeast of the Carolina Hotel was selected for the site of the station, and Mr. Benbow's permission was obtained to occupy the same.

On the evening of May 3 a meridian line was laid out from observations of α Ursæ Minoris with a theodolite, and on the following day the lines of the various buildings and piers were staked out.

The apparatus and instruments arrived on May 8, and were soon followed by the remaining members of the observing party. All hands assisted in the mounting of the several instruments, so that several days before the eclipse the apparatus was ready for service with the exception of the final adjustments.

On Saturday, May 12, a temporary telegraph line was run into the portable transit house by the courtesy of Superintendent J. B. Tree, Western Union Telegraph Company, Richmond, Va., the Naval Observatory noon time signals being received daily from that date at the eclipse station. From May 5 to May 11 the signals were received at the Pinehurst railway station. The party is indebted to Mr. C. R. Caperton and his assistant, Mr. Beall, for their very efficient services as telegraph operators. The gentlemen were also volunteer assistants in the astronomical work.

INSTRUMENTS AND BUILDINGS.

The accompanying plan, PLATE XII, shows the location and dimensions of the piers and buildings, which in general were arranged along a meridian line. All the piers were built of brick laid in cement and, except the transit instrument pier, capped with slate slabs.

At the north end was located a portable transit for the determination of the latitude and longitude of the station. The pier and instrument were protected by a portable wooden house about 9 feet square, which had seen extensive service in various parts of the world in the longitude campaigns under the auspices of the Hydrographic Office of the Navy Department.

To the south of the transit house about 10 feet apart were located, on the meridian line, piers for three coelostats for use in connection with the three spectrographs. The northern one was for the plane grating, the middle one for the concave grating, and the southern one for the objective prism. Immediately to the south of the objective prism spectrograph and separated from it by an interval of 10 feet was a shed 40 feet long from north to south and 16 feet from east to west, for the protection of the instruments mounted on the wooden polar axis and the three 5-inch equatorials. The eastern slope of the roof of the shed was built with removable rafters and provided with a sailcloth covering which could be readily rolled up by means of halyards.

The polar axis 11 feet long and 12 inches square cross-section, built of 2-inch pine planks and fitted with cast-iron journals bolted to the ends, was supported on roller bearings secured to timbers planted in the ground. The diurnal motion was effected by a clepsydra whose piston acted in the plane of the equator perpendicularly on the end of a 2-inch iron pipe 12 feet long screwed into the lower journal casting perpendicular to the polar axis. The instruments carried on the axis were two DALLMEYER cameras catalogued as 8. D., each 38 inches in focal length and 6 inches in aperture,. and a VOIGTLAENDER camera, 8 inches in focal length and 4 inches in aperture, loaned by the observatory of Yale University. One of the DALLMEYER cameras was fitted with a BAUSCH and LOMB color screen in front of the objective. In the south end of the shed were located three 5-inch equatorials, two of which were used for visual purposes and one for the polarizing apparatus of Dr. N. E. DORSEY.

Immediately to the south of the shed and separated from it by an interval of 5 feet was located the 40-foot camera of 5 inches aperture and 39 feet focal length, mounted with its optical axis directed to the predicted place of the Sun at the time of totality. The upper end of the apparatus was supported by a timber framework, consisting of two independent pyramidal scaffolds, one within the other. The outer scaffold, which supported the tube, was 15 feet square at the base and 25 feet high, while the inner one which supported the lens was 13 feet square at the base and of the same height as the outer. Twenty feet west of the scaffold was built a dark room 20 by 10 feet, the southern half of which was excavated 3 feet 6 inches to accommodate the mounting of the plate-holder, which was arranged to move on properly curved metal guides, so as to retain the image of the Sun motionless on the photographic plate. The motion of the plate-carrier was effected by a clepsydra.

THE ECLIPSE STATION AT PINEHURST, N. C., LOOKING SOUTHWEST.

Photographed by A. L. Colton.

THE ECLIPSE STATION AT PINEHURST, N. C., LOOKING NORTHWEST.

Photographed by A. L. Colton.

The dark room was fitted with a sink supplied with running water from the Pinehurst water service.

The pyramidal canvas tube, about 3 feet square at one end and 18 inches at the other, provided with suitable diaphragms, was secured within a skeleton framework of half-inch gas-pipe, the upper end being supported by the outer scaffold, and the lower end connected with a corresponding opening in the wall of the dark room. Black cloth was used wherever necessary to cut off all light from the photographic plate except that which passed through the lens.

The polar axis and 40-foot camera at Pinehurst were identical in construction and arrangement with the similar instruments at Barnesville. The elements of construction may be found in greater detail in the report of the Barnesville station.

ASSIGNMENTS OF OBSERVERS.

The different instruments were handled by the following persons:

The concave grating slit spectrograph by Prof. J. S. AMES, assisted by Dr. H. M. REESE, both of Johns Hopkins University.

The plane grating objective spectrograph by Dr. W. B. HUFF, assisted by Mr. N. E. GILBERT, both of Johns Hopkins University.

The objective prism spectrograph by Dr. F. L. CHASE, of Yale University.

The VOIGTLAENDER camera by Mr. N. A. KENT.

The 38-inch DALLMEYER camera, fitted with a color screen, by Prof. of Math. W. S. EICHELBERGER, U. S. N.

A second 38-inch DALLMEYER camera, without color screen, by Assistant Astronomer T. I. KING, from the Naval Observatory.

A 5-inch equatorial by Mr. E. I. YOWELL, from the Cincinnati Observatory.

A second 5-inch equatorial by Prof. of Math. EDGAR FRISBY, U. S. N. (Retired).

A third 5-inch equatorial for polariscopic work by Dr. N. E. DORSEY, assisted by Mr. L. A. PARSONS, both of Johns Hopkins University.

The 40-foot camera by Mr. A. L. COLTON, assisted by Mr. MELVILLE G. SKINNER.

Several instruments by Prof. R. W. WOOD, of the University of Wisconsin, described in his report, which is appended.

During the period of preparation the party received visits from Prof. of Math. S. J. BROWN, U. S. N., the Astronomical Director, and Dr. S. A. MITCHELL, who were on their way to the Naval Observatory stations in Georgia. Mr. L. E. JEWELL, also of the Georgia station, spent a number of days at Pinehurst assisting in adjusting the spectroscopic apparatus. Two calls were received from Prof. H. C. WILSON, of the Goodsell Observatory, Northfield, Minn., who occupied a station near the electric railway, about midway between Pinehurst and Southern Pines.

In order to render the operators of the instruments familiar with their work, regular drills were executed several times a day, for three or four days preceding the eclipse. Preparatory signals were given five minutes, one minute, and ten seconds previous to the predicted time of second contact. The seconds of totality were counted from 1 to 96, the count being started by the word "Go" which was to be called out loudly at the instant of second contact.

A careful consideration of the matter led Professor Brown and Mr. Jewell to the decision that the time of second contact could be most surely and accurately determined by observation with a binocular, one barrel of which was fitted with a small diffraction grating. In accordance with this decision, Professor Skinner arranged to give the preparatory signals himself and instructed the observer in charge of the plane grating spectrograph to give with a loud voice the final signal "Go." Unfortunately the small diffraction grating attached to the binocular failed to render visible the flash at the second contact and delayed the starting signal by 25 or 30 seconds, and consequently some valuable time was lost.

Professor Wood states in his report that he arranged to watch for the flash so as to be prepared if Doctor Huff's instrument should fail to show it; Professor Wood did not recognize the appearance of the flash, as shown by his spectroscope.

The failure of these two instruments to indicate the time of second contact demonstrates the inexpediency of depending upon spectroscopic means for this purpose.

CONTACT OBSERVATIONS.

The times of contact were noted at Pinehurst by several observers. The following table gives the predicted and observed times, with the names of the observers and the apertures of the telescopes employed:

Contact.	Local Mean Time.		Observer.	Aperture.
	Predicted.	Observed.		
	h m s	h m s		in.
I	19 18 53.1	19 18 48.6	Wood	4.75
	.. ..	19 18 48.6	Yowell	5
	.. ..	19 18 53.6	Eichelberger	3
	.. ..	19 18 56.6	Frisby	5
II	20 28 27.2	20 28 35.1	Yowell	5
IV	21 49 11.5	21 48 51.6	Eichelberger	3
	.. ..	21 49 5.6	Yowell	5
	.. ..	21 49 12.6	Frisby	5

Professor Wood makes the following note in reference to his observation of first contact. "I feel very certain of my observation, for it came several seconds before I expected it, and I happened to have my eye on the exact spot where the Moon made the first nick in the Sun's rim."

LONGITUDE AND LATITUDE.

The difference of longitude between the Naval Observatory, Washington, D. C., and the transit pier at Pinehurst, N. C., was determined by exchange of telegraphic signals on three nights.

The latitude of the transit pier was determined by observing fifteen pairs of stars, using TALCOTT'S method.

The longitude and latitude observations were made by Professor SKINNER, assisted by Mr. GEORGE K. LAWTON, of the Naval Observatory. The computations for the longitude and latitude work were executed by Mr. LAWTON.

The instrument used was a combined zenith telescope and transit instrument, STACKPOLE No. 1497, with an aperture of 2.5 inches and a focal length of about 30 inches. This was mounted on a pier built of brick laid in cement, with a sandstone cap. A wooden shed, elsewhere described, protected the instrument.

Time Observations at Pinehurst, N. C.

[Observer, A. N. SKINNER; Recorder, G. K. LAWTON.]

Date.	Clamp.	Name.	T			Aa+Bb+Cc	ΔT
1900			h	m	s	s	s
May 15	W.	δ Leonis	11	9	4.71	+0.47	−15.09
		ν Ursæ Majoris	11	13	22.19	+0.50	−15.26
		σ Leonis	11	16	16.21	+0.44	−15.23
		r Leonis	11	23	5.06	+0.43	−15.16
	W.	λ Draconis	11	25	46.21	+0.89	−15.17
	E.	υ Leonis	11	32	7.50	+0.08	−15.17
		3 Draconis	11	37	12.27	+0.42	−15.19
		β Leonis	11	44	15.31	+0.14	−15.14
		β Virginis	11	45	47.01	+0.08	−15.20
		π Virginis	11	56	2.85	+0.11	−15.25
		31 Comæ Berenices	12	47	7.94	−0.05	−15.24
		8 Draconis	12	51	49.13	−0.37	−15.29
		ε Virginis	12	57	30.21	−0.03	−15.22
		θ Virginis	13	5	4.77	−0.03	−15.30
	E.	43 Comæ Berenices	13	7	30.67	−0.06	−15.16
	W.	α Virginis	13	20	13.50	+0.46	−15.25
		9 B. Ursæ Minoris	13	23	53.78	+0.55	−15.29
		ζ Virginis	13	29	53.80	+0.43	−15.23
		m Virginis	13	36	39.91	+0.46	−15.32
	W.	r Bootis	13	42	48.51	+0.41	−15.22
19	E.	δ Leonis	11	9	4.29	−0.33	−13.92
		ν Ursæ Majoris	11	13	21.73	−0.40	−13.96
		σ Leonis	11	16	15.76	−0.26	−14.12
		r Leonis	11	23	4.63	−0.26	−14.08
	E.	λ Draconis	11	25	46.89	−1.05	−14.11
	W.	υ Leonis	11	32	6.44	+0.01	−14.08
		3 Draconis	11	37	11.65	−0.28	−14.04
	W.	β Leonis	11	44	14.36	−0.05	−14.05

Time Observations at Pinehurst, N. C.—Continued.

Date.	Clamp.	Name.	T			Aa+Bb+Cc	ΔT
1900			h	m	s	s	s
May 19	W.	*β* Virginis	11	45	45.84	−0.01	−13.97
		π Virginis	11	56	1.74	−0.02	−14.05
		31 Comæ Berenices	12	47	6.74	+0.01	−14.14
		8 Draconis	12	51	48.13	−0.61	−14.17
		ε Virginis	12	57	28.91	+0.16	−14.14
		θ Virginis	13	5	3.23	+0.31	−14.12
	W.	20 Canum Venaticorum	13	13	20.77	−0.12	−14.02
	E.	*α* Virginis	13	20	13.07	−0.21	−14.17
		9 B. Ursæ Minoris	13	23	54.53	−1.55	−14.09
		ζ Virginis	13	29	53.34	−0.26	−14.09
		m Virginis	13	36	39.36	−0.22	−14.10
	E.	*τ* Bootis	13	42	48.27	−0.36	−14.22
21	W.	*ν* Ursæ Majoris	11	13	20.91	+0.06	−13.63
		σ Leonis	11	16	14.84	+0.07	−13.55
		τ Leonis	11	23	3.70	+0.08	−13.51
		λ Draconis	11	25	44.27	+0.33	−13.57
	W.	*υ* Leonis	11	32	5.93	+0.09	−13.67
	E.	3 Draconis	11	37	12.36	−1.49	−13.63
		π Virginis	11	56	1.77	−0.57	−13.55
		ο Virginis	12	0	23.86	−0.58	−13.60
		2 Canum Venaticorum	12	11	24.17	−0.81	−13.47
		η Virginis	12	15	4.37	−0.55	−13.58
		κ Draconis	12	29	32.01	−1.80	−13.63
		f Virginis	12	31	55.43	−0.54	−13.64
		γ Virginis (*mean*)	12	36	52.70	−0.54	−13.60
		31 Comæ Berenices	12	47	6.99	−0.71	−13.69
	E.	*δ* Virginis	12	50	51.09	−0.57	−13.65
	W.	*ε* Virginis	12	57	28.70	−0.03	−13.76
		θ Virginis	13	5	2.90	+0.06	−13.55
		43 Comæ Berenices	13	7	29.14	−0.10	−13.63
		9 B. Ursæ Minoris	13	23	52.63	−0.26	−13.57
	W.	*ζ* Virginis	13	29	52.54	+0.03	−13.58

Adopted Chronometer Corrections from Least Square Solutions.

Date.	Sidereal Time.	Corr.
1900	h m	s
May 15	11 30. 31	—15. 185
	13 14. 25.	—15. 241
19	11 30. 30	—14. 032
	13 14. 83	—14. 130
21	11 41. 05	—13. 574
	12 56. 01	—13. 634

Longitude Exchange between Washington and Pinehurst.

Date.	Signals from—	Epoch of Signals.		Difference of Clocks Δ_1	Clock Correction.			$\Delta\lambda$	Double Transmission Time.	Mean $\Delta\lambda$
		Washington T_e	Pinehurst T_w		Washington ΔT_e	Pinehurst ΔT_w	$\Delta T_e - \Delta T_w$			
1900		h m	h m	m s	s	s	s	m s	s	m s
May. 15.4	Washington . . .	12 37. 2	12 27. 6	9 39. 939	—18. 005	—15. 216	—2. 789	9 37. 150		
	Pinehurst	12 21. 7	12 12. 0	9 39. 961	—18. 003	—15. 207	—2. 796	9 37. 165	0. 015	9 37. 158
19.4	Washington . . .	12 47. 9	12 38. 2	9 40. 187	—17. 347	—14. 096	—3. 251	9 36. 936		
	Pinehurst.	12 42. 9	12 33. 2	9 40. 360	—17. 347	—14. 091	—3. 256	9 37. 104	0. 168	9 37. 020
21.4	Washington . . .	12 32. 2	12 22. 5	9 41. 105	—17. 660	—13. 607	—4. 053	9 37. 052		
	Pinehurst	12 28. 0	12 18. 3	9 41. 200	—17. 661	—13. 604	—4. 057	9 37. 143	0. 091	9 37. 098

	h	m	s
Mean	0	9	37. 092
Longitude of 9-inch transit circle, east from center of clock room			0. 069
Longitude of Pinehurst, west from center of clock room, Naval Observatory	0	9	37. 023
Longitude of Washington, west from Greenwich	5	8	15. 78
Longitude of Pinehurst, west from Greenwich	5	17	52. 80

Latitude Observations at Pinehurst, N. C.

[Observer, A. N. SKINNER; Recorder, G. K. LAWTON.]

[One revolution of micrometer=68″.718.]

Date.	Star.		Micrometer Reading.	Declination.	Level Correction.	Latitude.	*v*
1900			ʳ	° ′ ″	″	° ′ ″	″
May 13	γ Ursæ Majoris	N.	41.319	+54 15 0.0	−5.76	+35 11 38.0	−0.2
	ο Leonis	S.	38.254	+16 11 58.2			
	1 Canum Venaticorum	N.	27.712	+53 59 25.1	−5.55	+35 11 38.4	+0.2
	α Canum Venaticorum	N.	32.333	+38 51 22.4			
	37 Comæ Berenices	S.	43.155	+31 19 18.0	+3.92	+35 11 36.1	−2.1
14	α Canum Venaticorum	N.	20.500	+38 51 22.6			
	37 Comæ Berenices	S.	31.442	+31 19 18.2	+0.91	+35 11 37.4	−0.8
	70 Virginis	S.	30.140	+14 18 32.8			
	81 Ursæ Majoris	N.	18.667	+55 51 34.5	−0.60	+35 11 37.4	−0.8
	370 Safford	S.	32.452	+20 27 29.1			
	η Ursæ Majoris	N.	26.206	+49 48 37.9	−0.36	+35 11 37.8	−0.4
16	α Canum Venaticorum	N.	27.110	+38 51 23.0			
	37 Comæ Berenices	S.	38.224	+31 19 18.5	−4.01	+35 11 38.7	+0.5
	70 Virginis	S.	36.362	+14 18 33.0			
	81 Ursæ Majoris	N.	24.859	+55 51 34.9	−2.37	+35 11 36.9	−1.3
22	Groombridge 1800	N.	33.588	+55 20 15.1			
	β Leonis	S.	29.475	+15 7 38.8	+3.61	+35 11 39.2	+1.0
	ο Leonis	S.	34.092	+16 11 59.0			
	1 Canum Venaticorum	N.	23.731	+53 59 26.5	+0.05	+35 11 38.8	+0.6
	η Virginis	S.	30.403	− 0 6 57.5			
	κ Draconis	N.	21.770	+70 20 23.0	−0.04	+35 11 39.5	+1.3
	26 Comæ Berenices	S.	20.007	+21 36 33.3			
	11 Canum Venaticorum	N.	32.210	+49 0 38.7	+1.42	+35 11 38.0	−0.2
	α Canum Venaticorum	N.	27.049	+38 51 24.1			
	37 Comæ Berenices	S.	37.975	+31 19 19.5	+1.44	+35 11 38.8	+0.6
	70 Virginis	S.	33.091	+14 18 33.7			
	81 Virginis	N.	21.736	+55 51 36.3	+3.59	+35 11 38.8	+0.6
	370 Safford	S.	31.399	+20 27 30.3			
	η Ursæ Majoris	N.	25.074	+49 48 39.9	−2.89	+35 11 39.6	+1.4

Latitude of Pinehurst, N. C .... +35° 11′ 38″.23 ± 0″.17

WORK OF THE VARIOUS INSTRUMENTS.

Professor BROWN, the Astronomical Director of the Naval Observatory, placed the spectroscopic negatives taken at the Pinehurst station in the hands of Mr. L. E. JEWELL for measurement and discussion. A preliminary report of the results derived from these plates was published by Professor BROWN in the Astrophysical Journal, Volume XII, page 58.

The following reports are in the main made up from information contained in the preliminary report to which reference has just been made.

The plane grating objective spectrograph.—The mounting of this grating was planned and supervised for the Naval Observatory by Mr. JEWELL. The solar image was furnished by means of a transit-of-Venus coelostat and a quartz lens about 3 inches in diameter. The coelostat and spectrograph were mounted on three brick piers whose arrangement may be seen by reference to PLATE XII. The entire spectrograph was so mounted that the lines of the grating should be parallel to a line equally inclined to tangents to the Sun's limb at the points of second and third contact. The grating which was furnished to the Naval Observatory by BRASHEAR has a ruled surface 3.5 by 5 inches with 15,000 lines to the inch. This grating is extremely bright in the first order on one side and in the second order on the opposite side. The spectrum which it gives is almost entirely free from diffused light. The plate-holder, which was arranged for five plates 1 inch wide, was shaped to the focal curve of the spectrum, but it was found that the thin glass plates would not bend the required amount, so that only a portion of the spectrum was in sharp focus.

With this instrument three photographs were obtained. (1) The flash spectrum at second contact of 1 second exposure. (2) The coronal spectrum, 25 to 30 seconds later, with an exposure of 5 to 6 seconds. (3) The FRAUNHOFER spectrum, after third contact, with an exposure of 1 second.

PLATE LXI is a reproduction of the flash spectrum obtained at second contact with an exposure of 1 second. The original photograph extends from wave-length 3000 to 6000, giving a dispersion of about 10 inches. Some important facts which may be drawn from a brief inspection of this portion of the spectrum are worthy of attention.

The prominences, as shown in the light of the H and K lines, give details which compare favorably with large scale photographs, and which are rather better than in small scale photographs. The plate shows marked differences in the prominences as given by the lines of helium and hydrogen and those by the calcium lines H and K. The bright horn-like prominences seen in H and K, as well as one entirely detached, are not shown at all in the helium and hydrogen lines. Some of the prominences are shown in the bright strontium line at 4078, just above H_δ. This is also the case with the titanium lines.

Three of the carbon bands at 3883 show very brilliantly up to a height of 100 to 200 miles, and faintly up to a height of 200 to 400.

Notwithstanding the short exposure of 1 second, considerable detail is shown in the green coronal line at 5303 and in the violet coronal line at 3987. The distribution of material producing these two lines is shown to be entirely different and to have no connection whatever with the prominences, and little, if any, with the material giving the continuous spectrum of the corona. The distribution of material in 3987 is more like that of the matter in the chromosphere than in 5303.

A faint though very remarkable line at 3965, which seems to be strongest at an elevation of from 1,000 to 4,000 miles, and very weak in the lower strata, is scarcely visible in the spectrum of the base of the chromosphere. This has been identified as one of the lines of the principal series of parhelium, and several lines in Professor

LORD'S flash spectra, which share the same peculiarity of distribution of light, also are identified as belonging to the same element, but not all to the same series.

The plate shows over 20 lines between H and K, and, if it had been in focus throughout its length, would probably have contained about 1,500 lines.

On the second negative, the coronal lines are well shown, and four new ones have been found in the ultra-violet at approximately 3381, 3456, 3643, and 380.1 The line at 3381 is remarkably strong and indicates a distribution of material similar to that shown by the green coronal line at 5303, while the other three show a similarity in distribution to that in the violet at 3987.

The separating power of this apparatus is well shown by the fact that in the original negative the hydrogen and calcium components of H are distinctly separated.

The negative showing the third contact was spoiled by continuing the exposure after the Sun appeared.

On the fourth negative, of the FRAUNHOFER spectrum, the strong lines are shown bright at the edges, and a displacement is noticeable between the dark and bright portions similar to that shown in Prof. W. W. CAMPBELL'S photographs taken in India during the 1898 eclipse. The photograph shows definitely that this displacement is due to the fact that the source of the dark and bright lines is different, and is purely an angular displacement, the dark FRAUNHOFER lines being produced by the photosphere, and the bright lines by the base of the chromosphere at considerable elevation above this. The aluminum and titanium lines also show both the dark lines and the bright extensions, in addition to helium, hydrogen, and strontium, though in none of these is there indicated more than a very slight displacement of the dark and bright portions.

The concave grating slit spectrograph.—The details of the mounting of this spectrograph were planned by Mr. L. E. JEWELL who supervised its construction for the Naval Observatory. The solar image was furnished by means of a transit-of-Venus coelostat and a quartz lens.

The coelostat and the various parts of the spectrograph were supported on five brick cement-laid piers, the general arrangement of which may be seen in PLATE XII. The spectrograph was so mounted that the slit would be parallel to a line equally inclined to tangents to the Sun's limb at the points of the second and third contact.

The plate-holder, which was made to carry five strips 1 inch wide, was made with a curved back with the intention of bending the thin glass plates to the proper radius. It was found on trial that the plates could not be bent the requisite amount without breaking and thus only a limited portion of the spectrum would be in sharp focus.

The concave grating which was furnished to the Naval Observatory by BRASHEAR had a radius of curvature of 10 feet and a ruled surface of 3.5 by 5 inches with 15,000 lines to the inch.

This instrument was used with a wide slit, which expedient was adopted after the instrument had been erected at Pinehurst on account of the difficulty which would be met in bringing and keeping the image of the reversing layer upon the slit. The quartz lens used with this grating was 3 inches in diameter and about 35 inches focal length, from which it is evident that only about one-third of the light from the reversing layer would be received by the grating. No results were derived from this instrument. The failure was due to the short focal length of the quartz lens, combined with the shortness of the exposure which could be obtained on the reversing layer at a station near the central line of totality.

The objective prism spectrograph.—This consisted of a 60° flint glass prism, of 6 inches length and faces 5 inches broad, used in connection with a 4-inch visual lens of 60 inches focus. The prism was loaned to the Naval Observatory by the Smithsonian Institution. The light was reflected into the spectrograph by means of a transit-of-Venus coelostat. The coelostat and spectrograph were mounted on three brick cement-laid piers, whose arrangement may be seen by reference to PLATE XII. The spectrograph was so mounted that the edge of the prism would be parallel to a line equally inclined to tangents to the Sun's limb at the points of second and third contact.

The plates used were 5 by 7 Erythro, very obligingly sent a short time before the eclipse by Mr. DOUGLASS. Although the definition of the negative is not good, due to the curvature of the focal plane, the results are worthy of careful study, as it shows lines between *C* and *K* at least 250 in number, including 20 between D_3 and *C*. The exposure on this plate was made at the second contact and is estimated to have been less than 1 second, and yet the *C* line comes out very distinct, bright, and extensive. On the second plate, with an exposure of 40 seconds, the clock worked badly, and the lines are somewhat drawn out. There are shown, however, as dark lines the various groups due to the Earth's atmosphere, including α, *B*, *a*, *A*, and traces of atmospheric lines near *D*.

The polar axis.—Of the two 38-inch DALLMEYER cameras on this axis, one was provided with a color screen containing a solution of picrate of copper and placed outside of the outer lens. Three photographs on plates were obtained with each of these of 2^s, 5^s, and 40^s exposure respectively. With the VOIGTLAENDER camera two photographs were taken, one with a color screen of 20 seconds exposure and the other without a color screen of 40 seconds. The placing of the color screen in front of the objective seems to have caused in both the DALLMEYER camera and the VOIGTLAENDER camera reflections and distortions of the image to such an extent as to seriously interfere with good definition. The four plates of long exposure are rather dark, and one of those taken with the VOIGTLAENDER camera shows an extension of the corona of about three diameters.

The 40-foot camera.—The photographs taken with this instrument were exposed 2^s, 5^s, 45^s, 10^s, and 2^s respectively. The plates used were SEED double coated 14 by 17, backed with a thick coat of artists' lampblack.

The negatives taken with the 40-foot camera at Pinehurst are not included by Mr. PETERS in the discussion of the Naval Observatory coronal photographs, as he considers that all of the features contained in them are present in the Barnesville negatives, which possess a somewhat sharper definition.

REPORT OF PROFESSOR R. W. WOOD.

SHADOW BANDS AND THE POLARIZATION OF THE CORONA.

In response to an invitation from Prof. of Math. S. J. Brown, U. S. N., I left Madison, Wis., on May 22, with such apparatus as I had arranged for observations of the total solar eclipse occurring on May 28, and proceeded to Pinehurst, N. C., via Barnesville, Ga., in accordance with instructions. I arrived at Pinehurst on May 25.

I had chosen as a special study the subject of the so-called shadow bands seen sweeping across the landscape during the few minutes immediately preceding and following totality.

These bands have been sometimes styled diffraction fringes bordering the Moon's shadow, but for obvious reasons this explanation has already been discarded. In the reports of previous eclipses to which I have had access they are described as having definite width, direction, and velocity, three characteristics which made the theory that they were produced by striæ in the atmosphere seem at least open to question. As great uncertainty must exist in roughly made observations of rapidly moving objects, it seemed to me very desirable to adopt some more exact method of observation than had been previously used. It is well known that any regularly recurring pattern, moving with a uniform velocity, can be apparently brought to rest by observing it through a stroboscope, or rotating disk furnished with radial slits, and driven at such speed that the slits pass in front of the eye at the same rate as that at which similar points on the moving pattern pass a fixed point. If the bands consisted of several systems of different width, moving with different velocities, which might explain the shimmering effect sometimes seen, the stroboscope would pick out the systems one after another, as its speed was varied. I therefore arranged an instrument of this description for viewing the bands as they swept across a white cloth screen. If they were found to be periodic, that is to say, capable of being held at rest by the stroboscope, their width and distance apart were to be determined by scales placed on the sheet in a direction perpendicular to them. At the same instant the speed of the stroboscope was to be recorded by means of a tuning fork, one prong of which carried a light stylus arranged to trace a record of the vibrations on the previously smoked disk of the instrument. From this record the velocity with which the band system was moving could be easily determined.

It seemed equally important to determine, if possible, which portion of the source of light was operative in the production of the bands; that is, whether it was the entire crescent of the Sun or only the cusps. A determination of the source of the light producing the bands would be of great value in ascertaining their cause if the atmospheric theory were found untenable, which would be the case, it seemed to me, if the bands were found to have a perfectly definite width and distance apart. An approximate periodicity might be produced by some such arrangement in the air as that producing the mackerel sky, or by ripples on the boundary surface between layers of hot and cold air, but it is extremely doubtful if such a system could be held at rest by the stroboscope. If alternate bands of light and shade are moving across the country it is obvious that the eye, when in a light band, will receive more light than when in a dark one. If the transfer from light to dark is not too rapid a fluctuation in the brilliancy of the light source producing the bands should be observed. Previous observations of the width and velocity of the bands showed that some fifty or sixty must cross the eye each second, a sufficient explanation of the absence of any observation of a periodic fluctuation in the brilliancy of the Sun's crescent.

By viewing the source of light through the revolving disk of the stroboscope it is obvious that, by properly regulating the speed, the eye can be kept permanently in a bright or dark area, and if the speed is changed slightly the eye will be in a dark area one moment and in a light one the next, and consequently that portion of the light source producing the bands will appear to fluctuate in brilliancy, the fluctuations being very slow at first and increasing in rapidity as the speed of the stroboscope disk is changed.

Two stroboscopes were prepared, consisting of heavy cardboard disks, provided with twelve radial openings and mounted on pulleys arranged to be driven by hand. Heavy brass disks were mounted on the same axes, to serve as fly-wheels and make the speed more uniform. These disks were smoked and served to receive the trace of the stylus attached to the tuning fork.

The instruments were firmly clamped to small wooden supports in front of the scaffold of the 40-foot camera, on which the sheet was stretched. Prof. J. W. GORE kindly undertook to make the observations of the bands on the sheet through one of the stroboscopes, while I devoted myself to the direct observation of the disappearing crescent through the other. Mr. HOFFMAN attended to the tuning fork and the recording of the speed. In order to get records of the appearances of the bands at different localities along and immediately outside of the track of totality, I sent requests to all of the leading southern newspapers, asking for assistance from amateur observers. My plan was to secure data regarding the direction, width, and velocity of the bands at as many different localities as possible and record the results on a map of the Southern States, together with any other observations that might be regarded as important, such as the direction of the wind, condition of the atmosphere, etc.

Previous attempts to photograph the moving bands having resulted in uniform failure, owing, doubtless, to lack of light, I arranged a plate in a holder behind a focal-plane shutter. This plate was to be exposed to the Sun directly, without any lens, for a very brief interval of time, as the narrow slit of the shutter rushed in front of it. In this way all the light would be utilized, and if any record was obtained a calculation of the velocity with which the bands were moving might be made from the angle of the slope of the bands on the plate due to the successive exposure of parallel strips of the plate. Unfortunately, I was unable to secure the assistance of anyone to operate this piece of apparatus until the last minute, and something went wrong with it, owing to the inexperience of the operator, who had never seen this type of shutter before, and who had not been sufficiently drilled in its use. During the period of totality I planned to divide my time between an attempt to determine whether any trace of polarization existed in the line spectrum of the corona, as well as in the continuous spectrum and visual observations with my 4.75-inch refractor.

Though it is hardly conceivable that the discontinuous spectrum should exhibit polarization, it appeared to be worth while to look for it, as no observations regarding it seem to have been made.

After much preliminary experimenting on mixed sources of light, such as a feebly polarized white light mixed with a certain amount of unpolarized light from a feeble sodium potassium lithium flame, I adopted the following form of polarizing spectroscope. A large direct vision prism was mounted before the object-glass of a 2.5-inch telescope, the eyepiece containing a SAVART plate and a NICOL prism. It was found that the direct vision prism partially polarized the light. This was compensated by a sheet of plate-glass placed at the proper angle before the prism.

This instrument gave a continuous spectrum crossed by very distinct diagonal interference bands when a white source of light containing 1 per cent or more of polarized light was examined. It was my object to see whether the SAVART bands were interrupted by the lines of the ring spectrum of the corona, or whether they passed through them. I also planned to watch for the flash spectrum with this instrument in case any unforeseen accident should befall the instrument in Doctor HUFF'S hands, on the testimony of which the starting signal was to be given.

On the day previous to the eclipse, there being still room on the polar axis for another instrument, I determined, in view of the interest manifested in the action of color filters on photographs of the corona, to arrange a camera fitted with a very dark green CARBUTT color screen, which I happened to have with me. Removing the front lens of my ZEISS anastigmat, I secured a means of getting an image of the Sun nearly half of an inch in diameter. The length of focus necessitated the rigging up of an extension on the front of the camera. This was made of a roll of heavy paper screwed into the front of the camera box and held rigid by four strings, arranged like the guys of a smokestack. The lens was carried on the front of this tube, the color screen placed over it, and a cloth laid over the whole. A stop corresponding to the ratio expressed by f/40 was used, and two exposures arranged for: one of 40 seconds with the color screen, and one of 7 seconds without it, fast orthochromatic plates being used. As things turned out, the latter exposure was not made until 20 seconds after third contact, yet the inner corona is distinctly shown, which makes the picture not without interest. On the day preceding the eclipse Professor GORE, Mr. HOFFMAN, and I practiced with the stroboscopes, observing one instrument through the other and training ourselves in holding at rest the observed disk by regulating the speed of the observing instrument, Mr. HOFFMAN recording the speed with the fork. The sheet on which the bands were to be observed was tightly stretched in such a position that the Sun's rays would fall normally upon it at the time of the eclipse. Prof. IRA REMSEN kindly consented to attend to the placing of the scales on the sheet by means of which the direction and width of the bands were to be determined.

Our work was planned as follows:

Up to about 30 seconds before totality we were to be occupied with the stroboscopes, Professor GORE watching the sheet and I the Sun, Mr. HOFFMAN standing between the two instruments prepared to register the speed of either. Half a minute before totality Professor GORE was to take his place at the polar axis and attend to the exposures with what I may call the smokestack camera, fitted with the color screen. At the word, "Attention," which was to be called 10 seconds before second contact, I was to move to the polarizing spectroscope and watch for the flash, signaling its appearance privately to Doctor HUFF, who was watching for it with a grating arranged in front of a field glass. Ninety-four seconds of totality were at our disposal, 40 of which I planned to give to the polarization work, the remainder to sketching the corona as seen through the 4.75-inch refractor, which was provided with a low power, large field eyepiece.

THE OBSERVATIONS.

Fifteen minutes before totality I commenced to watch for the shadow bands. It was but a few minutes before I detected faint moving shadows flitting down the sheet from the upper left-hand corner in a slightly oblique direction. I at once called for the time and it was given as 12 minutes before totality, which I believe is the earliest record of the appearance of the bands. They at first bore no resemblance to bands, whatever, appearing like the shadows cast by thin clouds of smoke. Soon they became more distinct, and on watching them closely I saw that the direction of motion was not constant. Every now and then there would be a sudden change of direction as if the moving smoke clouds had been struck by a sudden puff of air. I felt certain immediately that they were produced by the unevenly heated layers in the air, having seen very similar shadows cast by an arc-light shining through hot air currents. About 3 minutes before totality the shadows grew very distinct, appearing drawn out in a direction at right angles to their direction of motion, which gave them somewhat the appearance of bands. Their distance apart varied so that it was at once apparent to me that no estimate of their width was of any scientific value whatever. There remained, of course, the possibility that the shimmering and apparent irregularity might be due to the superposition of several systems. Professor GORE, however, found no element of periodicity with the stroboscope, though the speed was varied over wide limits. Observing the Sun's rapidly disappearing crescent through the other stroboscope, which was provided with an eye-shade of plate-glass lightly smoked, I could detect no fluctuation in the brilliancy of any portion of the source of light.

At the word "Attention" I left the stroboscope and took my place at the polarizing spectroscope to watch for the flash. As I brought my eye to the eyepiece I heard Mr. HOFFMAN, who was standing beside me, say "There's the corona," and glancing over the top of the instrument I had a momentary glimpse of the white mist around the Sun. As I knew from repeated rehearsals that 10 seconds gave me ample time to get from the stroboscope to the next instrument and point it at the Sun, my first thought was that this must be a case of the appearance of the corona before totality. I accordingly fixed my eye on the spectrum, which appeared continuous save for a thin crescent of yellowish green. The word "Go" did not come, so I felt sure that I was in time for the flash. I remember that the fleeting thought passed through my mind that the yellowish crescent that was visible must be the disappearing edge of the Sun, for it appeared almost exactly like the crescent through the smoked glass of the stroboscope a moment before. I mention this to show what absolutely idiotic ideas will sometimes enter one's head during moments of excitement. Of course a moment's thought only was necessary to convince me that a luminous crescent seen under the high dispersion of the prism could only mean that second contact had occurred. The realization that something was wrong made accurate observations almost impossible, and it was not until the word "Go" was given that I could make anything like a calm study of the spectrum in the instrument. It was crossed by the oblique bands indicating fairly strong polarization, between 10 and 15 per cent, I should say, while in the yellowish green appeared the thin crescent of light of which I have already spoken. This crescent was not continuous, but appeared broken in three places. The interference bands did not cross it, however, indicating that the bright line spectrum was not polarized. The appearance of the spectrum was very different from what I had prepared myself for, namely, a faint continuous spectrum with a number of bright coronal rings strung along it. As was the case in the present instance, a preconceived erroneous idea of how a thing is to look is often troublesome. It is difficult to adjust one's self to the new conditions in the very brief time, and one has the feeling all the while that something must be wrong with the instrument.

I remained at the polarizing spectroscope until the thirty-fifth second was counted, not realizing how late the start really was, and then moved to the telescope. My eye was at once arrested by a most magnificent prominence which appeared like a double loop filament of an incandescent lamp turned down low. It was quite small at the base, and glowed with a light red color like a hot wire. There was a detached flame near its apex. I at once commenced sketching the outline of the corona, regulating the speed of the work by the counting of the seconds, as I had planned. By this time the late start had wholly passed out of my mind, and I was working away comfortably and calmly with the assurance that I had plenty of time. On putting my eye at the telescope for the third time I was startled by the sudden kindling of a white blaze around the edge of the Moon, and on looking over the instrument saw the corona melt away. The count had reached 60, if I remember rightly.

The photograph taken with the color screen was under-exposed; it showed the inner corona and traces of the bases of the polar streamers. This exposure of 40 seconds continued until a few seconds after the third contact.

REPORT OF N. ERNEST DORSEY, PH. D.

THE POLARIZATION OF THE CORONA.

When I was first informed by Prof. J. S. AMES that I was included in the Johns Hopkins party, very kindly invited by the Astronomical Director of the Naval Observatory, to take part in the observation of the total solar eclipse of May 28, 1900, it was expected that I should work alone on the polarization of the corona, and my plans were made accordingly. However, a short time before leaving Baltimore it was found that Mr. L. A. PARSONS would be able to assist in this work, so a polarimeter for eye observations was hastily constructed, and the entire charge of the cameras was intrusted to Mr. PARSONS, who carried out the program in an eminently satisfactory manner. We were assigned to the party under the direction of Prof. A. N. SKINNER, at Pinehurst, N. C.

Though many points of this most interesting characteristic of the corona are still awaiting investigation, it seemed best, owing to the short duration of totality, that a single observer should limit himself to some photographic method so as to eliminate the uncertainty inherent in eye observations taken in a hurry under very abnormal conditions. It was finally decided to investigate photographically the direction of polarization of the corona and of its bright-line spectrum if this should by any chance be polarized.

The method adopted in the first case was the very obvious one of photographing the corona through a double-image prism, as Prof. A. W. WRIGHT had done in 1878. This gives us two photographs of the corona on each plate; one has cut out of it all the light polarized along the line joining the two images and the other all that polarized at right angles to this direction. Hence, if the corona is polarized either radially or tangentially, one image will be deficient in light along the line joining the images and the other will be lacking in light along the diameter perpendicular to this direction. Which image is deficient along the line joining the centers of the two images depends upon the kind of double-image prism used and whether the polarization is radial or tangential. The camera was about 17.5 inches focus and 0.5 of an inch in aperture. The photographic plates used were CRAMER isochromatic instantaneous. The plates illustrating this article are from contact prints from lantern-slide positives enlarged about 2.5 times from the original negatives. Negative No. 1, PLATE LXXIII, was taken 30 seconds after second contact, and was given 1 second exposure; the double-image prism was then turned approximately 45°, and

Negative No. 2, PLATE LXXIV, was taken with the same exposure. Then Negative No. 3, PLATE LXXV, was given a 10-second exposure, the double-image prism brought back to its original position, and Negative No. 4, PLATE LXXVI, was taken with an exposure of 10 seconds also. The end of this exposure almost coincided with the third contact.

On inspecting the plates it will be seen that the images are lacking in light nearly along the diameters mentioned above; and a study of the double-image prism used shows that the polarization is radial. The gaps are not exactly along these diameters, but are slightly inclined toward the direction of the solar axis. This is especially pronounced in negatives No. 1 and No. 4, and is due to the natural deficiency of light at the poles, and has nothing to do with the direction of polarization. These results are in accord with those obtained by Professors WRIGHT and HARKNESS in 1878, and others. It will also be noticed that each image consists of two eccentric rings. These are caused by the dispersion of the double-image prism. One corresponds to the orange portion of the spectrum and the other to the blue and violet. Between these regions the plate is less sensitive, hence the gap between the rings, except in Negative No. 4, where the light was very bright. The prominences are seen in the blue ring only, and, since the spectra in the two images are spread in opposite directions, if the lower ring in one image contains the prominences, the upper one will contain them in the other image.

For examining the bright-line spectrum, essentially the same arrangement was adopted. In front of a camera of 17.5 inches focus and 2 inches aperture was placed a fine, large, direct vision prism train, kindly loaned me by Mr. S. V. HOFFMAN, and having an aperture of 1 by 1.5 inches. In front of this was an exceedingly fine ROCHON double-image prism, loaned by Prof. R. W. WOOD, and having a clear aperture of 2 inches. The ROCHON prism was turned until the two spectra were as widely separated as possible, and two exposures of 15 and 40 seconds, respectively, were made. The blunt end of the spectrum is the orange portion and the two cusps seen on Negative No. 6, PLATE LXXVIII, are the H_β and H_γ lines.

It will be noted that one image of the spectrum on Negative No. 5, PLATE LXXVII, has a gap extending its entire length along its median line, and the other has its edges relatively fainter than its central portion, but through the very center of this runs an exceedingly narrow gap. This last is due to the polarization at the refracting surfaces of the direct vision prism train, and can be present only if the polarization is radial. This of itself is a crucial test of the direction of the polarization. The gaps produced by the double-image prism also indicate radial polarization. The exposure of 15 seconds was too short to bring out the coronal rings except the H_β prominence ring. This is unpolarized. Negative No. 6 was given 40 seconds exposure, but before the end of this time the Sun reappeared, thus blotting out the central portion of the spectra, though not entirely obliterating the indications of polarization of the coronal spectrum. Each double-image prism was examined both before and after the eclipse, so as to avoid any uncertainty as to the direction of polarization indicated. Both cameras were mounted equatorially and driven by clockwork.

The polarimeter consisted of a telescope with an object-glass of 3.25 inches diameter and 28 inches focus, and in the focal plane was placed a biquartz 0.5 of an inch square. The eyepiece containing a NICOL prism magnified 2.5 diameters. Between the object-glass and the biquartz was a double pile of plates, similar to those described by Professor WRIGHT in the report of the eclipse of 1878, which could be tilted about an axis perpendicular to the axis of the telescope. The biquartz was adjusted so as to give the maximum contrast of color when its junction line was parallel to the plane of polarization of the incident light and the axis about which the plates tilted was placed perpendicular to the plane through this line and the optic axis of the polarimeter. As soon as the corona flashed out, the biquartz was placed on the long streamer and rotated, with the pile of plates and the eyepiece, until its coloration was most intense. Its junction line was then radial to the Sun, indicating radial polarization. The plates were then tilted until the two halves of the biquartz appeared uncolored throughout. However, after a short time the eye became accustomed to slight differences of tint and it was found that the outer, right-hand quadrant and the inner, left quadrant were pink. The quartz at a point about one-half a radius, or 8′, from the Moon's limb still appeared uncolored. Leaving everything else unchanged, the eyepiece, biquartz, and pile of plates were turned all together about a line passing through the center of the Sun and the appearance of the biquartz appeared unchanged except as affected by the variation in the intensity of the incident light. Hence we may conclude that the amount of the light polarized at 8′ from the Moon is nearly independent of the position angle of the point observed. By this time the Sun had reappeared. The position of the plates was read on an arbitrary scale, and after returning to Baltimore the instrument was calibrated by two methods giving as the mean of several observations by each method 10.7 per cent as the amount of the light polarized for this position of the plates. Professor WRIGHT, in 1878, found 11.2 per cent of the light was polarized at 7′ from the Moon's limb, so I think we may depend on this quantity as being very approximately correct.

Immediately after the eclipse it was found that tilting the glass plates colored the inner, left quadrant of the biquartz pink. Hence the above observation indicates that the polarization increases as we leave the Moon's limb. This is contrary to what was found by Professor WRIGHT, and to what has been generally inferred from the increase in the distinctness of the SAVART bands, or the coloration of the biquartz as we approach the Moon's limb. It also appears to be contradicted by our photographs, for it seems hardly possible that a difference of only 11 per cent would be so marked. I can not explain the apparent discrepancy, unless the exceedingly bright portion immediately surrounding the Moon is very strongly polarized, while at a short distance from the Moon the polarization suddenly becomes small and then increases outward. I was not expecting such a distribution and did not look for nor notice it.

The results obtained are:

(1) Indisputable evidence that the corona is polarized radially.

(2) The amount of polarization is approximately independent of the position angle, at least within a radius of the Moon's limb.

(3) The amount of polarization, i. e., the ratio of the intensity of the polarized light to the intensity of the total light, is 11 per cent at 8′ from the Moon's limb.

(4) The amount of polarization apparently increases as we leave the Moon, except perhaps at a point very near the Moon's limb, where the polarization may be very great.

The thing most to be desired now is as many as possible exact polarimetric determinations of the amount of polarization at different parts of the corona.

REPORT OF MR. L. E. JEWELL.

A DISCUSSION OF THE PINEHURST SPECTROGRAMS.

In March, 1900, I was asked by Prof. of Math. S. J. BROWN, U. S. N., the Astronomical Director of the Naval Observatory, to prepare plans for the spectroscopic work of the expedition of the United States Naval Observatory to observe the total solar eclipse of May 28, 1900, in the Southern States.

It was not until a few weeks later that conditions were such as to permit of proceeding definitely with the work, and then it was necessary to consider what instruments were available, and what other instruments could be constructed within a limited time and at comparatively small expense. The late Prof. H. A. ROWLAND kindly loaned a plane grating with a ruled space of 3½ by 5½ inches and two quartz condensing lenses. An excellent 4-inch concave grating of 10 feet radius, belonging to the Northwestern University, and a 6-inch concave grating of 21 feet radius, belonging to the University of Virginia, were also available. A large prism by BRASHEAR was loaned by the Smithsonian Institution.

Considering the instruments available and the limited time for preparation, it was decided to have ruled a 6-inch plane grating and a 6-inch concave grating of 10 feet radius, and in addition to have made by BRASHEAR a quartz condensing lens and two large quartz objectives.

It was decided to use the 6-inch concave grating of 10 feet radius, with a condensing lens and slit, at Pinehurst, N. C., on the central line, and the 4-inch concave grating of 10 feet radius, as well as the 6-inch concave grating of 21 feet radius, with quartz condensing lenses, at Griffin, Ga., near the northern limit of totality. The two plane gratings with quartz objectives were arranged as objective gratings to be used at Pinehurst and Griffin. The data at hand for the use of gratings, except in the ordinary way, were meager, and there was not time for careful experimenting, but it was felt that the chief problem to be attacked was that of securing photographs of the ultra-violet spectrum of the chromosphere. As a consequence, it was arranged to use quartz lenses with the plane gratings. The larger quartz lens belonging to the Johns Hopkins University was used for a determination of spherical aberration, and the Smithsonian Physical Tables were depended upon for values of chromatic aberration.

The objective grating spectrographs were so planned as to have the spherical aberration correct the chromatic aberration as far as possible. For the focusing of the objective grating spectrographs the arrangements did not admit of the convenient use of star spectra, as the time was too short for a satisfactory use of this plan.

It was decided to use two theodolite objectives, one as a collimating and the other as a condensing lens, with a slit at their common focus. This collimating arrangement was to be used for obtaining the focus of the objective grating spectrograph in the green and yellow, and the corrections to be applied to the other portions of the spectrum were to be determined with the large plane grating spectroscope at the Johns Hopkins University. This plan could not be carried out, however, because of the failure to send the theodolite telescopes until just before starting for Pinehurst. Consequently the entire work of fitting them up had to be done as best we could at Pinehurst, and the corrections allowed for by observing the edges of the spectrum band. This was very unsatisfactory, but was all that could be done under the circumstances.

It was thought best to use the concave gratings with quartz condensing lenses and slits, so as to determine as accurately as possible the wave-lengths of the lines in the chromospheric spectrum.

At Pinehurst it was arranged to use a very wide slit and depend upon the narrow chromospheric crescent itself for the slit, but to limit its length so as to avoid the effect of curvature of the chromospheric arc in widening the lines of the spectrum through the astigmatism of the grating. This plan was hoped to provide against a possibility of not having the chromosphere within the slit. The slit used was a reflecting slit kindly loaned by Prof. H. C. LORD.

Unfortunately this plan did not succeed, because of the failure to announce the beginning of totality, the small, direct-vision spectroscopes which I had constructed for the use of the observers at the spectrographs to guide them in making exposures not giving a well-defined flash.

The plan of using a short section of the chromosphere in lieu of a slit could not be utilized at the northern edge station at Griffin, Ga., because of the change in the inclination of the chromospheric arc during totality.

THE PLANE GRATING OBJECTIVE SPECTROGRAPH.

Of the spectrograms obtained with this instrument, in charge of Dr. W. B. HUFF, two have been found available for measurement. The first one was taken at the beginning of totality (second contact) and the other one shortly before mid-totality.

Upon both of the spectrograms measured the definition of the spectral lines is good from wave-length 3850 to 4100 and remarkably fine near the *H* and *K* lines. The definition is fair from 3750 to 3850 in the ultra-violet and from 4100 to 4200 in the violet, but very poor at wave-lengths less than 3700 and greater than 4200, though better again beyond wave-length 5000 in the green.

TABLE I containing the results of a study of the spectrogram taken at the beginning of totality (second contact) is divided into two parts, the first giving the data derived from the spectrogram itself, the second that referring to the lines of various metallic and gaseous spectra which coincide in wave-length with the lines in the spectrogram. The first part is headed *Lines of the Chromospheric Spectrum*, and the second *Coincident Lines*.

The first column, headed *Notes*, contains references and comments. The second column gives some of the characteristics of the lines; *N* indicating that a line is hazy or nebulous; *d* that the line is probably double; braces that two or more lines are very close to or merged into each other; –1–, –2–, –?– that there is probably one line, two lines, or an uncertain indication of lines, between the lines whose positions are given. The third column, headed *C*, gives the relative brilliancy of that portion of a chromospheric arc, or spectral line, near the middle, where the lower portions of the chromosphere nearest to the photosphere, or surface of the Sun, are uncovered. There is more or less continuous spectrum in this region, and also in those portions of the chromospheric arcs where indentations in the Moon's edge uncover the lower parts of the chromosphere. The unevenness of the Moon's limb causes continuous spectrum streaks to appear near the middle of the chromospheric arcs in a spectrogram taken at the instant of the beginning of totality. The fourth column, headed *S*, gives the relative brilliancy of those portions of the chromospheric arcs in the spaces between the streaks of continuous spectrum, or toward the outer portions of the arcs outside of the continuous spectrum streaks. The degree of brightness is represented by numbers from 1 to 10, except for very faint lines which are represented by 0 or 00. The fifth column gives the lengths of the chromospheric arcs in degrees. The estimated length for the shorter arcs gives the extension into the spaces, the appearance of a given line in a spectrum streak due to prominences not being considered to be an extension of the arc as far as this unless the line in question can be traced across the intervening space. The sixth column gives the intensity of a line as a whole, both the length of the arc and its brilliancy being taken into consideration. The intensities range from 1 to 50 or more, but where very weak they are represented by 0, 00, or 000, the last-named intensity representing the limit of visibility. The seventh column contains the computed wave-lengths of the lines. Where the definition is poor the derived wave-lengths of the lines are necessarily uncertain to a considerable extent, and even where the definition is good the wave-lengths are more or less uncertain, depending upon the character of the line or distribution of the matter producing the chromospheric arcs measured, upon the character of the lines that were taken as standards in the computations, and upon whether or not the inside edge of the wider arcs was the part measured. The lines due to substances reaching a considerable elevation do not give the same results as lines due to substances confined to the lower levels of the chromosphere immediately above the photosphere, or more correctly those lines which are only rendered visible by substances close to the chromosphere. The eighth column gives the probable or possible origin of the chromospheric spectral line, the elements being represented by their ordinary symbols. In the case of the hydrogen lines the Greek letters by which these lines are generally known are given, and in the case of the helium (He) and parhelium (pHe) lines the designations given by RUNGE and PASCHEN in WATTS'S Index of Spectra, Appendix G, pages 69–70. Where several elements have lines approximately coinciding with the chromospheric line, but where one element is wholly or for the greater part responsible for the chromospheric line, the symbol for that element is given in italics. The ninth, tenth, and eleventh columns give, respectively, the intensities of the coincident lines in the spectra of the spark, arc, and Sun. Where the element is usually a gas its intensity in the vacuum tube is given under the heading *Spark.* The intensities given for the spark spectrum are usually those from EXNER and HASCHEK'S tables, but are modified where other data were available. The intensities for the arc spectrum are partly from material available at the physical laboratory of the Johns Hopkins University and partly from the tables of EXNER and HASCHEK or other sources. The intensities in the solar spectrum are from ROWLAND'S Preliminary Table of Solar Spectrum Wave-lengths, as are also the wave-lengths except where given in parentheses, in which case they are taken from other sources. In some cases the data derived from ROWLAND'S tables have been corrected.

TABLE I.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
Beginning of spectrum.				0		3332.					
					0	3349.3	Ti	8	3	7	3349.173
							Ti	10	8	12	3349.558
				30±	3	3360.8	Cr	20	3	1	3360.485
							Ti	30	10	12	3361.327
				20±	1	3368.8	Cr	20	5	5	3368.193
							Ti?	20	10	12	3372.948
				27±	1½	3379.3	Cr	5	3	5	3379.961
							Ti	15	7	6	3380.424
							Ni	10	9	6	3380.722
					3	3384.6	Ti	20	10	12	3383.892
					00	3387.7	Ti	10	5	5	3387.988
					1	3394.8	Ti	10	5	5	3394.716
					00	3411.2	Cr?	20	3	3	3408.911
				17±	1—	3423.7	Cr	10	3	4	3421.353
							Cr	10	4	4	3422.892
					000	3426.1					
					000	3430.1					
					00	3433.9	*Cr*	10	3	3	3433.453
							Ni	15	9	8	3433.715
						3442.0	Mn	40	7	6	3442.118
Three markings, may all be one line.				30±	3	3444.5	Ti	10	5	4	3444.467
						3448.2	Ni?	10	15	15	3446.406
						3460.0	Mn	40	3	4	3460.460
Markings may all be one line.				30±	3	3462.4	*Ti*	10	5	5	3461.633
							Ni	10	20	10	3461.801
						3466.2	Co?	5	7	4	3465.900
							Fe?	3	10	6	3466.015
							He †17?	1			(3466.04)
				30±	3	3477.2	Fe	3	7	8	3476.849
							Ti	10	5	5	3477.323
				30±	3	3482.9	Mn	30	3	5	3483.047
				25±	1	3490.1	*Mn*	30	3	4	3488.817
							Fe	4	10	10	3490.733
							Ti	·5	5	5	3491.195
							Mn	20	2	2	3495.974
				30±	3	3496.6	Mn	10	1	3	3496.952
					1½	3511.3	Mn	20	2	3	3497.668
							Ni	10	8	8	3510.466
							Ti	30	5	5	3510.985
					1—	3513.7	Co?	4	5	5	3513.623
							Fe?	3	8	7	3513.965
					1—	3525.5	Ni	15	30	20	3524.677
							Co?	6	6	6	3526.988

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Inten-sity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				o							
	-I-				2	3536.0	Ti	15	4	4	3535.554
					0	3549.7	Y	20	7	2	3549.151
					000	3558.2	Fe	4	9	8	3558.672
					1	3565.5	Fe	5	15	20	3565.535
					00	3576.0	Sc	30	20	3	3576.527
				25±	1	3581.3	Cr?	20	30	10	3578.832
							Fe	10	30	30	3581.349
					000	3587.0	Al?	100		0	3587.024
							Fe	3	8	8	3587.130
							Co	10	10	7	3587.370
							He$_{\dagger 9}$	2			(3587.426)
					000	3592.9	Cr	10	30	9	3593.636
				25±	1	3596.3	Ti	5	3	4	3596.195
				25±	1½	3605.2	Cr?	10	0	3	3603.922
							Cr	20	20	7	3605.479
					2	3614.4	pHe$_{*5}$?	3			(3613.785)
							Sc	100	4	4	3613.947
					1	3619.2	Fe	6	20	20	3618.919
							Ni	15	20	8	3619.539
					00	3622.4	Fe	3	4	6	3621.612
							Fe	3	4	6	3622.147
					1	3625.0	Ti	8	5	5	3624.979
					0	3628.5	Y	10	7	2	3628.847
					5	3631.8	*Sc*	100	3	4	3630.876
							Fe	6	20	20	3631.605
							Cr	10	?	0	3631.725
						3634.8	Y	30	4	2	3633.277
							He$_{\dagger 8}$	2			(3634.393)
					2	3642.9	Ti?	10	4	7	3641.473
							Ti	5	10	4	3642.820
							Sc	50	3	2	3642.912
					2	3645.5	Ca ?	4	5	5	3644.555
							Sc	15	1	3	3645.475
					1	3648.2	Fe	15	12	12	3647.988
							Sc	20	1	4	3651.940
					000	3660.3	Ti	10	4	5	3659.901
					000	3664.9	Y	20	8	2	3664.760
							H				(3664.74)
					00	3670.2	H_ψ				(3669.55)
							H_χ				(3671.53)
					00	3674.4	H_φ				(3673.87)
	d ?				0	3676.9	H_υ				(3676.51)
					1	3679.9	H_τ				(3679.52)
							Fe?	3	10	9	3680.069
					0	3682.6	H_σ				(3682.94)
				90±	10	3685.2	Ti	50	8	10	3685.339
Badly blurred.					8	3686.6	H_ρ				(3686.96)
(May be false)					8	3688.1					
(May be false)					3	3689.4					
Badly blurred.				75±	5	3691.7	H_π				(3691.70)
				60±	4	3694.4	Yb	200	10	3	3694.344
		3	2	60±	8	3697.8	H_o				(3697.28)
Probably false line.					6	3699.9					
		3	2	60±	7	3703.8	H_ξ				(3704.01)
		4	3	60±	10	3706.3	He$_{\dagger 7}$?	3			(3705.15)
							Ca	50	2	6	3706.175
							Ti	8	5	3	3706.363
					1	3710.3	Y	100	7	3	3710.431
		5	4	65±	12	3712.6	H_ν				(3712.13)
May be false line.					3	3713.7	Cr ?	6	2	3	3713.087
					2	3720.0	Fe	10	50	40	3720.084
		5	4	70±	12	3722.1	H_μ				(3721.98)
May partly be false line.					8	3724.1	Ti ?	2		1	3724.233
							Fe?	2	3	6	3724.526
							Ti ?	3	4	1	3724.716

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				°							
				45±	3	3728.5	Fe	5	6	5	3727.778
					0	3730.0	Ti	8	7	3	3729.952
		6	5	70±	13	3734.3	H_λ				(3734.53)
							Fe ?	10	40	40	3735.014
		5	4	60±	10	3736.8	*Ca*	50	3	5	3737.059
							Fe	7	30	30	3737.281
					1	3739.0					
May be only one line.					2	3741.7	Ti	2	7	4	3741.205
							Ti	10	4	4	3741.791
					2	3743.4	Fe	6	10	6	3743.508
All faint lines, uncertain thus far and measurements of little value, but better beyond.				30±	3	3745.9	Co ?	10	8	2	3745.491
							Fe	5	8	8	3745.717
							Fe	4	7	6	3746.058
					0	3748.2	Ti	6	4	1	3748.144
							Fe	4	12	10	3748.408
		6	5	75±	15	3750.5	H_κ				(3750.27)
					0	3754.8	Cr ?	2		1	3754.719
					0	3757.7	Ti	6	5	4	3757.824
							Fe	8	15	15	3758.375
		6	5	85	20	3759.9	Ti	35	7	10	3759.447
		6	5	85	25	3761.9	Ti	30	7	8	3761.464
					0	3768.0	*Fe*	5	10	8	3767.341
							Gd ?	20	20	0	3768.544
		6	5	80	18	3770.7	H_ι				(3770.73)
				25±	1	3775.7	*Y*	100	5	3	3774.473
							Ni	5	4	7	3775.717
					0	3783.4	Ni	5	6	6	3783.674
Very nebulous.	d ?			25±	3	3789.1	Fe	4	8	9	3788.046
							Y	30	5	2	3788.839
		7	6	80	20	3797.9	H_θ				(3798.00)
					000	3803.0					
				22±	0	3806.5	Fe	2	6	8 d ?	3806.865
							Mn	15	8		
							Ni	7	5	6	3807.293
				18±	00	3808.3	Fe	1	2	3	3808.873
							Mn ?	6	5	4	3809.724
				25±	0	3813.3	Fe	4	5	5	3813.100
							Ti	4	1	2	3813.537
				35	1	3816.0	Fe	10	20	15	3815.987
		4	3	50	3	3820.5	He†6	4			(3819.75)
							Fe	12	30	25	3820.586
		3	1	20	1	3824.8	Fe	5	8	6	3824.591
		3	1	25	2	3826.0	Fe	8	20	20	3826.027
Fair definition beyond this.		3	1	45	2	3829.6	Mg	200	30	10	3829.501
		5	4	65	5	3832.5	*Mg*	300	50	15	3832.450
							Y ?	20	2	3	3833.026
		8	7	85	30	3835.6	H_η				(3835.51)
		5	4	70	8	3838.4	Mg	500	100	25	3838.435
		1	1	20	0	3841.0	Fe	4	10	8	3840.580
							Fe	5	10	10	3841.195
							Mn	6	8		
							Cr	3		1	3841.420
		0		3	000	3843.2	C			3	3843.127
							Fe, C		1	2	3843.195
							Fe	2	3	4	3843.404
		2		4	00	3847.8	V ?	10	3	00	3847.477
							C ?			1	3847.961
							C ?			1	3848.006
Nebulous line.		1	1	13	0	3850.5	Cr	2	2	1	3849.675
							Ni ?	2			
							Fe	4	8	10	3850.118

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
				o				Spark.	Arc.	Sun.	
		2		3	00	3851.4	C ?			2 N d?	3851.427
		3		4	0	3854.4	C			2 N d?	3854.707
							C (4th head)			1	3854.989
		3	2	30	2	3856.7	Fe	6	8	8	3856.524
		0		3	000	3858.4	Ni	8	20	7	3858.442
		4	3	55	5	3860.1	Fe	9	20	20	3860.055
		2	0	10	0—	3861.6	Co	10	6	4	3861.299
							C (3d head)			1 N	3861.978
		0		3	000	3865.5	Fe	4	7	7	3865.674
		1		4	00	3867.7	Fe ?	2	2	3	3867.356
							Fe ?	1		2	3868.060
		4	1	15	2	3871.4	C (2d head)			2 d ?	3871.527
		2	1	12	0+	3873.8	Co ?	15	10	2	3873.224
							Co ?	15	8	4	3874.091
		2		3	000	3876.8	Co ?	5	5	4	3876.981
		4	3	30	3	3878.7	Fe	4	8	8	3878.152
							Fe	5	8	7	3878.720
	–1–						V ?	10		2	3878.884
		3		5	00	3881.3	Cr ?			0	3881.346
							C ?			2	3881.445
							C ?			1	3881.543
		5	2	18	3—	3883.2	C			2	3883.426
							Cr			1	3883.533
							C (1st head)				
		0		5	000	3884.8	Ca ?			1	3884.748
							Fe ?			1	3884.812
Very narrow line.		4	3	40	2	3886.45	*Fe*	8	15	15	3886.434
							Cr ?	3	3	3	3886.942
Not separated, but darker and more uneven on side toward the red.		9	7	90	40	3888.95	He*3	10			(3888.79)
							Hζ				(3889.15)
		1		5	0—	3889.64	Ni ?	2	2	2	3889.810
		0		4	00	3892.14	Fe	1		4	3892.069
							Ba	500	20	0	3892.450
	{	1		5	0—	3893.45	Fe	2	3	4	3893.542
		0		4	00	3894.06	Cr	3	3	3	3894.165
							Co	30	10	5	3894.241
		2	1	28	1	3895.80	Fe	4	7	7	3895.803
		0		3	00	3896.36	Er ?	6	15	?	(3896.42)
		0	0	18	00	3897.99	Fe	1	1	2	3897.596
							Fe	2	2	3	3898.032
		1	1	23	0	3899.82	V ?	5		2	3899.277
							Fe	4	8	8	3899.850
		7	5	60	4	3900.73	Ti	25	6	5	3900.681
		0	00	6	00	3902.04					
	{	1	1	20	0	3903.27	Fe	6	10	10	3903.090
							Cr	3	3		
							V ?	5		2	3903.398
		00		3	000	3903.64	Fe ?	1	1	5	3904.052
		1	0	15	0	3905.47	Ti	4	8	3	3904.926
							Si	5	15	12	3905.660
							Cr	2		2	3905.816
		0	00	7	00	3906.35	Er ?	10	20	000	3906.539
							Fe	2	5	8	3906.628
		2		4	0	3907.18	Fe			3 d ?	3907.615
	–1–?						Sc	6	3		
		1	00	6	0	3908.63	Cr	3	4	4	3908.900

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				0			Fe		1	4	3909.802
		0—		5	00	3909.88	Fe	1	1	5	3909.976
							Ca ?			3 d ?	3910.079
							Ba ?	10	5		
		0—		5	000	3911.35	Fe	1	1	4	3910.984
							Sc	6	4	2	3911.963
		0—	00	6	00	3912.52	Ni ?		1	2	3912.445
		7	5	50	5	3913.59	Ti	20	6	5	3913.609
		0	0—	10	0	3914.66	V ?	8		2	3914.477
							Ti		5		
	d?	1	0—	10	0	3916.12	Cr	1	3	5 d ?	3915.951
							Cr	2	3	2	3916.383
		00	00+	8	00	3917.10	V ?	8		3	3916.545
							Fe	2	2	5	3916.879
							Co	4	4	2	3917.264
							Fe	2	3	5	3917.324
		0	0	9	00+	3918.48	Fe	1	1	4	3918.464
							Fe	1	1	4	3918.563
							Fe	1	2	5	3918.789
		00		4±	00—	3919.10	Fe	1	1	3	3919.208
							Cr	1	3	3	3919.309
		1—	1—	20	1	3920.44	Fe	4	8	10	3920.410
		0	0—	8	00	3921.52	Cr	3	5	3	3921.188
							Ti	2	5	1	3921.563
							Mn	2	4	4	3921.855
		1	1—	18	1+	3923.05	Fe	4	10	12	3923.054
		00		4	00	3924.71	Ti	3	6	4	3924.673
		0—	0—	15	00+	3925.97	Fe	1	2	5	3925.790
							Fe	1	2	4	3926.086
							Mn	4	7	2	3926.597
							pHe$_{\dagger 8}$	1			(3926.68)
		1	1	20	1	3927.98	Fe	5	15	10	3928.075
		1—	1—	90±	1+	3928.18	Ghost of K				
		00		4±	00	3929.02	Cr	3	5	3	3928.783
		1 —	0+	20	0	3930.48	Ti	3	5	2	3930.022
							Fe	5	12	10	3930.450
K		10	8	120	60	3933.50	Ca	1000	100	1000	3933.825
		000	00	30±	00	3935.6±	pHe$_{\S 8}$	1			(3936.06)
		00		4	00	3937.06	Fe	1	1	3	3937.479
Probably another line coincident.		1+	1—	95±	2—	3938.49	Ghost of K				
		00		2±	000	3940.26	Fe ?			2	3940.183
		00		2±	000	3941.64	Cr	3	5	3	3941.637
		00		4	0	3942.54	Fe	1	2	3	3942.586
		2	1	37	2	3944.06	Al	50	800	15	3944.160
Probably a group.	d ?	0	0—	17	0+	3945.18	Fe ?			2	3944.884
							Fe	1	1	3	3945.033
							Fe	1	1	3	3945.260
							Co	5	4	3	3945.473
		00		2±	00	3946.49					
		00		5±	00	3948.11	Ti	2	5	2	3947:918
							Fe	1	2	5	3948.246
		1	0	14	0+	3948.99	Fe	2	2	4	3948.925
							Ti	4	7	4	3948.818
							Ca	1	8	1	3949.039
							La ?	50	20	1	3949.199
		1	1	16	1--	3950.38	Y	20	5	2	3950.497
		00		5±	000	3951.07	Fe	2	2	5	3951.311

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				0							
		1	0—	10	0—	3952.04	Mn	2	1	2	3952.103
							V ?	15	0		
		1—	0—	10	0—	3952.74	Fe		1	4	3952.754
							Fe	1	2	3	3952.850
							Mn ?	3	5	3	3953.043
							Co ?	6	7	3	3953.120
		0		5	00	3953.49	Fe	1	1	3	3953.303
							Cr	1	1		
Very weak in middle, strong in outer portions. May be line of inner corona.		000	0	60	00+	3954.95					
		00		1	000	3955.72	Fe		1	5	3955.482
							Ti	4	8	4	3956.476
	d	1	1	15	0+	3956.64	Fe	2	3	5	3956.603
							Fe	3	5	6	3956.819
							Ca	2	10	7 d ?	3957.177
	-1-	2	1+	15	1+	3958.38	Ti	5	10	5	3958.355
		00		6	00	3959.81	Fe ?			4	3960.422
		3	2—	40	3	3961.62	Al	100	1000	20	3961.674
		00	0—	80±	1—	3962.58	Ghost of H				
							Ti	2	4	3	3962.995
		0		6	000	3963.14	Fe	1	1	3	3963.252
							Cr ?	8	6	3	3963.831
		0+		6	00	3964.94	Ti	2	5	2	3964.416
		000	00	15	000	3964.94±	pHe$_{*4}$	4			(3964.88)
H		10	8	120	50	3968.20	Ca	500	80	700	3968.625
		9	7	90	30	3970.01	H$_{\epsilon}$			5 N	3970.177
		00		4	00	3972.02	En ?	50	50	0 ?	3972.134
							Ni ?	1	2	2	3972.313
							Ghost of H				
Possibly a small line coincident.		1+	1	90	1—	3973.54	V ?	10		2	3973.864
							Ca	2	10		
							Fe			6	3974.904
	d ?	00		3	00	3975.35	Co	4	4		
							Fe			2	3975.350
		0		8	00+	3976.66	Cr	8	6	3	3976.839
		00		1	000	3977.51	Fe	2	3	6	3977.891
		00		8±	00	3978.40	Fe			2	3978.604
							Cr			3	3978.809
		00		8±	00	3979.37	Co			4	3979.664
							Fe			3	3979.783
		00		2±	000	3980.76	Fe ?			1	3980.779
	d	2	1	15	1—	3981.87	Ti	4	9	4	3981.917
		2	1	15	1—	3982.70	Ti	2	4	2	3982.630
							Y	20	6	3	3982.742
		0—	0—	8	00	3983.81	Cr	5	5	3	3984.059
							Fe	2	2	4	3984.113
Coronal line absent in middle, strong outside in places.		00	0	105±	00+	3986.17					
		00		4	000	3987.00	?				3986.903
							Mn	4	4	1	3986.979
							Mn	4	4	3	3987.244
		00		4	000	3987.42	Co	3	3	1	3987.332
							Ti	1	1	2	3987.755
		0—		6	00	3988.73	Yb	15	10	0	3988.114
							La	30	15	1	3988.659
		1	00	10	0	3990.10	Ti	6	8	4	3989.912
		0+	0	10	0—	3991.30	Cr	4	4	3	3991.333
		0—	00	8	00	3991.86	Co	8	2	2	3991.830
							Cr	2	3		
		0—	00	8	00	3994.28	Ba?	20	10	00	3993.616
							Fe	1	1	4	3994.265
		0+	0—	10	00+	3995.76	Co	20	10	5	3995.463
							Fe?	1	1	3	3996.140

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				o							
		0	0	12	00	3997.13	Sc	2	15	00	3996.752
							V?	8		1	3997.258
		0	00	12	00—	3997.82	Fe	3	4	4	3997.547
							Co	10	9	4d?	3998.053
							Fe	2	2	4	3998.205
		1+	0—	13	0	3998.93	Ti	6	10	4	3998.790
		0	00	7	00	4000.39	Fe?			2	4000.403
							Fe?	1	1	2	4000.611
		0	00	7	00—	4001.50	Cr?			1	4001.595
							Fe?	1	1	3	4001.814
		00		5	000	4002.82	Ti	2	2	0	4002.652
							Cr?	2		00	4003.424
		00		5	000	4004.35	Ti	2	2	3	4003.912
Broad.	d ?	2	1	15	2	4005.35	Fe	7	10	8	4005.408
							V	20		3	4005.856
		0		5	00+	4007.12	Fe?	1	1	3	4007.429
		0		6	00	4008.92	Ti	4	6	3	4009.079
		0	00	15±	000	4009.90	pHe$_{\dagger 7}$	1			(4009.42)
							Ti ?	2	4	1	4009.807
							Fe ?	2	2	3	4009.864
		00		4	000	4011.28	Fe ?			2	4010.927
							Fe			2	4011.080
							Fe			3	4011.561
		3	2	18	2	4012.57	Ti	3	2	4	4012.541
		0	00	6	00+	4014.68	Sc	8		5d?	4014.677
							Fe	2	2		
		00		3	000	4015.72	?			3	4015.760
		00		5	00	4016.97	Fe?			2	4016.574
							Fe?			4	4017.308
		0		5	00+	4018.22	Ti ?	2	4	0	4017.925
							Mn	8	10	3	4018.234
							Mn			4	4018.269
		0	00	6	00	4020.58	Sc	8	4	1	4020.547
		1—	0—	9	0	4021.83	Ti?	2	4	0	4021.893
		0	00	7	00+	4023.49	Co	3	3	3	4023.533
							V ?	20			
							Sc	8	3	2	4023.834
		1	0	30±	0+	4025.02	pHe$_{\ddagger 7}$				(4024.14)
							Ti	3	10	3	
							Ti	2	2	3	
	-1-	1+	1	70	5	4026.35	He$_{\dagger 5}$	5			(4026.34)
							Ti	2	5	1	4026.691
							Mn	4	5	2	4026.583
		0	00	13	0—	4028.10	Ti	5	1	4	4028.497
		00	00	7	00	4029.78	Fe	1	1	5	4029.796
		1+	1—	20	1+	4030.81	Sr ?	5	6	0	4030.497
							Ti ?	2	8	5	4030.646
							Fe ?				
							Mn	20	30	12	4030.918
		0	00	7	00—	4031.60	Mn ?	3	2	2	4031.942
							La ?	20	5	2	4031.865
							Fe				
		1	1—	20	1	4033.20	Mn	20	25	10	4033.224
		1—	0+	15	0+	4034.55	Mn	10	20	8	4034.644
		0—		4	0	4035.80	V ?	20		4d?	4035.883
							Mn	8	5		
							Ti ?	2	3	00	4035.976
		00		2	000	4037.85					
		00		2	000	4040.01	Y ?			00	4040.013
							Fe ?			1	4040.093
							Fe ?			2	4040.243
		1	0+	10	0	4040.83	Fe	1	1	3	4040.792
							Fe	1		3	4041.431
							Mn	10	20	5	4041.525

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				°							
		0	00	7	00	4043.05	La?	20	5	0	4043.054
		0	00	7	00	4044.72	K?	20	200	0	4044.294
							Fe	1	1	3	4044.766
		3	2	25	3	4045.85	Co	5	8	5	4045.538
							Fe	15	25	30	4045.975
		0—		6	00+	4048.88	Sc?	2		0 N	4047.823
							Mn	7	7	5	4048.910
		00		2	000	4049.98	Fe?			2	4049.482
		00		2	000	4052.20	Fe			2	4052.070
							Fe			2	4052.454
							Mn	3	3	2	4052.603
		0		7	00+	4053.80	Fe			3	4053.981
							Ti	5			
		0—		8	00	4055.40	Fe	1	1	3	4055.023
							Ti	3	4	3	4055.189
							Mn	8	8	6	4055.701
	Nd?	00		6	00	4058.04	Pb?	300	1000	000	4057.961
							Co	3	4	4	4058.372
							Fe	1	1		
		00		4	000	4059.01	Fe		1	3	4058.915
							Cr	3	3		
							Mn	6	4	3	4059.081
		00		4	000	4061.44	Ti	3	5	1	4060.415
							Nd?	10	10	3	4061.244
							Mn	3	4	2	4061.881
		00		5	000	4062.76	Fe	2	2	5	4062.599
		2	1	18	1+	4063.75	Fe		1	4	4063.436
							Mn	6	5	0	4063.573
							Fe	12	18	20	4063.759
	-1-?	0	00	10	0—	4066.85	Co	5	7	2	4066.524
							Fe		1	2	4066.742
							Fe	1	0	5	4067.139
							Ni	3	2		
		0		5	000	4069.14					
		2	1	18	1—	4071.80	Fe	10	15	15	4071.908
		00		8±	00	4073.44	Fe?	1	1	4	4073.921
May be false line.		1	1	35	1	4076.35	Fe?			3	4076.101
							Cr?	4	2	00	4076.201
							Fe?	2	3	4	4076.792
		6	4	67	12	4077.74	Sr	1000	10	8	4077.885
End of sharp focus.		0		4	00	4080.95	Fe	1	1	3	4080.368
							Fe			2	4081.033
		0		5	00	4082.04	Fe			2	4082.264
							Sc	3	1	3	4082.589
							Fe				
							Ti	3	5		
		0		5	00	4083.35	Mn	6	5	4	4083.095
							Mn	8	5	4	4083.783
		0		4	00	4084.80	Fe	1	2	5	4084.647
							Fe	1	1	4	4085.161
		1	00	7	0	4087.68	Fe		1	3	4087.252
		00		3	000	4088.84	Fe			3	4088.713
							Si?	2			(4089.1)
							Fe			3	4089.374
		0		5	00	4090.36	Fe			2	4090.228
							V?	10	8	1	4090.728
		0		4	00	4092.72	Co	10	9	3	4092.547
							V?	3	15	3 d?	4092.821
							Ca	1	4		
	Nd?	00			000	4096.40	Fe	1		3	4096.129
							Fe			2	4096.262
							Si?				(4096.9)
		8	6	85	35	4101.18	Hδ				4102.000

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				°							
		00		4	00—	4104.79	Fe	1	1	5	4104.288
							Cr?	2		1	4105.099
		0	00	8	00+	4107.43	Fe	2	3	5	4107.649
	d?	1	00	8	0—	4109.74	V?	10	9	2	4109.905
							Fe	2	3	3	4109.953
							Co?	10	8	4	4110.691
		1		8	0—	4118.33	Fe	3	5	5	4118.708
							Co	20	9	4	4118.934
	d?	2		8	0	4123.23	La	30	10	1	4123.384
							Fe	1	1	5	4123.907
		1		8	0—	4127.94	Fe	1	2	4	4127.767
							Fe	1	1	4	4127.957
							V?	10		6 d?	4128.251
		1		8	0	4129.82	Eu?	100	100	1	4129.882
							Fe			2	4130.196
							Ba	800	8	2	4130.804
		00			000	4132.53	Fe	6	8	10	4132.235
		0		7±	00—	4134.05	Ce	10	8	0	4133.965
							Fe		1	3	4134.010
							V?	10	10	3	4134.589
							Fe?		1		
		1		5±	00+	4137.52	Fe		2	6	4137.156
		0		5±	00	4141.27					
		2	1—	20	1—	4143.22	Fe	3	5	4	4143.572
							pHe$_{16}$	2			(4143.92)
							Fe	7	10	10	4144.038
		1	0	10	0+	4149.38	Fe	1	1	4	4149.533
		0	00	4	00	4151.79	Ti	3	3	1	4151.129
		0	00	8	0—	4154.51	Fe	2	4	4	4154.071
							Fe			2	4154.265
							Fe	2	4	4	4154.667
							Fe	2	3	4	4154.976
		0	00	8	0	4156.25	Fe?	2	4	3 d?	4156.970
					000	4160.85					
		0	00	8	0—	4161.52	*Ti*	3		4	4161.682
							Sr	50	6	1	4161.961
		0	00	8	0—	4163.74	Cr	4	2	4	4163.818
							Ti	20	2		
		0	00	8	00+	4165.87	Fe?			3 d?	4165.550
							Ce?	10	4	1	4165.759
							Ba	100	4	0	4166.161
		0	00	8	00+	4167.42	?			8	4167.438
							Y?	4	3	1 d?	4167.737
					000	4170.54					
		1	0	15	0+	4172.11	Ti	15	1	2	4172.066
		1	0	15	0+	4173.68	Ti	3		3	4173.710
					00—	4176.37	Fe	2	3	5	4175.806
							Fe	1	2	5	4176.739
							Mn	4	3		
		2	0	18	0+	4177.75	Y	50	5	3	4177.698
							Fe	1	2	3	4177.772
		1	0	15	0—	4179.14	Fe	2	1	3	4179.025
		00		7	00—	4181.08	C?			2 N	4180.970
							Fe	4	4	5	4181.919
		00		7	00—	4183.74	V?	10	0	2	4183.619
							Ti	2		2	4184.472
							Yb?	10	2		
		0	00	8	00+	4187.47	Fe	4	5	6	4187.204
							Fe			2	4187.747
							Fe	4	4	5	4187.943
		0	00	6	00—	4191.25	Fe	4	4	6	4191.595
							Fe		1	3	4191.843

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				°							
		1	0	10	00+	4196.07	Fe	2	2	5	4195.492
							Fe		1	2	4195.785
							Fe	1	1	4	4196.372
		1	0	10	00+	4198.71	Fe			3	4198.402
							Fe	3	5	4	4198.494
							Fe		1	3	4198.800
							Fe	6	5	5	4199.267
		0	0	10	00	4202.11	*Fe*	6	10	8	4202.198
							V ?	8		0 d ?	4202.514
		1	0	10	00+	4205.09	Eu ?	50	100	1	4205.186
							V ?	10		1	4205.239
					?	4207.59	Fe	1	1	3	4207.291
							Fe, C			1	4207.566
		0	00	8	00—	4208.97	Fe	1	1	3	4208.766
							Zr	20	4	1	4209.144
							V ?	8	3	1	4209.985
					000	4212.16	Zr ?	5	3	2	4212.048
							Cr	1	2	3	4212.801
		6	4	55	10	4214.86	Sr	500	10	5 d ?	4215.703
					000	4217.57	Fe	1	2	5 d ?	4217.720
							Cr	2	2		
					000	4219.94	Fe	3	3	4	4219.516
					00	4222.44	Fe	2	4	5	4222.382
g		3	2	35	6	4226.92	Ca	100	75	20	4226.904
					000	4230.21	Fe		1	2	4229.677
							Fe		1	3	4229.926
		00	0	15	00	4231.6	Ni	1	2	4 N	4231.183
							Sc ?	1	1	1	4232.111
		2	1	18	3	4233.23	*Fe*	3	1	4	4233.328
							Fe	3	4	6	4233.772
		1	0	12	0—	4235.90	Mn	20	10	2	4235.298
							Mn		10	3	4235.450
							Fe	5	6	8	4236.112
					00—	4238.53	Fe ?	2	3	5	4238.970
					00—	4242.56	Mn	3		0	4242.443
							Cr	5	1	2	4242.535
Blurred with following line.					00+	4245.61	Fe	1	2	4	4245.422
							Pb ?	500			
Strongest line in spectrum of scandium.		4	2	40	7	4246.93	Sc	100	10	5	4246.996
					000	4248.53	Fe ?	1	1	2	4248.384
		0	00	7±	00—	4250.49	Fe	4	8	8	4250.287
							Fe	6	10	8	4250.945
					000	4253.11					
		2	1	25	2	4254.54	Cr	50	50	8	4254.505
					000	4256.1	Fe ?			2	4255.993
		0	00	10	00+	4258.5	Fe		1	2	4258.477
							Fe		1	2	4258.774
							Fe		1	2	4259.113
		0	00	10	00+	4260.6	Fe	10	15	10	4260.640
					000	4264.1	Ti ?	4	8	2	4263.290
							Cr ?	3	3		
							Fe		1	3	4264.370
	d ?	1	0	18	0+	4271.4	Fe	4	8	6	4271.325
							Fe	10	15	15	4271.934
		1	0	20	1—	4275.1	Ti	4	15	2	4274.746
							Cr	30	50	7	4274.958
					000	4278.8	Fe		1	3	4278.390
							Ti	2	3		
							Ti	1	2	1	4279.009
					00—	4280.7	Mn ?	5	10	2	4281.257
					00—	4282.3	Fe	3	6	5	4282.565
					00—	4284.2	Cr	2		2	4284.382
					000	4286.4	Ti	4	10	2	4286.168

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
May be false line from following line being out of focus, probably partly so.		1	0	18	0+	4287.8	Ti	4	10	1	4287.566
							Ti	2	1	2	4288.038
		3	2	20	1+	4290.1	Ca ?	20	4	4	4289.525
							Cr	30	30	5	4289.885
							Ti	10	5	2	4290.377
					000	4291.4	Ti	2	3	3	4291.114
							Ti	2	3	2	4291.276
		1	0	15	0+	4294.2	Ti	10	5	2	4294.204
							Fe	4	6	5	4294.301
					000	4296.4	Ti	4	10	2	4295.914
							Cr	2	1		
							Fe			3	4296.735
		3	2	20	1	4300.2	Ti	20	5	3	4300.211
		1	0	15	00	4302.1	Ti	5	2	2	4302.085
							Ca	50	6	4	4302.692
		1	0	15	00	4303.1	Fe	1		2	4303.337
		1	0	17	00+	4306.0	Sr ?	100	6	3	4305.614
							Sc	6	2	1	4306.006
							Ti	8	15	4	4306.078
G	d ?	3	2	25	1	4308.1	Ca	20	3	3	4307.907
							Fe	15	8	6	4308.081
		0		5	00	4309.6	Fe	1	2	3	4309.541
							Y	20	6	1	4309.792
					000	4311.3	Ti ?	1	2	2	4311.880
		1	0	10	0	4312.8	Ti	8	2	3	4313.034
		1	0	12	0	4314.6	Sc	30	3	3	4314.248
							Ti	3	5	1	4314.964
							Ti	5	4	3	4315.138
							Fe	3	6	4	4315.262
		0		4	00	4317.3	Ti	2		1	4316.962
		0	00	8	000	4318.9	Ti	3	10	4	4318.817
							Ca	30	4		
		2	0	15	0+	4321.0	Sc	20	3	3	4320.907
							Ti	3	1	2	4321.119
		1	00	6	00	4323.0					
		2	1	20	1−	4325.6	Sc	20	3	4	4325.152
							Ti	3	8	1	4325.306
							Fe	15	7	8	4325.939
		0		4	00−	4330.6	Ti	3		1	4330.405
							Ti	3		2	4330.866
May be false line.					000	4333.9	La ?	15	20	1	4333.925
Probably false line from H_γ out of focus.		6	3	50±	6	4335.6					
H_γ.		9	8	90±	40	4339.0	H_γ			20	4340.634
Possibly ghost of H_γ.		1	0	20±	00	4344.1	Mn	3		1	4344.130
							Ti	3	1	2	4344.451
							Cr	10	7	4	4344.670
		2	1	18±	1	4351.3	Ti	2		1	4351.000
							Cr	4	5	3	4351.216
							Cr	10	8	5	4351.930
							Fe	2			
		1	0	10±	0	4358.8	Fe	2	1	2	4358.670
							Y	8	5	0	4358.879
							Cr	6	8	3	4359.784
		0		4	000	4368.4	Fe	1	1	5	4367.749
							Ti	6		2	4367.839
							Fe		1	2	4368.071
		0		6	00	4370.2	Fe?	2	3	4	4369.941
							Cr	8	10	2	4371.442
	d ?	3	1	25	1+	4374.6	Sc	20	2	3	4374.628
							Ti	3		0	4374.981
							Y	100	8	2	4375.103
Inner coronal line possibly.		0	0	25±	00	4380.1	Zr	20	6	0	4379.927
							Cr	1	1		
							Co	2	2	2 Nd?	4380.325

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				°							
		2	1	30	1	4383.7	Fe	20	15	15	4383.720
		0	0	20±	00—	4389.9	pHe$_{\dagger 5}$	3			(4388.10)
		3	1	40	2—	4395.1	Ti	25	8	3	4395.201
		0	00	10	00	4398.6	Y	15	5	1	4398.178
		2	0	18	0+	4400.3	Ti	6	2	3	4399.935
							Sc	20	3	3	4400.555
		1	00	8	00+	4404.7	Ti	4	10	1	4404.433
							Fe	15	10	10	4404.927
		1	00	6	00	4408.3	Fe	2	2	4	4407.871
							Fe	2	3	3	4408.582
							V?	15	10	2	4408.683
		0	0	15	00—	4409.0	Ti?	1		0	4409.408
							Ti?	1		1	4409.683
		2	0	20	0—	4415.5	Mn?	6	10	2	4415.047
							Fe	10	7	8	4415.293
							Sc	15	2	3	4415.722
		1	0	18	00	4417.8	Ti	6	5	3	4417.884
		0			000	4421.3	Sc?	2	0	00	4420.832
							Ti	2		1	4422.104
		0	00	10±	00	4427.5	Ti	4	10	2	4427.266
							Fe	2	5	5	4427.482
		1	0	12±	00	4434.5	Ca	20	5	5	4435.129
							Ca	15	3	4	4435.851
May be false line.		0			000	4441.0					
		2	1	35	1+	4443.9	Ti	15	3	5	4443.976
		0			00—	4447.2	Fe			2	4447.008
							Fe		1	2	4447.302
							Fe	2	4	6	4447.892
		2	00	8±	00	4450.4	Ti	5	10	2	4449.313
							Ti	4	1	2	4450.654
		1			00	4454.8	Ca	30	8	5	4454.953
		0			000	4459.2	Cr ?	3	3	0	4458.690
							Ni	5	7	2	4459.199
					000	4461.3	Fe	1	4	4	4461.818
							Fe			3 Nd?	4462.165
							Mn	8	20		
		4	2	55±	3	4468.7	Ti	15	4	5	4468.663
		5	3	85±	20	4471.5	He$_{\dagger 4}$	6			(4471.65)
					000	4476.3	Fe	2	4	4	4476.185
							Ag ?	2	3	3	4476.253
					000	4479.4	Mn	2		0	4479.553
							Fe			1	4479.775
							Ba	15	8	00	4479.879
							Ti	2	4		
The two lines nearly coincident but Mg very weak over middle.		000	00	30	00—	4482.0	Mg	100		0	4481.298
		1	000	5			Fe	1	5	5	4482.338
							Fe	2	5	3	4482.438
					000	4484.4	Fe	1	1	4	4484.392
		1	0	20	00+	4489.1	Ti	6	1	1	4488.493
							Ti	3	6	0	4489.262
							Fe			2	4489.351
		1	00	20	00—	4491.6	Fe			2	4491.570
		0			000	4495.1	Fe	2	6	6	4494.738
		0			000	4499.1	Mn ?	4	10	1	4499.066
		4	2	35	2+	4501.4	Ti	15	6	5	4501.445
					000	4506.7	Ba ?	10	6	00	4506.259
		1		6±	00	4508.5	Fe	2	1	4	4508.455
					000	4513.6	Ti	4	15	3	4512.906
		1		6±	00	4515.3	Fe	2		3	4515.508
		0	0	12±	00	4520.6	Fe	2	1	3	4520.397
		2	1	15±	00	4522.8	Fe	2	1	3	4522.802
							Ti	4	15	2	4522.974
					000	4527.9	Ca ?	2	2	3	4527.101
							Ti	4	15	3	4527.490
							Fe	3	6	8	4528.798

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Inten-sity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				°							
					000	4531.3	Co	20	9	2	4531.123
							Fe	1	3	5	4531.327
		4	2	40	2+	4534.1	Ti	5	12	4	4533.419
							Ti	12	4	6	4534.139
							Ti	4	10	4	4534.953
					000	4537.8					
					000	4541.2	Cr?	3	3	2	4540.672
							Cr	4	3	2	4540.880
					000	4544.8	Cr	5	3	1	4544.788
							Ti	3	10	3	4544.864
		2	1	30	2—	4549.8	Fe	3	1	2	4549.642
							Ti	25	4	6	4549.808
							Co	5	4		
		1	0	15	00	4552.7	Ti	4	5	2	4552.632
							Si?	8		1	4552.725
							Fe				
		3	1	35	2	4554.2	Ba	1000	10	8	4554.211
		0	0	8	00	4556.0	Ti	3	5	3	4555.662
							Fe	2	1	3	4556.063
					000	4561.1	Fe			2	4560.266
							V?	10	0	00	4560.892
							Bi	20		00	4561.368
		3	1	25±	1—	4564.0	Ti	10	4	4	4563.939
Coronal line weak in middle, strongest outside.		00	1	50±	0	4569.0					
		2	1	35±	1+	4572.1	Mg	1	5	5	4571.275
							Ti	20	5	6	4572.156
		1	0	10	00	4576.7	Fe	1		2	4576.512
					000	4581.1	Ca	8	3	4	4581.575
							Co	10	7	4	4581.693
							Fe				
		2	1	30	1—	4584.0	Fe	4	1	4	4584.018
	{-1-	0	0	12±	00	4590.1	Cr	15	0	3	4588.381
							Ti	3	1	3	4590.126
					000	4611.1	Fe	1	3	5	4611.469
		2	0	15	00+	4616.3	Cr	7	5	4	4616.305
							Cr	3		1	4616.804
							Ti?	4	6	3	4617.452
					000	4626.9	Cr	1		0	4626.096
							Cr	6	10	5	4626.358
					000	4629.9	Ti	2	4	6	4629.521
							Co	5	5		
							Fe	2	1		
							Fe		1	4	4630.306
					000	4637.5	Fe		1	5	4637.685
Group?					00	4646.2	Cr	8	10	5	4646.347
Group?					000	4655.2	Fe	1	5	4	4654.672
							Fe	1	5	5	4654.800
							Ti	8	3	3	4656.644
Group?		1			00	4663.4	Cd			0	4662.693
							Cr			1	4663.492
Group?					000	4680.6	Zn			1	4680.317
							Cr?			1	4680.658
					000	4697.6	Cr?			1	4697.230
					000	4705.4	Fe			4	4705.131
		0	0	50	0+	4712.7	He$_{g4}$	3			(4713.25)
					000	4764.2	Ti			4 d?	4764.108
							Ni		3		
					000	4783.0	Mn?		10	6	4783.613
					000	4786.8	Ni		3	3	4786.727
							Fe	0	2	2	4787.003

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				°							
					000	4789.6	Fe			2	4788.952
							Cr			2	4789.528
							Fe	1	3	3	4789.849
		1	00	15±	00	4805.3	Ti	4	1	3	4805.285
		1	00	12±	00	4823.5	Mn		10	5	4823.697
							Fe?			3	4824.325
							Cr?	8	0		
F, H_β		10	7	95	40	4860.5	H_β			30	4861.527
May be a group of small lines.	N d?	1			000	4871.8	Fe	3	7	5	4871.512
							Fe	2	5	4	4872.332
		2		7	00	4883.9	Y		6	2	4883.867
		1		6	00—	4891.3	Fe	2	4	6	4890.948
							Fe	5	7	8	4891.683
		1		5	00+	4900.1	Ti			2	4900.095
							La				
							Y		6	2	4900.301
	N d?			5	000	4910.6	Fe			3	4910.198
							Fe			2	4910.505
							Fe			2	4910.753
Probably a short line coincident with long line.	-1-	2	1	35	0	4921.2	Fe	12	9	10	4920.685
							pHe†$_4$	4			(4922.10)
		4	2	40	1—	4924.1	Fe	15	2	4	4924.107
		0	00	7	00	4928.0	Fe			2	4928.050
		2	1	35	0	4934.2	Ba		100	7	4934.250
		1		4	000	4940.0	Fe?			3	4939.868
		1		4	000	4947.1	Fe?			3	4946.568
	d?	2		5	00+	4957.5	Fe	2	6	5	4957.480
							Fe	10	8	8	4957.785
		1	1	20±	0—	5015.5	pHe*$_3$	6			(5015.73)
		3	2	20±	0+	5018.8	Fe	10	3	4	5018.629
					000	5040.7	Ti			3	5040.138
							Fe			3 d?	5041.069
							Fe			4	5041.255
					000	5050.7	Fe			6	5050.008
	N				00	5080.4	Fe			4	5079.921
							Ni		7	4	5080.714
							Ni		6	3	5081.286
					000	5099.3	Fe			3	5098.885
							Ni		4	1	5099.497
							Ni		5	2	5100.108
					000	5122.2	Fe			2	5121.825
					000	5128.8	Ti			3	5129.336
							Ni?		4	2	5129.546
b_4		4	3	35	1	5167.5	Mg		10	15	5167.497
b_3		5	3	35	1	5169.2	Fe	5	4	3	5169.069
							Fe	10	2	4	5169.220
b_2		5		40	2—	5172.7	Mg		15	20	5172.856
		4			00	5180.2	Fe?			1	5180.233
b_1		6		45	3	5183.9	Mg		20	30	5183.791
					00	5189.2	Ti			2	5188.863
							Ca			3	5189.018
					00+	5192.0	Fe			4	5191.629
							Fe			5	5192.523
					000+	5194.9	Ti?			2	5193.139
							Fe?			4	5195.113
					000+	5197.4	Fe?			2	5197.743
	d?	1	0	15	0	5205.4	Cr		2	5	5204.680
							Fe			3	5204.768
							Cr		20	5	5206.215
							Ti				
	-1-	0		5	00—	5215.5	Fe			3	5215.353
							Fe			3	5216.437

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				°							
	d ?	1	0	10	0	5226. 1	Ti			2	5226. 707
							Fe Cr			3	5227. 043
							Fe			5 d ?	5227. 362
	d ?	1		5	00	5234. 5	Fe ?			7	5233. 122
					000	5243. 6	Fe ?			2	5242. 658
							Fe ?			1	5243. 946
					000	5250. 0	Fe ?			2	5250. 385
							Fe ?			3	5250. 817
					000	5254. 9	Fe ?			3	5255. 121
					000	5263. 6	Fe			4	5263. 486
							Cr		7	4	5264. 329
							Ca			3	5264. 415
					000	5266. 6	Ca			3	5265. 729
							Cr		5	2	5265. 893
							Fe			6	5266. 738
		1	0	18	0	5269. 9	Fe			8	5269. 723
							Ca		10	3	5270. 438
	-1-						Fe			4	5270. 558
	-1-	1		6	00	5273. 3	Fe			3	5273. 339
		1		6	00	5276. 1	Fe		3	3	5276. 169
					000	5280. 4	Fe ?			1	5280. 540
		0		4	00—	5283. 9	Fe			6	5283. 802
		0		5	00—	5294. 1					
					000	5297. 9	Cr ?		5	3	5296. 872
							Cr		3	2	5297. 555
							Cr		6	4	5298. 455
Coronal line seen only outside of middle in one place.			0	59±	00	5300. 1					
					000	5314. 2					
1474.	-2-	3	1	18	1	5316. 8	Fe			4	5316. 790
							Fe ?			2	5316. 958
		1		5	000	5324. 8	Fe		7	7	5324. 373
		1		5	00	5326. 0	Fe ?			1	5326. 331
		2	0	15	0+	5328. 0	Fe		8	8	5328. 236
							Cr			2	5328. 515
							Fe ?			6	5328. 722
	d ?				00—	5333. 5	Fe ?			4	5333. 089
					00	5336. 9	Ti			4	5336. 974
					co—	5340. 6	Fe			6	5340. 121
							Fe			7	5341. 213
Probably lines between.	d ? -?-	1		10	00+	5361. 8					
	d ?	1	0	15	00+	5371. 3	Fe			6	5370. 166
							Cr			4	5371. 656
							Fe			3	5371. 734
					00	5381. 2	Ti Fe			2	5381. 221
					000	5405. 0	Fe			2	5404. 028
							Fe?			5	5404. 357
							Fe?			6	5405. 989
					000	5410. 0	Cr			4	5410. 000
							Fe			4	5411. 124
					000	5418. 7	Ti?			1	5418. 979
	N d?	1	00	7	00+	5429. 5	Fe?			6 d?	5429. 911
					000	5432. 4	Mn?			1 N	5432. 753
							Fe?			2	5433. 160
		1	0	8	00	5434. 8	Fe			5	5434. 740
		0		6	000	5442. 6					
Shaded toward violet.	d?	1	0	10	00+	5446. 8	Ti			2	5446. 797
							Fe			6 d?	5447. 130

TABLE I—Continued.

Lines of the Chromospheric Spectrum.							Coincident Lines.				
Notes.		C	S	Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
								Spark.	Arc.	Sun.	
				°							
Coronal line on west side of Sun measured near inside edge.		I	I	85±	0	(5453.8*)					
		I	I	40	0	5455.9	Fe Fe			2 4	5455.671 5455.834
	N			5	000	5459.1					
Broad and hazy.				6	00—	5463.6	Fe Fe			3 3	5463.174 5463.494
		I	0	8	00	5474.5	Fe?			3	5474.113
		I	0	12	00+	5476.9	Fe Fe Ni		 20	I 3 5	5476.500 5476.778 5477.123
				6	000	5481.2	Fe Fe Fe Ti			I I I	5481.071 5481.452 5481.652
Group?					000	5511.9	Fe? Ti? Ca?			I 2 4	5512.470 5512.741 5513.198
		2	I	18	0	5526.9	Sc Mg?			3 8	5527.208 5528.641
		2	I	15	0	5535.0	Fe Fe Ba			2 2 0	5535.061 5535.644 5535.778
		2	0	12	00	5543.8	Fe Fe			2 2	5543.414 5544.157
		I	0	10	00—	5553.5	Fe?			I	5553.804
	Nd?	2		5	000	5572.3	Fe?			6	5573.075
Group?		I		10	00+	5586.3	Fe Ca?		 15	7 6	5586.991 5588.985
Probably some lines toward the red.				8	00	5598.8	Ca		7	4	5598.711
	-?-	2	I	15±	0—	5614.9	Fe Fe			2 6	5615.520 5615.877
		I	0	10	00+	5624.8	Fe?			4	5624.769
				5	000	5633.9	Fe?			3	5634.171
		I		5	000	5635.7	C? Fe?			 I	5635.6 5636.045
		I		8	00—	5641.0	Sc? Fe?			I 2	5641.206 5641.667
				4	000	5648.1					
		2	I	15±	0—	5658.1	Sc			2	5658.097
					000	5662.1	Fe?			4	5662.744
					000	5667.4	Fe?			2	5667.739
					000	5727.6	Ti?			2	5727.271
					000	5731.2	Fe?			4	5731.984
					000	5752.0	Fe Fe			4 5	5752.254 5753.344
					000	5761.0	Fe? Ni				5760.572 5761.052
					000	5784.4	Cr? Cr? Fe		6 6	3 2 3	5784.080 5785.188 5785.498
D$_3$		3	2	70±	10	5875.6	He$_{\dagger 3}$	10			(5875.87)
D$_2$					000	5892.4±	Na			30	5890.186
D$_1$					000	5896.5±	Na			20	5896.155

* Reduced value, corrected approximately for Sun's diameter, = 5300.3±

TABLE II contains the results derived from the spectrogram taken just before mid-totality. The first column is for notes. The second column is for relative intensities of the coronal and chromospheric lines, the former in the form of more or less complete rings or parts of rings, and the latter in the form of patches due to prominences or rings or arcs of prominences. The third column gives the computed wave-lengths. The fourth column gives the mean wave-lengths of the coronal lines approximately corrected for the diameter of the Sun where the measurements were made of portions of the coronal rings on the western limb of the Sun. The mean wave-lengths are derived from the wave-lengths given in the table thus corrected, and also some measurements not included in the table. When the definition is poor the wave-lengths can not be considered as being very accurate. The fifth and sixth columns give the origin and wave-length of the coincident line which is responsible for the chromospheric line.

The coronal lines observed are six in number whose mean wave-lengths are 3382.4; 3453.3; 3644.0; 3801.8; 3987.5, and 5304.1.

The coronal lines 3382.4 and 5304.1 have the same distribution and probably the same origin. The others differ from the two mentioned, but are much alike in their manner of distribution, and most of them are probably due to one element. The last-mentioned rings have a rather uniform distribution, while the two former are confined mostly to the regions of the sun-spot belts, and are strong on the western and weak on the eastern sides, which is exactly the reverse of the other four lines or rings. None of the coronal rings seem to bear any particular relation to the prominences seen.

Two of the coronal lines appear on the spectrogram taken at second contact, viz, the lines at 3987.5 and 5304.1. The line due to the inner corona at wave-length 3954.8 is visible upon the spectrogram taken at mid-totality, and also that taken at second contact. Probably a considerably greater number of coronal lines, especially those of the inner corona, would be visible if the definition of the spectrograms were good throughout their entire length.

In the case of some of the coronal rings there is an appearance of absorption close to the Moon's disk, but it is suspected that this is due to photographic reversal of the image, although it may possibly be true absorption in the outer portion of the chromosphere.

TABLE II.

Coronal and Prominence Lines.				Coincident Lines.	
Notes.	Intensity.	Wave-length.	Mean Corrected Wave-length.	Origin.	Wave-length.
Coronal ring on eastern limb of Sun. Position very uncertain, and not certainly visible on eastern side except to SE. and more faintly to NE.	0 ?	3381.8	3382.4		
Outer limit of coronal ring on eastern limb.		3446.6			
Inside edge of coronal ring on eastern limb much stronger on eastern than on western limb. Ring strong all along the eastern limb, with considerable uniformity.	30	3456.6	3453.3		

TABLE II—Continued.

Coronal and Prominence Lines.				Coincident Lines.	
Notes.	Intensity.	Wave-length.	Mean Corrected Wave-length.	Origin.	Wave-length.
Inside edge of coronal ring on western limb.	25	3538.6	3382.4		
Outer limit of coronal ring on western limb.		3546.8			
Strong on western limb, being strongest in W. and SW. and weaker to NW. Strongest in regions near sun-spot belts, and weak toward poles. Very weak on eastern limb. Distribution very similar to green coronal line at 5304.					
Inside edge of coronal ring on western limb.	18	3603.1	3453.3		
Outer limit of coronal ring on western limb.		3609.0			
Considerably weaker on western than on eastern limb, distribution fairly uniform but stronger in NW. than W. or SW.					
Outer limit of coronal ring on eastern limb.		3639.7			
Inside edge of coronal ring on eastern limb. Very weak on eastern limb, but distribution fairly uniform. Not certainly visible on western limb.	4	3644.5	3644.0		
Titanian prominence on eastern limb.	1	3761.0		Ti Ti	3759.447 3761.464
Hydrogen prominence on eastern limb.		3799.2		H_θ	3798.00
Outer limits of coronal ring on eastern limb.		3797.7			
Inside edge of coronal ring on eastern limb.	10	3802.0	3801.8		
Hydrogen prominence on eastern limb.	2	3836.2		H_η	3835.51
Helium and hydrogen prominence on eastern limb.	3	3888.8		He H_ζ	3888.79 3889.15
Ghost of calcium *K* prominences on eastern limb.	0	3928.4			
Calcium *K* ring of prominences on eastern limb.	15	3933.8		Ca	3933.825
Ghost of calcium *K* prominences on eastern limb.	0	3939.17			
Mean wave-length of *K* from ghosts.		3933.79			
Faint indications of weak inner coronal line on eastern limb but some uncertainty and confined to two streaks just N. of E. point of Sun's limb.	0 ?	3954.8			
Faint indication of coronal ring on western limb but very weak and uncertain.	0 ?	3955.0	3801.8		
Ghost of calcium *H* ring of prominences on eastern limb.	0	3963.64			
Calcium *H* ring of prominences on eastern limb.	12	3968.5		Ca	3968.625
Hydrogen prominence on eastern limb.	2	3970.0		H_ϵ	3970.177
Outer limit of coronal ring on eastern limb.		3982.9			
Inside edge of coronal ring on eastern limb.	12	3987.6	3987.5		
Rather sharp and nearly uniformly distributed around eastern limb.					
Helium prominence on eastern limb.	1	4026.6		He	4026.34
Calcium *K* prominences on western limb.	7	4088.3		Ca	3933.825
Calcium *H* prominences on western limb.	7	4102.4		Ca	3968.625
Inside edge of coronal ring on western limb.	7	4139.7	3987.5		
Outer limit of coronal ring on western limb.		4142.4			
Hydrogen prominence on eastern limb.	3	4341.2		H_γ	4340.634
Helium prominence on eastern limb.	6	4472.5		He	4471.65
Hydrogen prominence on western limb.	2	4495.4		H_γ	4340.634
Helium prominence on western limb.	4	4625.4		He	4471.65
Hydrogen prominence on eastern limb.	6	4860.7		H_β	4861.527
Hydrogen prominence on western limb.	8	5014.7		H_β	4861.527
Coronal ring on eastern limb. Very weak on east side, and not certainly visible except faintly in SE and NE.	00 ?	5295.1 ±	5304.1		
Inside edge of coronal ring on western limb.	30	5469.7	5304.1		
Strong outer part of coronal ring on western limb.		5474.1			
Faint outer limit of coronal ring on western limb.		5476.1			
Helium arc D_3 on eastern limb.	5	5876.1		He	5875.87
Helium D_3 prominences on western limb very weak and uncertain.	?	6026.9		He	5875.87

THE OBJECTIVE PRISM SPECTROGRAPH.

During the progress of the total phase of the eclipse at Pinehurst two spectrograms were obtained with the objective prism spectrograph by Dr. F. L. CHASE, only one of which was useful for the purposes of measurement.

The first exposure, taken at the time of the beginning of totality, is not in very good focus, and the clockwork of the coelostat was running badly, so that even during the short time of exposure the image was dragged considerably. During the second exposure at the end of totality the dragging of the image was very bad and the exposure did not end until after the Sun's limb had appeared.

The plate used was a stained SEED gilt edge,* sensitive to the red portion of the spectrum, and the red hydrogen line gave a fairly distinct crescent.

A curious feature of the second exposure is that the narrow crescent image of the Sun's limb just after the end of totality acted as a curved slit illuminated by sunlight and the lines of the flash and the FRAUNHOFER crescents are superimposed, but in the red end of the spectrum, where the flash lines were not sufficiently bright to be impressed upon the plate, there is a strip of continuous spectrum due to the Sun's limb, and across this continuous spectrum strip, which is in too bad focus to show the finer FRAUNHOFER lines, the atmospheric bands α, B, and also faintly a and A, show reversed as weak dark lines or bands as in the ordinary solar spectrum.

The spectrogram taken at the beginning of totality or second contact is not in good definition from the causes mentioned, but is interesting chiefly because of the presence of several lines of the chromospheric spectrum showing between the D lines and C.

TABLE III, giving the results of the measurement and study of this spectrogram, is divided into two parts, the first giving data derived from the spectrogram itself, the second that referring to the lines of the various elements which coincide in wave-length with the lines of the spectrogram. The first part is headed *Lines of the Chromospheric Spectrum*, and the second *Coincident Lines.*

The first column, headed *Notes*, contains references and comments. The second column gives some of the characteristics of the lines: *N* indicating that a line is nebulous or hazy; *d*, that the line is apparently double; braces, that the lines are close to or merged into each other, but hardly so close as the doubles; –1–, –2–, or –?–, that there is probably one line, two lines, or a possibility of lines between the lines whose positions are given, but that the lines are too uncertain to be measured. The third column gives the length in degrees of the chromospheric arcs, or spectral lines. The fourth column gives the estimated intensity of the lines, both the length and brightness being considered in the estimate. The fifth column gives the estimated wave-length of the spectral lines.

The definition is poor over the whole of the spectrogram, and particularly poor for the violet end. The green, yellow, and red portions are of better definition but are weak, and most of the lines are very difficult to see. As a consequence, the wave-lengths derived may be uncertain by a considerable margin, but most of them are probably fairly accurate.

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* The Erythro plate.

For the same reason the estimates of intensity and length of the chromospheric arcs are merely approximate, but they have been made as carefully as the character of the spectrogram would admit.

The sixth column gives the probable or possible origin of the chromospheric spectral lines, the elements being represented by their ordinary symbols. In the case of the hydrogen lines the Greek letters usually attached to those lines have been given, and in the case of the helium and parhelium lines the designations given by RUNGE and PASCHEN in WATTS'S Index of Spectra, Appendix G, pages 69–70. Where several elements have lines approximately coinciding with the chromospheric line, but where one element is wholly or for the greater part responsible for the chromospheric line, the symbol for that element is in italics. The seventh, eighth, and ninth columns give, respectively, the intensities of the coincident lines in the spectra of the spark, the arc, and the Sun. Where the element is a gas under ordinary circumstances, its intensity in the vacuum tube is given under the heading *Spark.*

The intensities given for the spark spectrum are usually those from EXNER and HASCHEK'S tables, but are modified where other data were available. The intensities for the arc spectrum are partly from material available at the Physical Laboratory of Johns Hopkins University and partly from the tables of EXNER and HASCHEK. The intensities in the solar spectrum are from ROWLAND'S Preliminary Table of Solar Spectrum Wave-lengths, as are also the wave-lengths, except where given in parentheses, in which case they are taken from other sources. In some cases the data derived from ROWLAND'S Tables have been corrected.

TABLE III.

Lines of the Chromospheric Spectrum.					Coincident Lines.				
Notes.		Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
						Spark.	Arc.	Sun.	
K in prominence at W. limb.				(3790.2±)	Ca				3933.825
H in prominence at W. limb.				(3817.7±)	Ca				3968.625
			2	3888.7	He$_{*3}$	10			(3888.79)
					H$_\zeta$				(3889.15)
		110	25	3934.3	Ca	1000	100	1000	3933.825
		110	25	3968.4	Ca	500	80	700	3968.625
					H$_\epsilon$			5N	3970.177
			0	4022.0	He$\dagger_5$	5			(4026.34)
			0	4045.8	Fe	15	25	30	4045.975
			00	4055.3	Fe	1	1	3	4055.023
					Ti	3	4	3	4055.189
					Mn	8	8	6	4055.701
			0	4063.4	Fe	12	8	20	4063.759
			00	4071.0	Fe	10	15	15	4071.908
		55	6	4078.3	Sr	1000	10	8	4077.885
		100	30	4103.1	H$_\delta$				4102.000
			0	4109.1	V ?	10	9	2	4109.905
					Fe	2	3	3	4109.953
			0	4118.5	Fe	3	5	5	4118.708
					Co	20	9	4	4118.934
			0	4122.6	Heξ_5	3			(4120.97)

TABLE III—Continued.

Lines of the Chromospheric Spectrum.					Coincident Lines.				
Notes.		Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
						Spark.	Arc.	Sun.	
		0							
			0	4127.6	Fe	1	1	4	4127.767
					Fe	1	1	4	4127.957
					V ?	10	2	6 d ?	4128.251
			0	4129.7	Ba	800	8	2	4130.804
			00	4133.7	Fe		1	3	4134.010
			00	4138.0	Fe		2	6	4137.156
			1	4143.5	pHe†6	2			(4143.92)
			0	4149.5	Fe	1	1	4	4149.533
					Ti	3	3	1	4151.129
			0	4155.6	Fe	2	4	4	4154.071
					Fe			2	4154.265
					Fe	2	4	4	4154.667
					Fe	2	3	4	4154.976
			00	4157.0	Fe ?	2	4	3 d ?	4156.970
					Fe	1	3	5	4157.948
			00	4161.0	*Ti*	3	0	4	4161.682
					Sr	50	6	1	4161.961
			00	4163.4	Cr	4	2	4	4163.818
					Ti	20	2		
			000	4165.7	Ba	100	4	0	4166.161
		30	1	4173.3	Ti	15	3	2	4172.066
					Ti	3		3	4173.710
			000	4177.3	Fe	1	2	5	4176.739
					Mn	4	3		
		30	1	4178.2	Y	50	5	3	4177.772
					Fe	2		3	4179.025
			0	4187.2	Ti	3	5	1	4186.280
					Fe	4	5	6	4187.204
			0	4197.2	Fe	1	1	4	4196.372
					Fe			3	4198.402
					Fe	3	5	4	4198.494
			0	4204.3	Fe	1	3	3	4204.101
					Y	6	4	1	4204.884
		60	8	4215.9	Sr	500	10	5 d ?	4215.703
g		40	4	4226.7	Ca	100	75	20	4226.904
		38	2	4233.4	*Fe*	3	1	4	4233.328
					Fe	3	4	6	4233.772
		15±	0	4237.6	Fe	2	1	3	4237.339
					Sc	1	2	3	4238.188
					Fe	1	1		
			000	4242.4	Mn	3		0	4242.443
					Cr	5	1	2	4242.535
The strongest of the scandium lines.		45	6	4247.5	Sc	100	10	5	4246.996
		35	2	4254.5	Cr	50	50	8	4254.505
		25	1	4261.5	Fe	10	15	10	4260.640
		10±	00	4266.7	Mn	5	10	2	4266.081
					C ?	10		3	4267.122
					Fe	1	0		
		35	2	4271.2	Fe	4	8	6	4271.325
					Fe	10	15	15	4271.934
		35	2	4275.1	Ti	4	15	2	4274.746
					Cr	30	50	7	4274.958
		20	1	4280.8	Sc	1		1	4280.027
					Cr	3	2	1	4280.556
		10	00	4286.3	Ti	4	10	2	4286.168
		40	4	4290.0	Ca ?	20	4	4	4289.525
					Cr	30	30	5	4289.885
					Ti	10	5	2	4290.377
Narrow line.		40	1	4294.2	*Ti*	10	5	2	4294.204
					Fe	4	6	5	4294.301
		40	4	4300.6	Ca	20	3	3	4299.149
					Ti	20	5	3	4300.211
		30	1	4302.9	Ti	5	2	2	4302.085
					Ca	50	6	4	4302.692

TABLE III—Continued.

Lines of the Chromospheric Spectrum.					Coincident Lines.				
Notes.		Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
						Spark.	Arc.	Sun.	
		o							
G		35	2	4308.7	Ca	20	3	3	4307.907
					Fe	15	8	6	4308.081
		40	3	4314.7	Ti	8	2	3	4313.034
					Sc	30	3	3	4314.248
		30	2	4320.4	Ti	3	10	4	4318.817
					Ca	30	4		
					Sc	20	3	3	4320.907
					Ti	3	1	2	4321.119
		25	1	4325.2	*Sc*	20	3	4	4325.152
					Ti	3	8	1	4325.306
		110	40	4341.3	H_γ	50		20	4340.634
		30	2	4351.9	Ti	2		1	4351.000
					Cr	4	5	3	4351.216
					Cr	10	8	5	4351.930
					Fe	2	0		
		20	1	4359.0	Fe	2	1	2	4358.670
					Y	8	5	0	4358.879
					Cr	6	8	3	4359.784
		10	00	4368.1	Fe	1	1	5	4367.749
					Ti	6		2	4367.839
					Fe		1	2	4368.071
		40	4	4375.6	*Sc*	20	2	3	4374.628
					Ti	3		0	4374.981
					Y	100	8	2	4375.103
					Fe	2	5	6	4376.107
			00	4380.0					
		40	5	4383.8	Fe	20	12	15	4383.720
					Sc	4	0	0	4384.986
			000	4390.2					
		45	6	4395.5	Ti	25	8	3	4395.201
		25	2	4400.0	Ti	6	2	3	4399.935
					Sc	20	3	3	4400.555
		20	1	4405.2	Fe	15	10	10	4404.927
			000	4409.3	Fe	1	3	3	4408.582
					V ?	15	10	2	4408.683
					Fe			1	4409.288
		35	2	4415.1	Mn ?	6	10	2	4415.047
					Fe	10	7	8	4415.293
					Sc	15	2	3	4415.722
		35	3	4417.2	Ti	5	3	3	4417.884
			000	4421.0	Sc	2	0	00	4420.832
					Ti	2		1	4422.104
			00	4427.2	Ti	4	3	2	4427.266
					Fe	2	5	5	4427.482
	d ?	25	0	4435.2	Ca	20	8	5	4435.129
					Ca	15	5	4	4435.851
		45	6	4443.7	Fe	2	3	3	4443.365
					Ti	12	3	5	4443.976
			000	4448.0	Fe	2	4	6	4447.892
		25±	0	4450.2	*Ti*	4	1	2	4450.654
					Ti	3	5	1	4451.087
		25±	0	4454.3	Fe	1	2	3	4454.552
					Ca	30	8	5	4454.953
		20±	0	4461.4	Fe	1	4	4	4461.818
					Mn	8	20	3 Nd?	4462.165
					Fe		1		
		55	6	4468.0	Fe	2	4	5	4466.727
					Ti	15	4	5	4468.663
		80	15	4471.5	He$_{\dagger4}$	6			(4471.65)
				4475.5	Fe	2	4	4	4476.185
			000	4478.0					
	{	30	0	4481.0	Mg	50		0	4481.298
					Ti	3	3	1	4481.438

TABLE III—Continued.

Lines of the Chromospheric Spectrum.					Coincident Lines.				
Notes.		Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
						Spark.	Arc.	Sun.	
		o							
		30	0	4488.0	Ti	6	1	1	4488.493
		30	0	4490.0	Ti	2	3	0	4489.262
					Fe	2	0	2	4489.351
					Fe		1	4	4489.911
					Mn	3	10	3	4490.253
					Fe		1		
		20±	00	4493.0	Fe?			2	4491.570
		20±	00	4496.2	Ti	3	5	1	4496.318
		45	4	4501.2	Ti	12	6	5	4501.445
		30	1	4506.2	Ba	10	6	00	4506.259
		20	0	4514.3	Fe	1		3	4515.508
		20	0	4520.0	Fe	2	1	3	4520.397
		25	1	4523.2	Fe	2	1	3	4522.802
					Ti	4	15	2	4522.974
		20	00	4529.0	Fe	3	6	8	4528.798
		45	5	4534.2	Ti	5	10	4	4533.419
					Ti	12	4	6	4534.139
					Ti	4	8	4	4534.953
			00	4540.0	Cr	3	3	2	4540.672
					Cr	4	3	2	4540.880
		45	4	4549.2	Fe	3	0	2	4549.642
					Ti	25	4	6	4549.808
					Co	5	4		
		45	5	4554.3	Ba	1000	10	8	4554.211
		30	0	4558.8	Cr	20	1	3	4558.827
		45	3	4564.0	Ti	10	4	4	4563.939
		45	4	4571.8	Mg	1	5	5	4571.275
					Ti	20	5	6	4572.156
			00	4576.6	Fe	1		2	4576.512
		40	3	4584.0	Fe	4	1	4	4584.018
		35	1	4589.0	Cr	15	0	3	4588.381
		20	0	4591.4	Ti	3	1	3	4590.126
		12	0	4599.8	Fe			2	4600.018
					Cr	2	2	1	4600.279
					Ni		5	2	4600.541
					Cr	5	4	3	4600.932
		12	0	4605.0	Ni	4	6	3	4605.171
					Mn	2	1	0	4605.536
			000	4610.4	Cr			0	4611.469
					Fe	1	3	5	
					Cr	6	1	00	4612..138
		10	00	4614.0	Fe		2	3	4613.386
					Cr	6	4	3	4613.544
		20	0	4619.4	Fe		1	4	4618.971
					Cr	5	2		4619.133
					Fe		2	3	4619.468
					Cr	3	3	1	4619.711
		15	0	4625.6	Fe		3	5	4625.227
		23	2	4628.5	Ti	2	4	6	4629.521
					Co	5	5		
					Fe	2	0		
			000	4635.2	Cr	6	1	2	4634.254
			00	4638.5	Fe		2	5	4637.685
					Fe		2	4	4638.193
		17	0	4646.8	Cr	8	7	5	4646.347
					Fe	1	3	4	4647.617
		15	0	4654.0	Fe	0	5	4	4654 672
					Fe	0	5	5	4654.800
			000	4657.0	Ti	2	4	3	4656.644
					Ti	1		2	4657.380
		10	00	4662.4	Fe			1	4662.149
					Cd	8	8	0	4662.693
		15	1	4666.5	Cr			1	4666.076
					Cr			0	4666.387
					Cr			1	4666.655

TABLE III—Continued.

Lines of the Chromospheric Spectrum.					Coincident Lines.				
Notes.		Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
						Spark.	Arc.	Sun.	
		o							
		15	0	4678.2	Cd	50	10	3	4678.347
					Fe	0	4	6	4679.027
					Zn	300	10	1	4680.317
			000	4682.4	Ti	3	5	3	4682.088
					Co		5	1	4682.529
					Y	4	6		
		12	00	4691.0	Fe			4	4690.317
					Ti	1	3	1	4691.523
					Fe	0	2	5	4691.602
					Ba	8	6	1	4691.777
		12	00	4698.3	Sc	1		00	4698.451
					Cr			1	4698.641
					Cr			1	4698.798
					Ti			1	4698.946
		12	00	4702.0	Mg	2	8	10	4703.177
		20±	0	4707.5	Fe	1	5	5	4707.457
					Fe			2	4707.672
					Fe		5	2	4708.196
		60	1	4714.0	He$_{34}$	3			(4713.25)
			00	4722.0	Zn	500	10	3	4722.342
					Sr ?	10	8	000	4722.464
			0	4727.4	Fe	2	2	3	4727.582
					Mn		7	2	4727.676
			000	4730.7	Y		4	4	4728.732
					Fe		1		
					Fe			4	4731.651
			00	4736.5	Fe	2	6	6	4736.963
					Cr		4	2	4737.540
					Sc	1	1	1	4737.817
			000	4749.0	Na ?			000	4748.167
					Fe			4	4748.325
			00	4757.0	Cr		6	2	4756.300
					Ni		5	3	4756.705
		20	1	4764.2	Ti			4 d?	4764.108
					Ni		3		
			00	4771.5	?			3	4771.664
					Fe		1	2	4771.903
			00	4778.0	Ti	2	0	00	4778.441
			000	4785.8	Mn ?			6	4783.613
					Ni		10	3	4786.727
					Fe		3	2	4787.003
			000	4793.0	Ti		3	2	4792.702
					Cr		4		
			0	4799.0	Ti		2	1	4799.984
					Cd		10	00	4800.080
		15	0	4805.4	Ti	4	1	3	4805.285
		15	0	4811.5	Zn		10	3	4810.724
		20	1	4823.8	Mn		10	5	4823.697
					Fe ?		2	3	4824.325
					Cr ?				
			0	4830.2	Ni		6	3	4829.214
					Cr		6	2	4829.551
					Ni		5	3	4831.365
					Fe		2	3	4832.905
F		110	50	4861.5	H$_\beta$	75		30	4861.527
		20	1	4871.6	Ni		1	3	4870.996
					Cr		5		
					Fe	3	7	5	4871.512
					Fe	1	5	4	4872.332
			0	4876.3	V		5	1	4875.671
					Fe		2	2	4876.060
		20	1	4883.5	Y		6	2	4883.867

TABLE III—Continued.

Lines of the Chromospheric Spectrum.					Coincident Lines.				
Notes.		Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
						Spark.	Arc.	Sun.	
		°							
		35	2	4891. 3	Fe	2	4	6	4890. 948
					Fe	5	7	8	4891. 683
		20	I	4899. 6	Ti		4	2	4900. 095
					Y		6	2	4900. 301
			000	4905. 0	Fe			5	4903. 502
					Ni			3	4904. 597
		15	I	4910. 5	Fe			3	4910. 198
					Fe			2	4910. 505
					Fe			2	4910. 753
					Ti			I	4911. 374
			000	4914. 2	Ti		4	2	4913. 803
					Ni		2	2	4914. 150
		25	I	4920. 3	Fe	12	9	10	4920. 685
		45	4	4925. 3	*Fe*	15	5	4	4924. 107
					Fe			3	4924. 956
		50	3	4934. 3	Ba		100	7	4934. 250
			00	4937. 5	Fe		I	2	4938. 350
					Fe		4	4	4938. 997
					Fe		I	2	4939. 416
					Fe ?		2	3	4939. 868
		25	2	4958. 0	Fe	2	6	5	4957. 480
					Fe	10	8	8	4957. 785
			000	4965. 2	Fe			4	4966. 270
			000	4969. 0	Fe			3	4968. 080
					Fe			I	4968. 880
					Fe			3	4969. 098
		15±	I	4984. 2	Fe		2	3	4984. 028
					Ni		5	2	4984. 297
			000	4990. 0	Fe			2	4989. 130
					Ti			3	4991. 247
					Fe			2	4991. 452
			0	5002. 0	*Fe*			5	5002. 044
					Fe			2	5002. 976
			00	5005. 9	Fe			4	5005. 896
					Fe			5	5006. 306
			00	5015. 2	pHe$_{*3}$	6			(5015. 73)
		45	4	5018. 5	Ni		6	3	5017. 762
					Ni		I	I	5018. 463
					Fe	10	3	4	5018. 629
			00	5026. 0	Ti		6	3	5025. 027
					Ti		5	I	5025. 749
					Fe		4	3	5027. 305
			00	5035. 9	Ni			5	5035. 542
					Ti			3	5036. 089
					Ni			2	5036. 155
					Ti			2	5036. 645
			I	5041. 6	Fe			3 d?	5041. 069
					Fe			4	5041. 255
					Ca			2	5041. 795
					Fe			4	5041. 936
			000	5048. 5	pHe$_{\S 4}$	2			(5047. 82)
					Fe			3	5048. 612
					Ni			2	5049. 035
			00	5050. 5	Fe			6	5050. 008
	N		00	5065. 6	Ti			3	5064. 836
					Fe			3	5065. 207
					Fe			2	5065. 380
	N		00	5081. 0	Fe			4	5079. 921
					Ni		6	4	5080. 714
					Ni		7	3	5081. 286
			0	5099. 6	Fe			3	5098. 885
					Ni		4	I	5099. 497
					Ni		5	2	5100. 108

TABLE III—Continued.

Lines of the Chromospheric Spectrum.					Coincident Lines.				
Notes.		Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
						Spark.	Arc.	Sun.	
		o							
			00	5108. 1	Fe			4	5107. 619
					Fe			4	5107. 823
			00	5112.0	Fe ?			5 d	5110. 574
			00	5124. 6	Fe			3	5123. 899
					Fe			3	5125. 300
			0	5129. 5	Ti			3	5129. 336
					Ni ?		4	2	5129. 546
			00	5139. 3	Fe			4	5139. 427
					Fe			4	5139. 644
			00	5142. 6	Fe			3	5141. 918
					Fe			4 d?	5142. 693
					Ni			2	5142. 958
					Fe			3	5143. 111
			000	5148. 1	Fe			2	5148. 222
					Fe			3	5148. 410
			00	5152. 0	Fe			3	5152. 087
					Ti			0	5152. 361
			00	5162. 5	Fe			5	5162. 449
		50	4	5169. 0	Mg		20	15	5167. 497
					Fe	5	4	3	5169. 069
					Fe	10	2	4	5169. 220
		45	3	5173. 0	Mg		25	20	5172. 856
		50	4	5184. 5	Mg		35	30	5183. 791
			000	5192. 2	Fe			4	5191. 629
					Fe			5	5192. 523
					Ti ?			2	5193. 139
			00	5196. 5	Fe			4	5195. 113
					Fe			2	5195. 647
					Fe			1	5196. 227
					Fe ?			2	5197. 743
		15	0	5207. 5	Cr Ti			5	5206. 215
					Cr			5	5208. 596
					Fe			2	5208. 776
		10±	00	5210. 8	Ti			3	5210. 555
			00	5217. 3	Fe			3	5215. 353
					Fe			3	5216. 437
					Fe			3	5217. 552
			0	5227. 2	Ti			2	5226. 707
					Fe Cr			3	52270. 43
					Fe			5 d?	5227. 362
			00	5234. 5	Fe ?			7	5233. 122
			000	5247. 6	Fe			1	5247. 229
					Cr			2	5247. 737
		8±	00	5253. 0	Fe ?			2	5250. 385
					Fe ?			3	5250. 817
					Fe			2	5253. 633
		12±	0	5264. 8	Fe			4	5263. 486
					Cr			4	5264. 329
					Ca			3	5264. 415
					Ca			3	5265. 729
E_2	N	8±	0	5270. 3	Fe			8	5269. 723
E_1					Ca			3	5270. 438
					Fe			4	5270. 558
			000	5276. 1	Cr			1	5275. 926
					Fe			3	5276. 169
					Cr			2	5276. 237
	N		000	5297. 0	Cr ?			3	5296. 872
					Cr			2	5297. 555
					Cr			1	5298. 194
					Cr			4	5298. 455

TABLE III—Continued.

Lines of the Chromospheric Spectrum.					Coincident Lines.				
Notes.		Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
						Spark.	Arc.	Sun.	
Coronal line not certainly visible upon this plate.		°							
1474		20±	1	5316.7	Fe			4	5316.790
		10±	00	5323.2	Fe			3	5322.227
					Fe		7	7	5324.373
		10±	0	5328.5	Fe		8	8	5328.236
					Cr			2	5328.515
					Fe ?			6	5328.722
	N d ?	10±	0	5339.5	Fe			6	5340.121
					Fe			7	5341.213
			00	5352.0	Fe Cr			3	5353.571
			00	5363.4	?			3	5363.058
					Fe			5	5365.069
					Fe			3	5365.596
			0	5371.2	Fe			6	5370.166
					Cr			4	5371.656
					Fe			3	5371.734
			00	5381.7	Fe			3	5379.775
					Ti Fe			2	5381.221
					Fe			6	5383.578
			000	5391.0	Fe			3	5389.683
					Fe			2	5391.660
					Fe			1	5391.820
					Fe			5	5393.375
			00	5397.0	*Fe*			7	5397.344
					Fe			1	5397.822
			00	5404.8	Fe			2	5404.028
					Fe			5	5404.357
					Fe			6	5405.989
			00	5408.6	Fe ?			2	5409.339
					Cr ?			4	5410.000
			00	5413.2	Fe ?			5	5415.416
	N		00	5433.2	Fe			2	5433.160
			00	5446.5	Fe			4	5445.259
					Ti			2	5446.797
					Fe			6 d ?	5447.130
			00	5456.0	Fe			2	5455.671
					Fe			4	5455.834
			00	5463.0	Fe			1	5463.174
					Fe			3	5463.494
			00	5476.9	Fe			3	5476.500
					Fe			3	5476.778
					Ni		20	5	5477.123
			000	5502.4	Fe			5	5501.683
			000	5513.0	Ti			2	5512.923
					Ca			4	5513.198
			0	5526.0	Fe			2	5525.765
					Sc			3	5527.033
			00	5535.7	Fe			2	5535.061
					Fe			2	5535.644
					Ba			0	5535.778
			000	5563.1	Fe			2	5562.933
					Fe			3	5563.824
			000	5570.0	Fe			6	5569.848
					Fe			6	5573.075
			0	5587.0	Fe		15	7	5586.991
			00	5598.8	Fe			1	5598.524
					Ca		7	4	5598.711
			00	5615.8	Fe			2	5615.520
					Fe			6	5615.877
			00	5624.8	Fe			1	5624.245
					Fe			4	5624.769
			000	5632.3	Fe			3	5634.171

TABLE III—Continued.

Lines of the Chromospheric Spectrum.					Coincident Lines.				
Notes.		Length.	Intensity.	Wave-length.	Origin.	Intensity.			Wave-length.
						Spark.	Arc.	Sun.	
		o							
			00	5639.5	Fe			3	5638.488
					Sc			1	5641.206
					Fe			2	5641.667
	N d?	12±	0	5658.9	Sc			2	5658.097
					Fe			4	5659.052
			000	5663.3	Fe			4	5662.744
					Ti			1	5663.155
					Fe				
					Y				
	N d?		00	5682.0	Fe			3	5679.249
					Ni			2	5682.427
					Na			5	5682.869
	N d?		00	5709.0	Fe			5	5709.601
					Ni			5	5709.775
					Mg ?			6	5711.313
			000	5750.0	Fe			2	5748.176
					Ni			2	5748.576
					Fe			4	5752.254
					Fe			5	5753.344
			000	5762.0	Fe			6	5763.218
			00	5783.5	Ca			7	5782.352
					Cr			2	5783.288
					Cr			3	5784.080
			000	5817.0	Fe			5	5816.601
			00	5854.3	Ba			5	5853.902
					Fe ?			2	5856.312
					Ca ?			8	5857.674
					Ni ?			3	5857.976
D_3		85±	15	5880.0	He$\dagger_3$	10			(5875.870)
D_2		20±	0	5890.2	Na			30	5890.186
D_1		20±	0	5896.0	Na			20	5896.155
			00	5918.0	Fe			3	5916.475
					Ti			0	5918.773
			000	5931.0	Fe			2	5929.898
					Fe			6	5930.406
			000	5958.0	Fe			4	5956.923
			000	5993.5					
			000	6020.5	Fe			4	6020.401
					Mn			6	6022.016
					Fe			7	6024.281
			00	6036.0					
			000	6056.5	Fe			5	6056.227
		12±	0	6162.0	Na			3	6160.956
					Ca			4	6161.503
					Ca			15	6162.390
			000	6185.5	Fe ?			5	6180.420
					Fe			1	6185.918
					Ni			2	6186.928
					Fe			4	6188.210
			00	6218.5	Fe			5	6215.360
					Fe			6	6219.494
			000	6239.0	?			3	6237.534
					Y			2	6238.598
					Fe			3	6240.863
	-1-		000	6246.0	Fe			8	6246.535
			000	6268.0	Fe			5	6265.348
					Fe			3	6270.442
			00	6280.0	Fe			3 d	6280.833
			000	6319.0	Fe			6	6318.239
			000	6335.5	Fe			6	6335.554
					Fe			7	6337.048
			000	6346.0	Fe			4	6344.371
					?			2 N	6347.310
			000	6495.0	Fe			8	6495.213
C		90±	20	6563.0	H$_\alpha$			40	6563.045

MISCELLANEOUS REPORTS

ON THE

TOTAL SOLAR ECLIPSE OF MAY 28, 1900.

OBSERVATIONS AT JULIETTE, GA.

REPORT OF PROF. C. W. CROCKETT, RENSSELAER POLYTECHNIC INSTITUTE.

I left Troy on May 9, intending to observe the eclipse at Barnesville or Forsyth, but upon my arrival at Macon it was suggested by Mr. C. A. CALDWELL, of that city, that I should go to Juliette, Ga., a small settlement about 23 miles northwest of Macon. Using the best map available, the position of Juliette was found to be, latitude $+33° 6'$, longitude $83° 48'$ west from Greenwich. With these values, a computation gave $1^m 26^s.6$ as the length of totality, indicating that this position was near the central line of the eclipse. I therefore decided to make my observations at that place. However, my latitude determination later showed that the assumed latitude was too great, and the observed length of totality was actually $1^m 18^s$.

The party as finally formed consisted of Profs. W. H. KILPATRICK and W. E. GODFREY, of Mercer University; P. J. CHRISTOPHER and J. B. HENSON, members of the senior class of Mercer University; C. A. CALDWELL, C. E., of Macon, and THOMAS HARROLD, C. E., of Americus, Ga., both graduates of Rensselaer Polytechnic Institute; Rev. JOHN G. HARRISON, O. H. CROCKETT, and ROY W. CROCKETT, of Macon; Mrs. C. W. CROCKETT; and the writer, in charge.

The instruments used were as follows:

(1) A FITZ 3.5-inch equatorial refractor, of 54.5 inches focal length, belonging to the Rensselaer Polytechnic Institute.

(2) A 4-inch equatorial refractor, belonging to Mercer University.

(3) A small reflector, belonging to Mercer University.

(4) A thermometer, belonging to Mercer University.

The work was assigned as follows:

Professor KILPATRICK and the writer were to observe the contacts, using the telescopes, and each was to make a drawing of half of the inner corona, if possible.

P. J. CHRISTOPHER was to count time for the first and second contacts, and to make a drawing of the fourth quadrant, trigonometrically, of the corona as seen with the naked eye.

J. B. HENSON was to count time for the third and fourth contacts.

Professor GODFREY was to superintend the counting of time, and also to make a drawing of the first quadrant of the corona as seen with the naked eye.

Messrs. CALDWELL and HARROLD were to make drawings of the second and third quadrants of the corona, respectively, as seen with the naked eye.

The drawings of Messrs. GODFREY, CALDWELL, HARROLD, and CHRISTOPHER, would thus cover the entire corona.

Mrs. C. W. CROCKETT was to make a drawing of the entire outer corona as seen with the naked eye.

Mr. HARRISON was to note the thermometer readings.

O. H. CROCKETT and ROY W. CROCKETT were to observe the shadow bands.

To facilitate the drawing I had obtained a number of pieces of heavy binding board 12 inches square, on each of which I had fastened a sheet of heavy white paper. In the center was drawn a blackened circle 1¼ inches in diameter, with lines radiating so as to divide the quadrants into 30° spaces. For the drawings of the inner corona the circle was 3 inches in diameter, but my experience proved that for use a smaller circle would have been better.

The morning of May 28 dawned with beautiful promise, the Sun rising in a cloudless sky, and we were early astir. After a hasty breakfast our instruments were conveyed in a wagon to the adopted site, on a hilltop about three-quarters of a mile from our headquarters, where there was an extended view in all directions. At 6 a. m. the instruments and observers were in position, and the few remaining minutes were utilized in practicing as preparation for the contact observations.

I used with my 3.5-inch telescope an eyepiece which gave a magnifying power of 38, the lowest that I had. Two shade glasses, one dense and the other lighter, were attached to the cap of the eyepiece by a long screw, eccentrically mounted, so that either or both of them could be pushed aside or used, as might prove desirable. I found it necessary to use the dense one at all times except during totality, when no shade glass was required.

The method of making the time observations was as follows:

Shortly before the contact was expected the timekeeper was told to count, after which he called out the number of each second, omitting the tens except at a multiple of ten, thus saying eight, nine, twenty, one, two, and so on. He continued counting until told to stop. At the telescope I watched the solar disk, listening to the counter, until I was certain that the contact had occurred and that the Moon's image was on that of the Sun, and then recorded the second at which I judged the contact took place.

The timepiece used was my Elgin watch, running on central standard time, but about 3 minutes fast. The results of its comparison with the Washington noon signal are given hereafter.

The first contact was observed by me at $6^h\ 35^m\ 1^s$, watch time, the observation being good.

A group of sun-spots, in the form of an angle with one leg much longer than the other, being visible, I decided to observe the time of bisection of the spot at the vertex by the advancing limb of the Moon, obtaining $6^h\ 56^m\ 42^s$ as the watch time of bisection.

For half an hour after first contact nothing peculiar was noted. About that time, however, the air began to get colder, and before totality the change was such that the ladies and children with the party put on their wraps which had been laid aside earlier in the morning. It also began to grow darker, but the light was still strong. In fact, with both the telescope and the naked eye, shade glasses were necessary in observing the Sun up to the instant of totality.

As the minutes sped by the light diminished, the landscape taking on a reddish hue that was strange and yet not unlike the appearance that is sometimes seen before a thunderstorm. The crescent grew smaller and smaller, and at last the timekeepers were notified that they should begin counting.

Just before totality the crescent divided into separate portions of light, the phenomenon known as BAILY'S Beads, and in a second or so the light suddenly disappeared, my recorded watch time being $7^h\ 41^m\ 59^s$. Throwing my shade glass out of the way, I observed the corona through the telescope. I then looked at it with the naked eye, estimated the extension to the right and upward to be about two apparent lunar diameters and that to the left and below about one. I also noticed an object near by which I afterwards identified as Mercury. Then I glanced at the distant landscape, noting that large objects could be seen clearly, and perhaps better than at the time of full Moon, although the light was more of a reddish hue than at that time. After this I turned once more to the telescope, looking at the inner corona. The text-books had led me to believe that in a short eclipse the inner corona would be very bright; however, I found the intensity much less than I had expected, for it was not as great as that of the Moon near the quarter. The glare from the quarter Moon, with the same telescope and eyepiece, quickly fatigues the eye, but here there was a sensation of rest. The color was pearly.

The image of the lunar disk did not quite fill the field of my instrument, but the latter unfortunately was not large enough to include the entire inner corona. I moved the telescope so that the following half, in the sense of the Moon's orbital motion, of the corona was visible, this being the portion assigned to me, and looked along the edge of the disk. Several prominences were visible, four I think, but my attention was at once drawn to two features whose appearance made me wish the eclipse would last much longer.

I was using an inverting telescope, and my description applies to the image as seen therein. In order to see the inner corona well I had to move the telescope so that only an arc of the lunar disk was visible, hence I found it difficult to estimate lengths and arcs. About 30° from the top and to the left were a number of lines or bands of light, covering an arc of perhaps 30° or more. These bands rose from the limb about at right angles to it and then curved over, resembling the upper half of a sheaf of wheat. They extended from the solar surface for a distance of about one-fourth of the lunar apparent diameter.

About 90° from the top of the image there was a petal-shaped formation, resembling a Gothic arch, with a prominence near the center of its base, by which its position may be more accurately determined. This formation extended from 30° to 45° along the lunar limb and projected from the limb a little farther than the polar streamers. The arch was symmetrical with respect to a radial line of the lunar disk, the bounding lines being more inclined to the limb than the streamers. Its edges were brighter than the inner portion, but the latter did not seem to have any markings.

The inner corona was uniform in appearance, with the exception of these two features, which were very pronounced.

About one minute after totality began Mr. HENSON commenced counting time, and I observed the third contact at $7^h\ 43^m\ 17^s$, watch time.

As soon as the least particle of the solar disk became visible there was a sudden burst of light. As Mr. HARROLD expressed it, it was as though some one had pressed the button of an electric light in a darkened room. The light then increased gradually, the temperature rose, and there was left only the task of observing the last contact, which I noted at $8^h\ 59^m\ 30^s$, watch time. My recorded time is 17^s earlier than that of Professor KILPATRICK; it is possible that the strain upon my eye, due to the fact that I commenced looking earlier than I should, may have caused the difference, but except for this possibility I consider the observation a good one.

LATITUDE AND LONGITUDE OF JULIETTE.

The latitude and longitude of the station were determined during the evening of May 28 by the writer, assisted by Mr. CALDWELL and Mr. HENSON, using an engineer's transit reading to 30″, made by W. and L. E. GURLEY, and loaned me by Captain WILCOX, city engineer of Macon.

The latitude was determined from a single meridian altitude of α Virginis, giving a value of $+33°\ 2'\ 42''$.

The longitude was found from five observed altitudes of β Geminorum, with the resulting value of $5^h\ 35^m\ 13^s \pm 0^s.8$ west from Greenwich, the watch correction being taken as $-3^m\ 12^s$ to reduce it to central standard time.

SOUTHERN LIMIT OF ECLIPSE.

While in Macon I made a computation to determine whether that city would be in the track of totality, using the location of the Government building, latitude $+32°\ 50'$, longitude $83°\ 38'$ west from Greenwich, and found that this position should be about a mile inside the track. When we returned to Macon I asked a number of citizens, who saw the eclipse from the streets near by, whether the eclipse was total, and they said it was "practically total." Their statements were that all of the Sun disappeared except a point of light, but upon inquiry it developed that they had not seen the corona.

SUMMARY OF OBSERVATIONS.

(1) A comparison of the watch with the Washington noon signal was made at the telegraph office in Macon on each day except May 28, when it was made at the railroad station at Juliette. Any error in the signal will, of course, affect the results.

Washington Noon Signal.	Watch Reading.		
	h	m	s
May 25	11	2	21.0
26	11	2	41.5
27	11	2	59.33
28	11	3	11.0
29	11	3	13.0
30	11	3	20.0
31	11	3	30.25

(2) The observed watch times of contact are as follows:

Contact.	Watch Time.
	h m s
I	6 35 1
Bisection of sun-spot	6 56 42
II	7 41 59
III	7 43 17
IV	8 59 30

(3) The latitude is dependent upon a single meridian altitude of α Virginis, as follows:

Observed altitude	46° 19′ 30″
Barometer	29.56 inches.
Thermometer	76° Fahrenheit.

(4) The longitude is derived from the following observations of β Geminorum:

Watch Time.	Observed Altitude.	
h m s	° ′ ″	
8 11 55	23 0 0	
8 13 49	22 36 0	Bar. 29.56 inches.
8 15 30	22 17 0	
8 17 7	21 58 0	Ther. 76° Fahrenheit.
8 18 3	21 47 0	

I sent a list of questions to the observers, and have received replies, of which the following are summaries:

PROF. W. H. KILPATRICK'S OBSERVATIONS.

Using a 4-inch equatorial, Professor KILPATRICK noted the following watch times of contact:

Contact.	Watch Time.
	h m s
I	6 35 0
Bisection of sun-spot	6 56 41
II	7 42 0
IV	8 59 47

Owing to the telescope being pointed at the Sun so long before contact took place, currents of air made the last contact difficult to get and very doubtful.

The third contact was not taken, the image of the Moon filling the entire field, and Professor KILPATRICK was intent upon examining the preceding side of the Moon, in the sense of its orbital motion, until too late.

The inner corona appeared to be of a pearly gold color, spreading uniformly around the lunar disk and extending out about half a radius or less. On the upper right hand, as seen in the inverting telescope, there was a flame-like prominence, and another on the lower right-hand side. On the lower right-hand side there were streaks of alternate brightness radiating from the center. He says he does not value his drawing very highly, for "it was very hastily and even carelessly done."

MR. P. J. CHRISTOPHER'S OBSERVATIONS.

Mr. Christopher was counting time at the first contact, and says he could not read the watch accurately during totality without artificial light, although he could see the pencil lines on his drawing pad.

Four readings of the thermometer were made by him, with the corresponding watch times, as follows:

Watch Time.	Temp.
h m	°
7 30	21.3 C.
7 39	20.3
7 45	19.7
8 1	20.5

In the fourth quadrant, trigonometrically, which he sketched, the bright lines of the corona extended nearly to the intersections of the circle with the horizontal and vertical radii. Coming out from the circle into this quadrant there seemed to be very dim white lines.

MR. THOMAS HARROLD'S OBSERVATIONS.

With reference to the approaching shadow, he says he did not see any defined shadow, but something like a huge dark cloud.

In the third quadrant, which he drew, there seemed to be two arms of the corona more prominent than anything else, one going pretty well down and the other to the left, and extending in length from 2 to 3 diameters of the Sun. The whole appearance was misty or hazy, and in the uncertain light it was difficult in the short interval totality lasted for a novice to make a very accurate sketch.

MR. C. A. CALDWELL'S OBSERVATIONS.

Mr. Caldwell's drawing was confined to the second quadrant. He says the corona in the upper right hand quadrant seemed to extend away from the Sun about 2½ or 3 times its diameter, and in the lower left hand about 2 times its diameter. In the others it was uniform and extended about three-fourths of the Sun's diameter.

PROF. W. E. GODFREY'S OBSERVATIONS.

Professor Godfrey was impressed with the gradualness of the approach of totality. Just before totality the darkness became that of dark twilight, and the thin crescent of the Sun diminished to a single point of light, appearing to the naked eye much like an electric light in darkness. The corona came out not suddenly, but very swiftly, seeming to glide into view, as though speedily brought from a distance into full view. It was of bright pearly light, about the intensity of the Moon near first quarter. Professor GODFREY was to draw the first quadrant, and notes that the corona extended about five diameters in the first and not so much in the third quadrant.

SHADOW BAND OBSERVATIONS.

A sheet was fastened at its corners to four stakes driven into the ground. The observers reported that the shadow bands, which did not appear until totality, were wavy and irregular rather than distinctly marked, that they were about the width of a man's hand, and that it was impossible to count them. They traveled toward the Sun.

None of the observers saw the corona before or after totality, and there were no stars seen, Mercury alone being visible. The attention of the observers was directed toward the Sun, so that stars may not have been noticed, although bright enough to be seen.

REPORT OF MRS. C. W. CROCKETT, TROY, N. Y.

The task of making a complete sketch of the outer corona was assigned to me; see PLATE XLIII.*

I had been provided with drawing pads, prepared by Professor CROCKETT, with a blackened circle in the center, 1¼ inches in diameter and divided into 30° sections, by radial lines extending to the edge of the board.

In trying to make a correct drawing of the outer corona in the short space of time available during totality, I had decided to adopt the well-known method used in drawing classes where five and ten minute sketches are made, in which a large portion of the time is spent in a careful study of the subject before the pencil touches the paper. This plan was followed strictly. I sat quietly and studied the corona with care before I began to draw, confining my attention, in spite of strong temptations to do otherwise, to my specific portion of the work.

As totality approached the Moon had no longer the appearance of a flat surface but seemed, as it truly was, a huge dark ball, hanging between us and the Sun. The darkness increased quite rapidly and took on a slightly reddish cast, giving a rather strange and weird aspect to the surrounding landscape. When the Sun's limb had become a small crescent, I rested my eyes for a moment; then, as the counting began, I raised my colored glasses, it being impossible to look at the Sun at any time without them until the eclipse had become total. I had fully expected to see some radiations on the farther side of the Moon's disk, suggestive of the corona, but nothing of the sort appeared until the last point of light on the Sun's limb went out. Then, in a flash, out streamed the blazing corona. It was as though an immense jewel had suddenly flashed out in the sky, with its dark center and surrounding halo and radiating streamers of light, and the desire to do nothing but gaze was almost irresistible.

The first step was to notice the general form of the outline, which was that of a four-rayed star, with an irregular shortening of the lower ray on the left of the Moon,

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*The original drawing was lost at the office of the engraver before the plate was made.

and the marked difference in length between the rays of the right and left wings. Then a quick comparison was made between the Moon's apparent diameter and the distances to the outer points of the corona, and these points were noted on the drawing board. Next the form of the right-hand portion of the corona was carefully studied and sketched, and then the same method was followed with that on the left of the Moon. After this, was drawn the outline of the narrow rim of light which appeared near the Sun's poles, and which was probably a portion of the inner corona, being much brighter than the wings.

This being done, a few seconds were still left for comparisons, in which time special study was made of three points. First, there was the general outline. Second, there was the bulging appearance at the base of the outlines of the right-hand wing, for here the edges of this wing were so bright that they could be distinctly traced to the Moon's limb, and at the points of meeting the limb there was a marked curvature. This feature has not been represented in any of the drawings which have come to my notice. Third, there was a peculiar projection of light on the lower right-hand side of the lunar disk, somewhat triangular in form.

Up to this point I feel justified in speaking with a certain degree of confidence concerning the work, since the observations had been so strictly confined to the specific line assigned. Nevertheless, it would be impossible to gaze so intently at any object without receiving some general impressions.

The inner corona immediately surrounding the Moon's disk was of an intense white light, having a slightly yellowish tinge at its outer edge. It seemed to surround the Moon like a halo and was to the naked eye of comparatively uniform breadth, extending out to a distance equaling about one-quarter of the Moon's apparent diameter or a little less. The inner corona seemed distinct from and brighter than the wings, which spread out on either side from the equatorial regions of the Sun with a beautiful yellowish pearly light.

It was impossible in the short time to make a careful study of the whole outline of the inner corona, but I tried to draw a faithful representation of the portions which appeared at the Sun's poles between the wings. There was difficulty in deciding at just what distance from the Moon's limb the rays of light faded into darkness, and I am convinced that I drew my line a trifle inside the outermost points. With a brush and color I felt sure that I could have made a much better representation of what was seen.

It was unnecessary to use the colored glasses during totality except for an instant when I found that the steady gazing was fatiguing the eye a trifle. The light at the time was such as to enable me to see the pencil lines on my drawing board, and the impression was that of a clear late twilight.

As we looked in almost breathless admiration, trying to impress every detail upon our memories, the beautiful corona disappeared, as it came, in a flash, and the tiny crescent of the Sun's disk crept slowly into view, leaving us to think the beautiful apparition a dream or a creature of our own imaginings, were it not for the faint likeness we had left on the insignificant sheets of paper which we held in our hands.

OBSERVATIONS AT MILLEDGEVILLE, GA.

REPORT OF MR. GEO. D. CASE, MILLEDGEVILLE, GA.

The period of total eclipse at this place, carefully taken with a racing watch, was exactly fifty seconds.

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OBSERVATIONS AT UNION POINT, GA.

CONDENSED FROM REPORT OF MR. A. J. HARDING, CHICAGO, ILL.

Location.—Starting from the northeast corner of the stone depot of the Georgia Railroad; thence due east 145 yards to the (stone) seventy-sixth milepost from Augusta on said railroad; thence south 78° east, 87 yards to the east line of Academy street; thence north 12° east, 252 yards along the east line of said street to new brick unfinished Presbyterian church. The observations were made from the east windows of the church, 60 feet east of the street line.

Timepiece.—An E. HOWARD & Co. watch, with the latest improved movement.

Instrument used.—A field glass, made by LAVAL, of Paris, magnifying nine times, clamped to a post, so arranged as to admit of both vertical and lateral movement. The times indicated by watch at reception of the Washington noon signal were as follows:

Date.	Time.		
	h	m	s
May 26	10	59	33
27	10	59	33+
28	10	59	33+
29	10	59	33.5

By special arrangement time was furnished by the telegraph company on Sunday the 27th, as well as Saturday, Monday, and Tuesday. Time was taken in the telegraph office, Union Point, on the 26th, 27th, and 28th, and in Cincinnati on the 29th..

The times of contact as read from the face of the watch without correction, noted with as much care as possible, were as follows:

Contact.	Watch Time.		
	h	m	s
I	6	33	41
II	7	40	57
III	7	42	28
IV	8	58	22

The time observer was Mr. CHARLES JACKSON, an undergraduate of the State University at Athens, Ga., wholly without experience, but in practice the day previous his work was fairly accurate.

REPORT OF THE CREIGHTON UNIVERSITY ECLIPSE EXPEDITION.

By Rev. WILLIAM F. RIGGE, S. J.

The work undertaken was the accurate observation of the four contacts, the determination of the latitude and longitude of our position, and the taking and subsequent enlarging of photographs of the corona.

The Creighton University eclipse party consisted of Rev. WILLIAM F. RIGGE, S. J., of Creighton University, Omaha, Nebr.; Rev. CHARLES CHARROPPIN, S. J., and Prof. ALOYSIUS FRUMVELLER, S. J., of St. Louis University, St. Louis, Mo.; and Prof.. WILLIAM P. QUINLAN, S. J., of St. Xavier College, Cincinnati, Ohio. Father CHARROPPIN used a 3.5-inch telescope visually and superintended the photographic part of our program, which was under the management of the other two members of our party. They had six cameras mounted upon the same support and secured about 20 photographs.

Our station was in Washington, Wilkes County, Ga., upon the grounds extending between St. Joseph's Male Orphanage and St. Joseph's Academy, at the western end of the town. Between these two institutions were a Catholic church and a pastoral residence. The order of the buildings was such that the orphanage was at the northern end of the grounds; then came the residence, then the church, and lastly the academy at the southern end. My station was upon the private walk connecting these four buildings, halfway between the northwest corner of the church and the short walk leading to the residence. I was alone during the eclipse. My object in isolating myself was to preclude all possibility of my being prejudiced by what I might see or hear others do.

From my position I could see the country for about a mile to the westward, but buildings and trees limited my view in the other directions. Toward the east, however, where the Sun was, I could see to within a few degrees of the horizon.

INSTRUMENTAL OUTFIT.

My instrumental outfit consisted of a telescope of 3 inches aperture and about 3 feet focus, and an excellent chronometer, H. H. HEINRICH No. 502, beating half-seconds.

WEATHER.

The sky was perfectly clear during the whole duration of the eclipse, except for a bank of stratus clouds low down in the southeast and south.

METHOD OF OBSERVING.

My method of observing the exterior contacts consisted in projecting the Sun's image upon a white screen made of wood and cardboard and secured by two light wooden rods to the telescope beyond the eyepiece. I prefer this method to the usual one of direct vision in the telescope by means of a sunshade or helioscope, because it does away with the heat and glare of the Sun, because it admits of the use of both eyes, and especially because it enables the observer to mark the point of first contact upon the screen and accordingly to concentrate his whole attention upon this important point.

The projected image of the Sun upon the screen was made as large as the light-gathering power of the 3-inch telescope allowed. It was about 4½ inches in diameter and was protected against the stray light of the Sun, which streamed down parallel and along the tube, by a cardboard screen secured to the objective.

As the telescope was not provided with clamp and slow-motion screws, the tube was moved by hand at short intervals in order to keep the image concentric with the diagram on the screen.

OBSERVATION OF FIRST CONTACT.

About five minutes before the computed time of first contact I brought the telescope out of the cottage and set it up. As I knew the correction to the chronometer within a few seconds, I did not fatigue my eyes unnecessarily. When the moment of contact actually came I am sure I was not more than 2 or 3 seconds late in observing it. I then took the telescope and chronometer into the cottage again in order to screen them from the Sun's heat.

THE TOTAL PHASE.

About ten minutes before the beginning of totality I set up the telescope again. Upon a small table near by lay the chronometer, a 1⅝-inch inverting telescope, etc.

The two wooden rods and the screen used in observing the first contact had been removed from the telescope, and the instrument was directed to the Sun and the progress of the eclipse watched upon a piece of white paper held by hand beyond the eyepiece.

During the last five seconds preceding the total phase the sunlight diminished rapidly. I was facing south 60° west, the point of the horizon from which the shadow was to come, and expecting to see a dense black cloud, the Moon's shadow, in the sky or on the landscape, but there was nothing of the kind visible.

The moment of totality was observed without the telescope while my back was turned to the Sun. Although I had taken up the beat of the chronometer, I looked instantly upon the face of the timepiece, and I am certain I was not more than half a second late. After a few moments of a naked-eye view I turned to the 3-inch telescope, but as I could not get a focus with it, I quickly picked up the small 1⅝-inch telescope. The unsteadiness of the image made me abandon that, too, after a little while, and I devoted the remaining few moments to a naked-eye view of the corona, the sky, and the landscape.

A sudden burst of sunlight, and I turned instantly to the chronometer and noted the time to the nearest half-second. After writing this in my book I at once carried telescope, chronometer, table, and everything into my room and, closing the door and not speaking to anyone, while the impression was still vivid, sat down and wrote the following remarks in my observing book.

VERBATIM COPY OF REMARKS IN OBSERVING BOOK.

Mercury was very brilliant, much brighter than Venus at her best, perhaps 100 per. cent brighter. α Tauri not seen. Venus was seen brilliant low down in the east for about five minutes after totality ended.

The suddenness of the beginning and of the ending of totality was by no means startling. The second could easily have been missed. The sunlight diminished rapidly about five seconds before totality.

The sunlight illumined the stratus clouds along the horizon east and south. Plenty of light to read the chronometer, about equal to twilight about ten minutes after sunset, except that it was all around the sky uniformly. The sky illumination was fine, like stage illumination with hidden lights. It could certainly not be called night.

The 1⅝-inch telescope gave a good view, but a small one. There were curved streamers bending away from the solar poles, and something like broad cloven streamers at right angles to the Sun's axis. They extended not more than a Sun's diameter on either side. The height of the polar streamers was only a semidiameter.

There was nothing startling or terrible about the whole affair; to me it gave only an impression of great beauty.

Only about three or four prominences were seen in the region of the sun-spots. The color of the prominences was a strong red, but they were small in my telescope.

The corona had very little color to my eye.

The onrush of the shadow was not seen.

No shadow bands were seen.

The illumination of the horizon seemed to be the same during totality as in full sunlight.

THE LAST CONTACT.

The last contact was observed in the same way as the first had been observed. The full image of the Sun was kept upon the cardboard screen, in order the better to note its circular shape and watch the Moon's egress. The moment of last contact was observed probably within a second.

THE CHRONOMETER.

The chronometer was the box chronometer, H. H. Heinrich No. 502, beating half-seconds. It was kept upon the chimney-piece in my room, and wound every night at the same hour. It showed central time, and its ordinary daily rate was about 9 seconds gaining.

The correction and actual rate were obtained from the seventy-fifth meridian noon signals at the railroad depot. This building was about five minutes walk from our headquarters. The chronometer was carefully carried to the depot and back again in a sling made of a handkerchief. In turning corners great care was exercised in turning the timepiece, about 5 seconds being consumed in a quarter of a revolution.

The chronometer times of the noon signals were as follows:

Date.	Chron. Time.
	h m s
May 26	10 58 58.8
28	10 59 13.0

Special inquiry at the Time Service Department of the U. S. Naval Observatory, Washington, D. C., brought the prompt reply that the signals were $0^s.04$ late on May 26, and $0^s.02$ early on May 28. These corrections are inappreciable in the above comparison of my timepiece.

The Times of the Four Contacts.

	I	II	III	IV
	h m s	h m s	h m s	h m s
Chronometer face	6 32 30.	7 40 2.	7 41 28.	8 58 31.
Correction at $11^h 0^m$	+47.0	+47.0	+47.0	+47.0
Rate to observed time	+ 1.3	+ 1.0	+ 1.0	+ 0.6
Central time	6 33 18.3	7 40 50.0	7 42 16.0	8 59 18.6

LATITUDE AND LONGITUDE OF STATION.

Mr. WILEY G. TATOM, the surveyor of Wilkes County, sent me the following bearings and distances connecting my station with that of the Massachusetts Institute of Technology:

	Bearings.	Distances in Chains.
1	S. 66° E.	5.00
2	S. 86½° E.	43.60
3	S. 5° W.	28.00
4	S. 60° E.	7.30

The position of the Massachusetts Institute of Technology station has been kindly furnished to me by Mr. GEORGE L. HOSMER, who determined it with a 2-inch combined zenith telescope and transit instrument. Hence the following position is deduced for my station:

	Latitude.	Longitude.
	° ′ ″	h m s
Massachusetts Institute of Technology Station......	+33 43 49.	5 30 56.2
Reduction..........	+23.7	+ 2.71
Creighton University Station......................	+33 44 13.	5 30 58.9

COMPARISON OF COMPUTED AND OBSERVED TIMES OF CONTACTS.

As soon as the true coordinates of my position became known to me, I recomputed the times of the phases and obtained the following results:

Central Time of Contacts.

	I	II	III	IV
	h m s	h m s	h m s	h m s
Computed...........	6 33 17.0	7 40 57.1	7 42 23.0	8 59 29.8
Observed............	6 33 18.3	7 40 50.0	7 42 16.0	8 59 18.6
C—O...............	− 1.3	+ 7.1	+ 7.0	+11.2

CREIGHTON UNIVERSITY SUPPLEMENTAL PARTIES AT MACON AND MOBILE.

Owing to the very favorable situation of Macon, Ga., and Mobile, Ala., near the southern border line of the shadow path, Rev. EDGAR J. BERNARD, S. J., of St. Stanislaus College, Macon, Ga., and Rev. A. L. WAGNER, S. J., of Spring Hill College, Mobile, Ala., at my suggestion, organized and drilled parties of students to observe the duration of the total phase. The results are as follows:

At Macon, Ga., 100 yards west-southwest of main building of St. Stanislaus College, the mean result from 8 observers for the duration of totality is 34ˢ.45.

At Mobile, Ala., on the top of the college building of Spring Hill College, latitude +30° 40′.9, longitude 88° 8′.7 west, the mean result from 15 observers for the duration of totality is 38ˢ.40.

OBSERVATIONS AT WADESBORO, N. C.

CONDENSED FROM REPORTS OF MR. O. J. BOND AND PROF. J. T. COLEMAN.

Under the direction of Mr. O. J. Bond, instructor in astronomy, and Prof. J. T. Coleman, a number of students of the South Carolina Military Academy observed the eclipse at a point about a half mile north of the court house of Wadesboro, N. C. Two parties of four each were assigned to draw the corona and one student was instructed to carefully observe the form of the entire corona and make a sketch of it immediately after totality. The reproduced drawings, Plates XLIV and XLV, are the results of the collected quadrant drawings. The two students assigned to draw the north polar region duplicated the work of the two students assigned to the south polar region, thus leaving the north polar region undrawn.

One observer observed the duration of totality as 93 seconds, using a telescope of 2.5 inches aperture and 3 feet focal length for the second contact and the unaided eye for third contact. A stop watch was used.

During totality it was not markedly dark. Mercury and Venus were seen, but very few stars were visible.

A party of eight students under Professor Coleman made observations of the shadow bands. These bands were visible about one minute before and one minute after totality. The width of the bands was from 1 to 2 inches; the interval between them, from 4 to 5 inches. The general direction of the bands was northwest to southeast, before and after. They were described as indistinct at first, but more distinct afterwards, and as being wavy, writhing, zigzag, irregular, flickering, complicated. As to motion in loco they were described as vibratory, quivering, swaying, dancing. As to progressive motion the evidence is conflicting. Every member of the party had as a strong mental suggestion that there would be a distinct progressive motion. Two reported a motion eastward, one was at first unable to decide on any progressive motion, but finally decided they were moving westward at a velocity of not more than 2 feet per second; but the majority of the observers did not detect any motion.

OBSERVATIONS AT WAKE FOREST, N. C.

REPORT OF PROF. J. F. LANNEAU, WAKE FOREST COLLEGE.

The place of observation was College Observatory; bearing from Wake Station of Seaboard Air Line Railroad, north 20° west; distance 342 yards. The timepiece was a watch used by our railroad agent. The telescope was of 5 inches aperture, 6 feet focal length, used with a power of about 50.

Comparisons of watch with noon signals:

Date.	Watch Time.
	h m s
May 25	11 59 41
26	11 59 43
28	11 59 35

Times of Contacts.

Contact.	Watch Time.
	h m s
I	7 38 40
II	8 48 22
III	8 49 20
IV	10 9 9

The first contact occurred probably one or two seconds before noted; the others just as noted.

A student assistant, Mr. John B. Powers, well practiced some days before, marked the times of contact at my call. He was careful and fairly precise.

By a strange oversight the watch was not wound at the usual time on the 27th, but much later, about 2 a. m. on the 28th.

Telescopic view of the corona.—At the base of each equatorial coronal streamer was an immense, twisted, whitish prominence. The polar rays were most remarkable. They were beautifully symmetrical, very bright, in clear-cut pairs, curving gracefully to either side. The pair at each pole, broader at the base and longer than the others, reached out a distance, perhaps, one-fourth of the Sun's diameter. Those at the south pole I fancied stronger than their northern mates; it may be because they were seen in the upper part of the field and were kept nearer the center of the field. In symmetry and curvature they seemed counterparts, on a grand scale, of the familiar lines of force of a strong magnet. A powerful electro-magnet, so powerful that its lines of force should, if possible, become luminous, would feebly simulate what was seen about the solar poles, extending, in lessening lengths, either way to the base of the coronal streamers.

I add the temperatures noted:

At first contact	70° F.
At 8.30 a. m	80
At second contact	74
At third contact	71

The shadow bands were too indistinct and rapid to allow of measurement except as to direction. Before totality they moved north 5°.25 east; after totality they moved south 57°.75 west.

OBSERVATIONS AT KELFORD, N. C.

A private expedition to observe the total solar eclipse of May 28, 1900, was located at Kelford, N. C. At this point the railroad follows the middle line of the shadow path for some miles. The town of Kelford is 74 miles below Norfolk, Va. The members of the expedition were Prof. GEO. A. HOADLEY, Mr. CHAS. H. BEDELL, Prof. FERRIS W. PRICE, and Mr. ARTHUR T. COLLINS, all of Swarthmore, Pa. The objects of the expedition were (1) photographing the corona, (2) a determination of the position of the coronal line, (3) observation of shadow bands, and (4) temperature readings during the time of the eclipse.

The photographic work was in charge of Professor HOADLEY and Mr. BEDELL. A 3-inch telescope objective of 47 inches focus was mounted in a camera box, with the photographic plate at the focus of the lens; the whole was mounted on a polar axis, which was operated both in right ascension and declination by screws driven by hand. A method suggested by Mr. BEDELL of using a photographic screen was employed, by which it was thought the light from the inner corona and prominences could be cut down in its effect, and by this means a photograph of both the inner and outer corona could be obtained on the same plate. The screen in question was made on a photographic film, by revolving a sensitive plate behind a star-shaped opening cut in cardboard, the center of the opening being the exact size of the Moon's image, and the points of the star extending about one diameter outside the Moon's disk. By a suitable contrivance the Moon's disk was kept central on the screen plate, which was placed just in front of the photographic plate.

Four exposures of one-fourth second, one-half second, one second, and one and one-half seconds respectively were made with the screen, and two exposures of one-fourth second and one-half second respectively without the screen. Owing to some mischance, the plates used were chemically fogged before they came into our hands, which injured to some extent their clearness; but even with this drawback the negatives show prominences of the horn variety, and quite an extent of the corona with polar streamers well marked. We are not sure that the photographic screen was of any advantage, as the best negatives were the ones obtained without the screen. The plates used were 5 by 7 double-coated nonhalation.

A micrometer measurement of the coronal line 1474 *k* was made by Mr. COLLINS, using a spectroscope containing one compound RUTHERFORD prism by BRASHEAR, and a collimating and telescope lens 1⅛ inches in diameter and 12¼ inches in focal length. The construction of the prism allowed the full beam of light to enter and emerge. The telescope objective was 1¾ inches in diameter, $\frac{f}{a}=13$.

This was fastened to the collimator at the focal distance and all mounted on a polar axis and driven by hand. Before totality, the pointer of the micrometer was set on λ5317 (1474 *k*) and the reading taken. A radial slit was used at the point of second contact. At the instant of second contact all the dark lines in the field of view flashed bright and the field extending from λ5900 to λ4900 for probably one and one-half seconds. The different lengths of the lines were noted. Most of the lines appeared as bright dots, while others appeared to be one-fourth of an inch in length. The line λ5317 was bright in common with others but faded out, and the true coronal line appeared just above it, toward the violet. This, too, faded out before a setting of the micrometer could be made. The slit of the spectroscope was then opened to allow more light to enter, and the line at once appeared. The pointer was moved up to the middle of the line and allowed to remain there until sunlight came again. The difference in reading makes the position λ5304±0.58. The large probable error is due to a too wide setting of the slit, which could not be readjusted on account of lack of time.

Observations of shadow bands were made by allowing them to fall on a sheet stretched tightly on the ground. Upon this was placed a strip of black paper, on which were laid off feet and inches in white extending in the direction of the path of the shadow; also a north and south line in black. A camera was placed on an extended tripod in such a position as to take in the whole surface of the sheet. On the appearance of the bands we found them quite too indistinct and fleeting to even attempt to photograph. On their second appearance dowel pins, painted black, were laid down in positions that represented, as nearly as possible, the distance of the bands apart and the direction of the crests. These, when the Sun came out, were photographed as they lay. They show that the distance apart of successive crests was about 7 inches, and the direction of the crests was normal to that of the Moon's shadow. The movement of the shadow bands was in the direction of the Moon's shadow in both instances. The crests were short and of different lengths, varying from 6 inches to 18 inches, and followed each other irregularly across the sheet at a speed of probably 10 feet per second.

OBSERVATIONS AT AHOSKIE, N. C.

REPORT OF THE LEHIGH UNIVERSITY ECLIPSE PARTY.

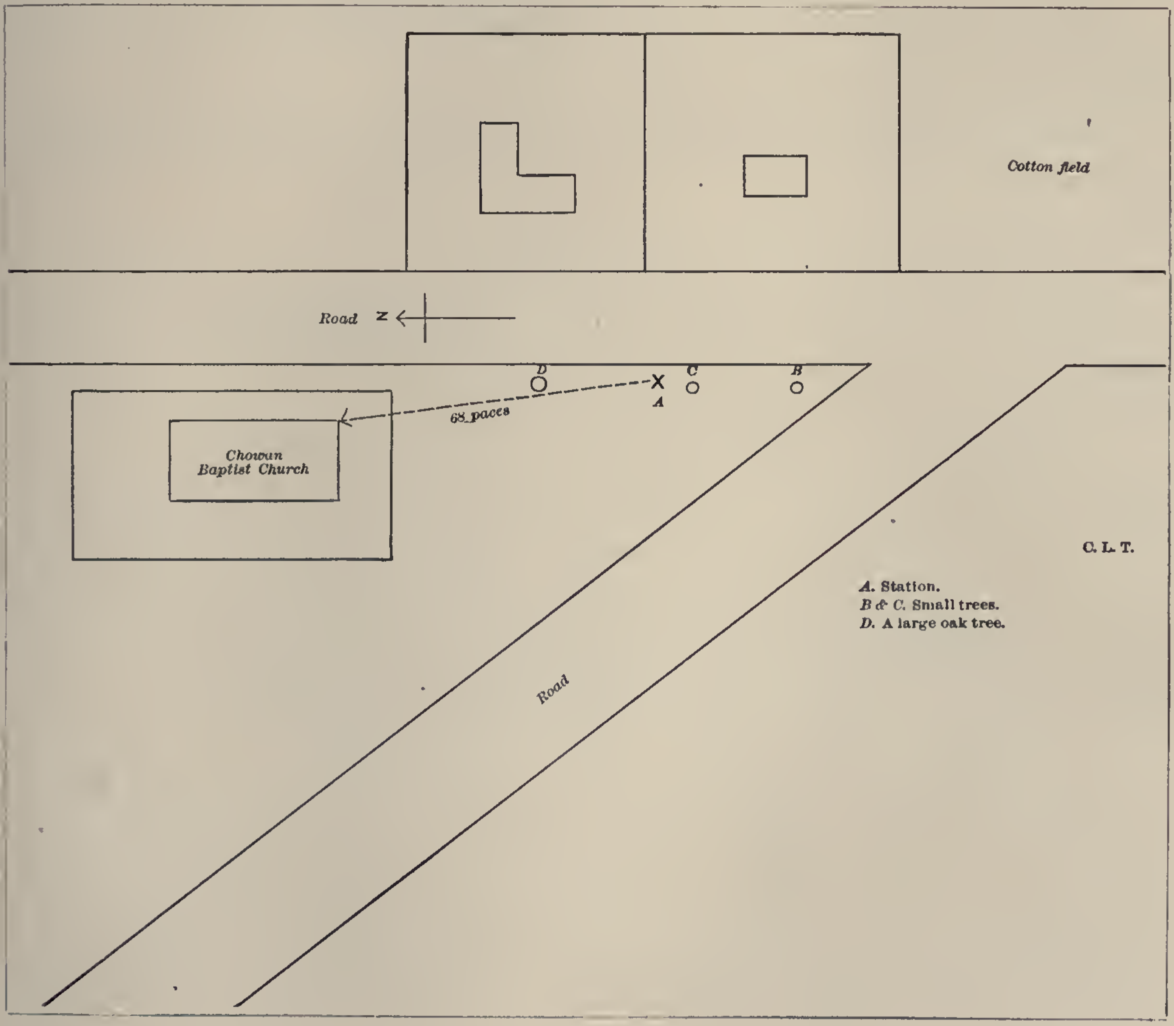
By Professor C. L. THORNBURG.

The party consisted of MANSFIELD MERRIMAN, professor of civil engineering; WILLIAM S. FRANKLIN, professor of physics and electrical engineering, and CHARLES L. THORNBURG, professor of mathematics and astronomy.

The position of Ahoskie, determined by scaling from the map in the Total Eclipse of the Sun, Supplement to the American Ephemeris, 1900, is

$$\text{Latitude} = +36^\circ\ 17'\ 21''$$
$$\text{Longitude} = 5^h\ 8^m\ 0^s \text{ west from Greenwich.}$$

The following sketch shows the environs of the station:



Observations were made of the first and last contacts, the shadow bands or fringes, and the corona.

CONTACTS.

The first and last contacts were observed by Professor THORNBURG with a field glass, made by CHEVALIER, Paris, having an aperture of 2 inches, and a focal length of 7 inches, and magnifying about five diameters. The instrument was steadied by holding it against the side of an elm tree.

Professor FRANKLIN noted the time on a mean time Elgin watch, and Professor MERRIMAN recorded the time.

Times of Contacts.

Contact.	Greenwich Mean Time.
	h m s
I	0 39 56.2
IV	3 12 24.6

The first contact took place before noted and was estimated to have occurred five seconds before the notch in the Sun's limb was first observed and this amount is accounted for in the time given above.

The limb of the Sun at the time of the first observation was clear and sharp, but in the last one it was a little unsteady.

SHADOW BANDS.

The weather was perfectly clear and remained so all day long, with scarcely any perceptible breeze during the progress of the eclipse; temperature about 60° to 65° Fahrenheit. Three or four minutes before totality began we could feel it growing sensibly cooler with a very slight breeze from the southeast.

Particular attention was directed toward securing observations of the shadow bands. A white sheet was placed on the ground with its edges directed toward the four points of the compass, and by tying strings to its corners and fastening them to stakes driven in the ground it was drawn down flat and smooth to the surface of the earth. The bands did not appear to our vision until about thirty seconds before the beginning of totality, and they lasted about the same length of time after totality. Their direction of motion was marked by placing a lath on the sheet, having the same direction as that in which the bands appeared to travel. The direction of the bands was estimated to be at right angles to their direction of travel. They were discontinuous upon the sheet, appearing as short, darkish lines which had no permanence of duration or length; some of them seemed to be slightly curved; they moved so rapidly that it was not possible to count the number passing a rule lying on the sheet in a given time or to measure with any degree of accuracy their distance apart. The distance apart was estimated to be from 6 to 12 inches, and their speed from 10 to 20 feet per second. The appearance of the sheet as the bands flitted over it was very much as if an irregular wave motion had been imparted to it by slightly tapping it, while taut, at many points, simultaneously. The direction of motion and other circumstances after totality were apparently the same as before. The direction of travel was in general the same as that of the central line of the shadow path of the Moon on the Earth's surface. The direction of the lath placed to mark the direction of travel of the bands, as determined by a pocket magnetic compass made by DOLLOND, London, was north 51° east, magnetic variation not being allowed for.

The feeling of the members of the party with reference to the observed phenomenon of the bands was that of great disappointment, as they were totally unprepared, by previous descriptions of the shadow bands, for the actual realization of what was observed.

CORONA.

PLATES XLVI, XLVII, and XLVIII are reproductions of drawings of the corona by the members of the party. These drawings were made at 3 p. m. May 28, 1900, by the several observers, each from his own sketch made at the time of the eclipse.

OBSERVATIONS AT BOONE STATION, WINTON, N. C.

REPORT OF MISS ANNE S. YOUNG, MOUNT HOLYOKE COLLEGE OBSERVATORY.

The telescope used had a focal length of 3.5 feet; its aperture was reduced by a cap from 3.25 inches to 2.5 inches; the magnifying power employed was about 67.

My timepiece was an Elgin watch. Tests that I made near the time of the eclipse showed a slightly variable rate. The time indicated by the watch at the reception of the noon signals was as follows:

Date.	Watch Time.
	h m s
May 26	11 59 46
28	11 59 22

The times of the contacts were recorded as follows:

Contact.	Time.
	h m s
I	7 39 32
II	8 50 15 (25?)
III	8 51 57
IV	10 12 32.5

The recorded time of the first contact may have been a little more than two seconds late. I used a red shade glass for the first contact. I think this confused me in the observation of the second contact, and that the first record is the correct one. There is no uncertainty about the third and fourth contacts.

REPORT BY MISS MARY E. BYRD, SMITH COLLEGE OBSERVATORY.

This station was located, with reference to the meridian posts on the court-house square, south 34° west 949 feet; thence south 56° east 756 feet. This description was given by Mr. J. F. Newsome, clerk of Hertford County, who surveyed Winton in 1874.

Aperture of telescope was 2.5 inches, focal length 37 inches, and magnifying power 24.

As the rate and error of the Elgin watch used were not satisfactorily obtained, only internal contacts are reported.

Contact.	Time.
	h m s
II	8 47 45
III	8 49 30

For third contact "Mark" was called twice, first when the limb of the Moon seemed to be growing brighter, but as the corona was still seen distinctly, three seconds later perhaps, before there was time to record, the signal was given which corresponds to the time entered above. Even after that the corona still persisted several seconds.

Dark smoke-colored spectacles were used for shade glasses.

The upper half of the inner corona, determined approximately by cross threads in the negative eyepiece, was roughly divided into halves by the polar streamers. The part to the right seen with the low power of 24 showed definite boundaries, with a circular outline very regular in contour, and extending beyond the Moon one-third of its diameter. It gave a vivid impression of thickness, as if one were looking upon a deep layer of filaments of light. At the extremities the appearance was like that of a fine brush. Thickness and brush effect were not so clearly marked to the left of the streamers. There the corona was not so circular in outline, and its radial extent was estimated to be one-third plus of the Moon's diameter.

In both these sections the straight-line structure was apparent, as if countless radii of the Sun had been prolonged outward.

The polar streamers were to the left of the vertical cross thread, about at right angles to the Sun's direction of motion through the field. Their curvature was strongly marked, with lines of irregular direction, so that here and there they crossed one another. They were estimated to extend beyond the Moon one-half of its diameter, narrow and bunched at the base, but with an open feathery effect at the outer boundary.

The lower half of the corona received only the casual notice, which could hardly be avoided, as it was in the field of view. Its outline was certainly less regular than the upper part, at one point coming very near the Moon's limb, and the polar streamers were less prominent. One of the three great prominences, pink in color, was low down on the right. The other two were rose red and to the left, not far below the Sun's horizontal diameter. The larger of this pair was estimated to be a quarter of the Moon's radius in height.

The positions up, right, and the like, refer to directions in the common inverting telescope.

OBSERVATIONS OF SHADOW BANDS.

Sheets were placed on the ground with two edges lying approximately north and south as determined by compass. Less than a minute before totality, shadow bands were seen. They were very narrow, faint at first but more distinct later. They were not straight, but decidedly curved, following the outline of a semi-ellipse, about 3 feet in diameter. They moved too rapidly to be counted, traveling from southwest to northeast, in the same direction as the wind, as determined by the smoke of a bonfire in sight. No shadow bands were seen after totality.

Observations were made by Miss Eppie Brown and Mr. Vivian Ward, of Winton.

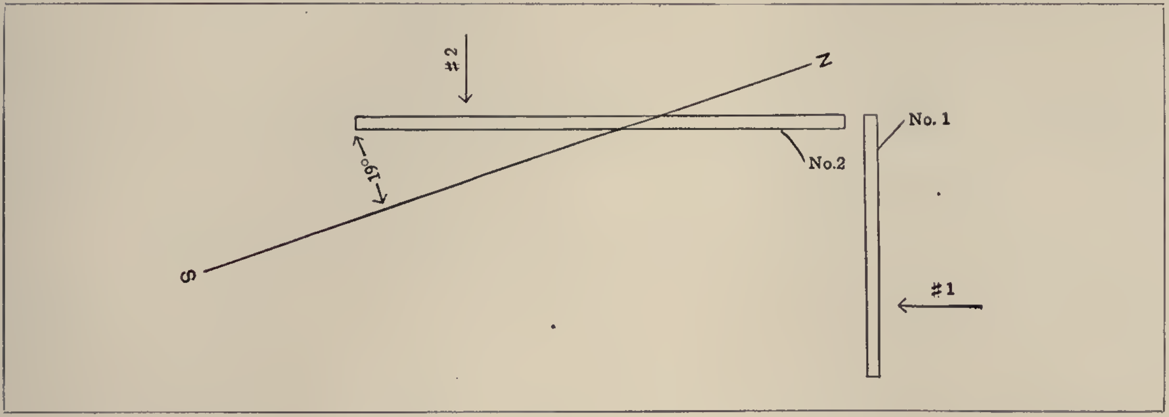
OBSERVATIONS AT POINT BREEZE, VA.

REPORT OF MR. O. P. LOOMIS, NEWPORT NEWS, VA.

The location of Point Breeze, as given by the chart of the James River and Hampton Roads issued by the U. S. Coast and Geodetic Survey, 1891, is

Latitude =+36° 57′ 51″
Longitude = 76° 24′ 48″ west from Greenwich.

A large white sheet was spread on the sand about half an hour previous to the eclipse, and a number of lath strips provided in readiness in accordance with the suggestion of Prof. R. W. Wood, of the University of Wisconsin. Less than a minute before totality these bands made their appearance, and lath No. 1 in the sketch below was laid parallel with them. Arrow #1 shows the direction of motion.



Just after totality the shadows were observed again, and contrary to expectations were observed to move at right angles to the first direction, and lath No. 2 was laid parallel with them. Arrow #2 shows their second direction. These shadows were not noticed during totality, but may have occurred and been missed, as my attention was taken up with the eclipse itself.

The north and south line was taken with a small compass having a dial graduated to degrees. This line formed an angle with the second lath of 19°, but an allowance of about 4° must be made for the magnetic variation in this vicinity. This will reduce the angle shown to about 15°.

The width and general appearance of these bands was very disappointing. It seemed next to impossible to measure them. I had provided a long white stick graduated to half feet, but it was useless, or at least in the limited time I was unable to make any comparison. The shadows seemed to flit across the sheet, rather hazy and difficult to see on close inspection. I should roughly estimate that they were about half an inch wide; this opinion was concurred in by at least one other person. I should also estimate that they were separated by a space of 3 inches. As to the velocity, it is difficult to even guess, but by making rough comparisons in my mind would call it between 15 and 20 feet per second.

The atmosphere was absolutely clear, not even a speck in the sky. I could look across the James River with ease. There was little or no wind.

The time of totality was calculated to be about 32 seconds. The time recorded by Mr. W. A. POST at the telescope was 34 seconds.

OBSERVATIONS AT BERKELEY, VA.

REPORT OF MR. FRANK H. LOUD, HAVERFORD, PA.

I observed at a point outside the village of Berkeley, Va., a little south of Norfolk. In a vacant lot, overgrown with grass and weeds, I spread down a sheet, fastened to the ground at the four corners and four intermediate points by tags sewed to the sheet and wrapped around spikes driven into the ground. The surface was, on the whole, level and fairly smooth. In the middle of the sheet was sewed a button, to which I attached lengths of colored twine, long enough to reach beyond the sheet and to be fastened to the ground by nails tied at their ends. I regarded this as quite as expeditious as a method of using rods, and less likely to be disturbed. After the eclipse was over I tacked the twine to the sheet with thread, and took up the sheet, to measure the angles made by the strings at my leisure, spreading the sheet for the purpose on the floor of my room. The absolute direction of the lines was determined by another thread fastened to the sheet in the direction of a shadow cast by a vertical rod at 7.30 a. m. (railroad time), which I compute must have fallen from an azimuth of 264° 27′ toward the opposite point.

The shadow bands were not as distinct as I had expected to see—my ideas, I suppose, having been formed by the suggestion given by NEWTON'S rings, or the diffraction circles around a star in a telescope. They were more like the uneven illumination seen at the bottom of a pond when the surface is slightly agitated, and that irregularly, as if by a number of exceedingly small pebbles, at a distance of 6 inches or more apart. A common motion was, however, perceptible, though difficult to define. I endeavored to place my strings parallel to the wave-front, or normal to the motion. The azimuth indicated by the strings proved to be, before totality, the line through 118°.5 and 298°.5; after totality, through 148° and 328°. Motion from south side toward north (not recorded at time of eclipse).

OBSERVATIONS AT VIRGINIA BEACH, VA.

REPORT OF MR. EDWARD K. PUTNAM, DAVENPORT, IOWA.

The shadow bands seemed to be from half an inch to an inch wide, following each other in quick succession, say 3 to 4 inches apart, but this distance varied, for the bands were not straight, but quivered and wabbled, which rendered them unequally distant one from another. The quiver appeared to me to run longitudinally along the band, and the band, as it moved onward, appeared to wabble backward and forward. I watched the bands as they passed over a plot of light-colored sand 30 feet or more wide. The lines appeared to reach across that distance, but possibly they were broken by their wavering nature, though I think they were continuous. The general direction of the lines was southeast and northwest, and they moved southwest approximately. They moved more slowly than I expected, which was from 12 to 15 feet a second. I had circles 5, 10, and 15 feet in diameter drawn on the sand in front of me, and had practiced counting seconds. My chief attention, however, was paid to their nature rather than to their speed. I watched the bands both before and after totality, the second observation confirming the impressions of the first.

TOTAL SOLAR ECLIPSE

OF

MAY 17, 1901.

U. S. NAVAL OBSERVATORY,
Washington, D. C., July 1, 1902.

SIR: I have the honor to submit the accompanying report of the operations of the expedition sent by the U. S. Naval Observatory to observe the total solar eclipse of May 17, 1901, on the island of Sumatra in the Dutch East Indies.

The observation of this eclipse was rendered possible by the liberality of Congress in making an appropriation of $10,000, which was immediately available on the passage of an act making appropriations to supply urgent deficiencies, approved January 4, 1901.

The time available for preparations was very limited, as it was imperative that the expedition should leave Washington about February 1, 1901.

Respectfully,

AARON N. SKINNER,
Professor of Mathematics, U. S. N.,
Chief of the Expedition.

The SUPERINTENDENT NAVAL OBSERVATORY.

REPORT

OF THE

U. S. NAVAL OBSERVATORY ECLIPSE EXPEDITION

TO OBSERVE THE

TOTAL SOLAR ECLIPSE OF MAY 17, 1901,

AT

SOLOK, FORT DE KOCK, AND SAWAH LOENTO, SUMATRA.

D 189

GENERAL REPORT OF THE SUMATRA ECLIPSE EXPEDITION.

Professor of Mathematics A. N. SKINNER, U. S. N., in charge.

INTRODUCTORY REMARKS.

The general plan of the work of the expedition, the choice of the instrumental equipment, and the selection of the personnel were made by Prof. of Math. S. J. BROWN, U. S. N., then Astronomical Director of the Observatory, who consulted freely with Mr. L. E. JEWELL in regard to all matters pertaining to preparations for the expedition. From sketches made by Mr. JEWELL two reflecting collimators and a coelostat with two 10-inch mirrors were ordered especially for this expedition from J. A. BRASHEAR, of Allegheny, Pa., as late as January 1, 1901. To prepare for use six transit-of-Venus coelostats, it became necessary to have the clocks belonging to them rebuilt by G. N. SAEGMULLER, of Washington.

The administration of the Observatory retained entire control of the expedition until the time of its departure from Washington, when Professor SKINNER was ordered to assume charge.

The Observatory acknowledges its indebtedness to various individuals and institutions for the loan of valuable apparatus for the use of the expedition. The individual loans are duly noted in the descriptions of the various stations.

PLACE OF OBSERVATION.

In the eclipse of May, 1901, the shadow of the Moon first touched the Earth in the Indian Ocean near the southern extremity of Madagascar. In its progress eastward over the ocean the shadow passed over the islands Reunion and Mauritius about 500 miles from Madagascar, but touched no more land until it reached the eastern side of the Indian Ocean, when it successively passed over the islands of Sumatra, Borneo, Celebes, and New Guinea, and left the Earth a few hundred miles to the eastward of the last named island.

In selecting a point of observation it was necessary to consider several elements:

First, the astronomical conditions; second, the meteorological conditions; third, the sanitary conditions; fourth, the protection of a secure government; fifth, the accessibility.

After a careful consideration the vicinity of Padang, on the west coast of Sumatra, was selected as a locality which, on the whole, best satisfied all the conditions.

The astronomical and sanitary conditions were perfectly satisfactory. The locality was readily accessible, and was favored with a strong and stable government. The government of the Netherlands East Indies courteously offered protection and assistance to every observing party. The meteorological conditions were as satisfactory as could be obtained in this region subject to almost daily tropical showers. The weather reports, which were accessible to us, indicated a probability of perhaps 50 per cent for clear sky at the critical moment. From personal observation it appeared to us that in this region the most favorable meteorological conditions would prevail on a low, small, isolated island far away from any mountain masses; but such a location could not be conveniently found. This preliminary examination influenced the administration of the Observatory to tentatively select Solok for a main station near the central line and Fort de Kock for a station near the northern edge of the shadow. The final selection of the stations was left with the chief of the expedition after an examination of the local circumstances.

The Dutch Government rendered valuable assistance in the selection of a suitable place for observation by contributing to the Observatory a printed report on the local meteorological conditions, and also a series of about twenty-five maps, mostly of Sumatra, by the Topographisch Bureau te Batavia, together with a few of portions of Borneo.

SELECTION OF THE PERSONNEL.

The administration of the Naval Observatory made the following selection from the staff of the institution to constitute the expedition:

Professor of Mathematics A. N. SKINNER, U. S. N., chief, in charge of the expedition from the date of its departure from Washington.

Professor of Mathematics W. S. EICHELBERGER, U. S. N.

Assistant Astronomer F. B. LITTELL.

Photographer G. H. PETERS.

Assistant L. E. JEWELL.

Assistant W. W. DINWIDDIE.

The following scientists accepted invitations to become members of the expedition, their expenses being defrayed by the Naval Observatory:

Prof. E. E. BARNARD, Yerkes Observatory.

Dr. W. J. HUMPHREYS, University of Virginia.

Dr. N. E. GILBERT, Johns Hopkins University.

Dr. S. A. MITCHELL, Columbia University.

Mr. H. D. CURTIS, University of Virginia.

THE SMITHSONIAN EXPEDITION.

The Naval Observatory party had as fellow-travelers throughout the trip, Messrs. CHARLES G. ABBOT and PAUL A. DRAPER, who constituted an independent party sent out by the Smithsonian Institution.

TRANSPORTATION.

The execution of the plans for observing the eclipse was rendered possible only by making use of Government transportation for members of the expedition and for the instrumental equipment wherever practicable.

The Navy Department is indebted to the Secretary of War for the courtesy extended in furnishing transportation for the party and its equipment from San Francisco to Manila, and for the return of the party from Manila to San Francisco.

The commander-in-chief of the Asiatic Station was directed by the Secretary of the Navy to furnish transportation for the expedition and equipment from Manila to Padang, Sumatra, and return.

On January 26, 1901, the greater part of the instrumental equipment, which occupied about three-fourths of the space in a large freight-car, was shipped via the Pennsylvania Railroad to San Francisco. Portions of the apparatus, which could not be completed in time for shipment on this car, followed by express. Among the articles expressed were the two reflecting collimators and the new double mirror coelostat built by BRASHEAR. All of the freight of both expeditions weighed fully 15 tons, and embraced nearly 300 packages. The Smithsonian Institution shipped the equipment for its expedition in the same freight-car with the outfit of the Naval Observatory. All of the freight had arrived in San Francisco by the morning of February 13.

THE JOURNEY TO SUMATRA.

Professor SKINNER and Mr. DINWIDDIE left Washington on the evening of Tuesday, February 5, 1901, and the remaining members from the Observatory followed on Thursday evening, February 7, both parties proceeding to San Francisco by way of the Southern Railway to New Orleans and thence by way of the Southern Pacific, arriving in San Francisco, respectively, on February 10 and 12. The other members of the expedition arrived there about the same date.

The vessel designated by the War Department to convey the party to Manila was the army transport *Sheridan*, which was ordered to sail at noon, February 16. The intervening days were busily occupied with the numerous duties preparatory to departure.

Mr. DINWIDDIE was commissioned to purchase in San Francisco several articles, such as lumber, three small portable houses, chemicals, and photographic plates. He was also directed to superintend the transfer of all the freight from the railway to the transport dock and from the dock to the hold of the *Sheridan*. In this he was assisted by several members of both expeditions.

Professor SKINNER obtained for the use of the expedition one mean time break-circuit chronometer, NEGUS No. 1228, from the Mare Island Navy Yard. Two other chronometers, BLISS No. 2407, and SEWILL No. 1195, were brought by the party from the Naval Observatory.

Lick Observatory.—Two days before sailing from San Francisco, Professors SKINNER, EICHELBERGER, and BARNARD, Messrs. ABBOT, MITCHELL, JEWELL, LITTELL, PETERS, and CURTIS spent a very pleasant day in visiting the Lick Observatory on the summit of Mount Hamilton. Making an early start from the city we traveled by rail to San José, 50 miles away, whence we proceeded by means of a six-horse stage over 28 miles of mountain road, stopping for lunch about noon at Smiths Creek, 7 miles from the summit. The route up the mountain led us through heavy banks of cloud and fog, but as we neared the summit we emerged from the fog into clear sky. The party arrived at the observatory about 2 in the afternoon and were warmly greeted by Director CAMPBELL and his staff. We found Mr. PERRINE busily occupied in putting the last touches on his eclipse apparatus with which he was to proceed by mail-steamer to the same destination as the Naval Observatory expedition. Our party spent some time in inspecting the equipment of the observatory, after which they were entertained at dinner by several members of the staff. After passing a most enjoyable day, at about 8 p. m. the visitors bid their friends a regretful farewell and entered the stage to make the descent of the mountain, reaching San José about 1 a. m. and San Francisco the following morning.

San Francisco to Honolulu.—The expedition sailed on the transport *Sheridan* on Saturday, February 16, at 12.35 p. m., with a crowd of friends on the dock to bid the good ship farewell. The Golden Gate was enveloped in fog and cloud as we steamed out but the fog lifted sufficiently to give us a good view of the Farallone group of islands, two hours out, which was the last land seen until we sighted the Hawaiian Islands, 2,100 miles distant, after a run of nearly nine days, during which we experienced stormy weather with high seas.

On the morning of February 25, a little after midnight, we passed the island of Molokai of the Hawaiian group. On the same morning, at about 2 a. m., Professors BARNARD and SKINNER took advantage of the first opportunity to have a view of the constellation, the Southern Cross.

Honolulu.—Before daylight on the morning of February 25 we passed Diamond Head Light, and about breakfast time steamed into the harbor of Honolulu and moored alongside the dock. After our stormy passage from San Francisco a three days' sojourn in this paradise of the Pacific was very restful indeed.

Introduced by Mr. THEODORE RICHARDS, as guests of the Young Men's Christian Association we were taken in carriages about the city and a few miles up the Nuuanu Valley to see a notable piece of mountain scenery called the Pali, which is a vertical precipice overlooking a valley about 500 feet below. In the evening, through the courtesy of Mr. RICHARDS, we were guests of the Social Science Society of Honolulu. On succeeding days we visited the Bishop Museum and the different school and college buildings, mostly constructed of stone, beautiful specimens of the best architecture. Some of us visited the extensive sugar plantations some 15 miles by railway from Honolulu, which are equipped with the most complete sugar-machinery plants in the world.

Honolulu to Manila.—At 5.30 a. m. on February 28 we steamed out through the tortuous channel among the coral reefs, and steering westward we glimpsed throughout the entire day the southern shores of islands of the Hawaiian group as we proceeded on our long voyage to Manila. Favored with quiet weather and smooth seas, these uneventful days were only varied by the omission of one day from our calendar, Tuesday, March 5, when we crossed the one hundred and eightieth degree of longitude from Greenwich.

On the morning of March 17 we caught sight of the highlands around Point Engaño, the northeastern corner of Luzon, the principal island of the Philippine group, on which is located the city of Manila. After steaming along the shores of this island for fully thirty-six hours we passed into the bay of Manila through the Boca Chica, the channel on the north side of Corregidor Island which lies directly in the entrance of the bay. Two hours steaming took us over the 22 miles across the bay to Manila where the *Sheridan* anchored about 1½ miles off from the shore at about 8 p. m., with the lights of the city gleaming in the distance.

Manila.—The city of Manila lies on the eastern shore of Manila Bay at the mouth of the Pasig River, a rather rapid flowing stream from 300 to 600 feet broad. At present the Pasig River forms the harbor for the city, but unfortunately it is accessible only for vessels drawing 12 feet or less. Thus, all ocean going vessels are compelled to occupy an exposed anchorage about 1½ miles offshore in order to secure the requisite depth of water. During the prevalence of the southwest monsoon from May until October, all vessels are compelled to seek shelter behind the breakwater near the mouth of the Pasig River or move over to the somewhat protected Cavite anchorage on the southwestern side of the bay, some 8 miles from Manila. This lack of harbor facilities will be remedied in a few years by the construction of an artificial harbor, by the extension of the existing breakwaters at the mouth of the Pasig River, and by dredging out the area thus inclosed to a depth of 30 feet.

On the morning after arrival Professor SKINNER went ashore and immediately proceeded to report to Rear-Admiral REMEY, commander in chief of the Asiatic Station on his flagship *Brooklyn* at Cavite, for instructions as to the further transportation of the expedition. He was informed by the admiral that he had issued orders to Lieutenant-Commander HALSEY, the commander of the gunboat *General Alava*, to convey the expedition and equipment from Manila to Padang, Sumatra, and return. Admiral REMEY also very graciously offered the facilities available at the Cavite navy-yard for transferring the equipment from the transport *Sheridan*, at anchor in front of Manila, across the bay to the gunboat *General Alava*, at anchor at Cavite. This transfer was promptly effected by a navy-yard tug and a 25-ton navy casco, under orders from Capt. FRANKLIN HANFORD, commandant of the naval station, Cavite, who very courteously assisted us in many ways. Mr. DINWIDDIE and Mr. JEWELL were detailed to superintend this transfer of freight to the *General Alava*. Eight days were spent in Manila in making preparations for our voyage of 2,200 miles to Sumatra.

Permission was granted by the chief quartermaster and the chief commissary, Division of the Philippines, enabling us to purchase any necessary supplies for carrying out the work of the expedition.

Capt. E. B. IVES, army signal officer at Manila, very courteously loaned us ten gravity cells and four telegraphic sounders.

This brief sojourn permitted the members of the party to become somewhat acquainted with this quaint Spanish city, which we found to be an example of a mediæval walled town, the massive masonry wall being surrounded by a moat crossed by drawbridges. This section of the city is called by strangers the Walled City, but by the inhabitants it is called Manila, as it is the original city, around which have clustered the various suburbs, which surpass the mother city in business, population, and extent. Among these suburbs are Tondo and Sampalog, the native quarters; San Nicolas and Binondo, the business sections; Santa Cruz, Quiapo, and San Miguel, residence sections; and Ermita and Malate, pleasant residence suburbs to the south. The population of Manila is in the neighborhood of 300,000, and consists mostly of Americans, Filipinos, and Chinese.

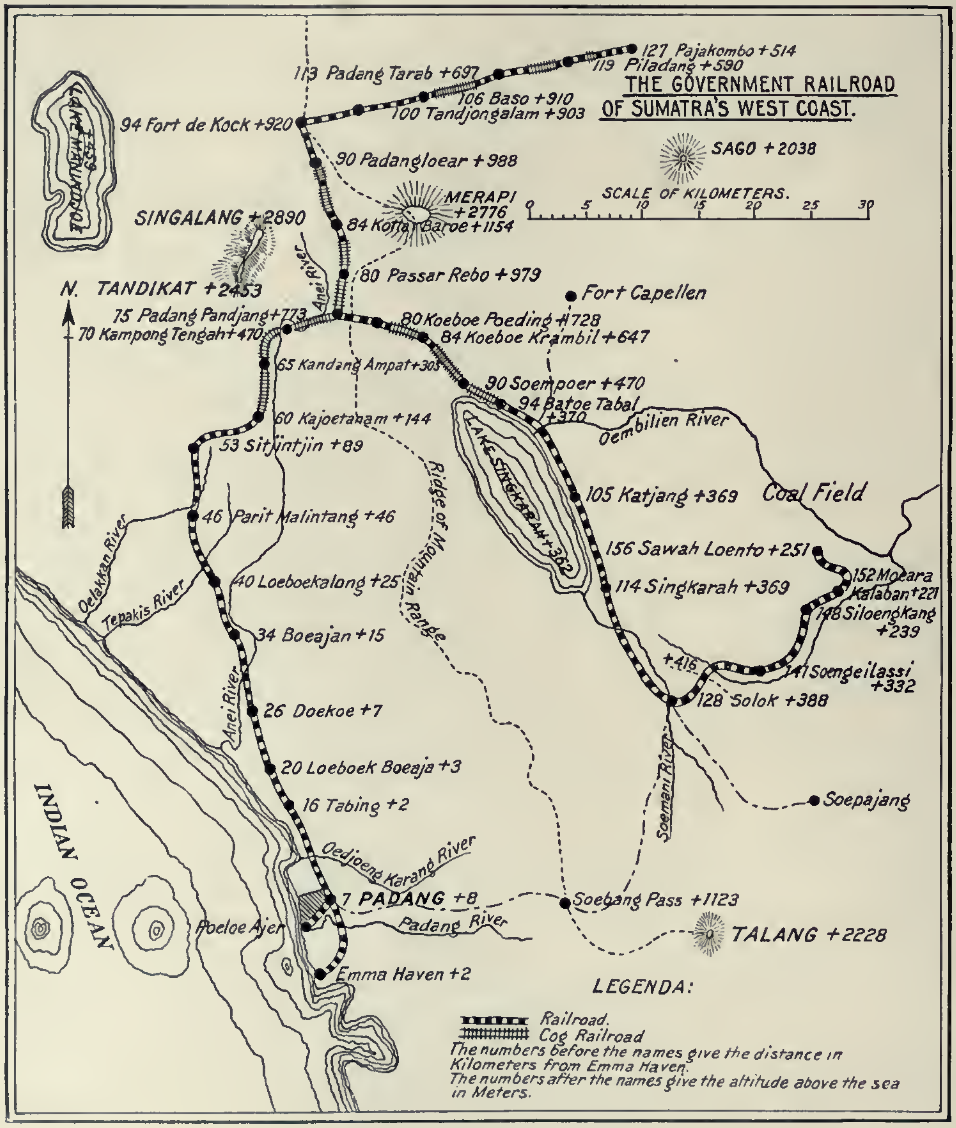
Manila Observatory.—During our stay we paid our respects to Father ALGUÉ, the director of the Manila Observatory, which is located in the suburb of Ermita. This observatory is equipped with an equatorial telescope mounted by SAEGMULLER, of Washington, and has a MERZ object-glass of 18 Paris inches aperture. Dangers resulting from military operations in the vicinity during the past three years impelled Father ALGUÉ to remove the object-glass from the tube to a place of safety. Shot-holes through the dome gave convincing proof that the danger sought to be avoided was real. Father ALGUÉ, having devoted a large part of his energies to magnetic and meteorological work, has made a long study of the movements of typhonic storms, so that, with the assistance of telegraphic advices, he is able to make very trustworthy predictions of their approach. Navigators of the China Sea implicitly trust his predictions.

Manila to Emma Haven.—At 4 p. m., March 26, the *General Alava* weighed anchor and steamed out through the Boca Grande, the channel south of the island of Corregidor, on her voyage to Sumatra. All day March 27 and 28 we skirted the long, narrow island of Palawan and all the morning of March 29 we had a distant view of the lofty summit of Kini Balu, or the Chinese Widow, a mountain 13,700 feet high, in the northwestern corner of the island of Borneo. For three or four days the shores of Borneo were visible to the eastward. On March 31 we crossed the equator and had an opportunity of witnessing the time-honored ceremony of the sailors in welcoming a visit of Neptune, who held court and solemnly administered ridiculous penalties on certain persons who were convicted of not having previously crossed the equator.

About 6 p. m. on March 31 we passed a small pyramidal shaped island called Direction Island, because its characteristic form enables mariners to use it as a day mark. From this island we steered a straight and unobstructed course for 120 miles to Gaspar Straits between the islands Billiton to the eastward and Banka to the westward, which are noted for their rich deposits of tin. We passed through Gaspar Straits on April 1, and on April 2 we passed through the Straits of Sunda, between Java on the southeast and Sumatra on the northwest. In the Sunda Straits we passed close to the noted volcano Krakatoa, now quiescent, but which produced such devastation and destruction of life in the year 1883. During April 3 and 4 we steamed northwest parallel to the coast of Sumatra, about 40 miles distant, and entered the harbor of Emma Haven, where we anchored about 4 p. m. on April 4.

SUMATRA.

Emma Haven.—Emma Haven, the port of Padang, the metropolis of the west coast of Sumatra, is a small harbor protected from the swells of the Indian Ocean by substantial breakwaters, and well supplied with an ample number of excellent moor-



THE VICINITY OF PADANG, SUMATRA.

ing buoys. The mountains which surround the harbor rise almost from the water's edge, and summits may be found not far inland which rise to the height of 9,000 to 12,000 feet. At Emma Haven may be found commodious wharves, alongside of which vessels may handle their cargoes with great facility; there are also capacious warehouses for freight, and coal sheds where steamers may fill their empty bunkers with a good quality of coal brought by rail from the almost inexhaustible Oembilien coal fields, about 100 miles in the interior. At least once a week steamers leave this port for Holland or Batavia.

The railway system.—Although rich deposits of coal were known to exist in this region as early as 1868, it was not until about 1890 that the construction of a railway to transport the coal to the seabord was determined on. The most favorable passes in the Barisan Mountains rise to an altitude of about 4,000 feet; consequently railway construction involved difficulties so great that they could be economically overcome only by the introduction of the rack-and-cog-wheel system through about 28 miles of the line. The remainder of the line is of the ordinary type.

Landing and introductions.—The morning after anchoring in Emma Haven we received a call from the United States consular agent, CORNELIUS G. VETH, who offered to assist the expedition in every way possible.

Having made the necessary arrangements, Mr. VETH escorted Lieutenant-Commander HALSEY, the commander of the *General Alava*, and Professor SKINNER to call on His Excellency Governor A. M. JOEKES and Col. H. F. C. VAN BIJLEVELT, the military commandant. The officials received us very graciously and offered generous assistance. We also made the acquaintance of Mr. TH. F. A. DELPRAT, the chief of the railway system, who very courteously informed us that free transportation would be granted over the railway for every member of the expedition and the equipment.

Mr. VETH favored several of our party with an enjoyable ride around the city of Padang, and invited to luncheon Lieutenant-Commander HALSEY, Professor SKINNER, Mr. JEWELL, and Mr. ABBOT, on which occasion we met Major MULLER, the chief of the Netherlands eclipse expedition, thus having an opportunity to exchange views on various questions connected with our work. While at Mr. VETH'S we made the acquaintance of Rev. R. W. MUNSON, an American missionary at Padang, who made many valuable suggestions. After luncheon some of the party returned to the ship and the remainder took quarters at the Oranje Hotel at Padang.

The same day we had the pleasure of greeting Messrs. PERRINE and CURTISS, of the Lick Observatory, who had just arrived on the Dutch steamer *Prinses Sophia* from Batavia.

Emma Haven to Fort de Kock.—On Saturday, April 6, Messrs. SKINNER, BARNARD, and JEWELL, accompanied by Mr. ABBOT, started on a brief trip by rail into the interior to inspect the places provisionally selected for observing stations and make a final decision. Mr. G. E. IRVING, agent of the British and Foreign Bible Society, volunteered to accompany and assist us as an interpreter.

A ride of 4 miles from Emma Haven through a level district brought the travelers to Padang, a city of about 15,000 inhabitants, embowered in tropical foliage. Approaching Padang we crossed the Padang River on a substantial iron bridge.

The city comprises a residence section of scattered houses uniformly one story in height, surrounded by ample grounds adorned with plants and flowers; a native section which seems rather uninviting from its lack of cleanliness; and a business quarter along the Padang River where the warehouses contain local products, such as hides, cinnamon, nutmegs, coffee, and the dried cocoanut, called copra, for export, and a great variety of European imported goods.

After leaving Padang the railroad passes through a nearly level region gradually ascending to an elevation of 472 feet at Kajoetanam, 37 miles from Emma Haven, where the road enters the valley of the Anei River, and following up the valley of this turbulent stream it is enabled to penetrate the Barisan mountain range reaching Padang Pandjang. Beyond Padang Pandjang, on the route to Fort de Kock, the railroad leaves the Anei Valley and reaches its greatest altitude, 3,785 feet, at Kotta Baroe as it passes over the saddle between Mount Singalang on the west and the always-smoking volcano Merapi on the east, each about 9,200 feet in elevation. In passing through the mountain range the railroad makes an ascent of 3,300 feet in traversing 15 miles, the maximum gradient being 8 per cent. Nearly all of this section of the railroad from Kajoetanam to Kotta Baroe is of the rack type and shows evidence of very skillful engineering in overcoming the natural difficulties.

Fort de Kock.—Fort de Kock is a healthy town of a few thousand people in an open valley at an elevation of 3,000 feet, situated 58 miles exactly north of Padang. The elevation gives the place a delightful coolness. The mountains, Singalang and Merapi, are near neighbors, each about 5 miles distant. Fort de Kock is a military post garrisoned with Javanese soldiers.

On arriving here the party obtained accommodations at the Sawah Hotel. While Professor SKINNER was considering a suitable location for the station at Fort de Kock, Messrs. BARNARD and ABBOT proceeded immediately to Solok to make a similar examination there.

Professor SKINNER was very courteously received by Secretary HEYTING and by Assistant Controller FRED. RIVIÈRE, who spent much time in escorting him to various points available for eclipse stations. A provisional selection was made, but the final decision was reserved for a later visit.

Fort de Kock to Solok.—On Monday, April 8, we returned to Padang Pandjang en route for Solok. We there changed cars and then skirted the eastern side of the beautiful mountain lake of Singkarah and having crossed its outlet the turbulent Oembilien River on a fine iron bridge, we reached Solok after a journey of 34 miles from Padang Pandjang and 45 miles from Fort de Kock.

After leaving Padang Pandjang the railroad makes a somewhat sharp descent of about 1,300 feet in traversing 9 miles, making it necessary in this section to use the rack construction. All the region traversed by the railroad southeastward from Padang Pandjang is on the eastern slope of the watershed of the Barisan Mountains, and all the streams are tributaries of rivers emptying on the eastern shore of the island of Sumatra.

Solok.—Solok is a town of perhaps a thousand people situated in an undulating valley to the east of the crest of the mountains on the Soemani River, which flows into the south end of Lake Singkarah. Solok has a small dismantled fort, having formerly been a military post.

Professor BARNARD and Mr. ABBOT had made an examination of the surroundings of Solok, and found nothing more suitable than the abandoned fort, which Assistant Resident DERX most courteously placed at the disposal of the Naval Observatory and the Smithsonian parties. On his arrival Professor SKINNER heartily endorsed this selection, and officially accepted the grant on behalf of the Naval Observatory.

Return to Padang.—On Tuesday, April 9, Professor SKINNER returned to Padang, leaving Professor BARNARD at Solok. At Soempoer, 24 miles from Solok, while waiting for a passing train, we had the pleasure of greeting for a moment Mr. and Mrs. H. F. NEWALL of Cambridge, England, who were on their way to Sawah Loento with a view of locating there an observing station.

GENERAL PREPARATIONS FOR THE ECLIPSE.

During the absence of Professor SKINNER in the interior of the country, the instrumental equipment had been unloaded from the ship and made ready for shipment to the observing stations under the superintendence of Professor EICHELBERGER, assisted by Messrs. DINWIDDIE, PETERS, LITTELL, and CURTIS. On Wednesday, April 10, the outfit was shipped by rail from Emma Haven to the stations selected for observation, one car-load to Fort de Kock and two car-loads to Solok.

While at Emma Haven we saw the English gunboat *Pygmy*, which had been detailed to assist Messrs. DYSON and ATKINSON, who had just arrived from England by mail-steamer, and whom we had the pleasure of meeting at the Oranje Hotel at Padang. At the same hotel we also met the following gentlemen: Messrs. BURTON, HOSMER, MATTHES, and SMITH of the party from the Massachusetts Institute of Technology, who later located at Sawah Loento; and Professor WILTERDINK, from Leyden, of the Dutch party, which was located at Karangsago, near Painan, on the coast, about 40 miles south of Padang.

On Wednesday evening Consul VETH entertained at dinner Messrs. MITCHELL, GILBERT, CURTIS, and DINWIDDIE, the members of our party who were to leave Padang on Thursday for Solok, while on Thursday evening he dined Messrs. SKINNER, EICHELBERGER, LITTELL, PETERS, and HUMPHREYS, who were to leave for Fort de Kock on Friday.

While at Padang Professor SKINNER made arrangements to secure the services of Master MELVIN MUNSON, the young son of Rev. R. W. MUNSON, as an interpreter at Fort de Kock, and Mr. G. E. IRVING as interpreter at Solok, both of whom were of great assistance in communicating with the native Malay workmen. Much to our gratification, we found that all the Dutch officials were able to read and write the English language with facility, and most of them could also speak it fluently, thus rendering intercourse with them very easy and pleasant.

After completing the preliminary arrangements at Fort de Kock, Professor SKINNER proceeded to Solok, where he made his headquarters, making occasional visits to the other stations.

The assignment of the members of the expedition to the different instruments and stations was made by Professor SKINNER, as far as possible, in accord with the preliminary scheme arranged before leaving Washington. The individual details will appear in the appropriate place in connection with the description of the different stations.

All of the members of the expedition were at their posts on Friday, April 12, ready to undertake the mounting of their instruments, which had been shipped previously.

Mr. LITTELL was directed to proceed first to Fort de Kock to assist in the installation of the instruments, after which, on May 6, he proceeded to Solok to take charge of the plane grating slit spectrograph.

To lessen the chances of failure from local cloudiness, two instruments were transferred to Sawah Loento, a town 17 miles eastward from Solok at the end of the railroad. Sawah Loento was visited by Mr. JEWELL shortly after his return from Alahan Pandjang, and it was largely on his representation that this vicinity was selected for the additional station. The station was placed in charge of Dr. S. A. MITCHELL, who selected the location and showed much energy and efficiency in installing the instruments in the face of considerable difficulties. Doctor MITCHELL was assisted by Mr. RENÉ GRANGER, of Cartersville, Ga., who reported, on April 16, to Professor SKINNER, at Solok, with a letter of introduction from Professor BROWN, Astronomical Director of the Naval Observatory, stating that Mr. GRANGER intended journeying from the United States to Sumatra at his own expense, in order to participate in the observation of the total solar eclipse. Professor SKINNER gladly accepted his services.

Mr. GRANGER reports as follows in regard to his connection with the expedition:

> After seeing the eclipse of May, 1900, at Barnesville, Ga., I became very desirous of witnessing the eclipse of much longer duration in Sumatra in 1901. Having found by correspondence that I would be unable to secure passage on the army transport conveying the Naval Observatory expedition, I left New York March 5, 1901, for Europe, on the *Kaiser Wilhelm der Grosse*, proceeded overland to Brindisi, and thence by steamer through the Suez Canal, arriving at Padang April 15. I reported to you at Solok the next day, and was assigned to duty as a volunteer assistant. On May 7, in accordance with your instructions, I proceeded to Sawah Loento to take charge, under Dr. S. A. MITCHELL, of the 104-inch camera.

Assistants from the General Alava.—Professors SKINNER and EICHELBERGER proceeded to Padang so as to be at Emma Haven on the morning of May 14 to carry out arrangements for transporting eight men from the *General Alava*, whose services were very courteously granted to the Naval Observatory party by Lieutenant-Commander HALSEY. Six of these men went to Solok and two went to Fort de Kock.

Eclipse expeditions around Padang.—On the occasion of this visit to Padang Professors SKINNER and EICHELBERGER visited the camps of the following eclipse parties located at Padang:

The Russian party under Professor DONITCH and the French party under Count DE LA BAUME PLUVINEL, located near the Plein van Rome.

The Japanese party under Professor HIRAYAMA of the Tokyo Astronomical Observatory, located on the ocean beach in front of the city.

The Lick Observatory party under Professor PERRINE, on the old race-track in the northern part of Padang.

Professor SKINNER was obliged, on account of pressing duties, to decline an invitation from Governor JOEKES to join an excursion on the governor's dispatch boat to visit the camp of the Netherlands astronomers at Karangsago, 40 miles down the coast.

PREPARATIONS FOR DEPARTURE.

The week following the eclipse was devoted to packing the instruments at the three stations preparatory to shipping them to Emma Haven. The instruments at Sawah Loento were promptly shipped to Solok. Mr. DELPRAT, the chief of the railway system, very courteously sent an ample supply of freight cars to Solok and Fort de Kock for the reception of the freight, which was promptly loaded and shipped, arriving at Emma Haven as early as noon May 27. It was immediately transferred to the hold of the *General Alava*, whose sailing date was set for the morning of May 28.

The few days previous to departure from Sumatra were spent at Padang, where the party had the pleasure of meeting many of the visiting astronomers, whose accommodation taxed to the utmost the capacity of the two leading hotels, the Oranje and the Atjeh.

Farewell ball.—On Monday evening, May 27, Mr. VETH, the United States consular agent, gave a farewell ball in the club house of the Societeit de Eendracht, in honor of the sailing of the *General Alava* on the following morning. All the prominent people of Padang, including Governor JOEKES, Colonel VAN BIJLEVELT, and Major MULLER, together with the officers of the *Pygmy*, were invited on this occasion to meet the officers of the *General Alava* and the American astronomers.

HOMEWARD JOURNEY.

Departure from Emma Haven.—The entire party with their equipment, having embarked on board the *General Alava*, sailed from Emma Haven at 10.35 a. m. May 28, bidding adieu to the shores of Sumatra, where they had been accorded such a hospitable reception and where they had sojourned most pleasantly for a period of nearly two months. We were accompanied to the entrance of the harbor by our good friends, Consular Agent VETH and his partner, Mr. JOHANN SCHILD, both of whom had been very helpful to us.

Batavia.—On the morning of May 31, the *General Alava*, en route for Manila, anchored in the harbor of Tandjong Priok, the port of Batavia, to take on coal. Tandjong Priok has an artificial harbor, formed by two substantial breakwaters. A ride of half a dozen miles by steam cars took us to the lower town of Batavia, which is rather low and intersected by numerous canals. Carriages met us at the railway station, which took us a couple of miles to the residence section of Weltevreden, the upper town of Batavia, where we saw the Hotel des Indes, the palace of the governor-general, the Waterlooplein, the museum, the Harmonie and Concordia clubs, and the Konigsplein. The main street leading to Weltevreden has a wide canal running through the middle of it with an ample roadway on either side.

Having taken on 75 tons of coal, we sailed from Tandjong Priok at 8.30 a. m., June 1.

Return to Manila.—After a quiet voyage the *General Alava* entered Manila Bay through the north channel, the Boca Chica, and anchored off Cavite about 11 a. m., June 8.

After conference with Rear-Admiral RODGERS on his flagship, the *New York*, Professor SKINNER was authorized to make the necessary arrangements for shipment of the equipment direct to the east coast of the United States on board the supply steamship *Culgoa*, which was expected to sail from Cavite about one month later. The transfer of the freight from the *General Alava* to the *Culgoa* was effected on June 10, under the supervision of Mr. DINWIDDIE, by means of a navy-yard tug and casco, furnished through the courtesy of Capt. FRANKLIN HANFORD, commandant of the naval station, Cavite.

On the day of arrival at Cavite, the party proceeded across the bay to Manila, and after some difficulty found quarters in this city, noted for deficient hotel accommodations. After frequent conferences with chief quartermaster of the Division of the Philippines, the following arrangement was effected for transportation of the party to the United States by way of San Francisco.

Manila to San Francisco.—Passage was secured on board the U. S. naval transport *Solace* from Manila to Yokohama, sailing on June 12, for Dr. W. J. HUMPHREYS and Dr. N. E. GILBERT, who were to go by rail thence to Nagasaki and take passage there on board the U. S. army transport *Meade* for San Francisco. This circuitous route was made necessary because no accommodations were available for these gentlemen on board the *Meade* between Manila and Nagasaki. The *Meade* sailed from Manila July 4 and Nagasaki on July 11.

Passage was secured for the remaining members of the expedition on board the U. S. chartered transport *Indiana*, which sailed June 20, and proceeded without stop to San Francisco, where she arrived July 16.

From San Francisco the different members proceeded to their homes by several routes, most of them reaching their destinations about August 1.

ACKNOWLEDGMENTS.

On the day of the eclipse valuable volunteer assistance was received from the following:

Ensign GILBERT CHASE, U. S. N., Assistant Surgeon H. E. ODELL, U. S. N., Cadet W. V. TOMB, U. S. N., from the *General Alava;* Mr. RENÉ GRANGER, Cartersville, Ga.; Mr. G. E. IRVING, agent of the British and Foreign Bible Society; Master MELVIN MUNSON, Padang; eight men from the *General Alava;* C. W. KEETER, A. L. SMITH, W. A. VAN AKEN, R. H. SCHOPS, M. C. SUMAN, J. J. FEW, W. J. CASSIDY, and G. H. GETZ, who showed great willingness, zeal, and aptitude in duties which were quite novel to them.

The generous assistance which was afforded to our party by every Netherlands official was in perfect accord with the marked courtesy with which we were received by His Excellency A. M. JOEKES, governor of the west coast of Sumatra.

The free transportation which was granted the observers and their instruments over the railway should be mentioned in connection with the name of Mr. Th. F. A. DELPRAT, chief of the railway system.

U. S. Consular Agent C. G. VETH was untiring in his services at all times in our behalf.

In addition to the names mentioned in other parts of this report, we wish to thankfully acknowledge various courtesies and assistance granted the expedition by many persons, among whom may be mentioned:

Col. H. F. C. VAN BIJLEVELT, Padang; N. K. DERX, assistant resident, Solok, afterward resident Fort de Kock; J. VAN HENGEL, controller, Fort de Kock; Mr. HEYTING, secretary, Fort de Kock; FRED. RIVIÈRE, assistant controller, Fort de Kock; Captain MUSCH, Topographisch Bureau, Fort de Kock; L. HUNDESHAGEN, Fort de Kock; A. H. CHAMOT, Pajakombo; A. VALMER VAN BROEK, controller, Solok; P. F. ROS, Solok; A. J. P. MAAGDENBURG, Solok; L. K. LINDHOUT, Padang Pandjang; J. REINTS BOK, Ned. Ind. Discount Bank, Padang; H. T. VAN STIPRIAN LUISCIUS, chief of the 3d division of the railway, Padang; JOHANN SCHILD, acting United States consular agent, Padang; Lieut. Commander WILLIAM BRAUNERSREUTHER, U. S. N., captain of the port, Manila, and his successor, Commander ADOLPH MARIX; and Maj. THOMAS CRUSE, U. S. A., depot quartermaster, Manila.

GENERAL PREPARATIONS FOR THE SPECTROGRAPHIC WORK.

By Assistant L. E. JEWELL.

In planning the spectrographic work for the total solar eclipse of May 17, 1901, the results which had been obtained and the experience gained from the eclipse of May 28, 1900, furnished many valuable lessons. One of the most important of these was, that any focusing device designed to furnish parallel light or place an illuminated slit at virtually an infinite distance must be composed of parabolic reflectors, with a slit at their common focus if all the light rays of all wave-lengths coming from such a collimator are to be exactly parallel when the source of light is at a distance equivalent to infinity.

Therefore such a collimator was designed and two of them constructed by BRASHEAR. It was necessary to construct them upon short notice, and the mechanical arrangements were not all that could be desired, but optically they proved to be perfectly satisfactory. As they were designed to be used with sunlight in such a way that an illuminated slit was virtually placed at infinity, the adjustments had to be such that the slit would be exactly at the common focus of the two mirrors and the construction such that the incident and reflected light should deviate as little as possible from the normal to the mirrors. Also, as the light was to come from the same coelostat mirror used at the time of the eclipse, it was necessary that the two parallel beams of light, one coming from the coelostat mirror and the other from the collimator, should be parallel and the distance between their paths as small as possible, so as to necessitate moving the spectrograph as little as possible. The whole instrument must be sufficiently short to go easily between the coelostat mirror and the end of the spectrograph, but within these limits the collimating mirror should be of as long a focus as possible. The condensing or image-forming mirror being of minor importance, it was made of shorter focus and smaller size.

The collimators used in Sumatra at the time of the eclipse of May, 1901, were adjusted by the aid of clouds surrounding Mount Merapi, which was at a distance of about 25 miles from the station at Solok.

Previous to the eclipse of May 28, 1900, the use of the concave grating direct, without slit or condensing lens, had been suggested by the late Prof. H. A. ROWLAND and some stellar spectrograms had been made by Dr. CHAS. L. POOR and Dr. S. A. MITCHELL, but the grating had not been used under advantageous circumstances, and the spectra were faint, and, though very promising, were not altogether satisfactory.

There was little time for experimenting, and it was much easier to rule plane gratings, so, although the matter was taken under consideration, it was decided that, considering the circumstances and the limited time for preparations, not to use concave gratings direct, the two concave gratings available being used with condensing quartz lenses and slits.

After the eclipse of May 28, 1900, the performance of the direct concave grating was investigated very carefully and found to be very good indeed. Since then the parabolic grating has been investigated and found, as anticipated, to be still better. The difficulties experienced with the concave grating used with condensing lens and slit in the usual manner led to its abandonment for the eclipse of 1901, but it was felt that it was very important to attempt photographs of the coronal spectrum with a slit stretched across the equatorial regions of the corona. The objects aimed at were, first, photographs of the bright lines in the coronal spectrum with a slit, as the wave-length determinations are much more accurate than with the slitless spectrograph and the character of the lines themselves could be determined with much greater certainty; second, it was desired to secure evidence of the presence or absence of the FRAUNHOFER lines in the spectrum of the corona; third, it was desired to obtain data for the determination of the velocity of rotation of the matter in the corona.

In order to utilize as far as possible the apparatus easily obtainable, a 6-inch plane grating belonging to the Johns Hopkins University was loaned through the kindness of Prof. H. A. ROWLAND, and was used with a quartz objective and a quartz condensing lens. The condensing lens was to be used with a large slit stretching across the corona in the equatorial regions. Such an instrument may be called a coronal spectrograph, as the spectrum of the corona was the main object of study, the spectrum of the chromosphere which it was also expected to obtain being merely a secondary object.

Having another large quartz objective and a 6-inch plane grating, it was decided to use them as an objective grating, but arranged differently from the one described above. Under the supposition that the diffracted light from a plane grating behaved essentially in the same manner as the reflected light, and there being a considerable advantage in some other respects, the quartz objective was designed to be used in the path of the incident light.

There was no opportunity, however, to test the arrangement before leaving for Sumatra, but upon setting up the instrument in the field it was discovered that the optical behavior of the diffracted light from a plane grating was essentially different in some respects from that of the reflected light, and later this was found to be the case theoretically.

It was decided to use the 6-inch concave grating of 10 feet radius belonging to the Naval Observatory as a direct grating, as it was considered that the results would be best when used in this manner, and the camera equipment used for one of the objective gratings in 1900 could be used with slight modifications.

For a station near the edge of the eclipse path for obtaining spectrographs of the bright portions of the chromosphere near the Sun's surface it was thought desirable to use a long focus concave grating of as large a size as could be constructed. Professor ROWLAND was consulted in the matter, and he approved of the plan, and the late THEODORE C. SCHNEIDER, his instrument maker, who constructed the ruling engines and had had charge of the ruling of all gratings at the Johns Hopkins University, made a grating with a ruled space of about 3½ by 8 inches. Upon being tested, the definition of this grating proved to be bad and another was attempted and only finished two or three days before it was necessary to start upon the expedition. In the meantime, owing to the uncertainty of getting a good grating of this size, arrangements were made to secure the 6-inch grating of 21 feet radius belonging to the University of Virginia. Plate-holders and an extension to the camera were constructed so that either grating could be used.

When the 9-inch grating of 30 feet radius was completed, the weather in Baltimore was very unsatisfactory for testing, and the great focal length made the operation difficult, but although used in the ordinary way the grating gave very poor definition, it looked as though it might answer in the first-order spectrum with parallel light. Under the circumstances we were obliged to take both gratings to Sumatra and test them in the field.

The large BRASHEAR prism belonging to the Smithsonian Institution was obtained to be used as a prismatic spectrograph. For use in gauging the time of exposure the same arrangement of direct-vision grating spectroscope was used as in 1900.

REPORT OF THE SOLOK STATION.

Professor of Mathematics A. N. SKINNER, U. S. N., in charge.

It was decided to establish the principal observing station at Solok, although it was about 40 miles north of the central line of the shadow, because difficulties of transportation precluded the selection of stations away from the line of the railroad. Mr. JEWELL made a tour of some 40 miles south from Solok beyond Alahan Pandjang, by cart and on foot, to investigate the possibilities of locating a station on the central line, but Professor SKINNER deemed that the difficulties surrounding the undertaking would more than counterbalance the advantages to be gained.

Mr. JEWELL'S report on his trip to Alahan Pandjang follows:

> Several days after arriving in Sumatra, with the permission of Professor SKINNER, and upon the advice of Major MULLER, of the Topographisch Bureau te Batavia, I started for Alahan Pandjang, 32 miles south of Solok, to see Mr. VERBEEK and learn what difficulties there would be in getting instruments to a station on the central line of the eclipse path. Mr. VERBEEK was at his mining camp at Lamoedjan, near the small native village of Soengai Aboe.
>
> After being very kindly entertained at Alahan Pandjang by Mrs. VERBEEK I started for the mining camp. To Sarik, about 18 miles down the Goemanti River, the trip was made with the same pony cart and native driver that were obtained at Solok, and the roads were excellent; but the 8 miles from Sarik to Soengai Aboe were by a trail, which, however, was very good walking, and from Soengai Aboe to Lamoedjan there was a good mountain trail of about 2 miles at an easy grade.
>
> I was received and entertained with great kindness by Mr. VERBEEK, who offered every assistance in his power should it be decided to locate an observing station at his place. His buildings are in a large clearing upon a mountain slope facing the north, at a moderate elevation, with plenty of cold clear water which could be easily carried to any place in the camp by means of bamboo pipes. In very many respects his place was an ideal location for a camp and very close to the central line of the eclipse path. After the eclipse I learned through Mr. VERBEEK, from some of his native assistants, that the sky was clear there at the time of the eclipse.
>
> The principal objections to placing the camp there were the time which would be required to establish a station at that point, as all the instruments would have had to be transported by kerbau carts to Sarik, and from there to Lamoedjan by native carriers. Also all the provisions would have to be transported from Solok in the same manner, and it would have been necessary to take along a cook and other help. All of these facts were reported to Professor SKINNER upon my return to Solok, and he decided against placing any instruments nearer the central line than Solok.

The station was located in an abandoned fort, an earthwork about 200 feet square, surrounded by a deep and wide ditch, which was surrounded in turn by a chevaux-de-frise of tangled barbed wire, making entrance to the fort impossible except by the gateway on the eastern side. The inclosure contained a few substantial one-story buildings which served for storerooms, dark room, and dormitory, and which fortunately supplemented the scanty accommodations of the Hotel Talang, where all the party boarded but where only a portion of the party had sleeping accommodations.

The observing party arrived at Solok April 12, and proceeded on the next day to have the instruments transported to the fort, about one-quarter of a mile northwest of the railroad station. This transportation was effected by means of bullock carts and with the assistance of a gang of about 50 convicts furnished without expense to the party by Assistant Resident DERX.

The installation of the apparatus immediately proceeded, all the members of the party participating. The location of the different instruments, whose descriptions follow under appropriate headings, is clearly indicated on the plan, PLATE XVI, drawn by Mr. W. W. DINWIDDIE from a sketch by Mr. H. D. CURTIS.

The maps of the Topographisch Bureau te Batavia show that the fort at Solok is 16′ 57″ east from the Padang zero monument. On the authority of Major MULLER, chief of the Netherlands eclipse expedition, the Padang zero monument is east from Greenwich 100° 21′ 55″. The longitude of the fort at Solok is therefore east from Greenwich 100° 38′ 52″ = $6^h\ 42^m\ 35^s.5$.

The latitude of the fort, as determined by circum-meridian altitudes of α Crucis, observed with a sextant by Mr. CURTIS, is south 0° 47′ 17″. According to the maps of the Topographisch Bureau te Batavia, the latitude is south 0° 47′ 16″ and the altitude is 1,273 feet.

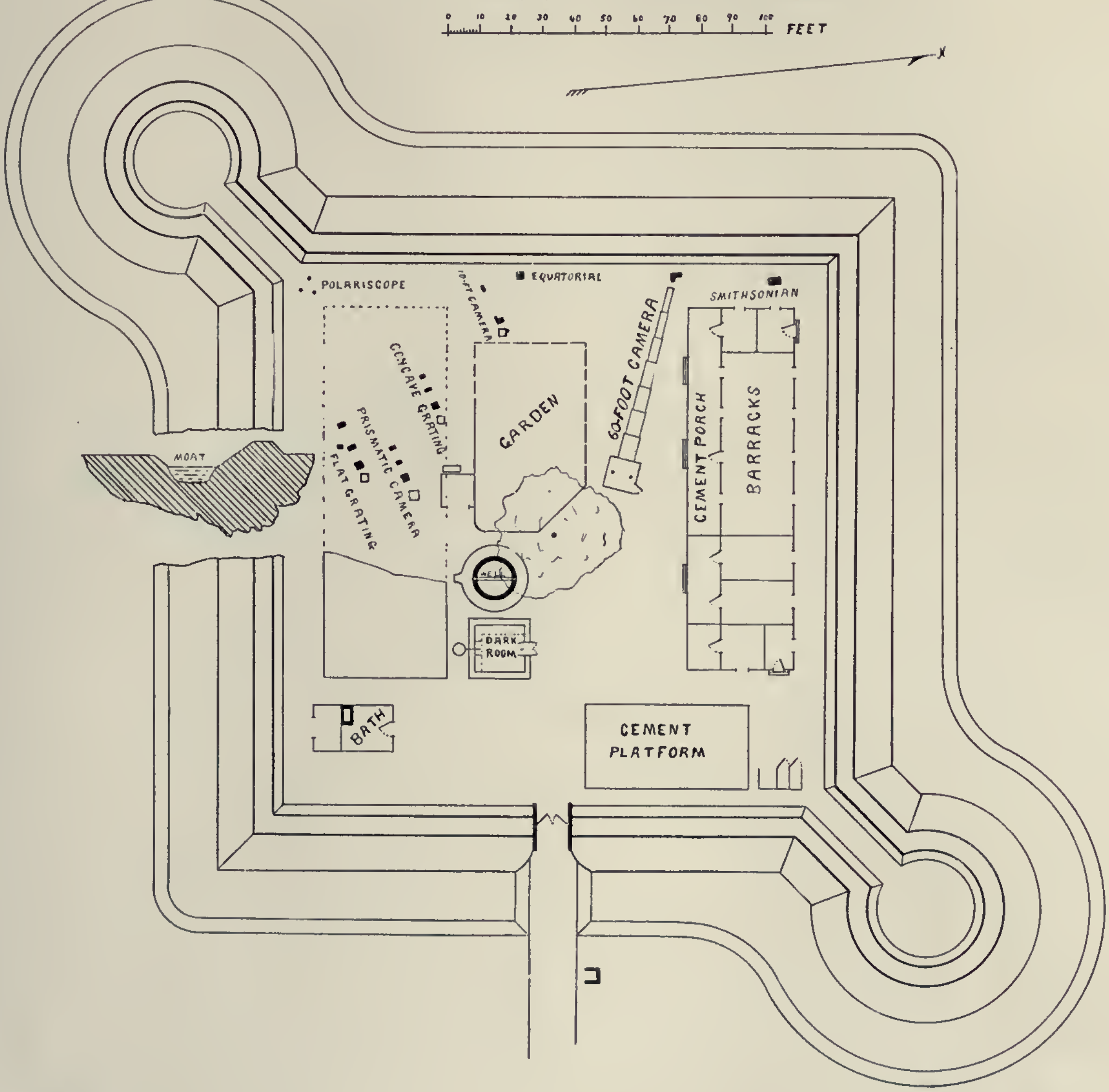
Mr. CURTIS also made the necessary time observations with a sextant and located the meridian line necessary for setting up the various instruments.

With the exception of the coelostat used in connection with the 60-foot camera, all the coelostats were originally constructed for the use of the American parties sent out to observe the transit of Venus of 1874. Their clock movements were reconstructed for this eclipse by Mr. G. N. SAEGMULLER, of Washington, but even with this improvement they all showed marked irregularities in running. In the case of one of them the irregularity was removed by careful adjustment, but in the case of the others the defect could not be remedied.

Mr. CURTIS makes the following report in regard to the preparation of the coelostat mirrors for the eclipse work:

> The week before the eclipse all the mirrors which were not in the best condition were resilvered by the writer. In times past considerable difficulty has been experienced in securing perfect results by BRASHEAR'S formula, the coating being generally too thin, and moreover resulting in failure even when all details of the process seemed to have been performed in exact accordance with the published directions (Astrophysical Journal, WADSWORTH, March, 1895). The following slight modification proved very successful in depositing a fine, thick coating of silver:
>
> A. Reducing Solution (unchanged).
> 840 grains rock candy
> 40 grains nitric acid
> 3¼ ounces alcohol
> distilled water to make up to 25 ounces.
> B. Silvering Solution.
> I. ½ ounce nitrate silver
> 4 ounces water.
> II. ¼ ounce potassa (pure by alcohol)
> 4 ounces water.

ECLIPSE STATION AT SOLOK SUMATRA



Surveyed by H. D. Curtis.

Drawn by W. W. Dinwiddie.

Also prepare about 2 ounces of reserve silvering solution in the same proportions in a separate beaker. These when mixed according to Mr. Brashear's directions are combined with 2 ounces of reducing solution for an 8-inch mirror.

To afford an ample supply of water for the dark room a wooden tank about 3 feet in diameter and 4 feet high was built by a Chinese cooper of Solok. The tank which was used at Fort de Kock was built by the same cooper and shipped there from Solok. The tank water, which was drawn from a well in the fort inclosure, was used for washing the photographic plates. Water for developing purposes was filtered in a Sumatra porous stone filter. We had also limited facilities for distilling water with a crude portable still which we purchased in San Francisco.

The Solok station was provided with ice for use in developing the eclipse negatives by a shipment of 150 pounds from the ice factory in Padang a few days before the eclipse.

Two flags were displayed daily at the entrance of the fort, the United States flag from a bamboo flag pole on the north side and the Netherlands flag, kindly loaned to us by Assistant Resident Derx, from a similar pole on the south side of the entrance.

To facilitate counting seconds during the total phase, wires were strung forming a continuous metallic circuit in which were located several telegraphic sounders which were operated by the mean time break-circuit chronometer working through a relay. Every observer in the fort, including the Smithsonian party, could thus hear the second's beat of the chronometer reproduced by a sounder. The same battery circuit operated the electric control of the clock of Professor Barnard's coelostat. Mr. Abbot contributed the use of his battery in this circuit, and in return we granted him the occasional use of our battery in charging the Smithsonian storage cells.

Mr. A. J. P. Maagdenburg, a Solok railway official, kindly loaned us a locomotive bell for sounding the minutes of totality. This bell he brought up to the fort and mounted for us, hanging it from the corner of the native kitchen near the chronometer and the 3.5-inch equatorial used by Professor Skinner. Ensign Gilbert Chase volunteered to execute the signaling of the minutes on this bell. The scheme of signals adopted was as follows:

Five minutes before the computed time of second contact	Several strokes.
One minute before the computed time of second contact	5 strokes.
At signal "Go" by Professor Skinner from visual observation of second contact	1 stroke.
At beginning of 2d minute of totality	2 strokes.
At beginning of 3d minute of totality	3 strokes.
At beginning of 4th minute of totality	4 strokes.
At beginning of 5th minute of totality	5 strokes.
At beginning of 6th minute of totality	6 strokes.
At signal "Done" by Professor Skinner from visual observation of third contact	1 stroke.

In addition to these signals each tenth second was called out by Ensign Chase.

Drills, in which every observer participated, were held frequently for several days previous to the eclipse.

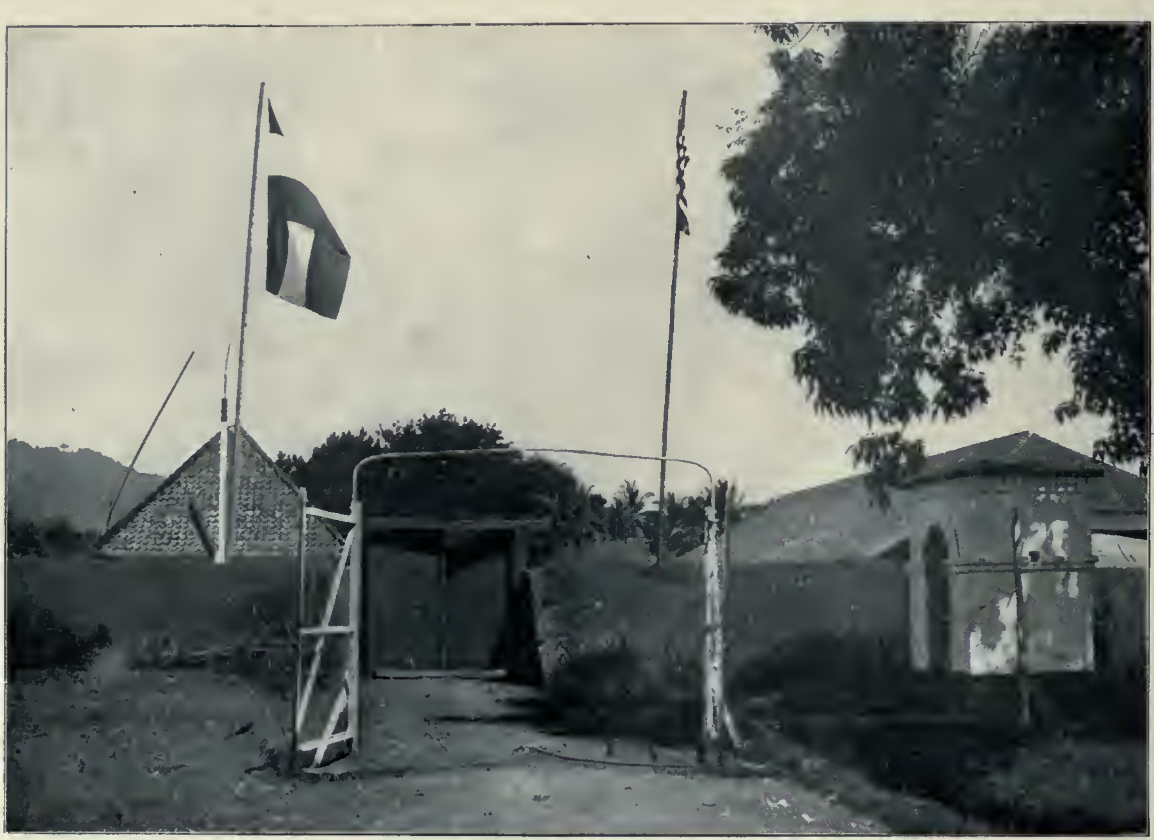
THE DAY OF THE ECLIPSE.

The labors of the many weeks of preparation were drawing to a close, with the instruments ready for the critical operations during totality. Saturday morning every one arose full of anxiety, only to find the sky entirely overcast with clouds. About 9 a. m. we were encouraged by breaks in the clouds, which opened up to such an extent as to permit the first contact to be very satisfactorily observed, with an unobscured Sun. But the revived hopes were chilled immediately thereafter by a spreading over the entire sky of an abundance of mackerel clouds, through which the Sun shone feebly. The preparations for work proceeded, and the prearranged program was carried out accurately, but with no hope of obtaining any results. The second contact was satisfactorily observed, although through thin clouds. Professor SKINNER noted clearly the phenomenon of the breaking up of the solar crescent into BAILY'S Beads. For perhaps one minute after the second contact a thin rim of light was faintly discerned through the drifting clouds, but this was all that could be seen of the corona. Professor BARNARD states that during the longer exposures he carefully examined the plates of the 60-foot camera and could detect on them no trace of an image. He also examined the eclipsed Sun during mid-totality with a small telescope prepared especially for the purpose of studying the corona, but nothing could be made out of it on account of the clouds. Professors BARNARD and SKINNER both noted that Venus and Mercury were plainly visible to the naked eye during totality, but during the latter half the Sun was so densely obscured by clouds that its location in the sky could not be detected; consequently the third contact passed by unobserved.

In view of the probable darkness on account of the long totality, lanterns were provided for each instrument, but they were found to be entirely unnecessary except in the dark room of the 60-foot camera. The light was sufficient to enable anyone to read the face of a chronometer or an ordinary printed page without difficulty. Mr. CURTIS remarks that the eclipse of May, 1900, which he observed under very favorable conditions at Thomaston, Ga., was certainly much darker, and that it was as light at Solok at mid-totality as it was in Georgia ten to twenty seconds before second contact. The light was about the same as that of a day with a sky overcast with moderately thick clouds.

A break in the clouds, visible to us during the morning to the northward of Lake Singkarah unfortunately did not reach Solok until shortly before fourth contact, which was well observed in a nearly cloudless sky.

In spite of the clouds some results were obtained by Doctor GILBERT and Mr. DINWIDDIE, as mentioned in their respective reports.



THE ENTRANCE TO THE ECLIPSE STATION AT SOLOK, SUMATRA.

Photographed by W. W. Dinwiddie.

THE INTERIOR OF THE 60-FOOT CAMERA.

Photographed by W. W. Dinwiddie.

CONTACT OBSERVATIONS.

The times of the contacts were observed at Solok as far as the clouds permitted by Professor Skinner and Mr. Curtis. Professor Skinner used a portable 3.5-inch Clark equatorial refractor and Mr. Curtis used the 6-inch Saegmuller equatorial refractor. The following is a statement of the times observed:

Contact.	Local Mean Time.		Observer.
	Observed.	Computed.	
	h m s	h m s	
I	22 47 19	22 47 29	Skinner.
	22 47 22	.. .. ..	Curtis.
II	0 21 7	0 21 21	Skinner.
III	Dense clouds.	0 27 13	
IV	1 59 22	1 59 35	Skinner.
	1 59 21.5	.. .. ..	Curtis.

THE GREAT SOUTHERN COMET.

On the evening of May 3, while waiting for supper on the veranda of Hotel Talang, Mr. Dinwiddie called our attention to a bright naked-eye comet which he had discovered in the western sky near the horizon just south of the setting Sun. A view through the 6-inch equatorial showed it to possess a head similar to the drawings of the head of Donati's comet. Clouds prevented seeing the comet on the evening of May 4, but on the evening of May 5 Professor Barnard succeeded in taking two photographs of the comet of ten minutes exposure each with his Voigtlaender lens.

THE 60-FOOT CAMERA.

Prof. E. E. Barnard, Yerkes Observatory, in charge.

This instrument, fed by a coelostat, was a horizontal telescope 61.5 feet long and had an object-glass, by Brashear, 6 inches in diameter. The coelostat mirror, perfectly flat and placed parallel to the axis of the Earth, is revolved westward by clockwork at one-half the speed of the Earth's rotation and throws a horizontal beam of light through the lens to form the image of the eclipsed Sun on a sensitive plate exposed in a dark room over 60 feet away, the revolving mirror keeping the image of the moving Sun perfectly stationary. The mirror used on this occasion was an excellent one, 18 inches in diameter, made by Mr. G. W. Ritchey, of Yerkes Observatory. To insure that no irregularities in the motion of the mirror should injure the definition during the long exposures, an electric control was attached to the clockwork. This controlled the motion every second of time. With this instrument the image of the Sun or Moon was 7 inches in diameter and the details of the corona would be on a correspondingly large scale. The coelostat was carefully adjusted to the motion of the Sun.

From its great focal length the action of this instrument is very much slower than that of smaller instruments. This difficulty, however, could be compensated to a certain extent at the present eclipse by a much longer exposure which the great duration of totality at Solok, 5 minutes and 50 seconds, would allow. What would be shown in a few seconds with either of the portrait lenses would take fully as many minutes to catch with the large one. Only the prominences and the closer, brighter portions of the corona would be secured in a few seconds with the 60-foot camera. But it would be possible with the longer exposures to get impressions of the fainter parts for over a degree from the Sun, an extent which had never been photographed on such a scale before.

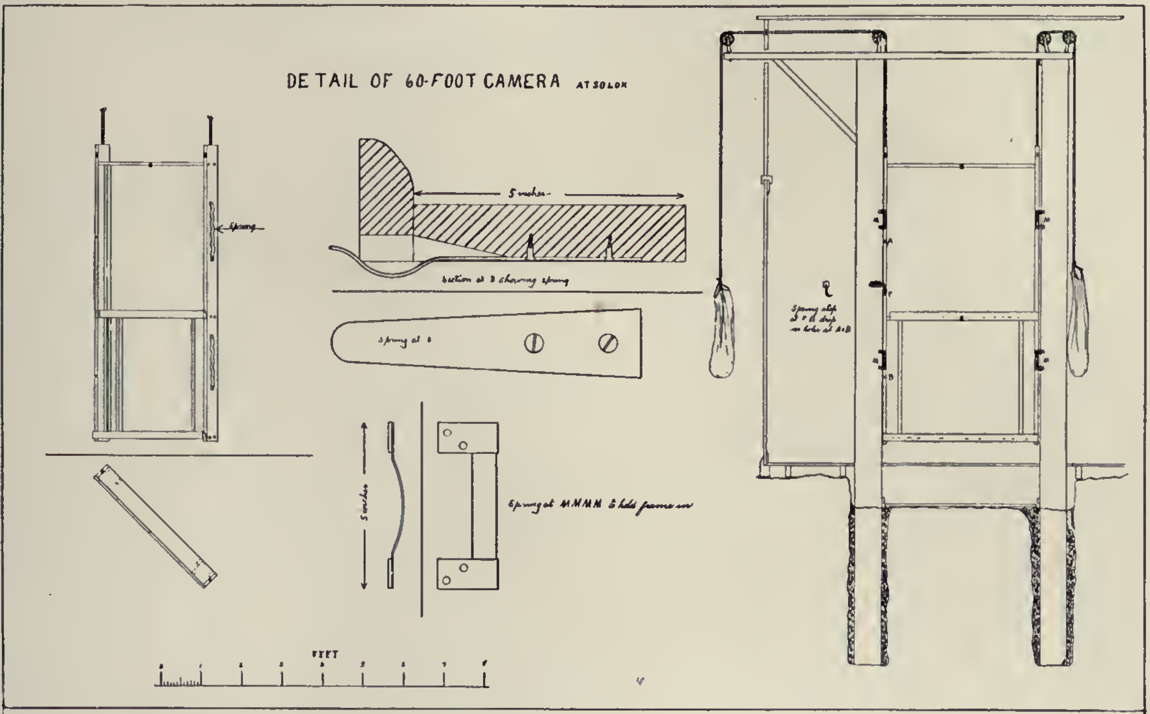
The horizontal camera tube, which was 2 feet square at the objective end and 40 inches square at the plate-holder end, was built in 8-foot sections of 4 by 1 inch strips screwed to square frames which served for diaphragms. The separate pieces of the tube had been put together at the Yerkes Observatory and each piece carefully numbered and then taken apart and crated for shipment. These were readily screwed together at Solok and then covered with dark-red waterproof paper. Over the top of the dark room a native roof of cocoanut leaves and bamboo had been built to keep off the direct heat of the Sun. A series of tent flies supported on a bamboo framework, was stretched above the camera tube and served the admirable purpose, besides shedding the rain, of keeping the tube cool and in preventing air currents within it. The coelostat was covered by a section of this tent, which could be shoved back to expose the mirror. This was a necessary protection, for it was found at Wadesboro, N. C., in the eclipse of May 28, 1900, that if the mirror was exposed to the direct sunlight for any length of time the effect was equivalent to a change in the focus of the lens of some 6 or 8 inches.

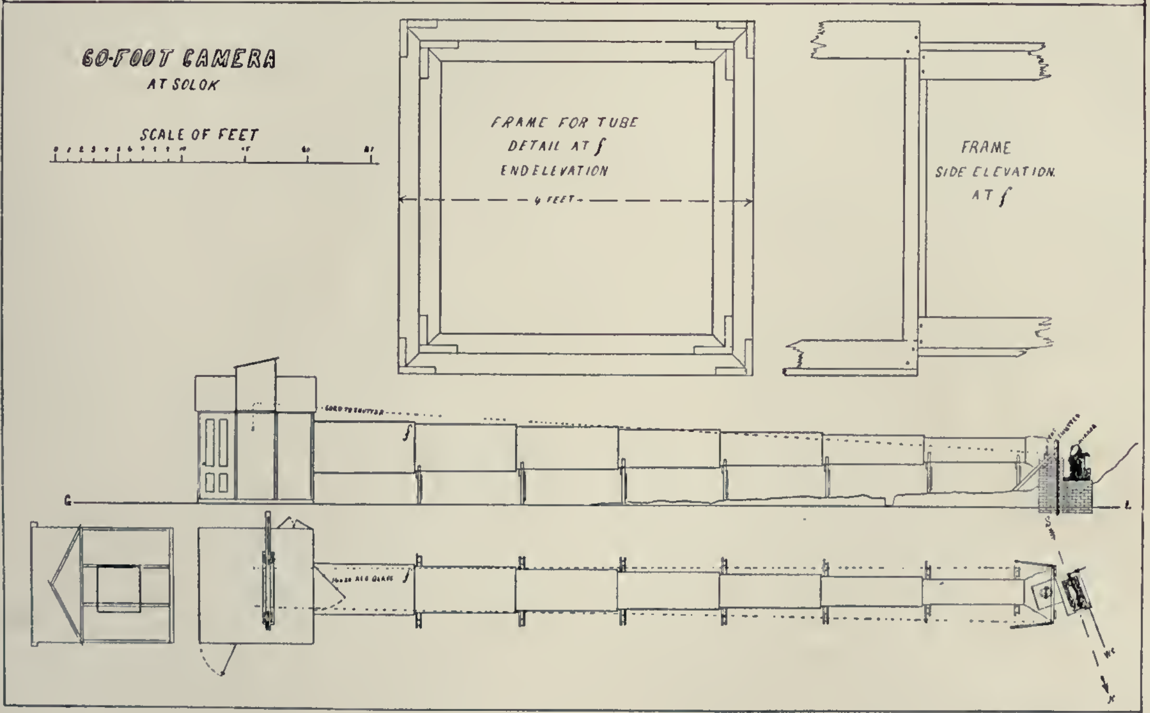
On account of the great size of the image an exceptionally large plate would be required to contain it. After a consideration of the difficulties it was concluded that a plate 40 inches square could be successfully handled and would contain the more important features of the corona. So large a plate had never before been used in astronomical photography. This plate, of plate-glass, was made specially by the CRAMER Dry Plate Company of St. Louis, and was given an exposure of two and one-half minutes. On the diagonal this could cover 4 degrees of the sky, and the least width would be 3 degrees, so that coronal details on a very large scale could be expected to be shown over a space from 3 to 4 degrees in extent.

Besides this large plate two other large ones 30 inches square and five smaller ones of 14 by 17 inches were used during the interval of totality—eight photographs in all—with the one instrument, with times of exposure varying from 1 second to 150 seconds.

The difficulty of handling such large plates was overcome by a very simple device. The problem was to stop in the midst of a series of exposures, bring into position, expose, and remove a heavy plate 40 inches square and then go ahead with the other exposures, all with the least possible loss of time. The big plate was to be exposed during the middle of totality.

The dark room was 10 feet square, with a door on the north side and an opening on the west side 40 inches square at the end of the camera tube. At a distance of





Drawn by W. W. Dinwiddie.

about 2 feet from the west side of the house were two timbers, 8 inches square, set fully 5 feet into the ground, with their inside faces 4 feet apart. These timbers rigidly connected furnished the support for the large plate-holders. Two cords running over pulleys on the top of the posts, and suitably counterpoised with bags of sand on the outer ends, supported a light wooden frame running in guides between the posts, like a window sash. This frame was built to contain in its upper section a 40 by 40 inch plate-holder, and in its lower section a 30 by 30 inch plate-holder. With the plate-holders in position the frame could be lowered and raised rapidly and with ease.

The two 30 by 30 inch plates and the five 14 by 17 inch plates were put into seven 30 by 30 inch plate-holders and placed in a rack to the right, perpendicular to the movable plate-holder frame, where they could be instantly taken up and placed in position, while the exposed plate-holder was lifted from the frame and leaned against the wall, on a table to the left, the operator not having to move from his position on the floor during the entire work of exposing. This method is a safer and better one than the sliding plate-holder used at Wadesboro in 1900.

The 40 by 40 inch plate-holder was put in position once for all in the frame. At the beginning of totality a 30 by 30 inch plate-holder was in position for the image to fall centrally on it. The exposure was made, the plate-holder lifted aside, another substituted and exposed, and when the time came for the 40 by 40 inch plate, the frame was pulled down to a stop, the exposure was made and the large plate-holder pushed up instantly and the exposures of the other plates proceeded with.

The construction of the plate-holders was specially admirable for the purpose. The covering slide was made up of narrow strips of wood glued to a cloth surface and was pulled open from behind and ran in grooves at the edge of the plate-holder both at the back and front. When the plate was exposed this flexible slide occupied a similar position at the back of the holder to that it had held in front when it protected the plate. The plate could therefore be uncovered by a person standing at the back of the plate-holder by pulling down the flexible slide. The 30 by 30 inch plate-holders were loaned by the Smithsonian Institution, and were the ones used by Mr. T. W. SMILLIE, of the U. S. National Museum, at Wadesboro, N. C., in 1900. The 40 by 40 inch plate-holder is the property of the Naval Observatory, and was made especially for the Sumatra eclipse by the SCOVILL & ADAMS Company of New York.

The actual exposing of the plate to the image was accomplished by a wooden slide, with a 7-inch hole in one end, running freely in a wooden horizontal frame supported independently on posts close to the lens, between it and the mirror. At each end of the slide was attached a strong cord. These cords ran back along the tube through screw eyes to the dark room, and were carried down through the roof and hung, with weights on them, just above the operator's head and within easy reach of his hands. Each weight was wrapped with a piece of white cloth to make it specially conspicuous. By pulling the left-hand cord the slide was instantly shot forward and the 7-inch hole brought over the object-glass exposing the plate; at the end of the exposure it was shot back with the right-hand cord and the exposure ended. This exposing shutter and the lens were built into the end of the tube with heavy dark cloth so that no light could enter except through the lens when the the shutter was drawn aside. With this arrangement an exposure of a very small fraction of a second could be successfully given. The coelostat and lens were on separate brick piers and the exposing slide, as above stated, was attached to posts independent of both.

The dark room was divided into two parts by a partition of heavy dark cloth impervious to light and situated in the plane of the posts supporting the plate-holders. The forward compartment into which the tube opened was occupied by the plate-side of the plate-holder, while the rear compartment was occupied by the observer, who, standing at the rear of the plate-holder, by pulling down the flexible slide could instantly uncover the plate, and by pulling on the two cords in reach overhead could expose the plate by uncovering and covering the lens some 60 feet away. To the left, between the post and the wall, was a heavy curtain which could be pushed aside and the observer could step into the front compartment and watch the plate during exposure. As a further convenience a mirror, borrowed from the native hotel, was placed at the proper angle in the further left-hand corner of the front compartment, so that by pulling the curtain slightly aside from behind the entire plate could be seen in the mirror. In this way at any moment the plate could be watched by the observer from his position at the rear of the plate-holder. The rear compartment could be strongly illuminated with several red lanterns so that the observer could plainly see what he was doing without in any way endangering the plate. A door opened outside from the rear compartment and a heavy curtain blocked out all light when the door was open. During totality the observer could open this door and go outside to view the eclipse while the longer exposures were going on, without danger to the plate. On the wall of the rear compartment a telegraph sounder ticked the seconds from the mean time chronometer, and thus the plates could be accurately timed.

It was the intention to shade the image during one of the long exposures. Three shaders of different dimensions on slender wire handles were conveniently placed in the front compartment near the plate so that they could be instantly taken up and the brighter parts of the corona shaded by a proper movement of the shader. These shaders were made of thin cardboard, the edges of which were covered with finely teased cotton which produced a soft diffusion of the edges. By a dexterous movement of one of these in front of the plate the action of the light at any point could be properly lessened without otherwise showing the effect of the shading. Cotton dyed red can be used for the shaders should it be thought that the light would be reflected dangerously from white cotton, but from the feebleness of the image in this class of instruments I do not think this is necessary. The advantage of this method is that you have the exposed plate in full view and can therefore intelligently shade any portion of the corona and grade the light to prevent over-exposure of the bright inner part. Experience at Wadesboro in the eclipse of May, 1900, had shown just how much shading could be successfully accomplished. A similar shader was then used but for a few seconds only because of the apparent faintness of the image. A longer use would have materially helped the resulting negatives.

The focus of the camera was carefully determined a number of times by trails of α Bootis, which fortunately had nearly the same declination as the Sun, and could therefore be brought into the camera without displacing the instrument. An 8 by 10 inch plate was placed on an inclined board between the two posts supporting the plate-holders. The image of the star trailing across this inclined plate would successively come into focus and pass out, so that the trail would have a point in it where it was sharp, and which would be the focus. After development this plate was carefully placed in the exact position it had on the board at the time of exposure, and the focal point on the plate could be accurately measured from the plane to be occupied by the sensitive surface of the plate at the time of the eclipse. The object-glass, which was mounted on a heavy iron base free to move on the pier, was then moved toward or away from the plate by the amount necessary to bring the focal point coincident with the plane of the sensitive plate. Other exposures were then made to see if the correction was perfect. The determinations on different nights, and it was only by glimpses that the star could be had between clouds, were very consistent in locating the focus. That this focus held during the eclipse was proved by the very sharp image of the crescent of the Sun made on Negative No. 9 at the close of totality.

The following exposure scheme was adopted for the plates:

No.	Length of Exposure.	Size of Plate.	Kind of Plate.
	s	in. in.	
1	1	14 by 17	CRAMER crown.
2	4	14 by 17	
3	16	14 by 17	
4	30	30 by 30	
5	150	40 by 40	
6	60	30 by 30	
7	8	14 by 17	
8	1	14 by 17	
9	½*	14 by 17	

* After totality.

Three 14 by 17 inch plates were ready in holders to be given quick exposures immediately upon the reappearance of the Sun to see how long the corona and prominences could be photographed after totality with such an instrument. One of these, No. 9, alone was used on account of the clouds.

In the careful drill that I went through in handling these large plates in the darkened room for a week before the eclipse, the above program from 1 to 8 was easily carried out in from $5^m 30^s$ to $5^m 35^s$. As the predicted duration of totality at Solok was $5^m 52^s$, this left ample margin for safety.

All the plates were thoroughly backed with a thick paint of burnt sienna and caramel. The large plates were put in their holders and their backs heavily painted with this mixture, and then further backed with soft newspaper to prevent injury to the backing. In preparing for the eclipse of 1900 I made a number of experiments with different backings to find their preventive effect on photographs of brightly illuminated objects, and finally decided in favor of burnt sienna and caramel. This mixture dissolves almost instantly from the back of the plate when placed in water before development.

A thorough drill had made the manipulation of these big plates easy and certain. Every precaution had been taken that no hitch should occur during totality. It was also found that no assistant was needed in making these large photographs, for one man could handle them as easily as two or more, and there would be less chance of confusion with no one to distract the attention of the observer with his presence.

The eclipse was over, and what I believe were the best preparations ever made for the observation of a total eclipse of the Sun had come to naught. It was with no light heart that the plates were developed. The large plates showed feeble fragments of the chromospheric ring, with a few prominences.

The development of the large plates was easily done. Wooden trays of the proper size had been brought along, and were heavily paraffined before using. In developing the 40 by 40 inch plate, which was of heavy plate-glass, the help of Mr. CURTIS made the handling of it a very simple affair. The two 30 by 30 inch plates and the six 14 by 17 inch plates were developed without any aid.

I wish, in closing, to express my personal indebtedness to every member of the party for the unselfish help they gave me in the erection of my somewhat extensive apparatus. Their own instruments were left untouched, essentially, until mine was safely on the way to completion. Especially am I indebted to Mr. DINWIDDIE, Mr. CURTIS, and Doctor GILBERT for their most valuable help. The word "help" does not properly convey my meaning, for they did almost the entire work of erection, and their intelligent advice and suggestions were of the utmost importance.

To Professor SKINNER I am indebted for every possible courtesy and help. He left nothing undone that would aid me in my work or that would make my comfort more certain.

I am also indebted to Professor BROWN, then Astronomical Director of the U. S. Naval Observatory, for the greatest kindness and courtesy in aiding me in the preparations for my part of the expedition.

To Professor HALE, director of the Yerkes Observatory, I am very gratefully indebted for every aid and encouragement in the work and for the use of the instruments comprising my outfit.

THE 10-FOOT CAMERA.

Mr. H. D. CURTIS, University of Virginia, in charge.

This 7.75-inch visual lens, belonging to the Naval Observatory, is the CLARK objective of the equatorial formerly mounted at the Naval Academy, Annapolis, and was used for photographic purposes by the Naval Observatory party during the total solar eclipse of August 7, 1869, at Des Moines, Iowa. The focal length is approximately 114 inches. This instrument was used in connection with a coelostat and clock.

VIEW OF THE ECLIPSE STATION AT SOLOK, SUMATRA. FROM SOUTHWEST CORNER, LOOKING NORTHEAST.

Photographed by W. W. Dinwiddie.

VIEW OF THE ECLIPSE STATION AT SOLOK, SUMATRA. FROM SOUTHWEST CORNER, LOOKING EAST.

Photographed by W. W. Dinwiddie.

There were no new devices used in the mounting of this instrument. The piers as well as the shutter and slow motions were carefully isolated. For convenience in testing the rate of the clock on the Sun a board about 3 feet long was firmly fixed to posts set flush with the surface of the ground against the earthern wall of the fort, so as to be nearly on a level with the optical axis of the telescope. By means of a surveyor's transit, mounted over the center of the coelostat mirror, the declinations of the Sun at Solok mean noon were laid off on the board as azimuth readings from west to south for intervals of three days preceding the eclipse. The values for each day were interpolated and the telescope moved so that the optical axis lay at the proper azimuth. Thus a convenient method of setting the telescope and using the Sun for some time before the eclipse was afforded. Considerable trouble was experienced in rating the coelostat on account of a periodic variation in the clock motion, which.was finally removed and perfect running secured.

The plates used were CRAMER isochromatic slow. The adjustment of focus was made by taking trails of α Bootis. For improving the definition the lens was stopped down to 4½ inches. All the plates were backed and the exposures were arranged in the order 5^s, 30^s, 180^s, 60^s, 15^s, 2^s, respectively, after third contact. The diameter of the Moon's image on the plate was 1.12 inches.

Under the cloudy conditions prevailing during the eclipse nothing of value was expected and nothing found on the slow plates used with this camera. Different methods of development calculated to bring out under-exposed features were tried, but there was nothing there to be brought out save a faint rim of light, while on the plates of the last part of the eclipse not a trace of anything but the fogging action of the sky could be seen. The exposure of two seconds after third contact showed the thin crescent sharply defined.

THE 31-INCH CAMERA.
THE 17-INCH CAMERA.

Mr. G. E. IRVING, Padang, Sumatra, in charge.
Seaman W. J. CASSIDY, U. S. S. *General Alava*, Assistant, May 14–21.
Seaman G. H. GETZ, U. S. S. *General Alava*. Assistant, May 14–21.

These short focus lenses, the first one with an aperture of 6.25 inches and the second of 3.25 inches, are the property of the Yerkes Observatory, and were provided by Professor BARNARD for photographing the greatest possible extent of the outlying portions of the corona and also for the detection of any intramercurial planet which might be within a few degrees of the Sun. Professor BARNARD brought these lenses with the hope of being able to use them also in taking some photographs of the southern portion of the Milky Way, but the hopeless succession of cloudy nights rendered this project impracticable.

The general charge of mounting and adjusting these cameras was in the hands of Mr. H. D. CURTIS, who showed great patience and mechanical skill in fitting them to the mounting of a 6-inch equatorial which was loaned by Mr. G. N. SAEGMULLER, of Washington.

The aperture of the larger instrument was reduced to 4 inches and 8 by 10 inch plates were used, while the aperture of the smaller was reduced to 2 inches and 6½ by 8½ inch plates used.

The following six exposures were made with these two instruments, using the same kind of plates with each:

No.	Length of Exposure.	Kind of Plate.
	s	
1	5	Cramer crown.
2	40	
3	120	Cramer isochromatic slow.
4	60	
5	15	Cramer crown.
6	20	

Professor Barnard says in regard to the results from these lenses:

> The small quick-acting lenses * * * secured at most the image of the Moon with a thin ring of light about it and the clouds themselves in the region of the eclipsed Sun. One of the long exposures, indeed, though it showed the clouds well, did not show any trace of the eclipse.

THE SPECTROPOLARIGRAPH.

Dr. N. E. Gilbert, Hobart College, in charge.
Seaman J. J. Few, U. S. S. *General Alava*, Assistant, May 14–21.

The plans for the polarization work of the Naval Observatory eclipse expedition of 1901 were made by Prof. R. W. Wood, of the University of Wisconsin, now of Johns Hopkins University, and most of the instruments were prepared by him at the laboratory of the University of Wisconsin. The instruments were mounted at the Solok station in Sumatra, and as clouds covered the Sun during the eclipse the following report is principally a description of the instruments and of the preparations made for the work.

The eclipse party reached Padang on April 5, and one week later the writer was comfortably quartered at Solok in the barracks of the deserted Dutch fort, within which the station was to be located. The position of the polarization apparatus was in the extreme southwest corner of the inclosure. From the top of the earthworks at this point it was possible to obtain an uninterrupted view of the heavens to within a few degrees of the horizon, a consideration of great importance for the visual work, while for the photographic work the projection of the line of sight fell on green fields and cocoanut groves.

The most important instrument for the polarization work was the polarizing photographic spectroscope, known to our party by the name of spectropolarigraph. This consisted of a 2-inch object-glass, a Nicol prism, a direct vision spectroscope, and a camera. The object-glass was mounted at the end of a rod, which was attached rigidly to the tube of the spectroscope. No telescope tube was used. The Nicol prism was placed immediately before the slit of the spectroscope, and was traversed by the light from the object-glass before the image was formed on the slit. The spectroscope was of the ordinary direct vision type, with a camera box at the eye end. When the plate-holder was removed the spectrum was visible through the eyepiece.

The instrument was mounted on the saddle of a 5-inch equatorial telescope from the Naval Observatory. The telescope was first mounted and adjusted. SCHAEBERLE'S method was used for the inclination of the axis, and two meridian marks, one on a hill to the north and the other on Mount Talang to the south, both several miles away, were used for the azimuth adjustment. The weather remained so persistently cloudy at night that it was decided not to wait for stellar adjustments. The instrument was later shifted slightly in azimuth so as to enable it to follow the Sun more closely.

The driving clock was of the BOND spring governor type, and possessed the usual characteristics of that machine. With the utmost care in adjustment it could not be depended upon to run steadily; at times it would run steadily for several hours, but at other times only for a few minutes. One cause for this difficulty was that the axis was overloaded. It was, however, so balanced as to run easily in the position in which it was to be used and the clock was carefully adjusted and tested for this position, but in spite of these precautions the behavior was such during the eclipse as to have hazarded the results had the sky been clear.

The purpose of the spectropolarigraph was to determine whether the FRAUNHOFER lines exist in the spectrum of the corona, and so to determine whether or not the corona is self-luminous. Professor WOOD has pointed out that in all recorded attempts to solve the question the slit has been placed radially or at best along a chord near the center of the Sun's image. With this arrangement the light from the corona, since it is polarized radially, falls upon the face of the prism at an angle such that it does not penetrate the surface but is totally reflected. To avoid this difficulty the slit was placed tangent to the Sun's limb. The NICOL prism was set so as to transmit light polarized only in a plane perpendicular to the direction of the slit. In order to obtain the greatest possible amount of light the instrument was mounted so that the slit was tangent to the limb at the Sun's equator.

A rectangular crib, of 2 by 2 inch scantling, was bolted to the saddle of the equatorial. To this were screwed two wedges of an angle equal to the complement of the angle made by the plane of the Sun's equator with the plane of the meridian. This angle was determined by Mr. JEWELL. The rectangular box containing the prisms, near the center of the spectroscope, was laid on these wedges, and iron straps were placed over the tube and bolted to the crib. Wooden blocks were placed between the tube and the crib to prevent the bending of the tube.

The photographic focus and the best width for the slit were carefully determined by taking a series of negatives. The eye was also trained to estimate the brightness of the visual spectrum necessary to give a properly exposed plate with an exposure of five minutes. The program for this instrument during the eclipse was as follows:

Have the instrument set on the Sun's limb and the spectrum, in the region of the *H* and *K* lines, visible in the eyepiece. Immediately after second contact move the slit away from the Sun's limb by means of the slow-motion screws until the light in the spectrum fades to the amount previously determined upon as necessary for a full exposure in five minutes. Rotate the prisms till the violet of the spectrum moves into the field, insert plate-holder and expose until twenty seconds before third contact.

The reason for moving the spectrum immediately before exposing was that the desired region in the violet would be invisible in the dim light and so could not be used in estimating the proper distance of the slit from the Moon's limb. A stop was placed in the screw so that no error could be made. The pitch of the slow-motion screws was determined beforehand so that they might be moved in the proper ratio, and that the distance of the slit from the Sun's limb might be estimated. Immediately after third contact this was to be determined again by examination of the Sun's image on the slit. During the eclipse the light was so far reduced by the clouds that no part of the spectrum was visible, nor was the image of the corona visible on the slit. The slit was moved a distance of one-eighth radius from the Sun's limb and the plate exposed, but the developed negative was a blank.

The instrument of next importance was a STEINHEIL telescope of about 2 inches aperture, arranged as a visual polariscope. The eyepiece was made into a very sensitive analyzer by placing between the two lenses a NICOL prism and a SAVART plate. The eyepiece could be easily rotated and a scale was placed on the tube so that the amount of rotation could be read in an uncertain light. The instrument was supported by a cord from a bamboo pole set on the top of the earthwork 5 steps from the spectropolarigraph.

The observations to be made with this instrument were:

1. To determine how far the polarized light of the equatorial streamers can be traced with a delicate polariscope.

2. To determine whether the polarization of the light in the polar streamers is radial or follows the curve of the streamers.

3. To determine whether the polarization of the light from the blue sky changes during the eclipse.

The last observation was the only one of the series which could be made, and the result is interesting, in that it fails to confirm the observations of Mr. and Mrs. NEWALL, made in Algeria in 1900. Mr. NEWALL reported to the Royal Society of London that the plane of polarization was observed to rotate suddenly through several degrees at the instant of third contact. During the eclipse at Solok there was a large patch of blue sky in the north and another in the west, each about 45 degrees from the horizon. For several minutes before and at the instant of second contact the clear patch in the north was watched, and for several seconds before and at the instant of third contact that in the west was watched, and it is certain that no perceptible change in the colored fringes took place. During the eclipse several other smaller spots of clear sky were examined, but in each case the polarization appeared to be exactly normal.

Another instrument used was a simple shadowgraph for comparing roughly the ratio between direct sunlight and skylight, with the ratio between direct corona light and skylight. The instrument consisted of a tube of fiber, three-eighths of an inch in diameter and 5 inches long, with a collar 1 inch broad near one end. A cap fitted over this end of the tube. This tube was supported by a wire over a piece of solio paper and, with the cap on, was directed toward the Sun. After a certain time the cap was removed and the time noted when the spot within the tube, which was exposed to full sunlight, was of the same color as the ring outside, which was shaded by the collar from direct sunlight. Numerous tests of this kind were made and the ratio was found to be reasonably constant. During the eclipse two such instruments attached to the same board were used. In one was a SEED gilt edge plate and in the other a CRAMER slow transparency plate. These plates were both exposed in the ratio previously determined upon from the experiments in full light. Both plates showed a great excess of light, but as the corona was almost entirely covered by clouds, it was not thought worth the trouble to make a careful determination of the ratio involved.

In conclusion, I wish to acknowledge my obligation to Prof. A. N. SKINNER and to the other members of the party who assisted in every way possible, and to Mr. FEW, of the U. S. S. *General Alava*, who assisted most efficiently in the final adjustments and in the manipulation of the instruments during the eclipse.

THE PLANE GRATING SPECTROGRAPH.

Assistant Astronomer F. B. LITTELL, U. S. Naval Observatory, in charge.

This instrument was arranged for the purpose of determining the evidence of rotation in the corona. The camera box consisted of a large pine box of triangular shape and about 18 inches deep. This rested on three brick piers laid in cement, while an extension about 4 feet long between it and the coelostat contained the condensing quartz lens $3\frac{17}{32}$ inches in aperture and 50⅛ inches focal length for green light. The image of the Sun formed by this lens fell upon an adjustable slit 1½ inches long at the eastern end of the camera box; the light emerging from the slit fell upon the objective quartz lens, $3\frac{23}{32}$ inches in aperture and 50½ inches focal length and thence upon the plane grating in the western end of the box; thence the diffracted light proceeded back to the photographic film at the eastern end of the camera box. The two lenses, the slit, and the grating were rigidly connected by a steel tube 2 inches in diameter, upon which they were mounted in such a way as to be readily adjusted.

The plate-holder was so constructed that films could be bent to follow the curvature of the focal plane and thus secure sharp definition in all parts of the spectrum. Three exposures were provided for and a simple and quick movement of the plate-holder was sufficient to bring a new film into position.

After the spectroscopic adjustments had been completed the camera box was covered with building paper and the connection between the boxes was packed with black cloth to make the apparatus light tight.

This instrument was designed and adjusted by Mr. L. E. JEWELL.

The grating which was loaned by Johns Hopkins University has a ruled surface 3½ by 5 inches with 15,000 lines to the inch.

The clouds prevented obtaining any results with this instrument.

THE CONCAVE OBJECTIVE GRATING SPECTROGRAPH.

Assistant L. E. Jewell, U. S. Naval Observatory, in charge.

As soon as the coelostat was set up at Fort de Kock I went there to test the 30-foot and 21-foot gratings, but on account of the prevailing bad weather it was six days before the collimator could be adjusted and the gratings tested. Finally an almost perfect day occurred on the 1st of May, and the gratings were thoroughly tested. Both Doctor Humphreys and I decided that it would be best to use the 30-foot grating on account of its brilliancy and very great dispersion, although nearly half of it had to be covered on account of defects of ruling.

From Fort de Kock I went to Sawah Loento, where we found that the proposed method of using the plane grating and 70-inch quartz objective would not answer and the lens had to be placed between the grating and photographic plate. This rendered necessary a change in the position of the grating and some changes in the camera box.

Shortly after returning to Solok another visit to Fort de Kock became necessary to see to the focusing of the large concave objective grating spectrograph, and then again to Sawah Loento to focus the objective grating spectrograph. The necessary work at Fort de Kock and Sawah Loento left little time to set up and adjust the concave objective grating and plane grating spectrographs at Solok, but it was accomplished in spite of much bad weather. Some facts in connection with the adjustment of the concave grating are of interest. On account of bad weather a preliminary adjustment was made from computed dimensions and the use of a steel tapeline for placing the plate-holder at just the right distance from the grating center. The spectrum was adjusted central and parallel to the plate by using the light of an acetylene bicycle lamp, and the middle of the plate-holder set to the correct wave-length by the use of matches which furnished the position of the *D* lines due to sodium. When a clear sky enabled me to make the final adjustments with the aid of the collimator, it was found that the previous adjustments, thought primitive, were nowhere in error by as much as a millimeter. A very efficient assistant from the *U. S. S. General Alava* was assigned to help with this spectrograph.

The grating which is the property of the Naval Observatory is a Rowland grating with 15,000 lines to the inch, the ruled surface being 3 by 5¼ inches and the radius 10 feet. It was mounted in a mahogany camera box provided with a sliding film-holder for 4 films, each 12 inches long. The films were bent to a curve of about 24 inches radius. This instrument was fed by a coelostat.

The definition of the concave grating spectrograph was very good with the collimator and also a few minutes before totality.

In the direct vision spectroscope a Zeiss prismatic binocular was substituted for the ordinary binocular as used in the total solar eclipse of May 28, 1900; the increase in magnifying power and sharpness was plainly noticeable, and the performance of the combination was excellent. The narrowing of the band of the Fraunhofer arcs, due to the narrowing of the crescent of the Sun's limb that remained uncovered, was carefully watched, and though the cloudiness was increasing rapidly the narrowing of the spectrum band to a line and its disappearance was noticed distinctly. The word "Go" was given at that instant and an exposure made in the spectrograph nearly two seconds before the direct sunlight disappeared, as determined by Professor SKINNER at the portable equatorial. Some of those watching with the eye saw direct sunlight until the signal given by Professor SKINNER, yet the spectrograms taken at the instant of my signal, by both Mr. DINWIDDIE and myself, show no signs of sunlight.

Two spectrograms with the concave grating spectrograph showed chromospheric lines, but they were faint and the photographic films had spoiled to a considerable extent. The first spectrogram was taken about 7 or 8 seconds before totality, and had an exposure of about ¼ of a second. A few hydrogen and calcium lines show, which are perfectly sharp, though very faint, because of the short exposure and weakness of the light. The lines that show are the horn-like tips of the strong chromospheric lines just outside the band of the FRAUNHOFER lines, which are very faint. The second exposure would have shown a considerable number of lines in spite of the cloudiness if the clockwork of the coelostat had run well, but as the exposure was about 5 seconds long the lines were very badly blurred, though the short exposure of ¼ of a second showed the lines perfectly sharp.

The photographic films were badly fogged. This was due to a considerable extent to the spoiling of the films, but very largely to the strong sky illumination coming in through the opening in the front of the camera box. The objective prism spectrograph used by Mr. DINWIDDIE was more perfectly inclosed and screened from sky illumination and the plates were not so badly fogged.

It follows from this that it is absolutely necessary with a direct grating spectrograph and other instruments of this character to protect them as carefully as possible from skylight coming from other directions than the Sun's immediate vicinity.

Although at Solok we were about 40 or 45 miles within the northern edge, the landscape features and all of the near surroundings were visible with great distinctness.

Mr. DIXON, an English mining engineer, and I had arranged to make sketches of the coronal equatorial extension during the longest of the exposures and had arranged a table with a lighted lantern to see by, drawing paper, etc., and I had also placed a watch close to the lantern to note the passage of time. Greatly to my surprise the sky illumination was such that the second hand of the watch was easily seen and the individual seconds could be read by the diffused light at a distance of about 3 feet with the greatest ease, the lantern not being necessary at all.

Neither of the photographs taken with the concave grating spectrograph is useful because of the faintness of the first and the blurring of the second, due to the bad following of the clock work and the very bad fogging of both films.

As soon as possible the films taken with the concave grating spectrograph were taken to Fort de Kock and developed, as well as those taken with the spectrographs at Fort de Kock and Sawah Loento.

THE OBJECTIVE PRISM SPECTROGRAPH.

Assistant W. W. DINWIDDIE, U. S. Naval Observatory, in charge.

The prism and lens of this instrument were loaned by the Smithsonian Institution. The dimensions of the prism are: Height, 6½ inches; width of face, 5¼ inches; angle, 59° 59′ 50″.

The lens is visually corrected, achromatic, of 7 feet 6 inches focus, and 6 inches aperture.

The instrument was mounted on three cement-laid brick piers, two for the prismatic camera and one for the coelostat. The construction and design of the mounting and the movable plate-holder were entirely the work of Mr. DINWIDDIE, who did the work on the spot with the limited facilities at hand.

The plate-holder was arranged to carry five films 2 by 12 inches, bent approximately to the focal curve. The films were SEED 27, gilt edge, manufactured expressly for this expedition.

The scheme of exposures was as follows:

No.	Length of Exposure.
1	2^s
2	25
3	260
4	15
5	½ *

* Just after totality.

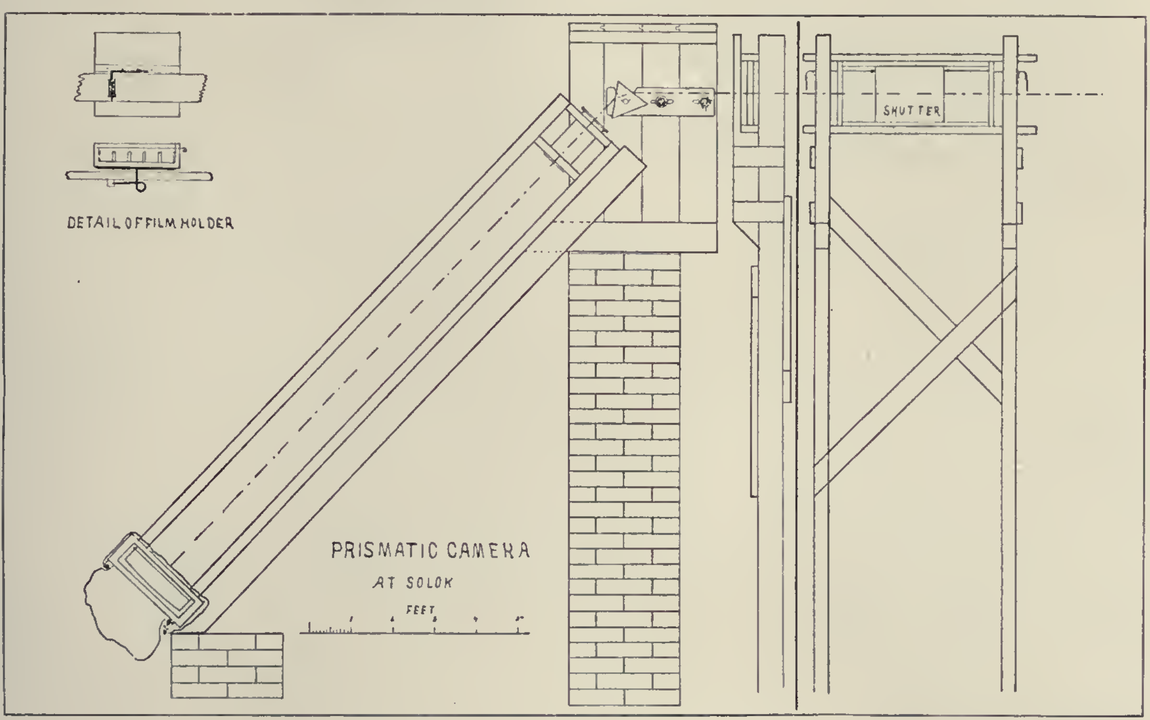
The instrument was focused by Mr. JEWELL by means of a reflecting collimator designed by himself, and described in the report of the Fort de Kock station. During the eclipse the exposures were made by Mr. DINWIDDIE without any assistant.

DETERMINATION OF WAVE-LENGTHS.

The determination of the wave-lengths was made by Professor SKINNER, using the plate measures of Mr. DINWIDDIE.

Film No. 1, which had an exposure of two seconds beginning at second contact, the only film of the series capable of measurement, was measured by Mr. DINWIDDIE on the University of Virginia measuring engine constructed by the Société Genevoise, and placed at the disposal of Mr. DINWIDDIE through the courtesy of the officials of the University. It shows over a hundred lines, most of which are in good focus. Each of the better defined lines was carefully measured three times. Many of the lines, especially the stronger ones, had the appearance on the plate of being double and where such was the case the apparent components were separately measured and the resulting wave-lengths connected by braces in the table. The apparent duplicity does not appear to have been the result of incorrect focusing or of irregular movement of the coelostat clock.

APPENDIX I, VOL. IV, PUBLICATIONS OF THE UNITED STATES NAVAL OBSERVATORY. PLATE XXII.



Drawn by W. W. Dinwiddie.

Mr. DINWIDDIE adopted a scale of intensities from 1, representing the faintest, to 10, the strongest line. A dash following an intensity marked 1 indicates some degree of difficulty in measuring the line.

The inclination of the crescent lines on this plate is due to the fact that the instrument was so adjusted that the lines of the grating should be tangent to the Sun's limb at the point of third contact.

The measured positions of the three strong lines K, H_γ, and H_β were first used in deriving approximate values of the constants of HARTMANN formula,* which becomes for this solution

$$\lambda = 2221.356 + \frac{499239}{369.654 - n}$$

Making use of these constants the wave-lengths of some 39 measured lines were computed and from these were selected 10 lines which appeared to be well identified which were then used to derive corrected values of the constants by the method of least squares. Using these corrected constants the wave-lengths of the lines were computed and compared with ROWLAND. An inspection of the residuals led to the rejection of some lines and the use of others, always testing the selection by a least square solution, the aim being to base the final values of the constants on a set of lines which should give a consistent set of differences between the computation and ROWLAND.

The following formula embodies the adopted constants which were derived from the final least square solution:

$$\lambda = 2227.120 + \frac{496387}{368.964 - n}$$

These constants were derived from the measured positions of the following seven lines. ROWLAND was used as a standard of reference for all these lines except the helium line, whose wave-length was derived from RUNGE and PASCHEN. The following table indicates the agreement of the computed wave-lengths of these seven lines with ROWLAND:

Line.	Computed λ.	Computed minus ROWLAND.
K	3933.844	+0.02
Sr	4077.957	+0.07
H_δ	4101.920	−0.08
H_γ	4340.493	−0.14
He	4471.478	(−0.17)
Ti	4501.495	+0.05
H_β	4861.815	+0.29

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* Astrophysical Journal, Vol. VIII, p. 218

Using the finally adopted constants, the wave-lengths of all of the lines measured on the plate were computed. These results are given in the following table.

The first column gives Mr. DINWIDDIE'S estimate of the angle subtended by the spectral crescents. The second column gives the estimated photographic intensities of the lines on a scale from 1, the faintest, to 10, the strongest, line on the plate. The designation of a few of the more prominent lines is also included in this column.

The third column gives Mr. DINWIDDIE'S remarks in reference to the character of the lines.

The fourth column gives the wave-length computed from the HARTMANN formula, using the finally adopted set of constants. Braces on the left of the column connect the wave-lengths of lines, which are judged by Mr. DINWIDDIE to be double images of single lines. Braces on the right have reference to uncertainties in identification.

The fifth column gives the wave-length from ROWLAND, with which the measured lines have been identified.

The sixth and seventh columns give the name of the substance and the solar intensity of the line as given by ROWLAND.

Table of Wave-lengths.

Arc.	Photo. Intensity.	Remarks.	Computed Wave-length.	ROWLAND.	Substance.	Solar Intensity.
°						
15	2	Out of focus	3760.1	3760.196	Fe	5
				3761.464	Ti	7
15	2	Out of focus	3761.4	3762.012	Ti	3
20	2	Out of focus	3763.0	3763.147	..	2
20	2	....	3772.4	3772.673	Ni	2
				3797.659	Fe	5
20	2	Out of focus	3798.1	3798.655	Fe	6
25	3	Not very sharp	3799.6	3799.693	Fe	7
25	Hη 3	Not very sharp	3835.4	....	Hη	.
25	3	Not very sharp	3837.0	....	..	.
5	1	Very faint	3840.4	3840.580	Fe–C	8
25	Hζ 4	Fair	3889.0	....	Hζ	.
30	4	....	3890.1	....	..	.
5	1	Very weak	3891.9	3892.069	Cr, Fe	4
5	1	Very weak and hazy	3900.2	3900.681	Ti–Fe	5
5	1	Very weak and hazy	3901.6			
5	1	Very weak and hazy	3913.4	3913.609	Ti	5 d?
5	1	Very weak and hazy	3914.5	3914.426	Fe?	3
5	1	Very weak and hazy	3914.7	3914.477	Ti	2
5	1	Very weak and hazy	3915.9	3915.751	..	3
				3915.951	Cr	5 d?
55	K 10	Strong and fairly sharp	3933.2	3933.825	Ca	1000
55	10	....	3934.5			
5	1	Exceedingly weak	3945.4	3945.033	Fe	3
				3945.260	Fe	3
				3945.473	Co	3 N

Table of Wave-lengths—Continued.

Arc.	Photo. Intensity.	Remarks.	Computed Wave-length.	ROWLAND.	Substance.	Solar Intensity.
°						
5	1	Exceedingly weak	3962.7	3962.995	Ti	3
55	H 10	Strong and sharp	3968.1	3968.625	Ca	700
55	10		3969.2			
35	9		3970.9	3970.177	H_ϵ	5 N
5	1—		3983.3	....	..	.
5	1—	Very faint and hazy	......	....	..	.
5	1—	Very faint and hazy	3998.4	3998.053 3998.205 3998.790	Co Fe Ti	4 d? 4 4
5	1—		4006.0	4005.856	..	3
5	1—		4013.0	4012.541	Ti, Ce	4
		Hazy bands between	......	....	..	.
5	1—		4041.6	4041.431 4041.525	Fe Mn	3 5
10	1		4046.2	4045.975	Fe	30
10	1		4064.1	4063.759	Fe	20
5	1—		4068.1	4068.137	Fe–Mn	6
5	1—		4073.0	....	..	.
20	4		4077.5	4077.885	Sr	8
20	3		4078.5			
5	1—		4087.3	4087.252	Fe	3
5	1—		4093.4	....	..	.
40	H_δ 8		4101.5	4102.000	H, In	40 N
40	7		4102.4			
5	1		4143.8	4144.038	Fe	15
10	1		4149.9	....	..	.
5	1		4156.8	4156.970	Fe	3 d?
10	1		4165.7	4165.550	C, Fe	3 d
10	1		4178.5	4178.223	..	2
20	4		4215.7	4215.703	Sr	5 d?
5	1—	Sharp and faint	4216.8	4216.760	..	1 N
15	g 3		4226.9	4226.904	Ca	20
10	3		4233.4	4233.328 4233.772	Mn Fe	4 6
3	1—		4239.6	....	..	.
15	3		4247.0	4246.996	Sc	5
10	2		4254.2	4254.505	Cr	8
10	1—		4260.8	4260.640	Fe	10
10	1		4271.5	4271.325	Fe	6
10	2		4274.5	4274.348 4274.746	.. Ti	2 N 2
10	3		4290.2	4289.885	Cr	5
10	2		4294.1	4294.204 4294.301	Ti Fe	2 5
10	1		4297.0	....	..	.
10	2		4299.7	4299.803	Fe, Ti	2
10	2		4300.5	4300.211	Ti	3

Table of Wave-lengths—Continued.

Arc.	Photo. Intensity.	Remarks.	Computed Wave-length.	ROWLAND.	Substance.	Solar Intensity.
o						
10	1		4302.6	4302.692	Ca	4
10	1		4303.4	4303.337	..	2
10	G 1	Does not appear double	4308.2	4307.907 4308.081	Ca Fe	3 6
10	1		4313.3	4313.034	Ti	3
10	2		4314.7	....	..	.
10	2		4320.9	4320.907	Sc	3
10	2		4325.5	4325.152 4325.939	Sc Fe	4 8
10	1—		4330.2	....	..	.
10	1—		9333.7	4333.925	La	1 N
10	1—		4337.2	4337.216	Fe	5
40	9		4340.5	4340.634	H_γ	20 N
5	1—		4344.1	....	..	.
10	2		4351.9	4351.930	Cr	5
10	1		4358.9	....	..	.
10	2		4375.1	4375.103	V, Mn	2
10	2	Hazy	4383.6	4383.720	Fe	15
10	1—		4391.8	....	..	.
15	2	Double	4394.6	....	..	.
15	2		4395.5	4395.201	Ti	3
10	2		4400.5	4400.555	Sc	3
10	1		4405.0	4404.927	Fe	10
10	1		4408.9	....	..	.
10	1	Hazy	4415.8	4415.722	..	3
10	1		4417.6	4417.884	Ti–	3
10	1		4427.6	4427.482	Fe	5
10	1		4435.2	4435.129 4435.321	Ca Fe	5 2
10	2		4444.0	4443.976	Ti	5
10	1		4450.5	4450.654	Ti?	2
10	1		4454.8	4454.953	Ca, Zr	5
10	1		4461.6	4461.818	Fe	4
10	2		4468.7	4468.663	Ti–	5
40	4	Sharp	4471.5	(4471.646)	He	.
10	1	Sharp	4476.4	4476.253	Ag	3
10	1	Very hazy	4482.6	4482.438	Fe	3
10	1—	Very hazy	4490.1	4489.911 4490.253	Fe Mn–Fe	4 3 N
15	2		4501.5	4501.445	Ti–	5
10	1	Hazy	4508.3	4508.455	Fe?–	4
10	1—		4515.1	....	..	.
10	1—		4521.0	....	..	.
10	1—		4523.1	4522.974	Ti	2
10	1—	Very hazy and weak	4529.3	....	..	.

Table of Wave-lengths—Continued.

Arc.	Photo. Intensity.	Remarks.	Computed Wave-length.	ROWLAND.	Substance.	Solar Intensity.
°						
10	2	....	4534.3	4534.139	Ti–Co	6
15	2	Hazy and double......................	4550.0	4549.808	Ti–Co	6 d?
15	2	Hazy and double......................	4554.5	4554.211	Ba	8
15	2	Hazy and double......................	4564.4	....	..	.
15	2	Hazy and double......................	4572.4	4572.156	Ti–	6
10	2	Hazy..................................	4584.3	4584.018	Fe–	4
10	1	Weak	4630.0	{4629.521 {4630.306	Ti–Co Fe	6 4
40	F 10	Fairly sharp but double	4861.8	4861.527	Hβ	30
10	1—	Very weak and out of focus............	4872.9	....	..	.
10	1—	Very weak and out of focus............	4878.0	4878.313	Ca	3
10	1—	Very weak and out of focus............	4885.3	4885.264	Ti–	2
10	1—	Very weak and out of focus............	4892.5	....	..	.
10	1—	Very weak and out of focus............	4901.2	....	..	.
10	1—	Very weak and out of focus............	4913.6	4913.803	Ti	2
10	1—	Very weak and out of focus............	4920.6	4920.685	Fe	10
10	1—	Very weak and out of focus...........	4925.1	4924.956	Fe	3
10	1—	Very weak and out of focus............	4935.0	....	..	.
10	1—	Very weak and out of focus............	4959.2	....	..	.
10	1—	Very weak and out of focus............	5019.7	....	..	.

From the angles subtended by the spectral crescents as estimated on the photographic plate, it is easy to deduce the elevation above the Sun's surface of the elements producing them. In this determination the Sun's semidiameter was taken as 948″.5 and the augmented semidiameter of the Moon was found to be 1012″.9.*

In this calculation the limb of the Moon was considered as coincident with the limb of the Sun at the point of contact. During the exposure of the plate a little more than 1″ in height of the chromosphere was covered near the point of contact by the motion of the Moon, so that the results in the table may be a fraction of a second too small. The following table gives the deduced elevations as shown by the different spectral lines:

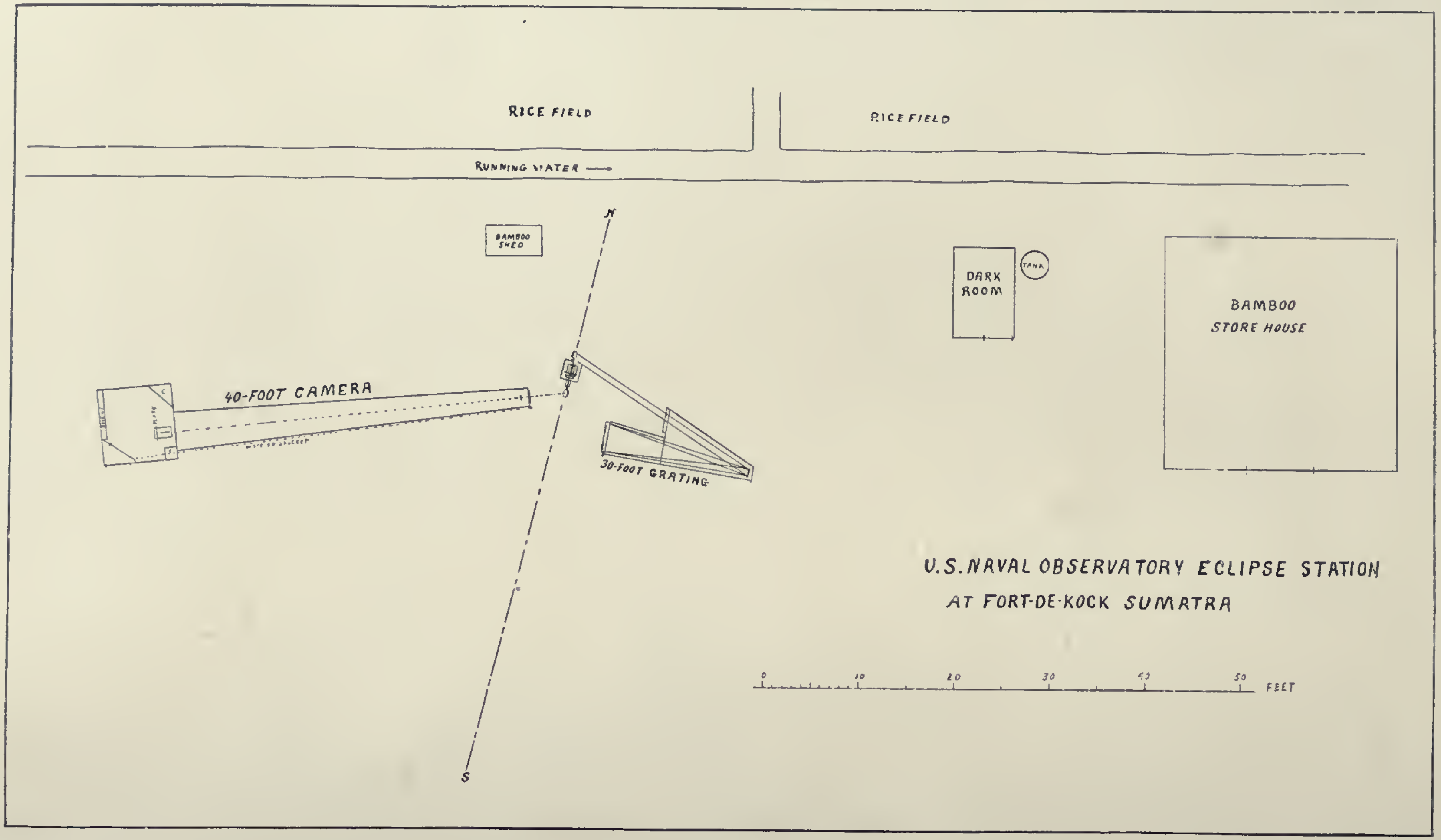
---

*In calculating the Moon's semidiameter the ratio between the horizontal parallax and the semidiameter was assumed to be 0.272274, as given in the American Ephemeris for 1901. The value 0.272506, however, is used in the American Ephemeris in eclipse computations for 1902–1904, but the value 0.272274 is resumed in the Ephemeris for 1905.

Spectrum Line.	H 3970	Sr 4078	H_δ 4102	Sr 4215	Ca 4226	Sc 4247	Cr 4254	Sc 4321
Arc	55°	20°	40°	20°	15°	15°	10°	10°
Intensity	10	4	8	4	3	3	2	2
Approximate height of layer	$7''$	$1''$	$3''.5$	$1''$	$0''.5$	$0''.5$	$0''.5$	$0''.5$

Spectrum Line.	H_γ 4340	Ti 4395	He 4471	Ti 4501	Ti 4549	Ba 4554	Ti 4572	H_β 4861
Arc	40°	15°	40°	15°	15°	15°	15°	40°
Intensity	9	2	4	2	2	2	2	10
Approximate height of layer	$3''.5$	$0''.5$	$3''.5$	$0''.5$	$0''.5$	$0''.5$	$0''.5$	$3''.5$

PLATE XXIII.



Drawn by W. W. Dinwiddie.

REPORT OF THE FORT DE KOCK STATION.

Professor of Mathematics W. S. EICHELBERGER, U. S. N., in charge.

Our party arrived at Fort de Kock in the late afternoon of April 12, and secured accommodations at the Sawah Hotel, a commodious one-story frame building, consisting of a large dining hall running through the center of the building its entire length, with guest rooms on each side.

Early the next morning we called on Secretary HEYTING, the Dutch official in charge of the town, and under his guidance, in conjunction with Controller J. VAN HENGEL, examined various localities for a site for our eclipse station. The artillery drill ground, five hundred feet long by three hundred wide, situated in a level stretch of country, unobstructed on any side and within ten minutes walk of the hotel and of the railroad station, was finally selected, and permission was given Professor SKINNER by Major VAN HAEFTEN to locate there.

The position of our camp, as taken from the very excellent map of the district issued by the Topographisch Bureau te Batavia, is

Latitude $= -0° \ 18' \ 45''$.
Longitude east from Padang $= \ 0^{h} \ 0^{m} \ 1^{s}.4$
Longitude east from Greenwich $= \ 6^{h} \ 41^{m} \ 29^{s}.1$
Height above sea level = 3,030 feet.

Fort de Kock is extremely healthy and has a very cool mountain climate. During the first three weeks of May the daily minimum temperature varied from 60° to 68°, and the maximum from 74° to 83°. The advantages of Fort de Kock were its altitude, which insured a minimum of atmospheric absorption, and its position near the northern edge of the shadow, which gave opportunity for special study of the northern polar streamers with the 40-foot camera and a much longer duration of the flash spectrum.

Its disadvantage was its nearness to two large mountain peaks, Singalang and Merapi, which rose about 6,000 feet above the plain and were about 5 miles distant, the one to the southwest and the other to the southeast. Merapi is an active volcano and the tops of both mountains were almost continually enveloped in clouds.

All our business transactions with the natives were conducted through the Dutch officials. As there was no structure upon the site selected in which to house our instruments or their accessories, we communicated to Controller VAN HENGEL our desire to have a storehouse erected. He in turn summoned the native chief of the town, who procured for us a Malay carpenter, and at the end of our first week's stay at Fort de Kock we had a perfectly ventilated and well nigh rain proof storehouse 6 meters square, built entirely of bamboo.

While this was being erected at the eastern end of our line of buildings, the four members of the eclipse party were putting together our photographic dark room and equipping it for work. This was brought in sections from San Francisco, as it was not known when we started what kind of carpenters we could find in Sumatra. To protect this as much as possible from the Sun there was built about a foot above its top an "atap" roof, supported on bamboo posts, extending several feet beyond the house in all directions. The natives working on the other house were very much amused to see white men doing manual labor, as the Europeans in Sumatra are not in the habit of doing anything of that kind.

During the same period we also had made a Portland cement foundation 1 meter square and a half meter in the ground for our coelostat pier, so that at the beginning of our second week we were ready to commence setting up our instruments.

Through the same official channel by which we obtained the services of a carpenter we were furnished a guard for our camp consisting of four Malays who were quartered on the grounds. At the end of each week those on duty were relieved by another four.

On May 1, by permission of Major VAN HAEFTEN, we raised the Stars and Stripes to the top of a bamboo pole 30 feet high, and beside this at the top of a similar pole was floated the Dutch flag. These remained there until we broke camp.

Time observations were made by Professor EICHELBERGER and Mr. LITTELL, using sextant and artificial horizon, with the following results:

Corrections to Chronometer, Bliss No. 2407.

Date.		Chronometer Time.			Chronometer Correction.		Daily Rate.
1901		h	m	s	m	s	s
April	19.9	21	23	10	+42	44.5	
	21.9	19	57	3	42	40.8	−1.9
	24.8	19	28	42	42	34.2	2.2
	30.1	2	47	52	42	21.1	2.5
May	3.2	2	53	26	42	13.7	2.5
	6.2	3	49	54	42	4.8	2.9
	16.2	3	4	9	41	38.0	2.7
	18.9	21	34	41	+41	30.6	−2.7

THE COELOSTAT.

This instrument was built by J. A. BRASHEAR, of Allegheny, Pa., for this expedition, and was used to reflect light to both the spectrograph and the 40-foot camera. In view of the short time available for its construction it was shipped directly from Allegheny to San Francisco, and consequently there was no chance to examine it until it was set up at Fort de Kock a few weeks before the eclipse. The pier is cast in one piece, 2 feet square at the base, 12 by 15 inches at the top, and 3 feet high,

VIEW OF THE ECLIPSE STATION AT FORT DE KOCK, SUMATRA, LOOKING NORTH.

Photographed by G. H. Peters.

VIEW OF THE ECLIPSE STATION AT FORT DE KOCK, SUMATRA, LOOKING SOUTHWEST.

Photographed by G. H. Peters.

the clockwork being placed within the upper half and the weights dropping into a hole 3 feet deep through the center of the cement foundation.

The polar axis is 3 feet long, supported by a semicircular arm of 1-foot radius, sliding in a casting attached to the top of the iron pier. A wheel on the polar axis, 18 inches in diameter, is driven by a worm screw connected with the clockwork by a steel shaft and bevel gears. At each end of the axis is mounted a silver-on-glass plane mirror 10 inches in diameter, arranged with a graduated declination circle and a slow-motion declination screw. The axis carries at its southern end, as set up at Fort de Kock, an hour circle, and there is a slow motion in right ascension attachment to the worm screw working the driving wheel. The south mirror has an independent slow motion right ascension screw. The coelostat was protected from the weather by an army tent, which was removed during observations.

After the coelostat was set up there was found to be a periodic irregularity in its motion, which, after careful investigation, was shown to be due to a slight bend in the worm screw. Efforts were made by Mr. H. D. CURTIS to straighten it, but without success. The effect on the image of the Sun as thrown upon a screen in the focal plane of the 40-foot camera was a motion of about a quarter of an inch in a few seconds, after which the image would remain stationary for nearly two minutes, then move back rapidly to its first position, where it remained for about two minutes again. The period of revolution of the worm screw was four minutes.

As the efforts to straighten the screw were continued until the day before the eclipse, and as it rained the afternoon of that day, the final rating of the coelostat clock was not made until the morning of May 18.

THE DAY OF THE ECLIPSE.

The weather.—During our five weeks sojourn at Fort de Kock there was so much rainy and cloudy weather that we had but little hope of seeing the eclipse. However, on the morning of May 18 the Sun shone, though numerous clouds were floating over the sky. As the morning advanced the clouds moved more slowly and began to gather near the horizon, so that an hour before totality there was not a cloud within 60 degrees of the zenith, and we were favored with perfect weather for the eclipse. This was the fifth such day during our stay at Fort de Kock.

Shadow bands.—Several minutes before totality Doctor HUMPHREYS noticed the shadow bands on the awning covering the 40-foot camera. They seemed to be about 2 inches wide and some 8 to 10 inches from center to center. He was especially struck by the fact that they seemed to be practically stationary except for a slight tremor. He only observed them for a few seconds, as it was then necessary for him to devote his attention to his spectrograph. One of the Dutch officials reported to us that he had watched the shadow bands carefully and found them at first apparently stationary and close together; but that as totality approached the bands gradually grew farther apart and dimmer, and soon began moving with a continually increasing velocity until they became invisible.

Totality.—Professor EICHELBERGER watched the diminishing crescent of the Sun's image formed by a 3-inch telescope on white paper and at its disappearance shouted "Go," the signal for the beginning of the first exposures and for Doctor

ODELL to begin counting the seconds of elapsed time of totality. At the sixtieth second Professor EICHELBERGER took up the count, being relieved at the one hundredth by Doctor ODELL, who continued to the end. The signal "All over" was given by Professor EICHELBERGER just as Doctor ODELL counted one hundred and seventy-six. The moment of third contact was determined by the aid of the 3-inch telescope and a diagonal eyepiece. Each of the counters compared a particular second after second contact with the face of the chronometer, BLISS No. 2407, and agreed on the same second for the beginning of totality.

Contact.	Local Mean Time.	
	Observed.	Computed.
	h m s	h m s
II	0 20 52	0 21 10
III	0 23 48	0 23 58

The computed times are derived from the elements given in the American Ephemeris, and are corrected for an altitude of 3,000 feet.

Several hundred natives had gathered at the edge of the drill ground to watch the eclipse and the observers. At our request perfect quiet was maintained, and the only sounds heard during totality were the voice of the counter and the flapping of the shutters. When the Sun reappeared and it was seen that our work was finished a great hurrah arose.

In order that there might be no possibility of smoke interfering with the observations, Mr. DELPRAT, the head of the railway service, at our request ordered that the train due to pass the eclipse camp within a few minutes of totality be held at the station just before Fort de Kock and be moved only after Professor EICHELBERGER had given the signal. Also, by the kindly intervention of Resident DERX, the natives refrained from burning rice straw on that day until the eclipse was over.

The plates of the Fort de Kock 40-foot camera and of all the spectrographs were developed at Fort de Kock by Mr. PETERS and Mr. JEWELL, respectively, working alternate nights. By doing the developing at night it was possible to work at a temperature of from 65° to 70°, the water for washing the negatives having about the same temperature.

PERSONNEL.

Those permanently attached to the station were Prof. of Math. W. S. EICHELBERGER, U. S. N., in charge of station; Mr. G. H. PETERS, photographer, in charge of 40-foot camera; Dr. W. J. HUMPHREYS, in charge of spectrograph.

In addition, Assistant Astronomer F. B. LITTELL assisted in setting up the instruments and in the final packing of the apparatus, and was present all the time except for a two weeks' stay at Solok. Assistant Surgeon HENRY E. ODELL, U. S. N., was present during the day of the eclipse and counted time during totality. Mr. A. L. SMITH, seaman from the U. S. S. *General Alava*, was present May 14–21, and assisted on the 40-foot camera. Mr. W. A. VAN AKEN, seaman from the U. S. S.

THE VOLCANO MERAPI. FROM THE ECLIPSE STATION AT FORT DE KOCK, SUMATRA.

Photographed by G. H. Peters.

NATIVES GATHERED NEAR THE ECLIPSE STATION TO WITNESS THE ECLIPSE. FROM THE ECLIPSE STATION AT FORT DE KOCK, SUMATRA.

Photographed by G. H. Peters.

General Alava, was present May 14–21, and assisted on the spectrograph. Master MELVIN MUNSON, the son of an American missionary at Padang, was with us most of the time and acted as our Malay interpreter. Mr. L. E. JEWELL was with us for about a week at different times adjusting the spectrograph in conjunction with Doctor HUMPHREYS. Mr. H. D. CURTIS spent two days working on the bent worm screw of the coelostat.

THE 40-FOOT CAMERA.

Photographer GEORGE H. PETERS, U. S. Naval Observatory, in charge.
Seaman A. L. SMITH, U. S. S. *General Alava*, Assistant, May 14–21.

Owing to the high altitude of the Sun in Sumatra at the time of totality, it was decided to use this instrument in a horizontal position instead of pointing it directly at the Sun, as was done with similar instruments at the Naval Observatory stations at Pinehurst, N. C., and at Barnesville, Ga., during the eclipse of the preceding year. The light of the Sun was reflected down the 40-foot camera tube by the south mirror on the coelostat just described.

The frame of the 40-foot camera tube was 38 feet long, made of 1-inch gas-pipe, and was loaned, together with the canvas tube, by Prof. ORMOND STONE, of the University of Virginia, having been used by him during the eclipse of May 28, 1900, at Winnsboro, S. C. This tube was used because it has a larger cross-section at the camera end than those used by the Observatory in 1900.

The lens used has an aperture of 5 inches and a focal length of 39 feet, and is one of those constructed by the CLARKS for the transit of Venus. With screw adjustment for collimation this lens was attached to a board capable of being moved vertically in an upright frame, which itself was firmly fastened and braced to a horizontal base board having a range of motion for focusing the lens on the photographic plate. The entire lens-holder was bolted to a wooden pier constructed of four heavy upright posts, set firmly into the ground, with cross supports at the top and side bracings. The canvas tube was lined inside with black cloth and furnished with several diaphragms of the same material, to prevent light reflected from its sides reaching the photographic plate. It was tied to the framework of gas-pipe, which rested on wooden supports about 10 feet apart, the one at the large end being attached to the camera house. Over the whole was stretched an awning of white canvas on a frame of bamboo poles, to protect the tube both from the Sun and the rain and allowing ventilation beneath.

The camera house was erected by native workmen from lumber obtained upon the island. It was approximately 8 feet in each dimension, the western wall, however, being only 7 feet high, with the roof sloping in that direction. Double doors with a vestibule were built in the southwest corner. A window 20 inches square in the eastern wall was provided, through which the image of the Sun was projected upon the photographic plate. Although the building was found to be light tight beyond our expectation, yet it was covered at the top and sides with waterproof building paper, so that no daylight could penetrate it. The whole was protected from the Sun's rays by an "atap" roof supported on bamboo posts, leaving an air space of about 6 inches above the roof of the house.

The pier upon which the camera back rested was similar to the one supporting the lens-holder, and was built independent of the floor of the room.

The camera back consisted of a vertical frame 14 by 17 inches, moving on the arc of a circle for collimation adjustment. It was painted black to prevent reflections, as was also the woodwork about the room near it.

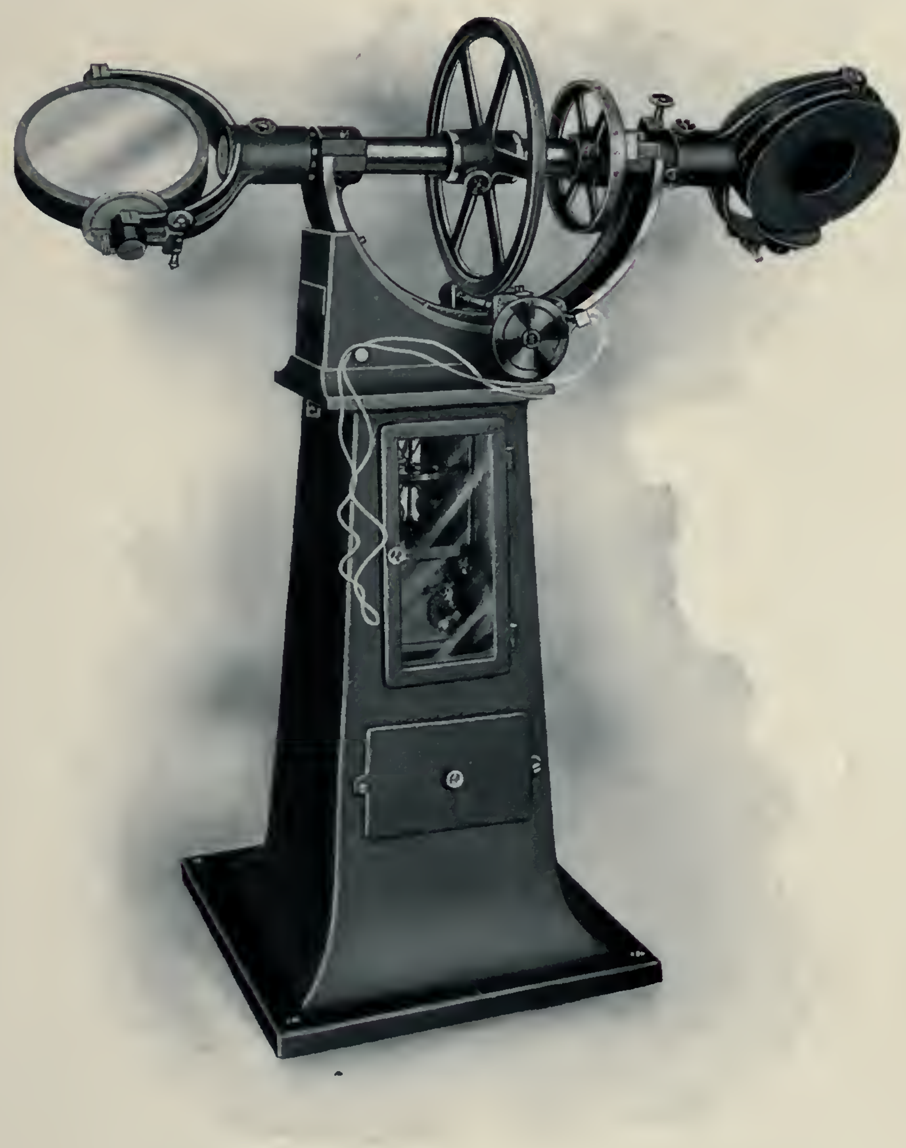
The photographic plate when in position was flush with the back of the frame away from the lens, resting in a groove at the bottom, against a projecting piece of brass to the left, and against metal diagonal supports at the upper corners. The plate was held firmly in place by a piece of bamboo attached to the upper corners of the frame by picture wire, so that a slight upward pressure of the hands upon the bamboo would release it.

To the right of the camera back was a dark closet, in which were stored, the night before the eclipse, the unexposed plates until the time of totality, when they were easily removed one at a time as needed. To the left was a similar closet, in which the exposed plates were placed by the assistant immediately after exposure. The plates were handled bare, without plate-holders or any other attachments.

A flap shutter used at Barnesville was fastened to the end of the tube frame just in front of the lens, and was used in making the exposures. A long piece of picture wire, one end attached to the lever arm of the shutter and the other leading into the camera house, was so arranged that a direct pull up opened the shutter, which closed of its own weight upon the wire being released. The entire space between the shutter and lens-holder was filled in with black cloth, as was done also where the tube joined the camera house.

On account of the excessive cloudiness and the heavy dews at night, which we feared might damage the silvered mirrors of our coelostat, it was determined to focus the instrument preliminarily without using the stars. In the first place a photograph of a native village on a distant hill was obtained on an inclined plate, which showed that the instrument was not much out of focus. The second method consisted in photographing artificial stars, produced by illuminating perforations in a piece of tin foil placed in the supposed focal plane. The light passing through these perforations and the lens was reflected back upon its path by the coelostat mirror, so that images of the artificial stars were formed on the photographic plate, tilted as before. As there was not light enough to form a trail when the mirror was run by the coelostat clock, star images were formed at numerous points of the plate by using the slow-motion screw and stopping the mirror from time to time. Early in the morning of May 18 two trails of α Bootis were obtained, and a careful study of results from the three different methods induced us to shorten the focus three-eighths of an inch.

Unfortunately it was necessary to use the coelostat mirror up to nearly the time of totality, for clock adjustment, so that its surface may have been deformed to some extent by the heat from the Sun and the effective focus of mirror and lens thereby somewhat changed.



THE COELOSTAT USED AT FORT DE KOCK, SUMATRA.

Photographed by G. H. Peters.

THE CONCAVE OBJECTIVE GRATING SPECTROGRAPH.

Dr. W. J. HUMPHREYS, University of Virginia, in charge.
Seaman W. A. VAN AKEN, U. S. S. *General Alava*, Assistant, May 14–21.

The camera, planned by Mr. L. E. JEWELL, consisted of a mahogany box of irregular shape 18 inches high, 15 feet long, 1 foot wide at one end and 6 feet wide at the other.

The 30-foot concave grating, the property of Mr. JEWELL, was mounted several inches inside the smaller end of the camera box. The light from the coelostat entered the larger end parallel to one of the sides and after diffraction fell upon the photographic plate at the same end of the box at which the light entered, several feet to one side of the entering beam. The grating was placed at right angles to the axis of the diffracted pencil in order to obtain a normal spectrum. The box, which rested on wooden supports set into the ground and firmly braced, was placed in a horizontal position, so that the horizontal plane through the center of the mirror that supplied the sunlight bisected the grating. This horizontal arrangement did not produce parallelism between the spectrum crescents and the lines of the grating at either flash, but it did secure about the best possible compromise between the two. The whole apparatus was covered with an army hospital tent. The camera back contained six plates so arranged that by successively dropping a few inches at a time the photographic films were brought one by one into the path of the diffracted beam. The shutter for making the exposures was placed just outside the spectrograph, in the path of the incident beam, and was supported on a frame independent of the spectrograph box, the space between being filled in with several thicknesses of black cloth to make the whole impervious to light. The mechanical arrangement was such that it was possible to close the shutter, drop the camera back, bringing into position the next plate, and open the shutter in about 2 seconds.

The grating used was finished too late to be tested before starting on the expedition and consequently, as soon as the coelostat was in position it was examined and compared with a somewhat smaller one, of shorter focal length, kindly loaned by the University of Virginia. As a result of this examination, in which both Mr. JEWELL and Doctor HUMPHREYS participated, it was decided to use the grating of 30 feet radius, as it proved to be very bright in the first spectrum and about two-thirds of it gave fairly good definition. The defective portion was covered, but there was still left a large active area, as the entire ruled surface measured 5 by 8 inches.

As the grating was to be used without slit or lenses, to focus the spectrograph it was necessary to have a beam of parallel light. The method used was devised by Mr. JEWELL. Two rectangular parabolic mirrors, each of about 3 feet focal length, were set up approximately facing each other, the distance between them being the sum of their focal lengths. An adjustable slit was placed in the common focus of the two mirrors. Sunlight was reflected from the mirror of the coelostat upon one of these parabolic mirrors which formed an image of the Sun on the slit, and of course the second parabolic mirror rendered the light that came through the slit parallel. It was this parallel beam that was thrown upon the grating in the direction in which the sunlight would be reflected on the day of the eclipse. The focusing was thus done on a line spectrum produced by sunlight through a slit at practically an infinite distance. The mirrors were slightly tipped so that the second mirror should not be in the path of the light incident upon the first, or the first in the path of the light reflected from the second. The difficult thing about the adjustment is getting the slit in the focus of the second mirror. As no satisfactory means of doing this was at hand, the small telescope of an engineer's transit was carefully focused on some trees a number of miles away, and then the slit, as reflected by the second parabolic mirror, was viewed by the telescope thus set presumably for parallel light, and moved till it came into sharpest definition.

REPORT OF PHOTOGRAPHER G. H. PETERS.

THE RESULTS WITH THE 40-FOOT CAMERA.

PHOTOGRAPHIC PLATES AND PROCESSES.

The plates used with the 40-foot camera were furnished by the M. A. SEED Dry Plate Company, of St. Louis, Mo., and are known as sensitometers 23 and 27 gilt edge, respectively.

The slower emulsion was used near the second and third contacts, while the speedier was employed on the longer exposures near mid-totality. The plates were used vertically, without plate-holders, being placed in position on the camera back for each exposure made.

The night before the eclipse the plates to be used at totality were thoroughly backed with a coating of WINSOR & NEWTON'S moist color lampblack to prevent halation. This was prepared by adding to it a few drops of water, together with a small quantity of alcohol, and after a thorough mixing was applied to the glass side of the plates with a camel's-hair brush.

A diamond was used to number the plates consecutively, in the upper left-hand corner on the glass side, in the order of exposure, while the sensitometer number was written in the opposite corner.

After the eclipse it was necessary to develop at night, as the dark room was so hot by day as to render the work unsafe. The developing was accomplished with an old and weak solution, containing both metol and hydroquinone, which had been used several times on landscape subjects, working slowly and giving a great amount of detail. On several of the plates the faint outer portions of the coronal streamers were slightly strengthened with a fresh hydroquinone developer, which was carefully applied with a piece of absorbent cotton, bringing out to some extent the weak image and increasing the contrast. The plates were fixed in a plain solution of hyposulphite of soda, made up fresh for each night's work.

A large tank was erected outside the developing house, and was filled with water from a brook in the vicinity. This water, which was used for washing the plates, was introduced through the wall of the dark room by means of a small rubber tube ending at the sink with a small brass stopcock.

During the eclipse, operations in the camera house of the 40-foot camera were carried on in the faint red light of a dark-room lantern placed at some distance from the photographic apparatus. Enough time had been devoted to practice in the manipulation of the plates and apparatus, so that everything worked well during the brief moments of totality.

On the day of the eclipse we entered the building about half an hour before the total phase, in order to accustom our eyes to the obscurity. Mr. A. L. SMITH, rendered efficient assistance at this instrument during the eclipse, removing the exposed plates from the camera back and placing them away. This required nice manipulation, for should the backing of one plate touch the sensitive surface of another considerable damage would ensue. After totality the exposed plates were carefully replaced in the original dark closet mentioned in the description of the instrument. This was wrapped with black cloth and the plates left to await development at night. The program of exposures as planned had been carried out successfully, and we realized our good fortune when we learned of the prevailing clouds and haze at the various other eclipse stations.

DISCUSSION OF RESULTS.

On the negatives of this eclipse the diameter of the Moon's image taken with the 40-foot camera is 4.6 inches; that of the Sun in consequence would be 4.3 inches. A summary of conditions and results as shown on the negatives from this instrument is given in the following table:

No.	Sensitometer of Plate.	Length of Exposure.	Approximate Period of Count.		Results and Remarks.
			From—	To—	
		s			
1	23	½	½	1	Shows chromosphere and prominences on northeast limb. Faint coronal rays, both polar and equatorial, and coronal disturbance.
2	23	1	9	10	Shows prominences and chromosphere to less extent but stronger coronal and polar rays than Negative No. 1. Polar rays emerging from chromosphere.
3	23	2	18	20	Shows prominences and small amount of chromosphere on northeast limb, together with considerable corona. Some clock rate is perceptible and development was checked in consequence.
4	27	5	28	33	A fine negative of inner corona, showing coronal disturbances well defined in outer parts, besides coronal loops or arches; also chromosphere and prominences faintly.
5	27	60	43	103	Shows coronal streamers extending faintly to the edge of the plate; clock rate fairly good. Some effect of atmospheric unsteadiness noted.
6	27	20	113	133	Considerable clock irregularity, owing to bent worm screw of coelostat. Image rather blurred. Developing not carried very far in consequence.
7	27	3	141	144	A fine negative. Shows chromosphere on the northwest limb, prominences and inner corona, together with coronal disturbance and arches.
8	23	1	152	153	Some clock irregularity; shows chromosphere on northwest limb; polar rays emerging from chromosphere; corona faint.
9	23	½	161	161½	Comparable with Negative No. 2, but showing slightly less coronal extent. The Moon has here covered the bases of the features on the northeast limb.
10	23	½	176	176½	Taken immediately after third contact. Shows a small ray of direct sunlight, giving position angle of contact, and a little of the corona.

Neither planets nor stars are shown on these negatives, and their orientation has been accomplished by obtaining the level of the plates from trails of αBootis and by using the computed position angle of third contact, which is found on Negative No. 10. This last shows the first rays of returning sunlight over a small arc, and was exposed on signal from Professor EICHELBERGER.

Owing to our location near the northern edge of the shadow the shorter exposures show but little of the corona and no prominences beyond the southern edge of the Moon, the brighter interior portions being hidden by that body. On the northern limb, however, the chromosphere, prominences, and corona are revealed close to the Sun's photosphere. The apparent path, at this station, of the Moon's northern limb lay close to and nearly tangent to the northern edge of the photosphere. The chromosphere, prominences, and inner corona would consequently be visible on either side of the Moon's northern limb during nearly the whole of totality, and especially so near the second and third contacts. The principal object in establishing the 40-foot camera at this station, near the edge of the shadow, was to show the origin of the coronal rays, especially about the pole. The results obtained fully justify it, for the negatives with the shorter exposures which were intended for this purpose show the coronal rays emerging from or projected on the chromosphere.

It was also decided to give an exposure of one minute duration on a rapid plate for coronal extension to supplement the work of Professor BARNARD with the 40-foot camera at Solok and to supply the deficiency should there be a failure of this feature of the program at the other stations on account of clouds. On the original negative of this long exposure the outer coronal streamers can be traced nearly across the plate. When it was found that the irregular performance of the clock could not be improved the question arose whether to confine our work to short exposures or to follow out the schedule as at first contemplated. A careful study of the motions of the Sun's image led us to expect that probably at least one of the long exposures would fall upon a stationary period, so the original program was adhered to. As a result the one-minute exposure was successful, but the 20-seconds plate showed a considerable drift of the image. It will be noticed that the long exposure corresponds to mid-totality.

On the western side of the Sun the coronal structure is quite similar to that observed in the eclipse of the previous year, being devoid of unusual features. This is especially true in regard to the inner regions, where most of the detailed formation is of the striated type.

The most remarkable features in the corona are found on the eastern side of the Sun, where it exhibits considerable activity. Two unique disturbances in the corona on a large scale, as well as other prominent features, are well shown in this region on these negatives. One of these begins near the solar equator and extends northward on the same limb for about 18°, showing three points of intensity, and has been termed "the coronal disturbance." The discussion of results is presented under the following headings:

I. Position angle, solar latitude, and description of the prominences from negatives No. 1, No. 2, No. 8, No. 9, and No. 10.

II. Remarks on the chromosphere and polar rays, based on the same negatives.

III. The inner corona from plates exposed up to three seconds. Negatives No. 1, No. 2, No. 3, No. 7, No. 8, and No. 9 are included in this discussion, the last three being taken after mid-totality. Negative No. 10 is not used here as it shows but little of the corona and that very faintly; it permits, however, a fairly good determination of the position angle of third contact. Negative No. 4 exposed for five seconds is consulted to some extent, giving best the details between the outer extensions and inner corona as found on these negatives. On it the structure may be traced quite to the lunar limb, and the chromosphere and some of the prominences faintly seen.

IV. The outer corona as found on negatives No. 4 and No. 5 with some reference to Negative No. 6. This latter was injured to some extent with respect to fine detail by the periodic rate of the coloestat clock. Most of the error fell upon this negative on account of the length of exposure and the particular part of the run of the screw, though many of the other plates show evidence of this irregularity in a slight degree.

POSITION ANGLE, LATITUDE, AND DESCRIPTION OF THE PROMINENCES.

The position angles were measured on the negatives from the north point toward the east. The figures are the mean results of measurement of the four negatives No. 1, No. 2, No. 8, and No. 9, and are probably accurate to 1° of arc, errors arising from the character of the features measured. The position angle of the solar equator from the north point toward the east at the date of the eclipse is taken as 69° 30′. This correction is applied in obtaining the latitudes of the different features noted.

P. A. 18° 30′ Lat. +51° 0′	A prominence of the horn variety apparently merging at the base with the one at position angle 19° 45′.
P. A. 19° 45′ Lat. +49° 45′	This prominence has a flame-like appearance, and in connection with the one above might be termed a double prominence. The two apparently emerge from the edge of the chromosphere, which has the greatest elevation above the Moon's limb on Negative No. 1. No fine detail is observable either in this prominence or the one above, but a spray-like tip is seen issuing from the top of the southern termination of the one at position angle 19° 45′.
P. A. 39° 0′ Lat. +30° 30′	A small prominence with the top curving and falling over on either side. The base is quite slender and rises from the chromosphere, which at this point has but slight elevation above the Moon's limb.
P. A. 45° 15′ Lat. +24° 15′	A small prominence of no distinctive form.
P. A. 55° 0′ Lat. +14° 30′	The northern part of the remarkable disturbance in the corona, which is covered by the Moon to some extent even on Negative No. 1.
P. A. 59° 0′ Lat. +10° 30′	The middle of the base of the coronal disturbance. This position is somewhat indefinite as the area is rather diffused, being strongest in the southern part, with a slight increase in density at 60°, which does not, however, resemble the top of a prominence. On Negative No. 1, which shows the least covering by the Moon in this region, the chromosphere and also the base of this disturbance are hidden to a slight degree.

P. A. 63° 30′ Lat. +6° 0′	The southern part of the coronal disturbance. This shows a single region of greatest condensation at its base, which is enveloped by more diffused matter.
P. A. 65° 0′ Lat. + 4° 30′	A small prominence, nearly occulted by the Moon, which has an inclination toward the south.
P. A. 67° 30′ Lat. + 2° 0′	This prominence resembles the one at position angle 65° 0′, though less inclined.
P. A. 81° 30′ Lat. −12° 0′	The top of a prominence showing two condensations just visible above the edge of the Moon on Negative No. 1.
P. A. 84° 45′ Lat. −15° 15′	Single and stronger than the one at position angle 81° 30′, the top just showing.
P. A. 86° 30′ Lat. −17° 0′	Similar in appearance to the one at position angle 84° 45′.
P. A. 113° 0′ Lat. −43° 30′	The apparent center of the coronal arch formation. No prominences are visible on Negative No. 1 at this point. This is considerably covered by the Moon at the base, because of our position near the northern edge of the shadow path.
P. A. 268° 30′ Lat. +19° 0′	A small, faint prominence, the top just showing above the Moon's limb.
P. A. 271° 0′ Lat. +21° 30′	Similar to the one at position angle 268° 30′, but stronger.
P. A. 275° 30′ Lat. +26° 0′	This has about the same appearance as the one at position angle 271° 0′.
P. A. 307° 30′ Lat. +58° 0′	A small, spike-like prominence, deeply forked at the end. It rises from the chromosphere, which is depressed on either side of it and curves toward the south in the direction taken by the polar rays at this point.
P. A. 333° 30′ Lat. +84° 0′	A very small round-top prominence of slight elevation and density, which might be considered a polar ray except for its abrupt ending. If, however, it is one of the polar rays, it probably lies in the line of sight. It emerges from the chromosphere, which here is in a normal condition.

REMARKS ON THE CHROMOSPHERE AND POLAR RAYS.

The chromosphere on Negative No. 1, exposed at the beginning of totality, extends through an arc of 58°, from position angle 341° 30′ to position angle 39° 30′ or from latitude +88° on the east down to latitude +30° on the same side. Its greatest elevation above the Moon's limb is 25″, not taking into account the height of the prominences. This chromospheric layer is considerably over-exposed on account of its actinic brilliancy, and is shown on the negative as a dense and somewhat irregular crescentic streak devoid of detail. The prominences are a little less dense, showing that they possess less photographic activity. Negative No. 9 shows an extent of chromosphere of 62° from position angle 295° 30′ to position angle 357° 30′, or from latitude +46° on the western limb over the north polar regions to latitude +72° on the eastern limb. The functions of negatives No. 1 and No. 9 in particular were to record as much of the projecting chromosphere and prominences as possible, and to secure at the same time a photographic impression of the inner coronal rays, especially near the northern pole.

The chromospheric crescent as shown on these negatives is not quite even in outline, but is broken up into billow-like ridges even where no true prominences appear. These elevations probably correspond to the brighter parts of the solar "reseau photospherique," "rice grains," or "willow leaves," as variously designated. They are prominent features of the chromospheric limb and resemble, to some extent, in contour the rough limb of the Moon when projected on the Sun. Compared with the prominences, they are of slight elevation and seem to have different characteristics. Some of these billows are slightly larger than others, but all have about the same general form.

Wherever these small billows appear on the limb of the chromosphere, the coronal rays seem to emanate from them. This is especially noticeable with respect to the polar rays, whose well-defined outlines enable them to be traced more clearly to their sources.

The larger irregularities, however, seem to interrupt the flow of coronal matter to some extent, and, in the case of prominences, to modify it and cut off the emission completely. It is here at the prominences that the coronal matter arches over in most cases, forming hoods or envelopes over the prominences in the northeast quadrant, several fine examples of which are found on these negatives. Arching over at its limits there generally exists a comparatively dark space, beyond which the brighter coronal matter again appears.

Thus the billows at the lower levels of the chromospheric surface seem to be the source of emission of the coronal rays and streamers, which are modified by the prominences. It is evident, from a careful study of these negatives, that when there is an upheaval of the chromosphere into billows and in the process of prominence formation, matter in a finely divided or nebulous state is projected outward from their crests. When the eruption has reached a certain stage, which is perhaps the limit of progressive activity, coronal matter is no longer given off, or only in diminishing quantity. The coronal matter from the chromosphere is then projected over the dark arch and between it and the hood. These hooded and arched prominences have been conspicuous features, in the more recent eclipses, on the large scale photographs.

The Fort de Kock station is the sole instance where observers have located near the edge of the shadow to photograph the inner solar surroundings on a large scale, though much spectroscopic work has been done in a like position. It would seem advisable in future eclipses of considerable duration to establish similar stations, if possible, near each limit of the shadow path to study closely the whole circumference of the solar surroundings.

THE INNER CORONA.

The polar rays here claim our first attention, after which the different features will be taken up in the order of their position angles. A general comparison of all the negatives reveals a greater extension of these rays about the northern than about the southern pole.

On account of our station's location near the northern edge of the shadow path the inner rays in the regions adjacent to the southern pole are considerably hidden at the base by the Moon's disk. In the north polar regions, on the contrary, they are visible throughout their whole extent down even to the chromosphere. The polar rays at the north are not evenly distributed, but show a tendency in several places to bunch into groups consisting of numerous fine rays. At the south pole this is not so noticeable and the rays are, in general, broader and more distinctly separated.

The following is a description of the prominent features of the inner corona, together with the solar latitudes in most cases. Beginning on the western side of the north pole, the first well-defined ray of the polar type occurs in latitude +70° and extending outward from the Sun gradually curves toward the south. It is quite strong, well defined, and of slightly greater length than the adjoining coronal rays on either side. To the northward there appears a narrow gap separating it from the ray following, whose lower parts are filled with coronal matter.

At latitude +74° another strong ray is visible, which seems to become double at a distance of about 7′ from the Moon's limb. This is probably due to the juxtaposition of two rays lying in the line of sight at their points of origin on the Sun, and which separate gradually as they recede, because of our point of view and their relative curvature. Still approaching the pole, the next conspicuous feature is an extensive pencil of rays extending from latitude +75° 30′ to latitude +85° 30′, the part nearest the pole exhibiting somewhat greater strength, although the whole is quite uniform in regard to evenness of structure. A small gap then occurs, beyond which is another brush extending across the pole over an arc of 10°, from latitude +86 30′ on the west side to latitude +83° 30′ on the east, with a slight gap at latitude +89° east. Beyond this for 2° are faint and finely divided polar rays, adjacent to which are two strong rays. Another gap follows and then a strong ray at latitude +79°, which doubles as it recedes from the Sun and which is the last of the distinctive north polar rays on this side.

The shorter exposures show these polar rays separated to the chromosphere, but when a longer exposure was given, these spaces on the negative became gradually filled with coronal matter. This is caused either by the extension of the faint edges of these rays as a result of prolonged photographic action, by the prevalence of diffused matter between them, which becomes apparent only when the time of exposure is increased, or perhaps by the spread of the photographic image in the coating of the plate. The atmospheric unsteadiness would also have a tendency to produce this effect.

The next feature of the inner corona is the great composite wing on the northeast limb, which, throughout its entire extent, is the most prominent streamer of the eclipse. Taken as a whole, its base extends from latitude +76°, at its northern limit, almost to the northern edge of the coronal disturbance near the equator, where the oblique rays from this adjoining part mingle with it. This great wing extends over a region on the solar limb where the prominences are largest and most numerous as seen at this station, but it is remarked on the short exposure negatives, where these inner features are best seen, that they contribute no coronal matter to it. They appear to have an influence in modifying the direction of the coronal rays and streamers, breaking up the continuity of the matter in this region, which in combination forms this wing. At position angle 19°, where the double prominence occurs with its hooded envelope and well-defined dark arch, it would appear that this arch was composed of less luminous matter than the corona in its vicinity and not produced by a scarcity of material. One of the streamers composing the wing apparently emerges from behind it, extending throughout the whole southern side of the arch and nearly to its top. The arch, however, maintains its dark appearance uniformly through its entire extent of curvature. This arch is the best defined of any shown over the prominences on our negatives, and is situated in the midst of this coronal activity. From the northernmost division of the tripartite coronal disturbance near the equator on the eastern side of the Sun an oblique ray apparently cuts across this large wing without changing or modifying it in any way. This would indicate that the ray and wing lie in different planes one behind the other.

The next prominent feature is the coronal disturbance above mentioned. Presenting structure of great complexity, its influence is seen in the coronal distribution on this side of the Sun to the outermost limits of the corona as shown on all of our negatives. To some extent it resembles the mottled and striated appearance noticeable in most photographs of the great Orion Nebula. There are three nuclei or centers of condensation at the Moon's limb, the central one being the most intense. The direction of this as it recedes from the Sun is about perpendicular to the solar surface, while its companions on either side are deflected obliquely from it. The latitudes and position angles of these objects have been recorded in the preceding list under prominences, although they appear to be strictly coronal in character. The northernmost of these nuclei sends forth rays which cross those of the great wing as they proceed outward. The southern edge of this object is well defined, shooting upward perpendicularly for about a minute of arc, where several faint rays continue beyond, then bending to the northward at an angle of about 45° for nearly the same distance, after which it extends straight outward again. This exterior part is crossed by diverging rays proceeding from the middle part of the central disturbance, the entire region exhibiting numerous mottlings and streaks.

The central nucleus of this coronal disturbance is nearly bisected by a narrow faint shading extending directly away from the Sun. At its base this central part of the disturbance is quite bright, extending out from the limb for about a minute of arc, with but slight abatement in its intensity. On either side the outlying portions extend somewhat beyond the middle part, giving a notched appearance to the end.

Beyond this the coronal matter is considerably less dense, but still quite intense compared with other portions of the corona at the same distance from the Sun. It is distinctly divided into two parts by a dark narrow rift which is a prolongation of that appearing in its lower levels, the southern area being the greater.

The outer northern part of this disturbance is also divided by a rift, which extends down to the bright interior parts. The southern nucleus of this object is midway in brilliancy between the northern and middle sections and exhibits an oval form at the termination of its brighter parts, which extend outward for about a minute and a half of arc. Leaning toward the south at a considerable angle, it has well-defined limits, bounded by an irregular dark arch of fair intensity extending completely over it, similar to that found over the prominences. A pencil of rays is seen shooting out from this locality, expanding slightly as it recedes from the Sun. On the one-second exposure these rays are comparatively faint and are observed beginning outside the dark arch, which probably indicates an origin behind it in the line of sight. This is one of the prominent features on the eastern side of the Sun, and, from its juxtaposition, is likely to have an intimate connection with the so-called coronal disturbance.

An unsuccessful attempt has been made to deduce from our negatives perceptible motion in these parts, which, from their explosive characteristics, would seem likely to be rapid. The lapse of time, however, between the comparable plates is too limited for motion to manifest itself, the nebulous character of the images also adding to the difficulty of detection.

From the southern part of this coronal disturbance to the prominence at about position angle 85° the corona has a brush-like aspect, being composed of filaments of a broken and twisted texture, especially near the Sun. At the above-mentioned prominences two dark gaps extend outward and, finally meeting, form an arch over them. Between this position and the coronal arches specified below the filaments are straighter and less fragmentary. There are three of these coronal arches or envelopes rising one above the other. They are conspicuous features in this region and apparently emanate from a common focus at position angle about 113°. Their apexes are distant from the limb by 1′.1, 2′.5, and 5′, respectively, and are separated from each other by darker concentric arches lying between them, having about the same albedo throughout their entire extent. Many narrow parallel filaments extend outward from the Sun in this vicinity, wholly of the arching type, showing a great complexity of formation of these objects. At their bases on the southern side the two inner arches exhibit a doubling on the short-exposure negatives. They originate as two distinct rays and in the case of the middle arch extend nearly parallel for about 1′. The outer ray then turns inward diagonally and blends with its companion. The same general appearance manifests itself in the inner arch, the duplication extending, however, only half this distance. On the northern side of these arches the rays are relatively fainter than on the opposite side, but in each case show a rapid increase in width and intensity in approaching the Sun.

South of this series of arches, between them and the southern polar rays, the corona is striated and partakes of a curvature corresponding to the outer layers of the arch envelope. This region is a counterpart of the great wing at the northeast quadrant, though dissimilar from it in structure, containing but little detail.

Continuing in the same direction, the south polar rays appear next. There is no sudden change here, but rather a gradual reversion from the streamer form to the polar type. The first typical ray on the east side of the pole is situated in latitude −64° and is comparatively short. At latitude −65° another stronger ray is seen, which, as it recedes from the Sun, divides into two, probably indicating a pair of streamers lying in the line of sight. A comparatively faint ray at latitude −69° extends outward for a considerable distance, while at latitude −73° is a stronger pair, double throughout their entire length but gradually separating as they proceed from the Sun. There next occurs a brush of strong rays, extending from latitude −72° to latitude −80°, which ends at a gap a degree wide, filled with faint coronal matter, following which is another strong brush of polar rays extending to the pole. The rays in this region do not project directly outward, but have a decided inclination toward the east.

While the north polar rays are located nearly concentrically on either side of the pole of rotation those at the antipodes are eccentrically placed with respect to the south pole, the displacement amounting to about eight degrees toward the east. At this latter point, moreover, they are projected directly away from the Sun. This is a striking coincidence, considering the greater coronal activity on the eastern side of the Sun than upon the western side.

Close to the south pole on the western side are two strong filaments, close together and extending outward for a considerable distance. A space of several degrees then occurs where the coronal rays are very sparsely distributed. In the neighborhood of latitude −85°, on the west side of the pole, a small brush composed of several rays is observed, which is separated by a gap from another cluster strong at the base but rapidly diminishing in intensity as it proceeds outward, located at latitude −80°.

The last of the distinctive south polar rays in this region extends from latitude −78° to latitude – 73° and is followed by a slight gap. Beyond this gap with an extent of 13° from latitude −72° to latitude −59° is a large wing composed of three broad rays, strong and somewhat blended together. They have lost the distinctive characteristics of the typical polar rays, and are more streamer like in aspect.

Nearer the equator and adjoining these is a long wing extending from latitude −57° to latitude −45° which on the longer exposed plates gradually blends with the one above. Between this and the equator is another and similar wing, these two being the most conspicuous objects on the western side of the Sun.

The remaining portion of the inner corona on this side, across the equatorial regions and extending to the north polar rays contains no marked features near the Sun, as shown on the short exposure negatives. Several small wings and streamers occur, but they are greatly obscured by the uniformity of the enveloping corona.

THE OUTER CORONA.

While it is interesting to trace the modification and prolongation of the coronal rays as they are projected into space, most of our knowledge of the solar surroundings will probably be obtained by studying these features near their sources, from photographs of short exposure and on a large scale.

Modifications to some extent take place as we recede from the Sun, but they consist mostly in the consolidation of detailed markings, which make up the inner corona. Outside of the limits of the polar regions they generally go to form the wing and equatorial extensions, though to some degree these interior features preserve their distinctive character throughout. This last is especially true of the polar rays and, in the present eclipse, with respect to some of the matter in the vicinity of the coronal disturbance.

In the polar regions the outer corona corresponds in its general features to the inner parts. There is simply an extension of the polar rays, corresponding to the increased exposure of the photographic plate. These filaments can be distinctly traced on the one minute exposure, Negative No. 5, for about a lunar radius from the Sun, and by holding the negative obliquely in the proper light can be seen to a somewhat greater distance. Because of the extended exposure, this negative shows a perceptible darkening outside the coronal image, owing to reflected skylight, but this effect is very slight.

The form of the equatorial streamers and coronal wings extending outward on either side of the Sun is quadrilateral in outline. This appearance is produced by the four large wings, one in each quadrant, which are, however, considerably broken up into finer striated detail, while many streamers and striæ are seen issuing from the equatorial regions.

On the eastern side the formations of the outer corona, like those of the inner parts, are much more complicated than those on the western side, but the extensions on the two sides are about equal. Streamers may be traced from three principal points of origin on the east, viz, the greater wing in the northeast quadrant; the coronal disturbance near the equator; and a large wing in the vicinity of the coronal arches. This last is apparently independent of the arch formation, whose outer parts may be observed preserving their distinctive form through this wing, which is displaced somewhat to the northward of it.

On this eastern side of the Sun the streamers present much complexity, and in most cases are double or in closely associated pairs. The great wing on the northeastern limb resolves itself into two extensive streamers, each of which is double. The northern edge of this wing is clean cut and sharply defined, following the same course as found on the shorter exposures. At first it extends slightly upward, northerly, then gently curves over toward the equator till it reaches a length of about a lunar radius, when it is projected outward practically in a straight line, and can be followed nearly to the edge of the plate. Below this upper streamer is another of which in many respects it is a counterpart, though gradually diverging from it toward the end on account of the mutual narrowing, as well as a slight difference in direction. We have here a case of double duplication, first the two similar streamers, each of which consists of a pair, the whole forming the great northeast wing.

With respect to the coronal disturbance near the equator there appears a short intense wing above it, somewhat rounded at the top, beyond which diffused matter of slight structural detail extends outward, nearly as far as the other parts of the corona on this side. The small amount of detail in it, however, shows a tendency toward the streamer type. The three rays shooting out in an oblique direction on the north side of this disturbed area, and partially crossing the great wing, can be seen on this negative also. This whole region, even in its exterior parts, takes on the appearance of an immense explosion, with streams of matter flung away from the Sun in different directions. On the southern side of this disturbance, the strong ray emanating from it, which is described in connection with the inner corona, gradually expands in diameter, and becoming by degrees fainter, takes a northerly curvature at about 10′ from the limb. On its lower side it is separated from the southern part of the corona by a gap, beginning as a thin line near the Sun, and slowly broadening as it extends outward.

Beyond this gap and extending to the southern polar rays are a number of broad filaments, which combine to form a double wing in the southeast quadrant. This in the original negative vanishes at a little more than a diameter of the Moon from its limb. These extensions draw somewhat together near their extremities and curve slightly to the northward. The outer layers of the coronal arch formation are seen projecting beyond this wing on the southern side as it recedes from the Sun and as the wing becomes narrower. In these outer parts the arch has a greater intensity than the wing at the same distance.

From the base of the southern edge of the coronal arch and close to the polar rays a long faint ray shoots forth, extending to a distance of over half a lunar diameter. At first it follows nearly the curvature of the arch to its limits, when it continues in an approximately straight line. This object is remarkable as being intermediate between the polar and streamer types, partaking of the characteristics of both. The rays of the outer corona on the east side of the south pole correspond in character to these rays as described under the heading, *Inner Corona;* their extension, however, is greater, due to the longer exposure of the plate.

The most noticeable of the rays in the south polar region is a long double one close to the west side of the pole. It has a greater length, is more brilliant than any of the others, and is nearly straight, having but a slight curvature toward the west. The remaining polar rays to the westward of this present a somewhat interlaced appearance on the long exposure. Passing to the corona on the west side of the Sun, we find that as a whole it is a little wider than on the opposite side. It exhibits many fine streamers and wings, mostly straight and well defined, and much simpler structurally than the corona on the eastern side of the Sun. The only notable exceptions are the streamers between the equator and the south polar rays, especially near the latter. Here they sweep away from the Sun and curve over before taking the same direction as the equatorial streamers. There is a slight tendency to curvature in the northwest quadrant, though in this region they are more nearly straight.

The wings on this side may be divided into three general groups, those near the polar rays and those in the vicinity of the equator. They are composite in type—that is to say, are built up by the aggregation of several different streamers. It will be remarked that this is somewhat analogous to the coronal division on the opposite side of the Sun, so far as the wings are concerned. In the southwest quadrant the corona is more complicated than upon any other part of the western side. Here there are three distinct wings, associated together. That nearest the equator, and extending over the middle latitudes, is quite broad at its base, but narrows rapidly as it recedes from the Sun. It is complementary to that wing in the corresponding latitude on the opposite side, though less extensive, straighter, and more pointed. The middle wing of this group is considerably narrower and of somewhat greater extent than the former, though of about the same intensity. Gently curving as it emerges from behind the Moon, it gradually straightens, and extends nearly parallel to its companion. The next of this series extends from the above wing to the polar rays and is filamentary in structure, containing two bright streamers and many fainter ones. The part next to the polar rays is somewhat of the polar variety, but of such extent and curvature that it can not properly be classed as such. Another streamer close to it is shorter and more strongly curved and separates into two distinct rays before ending, the point of division being abrupt and with considerable lateral displacement, presenting a forked appearance.

The equatorial group near the Sun has a brush-like aspect. As the streamers in this group extend outward, they draw together into narrow pointed wings in three places about equally spaced. The southernmost of these is distinctly double, being well separated at the end.

The wing in the northwest quadrant is composed of numerous filaments, which exhibit no tendency to draw together as they recede from the Sun, but have a coarse, brush-like aspect. In the midst of this brush is an intense double streamer, gradually separating toward the end. It is slightly curved equatorially and is of greater length and brilliancy than any other coronal feature on this side.

IN CONCLUSION.

A summary of the peculiarities of the corona at this eclipse are noted below:

The greater extension of the southern polar rays, together with their eccentric position toward the east with respect to the pole of solar rotation.

On the eastern side the coronal disturbance and wings, including many irregularities of structure. Also the coronal arch formations, all of which may be taken as indicating a state of considerable activity on this side of the Sun.

On the western side the corona resembles the general type found at sun-spot minima, to which period this eclipse properly belongs. Here the rays and streamers, though numerous, are quite straight, quiescent, and of simple formation.

On the return of the eclipse expedition the photographic sun-spot record at the Naval Observatory was immediately consulted, having in view a comparison with the eclipse negatives, in order to trace a possible connection between the coronal disturbance and solar phenomena. Owing to unusually cloudy weather at Washington during the period of the eclipse, and for some time after, our record with the photoheliograph, unfortunately, does not include any photographs of the Sun at this time.

A connection, however, has been established elsewhere between the disturbed area in the corona and a sun-spot group which appeared around the eastern limb of the Sun the day after the eclipse, which was shown on the solar photographs of Dehra Dûn, India.*

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*Lick Observatory Bulletin No. 18; and Monthly Notices of the Royal Astronomical Society, Vol. LXII, p. 381.

REPORT OF W. J. HUMPHREYS, PH. D.

THE RESULTS WITH THE SPECTROGRAPH.

EXPOSURES.

The focal curve of the grating was too sharp to admit of being followed by bending glass plates, consequently heavy celluloid films 2½ inches wide and 36 inches long were used. These the M. A. SEED Dry Plate Company had coated with their gilt edge emulsion, which is exceedingly sensitive to the blue, violet, and ultra-violet portions of the spectrum. The exposures were begun as promptly as possible after second contact and the prearranged plan carried out, except in the case of the last film, which we had expected to expose from two to three seconds, beginning just before third contact and extending through the second flash. The duration of totality, however, was several seconds longer than the computed time, and it was thought best, lest the film be ruined, to shut off the light at the end of eight seconds, which proved to be fully three seconds before third contact. This was probably well enough, as development showed the film to be fully exposed. Only about two seconds were consumed each time a fresh film was put in place, and in all six spectrograms were obtained in approximate accordance with TABLE I.

TABLE I.—*Spectrograms Obtained.*

No. of Film.	Length of Exposure.	When Exposed, Counted from 2nd Contact.
	s	s
1	2	0– 2
2	5	5– 9
3	15	12– 26
4	120	29–148
5	15	151–165
6	8	168–175

It was decided as best to leave the development of all spectrum films to one person, and this part of the work was assigned to Mr. JEWELL. Lines were found on all these films, those on Film No. 1 and Film No. 2 being best defined, and Film No. 6 having the greatest number. Each film showed that, unfortunately, it had not been placed exactly in focus; still the dispersion was so great that many of the lines could be very easily identified.

MEASUREMENTS AND RESULTS.

The films have been measured on a very excellent dividing engine, constructed by the Société Genevoise, fitted with a suitable microscope made by BAUSCH & LOMB. The engine reads directly to 0.001 of a millimeter, and the dispersion—the first spectrum was photographed—was such as to give approximately 3.66 ÅNGSTRÖM units to the millimeter. As stated above the focusing was not perfect, and the grating gave lines that split up into triplets as they went out of focus, instead of producing single broad blurs. Consequently, by always selecting the same fragment—I used the middle one—of each line, it was quite possible to secure fairly satisfactory and consistent measurements.

Each film had more or less pronounced light and dark streaks, due chiefly to irregularities in the Moon's outline, and these aided greatly in properly aligning it on the engine. The microscope was so set that one of its cross hairs was tangent to the crescents along that part of the film on which they were best defined.

Explanation of Table II.—The first column of TABLE II gives the relative wave-length as found by measurement and interpolation. The next three columns are taken from ROWLAND'S Preliminary Table of Solar Spectrum Wave-lengths and give the probable corresponding solar lines. The remaining columns give the intensities and lengths of the lines found on the several films. The intensities are only relative and, though the lines were gone over carefully for the purpose of comparing them, not much accuracy is claimed for the values assigned. A line marked 0 is one that can just be seen, a line marked 1 is somewhat more distinct, and so on with increasing numbers to the heaviest and broadest lines. Everyone knows that, even with a constant source of light, the relative energies of the several spectrum lines are not accurately proportional to their several photographic effects, and this want of agreement is still more pronounced when the luminous source undergoes such rapid and marked changes as those which take place during a solar eclipse. Still, imperfect as they are, these estimates may be of some service, and are therefore given.

A line marked *ss* is a very short one, covering an arc of not more than 10°; one marked *s* extends roughly 20°; *l* signifies that the line is 30° to 40° in extent, and *ll* that it is of still greater length. These values, like those of intensity, are only roughly approximate, but give some idea of the heights to which the several substances appear, at least to a marked extent in the solar atmosphere. Long arcs signify great elevations of the producing elements, while the short ones indicate but small heights.

That TABLE II contains occasional errors I am quite ready to believe, though every precaution has been taken to reduce them to the smallest possible number. A better focus would have given more accurate measurements, with less chances of error, and probably would have furnished many more lines. In a number of instances the spectrum arcs seemed to consist of two or more so overlapping, owing to want of sharp definition, that it was impossible to clearly separate them. In all such cases the solar wave-lengths of the probable constituents are indicated in the table by being bracketed together.

TABLE II.

Observed Wave-length.	From ROWLAND'S Table.			Intensity and Character of Lines.					
	Wave-length.	Substance.	Intensity and Character.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
3118.5	3118.498	V	3	....	....	....	....	....	0 ss
3121.3	3121.270	V	4	....	....	....	....	....	0 ss
3130.3	3130.380	V	3	....	....	....	....	....	1 ss
3161.9	3161.317	Ti	3	....	....	....	...	....	0 ss
	3161.887	Ti	3						
	3162.683	Ti	4						
3168.5	3168.640	Ti	4	....	....	....	....	....	0 ss
3191.2	3191.011	Ti	3	....	....	....	....	....	0 ss
3202.5	3202.651	Ti, Fe	2	....	....	....	....	....	0 ss
3218.0	3217.183	Ti	2	....	....	....	....	....	0 ss
	3218.389	Ti	2						
3228.8	3228.735	Ti ?	2	....	....	....	....	....	0 ss
3234.6	3234.635	Ti	3	....	0 ss	....	....	....	2 ss
3236.8	3236.703	Ti	7 N	....	0 ss	....	....	....	2 ss
3239.3	3239.170	Ti	7	....	0 ss	....	....	....	2 ss
3242.3	3242.125	Ti, —	8	....	....	....	....	....	0 ss
3248.8	3248.841	Ti	2	....	0 ss	....	....	....	2 ss
3252.0	3251.977	Ti	3	....	...	....	....	....	0 ss
3253.1	3253.012	Ti, Fe	5	....	....	....	....	....	0 ss
3254.2	3254.314	Ti	3	....	....	....	....	....	1 ss
3258.3	3258.542	Mn, Co	3	....	...	....	....	....	0 ss
3261.8	3261.705	Ti	3	....	....	....	....	....	0 ss
3263.8	3263.813	Ti	4	....	....	....	....	....	2 ss
3267.8	3267.834	V	6	....	....	....	....	....	2 ss
3272.0	3271.791	Ti, Fe	6 d ?	....	....	....	....	....	1 ss
	3272.217	Ti	5						
3278.3	3278.420	Ti	5	....	....	....	....	....	4 ss
3279.0	3279.060	Ti	4	....	....	....	....	....	4 ss
3282.4	3282.459	Ti, Zn	5	....	....	....	....	....	3 ss
3286.9	3286.898	Fe	7 N	....	....	....	....	....	1 ss
3287.9	3287.793	Ti	5	....	....	....	....	....	4 ss
3292.2	3292.151	Fe	4	....	....	....	....	....	0 ss
	3292.206	Ti, Co	3						
3295.8	3295.951	Fe, Mn	6	....	....	....	....	....	2 ss
3299.0	3298.869	V	3	....	....	....	....	....	0 ss
3302.8	3302.510	Na	6	....	....	....	....	....	3 ss
	3303.109	Na	5						
3308.5	3308.888	Mn	2	....	....	....	....	....	0 ss
	3308.947	Co, Ti	5						
3315.6	3315.457	Ti	3	....	....	....	....	....	0 ss
3318.3	3318.160	Ti	6	....	....	....	....	....	1 ss
3322.9	3323.056	Ti	5	....	2 l	....	0 ll	....	10 l
	3323.116	..	3						
3327.0	3326.907	Ti	5	....	....	....	....	....	1 ss
	3326.998	..	3						

TABLE II—Continued.

Observed Wave-length.	From ROWLAND'S Table.			Intensity and Character of Lines.					
	Wave-length.	Substance.	Intensity and Character.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
3329.6	3329.568 3329.648	Ti, Co	5 3	....	2 l	....	0 ll	....	10 l
3332.3	3332.240	Ti	3	....	....	....	....	....	2 ss
3335.3	3335.299	Ti	4	....	3 l	....	0 ll	....	8 l
3340.5	3340.464	Ti	3	2 l	3 l	...	1 ll	....	5 l
3342.1	3341.967	Ti	4	....	5 l	2 ll	....	0 l	10 l
3349.5	3349.597	Ti	7	4 l	15 l	5 ll	2 ll	3 l	20 l
3354.0	3353.875	Sc,—	4	....	....	....	....	....	3 ss
3361.5	3361.327	Ti	8	3 l	10 l	3 ll	2 ll	1 l	15 l
3368.2	3368.193	Cr,—	5 d ?	1 s	2 l	0 ll	0 ll	....	5 l
3372.9	3372.901 3372.994 } d?	Ti—Pd	10	3 l	10 l	3 ll	2 ll	1 l	15 l
3380.2	3380.397	Ti	3	....	1 l	....	....	....	3 l
3383.9	3383.951	Ti	3	1 l	10 l	3 ll	2 ll	1 l	15 l
3388.0	3387.988*	Ti—Zr	5 d ?	0 s	2 l	0 l	0 ll	....	5 l
3392.2	3392.109	Zr	2	....	....	....	....	....	0 ss
3394.8	3394.685	Ti	3	0 ss	2 l	....	0 ll	....	5 l
3403.4	3403.404	Cr	2	....	1 s	....	....	....	3 l
3408.9	3408.911	Cr	3	....	1 s	0 l	0 ll	....	4 l
3414.9	3414.911	Ni	15	....	....	....	....	....	3 s
3421.4	3421.353	Ni, Cr, Pd	4	....	1 l	0 l	0 ll	....	3 l
3422.9	3422.892	Cr	4	....	1 l	0 l	0 ll	....	3 l
3426.5	3426.466 3426.535 3426.769	Fe Fe Fe	3 3 3	....	....	....	....	....	1 ss
3433.6	3433.453	Cr	3	0 ss	2 l	0 l	0 ll	....	2 l
3438.5	3438.376	Zr	2	....	....	....	...	....	2 ss
3442.0	3442.118	Mn	6	....	3 l	1 l	1 ll	0 l	6 l
3444.4	3444.467	Ti	4	....	....	....	....	....	3 ss
3452.9	3453.039	Ni	6 d ?	....	....	....	....	....	2 ss
3456.6	3456.528*	Ti	3	....	....	0 ll	3 ll	....	1 ss
3460.6	3460.460	Mn,—	4 d ?	0 ss	1 l	0 l	0 ll	....	5 l
3466.0	3465.900 3466.015	Co Fe	4 6	....	....	....	....	....	2 ss
3474.3	3474.287	Mn	2	....	1 s	0 l	0 ll	....	4 l
3477.4	3477.323	Ti	5	0 ss	1 s	....	....	....	2 l
3482.9	3483.047	Mn—	5 d ?	....	1 s	....	0 ll	....	3 l
3488.9	3488.817	Mn	4	....	1 s	0 l	....	....	2 s
3491.2	3491.195	Ti	5	....	1 s	....	....	....	2 s
3496.4	3496.348	Zr	2	0 ss	1 s	....	....	....	5 s
3500.6	3500.474	Ti	3	....	....	....	....	....	1 ss
3505.0	3505.015 3505.056	Fe Ti	3 2	0 ss	1 s	....	....	....	5 s
3510.9	3510.985	Ti	5	....	1 s	....	....	....	5 s

*Coincident with a hazy line of great extent.

TABLE II—Continued.

Observed Wave-length.	From ROWLAND'S Table.			Intensity and Character of Lines.					
	Wave-length.	Substance.	Intensity and Character.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
3514.0	3513.965	Fe	7	....	....	....	....	....	3 s
	3514.082	..	4						
3520.3	3520.397	Ti	2	....	....	....	....	....	2 s
3524.5	3524.677	Ni	20	....	....	....	....	....	4 s
3530.8	3530.919*	..	3	....	....	....	....	....	2 ss
3535.4	3535.554	Ti	4	....	....	....	....	....	5 ss
3541.3	3541.237	Fe	7	....	....	....	....	....	0 ss
3545.2	3545.336	—, V	4	....	....	....	....	....	1 ss
3548.5	3548.332	Mn, Ni	5	....	....	....	....	....	1 ss
3552.2	3552.098	Zr	1	....	....	....	....	....	1 ss
3557.0	3556.738	Zr	2	....	....	....	....	....	4 ss
	3556.830	Fe	2						
	3556.944 †	Fe	4						
	3557.036	..	3						
3561.8	3561.898	Ni	3	....	....	....	....	....	2 ss
3565.6	3565.535	Fe	12	....	1 s	....	....	....	5 ss
3568.0	3567.835	..	4	....	....	....	....	....	1 ss
3570.3	3570.273	Fe	20	....	2 s	....	....	....	4 ss
3572.7	3572.617	..	4	0 ss	2 s	....	....	....	5 ss
	3572.712	—, Sc	6						
3575.2	3575.106	Cr—Co	5	....	....	....	....	....	0 ss
3576.5	3576.469	..	4	0 ss	1 s	....	....	....	5 s
	3576.527	—, Sc?	3						
3579.0	3578.832	Cr	10	....	....	....	....	....	2 ss
3581.3	3581.349	Fe	30	0 ss	2 s	....	....	....	5 s
3585.4	3585.479	Fe	7	0 ss	1 s	....	....	....	8 s
3590.0	3589.773	..	5	....	....	....	....	....	6 s
	3589.908 ‡	..	5 d?						
3593.4	3593.636	Cr	9	....	....	....	....	....	4 s
3596.1	3596.195	Ti	4	....	....	....	....	....	3 s
3600.7	3600.880	Y	3	....	....	....	....	....	5 s
3604.0	3603.922	Ti	3	....	....	....	....	....	2 s
	3603.972	Fe	4						
3609.2	3609.008	Fe	20	....	....	....	....	....	3 s
3613.8	3613.947	—, Sc	4	0 ss	3 l	....	....	....	5 l
3618.9	3618.919	Fe	20	0 ss	1 s	....	....	....	5 s
3624.9	3624.979	Ti, Fe	5	....	....	....	....	....	4 s
3630.8	3630.876	..	4	1 s	3 l	0 l	....	....	8 l
3636.3	3636.305	Fe	3	....	....	....	....	....	1 ss
3642.7	3642.820	Ti	7	0 ss	1 s	2 ll	2 ll	....	8 l
3645.5	3645.429	..	3	....	....	....	....	....	3 ss
	3645.475	Sc? ,—	3						

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* EXNER and HASCHEK give a heavy vanadium line at λ3530.96.
† EXNER and HASCHEK give a heavy vanadium line at λ3556.93.
‡ EXNER and HASCHEK give a heavy vanadium line at λ3589.90.

TABLE II—Continued.

Observed Wave-length.	From ROWLAND'S Table.			Intensity and Character of Lines.					
	Wave-length.	Substance.	Intensity and Character.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
3648.0	3647.988	Fe	12	0 ss	....	....	....	....	4 ss
3651.5	3651.614	Fe	7	0 ss	....	....	....	....	3 ss
3652.0	3651.940	—, Sc	4	....	....	....	....	....	5 ss
3656.0	3655.801	..	3	....	....	....	....	....	1 ss
3660.0	3659.901	Fe—Ti	5	....	....	....	....	....	4 ss
3662.4	3662.378	Ti	5	....	....	....	....	....	2 s
3663.8	3663.5	H 29	..			†....	†....	†....	1 s
3664.5	3664.7	H 28							1 s
3666.0	3666.1	H 27							2 s
3667.3	3667.4 *	H_ω		....	....				2 s
3668.8	3669.0	H_ψ							2 s
3671.0	3670.8	H_χ			0 ss				3 s
3672.5	3672.7	H_ϕ							3 s
3674.3	3674.2 ‡	H_υ	..	1 s	1 s	....	....	....	3 s
3676.4	3676.457	Fe, Cr	6	. ..	....	....	....	....	3 s
3679.6	3679.5 ‡	H_τ	..	1 s	1 s	....	....	....	3 s
3683.5	3683.5 §	H_σ	..	1 s	1 s	....	....	....	3 s
3685.3	3685.339	Ti	10 d?	10 l	15 l	6 ll	5 ll	5 l	20 l
3686.8	3686.7 ‖	H_ρ	..	2 l	2 l	....	....	....	6 s
3691.6	3691.5 ‖	H_π	..	2 l	3 l	1 l	0 ll	....	8 l
3697.4	3697.4 ‖	H_o	..	2 l	4 l	1 l	0 ll	0 l	8 l
3704.1	3704.0 ‖	H_ξ	..	3 l	5 l	1 l	1 ll	0 l	10 l
3706.3	3706.175	Ca, Mn	6 d?	0 s	....	....	....	....	5 s
3709.4	3709.389	Fe	8	....	....	....	....	....	2 s
3711.8	3711.8 ‖	H_ν	..	3 l	6 l	2 l	1 ll	0 l	12 l
3715.7	3715.615 ¶	Mn?	4	....	....	....	....	....	1 ss
3720.0	3720.084	Fe	40	0 s	1 l	....	....	....	4 ss
3721.8	3721.9 ‖	H_μ	..	4 l	8 l	3 l	1 ll	0 l	14 l
3727.8	3727.778	Fe	4	....	....	....	....	....	2 ss
3734.3	3734.2 §	H_λ	..	4 l	10 l	3 ll	2 ll	1 l	14 l
3737.3	3737.281	Fe	30	1 s	3 l	0 l	....	....	5 l
3741.8	3741.791	Ti	4	....	1 l	....	....	....	4 l
3745.8	3745.717	Fe	8	0 s	1 l	....	....	....	5 l
3750.3	3750.2 §	H_κ	..	6 l	15 l	8 ll	2 ll	1 l	15 l
3759.5	3759.447	Ti	12 d?	6 l	20 ll	10 ll	4 ll	2 l	15 l
3761.5	3761.464	Ti	7	6 l	20 ll	10 ll	4 ll	2 l	15 l
3764.1	3763.945	Fe	10	....	....	....	....	....	1 s

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* Computed from BALMER'S formula $\frac{1}{\lambda} = a\ (1\text{-}4\ m^{-2})$, using AMES' value of a, 27418.3.

† Not very well defined and probably still further confused by the strong iron, nickel, and other lines of this region.

‡ HALE'S value.

§ DESLANDRES' value.

‖ DESLANDRES and HALE'S value.

¶ EXNER and HASCHEK give a heavy vanadium line at λ3715.70.

TABLE II—Continued.

Observed Wave-length.	From ROWLAND'S Table.			Intensity and Character of Lines.					
	Wave-length.	Substance.	Intensity and Character.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
3767.5	3767.341	Fe	8	....	....	....	....	....	0 ss
3770.8	3770.8 *	H_ι	..	8 l	20 ll	10 ll	3 ll	1 l	15 l
3774.6	3774.473	Y	3	....	....	....	....	....	3 ss
3783.6	3783.674	Ni	6	....	....	....	....	....	0 ss
3788.9	3788.839	Y	2	....	....	....	....	....	3 ss
3798.2	3798.1 *	H_θ	..	10 l	25 ll	12 ll	5 ll	3 l	20 l
3806.9	3806.865	Mn—Fe	8 d?	....	....	....	....	....	1 ss
3814.6	3814.698	..	8 d	....	....	....	....	....	4 ss
3816.1	3815.987	Fe	15	....	....	....	....	....	4 ss
3820.7	3820.586	Fe—C	25	1 s	2 l	1 ll	2 ll	....	5 l
3824.7	3824.591	Fe	6	1 s	0 s	....	....	....	3 s
3825.8	3826.027	Fe	20	1 s	0 s	....	....	....	3 s
3829.5	3829.501	Mg	10	3 s	3 s	....	....	....	5 l
3832.5	3832.450	Mg	15	5 l	5 l	1 ll	....	....	8 l
3835.5	3835.54*	H_η	..	20 l	30 ll	15 ll	6 ll	5 l	20 l
3838.4	3838.435	Mg—C	25	5 l	10 l	5 ll	3 ll	....	8 l
3841.3	3841.195	Fe—Mn	10	....	....	....	....	....	2 ss
3850.1	3850.118	Fe—Cr	10	0 s	....	....	....	....	3 ss
3856.6	3856.524	Fe	8	1 s	1 s	....	....	....	4 ss
3860.2	3860.055	Fe—C	20	2 s	3 s	....	0 ll	....	5 l
3872.5	3872.639	Fe	6	....	....	....	....	....	3 ss
3878.8	3878.720	Fe	7 Nd?	0 s	1 s	....	....	....	5 s
3883.3	3883.426	C—Fe	2	....	....	....	....	....	3 ss
3889.0	3888.785 †	He	..	30 ll	80 ll	30 ll	20 ll	20 ll	40 ll
	3889.14 ‡	H_ζ	..						
3895.9	3895.803	Fe	7	....	....	....	....	....	5 ss
3900.7	3900.681	Ti—Fe	5	0 s	5 l	0 ll	1 ll	....	10 s
3905.7	3905.660	Si	12	....	....	....	1 ll	....	2 ss
3906.5	3906.628	Fe	10	....	....	....	....	....	3 ss
3913.5	3913.609	Ti—	5 d?	....	....	....	....	....	6 ss
3920.2	3920.410	Fe	10	....	....	....	....	....	0 ss
3923.0	3923.054	Fe	12 d?	....	....	....	....	....	3 ss
3928.2	3928.075	Fe	8	....	....	....	....	....	2 ss
3933.8	3933.825	Ca	1000	100 ll	200 ll	150 ll	100 ll	125 ll	200 ll
3944.0	3944.160	Al	15	....	1 s	....	....	....	4 l
3950.3	3950.102	Fe	5	§	§	§	§	§	3 ss
3956.6	3956.476	Ce, Co—Ti	4	....	1 s	....	....	....	3 ss
	3956.603	Fe	4						
	3956.819	Fe	6						
3961.6	3961.674	Al	20	0 s	1 l	....	....	....	3 l
3968.6	3968.625	Ca	700	75 ll	150 ll	130 ll	75 ll	100 ll	150 ll
3970.3	3970.177	H_ϵ	5	30 l	50 ll	20 ll	10 ll	?	30 ll
3977.8	3977.891	Fe	6	....	....	....	....	....	1 ss

* HALE'S value.
‡ YOUNG'S value.

† RUNGE and PASCHEN'S value.
§ Center of confused group.

TABLE II—Continued.

Observed Wave-length.	From ROWLAND'S Table.			Intensity and Character of Lines.					
	Wave-length.	Substance.	Intensity and Character.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
3982. 7	3982. 630 3982. 742	Ti Mn—Y	2 3	....	....	....	....	....	3 ss
3989. 8	3989. 912	Ti	4	....	....	....	....	....	2 ss
3998. 8	3998. 790	Ti	4	....	....	....	....	....	3 ss
4005. 6	4005. 408	Fe	7	....	....	....	....	....	3 ss
4012. 7	4012. 541	Ti, Ce	4	....	....	....	....	....	3 ss
4026. 3	4026. 342*	He	..	1 l	10 ll	5 ll	5 ll	5 l	8 ll
4031. 0	4030. 878 (4030. 918) 4030. 947	Mn	10 d ?	....	....	....	....	....	5 ss
4033. 3	4033. 224	Mn	8 d ?	....	....	....	....	....	5 ss
4034. 7	4034. 644	Mn	6 d	....	....	....	....	....	2 ss
4041. 5	4041. 431 4041. 525	Fe Mn	3 5	....	....	...	....	....	1 ss
4046. 0	4045. 975	Fe	30	0 s	1 l	....	....	....	8 s
4048. 9	4048. 818 (4048. 883) 4048. 910	Zr .. Mn—Cr	1 .. 5	....	....	....	....	....	1 ss
4055. 1	4055. 023 4055. 189	Fe Ce—Ti—Fe, Zr	3 3	....	....	....	....	....	1 ss
4055. 6	4055. 701	Mn	6	....	....	....	....	....	1 ss
4059. 0	4058. 915	Fe, Cr	3	....	....	....	...	....	1 ss
4063. 7	4063. 759	Fe	20	....	1 l	....	....	....	5 ss
4067. 3	4067. 139	Cr—Fe	5	....	....	....	....	....	2 ss
4071. 9	4071. 908	Fe	15	....	0 s	....	....	....	4 ss
4077. 9	4077. 885	Sr	8	10 l	20 ll	15 ll	8 ll	5 l	20 l
4085. 0	4084. 647 4085. 161 4085. 467	Fe Fe Fe	5 4 4	†	†	†	†	†	2 ss
4101. 9	4102. 000	Hδ, In	40 N	40 ll	90 ll	50 ll	20 ll	15 ll	60 ll
4109. 9	4109. 905 4109. 953	V Fe	2 3	....	....	....	....	....	2 ss
4118. 8	4118. 708 4118. 934	Fe Co	5 4	....	....	....	....	....	2 ss
4123. 2	4123. 384	La	1	....	0 s	0 l	0 ll	....	3 ss
4128. 3	4128. 251	Ce—V,—	6 d	....	....	....	....	....	2 ss
4132. 1	4132. 235	Fe—Co	10	....	....	....	....	....	2 ss
4137. 3	4137. 156	Fe	6	....	....	....	....	....	0 ss
4144. 0	4144. 038	Fe	15	....	0 s	....	....	....	5 ss
4149. 5	4149. 360 4149. 533	C, Zr Fe	2 4	....	....	....	....	....	4 ss
4156. 3	4156. 391	Zr	1	....	....	....	....	....	2 ss
4163. 9	4163. 818	Ti, Cr—	4	....	....	....	....	....	2 ss

* RUNGE and PASCHEN'S value.

† Center of confused group.

TABLE II—Continued.

Observed Wave-length.	From ROWLAND'S Table.			Intensity and Character of Lines.					
	Wave-length.	Substance.	Intensity and Character.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
4167.6	4167.438	..	8	....	....	....	....	....	0 ss
4171.9	4171.854	C, Fe?	2	....	....	....	....	....	3 ss
4173.7	4173.624 4173.710	.. ..	3 3	....	....	....	....	....	3 ss
4177.8	4177.698	..	3	....	....	....	...	....	3 ss
4179.0	4179.025	..	3	....	....	....	....	....	2 ss
4184.3	4184.158 4184.472	.. ..	4 2	....	....	....	....	....	1 ss
4188.0	4187.943	Fe	5	....	....	....	....	....	2 ss
4191.7	4191.595	Fe	6	....	....	....	....	....	1 ss
4199.2	4199.267	Zr—Fe	5	....	....	....	....	....	2 ss
4205.4	4205.545	Fe	1 N	....	....	....	....	....	2 ss
4210.4	4210.494	Fe	4	....	....	....	....	....	2 ss
4215.7	4215.703	Sr	5 d?	8 l	10 l	2 ll	1 ll	3 l	15 l
4222.2	4222.382	Fe	5	....	....	....	....	....	1 ss
4226.9	4226.904	Ca	20 d?	5 s	3 l	....	....	....	8 l
4233.4	4233.328	Mn	4	0 ss	....	....	....	. ..	4 l
4247.0	4246.996	Sc	5	5 s	2 l	0 l	....	....	8 l
4250.8	4250.945	Fe	8	....	....	....	....	....	3 ss
4254.5	4254.505	Cr	8	2 s	0 s	....	....	....	4 l
4260.5	4260.640	Fe	10	....	....	....	....	....	4 ss
4267.8	4267.985	Fe	3	....	....	....	....	....	0 ss
4271.8	4271.934	Fe	15	....	....	....	....	....	4 ss
4274.9	4274.958	Cr	7 d?	0 ss	....	....	....	....	5 ss
4282.4	4282.565	Fe	5	....	....	....	....	....	1 ss
4283.1	4283.169	Ca	4	....	....	....	....	....	2 ss
4289.6	4289.525	Ca	4	....	0 s	....	....	....	4 s
4289.9	4289.885	Cr	5	1 s	0 s	....	....	....	4 s
4294.3	4294.301	Fe	5	1 s	0 s	....	....	....	6 s
4300.2	4300.211	Ti	3	....	1 s	0 ll	....	....	8 s
4302.3	4302.353	Fe	2	....	....	....	....	....	2 ss
4302.8	4302.692	Ca	4	....	....	....	....	....	2 ss
4307.9	4307.907 4308.081	Ca Fe	3 6	1 s	1 s	....	....	....	6 ss
4313.2	4313.034	Ti	3	....	1 s	....	....	....	3 s
4319.0	4318.817	Ca, Mn?	4	0 s	1 s	....	....	....	3 s
4321.0	4320.907	Sc	3	....	1 s	....	....	....	5 s
4326.0	4325.939	Fe	8	0 s	1 s	....	....	....	8 s
4330.9	4330.866	Ti, Ni	2	....	....	....	....	....	1 ss
4340.6	4340.634	H_γ	20 N	60 ll	100 ll	60 ll	40 ll	30 ll	100 ll
4352.8	4352.908	Fe	4	0 s	....	....	....	....	6 ss
4359.9	4359.784	Cr	3	....	....	....	....	....	2 ss

TABLE II—Continued.

Observed Wave-length.	From ROWLAND'S Table.			Intensity and Character of Lines.					
	Wave-length.	Substance.	Intensity and Character.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
4363.3	4363.267	Cr	1 N	....	Film spoiled.	....	....	....	2 l
4367.8	4367.749	Fe	5	....		....	....	....	2 ss
4370.0	4369.941	Fe	4	....		....	....	....	2 ss
4374.7	4374.628	Sc, Fe?	3	....		....	....	....	3 ss
4376.0	4376.107	Fe	6	0 s		0 l	....	....	5 l
4383.6	4383.720	Fe	15	1 s		0 l	....	....	6 l
4395.1	4395.201	Ti	3	3 s		1 ll	....	....	8 l
4399.9	4399.935	Ti, Cr	3	0 s		....	....	....	3 l
4400.5	4400.555	Sc	3	0 s		....	....	....	3 l
4404.9	4404.927	Fe	10	0 s		....	....	....	5 l
4408.7	4408.582	Fe	3	....		....	....	....	4 ss
4415.2	4415.293	Fe	8	....		....	....	....	5 s
4417.7	4417.884	Ti—	3	....		....	....	....	6 s
4422.7	4422.741	Fe, Y	3	....		....	....	....	1 ss
4427.5	4427.482	Fe	5	....		....	....	....	3 ss
4430.9	4430.785	Fe	3	....		....	....	....	1 ss
4435.3	4435.129	Ca	5	....		....	....	....	4 ss
4443.8	4443.976	Ti	5	3 s		0 l	....	....	8 l
4450.6	4450.654	Ti?	2	....		....	....	....	4 s
4455.0	4454.953	Ca, Zr	5	....		....	....	....	4 s
4461.8	4461.818	Fe	4	....	....	....	....	....	4 s
4468.5	4468.663	Ti—	5	2 s	0 s	...	....	....	6 l
4471.6	4471.646*	He	..	20 ll	40 ll	25 ll	10 ll	15 ll	30 ll
4490.2	4490.253	Mn—Fe	3 N	....	....	....	....	....	4 ss
4494.8	4494.738	Fe	6	....	....	....	....	....	1 ss
4501.4	4501.445	Ti, —	5	2 s	1 s	0 l	....	....	8 l
4508.5	4508.455	Fe ?, —	4	....	....	....	...	....	3 ss
4515.6	4515.508	..	3	....	....	....	....	....	3 ss
4520.3	4520.397	Fe ?, —	3	....	....	....	....	....	3 ss
4522.9	4522.974	Ti	2	....	....	....	....	....	5 ss
4528.9	4528.798	Fe	8	....	....	....	....	....	2 ss
4534.1	4534.139	Ti—Co	6	2 s	2 s	1 l	....	....	8 l
4541.6	4541.690	Cr	2	...	....	....	....	....	1 ss
4549.8	4549.808	Ti—Co	6 d ?	3 s	2 s	1 l	....	....	8 l
4554.3	4554.211	Ba	8	3 s	2 s	....	....	....	10 l
4558.8	4558.827	Cr ?	3	....	....	....	....	....	2 ss
4564.0	4563.939	Ti	4	1 s	2 s	1 l	....	....	8 l
4572.1	4572.156	Ti—	6	2 s	2 s	1 l	....	....	8 l
4584.0	4584.018	Fe—	4	0 ss	0 s	....	....	....	6 s
4588.5	4588.381	..	3	....	....	....	....	....	2 s
4601.0	4600.932	Cr	3	....	....	....	....	....	0 ss
4611.3	4611.469	Fe	5	....	....	....	....	....	0 ss
4619.0	4618.971	Fe—	4 d ?	....	....	....	....	....	2 ss
4629.4,	4629.521	Ti—Co	6	....	....	....	....	....	4 ss

* RUNGE and PASCHEN'S value.

TABLE II—Continued.

Observed Wave-length.	From ROWLAND'S Table.			Intensity and Character of Lines.					
	Wave-length.	Substance.	Intensity and Character.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
4634.4	4634.254	..	2	....	....	....	....	....	0 ss
4646.5	4646.347	Cr	5	....	....	....	....	....	3 ss
4651.5	4651.461	Cr	4	....	....	....	....	....	2 ss
4656.5	4656.644	Ti	3	....	....	....	....	....	3 ss
4668.4	4668.331	Fe	4	....	....	....	....	....	3 ss
4685.4	4685.452	Ca	2 N	....	0 s	1 l	1 ll	2 ll	5 l
4704.0	4703.994	Ni	3	....	....	....	....	....	1 ss
4713.3	4713.252 *	He	..	....	3 l	2 ll	1 ll	2 ll	5 l
4731.6	4731.651	Fe ?	4	....	....	....	....	....	0 ss
4754.1	4754.225	Mn	7	....	....	....	....	....	0 ss
4763.9	4764.108	Ti—Ni	4 d	....	....	....	....	....	0 ss
4780.3	4780.169	Co	2	....	....	....	....	....	0 ss
4799.4	4799.598	Fe	1	....	....	....	....	....	0 ss
4805.3	4805.285	..	3	....	....	....	....	....	0 ss
4823.8	4823.697	Mn	5	....	....	....	....	....	3 ss
4827.9	4827.804	Ti	00	....	....	....	....	....	1 ss
4841.0	4841.074	Ti	3	....	....	....	....	....	0 ss
4847.6	4847.497	Ca	0	....	....	....	....	....	1 ss
4861.5	4861.527	H_β	30	80 ll	120 ll	80 ll	40 ll	60 ll	150 ll
4871.6	4871.512	Fe	5	....	....	....	....	....	3 ss
4877.6	4877.772	..	0	....	....	....	....	....	1 ss
4883.8	4883.867	Yt earth	2	....	....	....	....	....	2 ss
4891.5	4891.683	Fe	8	....	....	....	....	....	3 ss
4900.1	4900.095	Ti, La	2	....	....	....	....	....	2 ss
4911.2	4911.374	..	1	....	....	....	....	....	1 ss
4920.5	4920.685	Fe	10	....	....	....	....	....	3 ss
4924.2	4924.107	Fe	5	....	....	....	....	....	10 s
4934.3	4934.214 4934.277 }	Ba, Fe ?	6	....	....	....	....	....	6 s
4939.9	4639.868	Fe	3	....	....	....	....	....	1 ss
4957.8	4957.785	Fe	8	....	....	....	....	....	3 ss
4994.1	4994.316	Fe	3	....	....	....	....	....	0 ss
4999.8	4999.689	Ti, La	3	....	....	....	....	....	0 ss
5006.4	5006.306	Fe	5	....	....	....	....	....	0 ss
5014.5	5014.369 5014.457 }	Ti Fe	2 3	}	....	....	....	....	0 ss
5018.7	5018.629	Fe	4	....	....	....	....	....	6 ss
5031.3	5031.199	..	3	....	....	....	....	....	0 ss
5041.9	5041.795	Ca	2	....	....	....	....	....	0 ss
5167.5	5167.497	Mg	15	....	....	....	....	....	4 ss
5172.8	5172.856	Mg	20	....	....	....	....	....	4 ss
5183.8	5183.791	Mg	30	....	....	....	....	....	4 ss
5204.7	[5204.680 5204.768]	Cr Fe	5 3	}	....	....	....	....	0 ss

*RUNGE and PASCHEN'S value.

Explanation of Table III.—TABLE III gives a list of the elements and the number of long and short lines due to each found on the films. The symbols *ss*, *s*, *l*, and *ll* have the same meanings here that are given to them in TABLE II—that is, they designate respectively very short, short, long, and very long arcs. The long arcs, as already explained, are due to appreciable amounts of light of these particular wave-lengths coming from great elevations in the chromosphere, while the short ones denote wave-lengths that are given off from lower parts of the Sun's atmosphere.

A double column is given under the several lengths. The first in each pair, marked *Single*, refers to lines which in ROWLAND'S table are attributed to single substances, while the column designated *Mixed* has reference to lines which are assigned to two or more elements. It is impossible, of course, to determine just to what substance or substances any of the mixed lines are due, as they occur on my films, though in many cases one would naturally suspect them to be produced by iron or titanium rather than by other elements that give lines of nearly the same wave-lengths. But such a separation would be entirely arbitrary and I shall not attempt it.

TABLE III.

Substance.	ss		s		l		ll	
	Single.	Mixed.	Single.	Mixed.	Single.	Mixed.	Single.	Mixed.
Al	..	..	..	..	2	..	..	..
Ba	..	..	..	1	1	..	..	..
Ca	5	..	2	3	1	..	3	..
C	..	3	..	..	..	..	..	3
Ce	..	3	..	1	..	..	..	..
Co	3	5	..	2	..	2	..	2
Cr	8	3	3	3	3	1	3	2
He	..	..	..	..	..	..	4	..
H	..	..	10	..	1	..	14	1
In	..	..	..	..	..	..	..	1
Fe	65	19	25	5	8	..	..	3
La	..	..	..	..	..	..	1	..
Mg	3	..	..	..	1	..	1	1
Mn	9	8	..	2	2	..	2	2
Ni	6	3	2	..	..	..	..	1
Pd	..	..	..	..	..	..	..	3
Sc	..	4	1	2	2	1	..	..
Si	..	..	..	..	..	..	1	..
Na	2	..	..	..	..	..	..	..
Sr	..	..	..	..	..	..	2	..
Ti	34	18	10	3	4	6	15	6
V	6	2	..	..	..	..	..	..
Y	4	1	1	..	..	..	..	..
Zn	..	1	..	..	..	..	..	..
Zr	5	5	1	1	..	..	..	..
Unknown	20	11	6	4	1	4	1	3

TABLE IV gives the approximate heights, as determined from the spectrum arcs on Film No. 6, reached by appreciable amounts of several substances in the solar atmosphere. In making these estimates I took the semidiameter of the Sun 948″.4 and that of the Moon as 1013″.8, and used that part of each crescent that extends from the point of contact across the film in a direction roughly parallel to the rulings on the grating. The great majority of the arcs are so short that they indicate an elevation of less than one second, and many even less than half a second, but any substance must extend at least as high as the outermost source of its longest lines, and hence only the longest arcs are given in TABLE IV. These estimates of extreme heights are not in close agreement with those of certain other observers, but so much depends on the lines selected, on the light-gathering power of the spectrograph, and on the time of exposure that with differences in these particulars agreement could not be expected.

TABLE IV.

App. Ht. of Substance.	Substance.	Wave-length.
″ 0.25	Al	3444.160, 3961.674
0.25	Co	4780.169
0.25	La	4123.384
0.50	Na	3302.510, 3303.109
0.50	V	3118.498, 3121.270, 3130.380
1	Ni	3414.911, 3453.039
1	Y	3600.880
1	Zr	3496.348
3	Cr	3422.892, 3433.453
4	Ba	4554.211
4	Fe	3737.281, 4376.107, 4383.720
5	Sc	4246.996
5	Si	3905.660
6	Mg	3829.501, 3832.450
7	Mn	3442.118, 3460.460
9	Sr	4077.885, 4215.703
9	Ti	3349.597, 3383.951, 3685.339, 3759.447, 3761.464
34	Ca	(K) 3933.825, (H) 3968.625
34	He	4471.646
34	H	(H_γ) 4340.634, (H_β) 4861.527

DISCUSSION OF THE RESULTS.

It will be seen that most of the elements that produce a considerable number of lines give both long and short ones, which shows that the elements themselves are more or less similarly and pretty generally distributed throughout the solar atmosphere. It seems, too, from the photographs that the light intensity, and presumably the density of each substance, grows rapidly more pronounced at greater depths.

TABLE II shows that a number of lines which are short on the films that had only a few seconds' exposure came out as long ones on those which were exposed a greater length of time, and this, too, indicates a very extensive distribution of the elements in the chromosphere, with no narrow separating boundaries producing distinct layers of any kind.

The streaks of continuous spectra are most marked about prominences and at those places which, owing to irregularities in the Moon's outline, were exposed to the deeper portions of the Sun's atmosphere. But as Film No. 4, which was exposed for two minutes during mid-totality, has distinct bands of faintly continuous spectra extending approximately from λ3200 to λ5200—that is, from near the limit of the ultra-violet part of the solar spectrum up as far as the film was especially sensitive—it would seem that whatever this is due to, whether to great quantities of gas or to more condensed masses, it must extend without very abrupt changes pretty much throughout the solar atmosphere, but in rapidly decreasing amounts at higher levels.

There are two lines in the ultra-violet that perhaps deserve special mention, since they are quite distinct in appearance from any of the others, being very long, broad, and hazy, seemingly true coronal lines. Their approximate wave-lengths are respectively λ3388 and λ3456.5, so nearly coincident with the titanium lines λ3387.988 and λ3456.528 that I could not distinguish between them by measurement, and, in fact, it is not their positions on the films, but their general appearance, especially as produced by the long exposure, that makes me doubt their titanium origin.

I have tried to find what relations, if any, exist between the lines given in TABLE II and the spectra of the elements as produced under various other conditions, but so far no very close relation has been discovered, except the natural one that in general the heavier, and only the heavier, FRAUNHOFER lines appear as bright lines in the flash, and that the relative intensities in the two cases are roughly comparable.

A line that comes out strongly both in the arc and spark spectra is likely to appear also in the flash spectrum. Probably, too, the chances are more than even in favor of the appearance of the enhanced lines, but the exceptions are too many and too decided to justify speculations based on this important phenomenon.

It is evident from the tables that, with the exception of those produced by hydrogen and helium, the great bulk of the lines are due to elements belonging to that MENDELEJEFF series which terminates with the iron, nickel, and cobalt group; but there can be no surprise in this since the same is true of all the identified solar lines, and it simply shows that the upper and lower levels of the Sun's atmosphere contain in the main the same elements, and that the FRAUNHOFER lines are true reversals of gaseous bright lines.

SUGGESTIONS.

It seems to me that it would be very desirable in connection with the work on future eclipses to obtain photographs of as many of the flash and coronal lines as possible, and for this purpose both prism and direct grating spectrographs may be used, but in either case it would probably be well to make at least some very long exposures on carefully backed plates. The strong lines would of course be greatly over-exposed, but these are already known, and the long exposures would bring out many of the fainter ones. A few exposures could be made with advantage both just before and just after totality, and to allow for some judgment on the part of the operator the plate or film-magazine should be amply stocked so as to meet any such contingencies, as unexpected duration, that might arise. Perhaps it would even be well to have one exposure covering the whole of totality, except the two flashes, for the sake of detecting the faintest of the coronal lines.

I would suggest that the grating be put in approximate focus, either by careful measurement, based on a knowledge of the grating itself or by some such method as that devised by Mr. JEWELL. But since it is so essential to have excellent definition I would strongly urge final focusing, just before totality, on the narrow crescent of the Sun.

Besides the spectrographs already mentioned I should particularly like to see a concave grating used with a slit and mounted according to the ROWLAND method. In this case mirrors alone should be used in focusing the light on the slit, so as to avoid all chromatic aberration, and it should be done so as to get as much as possible of the light on the ruled surface of the grating, for the only serious danger is that there may not be light enough. A suitable portion of the spectrum could be observed visually by the operator, who should be able to shift the image so as to keep its brightest portion on the slit. It would be very desirable to have the disappearing and the reappearing crescents tangent to the slit, and this could be obtained either by an image rotator, or preferably, for the sake of economizing the light, by suitably rotating the spectrograph itself between the exposures. I would suggest an exposure at each flash, and a single long one between them with the instrument set so as to catch the brighter parts of the polar streamers, and further that each of these be followed by a comparison arc spectrum on the same plate. I am quite sure that getting a comparison spectrum need not consume much time, for I have obtained very fair iron spectra, using a grating of 21 feet focal length, with an exposure of one second. With such plates as these, even if the lines were not very numerous, it would be possible to detect any slight changes in wave-length due to velocity of the polar rays or to any other cause, since these changes would be the residuals, if any, after allowing for the ordinary line of sight motion due to such known causes as the rotations of the Sun and Earth on their axes, and the motion of the Earth in its orbit.

There is one other suggestion I should like to make. The photographic plates ought to be as sensitive through the whole range of the spectrum to which they are exposed as can be obtained. But those commercial plates which are most sensitive to the ultra-violet are not the best for the green and yellow, nor on the other hand are orthochromatic plates the most rapid in the region of short wave-lengths. This trouble, I fancy, may be overcome in several ways. The makers may be persuaded to coat the two ends of the plates or films with different emulsions, one for the violet the other for the green of the spectrum; or it would be quite practicable to take, say, a gilt edge plate and suitably stain one end of it, thus rendering that part orthochromatic while leaving the other end particularly sensitive to the violet.

Note.*—In his presidential address at the Belfast meeting of the British Association for the Advancement of Science, in September, 1902, Prof. JAMES DEWAR refers to the fact that the great majority of the spectrum lines found on my Fort de Kock eclipse negatives coincide closely with lines due to argon, helium, xenon, and other atmospheric constituents.

I have carefully compared the flash spectrum, as shown on my negatives, with the tables furnished by DEWAR, and others, of the spectra of the above gaseous elements, and while I find the agreement, of course, to be just as he says, I am not persuaded that the lines, except those already so assigned, are really due to these elements. My reasons are:

(1) Agreement in wave-length with prominent solar spectrum lines is, in general, much closer than with lines of argon, xenon, etc. It may be, I admit, that many of the lines in ROWLAND'S Preliminary Table of Solar Spectrum Wave-lengths are incorrectly assigned to iron, titanium, and other metallic elements, but from the character of that work this seems improbable.

(2) One would naturally expect the more prominent lines of any element in the Sun to show themselves, but in this case the heavier lines, as formed in the laboratory, of the above gases, with the exception of hydrogen and helium, are no more conspicuous on my negatives, if present at all, than are the lighter ones. This I interpret to mean, not the absence from the Sun's atmosphere of these elements, for I think it highly probably that they are present, but that their spectra in the Sun are relatively weak as compared with those of hydrogen, iron, titanium, and several other substances.

Professor DEWAR'S remark, in another part of his address, that the Sun's coronal atmosphere is probably rendered luminous by electrical discharges, analogous to auroral displays, implies, as others have suggested, that the coronal rays and streamers are only the lines or paths of electrical discharge, and not the trajectories of material particles. A spectroscopic line of sight examination, which ought to be possible at the time of a total eclipse, might materially aid in the definite solution of this problem.

In closing I would like to add that the exceeding feebleness of the lines on my negatives, between λ3100 and λ3300, is certainly due in large measure to the fact that the light was sent to the grating by means of a silver-on-glass reflector. It is in this particular region that silver has its least coefficient of reflection, and that a very small one.

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*Added March, 1903.

THE LOENTO VALLEY, LOOKING NORTH FROM THE ECLIPSE STATION NEAR SAWAH LOENTO, SUMATRA.

Photographed by W. W. Dinwiddie.

REPORT OF THE SAWAH LOENTO STATION.

Dr. S. A. MITCHELL, Columbia University, in charge.

Instead of the excellent weather that was expected to greet us at Solok it was found, after ten days' sojourn there, that clouds at noon were the rule rather than the exception. However, the sky, although almost always partly cloudy, was usually not wholly overcast, and hence it was concluded that on the day of the eclipse clouds might prevail at one station while a few miles distant perfect weather conditions would be experienced.

Consequently it was decided best to establish a third eclipse station, to be equipped with two instruments, the plane grating objective spectrograph and one of the smaller photographic lenses, and to be in charge of Dr. S. A. MITCHELL. The site selected for this was Sawah Loento, the terminus of the Sumatra Railway. Already two astronomical parties were at this place, one an English party under the direction of Mr. H. F. NEWALL, of Cambridge, England; the other an American one with Prof. ALFRED E. BURTON, of the Massachusetts Institute of Technology, as head. The general conditions at Sawah Loento seemed good, also it was not too far distant to prohibit Solok being used as a base of supplies, since it was only about 20 miles away.

The name Sawah Loento is Malay, and means the rice fields on the Loento River, but the Sawah had long been banished from the village and their place was now given up to the Oembilien coal mines of the Government. These mines are remarkable in having a vein 40 feet in thickness. They are worked mainly by convicts, of whom there are about 3,000, living in the village and near the mines on the hill just to the north of the little town. The village itself is typically East Indian, the houses uniformly of one story with their roofs of thatch or corrugated iron, surrounded by luxuriant tropical foliage, the trees of chief interest to the foreigner being the banana, and the cocoanut palms. Situated on the most imposing site is the residence of the controller, or Dutch official. In most of the villages the few white men of the community are officers in the Dutch army, or a merchant or two. In Sawah Loento there is no military, but the whites number about fifty or sixty made up of the Stationschef and the engineers employed in the mines.

To the west of the Loento River was the village proper with its "pasar" or market, with native and Chinese stores, while to the east were located the prison hospitals where lived about 800 sick convicts. Each and every man, woman, and child was interesting, and we were continually kept in open-eyed wonder at the innumerable and many-varied forms of plant and animal life.

The hotel in the village was a small affair with only four rooms, together with the one reserved always for the Dutch official. These rooms were all occupied, and it became necessary to find some other accommodation or camp out. This latter would have been decidedly uncomfortable under the tropical Sun and skies, and, fortunately, had not to be resorted to, excellent accommodations being found with Meinheer VAN LEEUWEN, the station master. The best guest chamber in the house was put at the disposal of the expedition, and everything was done to make the foreigners comfortable. Meals were obtained at the hotel, and excellent meals they were, too, after we became acquainted with the most approved way to mix the ingredients that go to make up the delightful "rijsttafel." East Indian life became very pleasant, looked after as we were by the Dutch officials, and our wants attended to by our Malay "jungus." The two months' stay in Sumatra was one filled with most interesting experiences.

The village was situated at the bottom of the Loento Valley, surrounded on all sides by hills of 500 to 1,000 feet elevation. A location for an eclipse camp being impossible in the village, two sites were available. One of these was to the northward of the railway station, and distant from it by about 2 miles, the place selected by Mr. NEWALL; the other was to the south where was situated the camp of Professor BURTON and his Boston party. The site decided upon for the Naval Observatory camp was near the latter. Situated on a small hill 400 feet above the railway station, overlooking the Loento Valley to the north, it seemed almost an ideal location to insure the best weather conditions. Hills about 500 feet higher were both to the east and west between a quarter and a half of a mile away. These hills seemed to attract and hold the clouds, so that often it was seen to be cloudy on either hill while at the Naval Observatory station there would be sunshine.

About 400 yards due east was the station of the party from the Massachusetts Institute of Technology. These gentlemen assisted in laying off the meridian line, and rendered many kindnesses for which we are deeply grateful.

The distance from the railway station to the eclipse camp was about a mile and a quarter; a very good wagon road running about two-thirds of the distance, the rest being a very good trail.

On account of the pendulum experiments of the Boston party it was necessary for them to know time very accurately, and this was determined by star observations with a portable transit instrument. From comparisons with their sidereal time the error of our mean time chronometer was found. The latitude of the station was also found from these star observations. The latitude and longitude were obtained from the topographical maps published by the Dutch Government, one of the bench marks being close to the Boston party's camp. The maps gave longitudes with reference to Padang, but as there seemed to be some uncertainty as to the location of the Padang meridian, no great faith was pinned on the accuracy of our longitudes from Greenwich.

The position of the Naval Observatory station at Sawah Loento, as taken from the maps, was:

$$\begin{array}{ll} \text{Latitude} & =-0^\circ\ 41'\ 52''. \\ \text{Longitude} & =100^\circ\ 46'\ 40'' \\ \quad\text{``} & =\ 6^h\ 43^m\ 6^s.7 \end{array}\left.\vphantom{\begin{array}{l}a\\a\end{array}}\right\}\text{east from Greenwich.}$$

VIEW OF THE ECLIPSE STATION NEAR SAWAH LOENTO, SUMATRA, LOOKING NORTHWEST.

Photographed by S. A. Mitchell.

VIEW OF THE ECLIPSE STATION NEAR SAWAH LOENTO, SUMATRA, LOOKING NORTHEAST.

Photographed by S. A. Mitchell.

The latitude from star observations was —0° 41′ 40″.

In order to check the longitude an agreement was entered into between the three different parties at Sawah Loento, the one English and the two American expeditions, whereby each was to compare its chronometers at the first observatory reached on the homeward journey, four chronometers altogether to be employed. In accordance with this plan Doctor MITCHELL transported the chronometer, SEWILL No. 1195, to the Manila observatory, where the error and rate was determined by Father ALGUÉ, the director. At Sawah Loento the observations were:

Date.	Local Mean Time.	Clock Corr.
	h m	s
May 8	22 4	+69.1
14	10 30	+83.2

From nine days' comparisons at Manila the chronometer was found to be 5^h 20^m $2^s.7$ slow on Greenwich mean time at noon June 19, and to be losing $3^s.3$ per day. As the rate is not the same for Sawah Loento and Manila, the rates were weighted according to the number of days' observations at each place, and a rate of 3 seconds losing per day assumed. The position of the Naval Observatory station near Sawah Loento as derived from observations is therefore

Latitude = —0° 41′ 40″.
Longitude = 6^h 43^m 8^s east from Greenwich.

Unfortunately, Professor BURTON and Mr. NEWALL were unable to compare their chronometers, and the above longitude rests therefore on the observations with one chronometer.

The elevation of the railway station at Sawah Loento, according to the Dutch maps, is 262 meters above sea level, or 859 feet. The height of the eclipse station above this was measured by means of an aneroid barometer as 400 feet; which therefore makes the elevation of the eclipse camp about 1,260 feet above sea level.

To mount the instruments, piers of brick were constructed. Tents were used as coverings for the instruments, with an extra one for a storehouse, four tents altogether being needed. As the Boston party had been at Sawah Loento about ten days before us, they had learned to some extent the best way in which to proceed. The benefit of their experience was freely imparted, and much valuable information cheerfully given. To Meinheer VAN LESSEN, the chief engineer of the coal mines, many thanks are due for the very generous way in which he looked after the supplying of all building material. The bricks, which were made near the coal mines, were transported to the eclipse location in three stages; first by rail to the residence of the controller; second, by the slow-moving "kreta kerbau," drawn by the sturdy water-buffalo; and third, the remainder of the distance, about a third of a mile, by coolies. The slowness of the operation can perhaps be imagined when it is stated that in a basket slung on a bamboo pole on the shoulders of two coolies, five ordinary sized bricks would be carried. This was indeed the minimum load, but the maximum was never more than ten. It was very interesting to see six coolies using three bamboo poles, carry a barrel of cement. The coolies provided were convicts. The way in which the Dutch East Indies look out for their prisoners is one of the interesting features in the management of the Malay. If a native of Sumatra commits a crime, he is sent to one of the other East India islands; and similarly natives of the other islands are sent to Sumatra to serve out the terms of their punishment. Consequently in a penal settlement in Sumatra are natives of Java, Borneo, Celebes, and from some of the smaller islands, but no Sumatrans. The reason for this strange separation is that there is great enmity between the different races, and so if a Javanese prisoner tries to escape he is immediately apprehended by the first Sumatran that meets him and sent back. And thus it is that there are large penal settlements with no surrounding walls and very few guards.

Such a settlement was at Sawah Loento. The convicts, to the number of 3,000, were used to work in the coal mines. There was no guard over them except the "mandur" or policeman, one of themselves raised to a position of authority and responsibility, and answerable for the conduct of the coolies under him. But, notwithstanding these conditions, one could go around with perfect safety to life, and with no fear of molestation greater than in New York City. In fact, the pistols we had brought, with which to defend ourselves from cannibals, were soon packed carefully away in the bottoms of our trunks.

In order to make the convicts more satisfied with their lot the Dutch authorities paid them the amount of 7 cents Dutch money, 2.8 cents American, per day. There seems to be a great amount of sickness among the convicts, possibly due to their confinement in the hot country, and several hundred of them were in hospital or were put on sick duty without pay. These sick coolies were provided to us by the controller free, and we were able to have of them about as many as we needed. They were very slow and were not overly fond of work, but nevertheless they could carry bricks about as fast as our Malay "tukang" could lay them. He used to squat down at his work, and it took five days for him to lay 2,200 bricks. But the piers were finally built, the tents raised, and the instruments gradually mounted.

On May 7 the size of our party was doubled by the arrival of Mr. René Granger, of Georgia. He had arrived by P. & O. steamer, coming from the United States via Europe, to assist in the observations. He remained at Sawah Loento till after the eclipse and rendered very valuable help. To him was assigned the 104-inch camera, which was to be used in a horizontal position, receiving its light from a coelostat.

THE DAY OF THE ECLIPSE.

The day of the eclipse dawned clear, and our hopes were that these favorable conditions would remain until after totality, which occurred shortly after noon. First contact was observed in a perfectly clear sky, but soon after this clouds began to gather, and a quarter of an hour before second contact the sky was completely overcast.

The disappearing crescent of the Sun was observed with a binocular before one barrel of which was arranged a small plane grating in such a way that with one eye the spectrum could be seen, and with the other eye the Sun itself. With this, shortly before the time of second contact, bright lines were seen for a few seconds at *F* and *H* and in several places in the green and yellow, but these disappeared almost at the instant of being seen, the Sun being completely hidden by clouds, and the flash passed without our being able to see it.

Toward the middle of totality conditions became a trifle better, so that it was possible to see, through clouds, the corona extending for about half a diameter from the Sun, and with the small spectroscope to trace the form of the coronium line quite distinctly. During no time of the $5^m 41^s$ of totality was an unclouded view of the corona obtained, but nevertheless the second flash was beautifully seen.

An hour after the total phase the clouds cleared away and a perfect sky remained for the rest of the day. Alas! that the eclipse did not occur at 1 o'clock instead of at 12!

The program was carried out as if it had been clear.

PERSONNEL.

Dr. S. A. MITCHELL, who was in charge of the station, and who made the exposures with the spectrograph on the day of the eclipse; Mr. RENÉ GRANGER, who was in charge of the 104-inch camera; Naval Cadet W. V. TOMB, U. S. N., who was present during the day of the eclipse, and who counted time during totality; Corpl. C. W. KEETER, U. S. M. C., who was present May 14–21, and who attended to changing the plates of the spectrograph during the eclipse.

THE PLANE GRATING SPECTROGRAPH.

Dr. S. A. MITCHELL, Columbia University, in charge.
Corpl. C. W. KEETER, U. S. M. C., Assistant, May 14–21.

Mr. L. E. JEWELL and the writer together observed the eclipse of 1900 at Griffin, Ga., using a plane grating spectrograph without slit. Light was reflected horizontally from the coelostat mirror and fell on the grating, where it was diffracted, and brought to a focus by a quartz lens of 50 inches focal length interposed between the grating and the photographic plate. Grating, lens, and plate were mounted in a box.

In arranging the details of the spectroscopic work of the eclipse of 1901, Mr. JEWELL planned to use the same grating and same box, but with a quartz lens of 72 inches focal length and $3\frac{23}{64}$ inches aperture, by BRASHEAR, instead of the one of 50 inches focal length. The box was not long enough to permit the lens to be inserted between the grating and the photographic plate, and it was, therefore, placed in the incident beam of light, 14 inches in front of the grating. Under the supposition that the action of a plane grating is equivalent to the combined action of a plane mirror and a dispersing apparatus, it was thought that the spectrum would be brought to a focus 58 inches from the grating, the combined distances making up the focal length of the quartz lens, or 72 inches.

The well-known equation representing the action of the grating is*

$$\sin \varphi + \sin \varphi' = \frac{n\lambda}{\omega}$$

where φ and φ' are the angles which the incident and diffracted light respectively make with the grating normal, λ is the wave-length of the diffracted ray, n the order of the spectrum and ω the grating space.

Three different ways of using the grating are as follows:

(1) $\varphi = 0$, or the incident light falls normally on the grating, and hence,

$$\sin \varphi' = \frac{n\lambda}{\omega}$$

(2) $\varphi' = 0$, for light of some definite wave-length, and the diffracted ray is perpendicular to the grating.

(3) $\varphi' = \varphi$, i. e., the incident and diffracted rays coincide, hence,

$$\sin \varphi' = \sin \varphi = \frac{n\lambda}{2\omega}$$

The grating, a ROWLAND plane grating of 15,000 lines per inch with a ruled space of 3½ by 5 inches, was mounted according to the second method which gives the normal spectrum, or one in which distances between lines in the spectrum are proportional to the differences in their wave-lengths.†

For the eclipse work the first order spectrum was used, and an attempt was made to photograph from λ3000 to λ6000. λ4500 was thus at the middle of the plate, and for this wave-length $\varphi' = 0$.

Hence,

$$\sin \varphi = \frac{n\lambda\ (4500)}{\omega}$$

Values of φ' for the other rays can be found by substituting this value of φ in the above general equation.

According to the investigations of Mr. L. E. JEWELL, the focal lengths of the quartz lens for different wave-lengths were:

λ	Focal Length.
	in.
2500	69.731
3000	70.826
3500	71.259
4000	71.614
4500	71.881
5000	72.034
5500	72.165
6000	72.277
6500	72.361

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*KAYSER, Handbuch der Spectroscopie, Bd. 1, s. 419.

†KAYSER, Handbuch der Spectroscopie, Bd. 1, s. 429.

With these quantities and the values of φ' just found, it was possible to plot the curve on which the spectrum was brought to a focus. On doing this it was found impossible to procure glass plates which would bend to such a curvature, and it was therefore thought advisable to use films. Through the kindness of the M. A. SEED Dry Plate Company, heavy films were coated with their gilt edge and orthochromatic emulsions. The films used were 1¼ by 12 inches.

Unfortunately, there was not sufficient time for Mr. JEWELL to test the action of this arrangement at the Observatory before leaving for Sumatra.

After setting up the instrument at Sawah Loento, and attempting to adjust and focus with the assistance of Mr. JEWELL, it was found that the spectrum was not brought to a focus in the manner expected, the focusing being accomplished with the help of a collimator designed by Mr. JEWELL, which gave parallel rays of light, but from a slit source.

It was found that the dust lines caused by the slit, and the image of the slit caused by reflection from the grating, were brought to a focus 58 inches from the grating, but not so the spectrum. When the grating was made normal to the diffracted light, i. e., grating and photographic plate parallel, which gives a normal spectrum, and the spectrum of the first order from λ3000 to λ6000 was examined, it was found to be in focus from 3 to 7 inches too far from the grating, depending on the color of the light, the violet being brought to the shorter focus. When the incident light was normal to the grating, and the first order on the other side examined, the spectrum was focused from 2 to 5 inches too near the grating.

It was found impossible to use the spectrograph as arranged, owing to the spectrum being so much inclined, and it became necessary to make an extension to the box to enable us to place the lens between the grating and the photographic plate. In this arrangement no difficulty was experienced in bringing the spectrum to a focus. Used in the latter manner, parallel rays of light are incident on the grating, and as parallel rays are diffracted. This is the manner in which the plane grating is usually employed. To my knowledge attention has not been called to the singularities in focus brought in by using a convergent pencil of light.*

The coelostat was one of those built for the 1874 transit of Venus, and similar to the smaller ones used by the other members of the party. Its clock movement was reconstructed for this eclipse, but even with this improvement many difficulties were experienced, and it seemed practically impossible to secure perfectly uniform motion of the mirror.

A few days before the eclipse the instrument was finally focused visually by Mr. JEWELL by means of the collimator already referred to.

During the eclipse eight plates, or rather films, were exposed, one before and one just after totality for the cusp spectrum, one at first and one at second flash, and four during the total phase with exposures of 12^s, 120^s, 90^s, and 45^s, respectively.

Description of plates.—The first plate was taken 10 seconds before the computed time of second contact, and was exposed for ½ second. It shows the cusp spectrum and about 60 lines between H_β and H_ε.

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*Since returning from Sumatra my attention has been directed to an excellent article by A. CORNU on A Study of Diffraction Gratings.—Focal Anomalies, Astronomy and Astro-Physics, Vol. XIII, pp. 207–215, where

As noted before, clouds thickened at an inopportune time, with the result that nothing appears on the plate exposed for the first flash.

The four plates exposed during totality show faint continuous spectra of a width equal to the diameter of the Sun, and extending from about $\lambda 4900$ to $\lambda 3400$; also bright lines of hydrogen from H_β to H_η and the helium line $\lambda 4471.6$, undoubtedly due to the upper chromosphere.

The negative taken at second flash seems fully exposed in spite of the clouds.

An exposure was made as soon after totality as possible, probably 5 seconds after third contact, for the cusp spectrum. An exposure of ½ second was given, the plate closely resembling that made before second contact.

For some reason the spectra were not all of them in perfect focus. As absorption lines suffer from this defect more than bright lines, it was found practically impossible to measure the cusp spectra. For wave-lengths we are therefore confined to one plate, or rather film, that of the second flash. This was exposed for 3 seconds, the exposure being stopped at the first sign of the reappearing Sun.

The second flash.—The peculiarities of this photograph of the flash are, first, normal spectrum, and second, great dispersion.

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he investigates the focal anomalies brought in through unequal ruling. Although he did not touch on the question of convergent light, its action can be readily found from the formula given there.

According to CORNU'S equations, if the lines of the grating are equally spaced, and the radius of curvature is infinite, or the grating is plane, the equation in polar coordinates of the curve on which the spectrum is brought to a focus is

$$\frac{\cos^2 \varphi}{r} + \frac{\cos^2 \varphi'}{r'} = 0,$$

or

$$r' = -r \frac{\cos^2 \varphi'}{\cos^2 \varphi},$$

where r and r' are the distances of the source and spectrum from the grating, and φ and φ' the angles they make, respectively, with the grating normal. It may be well to call attention to the fact that the above equation is independent of the grating space and of the size of the grating.

The above equation can be directly deduced from the theory of the concave grating, published by the writer in the Astrophysical Journal, Vol. VIII, p. 102, by making in the equation of the focal curve the radius of curvature of the grating equal to infinity.

As the source is virtual, the value of r is negative, and is found, for the different wave-lengths, by subtracting 14 inches from each of the focal lengths as given above.

(1) If in the equation of the focal curve we put $r = \infty$, then $r' = \infty$, the usual method of using the plane grating.

(2) If the incident light is normal to the grating, $\varphi = 0$, and φ' can be found from the ordinary equation of the plane grating,

$$\sin \varphi + \sin \varphi' = \frac{n\lambda}{\omega}.$$

If r is not equal to infinity, and we put, successively, values for r, φ, and φ' in the equation of the focal curve, we find the corresponding values of r', or the distances from the grating at which the spectrum is brought to a focus. We find these distances to be, for

in.
$\lambda 3000$, $r' = 55.04$
$\lambda 4500$, $r' = 53.70$
$\lambda 6000$, $r' = 50.95$

(3) If the diffracted light is perpendicular to the grating, we get the normal spectrum. If $\varphi' = 0$ for $\lambda 4500$, by inserting values of r, φ, and φ' in the equation, as before, we find, for

in.
$\lambda 3000$, $r' = 60.66$
$\lambda 4500$, $r' = 62.17$
$\lambda 6000$, $r' = 62.21$

These values represent very closely the action of the grating noticed at the Sumatra eclipse.

On the plate the distance from H_β to H_ε is 95.4 millimeters, and as the spectrum is normal, 1 millimeter therefore corresponds to a difference of wave-length of 9.37 tenth-meters, or 1 tenth-meter corresponds roughly to a dispersion of 0.1 millimeter. This is about equal to the dispersion of the new BRUCE three-prism spectrograph of the Yerkes Observatory, and slightly greater than the dispersions of the MILLS and POTSDAM spectrographs, the three most powerful instruments used in stellar work; or it is about one-fifth of the dispersion obtained with the ordinary ROWLAND mounting with a grating of 20,000 lines and radius of 21½ feet.

The plate was measured on one of the REPSOLD machines belonging to the Columbia University Observatory, by comparing the position of the spectrum lines directly with a millimeter scale. Measurements with this instrument can be made directly to 0.005 of a millimeter, and by estimation to 0.0005 of a millimeter, i. e., to 0.005λ; the sharpness of the lines, however, did not permit the measurements being carried to this degree of accuracy.

Although the spectrum was not in the most perfect focus, in view of the great dispersion, measurements could be made with a high degree of accuracy. The values thus obtained were transformed into wave-lengths by multiplying by a constant. Wave-lengths were determined by taking well-defined standards properly distributed whose wave-lengths were taken from ROWLAND'S Preliminary Table of Solar Spectrum Wave-lengths, and as wave-lengths were found so readily from the measures, practically every well-identified line became a standard, the flash spectrum as a whole being thus most closely adjusted with the solar spectrum. Three independent measurements of the film were made.

Comparisons with the solar spectrum.—Those who have attempted to identify the bright lines with the lines in ROWLAND'S map know the difficulties of this undertaking, which depends on the differences of dispersion between the flash and solar spectra and the differences of the intensities of the lines. Great care was exercised in the determination of the wave-lengths and in the comparisons with ROWLAND'S tables. In the flash an arbitrary scale of intensities was first taken where 10 indicates the strongest lines, 0 the faintest lines seen without difficulty, and 00 lines seen with difficulty.

Subsequent to the publication of a preliminary report in the Astrophysical Journal, Volume XV, page 97, the Sawah Loento spectrum negatives were sent to Mr. L. E. JEWELL, who made an entirely independent determination of wave-lengths, intensities, etc. Shortly afterwards, realizing that the scale 0 to 10 did not give enough latitude, and in order to be more in accord with other eclipse observers, the intensities of the flash lines were reestimated by the writer. The intensities 0 and 00 have the same meaning as before, but H_β and H_γ are called 75 instead of 10. Both estimates of intensity are given, the smaller scale being called "*Preliminary Flash Intensity.*"

A careful comparison of Mr. JEWELL'S results with those of the writer shows a remarkably close agreement. Where differences were found, the spectrum negatives were reexamined. The wave-lengths, intensities, lengths of the chromospheric arcs, and the identification with ROWLAND are practically a mean of the separate determinations of Mr. JEWELL and the writer.

In addition, a close study of the flash lines was made to determine their important characteristics, which are shown in an excellent drawing by Mr. Jewell, Plate LXXII.

It is interesting to note that the magnesium line 4481 appears in the flash spectrum. As far as I know, it has never before been detected in eclipse photographs. This line was measured by the writer, but was not published in the preliminary report just mentioned. When Mr. Jewell examined the photographs the line was independently seen by him; in fact, he called the writer's attention to its character. Both observers agree in determining its wave-length, intensity, and length of chromospheric arc. This line is stronger in the flash than in the ordinary solar spectrum, and, in the opinion of a great many authorities, this would mean a higher temperature for the Sun's layer causing the flash than for that which gives rise to the ordinary Fraunhofer lines. The appearance of 4481 in arc and spark spectra has probably been discussed more than that of any other line of the whole spectrum, but as yet remarkably little is known of the reasons for its behavior. In contrast to the general idea of higher temperatures for the spark,[*] C. C. Schenck, in the Astrophysical Journal, Volume XIV, pages 116–135, and Johns Hopkins Circulars, Volume XIX, No. 146, page 63, finds that the spark line of magnesium at 4481 disappears when the electrodes become glowing and begin to melt. When we understand our laboratory experiments with the spectroscope better, we may then be able to draw safe conclusions regarding the phenomena taking place at the distance of the Sun.

Table I contains the results of the comparisons. The spectrum extends from λ4924 to λ3320, but the focus becomes poor at the violet end beyond *K*, and measures were discontinued at λ3835, H_η.

Table I.

Flash Intensity.	Length of Arc.	Wave-length.	Rowland.	Origin.	Solar Intensity.	Preliminary Flash Intensity.
	°					
H_η 15	65	3835.2		H_η		8
3 d	40	3839.9	3838.435 3840.580	Mg—C Fe—C	25 8	2 d
4	40	3859.9	3860.055	Fe—C	20	2
2 d		3878.4	3878.152 3878.720	Fe—C Fe	8 7 N d?	2 d
H_ζ 20	70	3889.0		H_ζ		8
2	30	3894.2	3894.165 (3894.211) 3894.241	Cr Co	3 8 d 5	0
2	30	3895.8	3895.803	Fe	7	0
6	50	3900.5	3900.681*	Ti	5	2
∞	10	3902.3	3902.399	V	3	∞
0	30	3904.2	3903.991 (3904.023) 3904.052	 Fe	2 8 d 5	0
1	30	3906.6	3906.628	Fe	10	0
∞	30?	3907.6	3907.615	Fe—Sc	3 d?	∞
7	50	3913.3	3913.609	Ti—	5 d?	2 d?

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[*] Kayser, Handbuch der Spectroscopie, Bd. 11, s. 171–181.

TABLE I—Continued.

Flash Intensity.	Length of Arc.	Wave-length.	ROWLAND.	Origin.	Solar Intensity.	Preliminary Flash Intensity.
	°					
2	30	3916.1	3915.951 3916.545	Cr— V?	5 d? 3	0
00	30?	3917.5	3917.324	Fe	5	00
00	10?	3918.6	3918.464 3918.563 3918.789	Fe Fe Fe	4 4 5	00 Group
3	30?	3920.3	3920.410	Fe	10	00
2	30?	3923.0	3923.054	Fe	12 d?	00
2	30?	3928.3	3928.075 3928.357	Fe —, Mn	8 2 N d?	0
K 75	95	3933.8	3933.825	Ca	1000	10
5	30	3944.6	3944.160	Al	15	1
00	5	3947.1	3947.142	Fe	3	00
0	10	3948.3	3948.246	Fe	5	00
2	20	3948.9	3948.818 3948.925	Ti, V Fe	4 4	0
00	?	3951.9	3952.103	Mn, V	2	00
0	20	3953.1	3953.043 3953.120	 Co	3 3	0
00?	0?	3954.0	3954.002	Fe	3	00?
00	?	3957.1	3957.177	Fe—Ca	7 d?	00
5 Triple	35	3961.3	3960.422 3961.281 3961.674	Fe Fe Al	4 3 20	0 Triple
60 25	95	3969.0	3968.625 3970.177	Ca Hε	700	10
00?	0?	3977.9	3977.891	Fe	6	00?
3 Triple	25	3982.5	3981.917 3982.630 3982.742	Ti Ti Y	4 2 3	1 Triple
0 d?	10	3989.0	3989.137 3989.232	Mn Ti	3 2	0 d?
1	20	3991.0	3991.333	Cr, Zr	3	0
1	10	3995.5 Group	6 lines		3 and greater	1
1	10	3998.3				1
1 d	15	4004.9	4003.912 4005.408	Ce—Fe—Ti Fe	3 7	1 d
3	30	4006.0	4005.856	Fe—V?	3	1
00 d?	10	4009.1	4009.079	Ti	3	00 d?
2	25	4012.4	4012.541	Ti, Ce	4	1
1	20	4018.1	4018.234 4018.269	Mn Mn	3 4	00
0	15	4021.9	4022.018	Ti—Fe—V	5 d?	1
10	50	4026.0	4026.342 *	He		4
0	20	4028.4	4028.497	Ti—Ce	4	0
3	25	4030.8	4030.878 (4030.918) 4030.947	Mn	10 d?	1
00	10	4032.0	4031.942	Fe?, Nd, Mn, V	2	0
2	25	4033.3	4033.224	Mn	8 d?	1
2	20	4034.6	4034.644	Mn	6 d	1
00	10	4035.7	4035.883	Mn	4 d?	0
0	15	4041.4	4041.431 4041.525	Fe Mn	3 5	
1 d?	20	4044.6	4044.766	Fe	3	
8	35	4045.9	4045.975	Fe	30	2
00	20	4047.8 †				0
00	10	4048.9	4048.910	Mn—Cr	5	00
0 d?	10	4049.7	4049.716		1 N d?	0 d?
00	5	4052.0 Group	10 lines		2 and greater	0
		4055.7				0
00	10	4058.3	4058.372	Co—Fe	4	00
6	35	4063.5	4063.759	Fe	20	2
2	15	4066.6	4066.524 4066.742	Co Fe	2 2	1

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* RUNGE and PASCHEN'S value.

† This line is due to the "more volatile gases in atmospheric air," λ4047. See LIVEING and DEWAR, Proceedings of the Royal Society of London, Vol. LXVII, p. 467.

Table I—Continued.

Flash Intensity.	Length of Arc.	Wave-length.	Rowland.	Origin.	Solar Intensity.	Preliminary Flash Intensity.
	°					
00 ?	2	4069.3	4069.221		2	0
4	30	4072.0	4071.908	Fe	15	2
		4077.7	4077.885	Sr	8	6
00	?	4083.1 4087.2 Group	7 lines		2 and greater	00 00
00	30	4095.1	4095.094	Ca ?	4	00
Hδ 25	75	4102.0	4102.000	Hδ		10
0	20	4107.7	4107.649	Fe	5	0
0 Triple	20	4109.5	4108.687 4109.215 4109.905 4109.953	 Fe V Fe	2 3 2 3	0 Triple
1	10	4118.7	4118.708 4118.934	Fe Co	5 4	0
0	40	4120.6		He		00
0	20	4121.4	4121.477	Co	6 d ?	0
1	20	4123.2	4123.384	La	1	0
00	10	4127.7 4134.8 Group	16 lines		2 and greater	0 0
0 d	15	4137.3	4137.156 4137.567	Fe	6 2	1 d
00 d	5	4140.3	4140.089 4140.558	Fe —, Fe ?	6 3	0 d
00	5	4142.0	4142.025	Fe	4	0
2	25	4143.5	4143.572 4143.664	Fe	4 2	
4 d ?	40	4144.0	4143.919* 4144 038	p He Fe	 15	2 d?
0	2	4146.3	4146.225	Fe	3	0
00	2	4147.9	4147.836	Fe	4	00
1 d	15	4149.3	4149.360	C, Zr	2	1 d
2	30	4149.9				0
00 ?	2	4151.2	4151 129	Ti	1	00 ?
00	5	4152.3	4152.343	Fe	3	00
1	10	4154.1	4154.071	Fe	4	1
1	20	4156.2				1
0	10	4156.4				0
1	20	4157.7	4157.948	Fe	5	0
1	15	4161.7	4161.682	Ti, Sr	4	0
2	25	4163.8	4163.818	Cr—Ti, —	4	1
0 0	4 4	4167.0 4167.9	4167.438	Y, Fe ?	8	0 0
		4168.7	4168.784		2	0
00	5	4171.6	4171.213 4171.854 4172.066	Ti C, Fe ? Ti, Fe	4 2 2	0
2	25	4172.4				1
2	25	4173.6	4173.624 4173.710	 Ti	3 3	1
0	1.5	4175.3	4175.082	Fe	4	0
00	1.5	4175.8	4175.806	Fe	5	0
0	15	4176.5	4176.739	Fe—Mn	5	0
2	25	4177.3 4179.1 Group	4177.698 4177.772 4178.223 4179.025	Fe Fe Fe	3 3 2 3	1 1
00 d ?	15	4180.3 †				0 d ?
00	4	4181.8	4181.919	Fe	5	0
0	4	4184.4	4184.472	Ti	2	0
00	2	4186.2	4186.280	Ti	1	00
2	20	4187.2	4187.204	Fe	6	0
0	20	4187.9	4187.943 4188.019	Fe	5 3	0
00 ?	2	4188.9	4188.894		4	0
1 d	10	4191.7	4191.595 4191.843	Fe Fe	6 3	0 d
0	20	4193.0 ‡				0

* Runge and Paschen's value. † Argon line at λ4180.38, xenon line at λ4181. ‡ Xenon line at λ4193.

Table I—Continued.

Flash Intensity.	Length of Arc. °	Wave-length.	Rowland.	Origin.	Solar Intensity.	Preliminary Flash Intensity.
00 ?	2	4194.0				0
0	4	4195.3	4195.492	Fe	5	0
0	20	4198.6	3 lines	—, Fe, Fe	4, 4, 3	1
1	20	4199.2	4199.267	Zr—Fe	5	1
00 Triple	20	4200.8 *	4200.761 4200.946 4201.089	 Ti Fe	1 1 3	00 Triple
1	20	4202.2	4202.198	Fe	8	1
00	2	4204.0	4204.101	Fe	3	00
00	5	4204.9	4204.884	Y	1	00
0	20	4205.2	4205.186	Eu ?	1	0
00	1	4206.1				00
00	2	4206.8	4206.862	Fe	3	0
00 ?	1	4207.7				00
00	1	4208.6	4208.766	Fe	3	0
0	8	4209.1	4209.144	Zr	1	0
00 ?	1	4209.9	4209.985	V ?	1	0
0	3	4210.5	4210.494 4210.561	Fe	4 3	0
00 ?	1	4211.2	4211.127		3 N	0
00	2	4212.0	4212.048	Zr ?	2	00
00 ?	1	4212.8	4212.801	Cr ?	3 N	00
00 ?	1	4213.7	4213.812	Fe	3	00
15	50	4215.7	4215.703	Sr	5 d ?	8
0 d ?	2	4217.8	4217.720	La, Fe—Cr	5 d ?	0 d ?
00	5	4219.5	4219.516 4219.580	Fe	4 3	00
0 d ?	5	4220.3	4220.509	Fe	3	0 d ?
1	25	4222.7 †				0 d ?
00	15	4223.4 ‡				0
00	2	4224.5	4224.337 4224.673	Fe Cr—Fe	4 3	0
2	25	4225.6	4225.619	Fe	3	0 d ?
g 8	35	4226.9	4226.904	Ca	20 d ?	3
00	1	4230.0	4229.926	Fe, Se ?	2	00
00	2	4231.1	4231.183	Ni	4 N	0
0	25	4231.7				
4	30	4233.2	4233.328	Fe	4	3
0	15	4235.4	4235.298 4235.450	Mn Mn	2 3	0
2	25	4235.8	4236.112	Fe	8	2
00	2	4237.2	4237.339	Fe	3	00
1	3	4238.0	4238.188	Se, Fe	3	1
1 d	3	4239.9	4239.890 4240.014	Fe, Mn Fe	3 3	1 d
00?	25	4242.3	4242.535	Cr	2	
0 d?	5	4243.1	4242.897 4243.608	Fe Fe	2 3	1 d?
10	40	4247.0	4246.996	Sc?	5	4
0 d	2	4248.7				1 d
2	20	4250.3	4250.287	Fe	8	2
1	20	4251.1	4250.945	Fe	8	2
		4253.1				1
5	30	4254.4	4254.505	Cr	8	3
0 d	2	4255.9	4255.993	Fe	2 N	0 d
00	2	4256.7				0
1	15	4258.4	4258.477	Fe	2	1
0 d?	20	4259.5 §				0 d?
2	25	4260.6	4260.640	Fe	10	2
00	5	4262.2				0
1 d	2	4263.9	4263.290 4264.370	Ti, Cr Fe	2 3	1 d
00 d?	15	4266.8 ‖				0 d?
0 d	15	4267.8	4267.985	Fe	3	0 d
0	7	4269.8	4269.898		2	1

* Argon line at λ4200.8.

† Possibly coronal line.

‡ Xenon line at λ4223.

§ Argon line at λ4259.491; neon line at λ4259.53.

‖ Argon line at λ4266.425; blue argon spectrum at λ4266.684.

TABLE I—Continued.

Flash Intensity.	Length of Arc.	Wave-length.	ROWLAND.	Origin.	Solar Intensity.	Preliminary Flash Intensity.
	°					
1	25	4271.3	4271.325	Fe	6	1
3	35	4271.9	4271.934	Fe	15	3
		4272.5	4272.701	Ti—	1	
1 d?	5	4273.5	4273.482 4273.643	Fe? Zr?	3 N 2 N	1 d?
1	25	4274.3	4274.348		2 N	1
5	35	4274.9	4274.958	Cr	7 d?	3
0 d	2	4277.0	4276.836 4277.147	—Zr V—	2 1 N	1 d
00?	5	4278.3	4278.390	Fe—Ti	3	00
00 d?	5	4279.8	4279.874		2 N d?	0
0	5	4281.2	4281.257	Mn	2	0
1	20	4282.1	4282.127		2 N	1
1	20	4282.6	4282.565	Fe	5	1
00	10	4286.1	4286.168	Ti—	2	1
00	10	4287.8	4288.038	Ti	2	1
00	2	4288.5				0
4	20	4289.9	4289.885	Cr	5	2
4	35	4290.2	4290.377	Ti	2	
1	3	4291.1	4291.114	Ti	3	1
0	3	4292.1				1
1 d?	25	4293.3	4293.192 4293.273		2 3	1 d?
4	35	4294.2	4294.204 4294.301	Ti Fe	2 5	2
0	5	4295.3	4295.383	Sc?	3 N d?	0
00	10	4296.0	4295.914	Cr, Ti	2	0
1	15	4296.7	4296.735	Fe	3	2
0	10	4298.9	4298.828	Ti	2	0
2 d	30	4299.6	4299.410 4299.803	Ti, Fe Fe, Ti	4 2	2 d
5	40	4300.4	4300.211 4300.732	Ti Ti	3 2	3
0	2	4301.3 Group				0
2	30	4302.4 Group	8 lines		2 and greater	2 d
2	30	4303.5 Group				1 d
00	2	4304.1	4304.098		4	0
00	2	4304.6	4304.729	Fe?	2	1
2	25	4305.9	4306.078	Ti	4	2
2	25	4306.9				2
G 5	40	4307.9	4307.907 4308.081	Ca Fe	3 6	3
2 d	15	4309.4	4309.541	Fe	3	2 d
1 d	20	4312.3	4312.247 4312.462		2 2	2 d
3	30	4312.9	4313.034	Ti	3	3
3	30	4314.2	4314.248	Sc	3	3
3	30	4315.2	4315.138 4315.262	Ti Fe	3 4	3
0	5	4317.2				0
1	15	4318.9	4318.817	Ti, Ca	4	1
5	35	4320.9	4320.907	Sc	3	3
1	5	4323.9	4324.007		3	1
3	25	4325.0	4325.152	Sc	4	3
3	25	4326.0	4325.939	Fe	8	3
0	2	4327.2	4327.274	Fe	3	0
00	1	4328.4				00
00	1	4329.7				0
1	15	4330.9	4330.866	Ti, Ni	2	2
0	1	4331.8	4331.811	Ni	2	0
0	2	4332.6				1
1	45	4334.2*				2
00	1	4335.1				0
00	1	4336.1				0
2 d?	15	4337.3	4337.216 4337.725	Fe Cr	5 3	2 d?
H_γ 35	75	4340.6	4340.634	H	20 N	10

* Ghost of H_γ.

TABLE I—Continued.

Flash Intensity.	Length of Arc.	Wave-length.	ROWLAND.	Origin.	Solar Intensity.	Preliminary Flash Intensity.
	o					
o	12	4343. 9	4343. 861	Fe	2	o
2 d ?	35	4344. 5*	4344. 451 4344. 670	Ti— Cr	2 4	2 d ?
oo	2	4347. o	4346. 987	Cr	1	oo
oo d ?	20	4347. 6	4347. 403 4347. 705	Fe	1 1 N	o d ?
2	10	4351. 3	4351. 216	Cr	3	3
3	30	4352. o	4351. 711 4351. 930	Fe Cr	2 5	4
o	10	4353. 1	4352. 908	Fe	4	2
o	10	4354. 4				2
o	2	4355. 2				2
2	20	4358. 7	4358. 670	Fe	2	2
1	20	4359. 8	4359. 784	Cr	3	2
1	5	4360. 6	4360. 644	Ti	1	1
o	35	4362. 8†				
o d?	3	4363. 2	4363. 267	Cr	1 N	1 d
o	2	4363. 9				1
o	2	4364. 7				o
1	10	4367. 9	4367. 749 4367. 839	Fe Ti	5 2	2 d
oo	2	4369. 3				1
1	10	4369. 9	4369. 941	Fe	4	2
oo	5	4371. 1				1
o	10	4371. 5	4371. 442	Cr	o	
5 d	25	4374. 7	4374. 628	Sc, Fe ?	3	2
2	30	4375. 3	4375. 103	V, Mn	2	2
1	25	4376. 2	4376. 107	Fe	6	2
o	2	4377. 3	4377. 388		2 N	1
o	3	4378. 4	4378. 419		2 N d ?	o
o	30	4378. 8†				
o	7	4379. 4	4379. 396	V	4	2
o	2	4381. 2	4381. 274	Cr	o	o
5	40	4383. 7	4383. 720	Fe	15	4
o	3	4384. 6	4384. 873	V	3	2
1	20	4385. 5	4385. 548	Fe	2	2
1	7	4387. o	4387. 007	Ti	1	1
1	35	4387. 9				
o	1	4388. 5	4388. 571	Fe	3	1
oo	1	4389. 4	4389. 413	Fe—	2	o
oo	1	4390. 1	4390. 149	V	2	o
1	8	4391. o	4391. 123 4391. 192	Fe Ti	2 1	1
1	8	4391. 9	4391. 924	Cr	1	1
2	30	4394. 1	4394. 225	Ti ?	2	
10	45	4395. 3	4395. 201 4395. 413	Ti V, Zr	3 2	5
o	10	4397. 9‡				1
2	25	4399. 8	4399. 935	Ti	3	2
2	25	4400. 6	4400. 555	Sc	3	2
o	3	4401. 5	3 lines	Fe, Fe, Ni	2, 1, 2	o
4	30	4404. 8	4404. 927	Fe	10	3
o	3	4407. 9	4407. 810 4407. 871	V Fe	2 4	1
1	3	4408. 8	4408. 364 4408. 582 4408. 683	V Fe V	2 3 2	2
1 d ?	5	4411. o	4411. 240	Ti, Cr	1	2 d ?
o	3	4412. o	4412. 092	Fe ?	1	1
2 d	20	4415. 3	4415. 293	Fe	8	3 d ?
3	25	4415. 6	4415. 722	Sc	3	
3	25	4417. 2				3
3	30	4418. o	4417. 884	Ti—	3	3
o	15	4422. 1§	4422. 104	Ti	1	o
1	7	4422. 9	4422. 741	Fe, Y	3	2

*Ghost of H_γ.

†May be a coronal line.

‡ Due to the "more volatile gases in atmospheric air," λ4398.

§ Due to the "more volatile gases in atmospheric air," λ4422.

TABLE I—Continued.

Flash Intensity.	Length of Arc.	Wave-length.	ROWLAND.	Origin.	Solar Intensity.	Preliminary Flash Intensity.
	°					
1 d ?	7	4424.6				1 d ?
0 d	15	4425.7	4425.608	Ca	4	0 d
3	25	4427.7	4427.482	Fe	5	3
1	7	4430.3 *				1
1	7	4430.7	4430.785	Fe	3	1
2 d	25	4435.4	4435.129 4435.851	Ca Ca	5 4	2 d
00	8	4436.5	4436.516	Mn	2	0
00	2	4438.0				0
1	2	4441.7	4441.881	V—	3 N d ?	1
0	2	4442.7	4442.510	Fe	6	1
10	45	4444.0	4443.976	Ti	5	5
00	2	4445.8	4445.641	Fe	1	0
0 d ?	5	4447.5	4447.302 4447.892	Mn, Fe Fe	2 6	1 d ?
00	5	4448.3				0
1 d ?	15	4449.6	4449.313	Ti	2	1 d ?
3	35	4450.6	4450.654	Ti ?	2	3
1	15	4452.0	4451.752	Mn	3	1
0 d ?	3	4453.4	4453.486	Ti	2	1 d ?
0	3	4454.2	4454.552	Fe	3	1
3	30	4455.0	4454.953	Ca	5	3
00	6	4456.0	4455.980	Mn	2	00
0	5	4457.8	4457.600 4457.712	Ti Mn	2 2	0 d
1	15	4459.1	4459.199	Ni	2	1
0	3	4460.4	4460.462	Mn	1	0
2	20	4461.8	4461.818	Fe	4	2
00	2	4463.3				0
2	20	4464.7	4464.617 4464.844	Ti ? Mn	2 2	2
1	20	4466.7	4466.727	Fe	5	1
7	40	4468.7	4468.663	Ti—	5	3
25	70	4471.6	4471.646 †	He		8
0 d ?	3	4473.3				0
1	10	4476.3	4476.185	Fe	4	1
0	3	4479.8				1
00	20	4481.4	4481.298 4481.438	Mg Ti	0 1	
0	15	4482.3	4482.338 4482.438	Fe— Fe	5 3	0
1	15	4483.0	4482.904	Ti—Fe	1	1
0	3	4484.4	4484.392	Fe	4	0
0	2	4486.2				0
1	15	4489.3	4489.351	Fe	2	1
0	1	4490.2	4490.253	Mn—Fe	3 N	0
1	15	4491.7	4491.570 4491.823	Fe Cr, Mn	2 0	1 Wide
1	8	4494.7	4494.738	Fe, Zr ?	6	1
1	15	4497.0	4497.023	Cr	3	1
0	3	4499.1	4499.066	Mn	1	0
8	45	4501.4	4501.445	Ti, —	5	3
3	20	4508.5	4508.455	Fe ? —	4	3
2	20	4515.6	4515.508	Fe	3	2
0	6	4517.7	4517.702	Fe	3	1
1	8	4518.2	4518.198	Ti	3	1
2	20	4520.3	4520.397	Fe	3	2
3	25	4522.9	4522.802 4522.974	Fe Ti	3 2	3
0	1	4525.0	4525.314	Fe	5	0
1	5	4527.5	4527.490	Y, Ti	3	1
1	5	4529.2	4528.798 4529.656	Fe Ti	8 1	1
1	5	4531.4	4531.327	Fe	5	1
10	50	4534.1	4534.139	Ti	6	5

* Blue argon spectrum at λ4430.355; the "more volatile gases in atmospheric air," λ4431.

† RUNGE and PASCHEN'S value.

TABLE I—Continued.

Flash Intensity.	Length of Arc.	Wave-length.	ROWLAND.	Origin.	Solar Intensity.	Preliminary Flash Intensity.
	°					
1 d	5	4535.9	4535.741 4536.094 4536.222	Ti Ti Ti	3 2 2	1 d
0	3	4539.7*	4539.946	Cr	0 N	0
1 Wide	10	4541.8	4541.690	Cr	2	1 Wide
0	5	4544.9	4544.864	Ti	3	0
00	2	4546.1	4546.129	Cr	3	0
15	40	4549.9	4549.808	Ti	6 d?	5
14	35	4554.2	4554.211	Ba	8	5
2	20	4556.2	4556.306	Fe—Cr	4	2
2	25	4558.8	4558.827	Cr	3	2
0	2	4560.6				1
12	35	4563.8	4563.939	Ti	4	5
0	3	4566.0	4565.842	Co—Fe	2	0
14	50	4572.2	4572.156	Ti—	6	6
0	2	4575.0	4574.899	Fe	2	0
1	5	4576.6	4576.512	Fe	2	1
00	10	4580.2	4580.228	Cr	3	00
10	30	4584.0	4584.018	Fe—	4	4
1	4	4586.4	4586.408 4586.552	Cr V	1 1	1
1	30	4588.2	4588.381	Cr	3	1
2	25	4590.1	4590.126	Ti	3	2
1	3	4592.7	4592.707 4592.840	Ni Fe	2 4	1
00	3	4593.8				0
00	1	4594.3	4594.297	Mn, V	2 N—	0
00	2	4595.7				0
00	2	4596.2	4596.245	Fe	2	0
00	2	4598.3	4598.303	Fe	3	0
0	3	4600.2	4600.018 4600.279 4600.541	Fe ? Cr Ni	2 1 2	2
0	4	4601.0	4600.932	Cr	3	2
0	3	4602.1	4602.183	Fe	3	1
0	3	4603.1	4603.126	Fe	6	1
0	2	4607.7	4607.831	Fe	4	1
0 d?	3	4611.3	4611.368 4611.469	Cr Fe	0 5	1 d?
0	4	4613.5	4613.386 4613.544	Fe Cr	3 3	2 d
0	4	4615.8				1
1	5	4616.4	4616.305	Cr	4	1
0	7	4619.1	4618.971	Fe, Cr	4 d?	2
0	7	4619.9	4619.711	Cr	1	0
1	5	4620.6	4620.693	Fe	1	1
0	3	4622.0	4622.065 4622.128	Cr Cr	0 1	1
0	3	4622.7	4622.627	Cr	1	1
0	3	4623.4	4623.279	Ti	2	1
0	2	4625.2	4625.227	Fe	5	1
0	2	4626.4	4626.358	Cr	5	2
0	4	4627.7				1
7	25	4629.5	4629.521	Ti, Co, Fe	6	3
0	10	4630.2	4630.306	Fe	4	0
2	25	4634.2	4634.254	Cr	2	2
00	2	4636.2				0
0	2	4637.7	4637.685	Fe	5	2
1 d	4	4639.8	3 lines	Ti, Ti, Ti	2, 2, 1	2 d
1	15	4646.3	4646.347	Cr	5	2
0	1	4647.7	4647.617	Fe	4	1
0	5	4648.9	4648.835	Ni	4	1
1 d	15	4651.9	4651.461 4652.343	Cr Cr	4 5	2 d
1 d	5	4654.7	4654.672 4654.800	Fe Fe	4 5	2 d
1	8	4656.5	4656.644	Ti	3	1

*Due to the "more volatile gases in atmospheric air," $\lambda 4540$.

TABLE I—Continued.

Flash Intensity.	Length of Arc.	Wave-length.	ROWLAND.	Origin.	Solar Intensity.	Preliminary Flash Intensity.
	o					
2	12	4657.3	4657.380	Ti	2	2
0	3	4662.4				1
0	3	4663.8				1
2	10	4667.4	4667.626 4667.768	Fe Ti	4 3	2
1	10	4670.3	4670.590	Sc	2	2
00	3	4678.4	4678.347	Cd	3 N	0
00	3	4678.9	4679.027	Fe	6	
0 d ?	3	4680.4				1 d ?
1	3	4682.6	4682.529	Co, Y	1	2
1	40	4685.3 *	4685.452	Ca	2 N	2
00	20 ?	4691.6	4691.602	Fe	5	0
00	4	4698.6	3 lines	Cr, Cr, Ti	1, 1, 1	0
00	2	4700.3	4700.337		4	0
0	3	4701.3	4701.231	Fe ?	1	0
0	10 ?	4702.9 Group	4703.177 4703.994 4705.131	Mg Ni Fe	10 3 4	1
0	3	4704.8				1
0	7	4704.4 Group	6 lines		2 and greater	1
0	7	4710.0				1
10	50	4713.3	4713.252†	He		3
1	3	4714.7	4714.599	Ni	6	1
1 Wide	3	4727.9	4727.582 4727.676 4728.732	Fe Mn Fe	3 2 4	1 Wide
2	5	4731.6	4731.651	Fe ?	4	2
00	2	4733.6	4733.779	Fe	4	00
2	4	4737.0	4736.963	Fe	6	2
1 d	4	4740.9				1 d
00	2	4746.0	4745.992	Fe	4	00
0	2	4748.8				0
0	4	4761.8 Group	5 lines	4 Mn, 1 Ti	3 and greater	1
0	4	4766.6				1
0 d ?	3	4768.5	4768.519 4768.595	Fe	3 2	1 d ?
0	4	4771.4	4771.664		3	1
0	4	4773.0	4773.007	Fe	4	1
00	3 ?	4776.7				00
2	40	4780.2	4780.169	Co, Ti ?	2	2
2	6	4783.7	3783.613	Mn	6	2
2	6	4786.8	4786.727 4787.003	Ni Fe	3 2	2
2	4	4789.5	4789.528	Cr	2	2
00	3	4792.6	4792.702	Ti—Cr	2	1
3	15	4805.4	4805.285	Ti	3	2
00	3	4810.9	4810.724	Zn	3	00
6	15	4824.0	4823.697 4824.325	Mn Fe, Cr	5 3	2
00	3	4829.3	4829.214	Ni	3	
		4836.1	4836.059	Fe	2	
00	2	4840.4	4 lines		3, 2, 3, 3	1 Wide
		4843.8‡				00
1	6	4848.4	4848.438	Cr	2	1
2	50	4855.6§				2
Hβ 40	75	4861.5	4861.527	H	30	10
2	50	4867.7§				2
2	15	4871.2	4870.996 4871.512	Ni, Cr Fe	3 5	2
1	15 ?	4890.7	4890.948	Fe	6	1
1	15 ?	4891.6	4891.683	Fe	8	1
2	15	4899.7	4900.095	Ti	2	2
0 Wide	4	4903.4	4903.502	Fe	5	0 Wide
0 Wide	5	4910.4	4 lines	4 Fe	2, 3, 2, 2	0 Wide
1	4	4918.2	4918.190	Fe	1	1
1	10	4920.2	4920.685	Fe	10	1
9	25	4924.1	4924.107	Fe	5	3
4	25	4934.2	4934.250	Ba	7	
2	20 ?	4957.8	4957.480 4957.785	Fe Fe	5 8	

* May be a coronal line. † RUNGE and PASCHEN'S value. ‡ Xenon line at λ4844. § Ghost of Hβ.

In comparing wave-lengths of the flash spectrum with those of the solar spectrum, it is necessary to bear in mind two points:

First, we are dealing with a dispersion of about one-fifth of ROWLAND'S, with a focus not so exact, and therefore it will be impossible to separate in the flash the counterparts of close dark solar lines; second, the emission and absorption lines are formed at different heights above the Sun's surface, and as the emission lines are at the greater heights, they will, as a result, be shifted small amounts, which in this particular flash are toward the violet.

TABLE II gives a summary of the results contained in TABLE I before the examination of the negative by Mr. Jewell and the writer spoken of on page D 277. As the focus is best between $H\beta$ and $H\varepsilon$, for the present purpose this region only will be considered. Neglecting hydrogen and helium lines, and those lines identified with groups, 374 lines were measured in the flash between $H\beta$ and $H\varepsilon$. Ninety-one of these were unidentified, and 283 identified with lines in the solar spectrum. The results are arranged according to their intensities. It will be noticed that the intensities given are those of the smaller scale where 10 represents the strongest line in the flash. The conclusions are practically the same as if the other and larger scale had been used.

TABLE II.—*Lines in the Flash between $H\beta$ and $H\varepsilon$.*

[Scale 0–10.]

Element.	00	0	1	2	3	4	5	6	7	8	10	Total.	Average Intensity.
Fe	11	39	37	28	8	2	...	...	...	...	...	125	1.00
Ti	2	7	22	15	10	...	5	1	...	...	...	62	1.84
Cr	3	9	10	12	3	1	...	...	...	...	...	38	1.24
Mn	4	9	9	4	1	...	...	...	...	...	...	27	0.74
V	...	5	4	5	...	...	1	...	...	...	...	15	1.27
Zr	1	3	3	...	1	...	1	...	...	...	...	9	1.22
Ni	...	1	6	2	...	...	...	...	...	...	...	9	1.11
Ca	...	1	1	3	3	...	...	...	...	...	...	8	2.00
Sc	...	...	...	2	3	1	...	...	...	...	...	6	2.83
Co	2	2	1	1	...	...	...	...	...	...	...	6	0.50
Y	...	...	1	1	...	...	...	...	...	...	...	2	1.50
La	...	2	...	1	...	...	...	...	...	...	...	3	0.67
Sr	...	...	...	...	...	...	...	1	...	1	...	2	7.00
Ba	...	...	...	...	...	...	1	...	...	...	...	1	5.00
Mg	...	...	1	...	...	...	...	...	...	...	...	1	1.00
Zn	1	...	...	...	...	...	...	...	...	...	...	1	0.00
Ce	1	...	1	...	...	...	...	...	...	...	...	2	0.50
—	4	16	17	8	1	...	...	...	...	...	...	46	0.78
Unidentified	3	37	39	11	1	...	...	...	...	...	...	91	0.70
Total	32	131	152	93	31	4	8	2	0	1	0	454	

In the column *Element*, — means that flash lines were identified with those lines whose chemical origins are unassigned in ROWLAND'S tables.

The total, 454, includes 80 lines identified with more than one element either in ROWLAND'S tables or in the comparisons between flash and solar spectra.

Two points are immediately noticed in comparing the two spectra:

First, for each element the brighter the solar line the brighter the flash line in general corresponding to it; second, the intensities of the solar lines which correspond to a line of given brightness in the flash differ with different metals. Iron and nickel lines of intensity 5, titanium, scandium, and vanadium lines of intensity 2 are identified with flash lines of equal strength. These differences for the various elements were so marked that in order to arrive at their significance, and hence draw some conclusions regarding the reversing layer, detailed comparisons were made between the flash and the solar spectra.

The 363 solar lines identified with lines in the flash are arranged according to their solar intensities in Table III, while in Table IV are given all the lines in ROWLAND'S tables having an intensity of 2 or greater, arranged similarly. There are 874 such lines, 41 of the 915 being identified with more than one element, 657 of them having an intensity less than 4.

TABLE III.—*Solar Lines with which Flash Lines were Identified.*

[Scale 1–1000.]

Element.	0	1	2	3	4	5	6	7	8	10	12	15	20	30	Total.	Average Intensity.
Fe	...	3	11	28	33	22	12	2	6	2	0	4	1	1	125	4.92
Ti	...	11	23	13	8	3	4	...	...	...	...	...	...	...	62	2.69
Cr	4	8	3	13	3	4	1	1	1	...	...	...	...	...	38	2.27
Mn	...	3	9	5	5	3	2	...	...	...	...	...	...	...	27	3.08
V	...	5	8	1	1	...	...	...	...	...	...	...	...	...	15	1.87
Zr	...	1	5	1	...	2	...	...	...	...	...	...	...	...	9	2.67
Ni	...	...	4	2	2	...	1	...	...	...	...	...	...	...	9	3.11
Ca	...	...	1	1	3	2	...	...	...	...	...	...	1	...	8	5.88
Sc	...	...	...	4	1	1	...	...	...	...	...	...	...	...	6	3.50
Co	...	...	2	1	2	1	...	...	...	...	...	...	...	...	6	2.67
Y	...	...	...	2	...	...	...	...	...	...	...	...	...	...	2	3.00
La	...	...	...	1	...	1	...	...	...	...	1	...	...	...	3	6.67
Sr	...	...	...	...	...	1	...	...	1		...	...	...	...	2	6.50
Ba	...	...	...	...	...	...	...	...	1	...	...	...	...	...	1	8.00
Mg	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	10.00
Zn	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	3.00
Ce	...	...	...	1	...	1	...	...	...	...	...	...	...	...	2	4.00
—	...	3	21	17	4	...	...	...	1	...	...	...	...	...	46	2.44
Total	4	34	87	91	62	41	20	3	10	3	1	4	2	1	363	

TABLE IV.—*Lines in Rowland's Table between F and H.*

[Scale 1–1000.]

Element.	2	3	4	5	6	7	8	10	12	15	20	30	Total.
Fe	135	108	75	40	15	2	7	3	0	4	1	1	391
Ti	42	24	15	3	4	...	...	...	...	...	...	...	88
Cr	22	19	6	5	1	1	1	...	...	...	...	...	55
Mn	24	14	8	6	3	1	...	...	...	...	...	...	56
V	12	7	2	...	1	...	...	...	...	...	...	...	22
Zr	9	2	...	2	...	...	...	...	...	...	...	...	13
Ni	18	10	3	...	1	...	...	...	...	...	...	...	32
Ca	4	5	9	2	...	...	...	...	...	...	1	...	21
Sc	1	5	1	1	...	...	...	...	...	...	...	...	8
Co	9	4	5	2	1	...	...	...	...	...	...	...	21
Y	...	2	1	...	...	...	...	...	...	...	...	...	3
La	4	1	1	1	...	...	...	...	1	...	...	...	8
Sr	...	1	...	1	...	...	1	...	...	...	...	...	3
Ba	1	...	...	...	...	...	1	...	...	...	...	...	2
Zn	...	2	...	...	...	...	...	...	...	...	...	...	2
Nd	4	1	...	...	...	...	...	...	...	...	...	...	5
Si	...	...	...	1	...	...	...	...	...	...	...	...	1
C	4	...	...	...	...	...	...	...	...	...	...	...	4
Mg	...	...	...	2	...	...	...	1	...	...	...	...	3
Ag	...	1	...	...	...	...	...	...	...	...	...	...	1
Cd	...	1	...	...	...	...	...	...	...	...	...	...	1
Ce	3	2	...	1	...	...	...	...	...	...	...	...	6
—	120	36	9	1	1	1	1	...	...	...	...	...	169
Total	412	245	135	68	27	5	11	4	1	4	2	1	915

Although we can not directly compare the intensities of the bright lines of the flash, scale 0 to 10, with those of the dark lines given in ROWLAND'S tables, scale 1 to 1000, we arrive at certain theoretical considerations if we compare the ratios of the average intensities of the different elements, i. e.,

$$\frac{\text{Flash Intensities}}{\text{Solar Intensities}},$$

and also the ratio of the number of lines of each element identified to the whole number of solar lines for that metal. Forming these ratios, and arranging them, we are at once struck with the systematic variations not only in the ratio of intensities but also in the per cent of lines identified.

The meaning of these systematic differences will be understood if we consider these ratios in combination with the atomic weights of the various elements, as is done in TABLE V, where also are put down the number of lines of the flash due to each metal.

TABLE V.

Element.	Atomic Weight.	Number of Lines.	$\frac{\text{Flash Intensity}}{\text{Solar Intensity}}$	$\frac{\text{Lines Identified}}{\text{Total No. of Lines}}$
Group I. Lines strong in the flash and in the solar spectrum.				
Na	23.0			
Mg	24.3	1	0.10	1.00
Al	27.1			
Ca	40.0	8	0.34	0.38
Group II. Lines strong in the flash and weak in the solar spectrum.				
Sc	44.1	6	0.81	0.75
Ti	48.1	62	0.68	0.70
V	51.2	15	0.68	0.67
Cr	52.1	38	0.55	0.69
Mn	55.1	27	0.24	0.48
Sr	87.6	2	1.08	0.67
Y	88.7	2	0.50	0.67
Zr	90.6	9	0.46	0.70
Group III. Lines weak in the flash and strong in the solar spectrum.				
Fe	56.0	125	0.20	0.32
Ni	58.7	9	0.36	0.28
Co	59.0	6	0.19	0.29

Looking at the numbers in the last two columns we see that the lines naturally fall into three groups, as given in the above table. In addition to these are lines due to lanthanum, barium, and possibly to silicon, zinc, cerium, and the newly discovered gases of the atmosphere—argon, neon, krypton, and xenon.

In Group I would also fall aluminium, if we consider the relative intensities of the two lines $\lambda 3944.160$ and $\lambda 3961.674$; and undoubtedly sodium, if our plate took in the *D* lines.

In Group II should be included *H* and *He*.

The grouping of these lines is exactly that adopted by EVERSHED from his investigations of the Indian eclipse, except that I have put zirconium with strontium and vanadium in Group II. Manganese seems to represent the transition from Group II to Group III.

Sir WILLIAM and Lady HUGGINS* called attention to the great heights to which calcium extends in the Sun's atmosphere, and it is on account of this great extent that *H* and *K* are such prominent lines not only in the absorption spectrum but in the emission spectrum. As EVERSHED† has pointed out, the remarkable variations of the relative intensities in the flash and FRAUNHOFER spectra are undoubtedly

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* The Relative Behavior of the *H* and *K* Lines of the Spectrum of Calcium, Astrophysical Journal, Vol. VI, p. 77.

† Wave-length Determinations and General Results Obtained from a Detailed Examination of Spectra Photographed at the Solar Eclipse of January 22, 1898, Philosophical Transactions of the Royal Society of London, Series A, vol. 197, pp. 381-413.

due to the heights to which the vapors of the different metals ascend in the chromosphere. We would naturally expect that these heights would vary according to the atomic weights of the metals, those of least atomic weight ascending to the greatest distance; and generally speaking this no doubt is true. But if we have two gases in the chromosphere, one a gas with an intrinsic brightness 1 and a layer 100 miles in thickness, it would give a photographic line in the flash spectrum just as bright as the other gas of intrinsic brightness 100 and only 1 mile thick, if the Sun and Moon were relatively at rest during the period of the flash; but considering the gradual advance of the Moon in covering successive layers of the Sun's atmosphere, we see that in the emission spectrum the photographic brightness of the fainter gas would be many times that of the brighter. The absorption caused by the gas depends on the total number of molecules the solar ray comes in contact with, and the photograph will show lines of very nearly equal intensity in the two cases.

In view of these considerations, it would therefore seem that the gases of the metals of Group II extend very high, that they are nowhere very much condensed, and that practically all the gas contributes to the formation of the emission line, and hence the flash lines are to be regarded as true reversals of the corresponding solar lines.

The vapors of Groups I and III are somewhat condensed near the Sun's surface. Those of Group I, particularly calcium, reach far greater heights than those of Group III, but as it is the upper portions that contribute most to the formation of the emission lines, owing to the progressive motion of the Moon, the flash lines are to be regarded as only partial reversals of the FRAUNHOFER lines, the solar intensities being greater than the flash intensities.

Unknown lines.—Taking account of the lines in the flash identified with groups in the solar spectrum, about half the lines in TABLE IV have corresponding lines in the flash. From the above considerations we see that it is highly improbable that lines of intensity 2 in the solar spectrum and belonging to Groups I and III will have flash lines corresponding to them of sufficient brightness to show in this flash. In fact, by reference to TABLES III and IV we see that, although there are 135 iron lines of intensity 2 in ROWLAND'S table, only 11 of these are found in the flash, and, indeed, great numbers of the feebler solar lines are lacking in the flash. But if, on the other hand, we compare the stronger lines we see that every strong line of the solar spectrum almost without exception is found in the flash spectrum. And so, remembering the meaning of the differences of intensities, we see no reason for giving up our faith in the existence of the reversing layer.

We may obtain an approximate estimate of the depths of the layers producing the bright arcs by measuring the angular extent of the arcs. Accordingly, the lengths of some of the more conspicuous bright lines have been measured, and thence were deduced the elevations of the luminous layers producing the bright lines of the flash spectrum. In the calculation, the semidiameter of the Sun was taken as 948″.4 and the Moon's augmented semidiameter 1013″.8. For the purposes of comparison, the same arcs were taken that FROST has measured.* The depths of the luminous layers of the various metallic vapors come out as follows:

Spectrum Line.	H 3970	He 4026	Sr 4078	H_δ 4102	Sr 4215	Ca 4226	Sc 4247	Fe (Pair) 4250	Cr 4254
Approximate height of layer	″ 8	″ 4	″ 4	″ 7	″ 4	″ 2.5	″ 2.5	″ <0.5	″ 2.5

Spectrum Line.	Cr 4274	Sc 4321	H_γ 4340	Ti 4395	He 4471	Ti 4501	Ti 4549	Ba 4554	H_β 4861
Approximate height of layer	″ 2	″ 2	″ 8	″ 2	″ 7	″ 2	″ 2	″ 2.5	″ 8

Comparing these heights with the intensities given in my scale 0 to 10, it is seen that roughly speaking the height in seconds of arc is 0.8 of the value of the intensity for Group II and 0.4 for Groups I and III. The arcs of the great majority of the lines are no longer than the iron pair at λ4250, which correspond to an extent of 0″.5.

As a result we may safely infer that the average depth of the reversing layer is about 1″, although from the above considerations we see that the heights to which the gases extend and their condensations are different for the different elements.

These results differ materially from those of Sir NORMAN LOCKYER, given in his Recent and Coming Eclipses, page 111. The numbers of lines photographed at the eclipses of 1893 and 1896 are there given by him as 164 and 464, respectively. As there are 5,694 lines in the same region in ROWLAND'S table, he decides that only 3 and 8 per cent, respectively, of the solar lines are reversed in the flash at these two eclipses. But as Professor FROST has pointed out,† the instruments employed were capable of photographing only a small fraction of the 5,694 lines of ROWLAND'S.

NEW GASES IN THE SUN.

The interdependence of the sciences is nowhere better illustrated than in spectroscopic work, when astronomy, the most ancient of all the sciences, goes hand in hand with physics to find a new chemical element. In recent years, through spectroscopic researches, several metals have been added to the list of elements. In April, 1895, from investigations on a specimen of cleveite, RAMSAY discovered terrestrial helium, which gives a line in its spectrum agreeing with the D_3 line, familiar for more than twenty-five years in stellar, prominence, and chromospheric spectra. About the same time RAYLEIGH and RAMSAY announced the discovery of another new element, which was called argon. In the early summer of 1898 RAMSAY found two more gaseous elements, neon and krypton, and subsequently a heavier gas to which the name xenon was applied. These five new elements are found in atmospheric air and can be obtained from air by fractional distillation by

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*Astrophysical Journal, Vol. XII, p. 321.

† Astrophysical Journal, Vol. XII, p. 346.

making use of the extremely low temperatures of liquid air and liquid hydrogen. Atomic weights have been assigned as follows:[*] Helium, 4; neon, 20; argon, 40; krypton, 82; and xenon, 128, and the gases seem to form a series in the periodic table of elements between the fluorine and sodium groups.

The lines of helium are such prominent ones in the chromospheric spectrum that it would be interesting to see if the other new gases are also present in the chromosphere, and accordingly comparisons have been made between the spectra of the flash and of the new elements whose wave-lengths have lately been published.

Comparisons of the intensities of the lines and of the numbers of the lines due to the different elements in the flash and in the solar spectrum, as given by ROWLAND, led to the division of the elements into three groups, TABLE V, those giving (1) lines strong in the flash and in the solar spectrum; (2) lines strong in the flash and weak in the solar spectrum; and (3) lines weak in the flash but strong in the solar spectrum.

To the second group belong hydrogen, helium, scandium, titanium, vanadium, chromium, manganese, strontium, yttrium, and zirconium. It has been shown that helium, in consequence of its small density, ascends to great heights above the Sun's surface, and as its layer is covered up gradually by the Moon at the time of an eclipse the resulting exposure is many times that given to denser but shallower layers, and consequently helium lines in the flash spectrum are very prominent. Taking into account the increasing atomic weights of the series of new gases and also the behavior of the light and heavy vapors in the Sun's atmosphere, as found out by investigations of the flash, we should expect, as in the case of helium, none of these gases to be found in the ordinary solar spectrum. We should also expect lines of the more volatile gases of the Earth's atmosphere, neon and argon, of atomic weights 20 and 40, respectively, to be present in the flash; while those of the less volatile gases, krypton and xenon, of atomic weights 82 and 128, respectively, are most probably not to be found there.

No lines of these gases appear in the ordinary solar spectrum; but, if we make a detailed comparison of their spectra with that of the flash, there seem to be certain lines of the latter that are probably due to these newly discovered gases of the atmosphere.

The most volatile of these were obtained[†] from their solution in liquid air by fractional distillation at low pressure, in this way removing the greater portion of the helium and neon from this mixture of gases, leaving the argon behind. Many attempts were made to separate the helium from the neon, which were not successful until these gases were subjected to the temperature of liquid hydrogen, when neon was liquified and perhaps solidified, while the helium remained gaseous.

The more volatile gases of atmospheric air uncondensed at this temperature have been examined spectroscopically by LIVEING and DEWAR, and wave-lengths have been published.[‡] In this spectrum appear lines due to neon, to helium, and to free hydrogen in the Earth's atmosphere. Recently more accurate wave-lengths have

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[*] RAMSAY and TRAVERS, Proceedings of the Royal Society of London, Vol. LXVII, p. 329.

[†] RAMSAY and TRAVERS, Proceedings of the Royal Society of London, Vol. LXVII, p. 329.

[‡] Proceedings of the Royal Society of London, Vol. LXVII, p. 467.

been determined by Mr. E. C. C. BALY,* using a concave grating. Nearly all of the strongest lines of neon in the region photographed in the flash spectrum coincide with lines in the flash already identified with other metals. The strongest neon line in this region is λ4259.53, which coincides in position with the flash line at λ4259.5 and the argon line at λ4259.49. Long chromospheric arcs, which correspond to lines given by LIVEING and DEWAR, are found at λ4047, λ4398, λ4422, λ4431, λ4540, and λ4844.

Several tables of wave-lengths of argon have been published. KAYSER † using a large concave grating gives results to thousandths of a tenth-meter. Most of the strong lines of argon are found in the flash spectrum—but again as weak lines only. Argon lines appear at λ4180.3, λ4200.8, λ4259.5, λ4266.8, and λ4430.3.

The most accurate wave-lengths of krypton are those of RUNGE, measured with a concave grating and given ‡ to thousandths of a tenth-meter. The strongest lines are in a part of the spectrum not covered by the flash photographs, and there seem to be no krypton lines in the flash.

The only wave-lengths of xenon are those of LIVEING and DEWAR,§ given only to the nearest tenth-meter. Some of the strongest of the xenon lines do not appear in the flash, while the wave-lengths of some less strong seem to agree with those of flash lines; but, as the wave-lengths are not accurate enough, it is impossible to say more than that the presence of xenon in the Sun's atmosphere is doubtful.

Consequently, it seems probable that the more volatile gases of atmospheric air uncondensed at the temperature of liquid hydrogen, together with hydrogen, helium, neon, and argon, are present in the chromosphere, while the evidence in regard to krypton and xenon is inconclusive. But it must not be forgotten that these lines are so few in number and of such small intensity that it is impossible to say with certainty that these metals are in the Sun. It is remarkable, however, that most of the lines supposed to be due to these rare metals were measured as long arcs, showing a great height.

The finding of these gases in the Sun and the undoubted presence of free hydrogen in the Earth's atmosphere have an importance in cosmical physics that can hardly be overestimated. According to LIVEING and DEWAR, "if the Earth can not retain hydrogen or originate it, then there must be a continued accession of hydrogen to the atmosphere (from interplanetary space) and we can hardly resist the conclusion that a similar transfer of other gases also must take place." || As has been shown by these distinguished physicists, and again by DEWAR in his presidential address before the British Association for the Advancement of Science, 1902, these new gases, and particularly the more volatile gases of atmospheric air, play an important part in the spectra of the aurora, of nebulæ, and of the corona. "Of more than a hundred auroral rays observed by STASSANO, more than two-thirds appear to

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* Philosophical Transactions of the Royal Society of London, Series A, vol. 202, p. 183.

† Astrophysical Journal, Vol. IV, p. 1.

‡ Astrophysical Journal, Vol. X, p. 73.

§ Proceedings of the Royal Society of London, Vol. LXVIII, p. 389.

|| Proceedings of the Royal Society of London, Vol. LXVII, p. 468.

belong to the more volatile gases of atmospheric air, while the majority of the remainder seem to belong to argon, krypton, and xenon." We are also told by Dewar that in the Astrophysical Journal* for June last is a list of 339 lines in the spectrum of the corona,† photographed by Humphreys, during totality, with a very large concave grating. Of these, no fewer than 209 do not differ from lines we have measured in the more volatile gases of the atmosphere, or in krypton or xenon, by more than one unit of wave-length on the Ångström scale, a quantity within the limit of probable error. It seems rather to the present writer that the great majority of these lines more closely correspond to Fraunhofer lines than to the lines of these rare gases.

These gases may take their origin from the Earth itself; in fact, helium and neon are obtained from the waters of the Bath Spring in England. The presence of free hydrogen in the atmosphere can not be explained in this way. It is more likely that hydrogen comes to us in small ionized particles from the Sun, being sent hither, as has been shown by Arrhenius,‡ by the pressure of light, and likewise helium and the more volatile gases are present in the atmosphere through being repulsed from the Sun by the ionization of small particles of these gases.

It seems, therefore, that the finding of these new gases in the Sun's chromosphere is an independent verification of the truth of the theory of Arrhenius, which states that particles of matter are being continually scattered throughout the universe, starting from one sun and reaching another, with the result that all bodies of the universe are gradually becoming more and more alike.

THE 104-INCH CAMERA.

Mr. René Granger, in charge.

This instrument, which was provided with a visually corrected lens of 104 inches focal length and 6 inches aperture, was operated in a horizontal position and fed by a modified transit-of-Venus coelostat. The shipping memorandum gave the focal length of the lens as 96 inches by mistake, which occasioned some trouble in the lengthening of the tube thus made necessary.

The operation of the coelostat proved to be very unsatisfactory.

This instrument was set up, adjusted, and focused by Doctor Mitchell. The selection of photographic plates and the times of exposure were made by Mr. L. E. Jewell.

The lens was stopped down to 4.5 inches during the eclipse, in order to reduce the effect of the secondary spectrum, and to make the image as sharp as possible. Fifteen seconds were allowed between exposures, with the exception of the last, for

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* Astrophysical Journal, Vol. XV, p. 313.

† This, however, was the spectrum of the chromosphere, not of the corona.—S. A. M.

‡ Lehrbuch der kosmieschen Physik, s. 150. Physikalische Zeitschrift, November, 1900; see also Cox, Popular Science Monthly, January, 1902.

changing plates, and the first exposure was made when Doctor MITCHELL called "Go!" The following is a table of exposures, together with the time and duration of same:

No.	Length of Exposure.	Local Mean Time.					
		From—			To—		
	s	h	m	s	h	m	s
1	½	12	20	52	12	20	52.5
2	20	12	21	7	12	21	27
3	180	12	21	42	12	24	42
4	50	12	24	57	12	25	47
5	10	12	26	2	12	26	12
6	½	12	26	17	12	26	17.5

REPORT ON THE PHOTOGRAPHIC PLATES.

By Photographer G. H. PETERS.

On the photographs obtained with the 104-inch camera the effect of the thin clouds veiling the corona is in evidence from the reduced extent of the coronal streamers. The plates used were 8 by 10 inch CRAMER isochromatic slow, and on account of their sensitiveness to the yellow rays they would tend to mitigate to some extent the absorption of the light at the blue end of the spectrum by the obscured atmosphere.

Negative No. 1, exposed for one-half second at the beginning of totality, shows four strong prominences on the eastern limb, three being above the equator and one just south of it. South of this latter are two fainter ones. The small amount of contrast between the dark body of the Moon and the corona on this negative precludes any exact measurements of the position angles of these objects, while the comparatively small scale of the Moon's image, 1 inch in diameter, would render them of less value than those derived from the measurement of the negatives obtained with the larger instrument at Fort de Kock.

The outline of the Moon is invisible on this negative in some parts of its circumference on the western side, while the corona is brightest in the northeast quadrant, but the image is too faint to bring out any detail.

Negative No. 2, exposed for 20 seconds, shows the corona fairly well. The photographic image is rather dense, and exhibits the best coronal detail in the outer parts. The focus and the following is good and the detail stands out sharply. The coronal extension is about as great as that found on Negative No. 3, taken with the 40-foot camera at the Fort de Kock station, on a SEED 23 plate, with an exposure of 2 seconds. The working rapidity for an object with a surface like the corona, with the same variety of photographic plates, atmospheric conditions being equal, is in the ratio of 1 for the 40-foot camera to 2.64 for this instrument. According to Mr. JEWELL the relative speeds for the three kinds of plates—SEED 27 gilt edge, SEED 23, and CRAMER isochromatic slow—are 1, 1/3, 1/7.5. This would make the ratio of the working rapidities of these two instruments approximately the reciprocal of the rates of the speeds of the plates used with each respectively. A comparison, therefore, of Negative No. 2 at Sawah Loento with Negative No. 3 at Fort de Kock would show that the atmospheric absorption of the photographic rays was about ten times as great at Sawah Loento during this exposure as in the clear air of Fort de Kock.

The coronal disturbance near the equator and the series of coronal arches at position angle 113° on the eastern side are well shown on this negative, but on the western side no detailed structure is discernible.

Negative No. 3, exposed for three minutes, shows the corona for about a lunar diameter from the limb in the equatorial parts, and for about half this extent for the polar rays. It exhibits about the same amount of detail as that obtained on Negative No. 5 with the 40-foot camera at Fort de Kock, with slightly less equatorial extension of the corona. Some part of the apparatus evidently moved during this long exposure, as a doubling of the Moon's limb is perceptible on the western side of the Moon's image, while beyond is another and fainter image. This would, of course, destroy the details to some extent. This negative shows a greater extension of the rays about the south pole than at the north, and also confirms the displacement of the south polar rays toward the east, as found on the Fort de Kock negatives.

Negative No. 5, exposed ten seconds, exhibits nearly as great an extension of the coronal rays as Negative No. 4, and shows more structural detail. Evidently the sky was clearing somewhat, allowing more light from the corona to fall upon the plate. A slight movement of the image is also noticed here, while in all directions it is more diffused than upon the former negatives. This diffusion, though small in quantity, is probably due to the uncorrected rays of the visual objective, in connection with the isochromatic plate used, the clearing of the sky allowing the more refrangible rays to penetrate the atmosphere. This lens was used at the eclipse of the Sun of May 28, 1900, with a color screen and isochromatic quick plates, and the definition was remarkably fine.

Negative No. 6, exposed one-half second, was taken just after third contact. The Sun has just reappeared at one point, and its position is obscured by a large patch of halation. On each side of this locality a thin layer of chromosphere is seen extending some distance in either direction, but with no detail. A small amount of corona is shown extending entirely around the body of the Moon. This plate was exposed as soon after Negative No. 5 as possible.

ADDITIONAL REPORT ON SPECTROGRAPHIC WORK.*

By Mr. L. E. Jewell.

In planning the spectroscopic work for the total solar eclipses of 1900 and 1901, much assistance was derived from the very beautiful spectrograms obtained by Dr. J. Evershed during the eclipse of 1898 in India. He very kindly sent me positive copies of his spectrograms, together with some of the results of his measurements, previous to their publication. As the region of the spectrum in which it seems particularly desirable to obtain results is the ultra-violet the spectrograms of Doctor Evershed, which are especially good in this section were of the greatest assistance in mapping out a program for the work to be attempted. The published results ot Sir Norman Lockyer were also freely consulted with much benefit. A careful study of the spectrograms of Evershed, and the published results of Lockyer, strongly confirmed and supplemented the conclusions which had been formed from a careful and detailed study of the appearance of the lines of the solar spectrum under varying conditions.

These conclusions, in brief, are that there are three principal classes of lines in the solar spectrum and presumably also in the chromospheric spectrum, but the latter as studied at the Sun's edge, or at the time of an eclipse, would probably not show lines due to *very* low-lying matter immediately above the Sun's surface. To the first class belong the lines due to low-lying vapors, all, or nearly all, of metallic origin, and the broad shadings of the *H* and *K* lines of calcium, and of certain lines of iron, magnesium, and aluminium. The material producing these lines lies very low in the solar chromosphere and in all probability much of it in the depressions in the photosphere. These lines and shadings are not visible upon Evershed's photographs. The second class of characteristic lines are of moderate strength in the solar spectrum, and are largely due to iron, calcium, titanium, chromium, and manganese. The material producing these lines extends to a considerably greater height in the chromosphere than the material producing the lines of the first class. The lines composing the bands of carbon or cyanogen and some other lines lie between these classes. In Evershed's photographs, lines of this character are conspicuous in the spectrum of the lower portions of the chromosphere over or near the continuous spectrum streaks, but are very weak or absent elsewhere.

The third class is represented by the lines of hydrogen and the *H* and *K* lines of calcium. Evershed's photographs confirm the opinion that a number of the lines of titanium in the ultra-violet portions of the spectrum belong to this class, and in addition show several lines of manganese and chromium in the ultra-violet portions of the spectrum. Some of the titanium lines referred to reach at least as great a

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*Note.—This discussion appears at the end of this Appendix, as it was received at the Observatory June 28, 1905, after the rest of the report was in type.

height in the chromosphere as the hydrogen lines. His plates show that the stronger lines of helium, strontium, and barium belong to this class, and that the central components of the shaded lines of iron and some other elements are between the second and third classes. The results of the eclipses of 1900 and 1901 show another class of lines in the upper portions of the chromosphere, and lines of much the same character in the lower portions of the corona.

A careful study of the data at hand shows the importance of confining the work with the spectrograph to a few well-chosen exposures and the serious error of wasting effort and precious time during an eclipse in an attempt to secure as large a number of photographs as possible without much regard to the necessities of the case. As a result of such conclusions it would be well to make an exposure just at the instant of totality, when the eastern edges of the Moon and Sun are in contact, and allow this exposure to last at least three seconds, but not more than four or five seconds, or until the advancing disk of the Moon covers about 400 or 500, but not more than 700 or 800, miles of the Sun's chromosphere. The object should be to secure the best possible photograph of the spectrum of the lowest portions of the chromosphere.

The second exposure should be made as soon afterwards as possible and should last from ten to fifteen seconds for photographs taken at a station upon the central line of the eclipse path, or if the duration of totality be especially long this exposure can be made somewhat longer. The object should be to secure as good a photograph as possible of the middle and upper regions of the chromosphere, such as will show the central components of the shaded lines of iron, magnesium, aluminium, etc., and the stronger and medium-strong spark lines of the elements. The helium and parhelium lines and the lines belonging to the inner portions of the corona should also show well in this exposure.

The third exposure should be as long as can be conveniently made and should be made especially for the spectrum of the corona and incidentally for the spectrum of the most elevated regions of the chromosphere and the prominences.

A fourth and fifth exposure should be made to obtain similar results to those in the case of the second and first exposures, but for the western side of the chromosphere. If the duration of totality be very short, the set of exposures during totality would be advantageously reduced to three.

It would also be well to make exposures just before the beginning and immediately after the end of totality, which will give the spectrum of the FRAUNHOFER crescents tipped with bright horns. These, besides showing other features of interest, are valuable in showing that the FRAUNHOFER crescents, or dark lines of the solar spectrum to which they are equivalent, are for the greater part produced at a lower elevation than the chromospheric lines seen at the time of totality. This is evident, for whether the crescents are on the western or eastern limb of the Sun, the bright tips or horns are arcs of circles of greater diameter than those of the FRAUNHOFER crescents. Such photographs are interesting, but should not be allowed to interfere with securing, as perfectly as possible, the exposures during totality. Such a program, carried out, would give the most generally useful results.

My experience at Experiment, Georgia, on May 28, 1900, shows that the so-called "flash spectrum" is by no means a suddenly appearing and suddenly disappearing phenomenon. The lines in question are produced by matter at varying heights, although the greater number of the stronger lines are produced within a layer less than 1,000 miles thick. Nearly all of the low-lying lines seen at the time of an eclipse are produced within a layer less than 500 miles thick. It does not follow, however, that the lower limits of this layer rest upon the solar surface, for in all probability the lower limits of the region of the chromosphere producing lines seen during totality are at least 200 or 300 miles and possibly 500 miles above the Sun's surface. This will explain the absence of the smaller metallic lines in the flash spectrum and the absence of any trace whatever of the shadings of *H* and *K*, which are without doubt produced by matter much closer to the Sun's surface than the lines of the flash spectrum.

The lower portions of the chromosphere also give a very considerable amount of continuous spectrum, while a small amount is probably furnished by matter at a height of 1,000 miles or more. The matter in prominences also furnishes a considerable amount of continuous spectrum. This is brought out in the spectrograms obtained during the eclipses of 1900 and 1901, and in the recently published photographs of EVERSHED, LOCKYER, and others. I also noticed it very clearly in my observations with the direct-vision spectroscope at Experiment, Georgia, in 1900, the FRAUNHOFER crescents giving place somewhat gradually to a streak of continuous spectrum which seemed to last for a plainly perceptible time of perhaps one or two seconds, and then disappear, giving place to a spectrum of short arcs representing low-lying matter. The change was not sudden, and many of the even fairly short arcs were seen before the continuous spectrum streak faded. These observations were made only a few miles from the northern edge of the eclipse path, but the continuous spectrum streak would not last so long at the central line. The appearance was seen imperfectly through clouds, however, at Solok, Sumatra, during the eclipse of 1901.

These conclusions are fully borne out by the spectrograms taken at Pinehurst, North Carolina, in 1900, and at Sawah Loento and Fort de Kock, Sumatra, in 1901, and agree with comparison spectrograms taken at the center of the Sun's disk and on the Sun's limb. Also there is a close agreement with the telescopic appearance of the Sun's surface. A careful study of the telescopic appearance of the Sun's surface shows the presence of very irregular bright ridges running over the surface, the more extensive and elevated portions showing as faculæ. Between these ridges are rather indefinite darker patches, generally faint and indefinite, sometimes small and distinct, like small, weak spots.

In all probability these ridges are the upper limits of the eruptions of matter which are continually taking place upon the Sun's surface. Where eruptions are more extensive and violent or reach greater elevations we have faculæ and prominences. Probably the reason why the tops of the erupted masses are so much brighter than the other portions of the Sun's surface is because of the absorptive action upon light of matter in the chromosphere. This matter is apparently scattered throughout the chromosphere, and probably the corona, in a fine state of division, and very likely is both the condensed products of eruptions and meteoric matter coming in from outer space. Where it settles in pockets or depressions we have the dark patches referred to, and these patches are largely the sources of the shadings of the *H* and *K* lines and other shaded lines in the solar spectrum. The darkening near the Sun's limb, however, shows that this matter forms a sort of dust-like envelope surrounding the Sun, the photospheric ridges reaching up above much of the denser portion and the faculæ above nearly all of it. Being subject to less absorption faculæ are much brighter than the rest of the Sun's disk. This absorption seems largely to be of a general character, but particularly strong in the ultra-violet portions of the spectrum, thus giving evidence that much of the darkening noticed is due to very fine dust-like particles. The absorption producing the lines of the solar spectrum is, however, from matter in a truly gaseous condition, but this is probably but a small part of all the matter present.

The somewhat indefinite dark patches before mentioned between the eruptive ridges may be considered as pockets filled with denser vapors under great pressure. They are probably the seats of the shadings of the stronger metallic lines and also the greater number of small solar lines which do not appear in the flash spectrum, and are very much weakened in the spectrum of the Sun's limb. Probably the Sun's true surface is just below these pockets and at least a few hundred miles below the upper limits of the photospheric ridges. It is only the upper portions of these ridges which we see at the Sun's limb, and as they form the visible boundary or limb of the Sun the pockets or depressions and the Sun's real surface are never visible to us at the Sun's edge. As a consequence, the spectrum of the lower portion of the Sun's chromosphere is not represented in the spectrum of the limb except as possibly derived to a small extent from reflected light.

The obliteration of the spectrum of the lower depths of the chromosphere is still more complete when the Sun's limb is covered by the Moon's disk at the time of a total solar eclipse, while the spectra of these lower depths are represented quite prominently in the spectra of the middle parts of the Sun's disk, since the interfering photospheric ridges are not in the way of our line of sight.

The continuous spectrum is probably due in part to incandescent matter scattered throughout the chromosphere, particularly the lower portions, and in part to reflection of the light from the Sun's surface by dust like or meteoric matter, the condensed products of eruptions or meteoric matter coming in from outer space.

Data Regarding Typical Lines in Total Solar Eclipse Spectrograms.

Origin.	Wave-length.	Length of Arc.	Height above Sun's Limb.
		°	
Calcium	3933.8	120±	15,000 miles.
	3706.2	60	4,000 miles.
	3737.0	60	4,000 miles.
	4226.9	37	1,500 miles.
	4455.1	30	1,000 miles.
	4456.0	3	150 miles or less.
	4456.8	1	100 miles or less.
Hydrogen	4340.6	9±	8,000 miles.
Strong spark lines in ultra-violet of titanium, chromium, and manganese.	. . . . .	75 to 90±	6,000 to 8,000 miles.

Data Regarding Typical Lines in Total Solar Eclipse Spectrograms—Continued.

Origin.	Wave-length.	Length of Arc. °	Height above Sun's Limb.
Helium	4471.7	85	7,500 miles.
	4713.3	50	3,000 miles or more.
Parhelium	4388.1	40	1,700 miles or more.
Lines of unknown origin.	4568.5	55+	3,500 miles or more.
	4685.5	40+	1,700 miles or more.
	4362.8	35+	1,400 miles or more.
	4253.4	20+	500 miles or more.
Magnesium	3838.4	70	5,000 miles.
	4481.3	30+	1,000 miles or probably considerably more.
Strontium	4215.7	55	3,500 miles.
	4305.6	10	200 miles.
Barium	4554.2	35	1,500 miles or more.
	4525.3	4	150 miles more or less.
Aluminium	3961.6	40	1,800 miles.
Ytterbium	3694.3	60±	4,000 miles more or less.
Scandium	4247.0	40	1,800 miles.
	4314.2	32	200 miles.
Titanium	4468.7	55	3,500 miles.
	3913.6	50	3,000 miles.
	4395.2	45	2,500 miles.
	4313.0	30	1,000 miles.
	4590.1	25	900 miles.
	4464.6	20	800 miles.
	4387.0	6	200 miles.
	4466.0	2	100 miles.
Chromium	4275.0	37	1,200 miles.
	4254.5	30	1,000 miles.
	4558.8	30±	1,000 miles.
	4588.4	30	1,000 miles.
	4280.2	2½	100 miles.
Iron	4584.0	30	1,000 miles.
	4233.3	30	1,000 miles.
	4260.8	25	800 miles.
	4508.5	22	600 miles.
	4520.4	22	600 miles.
	4482.4	10	200 miles.
Manganese	4030.9	25	800 miles or more.
	4451.8	2½	100 miles or more.
Yttrium	4375.1	30	1,000 miles.
	4398.2	10	200 miles.
Cadmium	4678.4	3±	150 miles or possibly more.
Zinc	4680.3	3±	150 miles or possibly more.
	4722.3	3±	150 miles or possibly more.
Cyanogen compound of carbon and nitrogen.	1st head of band at 3883.5.	18	700 miles.
Vanadium	4379.4	7	200 miles.
	4390.1	1	100 miles.

Nearly all of the lines in this table are given in the drawing of typical lines, Plate LXXII.

In the foregoing table I have given some data regarding the elevation in the chromosphere at which the different elements are in the proper condition to produce spectral lines or the elevation to which the matter giving the spectral lines reaches.

The first column gives the element to which the lines are due, the second column the wave-length of the lines, the third column the length of the arcs representing the lines in question at the beginning of totality, the fourth column gives the height of the matter in the chromosphere producing the lines. This height is reckoned from the edge of the Sun's visible limb or from the upper portions of the photospheric ridges. This is probably at least 200 or 300, and possibly as much as 500, miles above the Sun's true surface, or what may be called the Sun's surface if we consider the photospheric ridges as elevations above instead of the dark patches as depressions below the surface.

In the table I have tried to give a fair and conservative estimate derived from several plates. The Pinehurst plate in particular probably gives very reliable values for wave-lengths near 3900 to 4000 Ångström units. There are some substances for which I could get no really reliable values from the material at hand, nickel and cobalt being examples. The matter giving the middle portion of the strong, shaded lines of iron in the ultra-violet probably reaches a height of about 2,000 miles and sodium as represented by the *D* lines probably reaches to over 1,000 miles at least. Cobalt and nickel do not show their presence at any great elevation by any lines which I have observed.

The appearance of an arc representing a line gives a good indication of the character of the distribution of the matter producing the line in question. If the arc is limited to the vicinity of the contact point on the continuous spectrum streaks, then the material producing the line is present in a condition to give the line only very low in the chromosphere, and it is safe to conclude that it is only in the lower portions of the chromosphere that the material is at a sufficiently high temperature or present in sufficient amount to produce a line strong enough to be visible. If, however, the arc is considerably stronger over the continuous spectrum and gradually becomes weaker away from the streaks of continuous spectrum, then the material is distributed in such a manner as would be expected under gravitational forces or is distributed normally. Most lines have an appearance that would suggest a generally normal distribution with more or less local irregularities from various causes. If, however, that portion of the arc over or near the continuous spectrum streaks is weak or absent, then the distribution of matter producing the line is abnormal or present in larger quantities in the upper regions of the chromosphere than closer to the Sun's surface; or, what is more likely, the conditions in the lower portions of the chromosphere are not favorable for the production of these lines. It may be that the higher temperatures which probably exist near the surface are unfavorable for the development of the vibrations represented by the line in question, or that the greater concentration of matter or the greater pressure is unfavorable, or that the presence of larger amounts of other material acts unfavorably. It may be that certain lines are best developed by friction or meteoric impact, and the collisions of meteoric matter would be more violent at some elevation in the chromosphere where the meteoric matter coming in from outer space meets the outrush of eruptive matter with the greatest violence. This last seems the most probable reason for the abnormal appearance of certain lines, mainly the stronger spark lines of certain elements. However, in the light of spectrum work with gases at different pressures it seems likely that the pressure and density may have much influence with gases such as helium and hydrogen.

There are a number of abnormal lines of unknown origin and a few spark lines of metals which are somewhat abnormal. The most remarkable is the spark line of magnesium at wave-length of 4481. This line is faint and apparently escaped the notice of LOCKYER, but it is unquestionably present on HUFF'S Pinehurst plate and MITCHELL'S Sawah Loento plate and shows a very abnormal distribution. Of the gas lines the most abnormal are the parhelium lines, while the helium lines are somewhat so. The hydrogen lines are relatively stronger in the upper portions of the chromosphere than they should be from the probable distribution of hydrogen unless the lines are unfavorably affected by increased pressure; or, as is more than likely to be the case, meteoric matter falling rapidly through the upper portions of the chromosphere has a strong influence in bringing out the lines. The *H* and *K* calcium lines have an appearance indicating somewhat the conditions holding in the case of hydrogen.

Seemingly having an apparent bearing upon this matter is some work done a few years ago, during which it was shown that the middle component of the *H* and *K* calcium lines were not only produced by matter at a considerable elevation, but at a very low pressure and by matter falling through the chromosphere at a high rate of velocity. The matter producing the middle components of the *D* lines of sodium, iron, and magnesium showed a falling velocity of a few miles a second and a pressure of about one and one-fourth atmospheres, while the small lines of iron, sodium, and other substances showed an upward velocity of a few miles a second on the average, and a pressure of perhaps two or three atmospheres. The shadings of the shaded lines, particularly *H* and *K*, are produced by matter at a somewhat greater pressure and upward velocity and close to the Sun's surface.

The evidence from these several sources indicates that the smaller solar lines and particularly the shadings, such as those of *H* and *K*, are produced by matter in a state of eruption; that the lower-lying lines of the chromospheric spectrum or flash spectrum are produced in the same manner by material reaching a greater height while still in a condition to produce spectrum lines. The highest level lines of the chromosphere are produced by meteoric matter in the outer portion of the chromosphere and the great bulk of the strong lines of the chromosphere and most of the brightest ones, and particularly the stronger spark lines of the elements, are very likely produced by the impact and friction of the meteoric matter with the streams of matter due to eruptions. This would seemingly give a satisfactory explanation of the great relative intensity of the spark lines of metals which have very strong and easily produced spark lines.

The prominence of the shaded lines at rather high or moderate elevations, while not a trace of the shading itself shows, is probably due to the great ease with which these lines are produced either by the arc or spark with very little matter present.

Another very important thing which has been almost entirely lost sight of in discussion of this and other related subjects is the extremely small amount of matter which it would take to produce all of the observed phenomena. The matter giving most of the absorption lines of the solar spectrum if condensed to a thickness of about a centimeter would not represent a greater density for any given material than that representing the density of sodium, calcium, and some other elements in the arc flame of an ordinary electric arc light, when those materials are merely present as ordinary impurities in the electric-light carbons.

Remembering these facts it is absurd to think of the chromosphere as an atmosphere of the Sun made up of such elements as iron, calcium, titanium, etc., in a gaseous state. Such an atmosphere would not produce at all the sort of spectrum observed. The true state of affairs is probably an atmosphere of hydrogen, helium, and a few other permanent gases, perhaps of considerable density, immediately at the Sun's surface, but rapidly becoming less dense until it is not denser at a height of a few hundred or at most about 1,000 miles than the Earth's atmosphere at sea level. At a height of not over 100 or 200 miles it probably has a density only two or three times that of the Earth's atmosphere at sea level, while at a height of 10,000 miles the density of the chromosphere is quite small.

In this atmosphere there is more or less matter, not as a permanent gaseous constituent, but as a sort of temporary constituent, the product of eruptions and of meteoric matter coming in from outer space. A very small amount of this matter, by reason of friction or impact, or by reason of high temperature in the lower portions of the chromosphere, is rendered gaseous and gives rise to the absorption lines of the solar spectrum or the bright-line spectrum seen at times of a total solar eclipse. In this way we can account for the spectroscopic phenomena, and also the darkening of the solar disk near the Sun's limb and the strong absorption of ultra-violet light by the chromosphere.

The lines of the corona present many difficulties, and until we know more regarding them it does little good to discuss the matter. That much of the corona, if not almost all of it, is composed of dust-like or fine meteoric-like matter is shown by the dark lines in the spectrum of the outer portions of the corona. The inner portions, however, are partly due to matter giving bright lines. Some of these lines extend to a considerable distance in the corona, and of these some indicate matter having a fairly even distribution at different latitudes, while some other lines show a marked abnormality of distribution in latitude, being confined for the greater part to what are known as the sun-spot zones. Yet other coronal lines do not reach such great elevations, and indicate a distribution of matter and condition of things very similar to the magnesium spark line 4481, the parhelium lines, and the lines of unknown origin mentioned.

The green coronal line has a distribution very similar to a remarkably strong line in the extreme ultra-violet, while some other fairly strong high-level lines while similar to one another are quite unlike the green line in distribution. Some of these coronal lines, although difficult to see because of faintness, are well represented upon the plate taken at mid-totality by HUMPHREYS at Fort de Kock in Sumatra. His plate also shows a number of the inner coronal lines, as do those of HUFF and

MITCHELL, which have been mentioned. Upon the plate by HUMPHREYS coronal lines have been detected either with certainty or a great deal of probability at wave-lengths 3390, 3454, 3643, 3800, 3987, 4086 (?), 4232, 4361, 4567, 4587, 4685, and 5064 (?). The wave-lengths given are only roughly approximate.

The spectrum of the corona is one of the most important of the problems connected with a solar eclipse and one of those about which we know the least. Even the character of the lines themselves is open to doubt. They are very likely single and form some sort of series, or two or three series more likely. However, they may possibly be compound, and it is important to determine this with certainty, but as this can only be done with a spectrograph having a slit the problem is one of some difficulty.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS PHOTOGRAPHED WITH THE 40-FOOT CAMERA AT BARNESVILLE, GA. NEGATIVE 1, 2 SECONDS EXPOSURE. ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS PHOTOGRAPHED WITH THE 40-FOOT CAMERA, AT BARNESVILLE, GA. NEGATIVE 3, 35 SECONDS EXPOSURE. SIX-TENTHS ORIGINAL SIZE.

THE MERIDEN GRAVURE CO.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS PHOTOGRAPHED WITH THE 104-INCH CAMERA AT BARNESVILLE, GA. NEGATIVE 3, 5 SECONDS EXPOSURE. TWICE ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS PHOTOGRAPHED WITH THE 104-INCH CAMERA, AT BARNESVILLE, GA, NEGATIVE 4, 20 SECONDS EXPOSURE.
TWICE ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS PHOTOGRAPHED WITH THE 9½-INCH CAMERA, DALLMEYER 3c, AT BARNESVILLE, GA. NEGATIVE 3, 5 SECONDS EXPOSURE. THREE TIMES ORIGINAL SIZE.

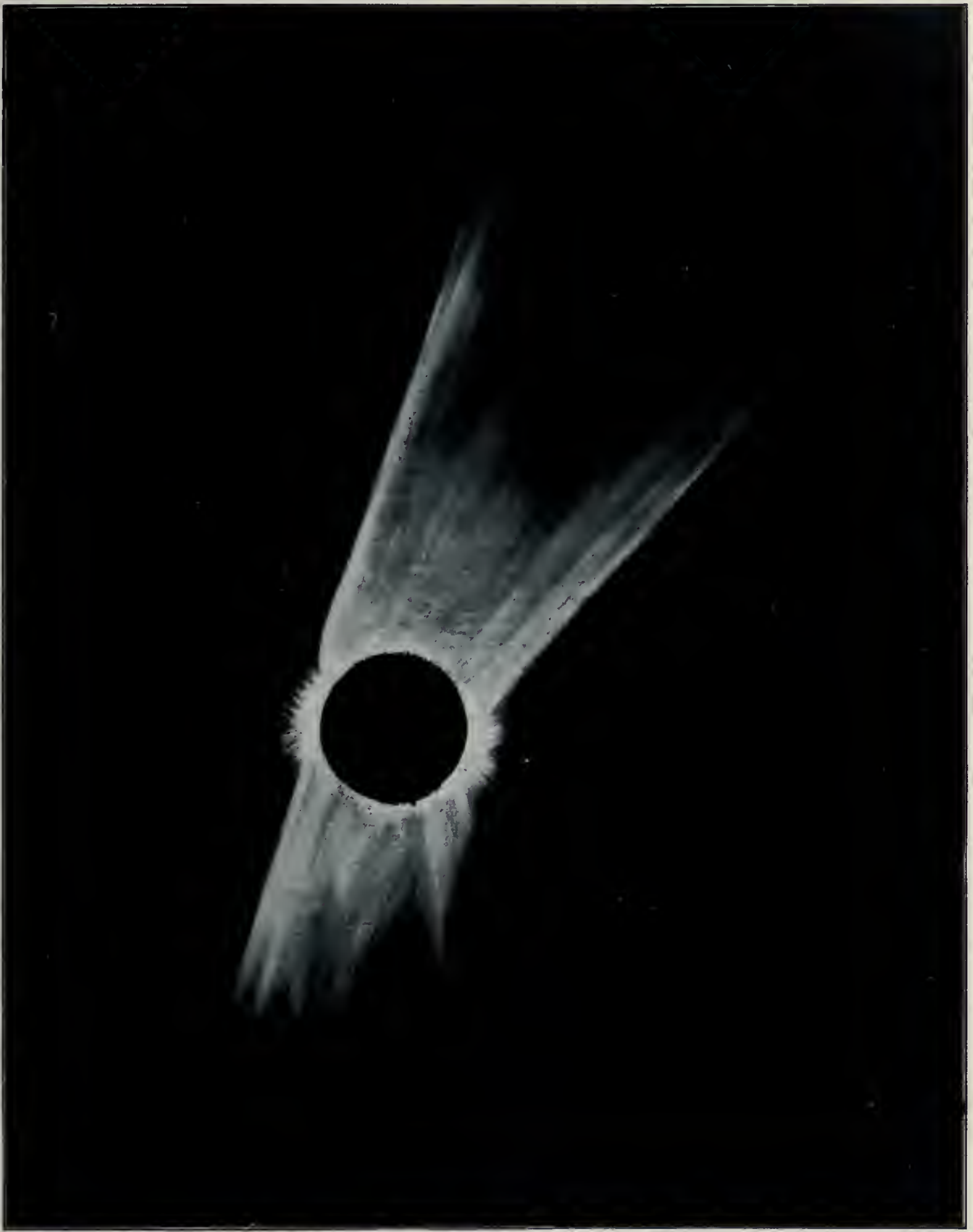
THE MERIDEN GRAVURE CO.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE INNER CORONA AS DRAWN BY H. R. MORGAN FROM THE NEGATIVES.

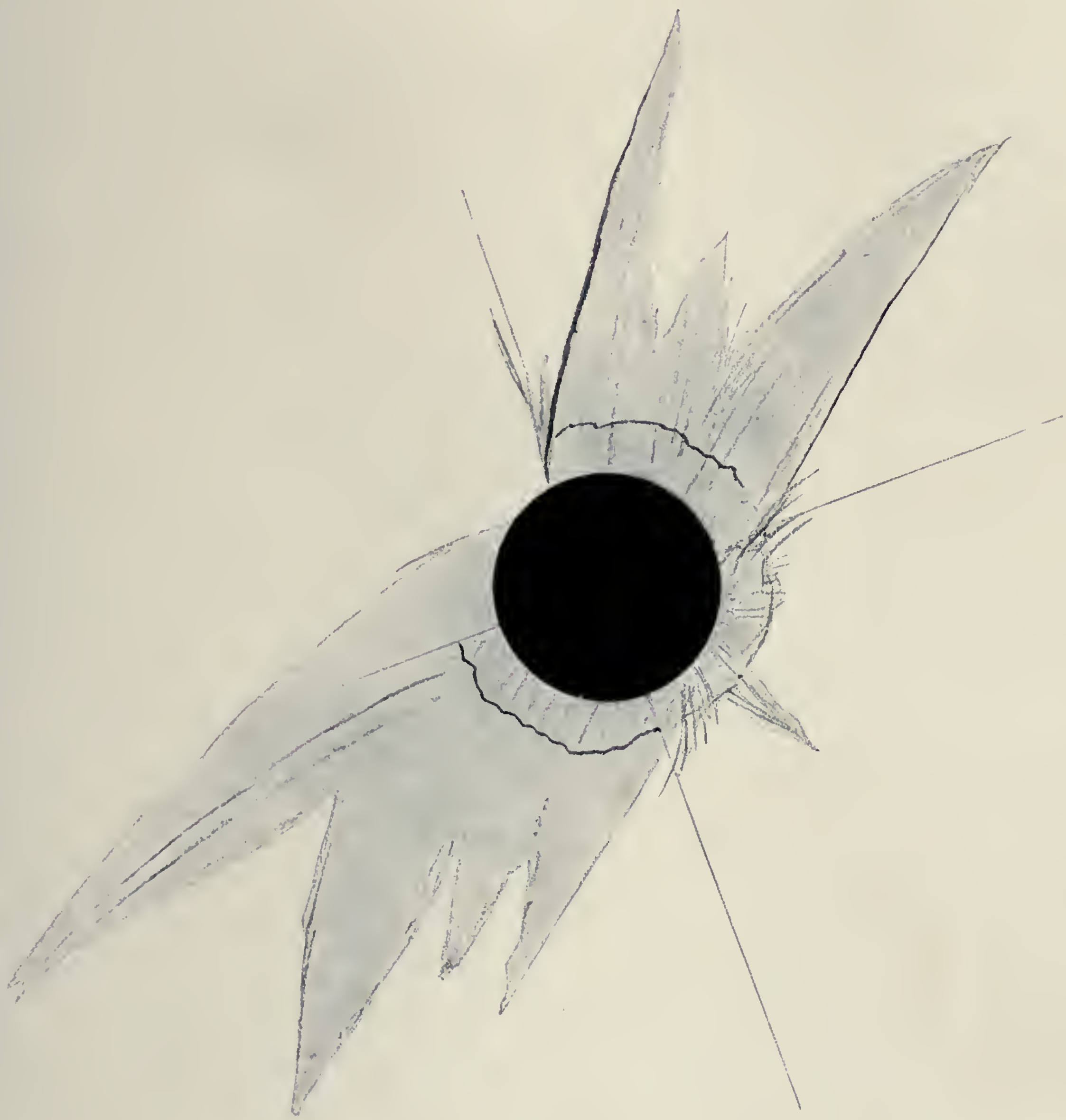
TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY J. R. EASTMAN AT BARNESVILLE, GA.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY T. J. J. SEE AT BARNESVILLE, GA.

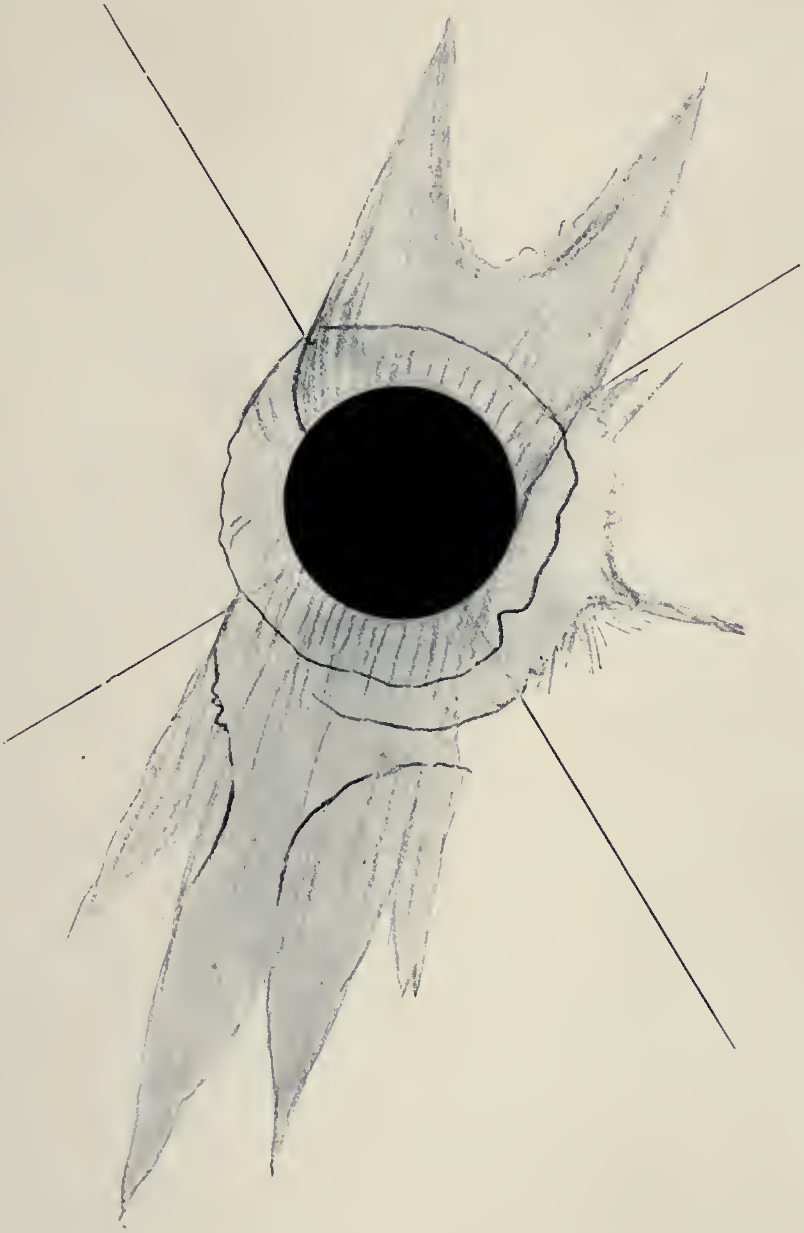
TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY J. N. HART AT BARNESVILLE, GA.



TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY OTIS ASHMORE AT BARNESVILLE, GA.

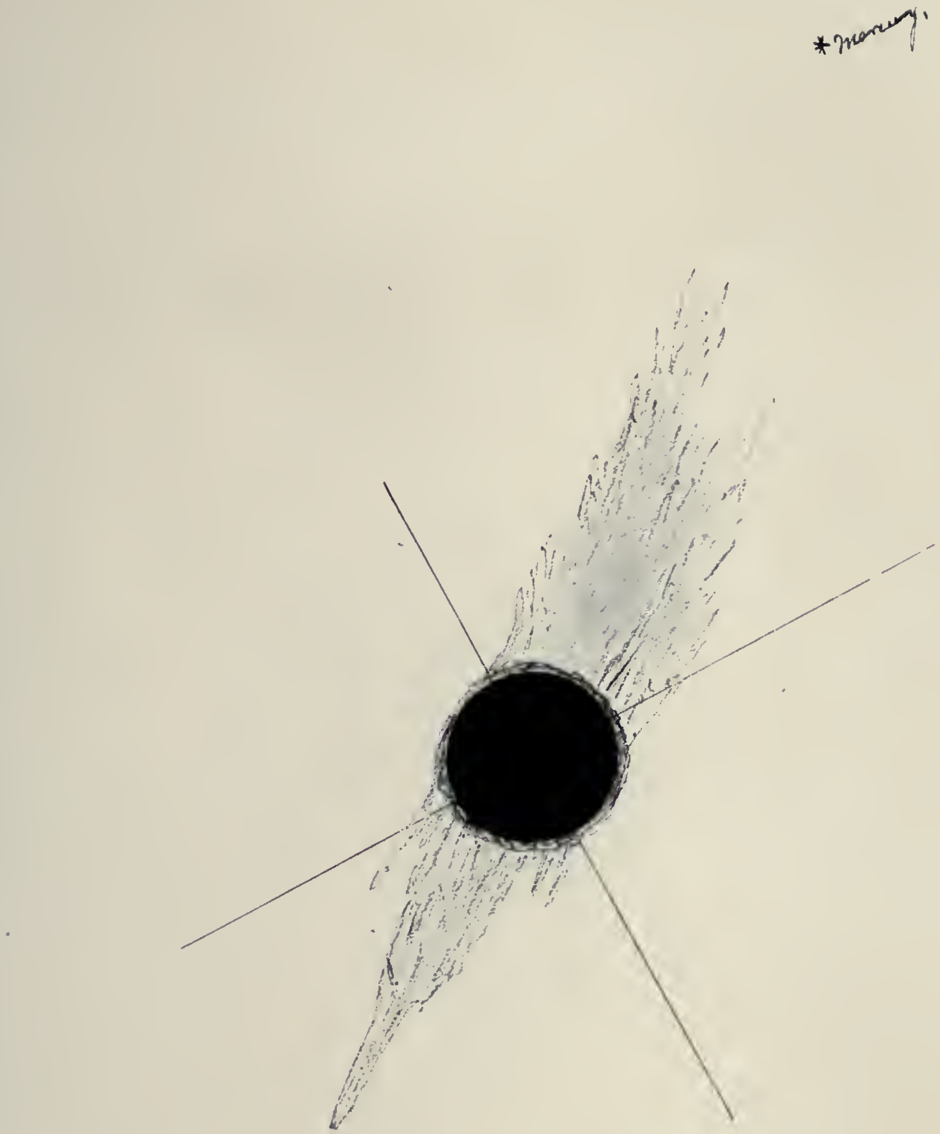


TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY FIVE STUDENTS OF THE SOUTH CAROLINA MILITARY ACADEMY AT WADESBORO, N. C.

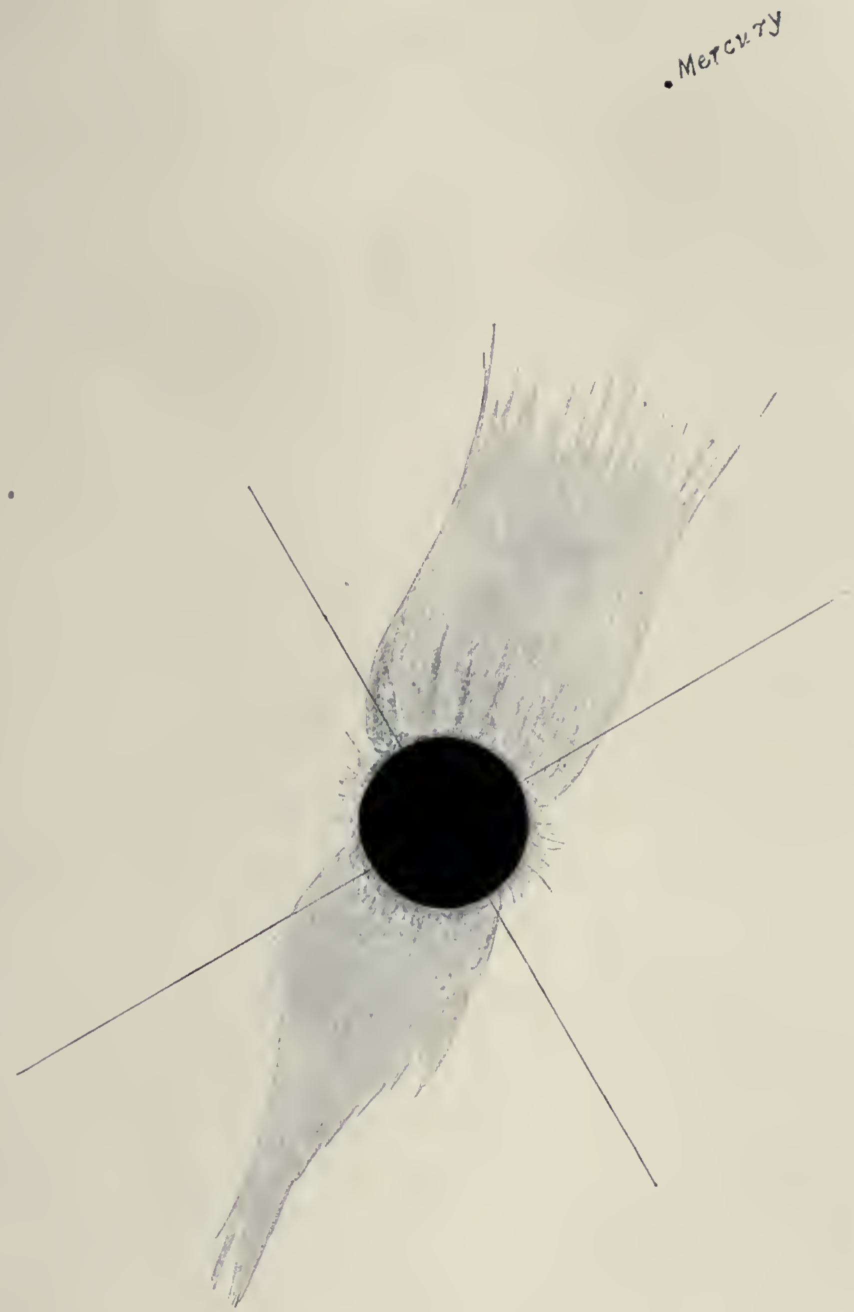


TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY THREE STUDENTS OF THE SOUTH CAROLINA MILITARY ACADEMY AT WADESBORO, N. C.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY C. L. THORNBURG AT AHOSKIE, N. C.



TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY MANSFIELD MERRIMAN AT AHOSKIE, N. C.



TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS DRAWN BY W. S. FRANKLIN AT AHOSKIE, N. C.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE CORONA AS PHOTOGRAPHED WITH THE 40-FOOT CAMERA AT FORT DE KOCK, SUMATRA. NEGATIVE 1, ONE-HALF SECOND EXPOSURE. TWICE ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE CORONA AS PHOTOGRAPHED WITH THE 40-FOOT CAMERA AT FORT DE KOCK, SUMATRA. NEGATIVE 2, 1 SECOND EXPOSURE. ONE AND THREE-TENTHS ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE CORONA AS PHOTOGRAPHED WITH THE 40-FOOT CAMERA AT FORT DE KOCK, SUMATRA. NEGATIVE 4, 5 SECONDS EXPOSURE. NINE-TENTHS ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 17-18, 1901. THE CORONA AS PHOTOGRAPHED WITH THE 40-FOOT CAMERA AT FORT DE KOCK, SUMATRA. NEGATIVE 4, 5 SECONDS EXPOSURE. NINE-TENTHS ORIGINAL SIZE.

THE MERIDEN GRAVURE CO.

TOTAL SOLAR ECLIPSE OF MAY 17-18, 1901. THE CORONA AS PHOTOGRAPHED WITH THE 40-FOOT CAMERA AT FORT DE KOCK, SUMATRA. NEGATIVE 5, 60 SECONDS EXPOSURE.
SIX-TENTHS ORIGINAL SIZE.

THE MERIDEN GRAVURE CO.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE CORONA AS PHOTOGRAPHED WITH THE 40-FOOT CAMERA AT FORT DE KOCK, SUMATRA. NEGATIVE 7, 3 SECONDS EXPOSURE. ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE CORONA AS PHOTOGRAPHED WITH THE 40-FOOT CAMERA AT FORT DE KOCK, SUMATRA. NEGATIVE 9, ONE-HALF SECOND EXPOSURE. ONE AND THREE-TENTHS ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 17-18, 1901. THE CORONA AS PHOTOGRAPHED WITH THE 104-INCH CAMERA NEAR SAWAH LOENTO, SUMATRA. NEGATIVE 5, 10 SECONDS EXPOSURE. ONE AND FOUR-TENTHS ORIGINAL SIZE.

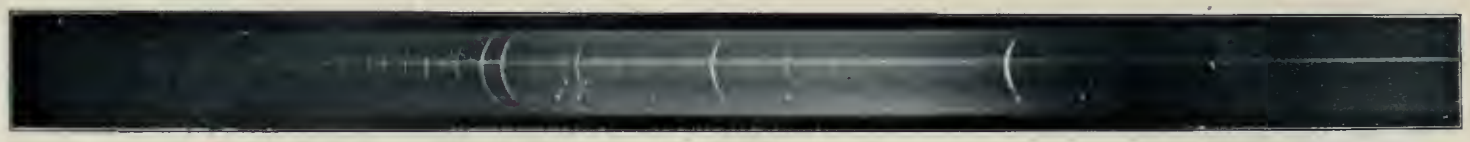
THE MERIDEN GRAVURE CO.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE CORONA AS DRAWN BY H. R. MORGAN FROM THE NEGATIVES.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE INNER CORONA AS DRAWN BY H. R. MORGAN FROM THE NEGATIVES.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE SPECTRUM AS PHOTOGRAPHED WITH THE SPECTROGRAPH AT BARNESVILLE, GA. NEGATIVE 3.
THREE AND ONE-HALF TIMES ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE SPECTRUM AS PHOTOGRAPHED WITH THE SPECTROGRAPH AT BARNESVILLE, GA. NEGATIVE 6.
THREE AND ONE-HALF TIMES ORIGINAL SIZE.



TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE SPECTRUM AS PHOTOGRAPHED WITH THE PLANE GRATING OBJECTIVE SPECTROGRAPH AT PINEHURST, N. C. NEGATIVE 1, 1 SECOND EXPOSURE.
ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE SPECTRUM AS PHOTOGRAPHED WITH THE PLANE GRATING OBJECTIVE SPECTROGRAPH AT PINEHURST, N. C. NEGATIVE 4, 1 SECOND EXPOSURE.
ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. A PORTION OF THE SPECTRUM AS PHOTOGRAPHED WITH THE PLANE GRATING OBJECTIVE SPECTROGRAPH AT PINEHURST, N. C. NEGATIVE 1, 1 SECOND EXPOSURE.

THREE TIMES ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. A PORTION OF THE SPECTRUM AS PHOTOGRAPHED WITH THE PLANE GRATING OBJECTIVE SPECTROGRAPH AT PINEHURST, N. C. NEGATIVE 2, 5 SECONDS EXPOSURE.

THREE TIMES ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. A PORTION OF THE SPECTRUM AS PHOTOGRAPHED WITH THE PLANE GRATING OBJECTIVE SPECTROGRAPH AT PINEHURST, N. C. NEGATIVE 4, 1 SECOND EXPOSURE.

SIX TIMES ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE ULTRA-VIOLET PORTION OF THE SPECTRUM AS PHOTOGRAPHED WITH THE SPECTROGRAPH AT FORT DE KOCK, SUMATRA. NEGATIVE 2, 5 SECONDS EXPOSURE.
ORIGINAL SIZE.

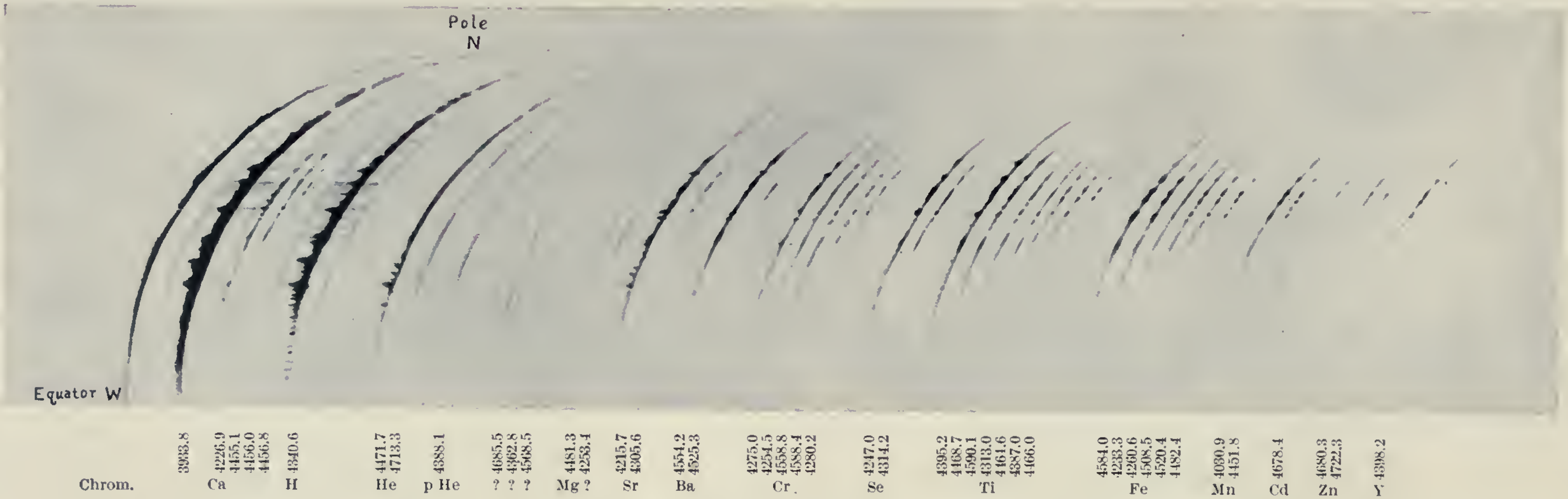
TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE ULTRA-VIOLET PORTION OF THE SPECTRUM AS PHOTOGRAPHED WITH THE SPECTROGRAPH AT FORT DE KOCK, SUMATRA. NEGATIVE 6, 8 SECONDS EXPOSURE.
ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE SPECTRUM AS PHOTOGRAPHED WITH THE SPECTROGRAPH NEAR SAWAH LOENTO, SUMATRA. NEGATIVE 7, 3 SECONDS EXPOSURE.
ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. A PORTION OF THE SPECTRUM AS PHOTOGRAPHED WITH THE SPECTROGRAPH NEAR SAWAH LOENTO, SUMATRA. NEGATIVE 7, 3 SECONDS EXPOSURE.
TWICE ORIGINAL SIZE.

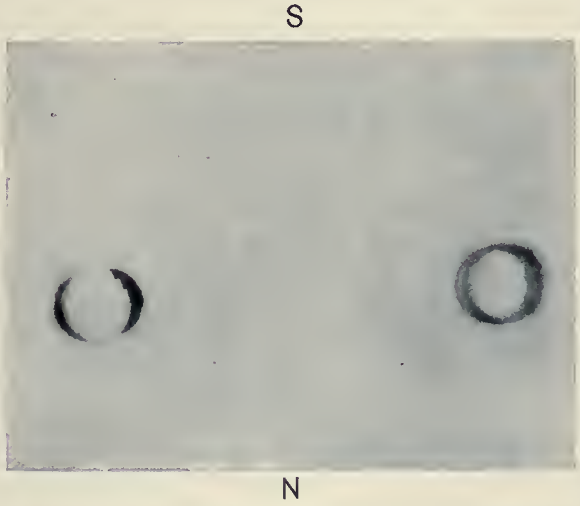
TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE SPECTRUM AS PHOTOGRAPHED WITH THE SPECTROGRAPH NEAR SAWAH LOENTO, SUMATRA. NEGATIVE 8, ONE-HALF SECOND EXPOSURE.
ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 17, 1901. THE SPECTRUM AS PHOTOGRAPHED WITH THE OBJECTIVE PRISM SPECTROGRAPH AT SOLOK, SUMATRA. NEGATIVE 1, 2 SECONDS EXPOSURE.
ORIGINAL SIZE.

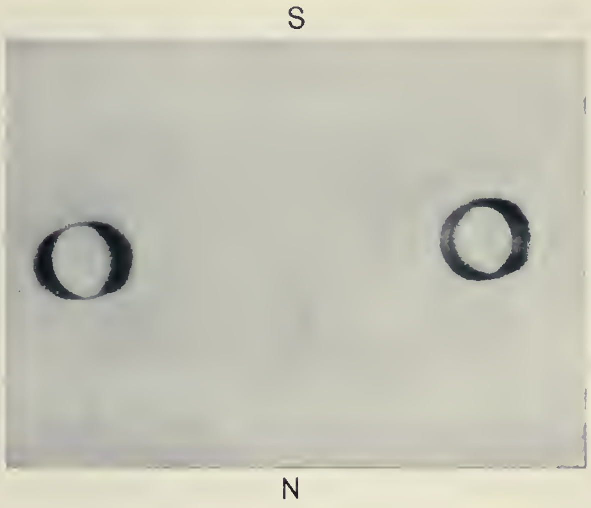


TOTAL SOLAR ECLIPSE OF MAY 17, 1901. CHARACTERISTIC LINES FROM NEGATIVE 7, 3 SECONDS EXPOSURE, AS DRAWN BY L. E. JEWELL FROM THE ORIGINAL NEGATIVE.

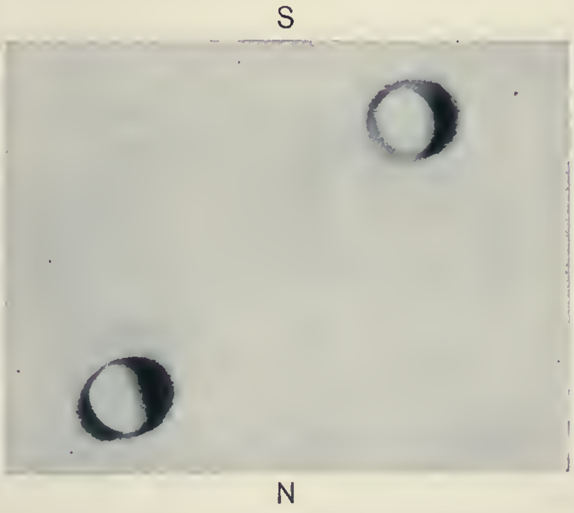
TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS PHOTOGRAPHED WITH THE POLARIGRAPH AT PINEHURST, N. C. NEGATIVE 1, 1 SECOND EXPOSURE. TWO AND ONE-HALF TIMES ORIGINAL SIZE.



TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS PHOTOGRAPHED WITH THE POLARIGRAPH AT PINEHURST, N. C. NEGATIVE 2, 1 SECOND EXPOSURE. TWO AND ONE-HALF TIMES ORIGINAL SIZE.

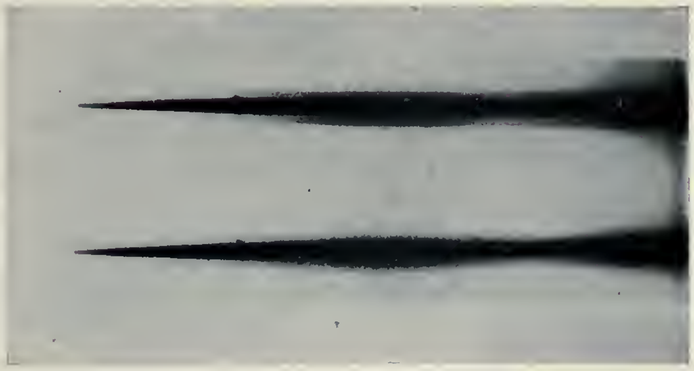


TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS PHOTOGRAPHED WITH THE POLARIGRAPH AT PINEHURST, N. C. NEGATIVE 3, 10 SECONDS EXPOSURE. TWO AND ONE-HALF TIMES ORIGINAL SIZE.



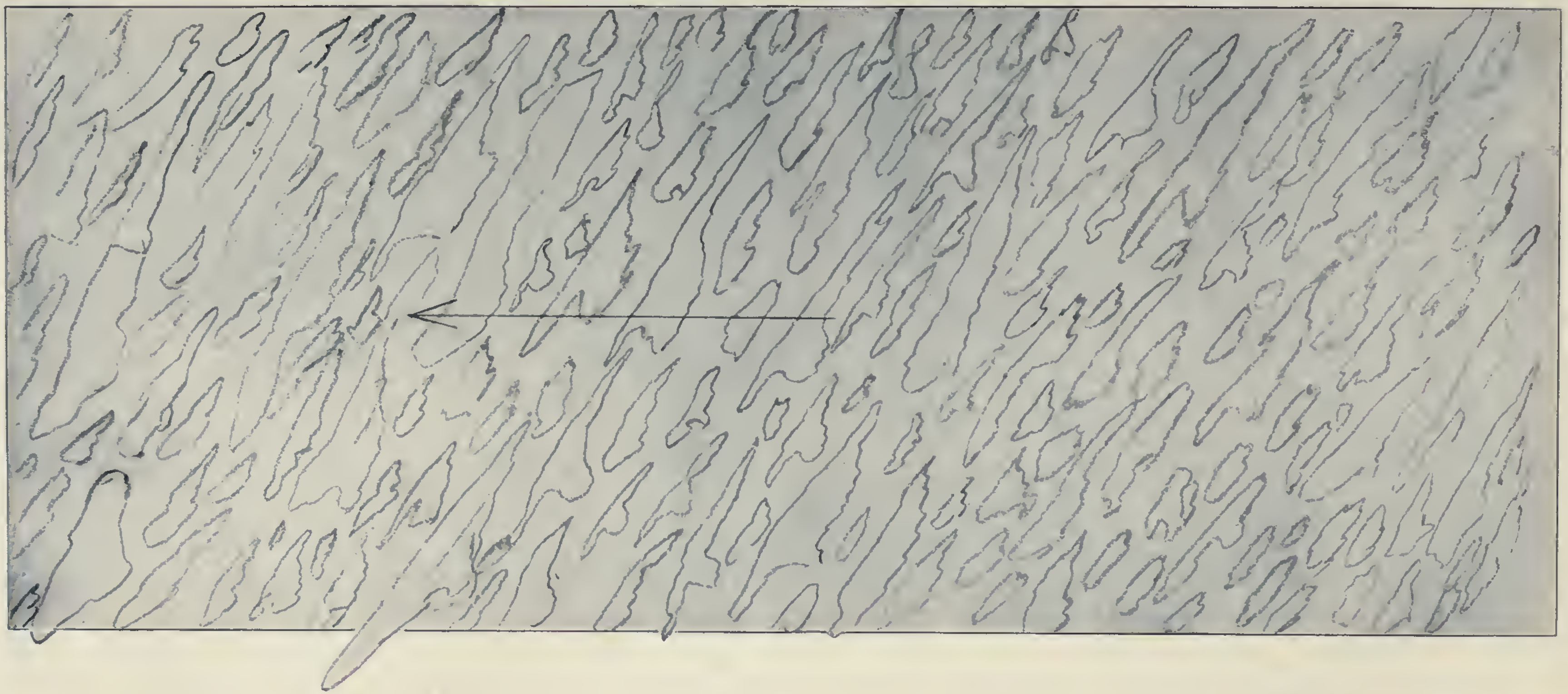
TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE CORONA AS PHOTOGRAPHED WITH THE POLARIGRAPH AT PINEHURST, N. C. NEGATIVE 4, 10 SECONDS EXPOSURE. TWO AND ONE-HALF TIMES ORIGINAL SIZE.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE SPECTRUM AS PHOTOGRAPHED WITH THE POLARIGRAPH AT PINEHURST, N. C. NEGATIVE 5, 15 SECONDS EXPOSURE. TWO AND ONE-HALF TIMES ORIGINAL SIZE.



TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE SPECTRUM AS PHOTOGRAPHED WITH THE POLARIGRAPH AT PINEHURST, N. C. NEGATIVE 6, 40 SECONDS EXPOSURE. TWO AND ONE-HALF TIMES ORIGINAL SIZE.

PLATE LXXIX.



TOTAL SOLAR ECLIPSE OF MAY 28, 1900. THE SHADOW BANDS AS DRAWN BY C. E. GILLETTE AT BARNESVILLE, GA.

APPENDIX II.

REDUCTION TABLES

FOR

TRANSIT CIRCLE OBSERVATIONS,

COMPILED UNDER THE DIRECTION OF

W. S. EICHELBERGER, Professor of Mathematics, U. S. N.,
Head of Division of Meridian Instruments.

TABLE OF CONTENTS.

INTRODUCTION.

The following tables were constructed for use at the U. S. Naval Observatory, and with the exception of the refraction tables are, in general, not applicable elsewhere. The explanations necessary for the use of each table are given with it.

TABLES I–VIII, XV, XVI, and XVIII–XXII were devised and constructed by Assistant Astronomer H. L. RICE. TABLES XXVI–XXXIV follow the form used in the Refraction Tables published by the Observatory in 1887, but are based upon the Pulkowa Refraction Tables instead of upon those of BESSEL. The transformation of the Pulkowa Tables into the form here used was made by Mr. RICE. The remaining tables simply follow the form of manuscript tables long in use at the Observatory.

These tables are used in the reduction of the observations made with the 9-inch transit circle since September 3, 1903, and TABLES VII and IX–XIV are constructed with special reference to the reticule of the 9-inch transit circle as it has existed since that date.

REDUCTION OF BROKEN TRANSITS OF THE MOON.

TABLE II.

δ	F_0
°	
0	136
± 1	136
2	136
3	136
4	135
5	135
6	135
7	135
8	134
9	134
10	133
11	133
12	133
13	132
14	131
15	131
16	130
17	129
18	128
19	128
20	127
21	126
22	125
23	124
24	122
25	121
26	120
27	118
28	117
29	115
± 30	114

TABLE III.

π		F_1	π		F_1
′	″		′	″	
53	0	20	57	0	10
	10	19		10	9
	20	19		20	9
	30	19		30	9
	40	18		40	8
	50	18		50	8
54	0	17	58	0	7
	10	17		10	7
	20	16		20	7
	30	16		30	6
	40	16		40	6
	50	15		50	5
55	0	15	59	0	5
	10	14		10	5
	20	14		20	4
	30	14		30	4
	40	13		40	3
	50	13		50	3
56	0	12	60	0	2
	10	12		10	2
	20	12		20	2
	30	11		30	1
	40	11		40	1
	50	10		50	0

TABLE IV.

D_2	F_2	D_2	F_2	D_2	F_2
s		s		s	
100	0	127	74	154	148
101	3	128	77	155	151
102	5	129	79	156	153
103	8	130	82	157	156
104	11	131	85	158	159
105	14	132	88	159	162
106	16	133	90	160	164
107	19	134	93	161	167
108	22	135	96	162	170
109	25	136	99	163	173
110	27	137	101	164	175
111	30	138	104	165	178
112	33	139	107	166	181
113	36	140	110	167	184
114	38	141	112	168	186
115	41	142	115	169	189
116	44	143	118	170	192
117	47	144	121	171	195
118	49	145	123	172	197
119	52	146	126	173	200
120	55	147	129	174	203
121	58	148	132	175	205
122	60	149	134	176	208
123	63	150	137	177	211
124	66	151	140	178	214
125	68	152	142	179	216
126	71	153	145	180	219

The tabular quantities F_0, F_1, and F_2 are expressed in units of the fourth decimal, and are always positive.

PRECEPTS FOR USING TABLES II, III, AND IV.

Take from the Washington Moon Culminations, for the date of observation,

δ=the geocentric declination of the Moon's center to tenths of a degree;
π=the Moon's equatorial horizontal parallax, to the nearest ten seconds of arc;
D_2=the change in the Moon's right ascension for one hour of longitude, to tenths of a second of time.

Let

t=the observed time of transit of the Moon's limb over a given thread;
I=the reduction of t to the mean thread, taken from the usual tables (as for a fixed star), with the circle setting of the Moon's *center* as argument.

Take from TABLES II, III, and IV, the values of F_0, F_1, and F_2, and form

$$F=F_0+F_1+F_2;$$
$$\Delta I=I\,F.$$

Finally, denoting by T the required clock time of transit of the Moon's limb over the mean thread, we have

$$T=t+I+\Delta I$$

in which I and ΔI always have the same sign. In this manner reduce separately each thread of a given broken transit.

To correct for the change in the Moon's right ascension while passing from the mean thread to the true meridian.

Let $\tau=Aa+Bb+Cc=m+n\tan\delta+c\sec\delta$
=the sum of the instrumental corrections in right ascension, including diurnal aberration.

Then the required correction to the Moon's right ascension is

$$\Delta\alpha=F\,\tau,$$

where F is the essentially positive quantity found above.

REDUCTION OF UNSYMMETRICAL OBSERVATIONS OF THE MOON IN DECLINATION.

TABLE V.—*Giving P, the Correction in Zenith Distance for the Motion of the Moon in Declination while Passing from the Mean Thread to the True Meridian.*

τ / D_3	s 0.00	s 0.05	s 0.10	s 0.15	s 0.20	s 0.25	s 0.30	s 0.35	s 0.40	s 0.45	s 0.50	s 0.55	s 0.60
″													
0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	1	1	1	1	1	1	1	2	2
200	0	0	1	1	1	1	2	2	2	2	3	3	3
300	0	0	1	1	2	2	2	3	3	4	4	5	5
400	0	1	1	2	2	3	3	4	4	5	6	6	7
500	0	1	1	2	3	3	4	5	6	6	7	8	8
600	0	1	2	3	3	4	5	6	7	8	8	9	10
700	0	1	2	3	4	5	6	7	8	9	10	11	12
800	0	1	2	3	4	6	7	8	9	10	11	12	13
900	0	1	3	4	5	6	7	9	10	11	13	14	15
1000	0	1	3	4	6	7	8	10	11	12	14	15	17
1100	0	2	3	5	6	8	9	11	12	14	15	17	18
1200	0	2	3	5	7	8	10	12	13	15	17	18	20

TABLE VI.—*Giving ΔQ.*

$\pm Q_0$ / δ_0	″ 0	″ 1	″ 2	″ 3	″ 4	″ 5	″ 6	″ 7	″ 8	″ 9	″ 10	″ 11	″ 12
°													
+30	0	2	3	5	7	8	10	11	13	15	16	18	20
25	0	2	3	5	6	8	10	11	13	14	16	18	19
20	0	2	3	5	6	8	9	11	13	14	16	17	19
+15	0	2	3	5	6	8	9	11	12	14	15	17	18
+10	0	1	3	4	6	7	9	10	12	13	14	16	17
+ 5	0	1	3	4	5	7	8	10	11	12	14	15	16
0	0	1	3	4	5	6	8	9	10	12	13	14	15
− 5	0	1	2	4	5	6	7	8	10	11	12	13	14
−10	0	1	2	3	4	5	7	8	9	10	11	12	13
−15	0	1	2	3	4	5	6	7	8	9	10	11	12
20	0	1	2	3	3	4	5	6	7	8	9	9	10
25	0	1	1	2	3	4	4	5	6	7	7	8	9
−30	0	1	1	2	2	3	4	4	5	5	6	7	7

In these tables the tabular quantities are expressed in hundredths of a second of arc.

PRECEPTS FOR USING TABLES V AND VI.

Take from the Washington Moon Culminations, for the date of observation,

D_3 = the change in the Moon's declination for one hour of longitude; and put

$\tau = Aa + Bb + Cc = m + n \tan \delta + c \sec \delta$

= the sum of the instrumental corrections in right ascension, computed for the Moon's center.

With D_3 and τ as arguments, take from TABLE V the quantity P, giving to it the sign of the product $D_3\,\tau$.

The required correction to the observed zenith distance of the Moon's limb will then be

$$\Delta z = \pm P \begin{cases} +, & \text{for zenith distance north,} \\ -, & \text{for zenith distance south.} \end{cases}$$

When bisections of the Moon's limb have been made symmetrically with respect to the mean thread, no further correction for motion is necessary. Otherwise, given a number of bisections at certain unsymmetrical threads of the reticule, put, for any one of these threads,

i = its equatorial interval from the mean thread, expressed in seconds of time;

n = the number of threads in question.

Compute the mean value of i, namely,

$$i_0 = \frac{\Sigma\, i}{n},$$

having careful regard to signs.

Take from the Washington Moon Culminations, for the date of observation,

δ = the geocentric declination of the Moon's center;

D_3 = the change in δ for one hour of longitude;

s = the Moon's geocentric semidiameter.

Form the quantity

$$\delta_0 = \delta \pm s \begin{cases} +, & \text{for north limb,} \\ -, & \text{for south limb.} \end{cases}$$

Now compute Q_0 in seconds of arc from the formula

$$Q_0 = [6.4437]\ D_3\, i_0 \sec \delta_0$$

having careful regard to signs.

Enter TABLE VI with δ_0 and the absolute value of Q_0 as arguments, and take out ΔQ.

Next form the quantity

$$Q = Q_0 - \Delta Q$$

observing that ΔQ and Q_0 have always the same sign.

Finally, the correction to the observed zenith distance of the limb, on account of unsymmetrical bisections, is

$$\Delta_1 z = \pm Q \begin{cases} +, & \text{for zenith distance north,} \\ -, & \text{for zenith distance south.} \end{cases}$$

Hence, when the bisections are not symmetrical, the total correction to an observed zenith distance of the Moon's limb is

$$\Delta z + \Delta_1 z = \pm (P + Q)$$

the sign being taken as above.

REDUCTION OF UNSYMMETRICAL OBSERVATIONS OF THE PLANETS IN DECLINATION.

TABLE VII.—*Giving y.*

[9-inch Transit Circle.]

δ	I, VI.	I, II, VII.	I, II, VI.	II.	I, II.	I.
°						
0	35	57	80	170	205	240
± 3	35	57	80	170	205	240
6	35	57	80	171	206	241
9	35	57	81	172	208	243
12	36	58	82	174	210	245
15	36	59	83	176	212	248
18	37	60	84	179	216	252
21	37	61	86	182	220	257
24	38	62	88	186	224	263
27	39	64	90	191	230	269
± 30	40	65	92	196	237	277
	II, VII.	I, VI, VII.	II, VI, VII.	VI.	VI, VII.	VII.

When the arrangement of threads is that indicated at the top of the table, the tabular quantity is positive; when that at the bottom, the quantity is negative.

TABLE VIII.—*Giving M.*

Δδ	Values of Argument *y*.																			
	35	40	55	60	65	80	85	90	95	170	180	190	200	210	220	230	240	250	260	270	280
″																					
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
± 10	1	1	2	2	2	2	2	2	3	5	5	5	6	6	6	6	7	7	7	8	8
20	2	2	3	3	4	4	5	5	5	9	10	11	11	12	12	13	13	14	14	15	16
30	3	3	5	5	5	7	7	8	8	14	15	16	17	18	18	19	20	21	22	23	23
40	4	4	6	7	7	9	9	10	11	19	20	21	22	23	24	26	27	28	29	30	31
50	5	6	8	8	9	11	12	12	13	24	25	26	28	29	31	32	33	35	36	38	39
60	6	7	9	10	11	13	14	15	16	28	30	32	33	35	37	38	40	42	43	45	47
70	7	8	11	12	13	16	17	18	18	33	35	37	39	41	43	45	47	49	51	53	54
80	8	9	12	13	14	18	19	20	21	38	40	42	44	47	49	51	53	56	58	60	62
90	9	10	14	15	16	20	21	22	24	43	45	48	50	53	55	58	60	63	65	68	70
100	10	11	15	17	18	22	24	25	26	47	50	53	56	58	61	64	67	69	72	75	78
110	11	12	17	18	20	24	26	28	29	52	55	58	61	64	67	70	73	76	80	83	86
120	12	13	18	20	22	27	28	30	32	57	60	63	67	70	73	77	80	83	87	90	93
130	13	14	20	22	24	29	31	32	34	61	65	69	72	76	80	83	87	90	94	98	101
140	14	16	21	23	25	31	33	35	37	66	70	74	78	82	86	89	93	97	101	105	109
± 150	15	17	23	25	27	33	35	37	40	71	75	79	83	88	92	96	100	104	108	113	117

The tabular quantities are expressed in hundredths of a second of arc.

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PRECEPTS FOR USING TABLES VII AND VIII.

Take from the American Ephemeris, for the date of observation,

$\delta =$ the geocentric declination of the planet;
$\Delta\delta =$ the change in δ for one hour of mean time.

Enter the proper column of TABLE VII with the side argument δ, and take out y, carefully noting its sign. Then enter TABLE VIII with the absolute values of $\Delta\delta$ and y as arguments, and take out M, giving to it the sign of the product $y\Delta\delta$. The correction to be applied to the observed zenith distance, on account of motion in declination, is

$$\Delta z = \pm M \begin{cases} +, \text{ for zenith distance north,} \\ -, \text{ for zenith distance south.} \end{cases}$$

REDUCTION OF UNSYMMETRICAL OBSERVATIONS OF THE SUN IN DECLINATION.

TABLE IX.—*Giving Correction for Motion.*
[9-inch Transit Circle.]

Circle Setting Clamp West.		December 22 to June 22.		
		I.	II.	III.
		June 22 to December 22.		
		VII.	VI.	V.
°	′	″	″	″
297	36	0.00	0.00	0.00
297	44	0.05	0.03	0.02
297	52	0.07	0.05	0.03
298	0	0.09	0.06	0.03
298	30	0.13	0.09	0.05
299	0	0.16	0.11	0.06
300	0	0.20	0.14	0.08
301	0	0.23	0.16	0.09
302	0	0.26	0.18	0.10
303	0	0.28	0.20	0.11
304	0	0.30	0.21	0.11
305	0	0.31	0.22	0.12
306	0	0.33	0.23	0.12
307	0	0.34	0.24	0.13
308	0	0.35	0.25	0.13
309	0	0.36	0.25	0.13
310	0	0.36	0.26	0.14
311	0	0.37	0.26	0.14
312	0	0.38	0.27	0.14
313	0	0.38	0.27	0.14
314	0	0.38	0.27	0.14
315	0	0.38	0.27	0.14
316	0	0.39	0.28	0.15
317	0	0.39	0.28	0.15
318	0	0.39	0.28	0.15
319	0	0.39	0.28	0.15
320	0	0.39	0.28	0.15
321	0	0.39	0.28	0.15
322	0	0.39	0.28	0.15
323	0	0.39	0.28	0.15
324	0	0.39	0.27	0.15
325	0	0.39	0.27	0.14
326	0	0.38	0.27	0.14
327	0	0.38	0.27	0.14
328	0	0.38	0.27	0.14
329	0	0.37	0.26	0.14
330	0	0.37	0.26	0.14
331	0	0.36	0.25	0.14
332	0	0.35	0.25	0.13
333	0	0.34	0.24	0.13
334	0	0.34	0.24	0.13
335	0	0.33	0.23	0.12
336	0	0.31	0.22	0.12
337	0	0.30	0.21	0.11
338	0	0.28	0.20	0.11
339	0	0.27	0.19	0.10
340	0	0.25	0.17	0.09
341	0	0.22	0.16	0.08
342	0	0.19	0.14	0.07
343	0	0.15	0.11	0.06
343	30	0.12	0.09	0.05
344	0	0.09	0.06	0.03
344	10	0.07	0.05	0.03
344	20	0.05	0.03	0.02
344	28	0.00	0.00	0.00
		June 22 to December 22.		
		I.	II.	III.
		December 22 to June 22.		
		VII.	VI.	V.

TABLE X.—*Giving Correction for Motion.*
[9-inch Transit Circle.]

Circle Setting Clamp East.		June 22 to December 22.		
		I.	II.	III.
		December 22 to June 22.		
		VII.	VI.	V.
°	′	″	″	″
15	24	0.00	0.00	0.00
15	33	0.05	0.03	0.02
15	42	0.07	0.05	0.03
15	51	0.09	0.06	0.03
16	0	0.10	0.07	0.04
16	30	0.13	0.09	0.05
17	0	0.16	0.11	0.06
18	0	0.19	0.14	0.07
19	0	0.22	0.16	0.08
20	0	0.25	0.18	0.09
21	0	0.27	0.19	0.10
22	0	0.29	0.20	0.11
23	0	0.30	0.21	0.11
24	0	0.32	0.22	0.12
25	0	0.33	0.23	0.12
26	0	0.34	0.24	0.13
27	0	0.35	0.24	0.13
28	0	0.35	0.25	0.13
29	0	0.36	0.26	0.14
30	0	0.37	0.26	0.14
31	0	0.37	0.26	0.14
32	0	0.38	0.27	0.14
33	0	0.38	0.27	0.14
34	0	0.38	0.27	0.14
35	0	0.39	0.27	0.14
36	0	0.39	0.28	0.15
37	0	0.39	0.28	0.15
38	0	0.39	0.28	0.15
39	0	0.39	0.28	0.15
40	0	0.39	0.28	0.15
41	0	0.39	0.28	0.15
42	0	0.39	0.28	0.15
43	0	0.39	0.28	0.15
44	0	0.39	0.28	0.15
45	0	0.38	0.27	0.14
46	0	0.38	0.27	0.14
47	0	0.38	0.27	0.14
48	0	0.38	0.27	0.14
49	0	0.37	0.26	0.14
50	0	0.36	0.26	0.14
51	0	0.36	0.25	0.13
52	0	0.35	0.24	0.13
53	0	0.34	0.24	0.13
54	0	0.32	0.23	0.12
55	0	0.31	0.22	0.12
56	0	0.30	0.21	0.11
57	0	0.28	0.20	0.10
58	0	0.26	0.18	0.10
59	0	0.23	0.16	0.09
60	0	0.20	0.14	0.07
61	0	0.15	0.11	0.06
61	30	0.12	0.08	0.05
62	0	0.07	0.05	0.03
62	8	0.05	0.04	0.02
62	16	0.00	0.00	0.00
		December 22 to June 22.		
		I.	II.	III.
		June 22 to December 22.		
		VII.	VI.	V.

REDUCTION OF UNSYMMETRICAL OBSERVATIONS OF THE SUN IN DECLINATION—Continued.

TABLE XI.—*Reduction to Meridian+Motion.*

[9-inch Transit Circle.]

Circle Setting Clamp West.		December 22 to June 22.	
		I, II.	VI, VII.
		June 22 to December 22.	
		VI, VII.	I, II.
°	′	″	″
297	36	+ 5.10	+ 5.10
297	44	5.14	5.06
297	52	5.16	5.04
298	0	5.18	5.02
298	30	5.20	4.99
299	0	5.23	4.96
300	0	5.26	4.92
301	0	5.28	4.89
302	0	5.30	4.86
303	0	5.32	4.84
304	0	5.33	4.82
305	0	5.33	4.80
306	0	5.34	4.78
307	0	5.35	4.77
308	0	5.35	4.76
309	0	5.36	4.75
310	0	5.36	4.74
311	0	5.36	4.73
312	0	5.36	4.72
313	0	5.36	4.71
314	0	5.35	4.70
315	0	5.35	4.70
316	0	5.35	4.69
317	0	5.35	4.68
318	0	5.35	4.68
319	0	5.34	4.67
320	0	5.34	4.67
321	0	5.34	4.66
322	0	5.33	4.66
323	0	5.33	4.66
324	0	5.32	4.66
325	0	5.31	4.65
326	0	5.31	4.65
327	0	5.30	4.65
328	0	5.29	4.65
329	0	5.28	4.65
330	0	5.27	4.65
331	0	5.26	4.65
332	0	5.25	4.65
333	0	5.24	4.66
334	0	5.23	4.66
335	0	5.22	4.66
336	0	5.20	4.67
337	0	5.19	4.68
338	0	5.17	4.69
339	0	5.15	4.70
340	0	5.13	4.71
341	0	5.10	4.73
342	0	5.07	4.75
343	0	5.03	4.78
343	30	5.01	4.80
344	0	4.97	4.83
344	10	4.96	4.84
344	20	4.94	4.86
344	28	+ 4.90	+ 4.90

TABLE XII.—*Reduction to Meridian+Motion.*

[9-inch Transit Circle.]

Circle Setting Clamp East.		December 22 to June 22.	
		I, II.	VI, VII.
		June 22 to December 22.	
		VI, VII.	I, II.
°	′	″	″
15	24	+ 5.10	+ 5.10
15	33	5.06	5.14
15	42	5.04	5.16
15	51	5.03	5.17
16	0	5.02	5.18
16	30	4.99	5.21
17	0	4.96	5.23
18	0	4.92	5.26
19	0	4.89	5.28
20	0	4.87	5.29
21	0	4.85	5.30
22	0	4.83	5.31
23	0	4.81	5.32
24	0	4.79	5.33
25	0	4.78	5.34
26	0	4.77	5.34
27	0	4.76	5.34
28	0	4.74	5.35
29	0	4.73	5.35
30	0	4.72	5.35
31	0	4.72	5.35
32	0	4.71	5.35
33	0	4.70	5.35
34	0	4.69	5.35
35	0	4.68	5.35
36	0	4.68	5.34
37	0	4.67	5.34
38	0	4.67	5.34
39	0	4.66	5.34
40	0	4.66	5.33
41	0	4.66	5.33
42	0	4.65	5.32
43	0	4.65	5.32
44	0	4.65	5.31
45	0	4.65	5.30
46	0	4.64	5.30
47	0	4.64	5.29
48	0	4.64	5.28
49	0	4.64	5.27
50	0	4.64	5.26
51	0	4.64	5.25
52	0	4.65	5.24
53	0	4.65	5.23
54	0	4.66	5.21
55	0	4.67	5.20
56	0	4.68	5.18
57	0	4.69	5.16
58	0	4.70	5.14
59	0	4.72	5.11
60	0	4.74	5.08
61	0	4.78	5.03
61	30	4.80	5.00
62	0	4.84	4.96
62	8	4.86	4.94
62	16	+ 4.90	+ 4.90

The argument of TABLES IX, X, XI, and XII is the circle setting of the Sun's center, a mean value of the micrometer reading having been applied in forming the tables.

The tabular quantities of TABLES IX and X are *positive* when the conditions are those found at the top of the table; *negative*, when the conditions are those at the bottom.

An arbitrary constant of 5″.00 is added in TABLES XI and XII.

REDUCTION TO MERIDIAN.

Table XIII.

[9-inch Transit Circle.]

Zenith Distance North.	III, V.	II, VI.	I, VII.	II, III, IV, V, VI.	Zenith Distance North.	III, V.	II, VI.	I, VII.	II, III, IV, V, VI.	Zenith Distance North.	III, V.	II, VI.	I, VII.
°	″	″	″	″	°	″	″	″	″	° ′	″	″	″
280	5.04	5.14	5.27	....	340	4.98	4.95	4.89	4.97	40 0	4.77	4.19	3.39
281	5.04	5.13	5.26	....	341	4.98	4.94	4.89	4.97	41 0	4.75	4.11	3.22
282	5.04	5.13	5.26	....	342	4.98	4.94	4.88	4.97	42 0	4.72	4.00	....
283	5.03	5.12	5.25	....	343	4.98	4.94	4.87	4.97	43 0	4.69	3.88	....
284	5.03	5.12	5.24	....	344	4.98	4.93	4.87	4.97	44 0	4.64	3.72	....
285	5.03	5.12	5.23	....	345	4.98	4.93	4.86	4.96	45 0	4.58	3.50	....
286	5.03	5.11	5.22	....	346	4.98	4.93	4.85	4.96	46 0	4.50	3.20	....
287	5.03	5.11	5.21	....	347	4.98	4.92	4.85	4.96	46 30	4.44	....	....
288	5.03	5.10	5.20	....	348	4.98	4.92	4.84	4.96	47 0	4.37	....	....
289	5.03	5.10	5.20	....	349	4.98	4.92	4.83	4.96	47 30	4.28	....	....
290	5.03	5.10	5.19	....	350	4.98	4.91	4.83	4.96	48 0	4.16	....	....
291	5.03	5.09	5.18	5.05	351	4.97	4.91	4.82	4.95	48 10	4.11	....	....
292	5.02	5.09	5.18	5.05	352	4.97	4.91	4.81	....	48 20	4.05	....	...
293	5.02	5.08	5.17	5.04	353	4.97	4.90	4.80	....	48 30	3.99	....	....
294	5.02	5.08	5.16	5.04	354	4.97	4.90	4.80	....	48 40	3.91	....	....
295	5.02	5.08	5.15	5.04	355	4.97	4.89	4.79	....	48 50	3.83	....	....
296	5.02	5.07	5.15	5.04	356	4.97	4.89	4.78	....	49 0	3.73	....	....
297	5.02	5.07	5.14	5.04	357	4.97	4.89	4.77	....	49 10	3.62	....	....
298	5.02	5.07	5.13	5.03	358	4.97	4.88	4.76	....	49 20	3.48	....	....
299	5.02	5.06	5.13	5.03	359	4.97	4.88	4.76	....	49 30	3.31	....	....
300	5.02	5.06	5.12	5.03	0	4.96	4.87	4.75	....	.. ..	....	....	....
301	5.02	5.06	5.11	5.03	1	4.96	4.87	4.74	....	.. ..	....	....	....
302	5.02	5.05	5.11	5.03	2	4.96	4.86	4.73	....	52 30	6.68	....	....
303	5.01	5.05	5.10	5.02	3	4.96	4.86	4.72	....	52 40	6.51	....	....
304	5.01	5.05	5.10	5.02	4	4.96	4.85	4.71	....	52 50	6.37	....	....
305	5.01	5.04	5.09	5.02	5	4.96	4.85	4.70	....	53 0	6.26	....	....
306	5.01	5.04	5.08	5.02	6	4.96	4.84	4.69	....	53 10	6.16	....	....
307	5.01	5.04	5.08	5.02	7	4.95	4.84	4.67	....	53 20	6.08	....	....
308	5.01	5.04	5.07	5.02	8	4.95	4.83	4.66	....	53 30	6.01	....	....
309	5.01	5.03	5.07	5.02	9	4.95	4.82	4.65	....	53 40	5.94	....	....
310	5.01	5.03	5.06	5.02	10	4.95	4.82	4.64	....	53 50	5.89	....	....
311	5.01	5.03	5.06	5.01	11	4.95	4.81	4.63	....	54 0	5.84	....	....
312	5.01	5.03	5.05	5.01	12	4.94	4.80	4.61	....	54 30	5.72	....	....
313	5.01	5.02	5.04	5.01	13	4.94	4.80	4.60	....	55 0	5.63	....	....
314	5.01	5.02	5.04	5.01	14	4.94	4.79	4.58	....	55 30	5.56	....	....
315	5.00	5.02	5.03	5.01	15	4.94	4.78	4.57	....	56 0	5.50	6.80	....
316	5.00	5.01	5.03	5.01	16	4.94	4.78	4.55	....	57 0	5.42	6.50	....
317	5.00	5.01	5.02	5.01	17	4.93	4.77	4.54	....	58 0	5.36	6.28	....
318	5.00	5.01	5.02	5.00	18	4.93	4.76	4.52	....	59 0	5.31	6.12	....
319	5.00	5.01	5.01	5.00	19	4.93	4.75	4.50	....	60 0	5.28	5.99	6.98
320	5.00	5.00	5.01	5.00	20	4.93	4.74	4.48	....	61 0	5.25	5.89	6.78
321	5.00	5.00	5.00	5.00	21	4.92	4.73	4.46	....	62 0	5.23	5.81	6.61
322	5.00	5.00	5.00	5.00	22	4.92	4.72	4.43	....	63 0	5.21	5.74	6.47
323	5.00	5.00	4.99	5.00	23	4.92	4.70	4.41	....	64 0	5.19	5.68	6.36
324	5.00	4.99	4.98	5.00	24	4.91	4.69	4.38	....	65 0	5.18	5.63	6.26
325	5.00	4.99	4.98	4.99	25	4.91	4.67	4.36	....	66 0	5.16	5.59	6.17
326	5.00	4.99	4.97	4.99	26	4.90	4.66	4.33	....	67 0	5.15	5.55	6.09
327	5.00	4.98	4.97	4.99	27	4.90	4.65	4.30	....	68 0	5.14	5.51	6.02
328	4.99	4.98	4.96	4.99	28	4.90	4.63	4.26	....	69 0	5.14	5.48	5.96
329	4.99	4.98	4.96	4.99	29	4.89	4.61	4.22	....	70 0	5.13	5.46	5.91
330	4.99	4.98	4.95	4.99	30	4.88	4.59	4.18	....	71 0	5.12	5.43	5.86
331	4.99	4.97	4.94	4.99	31	4.88	4.57	4.14	....	72 0	5.12	5.41	5.82
332	4.99	4.97	4.94	4.98	32	4.87	4.54	4.09	....	73 0	5.11	5.39	5.78
333	4.99	4.97	4.93	4.98	33	4.86	4.52	4.04	....	74 0	5.10	5.37	5.74
334	4.99	4.96	4.93	4.98	34	4.86	4.48	3.97	....	75 0	5.10	5.35	5.70
335	4.99	4.96	4.92	4.98	35	4.85	4.45	3.91	....	76 0	5.10	5.34	5.67
336	4.99	4.96	4.92	4.98	36	4.84	4.41	3.83	....	77 0	5.09	5.32	5.64
337	4.99	4.96	4.91	4.98	37	4.82	4.37	3.74	....	78 0	5.09	5.31	5.61
338	4.99	4.95	4.90	4.98	38	4.81	4.32	3.64	....	79 0	5.08	5.30	5.59
339	4.99	4.95	4.90	4.97	39	4.79	4.26	3.52	....	80 0	5.08	5.28	5.56

An arbitrary constant of 5″.00 is added in this table, in order to make all the quantities positive.

REDUCTION TO MERIDIAN—Continued.

TABLE XIV.

[9-inch Transit Circle.]

Zenith Distance South.	III, V.	II, VI.	I, VII.	II, III, IV, V, VI.	Zenith Distance South.	III, V.	II, VI.	I, VII.	II, III, IV, V, VI.	Zenith Distance South.	III, V.	II, VI.	I, VII.
°	″	″	″	″	°	″	″	″	″	° ″	″	″	″
80	4.96	4.86	4.73	....	20	5.02	5.05	5.11	5.03	320 0	5.23	5.81	6.61
79	4.96	4.87	4.74	....	19	5.02	5.06	5.11	5.03	319 0	5.25	5.89	6.78
78	4.96	4.87	4.74	....	18	5.02	5.06	5.12	5.03	318 0	5.28	6.00	....
77	4.97	4.88	4.75	....	17	5.02	5.06	5.13	5.03	317 0	5.31	6.12	....
76	4.97	4.88	4.76	....	16	5.02	5.07	5.13	5.03	316 0	5.36	6.28	....
75	4.97	4.88	4.77	....	15	5.02	5.07	5.14	5.04	315 0	5.42	6.50	...
74	4.97	4.89	4.78	....	14	5.02	5.07	5.15	5.04	314 0	5.50	6.80	....
73	4.97	4.89	4.79	....	13	5.02	5.08	5.15	5.04	313 30	5.56	....	....
72	4.97	4.90	4.80	....	12	5.02	5.08	5.16	5.04	313 0	5.63	....	....
71	4.97	4.90	4.80	....	11	5.02	5.08	5.17	5.04	312 30	5.72	....	....
70	4.97	4.90	4.81	....	10	5.02	5.09	5.17	5.04	312 0	5.84	....	....
69	4.97	4.91	4.82	4.95	9	5.03	5.09	5.18	5.05	311 50	5.89	....	....
68	4.98	4.91	4.82	4.95	8	5.03	5.09	5.19	....	311 40	5.95	....	....
67	4.98	4.92	4.83	4.96	7	5.03	5.10	5.20	....	311 30	6.01	....	....
66	4.98	4.92	4.84	4.96	6	5.03	5.10	5.20	....	311 20	6.09	....	....
65	4.98	4.92	4.85	4.96	5	5.03	5.11	5.21	....	311 10	6.17	....	....
64	4.98	4.93	4.85	4.96	4	5.03	5.11	5.22	....	311 0	6.27	....	....
63	4.98	4.93	4.86	4.96	3	5.03	5.11	5.23	....	310 50	6.38	....	....
62	4.98	4.93	4.87	4.97	2	5.03	5.12	5.24	....	310 40	6.52	....	....
61	4.98	4.94	4.87	4.97	1	5.03	5.12	5.24	....	310 30	6.69	....	....
60	4.98	4.94	4.88	4.97	360	5.04	5.13	5.25	....	... ..	....	....	....
59	4.98	4.94	4.89	4.97	359	5.04	5.13	5.26	....	... ..	....	....	....
58	4.98	4.95	4.89	4.97	358	5.04	5.14	5.27	....	307 30	3.32	....	....
57	4.99	4.95	4.90	4.98	357	5.04	5.14	5.28	....	307 20	3.49	....	....
56	4.99	4.95	4.90	4.98	356	5.04	5.15	5.29	....	307 10	3.63	....	....
55	4.99	4.96	4.91	4.98	355	5.04	5.15	5.30	....	307 0	3.74	....	....
54	4.99	4.96	4.92	4.98	354	5.04	5.16	5.31	....	306 50	3.84	....	....
53	4.99	4.96	4.92	4.98	353	5.05	5.16	5.33	....	306 40	3.92	....	....
52	4.99	4.96	4.93	4.98	352	5.05	5.17	5.34	....	306 30	3.99	....	....
51	4.99	4.97	4.93	4.98	351	5.05	5.18	5.35	....	306 20	4.06	....	....
50	4.99	4.97	4.94	4.98	350	5.05	5.18	5.36	....	306 10	4.11	....	....
49	4.99	4.97	4.94	4.99	349	5.05	5.19	5.37	...	306 0	4.16	....	....
48	4.99	4.97	4.95	4.99	348	5.06	5.20	5.39	....	305 30	4.28	....	....
47	4.99	4.98	4.96	4.99	347	5.06	5.20	5.40	....	305 0	4.37	....	....
46	4.99	4.98	4.96	4.99	346	5.06	5.21	5.42	....	304 30	4.44	....	....
45	5.00	4.98	4.97	4.99	345	5.06	5.22	5.43	....	304 0	4.50	3.20	....
44	5.00	4.99	4.97	4.99	344	5.06	5.22	5.45	....	303 0	4.58	3.50	....
43	5.00	4.99	4.98	4.99	343	5.07	5.23	5.46	....	302 0	4.64	3.72	....
42	5.00	4.99	4.98	5.00	342	5.07	5.24	5.48	....	301 0	4.69	3.88	....
41	5.00	4.99	4.99	5.00	341	5.07	5.25	5.50	....	300 0	4.72	4.01	3.02
40	5.00	5.00	4.99	5.00	340	5.07	5.26	5.52	....	299 0	4.75	4.11	3.22
39	5.00	5.00	5.00	5.00	339	5.08	5.27	5.54	....	298 0	4.77	4.19	3.39
38	5.00	5.00	5.00	5.00	338	5.08	5.28	5.57	....	297 0	4.79	4.26	3.53
37	5.00	5.00	5.01	5.00	337	5.08	5.30	5.59	....	296 0	4.81	4.32	3.64
36	5.00	5.01	5.02	5.00	336	5.09	5.31	5.62	....	295 0	4.82	4.37	3.74
35	5.00	5.01	5.02	5.01	335	5.09	5.33	5.64	....	294 0	4.84	4.41	3.83
34	5.00	5.01	5.03	5.01	334	5.10	5.34	5.67	....	293 0	4.85	4.45	3.91
33	5.00	5.02	5.03	5.01	333	5.10	5.35	5.70	....	292 0	4.86	4.49	3.98
32	5.01	5.02	5.04	5.01	332	5.10	5.37	5.74	...	291 0	4.86	4.52	4.04
31	5.01	5.02	5.04	5.01	331	5.11	5.39	5.78	....	290 0	4.87	4.54	4.09
30	5.01	5.02	5.05	5.01	330	5.12	5.41	5.82	....	289 0	4.88	4.57	4.14
29	5.01	5.03	5.06	5.01	329	5.12	5.43	5.86	....	288 0	4.88	4.59	4.18
28	5.01	5.03	5.06	5.02	328	5.13	5.46	5.91	....	287 0	4.89	4.61	4.22
27	5.01	5.03	5.07	5.02	327	5.14	5.48	5.96	....	286 0	4.90	4.63	4.26
26	5.01	5.04	5.07	5.02	326	5.14	5.52	6.03	....	285 0	4.90	4.65	4.30
25	5.01	5.04	5.08	5.02	325	5.15	5.55	6.09	....	284 0	4.90	4.66	4.33
24	5.01	5.04	5.08	5.02	324	5.16	5.59	6.17	....	283 0	4.91	4.68	4.36
23	5.01	5.04	5.09	5.02	323	5.18	5.63	6.26	....	282 0	4.91	4.69	4.39
22	5.01	5.05	5.10	5.02	322	5.19	5.68	6.36	....	281 0	4.92	4.70	4.41
21	5.01	5.05	5.10	5.03	321	5.21	5.74	6.48	....	280 0	4.92	4.72	4.44

An arbitrary constant of 5″.00 is added in this table, in order to make all the quantities positive.

REDUCTION FOR PARALLAX OF AN OBSERVATION OF THE MOON.

TABLE XV.—*Giving Δp for North Limb.*

p_0	Values of π.				
	53′	55′	57′	59′	61′
′	″	″	″	″	″
10	− 0.82	− 0.82	− 0.82	− 0.82	− 0.83
11	0.90	0.90	0.91	0.91	0.91
12	0.98	0.99	0.99	0.99	0.99
13	1.07	1.07	1.07	1.07	1.08
14	1.15	1.15	1.15	1.16	1.16
15	1.23	1.23	1.24	1.24	1.24
16	1.31	1.32	1.32	1.32	1.33
17	1.40	1.40	1.40	1.40	1.41
18	1.48	1.48	1.48	1.49	1.49
19	1.56	1.56	1.57	1.57	1.57
20	1.64	1.65	1.65	1.65	1.66
21	1.72	1.73	1.73	1.74	1.74
22	1.81	1.81	1.81	1.82	1.82
23	1.89	1.89	1.90	1.90	1.91
24	1.97	1.97	1.98	1.98	1.99
25	2.05	2.06	2.06	2.07	2.07
26	2.13	2.14	2.14	2.15	2.15
27	2.22	2.22	2.23	2.23	2.24
28	2.30	2.30	2.31	2.31	2.32
29	2.38	2.38	2.39	2.40	2.40
30	2.46	2.47	2.47	2.48	2.48
31	2.54	2.55	2.56	2.56	2.57
32	2.62	2.63	2.64	2.64	2.65
33	2.71	2.71	2.72	2.73	2.73
34	2.79	2.79	2.80	2.81	2.81
35	2.87	2.88	2.88	2.89	2.90
36	2.95	2.96	2.96	2.97	2.98
37	3.03	3.04	3.04	3.05	3.06
38	3.11	3.12	3.13	3.14	3.14
39	3.19	3.20	3.21	3.22	3.22
40	3.27	3.28	3.29	3.30	3.31
41	3.35	3.36	3.37	3.38	3.39
42	3.43	3.44	3.45	3.46	3.47
43	3.51	3.52	3.53	3.54	3.55
44	3.59	3.60	3.61	3.62	3.63
45	3.67	3.68	3.69	3.70	3.71
46	3.75	3.76	3.77	3.78	3.79
47	3.83	3.84	3.85	3.86	3.87
48	3.91	3.92	3.93	3.94	3.95
49	3.99	4.00	4.01	4.02	4.03
50	4.07	4.08	4.09	4.10	4.11
51	4.15	4.16	4.17	4.18	4.19
52	4.23	4.24	4.25	4.26	4.27
53	4.31	4.32	4.33	4.34	4.35
54	4.39	4.40	4.41	4.42	4.43
55	− 4.46	− 4.48	− 4.49	− 4.50	− 4.51

TABLE XVI.—*Giving Δp for South Limb.*

p_0	Values of π.		
	53′	57′	61′
′	″	″	″
10	− 0.81	− 0.82	− 0.82
11	0.89	0.90	0.90
12	0.97	0.98	0 98
13	1.05	1.06	1.06
14	1.14	1.14	1.14
15	1.22	1.22	1.22
16	1.30	1.30	1.30
17	1.37	1.38	1.38
18	1.45	1.46	1.46
19	1.53	1.54	1.54
20	1.61	1.62	1.62
21	1.69	1.70	1.70
22	1.77	1.78	1.78
23	1.85	1.86	1.86
24	1.93	1.93	1.94
25	2.01	2.01	2.02
26	2.08	2.09	2.10
27	2.16	2.17	2.17
28	2.24	2.25	2.25
29	2.32	2.32	2.33
30	2.40	2.40	2.41
31	2.47	2.48	2.49
32	2.55	2.56	2.56
33	2.63	2.63	2.64
34	2.70	2.71	2.72
35	2.78	2.79	2.79
36	2.86	2.86	2.87
37	2.93	2.94	2.94
38	3.01	3.01	3.02
39	3.08	3.09	3.10
40	3.15	3.16	3.17
41	3.23	3.24	3.24
42	3.30	3.31	3.32
43	3.38	3.39	3.39
44	3.45	3.46	3.47
45	3.53	3.53	3.54
46	3.60	3.61	3.62
47	3.67	3.68	3.69
48	3.74	3.75	3.76
49	3.82	3.82	3.83
50	3.89	3.89	3.90
51	3.96	3.97	3.98
52	4.03	4.04	4.05
53	4.10	4.11	4.12
54	4.17	4.18	4.19
55	− 4.24	− 4.25	− 4.26

PRECEPTS FOR USING TABLES XV AND XVI.

Take from the American Ephemeris, for the date of observation,

π = the Moon's equatorial horizontal parallax at the time of transit;
s = the Moon's geocentric semidiameter at the same instant.

Let

z_0 = the observed zenith distance of the Moon's limb, including every correction but that for parallax.

Compute

$$\left.\begin{aligned} \delta_0 &= \varphi \pm z_0, \\ z &= \mp z_0 - 11' \, 24'', \\ p_0 &= \pi \sin z, \end{aligned}\right\} \begin{cases} \text{the upper sign for zenith distance north.} \\ \text{the lower sign for zenith distance south.} \end{cases}$$

Then, with p_0 and π as arguments, take from either Table XV or XVI, the value of $\varDelta p$, and form

$$p_1 = p_0 + \varDelta p.$$

Denoting by δ the required geocentric declination of the Moon's center at the instant of transit, we have

$$\delta = \delta_0 + (p_1 \mp s) \begin{cases} -, \text{ when the north limb was observed.} \\ +, \text{ when the south limb was observed.} \end{cases}$$

Tables XV and XVI and the above formulæ are based upon CLARK'S spheroid of 1866.

REDUCTION FOR PARALLAX OF AN OBSERVATION OF THE SUN OR A PLANET.

TABLE XVII.

Sun. $\pi_0 = 8''.80$		Z. D. S.	Z. D. N.	Horizontal Parallax of the Planets.																Z. D. N.	Z. D. S.
				″ 3.0	″ 4.0	″ 5.0	″ 6.0	″ 7.0	″ 8.0	″ 9.0	″ 10.0	″ 11.0	″ 12.0	″ 13.0	″ 14.0	″ 15.0	″ 16.0	″ 17.0	″ 18.0		
		°	°																	°	°
		10	350	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70	1.87	2.04	2.21	2.38	2.55	2.72	2.89	3.06	350	10
June 22 to Dec. 22.	Dec. 22 to June 22.	11	349	0.56	0.75	0.94	1.12	1.31	1.50	1.69	1.87	2.06	2.25	2.44	2.62	2.81	3.00	3.19	3.37	349	11
		12	348	0.61	0.82	1.02	1.23	1.43	1.64	1.84	2.04	2.25	2.45	2.66	2.86	3.07	3.27	3.48	3.68	348	12
		13	347	0.66	0.89	1.11	1.33	1.55	1.77	1.99	2.21	2.44	2.66	2.88	3.10	3.32	3.54	3.76	3.98	347	13
		14	346	0.72	0.95	1.19	1.43	1.67	1.91	2.15	2.38	2.62	2.86	3.10	3.34	3.58	3.81	4.05	4.29	346	14
″	″																				
2.21	2.21	15	345	0.77	1.02	1.28	1.53	1.79	2.04	2.30	2.55	2.81	3.06	3.32	3.57	3.83	4.09	4.34	4.60	345	15
2.36	2.36	16	344	0.82	1.09	1.36	1.63	1.90	2.18	2.45	2.72	2.99	3.26	3.54	3.81	4.08	4.35	4.62	4.90	344	16
2.50	2.50	17	343	0.87	1.16	1.44	1.73	2.02	2.31	2.60	2.89	3.18	3.47	3.76	4.05	4.33	4.62	4.91	5.20	343	17
2.64	2.65	18	342	0.92	1.22	1.53	1.83	2.14	2.44	2.75	3.06	3.36	3.67	3.97	4.28	4.58	4.89	5.19	5.50	342	18
2.79	2.79	19	341	0.97	1.29	1.61	1.93	2.25	2.58	2.90	3.22	3.54	3.86	4.19	4.51	4.83	5.15	5.47	5.80	341	19
2.93	2.94	20	340	1.02	1.35	1.69	2.03	2.37	2.71	3.05	3.39	3.72	4.06	4.40	4.74	5.08	5.42	5.76	6.09	340	20
3.07	3.08	21	339	1.06	1.42	1.77	2.13	2.48	2.84	3.19	3.55	3.90	4.26	4.61	4.97	5.32	5.68	6.03	6.39	339	21
3.22	3.23	22	338	1.11	1.48	1.86	2.23	2.60	2.97	3.34	3.71	4.08	4.45	4.83	5.20	5.57	5.94	6.31	6.68	338	22
3.36	3.37	23	337	1.16	1.55	1.94	2.32	2.71	3.10	3.48	3.87	4.26	4.64	5.03	5.42	5.81	6.19	6.58	6.97	337	23
3.50	3.52	24	336	1.21	1.61	2.02	2.42	2.82	3.22	3.63	4.03	4.43	4.84	5.24	5.64	6.05	6.45	6.85	7.26	336	24
3.64	3.66	25	335	1.26	1.68	2.10	2.51	2.93	3.35	3.77	4.19	4.61	5.03	5.45	5.87	6.29	6.71	7.12	7.54	335	25
3.78	3.80	26	334	1.30	1.74	2.17	2.61	3.04	3.48	3.91	4.35	4.78	5.22	5.65	6.09	6.52	6.96	7.39	7.83	334	26
3.92	3.94	27	333	1.35	1.80	2.25	2.70	3.15	3.60	4.05	4.51	4.96	5.41	5.86	6.31	6.76	7.21	7.66	8.11	333	27
4.05	4.07	28	332	1.40	1.86	2.33	2.79	3.26	3.73	4.19	4.66	5.13	5.59	6.06	6.53	6.99	7.45	7.92	8.39	332	28
4.19	4.21	29	331	1.44	1.92	2.41	2.89	3.37	3.85	4.33	4.81	5.29	5.77	6.25	6.74	7.22	7.70	8.18	8.66	331	29
4.33	4.35	30	330	1.49	1.98	2.48	2.98	3.47	3.97	4.47	4.96	5.46	5.96	6.45	6.95	7.44	7.94	8.44	8.93	330	30
4.46	4.48	31	329	1.54	2.05	2.56	3.07	3.58	4.09	4.60	5.12	5.63	6.14	6.65	7.16	7.67	8.19	8.70	9.21	329	31
4.60	4.62	32	328	1.58	2.10	2.63	3.16	3.68	4.21	4.74	5.26	5.79	6.32	6.84	7.37	7.89	8.42	8.95	9.47	328	32
4.73	4.75	33	327	1.62	2.16	2.71	3.25	3.79	4.33	4.87	5.41	5.95	6.49	7.03	7.58	8.12	8.66	9.20	9.74	327	33
4.86	4.89	34	326	1.67	2.22	2.78	3.33	3.89	4.45	5.00	5.56	6.11	6.67	7.23	7.78	8.34	8.89	9.45	10.00	326	34
4.99	5.02	35	325	1.71	2.28	2.85	3.42	3.99	4.56	5.13	5.70	6.27	6.84	7.41	7.98	8.55	9.12	9.69	10.26	325	35
5.11	5.15	36	324	1.75	2.34	2.92	3.51	4.09	4.68	5.26	5.84	6.43	7.01	7.60	8.18	8.77	9.35	9.94	10.52	324	36
5.24	5.27	37	323	1.80	2.39	2.99	3.59	4.19	4.79	5.38	5.98	6.58	7.18	7.78	8.38	8.97	9.57	10.17	10.77	323	37
5.36	5.40	38	322	1.84	2.45	3.06	3.67	4.28	4.90	5.51	6.12	6.73	7.35	7.96	8.57	9.18	9.79	10.41	11.02	322	38
5.49	5.52	39	321	1.88	2.50	3.13	3.76	4.38	5.01	5.63	6.26	6.88	7.51	8.14	8.76	9.39	10.01	10.64	11.27	321	39
5.61	5.65	40	320	1.92	2.56	3.20	3.84	4.48	5.12	5.76	6.39	7.03	7.67	8.31	8.95	9.59	10.23	10.87	11.51	320	40
5.73	5.77	41	319	1.96	2.61	3.26	3.92	4.57	5.22	5.88	6.53	7.18	7.83	8.49	9.14	9.79	10.44	11.10	11.75	319	41
5.85	5.89	42	318	2.00	2.66	3.33	3.99	4.66	5.33	5.99	6.66	7.32	7.99	8.65	9.32	9.98	10.65	11.32	11.98	318	42
5.96	6.00	43	317	2.04	2.71	3.39	4.07	4.75	5.43	6.11	6.79	7.47	8.14	8.82	9.50	10.18	10.86	11.54	12.22	317	43
6.08	6.12	44	316	2.07	2.76	3.46	4.15	4.84	5.53	6.22	6.91	7.60	8.29	8.99	9.68	10.37	11.06	11.75	12.44	316	44
6.20	6.24	45	315	2.11	2.81	3.52	4.22	4.93	5.63	6.33	7.04	7.74	8.45	9.15	9.85	10.56	11.26	11.96	12.67	315	45
6.31	6.35	46	314	2.15	2.86	3.58	4.30	5.01	5.73	6.45	7.16	7.88	8.59	9.31	10.03	10.74	11.46	12.18	12.89	314	46
6.42	6.46	47	313	2.18	2.91	3.64	4.37	5.09	5.82	6.55	7.28	8.01	8.74	9.47	10.19	10.92	11.65	12.38	13.11	313	47
6.53	6.57	48	312	2.22	2.96	3.70	4.44	5.18	5.92	6.66	7.40	8.14	8.88	9.62	10.36	11.10	11.84	12.58	13.32	312	48
6.64	6.68	49	311	2.25	3.00	3.76	4.51	5.26	6.01	6.76	7.51	8.27	9.02	9.77	10.52	11.27	12.02	12.77	13.52	311	49
6.75	6.79	50	310	2.29	3.05	3.82	4.58	5.34	6.10	6.87	7.63	8.39	9.16	9.92	10.68	11.44	12.21	12.97	13.73	310	50
6.85	6.89	51	309	2.32	3.10	3.87	4.64	5.42	6.19	6.97	7.74	8.51	9.29	10.06	10.83	11.61	12.38	13.16	13.93	309	51
6.95	6.99	52	308	2.35	3.14	3.92	4.71	5.49	6.28	7.06	7.85	8.63	9.42	10.20	10.99	11.77	12.56	13.34	14.13	308	52
7.05	7.08	53	307	2.39	3.18	3.98	4.77	5.57	6.36	7.16	7.96	8.75	9.55	10.34	11.14	11.93	12.73	13.53	14.32	307	53
7.15	7.18	54	306	2.42	3.22	4.03	4.84	5.64	6.45	7.25	8.06	8.86	9.67	10.48	11.28	12.09	12.89	13.70	14.51	306	54
7.25	7.28	55	305	2.45	3.26	4.08	4.90	5.71	6.53	7.34	8.16	8.98	9.79	10.61	11.43	12.24	13.06	13.87	14.69	305	55
7.34	7.37	56	304	2.48	3.30	4.13	4.96	5.78	6.61	7.43	8.26	9.09	9.91	10.74	11.56	12.39	13.22	14.04	14.87	304	56
7.43	7.46	57	303	2.51	3.34	4.18	5.01	5.85	6.69	7.52	8.36	9.19	10.03	10.86	11.70	12.53	13.37	14.21	15.04	303	57
7.52	7.54	58	302	2.54	3.38	4.23	5.07	5.92	6.76	7.61	8.45	9.30	10.14	10.99	11.83	12.68	13.52	14.37	15.21	302	58
7.61	7.63	59	301	2.56	3.42	4.27	5.13	5.98	6.83	7.69	8.54	9.40	10.25	11.10	11.96	12.81	13.67	14.52	15.38	301	59
7.70	7.72	60	300	2.59	3.45	4.32	5.18	6.04	6.90	7.77	8.63	9.49	10.36	11.22	12.08	12.95	13.81	14.67	15.54	300	60
7.79	7.80	61	299	2.62	3.49	4.36	5.23	6.10	6.97	7.85	8.72	9.59	10.46	11.33	12.21	13.08	13.95	14.82	15.69	299	61
7.87	7.88	62	298	2.64	3.52	4.40	5.28	6.16	7.04	7.92	8.80	9.68	10.56	11.44	12.32	13.20	14.08	14.96	15.84	298	62
7.95	7.95	63	297	2.66	3.56	4.44	5.33	6.22	7.11	7.99	8.88	9.77	10.66	11.55	12.44	13.32	14.21	15.10	15.99	297	63
		64	296	2.69	3.59	4.48	5.38	6.27	7.17	8.06	8.96	9.86	10.75	11.65	12.54	13.44	14.34	15.23	16.13	296	64
		65	295	2.71	3.62	4.52	5.42	6.32	7.23	8.13	9.03	9.94	10.84	11.74	12.65	13.55	14.46	15.36	16.26	295	65
		66	294	2.73	3.64	4.55	5.46	6.38	7.29	8.20	9.11	10.02	10.93	11.84	12.75	13.66	14.57	15.48	16.39	294	66
June 22 to Dec. 22.	Dec. 22 to June 22.	67	293	2.75	3.67	4.59	5.51	6.43	7.34	8.26	9.18	10.09	11.02	11.93	12.85	13.77	14.69	15.60	16.52	293	67
		68	292	2.77	3.70	4.62	5.55	6.47	7.40	8.32	9.25	10.17	11.10	12.02	12.95	13.87	14.80	15.72	16.64	292	68
		69	291	2.79	3.72	4.65	5.59	6.52	7.45	8.38	9.31	10.24	11.17	12.10	13.03	13.96	14.90	15.83	16.76	291	69
		70	290	2.81	3.75	4.67	5.62	6.56	7.50	8.44	9.37	10.31	11.25	12.18	13.12	14.05	15.00	15.93	16.87	290	70
				″ 3.0	″ 4.0	″ 5.0	″ 6.0	″ 7.0	″ 8.0	″ 9.0	″ 10.0	″ 11.0	″ 12.0	″ 13.0	″ 14.0	″ 15.0	″ 16.0	″ 17.0	″ 18.0		

REDUCTION FOR PARALLAX OF AN OBSERVATION OF THE SUN OR A PLANET

TABLE XVII—Continued.

Z. D. S.	Z. D. N.	Horizontal Parallax of the Planets.																		Z. D. N.	Z. D. S.
		″ 18.0	″ 19.0	″ 20.0	″ 21.0	″ 22.0	″ 23.0	″ 24.0	″ 25.0	″ 26.0	″ 27.0	″ 28.0	″ 29.0	″ 30.0	″ 31.0	″ 32.0	″ 33.0	″ 34.0	″ 35.0		
°	°																			°	°
10	350	3.06	3.23	3.40	3.57	3.74	3.91	4.08	4.25	4.42	4.59	4.76	4.93	5.11	5.28	5.45	5.62	5.79	5.96	350	10
11	349	3.37	3.56	3.75	3.94	4.12	4.31	4.50	4.68	4.87	5.06	5.25	5.43	5.62	5.81	6.00	6.18	6.37	6.56	349	11
12	348	3.68	3.88	4.09	4.29	4.50	4.70	4.91	5.11	5.31	5.52	5.72	5.93	6.13	6.34	6.54	6.75	6.95	7.15	348	12
13	347	3.98	4.21	4.43	4.65	4.87	5.09	5.31	5.53	5.76	5.98	6.20	6.42	6.64	6.86	7.08	7.31	7.53	7.75	347	13
14	346	4.29	4.53	4.77	5.01	5.24	5.48	5.72	5.96	6.20	6.44	6.68	6.91	7.15	7.39	7.63	7.87	8.10	8.34	346	14
15	345	4.60	4.85	5.11	5.36	5.61	5.87	6.12	6.38	6.63	6.89	7.15	7.41	7.66	7.91	8.17	8.42	8.68	8.93	345	15
16	344	4.90	5.17	5.44	5.71	5.98	6.26	6.53	6.80	7.07	7.34	7.62	7.89	8.16	8.43	8.71	8.98	9.25	9.52	344	16
17	343	5.20	5.49	5.78	6.07	6.36	6.64	6.93	7.22	7.51	7.80	8.09	8.38	8.66	8.95	9.24	9.53	9.82	10.11	343	17
18	342	5.50	5.80	6.11	6.42	6.72	7.03	7.33	7.64	7.94	8.25	8.55	8.86	9.16	9.47	9.78	10.08	10.39	10.69	342	18
19	341	5.80	6.12	6.44	6.76	7.08	7.41	7.73	8.05	8.37	8.69	9.02	9.34	9.66	9.98	10.30	10.63	10.95	11.27	341	19
20	340	6.09	6.43	6.77	7.11	7.45	7.79	8.13	8.46	8.80	9.14	9.48	9.82	10.16	10.50	10.84	11.17	11.51	11.85	340	20
21	339	6.39	6.74	7.10	7.45	7.81	8.16	8.52	8.87	9.22	9.58	9.93	10.29	10.64	11.00	11.35	11.71	12.06	12.42	339	21
22	338	6.68	7.05	7.42	7.80	8.17	8.54	8.91	9.28	9.65	10.02	10.39	10.76	11.13	11.51	11.88	12.25	12.62	12.99	338	22
23	337	6.97	7.35	7.74	8.13	8.52	8.90	9.29	9.68	10.06	10.45	10.84	11.23	11.61	12.00	12.39	12.77	13.16	13.55	337	23
24	336	7.26	7.66	8.06	8.47	8.87	9.27	9.67	10.08	10.48	10.88	11.29	11.69	12.09	12.50	12.90	13.30	13.70	14.11	336	24
25	335	7.54	7.96	8.38	8.80	9.22	9.64	10.06	10.48	10.90	11.32	11.73	12.15	12.57	12.99	13.41	13.83	14.25	14.67	335	25
26	334	7.83	8.26	8.70	9.13	9.57	10.00	10.44	10.88	11.31	11.74	12.18	12.61	13.05	13.48	13.92	14.35	14.79	15.22	334	26
27	333	8.11	8.56	9.01	9.46	9.91	10.36	10.81	11.26	11.71	12.16	12.61	13.06	13.51	13.97	14.42	14.87	15.32	15.77	333	27
28	332	8.39	8.85	9.32	9.78	10.25	10.71	11.18	11.65	12.11	12.58	13.05	13.51	13.97	14.44	14.91	15.37	15.84	16.30	332	28
29	331	8.66	9.14	9.62	10.10	10.59	11.07	11.55	12.03	12.51	12.99	13.47	13.95	14.44	14.92	15.40	15.88	16.36	16.84	331	29
30	330	8.93	9.43	9.92	10.42	10.92	11.41	11.91	12.41	12.90	13.40	13.90	14.39	14.89	15.39	15.88	16.38	16.87	17.37	330	30
31	329	9.21	9.72	10.23	10.74	11.26	11.76	12.28	12.79	13.30	13.81	14.32	14.83	15.35	15.86	16.37	16.88	17.39	17.90	329	31
32	328	9.47	10.00	10.53	11.05	11.58	12.10	12.63	13.16	13.68	14.21	14.74	15.26	15.79	16.32	16.84	17.37	17.90	18.42	328	32
33	327	9.74	10.28	10.82	11.36	11.90	12.45	12.99	13.53	14.07	14.61	15.15	15.69	16.23	16.77	17.31	17.86	18.40	18.94	327	33
34	326	10.00	10.56	11.12	11.67	12.23	12.79	13.34	13.90	14.45	15.01	15.56	16.12	16.67	17.23	17.78	18.34	18.90	19.45	326	34
35	325	10.26	10.83	11.40	11.97	12.54	13.11	13.68	14.25	14.82	15.39	15.96	16.53	17.10	17.67	18.24	18.81	19.38	19.95	325	35
36	324	10.52	11.11	11.69	12.27	12.86	13.44	14.03	14.61	15.20	15.78	16.36	16.95	17.53	18.12	18.70	19.29	19.87	20.46	324	36
37	323	10.77	11.37	11.97	12.56	13.16	13.76	14.36	14.96	15.56	16.15	16.75	17.35	17.95	18.55	19.15	19.75	20.35	20.95	323	37
38	322	11.02	11.63	12.24	12.85	13.47	14.08	14.69	15.30	15.91	16.53	17.14	17.75	18.36	18.98	19.59	20.20	20.81	21.43	322	38
39	321	11.27	11.89	12.52	13.14	13.77	14.40	15.02	15.65	16.27	16.90	17.53	18.15	18.78	19.40	20.03	20.65	21.28	21.91	321	39
40	320	11.51	12.15	12.79	13.43	14.07	14.71	15.35	15.99	16.63	17.27	17.91	18.54	19.18	19.82	20.46	21.10	21.74	22.38	320	40
41	319	11.75	12.40	13.05	13.71	14.36	15.01	15.67	16.32	16.97	17.62	18.28	18.93	19.58	20.24	20.89	21.54	22.19	22.85	319	41
42	318	11.98	12.65	13.31	13.98	14.64	15.31	15.98	16.64	17.31	17.97	18.64	19.30	19.97	20.64	21.30	21.97	22.63	23.30	318	42
43	317	12.22	12.90	13.57	14.25	14.93	15.61	16.29	16.97	17.65	18.32	19.00	19.68	20.36	21.04	21.72	22.40	23.07	23.75	317	43
44	316	12.44	13.13	13.83	14.52	15.21	15.90	16.59	17.28	17.97	18.66	19.35	20.05	20.74	21.43	22.12	22.81	23.50	24.19	316	44
45	315	12.67	13.37	14.08	14.78	15.48	16.19	16.89	17.60	18.30	19.00	19.71	20.41	21.11	21.82	22.52	23.22	23.93	24.63	315	45
46	314	12.89	13.61	14.32	15.04	15.76	16.47	17.19	17.91	18.62	19.34	20.05	20.77	21.48	22.20	22.92	23.63	24.35	25.06	314	46
47	313	13.11	13.83	14.56	15.29	16.02	16.75	17.47	18.20	18.93	19.66	20.39	21.11	21.84	22.57	23.30	24.03	24.76	25.48	313	47
48	312	13.32	14.06	14.80	15.54	16.28	17.02	17.76	18.50	19.24	19.98	20.72	21.46	22.20	22.94	23.68	24.42	25.16	25.90	312	48
49	311	13.52	14.27	15.03	15.78	16.53	17.28	18.03	18.78	19.54	20.29	21.04	21.79	22.54	23.29	24.05	24.80	25.55	26.30	311	49
50	310	13.73	14.49	15.26	16.02	16.79	17.55	18.31	19.08	19.84	20.60	21.36	22.12	22.89	23.65	24.42	25.18	25.94	26.70	310	50
51	309	13.93	14.70	15.48	16.25	17.03	17.80	18.57	19.35	20.12	20.90	21.67	22.44	23.22	23.99	24.77	25.54	26 31	27.09	309	51
52	308	14.13	14.91	15.70	16.48	17.27	18.05	18.84	19.62	20.40	21.19	21.97	22.76	23.54	24.33	25.11	25.90	26.68	27.47	308	52
53	307	14.32	15.12	15.91	16.71	17.50	18.30	19.09	19.89	20.68	21.48	22.28	23.07	23.87	24.66	25.45	26.25	27.05	27.85	307	53
54	306	14.51	15.31	16.12	16.92	17.73	18.54	19.34	20.15	20.95	21.76	22.57	23.37	24.18	24.98	25.79	26.59	27.40	28.21	306	54
55	305	14.69	15.51	16.32	17.14	17.95	18.77	19.59	20.40	21.22	22.03	22.85	23.66	24.48	25.30	26.12	26.93	27.75	28.56	305	55
56	304	14.87	15.69	16.52	17.35	18.17	19.00	19.82	20.65	21.47	22.30	23.13	23.95	24.78	25.60	26.43	27.26	28.08	28.91	304	56
57	303	15.04	15.88	16.71	17.55	18.39	19.22	20.06	20.89	21.73	22.56	23.40	24.24	25.07	25.90	26.74	27.58	28.41	29.25	303	57
58	302	15.21	16.06	16.90	17.75	18.59	19.44	20.28	21.13	21.97	22.82	23.66	24.51	25.35	26.20	27.04	27.89	28.73	29.58	302	58
59	301	15.38	16.23	17.08	17.94	18.79	19.65	20.50	21.36	22.21	23.07	23.92	24.77	25.63	26.49	27.34	28.19	29.04	29.90	301	59
60	300	15.54	16.40	17.26	18.13	18.99	19.85	20.71	21.58	22.44	23.30	24.17	25.03	25.89	26.76	27.62	28.48	29.34	30.21	300	60
61	299	15.69	16.56	17.44	18.31	19.18	20.05	20.92	21.80	22.67	23.54	24.41	25.28	26.15	27.03	27.90	28.77	29.64	30.51	299	61
62	298	15.84	16.72	17.60	18.48	19.36	20.24	21.12	22.00	22.88	23.76	24.64	25.52	26.41	27.29	28.17	29.05	29.93	30.80	298	62
63	297	15.99	16.88	17.76	18.65	19.54	20.43	21.32	22.20	23.09	23.98	24.87	25.76	26.65	27.54	28.43	29.32	30.20	31.09	297	63
64	296	16.13	17.03	17.92	18.82	19.71	20.61	21.51	22.40	23.29	24.19	25.09	25.99	26.88	27.78	28.68	29.57	30.47	31.36	296	64
65	295	16.26	17.17	18.07	18.97	19.88	20.78	21.68	22.59	23.49	24.39	25.30	26.20	27.11	28.01	28.91	29.81	30.72	31.62	295	65
66	294	16.39	17.31	18.22	19.13	20.04	20.95	21.86	22.77	23.68	24.59	25.50	26.41	27.33	28.23	29.14	30.05	30.96	31.88	294	66
67	293	16.52	17.44	18.36	19.28	20.19	21.11	22.03	22.95	23.87	24.78	25.70	26.62	27.54	28.45	29.37	30.29	31.21	32.13	293	67
68	292	16.64	17.57	18.49	19.42	20.34	21.27	22.19	23.12	24.04	24.97	25.89	26.82	27.74	28.66	29.59	30.52	31.44	32.37	292	68
69	291	16.76	17.69	18.62	19.55	20.48	21.41	22.34	23.28	24.21	25.14	26.07	27.00	27.93	28.86	29.79	30.73	31.66	32.59	291	69
70	290	16.87	17.81	18.75	19.68	20.62	21.56	22.49	23.43	24.37	25.30	26.24	27.18	28.12	29.05	29.99	30.93	31.87	32.81	290	70
		″ 18.0	″ 19.0	″ 20.0	″ 21.0	″ 22.0	″ 23.0	″ 24.0	″ 25.0	″ 26.0	″ 27.0	″ 28.0	″ 29.0	″ 30.0	″ 31.0	″ 32.0	″ 33.0	″ 34.0	″ 35.0		

REDUCTION FOR DEFECTIVE ILLUMINATION OF AN OBSERVATION OF THE MOON'S RIGHT ASCENSION.

TABLE XVIII.—*Giving f.*

H	$\delta_\odot$						
	0°	4°	8°	12°	16°	20°	24°
m							
0.0	0	0	0	0	0	0	0
0.5	0	0	0	0	0	0	0
1.0	1	1	1	1	1	1	1
1.5	3	3	3	3	3	3	3
2.0	6	6	6	6	6	5	5
2.5	9	9	9	9	8	8	8
3.0	13	13	13	12	12	11	11
3.5	18	18	18	17	17	16	15
4.0	23	23	23	22	21	20	19
4.5	29	29	28	28	27	26	24
5.0	36	36	35	34	33	32	30
5.5	43	43	42	41	40	38	36
6.0	51	51	50	49	47	45	43
6.5	60	60	59	57	55	53	50
7.0	70	70	69	67	65	62	58
7.5	80	80	79	77	74	71	67
8.0	91	91	89	87	84	80	76
8.5	103	102	101	99	95	91	86
9.0	116	115	114	111	107	102	97
9.5	129	128	126	123	119	114	108
10.0	143	142	140	137	132	126	119
10.5	158	157	155	151	146	139	132
11.0	173	172	170	166	160	153	144
11.5	189	188	185	181	175	167	158
12.0	206	205	202	197	190	182	172

TABLE XIX.—*Giving $\Delta\tau$.*

f	τ				
	s 60	s 65	s 70	s 75	s 80
	s	s	s	s	s
0	0.000	0.000	0.000	0.000	0.000
10	0.004	0.004	0.005	0.005	0.005
20	0.008	0.009	0.009	0.010	0.011
30	0.012	0.013	0.014	0.015	0.016
40	0.016	0.017	0.019	0.020	0.021
50	0.020	0.022	0.023	0.025	0.027
60	0.024	0.026	0.028	0.030	0.032
70	0.028	0.030	0.033	0.035	0.037
80	0.032	0.035	0.037	0.040	0.043
90	0.036	0.039	0.042	0.045	0.048
100	0.040	0.043	0.047	0.050	0.053
110	0.044	0.048	0.051	0.055	0.059
120	0.048	0.052	0.056	0.060	0.064
130	0.052	0.056	0.061	0.065	0.069
140	0.056	0.061	0.065	0.070	0.075
150	0.060	0.065	0.070	0.075	0.080
160	0.064	0.069	0.075	0.080	0.085
170	0.068	0.074	0.079	0.085	0.091
180	0.072	0.078	0.084	0.090	0.096
190	0.076	0.082	0.089	0.095	0.101
200	0.080	0.087	0.093	0.100	0.107
210	0.084	0.091	0.098	0.105	0.112

PRECEPTS FOR USING TABLES XVIII AND XIX.

Take from the American Ephemeris, for the date of observation,

$\delta_{\odot}$=the Sun's declination at the time of the Moon's transit;
E_{a}=the equation of time for apparent noon;
T=the mean time of the Moon's transit;
τ=the sidereal time of the Moon's semidiameter passing the meridian.

Then

$A=T-E_{a}$=the apparent time of the Moon's transit;
$H=12^{h}\sim A$=the difference between A and 12 hours, in minutes of time, without regard to sign;
D=the difference between the observed right ascension of the Moon's first and second limbs.

Enter TABLE XVIII with the arguments H and $\delta_{\odot}$, and take out f. Then from TABLE XIX, with f and τ as arguments, take out $\Delta\tau$, the required correction for defective illumination.

Since the table gives thousandths of a second of time, whereas only hundredths are actually required, the greatest final accuracy will be attained by observing the following rule:

Adopt as the actual value of $\Delta\tau$ the nearest even hundredth of a second when D is even, and the nearest odd hundredth when D is odd.

The observed sidereal time of the Moon's semidiameter passing the meridian is given by the formula

$$\tau_{o}=\tfrac{1}{2}(D+\Delta\tau).$$

Limb I is defective when $A>12^{h}$; Limb II, when $A<12^{h}$.

REDUCTION FOR DEFECTIVE ILLUMINATION OF AN OBSERVATION OF THE MOON'S DECLINATION.

TABLE XX.—*Giving K.*

$\pm\delta_{☾}$	$\pm E$																											
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°
0°	160	160																										
1	160	160	160																									
2	160	160	160	161																								
3	159	159	159	160	161																							
4	158	158	158	159	160	161																						
5	157	157	157	158	159	160	162																					
6	155	155	155	156	157	158	160	162																				
7	153	153	153	154	155	156	158	160	163																			
8	150	150	150	151	152	153	155	157	160	163																		
9	147	147	147	148	149	150	152	154	157	160	163																	
10	144	144	144	145	146	147	149	151	154	157	160	163																
11	141	141	141	142	143	144	146	148	151	154	157	160	163															
12	138	138	138	139	140	141	143	145	148	151	154	157	160	164														
13	134	134	134	135	136	137	139	141	144	147	150	153	156	160	164													
14	130	130	130	131	132	133	135	137	140	143	146	149	152	156	160	164												
15	126	126	126	127	128	129	131	133	135	138	141	144	148	152	156	160	165											
16	121	121	121	122	123	124	126	128	130	133	136	139	143	147	151	155	160	165										
17	116	116	116	117	118	119	121	123	125	128	131	134	138	142	146	150	155	160	165									
18	111	111	111	112	113	114	116	118	120	123	126	129	133	137	141	145	150	155	160	166								
19	106	106	106	107	108	109	111	113	115	118	121	124	127	131	135	139	144	149	154	160	166							
20	100	100	100	101	102	103	105	107	109	112	115	118	121	125	129	133	138	143	148	154	160	166						
21	94	94	94	95	96	97	99	101	103	106	109	112	115	119	123	127	132	137	142	148	154	160	167					
22	88	88	88	89	90	91	93	95	97	99	102	105	108	112	116	120	125	130	135	141	147	153	160	167				
23	81	81	81	82	83	84	86	88	90	92	95	98	101	105	109	113	118	123	128	134	140	146	153	160	167			
24	74	74	74	75	76	77	79	81	83	85	88	91	94	98	102	106	111	116	121	127	133	139	146	153	160	168		
25	67	67	67	68	69	70	72	74	76	78	81	84	87	91	95	99	103	108	113	119	125	131	138	145	152	160	168	
26	59	59	59	60	61	62	64	66	68	70	73	76	79	83	87	91	95	100	105	111	117	123	130	137	144	152	160	169
27	51	51	51	52	53	54	56	58	60	62	65	68	71	75	79	83	87	92	97	103	109	115	121	128	135	143	151	160
28	43	43	43	44	45	46	48	50	52	54	57	60	63	67	71	75	79	84	89	94	100	106	112	119	126	134	142	151
29	35	35	35	36	37	38	40	42	44	46	49	52	55	58	62	66	70	75	80	85	91	97	103	110	117	125	133	142

TABLE XXI.—*Giving x.*

$\delta_{\odot}-E$	K													
	30	40	50	60	70	80	90	100	110	120	130	140	150	160
° ′														
0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
± 10	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	6	6	6	6	6	6	7	7	7	7	7	7	7	8
40	10	10	11	11	11	11	12	12	12	12	13	13	13	14
50	16	16	17	17	18	18	18	19	19	20	20	20	21	21
1 0	23	24	24	25	25	26	26	27	28	28	29	29	30	30
5	27	28	28	29	29	30	31	32	32	33	34	34	35	35
10	31	32	33	34	34	35	36	37	37	38	39	40	41	41
15	36	37	38	39	39	40	41	42	43	44	45	46	47	47
20	41	42	43	44	45	46	47	48	49	50	51	52	53	54
25	46	47	48	49	51	52	53	54	55	56	57	59	60	61
30	52	53	54	55	57	58	59	61	62	63	64	66	67	69
35	58	59	60	61	63	65	66	68	69	70	72	73	75	77
40	64	66	67	68	70	72	73	75	76	78	80	81	83	85
45	70	72	74	75	77	79	81	83	84	86	88	89	91	93
50	77	79	81	83	85	87	89	91	92	94	96	98	100	102
55	84	86	88	91	93	95	97	99	101	103	105	107	109	112
2 0	92	94	96	99	101	103	105	108	110	112	115	117	119	122
5	100	102	104	107	109	112	114	117	119	122	125	127	129	132
10	108	111	113	116	118	121	124	126	129	132	135	137	140	143
15	116	119	122	125	127	130	133	136	139	142	145	148	151	154
20	125	128	131	134	137	140	143	147	150	153	156	159	162	166
25	134	137	141	144	147	150	154	157	161	164	167	171	174	178
30	144	147	151	154	158	161	165	168	172	176	179	183	187	190
35	154	157	161	164	168	172	176	179	184	188	191	195	199	203
40	164	168	172	175	179	183	187	191	196	200	204	208	212	217
45	174	178	183	186	190	195	199	203	208	212	217	221	226	230
50	185	189	194	198	202	207	212	216	221	225	230	235	240	244
55	196	200	205	210	214	219	224	229	234	239	244	249	254	259
±3 0	207	212	217	222	227	232	237	242	248	253	258	263	269	274

TABLE XXII.—*Giving Δs.*

x	s											
	14′			15′				16′				17′
	″ 15	″ 30	″ 45	″ 0	″ 15	″ 30	″ 45	″ 0	″ 15	″ 30	″ 45	″ 0
	″	″	″	″	″	″	″	″	″	″	″	″
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
20	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10
30	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15
40	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19	0.20	0.20	0.20	0.20
50	0.21	0.22	0.22	0.22	0.23	0.23	0.24	0.24	0.24	0.25	0.25	0.26
60	0.26	0.26	0.27	0.27	0.27	0.28	0.28	0.29	0.29	0.30	0.30	0.31
70	0.30	0.30	0.31	0.32	0.32	0.33	0.33	0.34	0.34	0.35	0.35	0.36
80	0.34	0.35	0.35	0.36	0.37	0.37	0.38	0.38	0.39	0.40	0.40	0.41
90	0.38	0.39	0.40	0.40	0.41	0.42	0.43	0.43	0.44	0.45	0.45	0.46
100	0.43	0.44	0.44	0.45	0.46	0.46	0.47	0.48	0.49	0.50	0.50	0.51
110	0.47	0.48	0.49	0.50	0.50	0.51	0.52	0.53	0.54	0.54	0.55	0.56
120	0.51	0.52	0.53	0.54	0.55	0.56	0.57	0.58	0.58	0.59	0.60	0.61
130	0.56	0.57	0.58	0.58	0.59	0.60	0.61	0.62	0.63	0.64	0.65	0.66
140	0.60	0.61	0.62	0.63	0.64	0.65	0.66	0.67	0.68	0.69	0.70	0.71
150	0.64	0.65	0.66	0.68	0.69	0.70	0.71	0.72	0.73	0.74	0.75	0.76
160	0.68	0.70	0.71	0.72	0.73	0.74	0.76	0.77	0.78	0.79	0.80	0.82
170	0.73	0.74	0.75	0.76	0.78	0.79	0.80	0.82	0.83	0.84	0.85	0.87
180	0.77	0.78	0.80	0.81	0.82	0.84	0.85	0.86	0.88	0.89	0.90	0.92
190	0.81	0.83	0.84	0.86	0.87	0.88	0.90	0.91	0.93	0.94	0.95	0.97
200	0.86	0.87	0.88	0.90	0.92	0.93	0.94	0.96	0.98	0.99	1.00	1.02
210	0.90	0.91	0.93	0.94	0.96	0.98	0.99	1.01	1.02	1.04	1.06	1.07
220	0.94	0.96	0.97	0.99	1.01	1.02	1.04	1.06	1.07	1.09	1.11	1.12
230	0.98	1.00	1.02	1.04	1.05	1.07	1.09	1.10	1.12	1.14	1.16	1.17
240	1.03	1.04	1.06	1.08	1.10	1.12	1.13	1.15	1.17	1.19	1.21	1.22
250	1.07	1.09	1.11	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28
260	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.31	1.33
270	1.15	1.17	1.19	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38
280	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.39	1.41	1.43

PRECEPTS FOR USING TABLES XX, XXI, AND XXII.

Take from the American Ephemeris, for the date of observation,

$\delta_{\odot}$ = the Sun's declination at the time of the Moon's transit;
E_a = the equation of time for apparent noon;
T = the mean time of the Moon's transit;
$\delta_{☾}$ = the geocentric declination of the Moon's center at transit;
s = the Moon's geocentric semidiameter at transit.

Then

$A = T - E_a$ = the apparent time of the Moon's transit;
D' = the difference between the observed geocentric declinations* of the Moon's north and south limbs.

Compute E to tenths of a minute of arc from the formula

$$\tan E = \tan \delta_{☾} \cos A,$$

taking E always between $-90°$ and $+90°$. Then enter TABLE XX with the arguments $\delta_{☾}$ and E, and take out K. Next enter TABLE XXI with $\delta_{\odot} - E$ and K as arguments, and take out x. Enter TABLE XXII with x and s as arguments, and take out Δs, the required correction for defective illumination in declination. Since the table gives Δs to hundredths of a second of arc, one place farther than is actually required, we proceed by the following rule:

Adopt as the final value of Δs the nearest even tenth of a second when D' is even, and the nearest odd tenth when D' is odd.

We then have, for the observed geocentric semidiameter of the Moon,

$$s_o = \tfrac{1}{2}(D' + \Delta s).$$

The north limb is defective when $\delta_{\odot} - E$ is negative; the south limb when $\delta_{\odot} - E$ is positive.

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* By the phrase "observed geocentric declination" of either limb is meant the declination deduced from observation by the application of all corrections except those for geocentric semidiameter and defective illumination.

REDUCTION FOR DEFECTIVE ILLUMINATION OF AN OBSERVATION OF A PLANET.

TABLE XXIII.—*To Be Used When the Center Is Observed, But Not To Be Used for Mercury.*

θ i	0° 180	5° 175	10° 170	15° 165	20° 160	25° 155	30° 150	35° 145	40° 140	45° 135	50° 130	55° 125	60° 120	65° 115	70° 110	75° 105	80° 100	85° 95	90° 90
0°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2
10	0	0	0	1	1	1	2	3	3	4	4	5	6	6	7	7	7	8	8
15	0	0	1	1	2	3	4	6	7	8	10	11	13	14	15	16	17	17	17
20	0	0	1	2	3	5	7	10	12	15	17	20	22	25	26	28	29	30	30
25	0	0	1	3	5	8	11	15	19	23	27	31	35	38	41	44	46	46	47
30	0	0	2	4	7	11	16	21	26	32	38	44	49	54	59	62	65	66	67
35	0	1	3	6	10	15	21	28	36	43	51	59	66	73	79	84	87	90	91
40	0	1	3	7	12	19	26	36	45	55	65	75	85	94	101	108	113	116	117
45	0	1	4	8	15	23	32	43	55	67	80	92	105	116	126	135	141	145	146
50	0	1	4	10	17	27	38	51	65	80	95	111	126	140	153	164	172	177	179
55	0	1	5	11	20	31	44	59	75	92	111	129	147	165	181	194	205	211	213
60	0	1	6	13	22	35	49	66	85	105	126	147	169	190	210	226	239	247	250
65	0	2	6	14	25	38	54	73	94	116	140	165	190	215	238	258	274	284	288
70	0	2	7	15	26	41	59	79	102	126	153	181	210	238	266	291	311	324	329
75	0	2	7	16	28	44	62	84	108	135	164	194	226	258	291	320	347	364	370
80	0	2	7	17	29	46	65	87	113	141	172	205	239	274	311	347	378	403	414
85	0	2	8	17	30	46	66	90	116	145	177	211	247	284	324	364	403	437	455
90	0	2	8	17	30	47	67	91	117	146	179	213	250	288	329	370	414	455	500

TABLE XXIV.—*To Be Used When the Center Is Observed, But for Mercury Only.*

θ i	0° 180	5° 175	10° 170	15° 165	20° 160	25° 155	30° 150	35° 145	40° 140	45° 135	50° 130	55° 125	60° 120	65° 115	70° 110	75° 105	80° 100	85° 95	90° 90
° 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
10	0	1	1	2	3	3	4	4	5	5	6	6	7	7	7	7	7	8	8
15	0	1	3	4	6	7	8	10	11	12	13	14	15	15	16	16	17	17	17
20	0	3	5	8	10	13	15	17	19	21	23	24	26	27	28	29	29	30	30
25	0	4	8	12	16	20	23	26	30	33	35	38	40	42	43	45	45	46	46
30	0	6	11	17	22	28	33	38	42	46	50	54	57	59	62	63	64	65	65
35	0	8	15	23	30	37	44	50	56	62	67	72	76	79	82	85	86	87	88
40	0	10	20	29	38	48	56	65	72	80	86	92	98	102	106	109	111	112	112
45	0	12	24	36	48	59	70	80	90	99	107	114	121	126	131	135	137	139	139
50	0	15	29	43	57	71	84	96	108	119	128	137	146	152	158	162	165	167	168
55	0	17	34	51	68	84	99	114	127	140	152	162	172	180	186	191	195	197	198
60	0	20	40	59	78	97	115	132	147	162	175	188	199	208	215	221	225	228	229
65	0	23	45	67	89	110	130	150	168	185	200	213	226	236	245	252	256	259	261
70	0	26	51	76	100	124	147	168	188	207	224	240	254	265	275	283	288	292	293
75	0	28	56	84	111	137	163	187	209	230	249	266	282	294	305	314	320	324	325
80	0	31	62	92	122	151	178	205	229	252	273	292	309	323	335	344	351	355	356
85	0	34	67	100	132	164	194	222	249	274	296	317	335	351	364	374	381	386	387
90	0	36	72	108	143	176	208	239	268	294	319	341	361	378	392	403	410	415	417
95	0	39	77	115	152	188	222	255	286	314	340	364	385	403	418	430	438	443	445
100	0	41	82	122	161	199	236	271	303	333	361	386	408	428	444	456	464	470	472
105	0	43	86	129	170	210	249	286	320	352	381	407	430	451	468	481	490	495	498
110	0	45	91	135	178	220	261	299	335	368	399	427	451	472	490	504	513	519	521
115	0	47	94	140	185	229	271	311	348	383	415	444	469	491	509	524	533	540	542
120	0	49	98	146	192	238	281	323	361	397	430	460	486	509	528	543	553	560	562
125	0	51	101	150	199	246	290	333	373	410	445	475	502	526	546	561	572	578	581
130	0	52	104	154	204	252	298	343	384	422	457	489	517	541	561	577	588	594	597
135	0	53	106	158	209	258	306	351	393	432	468	500	529	553	574	590	601	608	611
140	0	54	108	161	213	264	312	358	401	441	478	510	540	565	586	603	614	621	624
145	0	55	110	164	217	268	317	364	407	448	485	519	549	574	596	612	624	631	634
150	0	56	112	166	220	272	321	369	413	454	492	526	557	582	604	621	632	640	643
155	0	57	113	168	222	275	325	373	418	459	498	532	563	589	611	628	640	647	650
160	0	57	114	170	224	277	328	377	422	463	502	537	568	594	617	634	646	653	656
165	0	58	115	171	226	279	330	379	425	467	506	541	572	598	621	638	650	658	661
170	0	58	115	172	227	280	332	381	427	469	508	543	575	601	624	641	653	661	664
175	0	58	116	172	228	281	333	382	428	470	509	545	577	603	625	643	655	662	665
180	0	58	116	173	228	281	333	383	428	471	510	546	578	604	627	644	656	664	667

The quantities in TABLES XXIII and XXIV are expressed in units of the third decimal, and those in TABLE XXIV are computed from the empirical formula

$$\frac{(1-\cos i)\ (5+\cos i)}{12}\sin\ (\theta).$$

PRECEPTS FOR USING TABLES XXIII AND XXIV.

Take from the American Ephemeris, for the date of observation,

θ = the angle which the line joining the cusps, or extremities of the illuminated portion, makes with the meridian;

i = the angle between the Sun and the Earth, as seen from the planet.

To obtain the declination factor, enter the tables with the arguments i and θ or $\theta - 180°$.

To obtain the right ascension factor, enter the tables with the arguments i and $\theta - 90°$ or $\theta + 90°$.

The correction to the observed center of light is obtained by multiplying the ephemeris semidiameter by the factor just obtained.

If θ is between 0° and 180°, the correction in declination is negative; if between 180° and 360°, the correction is positive.

If the planet transits after noon and before midnight, the correction in right ascension is positive; if after midnight and before noon, the correction is negative.

REDUCTION FOR DEFECTIVE ILLUMINATION OF AN OBSERVATION OF A PLANET—Continued.

TABLE XXV.—*To Be Used When the Limbs Are Observed.*

θ i	0° 180	5° 175	10° 170	15° 165	20° 160	25° 155	30° 150	35° 145	40° 140	45° 135	50° 130	55° 125	60° 120	65° 115	70° 110	75° 105	80° 100	85° 95	90° 90
°																			
0	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500
5	.500	.500	.500	.500	.500	.500	.500	.500	.500	.501	.501	.501	.501	.501	.501	.501	.501	.501	.501
10	.500	.500	.500	.500	.500	.501	.501	.501	.502	.502	.502	.503	.503	.503	.503	.504	.504	.504	.504
15	.500	.500	.500	.501	.501	.502	.502	.503	.503	.504	.505	.506	.506	.507	.508	.508	.508	.509	.509
20	.500	.500	.500	.501	.502	.503	.504	.505	.506	.508	.509	.510	.511	.513	.514	.514	.515	.515	.516
25	.500	.500	.501	.502	.503	.504	.506	.508	.510	.512	.514	.516	.518	.520	.521	.523	.524	.524	.525
30	.500	.500	.501	.502	.504	.506	.508	.511	.514	.517	.520	.523	.526	.529	.531	.533	.535	.536	.536
35	.500	.500	.501	.503	.505	.508	.511	.514	.518	.522	.527	.531	.535	.539	.543	.546	.548	.549	.550
40	.500	.500	.502	.503	.506	.510	.514	.518	.523	.529	.535	.541	.546	.552	.557	.561	.564	.566	.566
45	.500	.501	.502	.504	.508	.512	.517	.522	.529	.536	.543	.551	.558	.566	.572	.578	.582	.585	.586
50	.500	.501	.502	.505	.509	.514	.520	.527	.535	.543	.553	.562	.572	.581	.590	.598	.604	.607	.609
55	.500	.501	.503	.506	.510	.516	.523	.531	.541	.551	.562	.574	.587	.599	.610	.621	.629	.634	.636
60	.500	.501	.503	.506	.511	.518	.526	.535	.546	.558	.572	.587	.603	.617	.633	.646	.657	.664	.667
65	.500	.501	.503	.507	.513	.520	.529	.539	.552	.566	.581	.599	.617	.637	.656	.674	.689	.699	.703
70	.500	.501	.503	.508	.514	.521	.531	.543	.557	.572	.590	.610	.633	.656	.681	.704	.725	.740	.745
75	.500	.501	.504	.508	.514	.523	.533	.546	.561	.578	.598	.621	.646	.674	.704	.735	.764	.786	.794
80	.500	.501	.504	.508	.515	.524	.535	.548	.564	.582	.604	.629	.657	.689	.725	.764	.805	.840	.852
85	.500	.501	.504	.509	.515	.524	.536	.549	.566	.585	.607	.634	.664	.699	.740	.786	.840	.889	.920
90	.500	.501	.504	.509	.516	.525	.536	.550	.566	.586	.609	.636	.667	.703	.745	.794	.852	.920	1.000

PRECEPTS FOR USING TABLE XXV.

Take from the American Ephemeris, for the date of observation,

θ = the angle which the line joining the cusps, or extremities of the illuminated portion, makes with the meridian;
i = the angle between the Sun and the Earth, as seen from the planet.

To obtain the declination factor enter TABLE XXV with the arguments i and θ or $\theta-180°$.

To obtain the right ascension factor enter TABLE XXV with the arguments i and $\theta-90°$ or $\theta+90°$.

If $i>90°$, the planet is crescent, and a limb and a cusp are observed, in which case the factor is the same as for $i=90°$.

The observed semidiameter is obtained by multiplying the difference between the two observed limbs by the factor just obtained.

If θ is between 0° and 180°, the south limb is defective; if between 180° and 360°, the north limb is defective.

If the planet transits after noon and before midnight, Limb II is defective; if after midnight and before noon, Limb I is defective.

REFRACTION TABLES.

[Based upon the constants of the Pulkowa Tables.]

Table XXVI.—Values of log R. Logarithm of the refraction for each minute of apparent zenith distance from 0° to 85°. Barometer, 28.50 inches; thermometer, 100°.0 Fahrenheit.

Log $R = \mu +$ log tan app. zen. dist. $- 0.06103 - 0.04201\ (\lambda - 1) - 0.01902\ (A - 1)$.

The values of μ, λ, and A are taken from the Pulkowa Refraction Tables.

Table XXVII.—Values of log T for each tenth of a degree Fahrenheit of the external thermometer.

Table XXVIII.—Values of log T for each tenth of a degree Centigrade of the external thermometer.

Log $T =$ Pulkowa $\gamma + 0.04201$.

Table XXIX.—Values of log t for each degree Fahrenheit of the attached thermometer.

Table XXX.—Values of log t for each degree Centigrade of the attached thermometer.

Log $t =$ Pulkowa $T + 0.00262$.

Table XXXI.—Values of log B for each hundredth of an inch of the barometer.

Table XXXII.—Values of log B for each tenth of a millimeter of the barometer.

Log $B =$ Pulkowa $B + 0.01640$.

Table XXXIII.—Values of log b with arguments log B and apparent zenith distance.

Log $b = (A - 1)$ log B.

Table XXXIV.—Values of log t' with arguments log T and apparent zenith distance.

Log $t' = (\lambda - 1)$ log $T + (A - 1)$ log t.

EXAMPLE.

Observed Data.

Apparent zenith distance	70° 29′ 36″
External thermometer	65°.5 F.
Attached thermometer	66°.0 F.
Barometer	30.25 in.

Table XXVI.	Log R,	2.14553
Table XXVII.	Log T,	0.02783
Table XXIX.	Log t,	0.00131
Table XXXI.	Log B,	0.02588
Table XXXIII.	Log b,	4
Table XXXIV.	Log t'	30

Sum = Log Refraction, 2.20089; Refraction = 158″.81.

TABLE XXVI.—*Log R.*

App. Z. D.	0°		1°		2°		3°		4°		5°		6°		7°		8°		9°		
0′	.....		9.9412	72	0.2424	36	0.4187	24	0.5440	18	0.6413	14	0.7209	13	0.7885	10	0.8471	9	0.8990	8	60′
1	8.163	301	.9484	71	.2460	36	.4211	24	.5458	18	.6427	15	.7222	12	.7895	11	.8480	9	.8998	8	59
2	.464	176	.9555	69	.2496	35	.4235	24	.5476	18	.6442	14	.7234	12	.7906	10	.8489	9	.9006	9	58
3	.640	125	.9624	69	.2531	35	.4259	24	.5494	18	.6456	15	.7246	12	.7916	10	.8498	10	.9015	8	57
4	8.765	97	9.9693	67	0.2566	35	0.4283	23	0.5512	18	0.6471	14	0.7258	12	0.7926	11	0.8508	9	0.9023	8	56
5	8.862	79	9.9760	66	0.2601	35	0.4306	24	0.5530	17	0.6485	14	0.7270	12	0.7937	10	0.8517	9	0.9031	8	55
6	8.941	67	.9826	66	.2636	35	.4330	23	.5547	18	.6499	14	.7282	12	.7947	10	.8526	9	.9039	8	54
7	9.008	58	.9892	64	.2671	34	.4353	23	.5565	17	.6513	15	.7294	12	.7957	10	.8535	9	.9047	8	53
8	9.066	51	9.9956	64	.2705	33	.4376	23	.5582	18	.6528	14	.7306	11	.7967	11	.8544	9	.9055	8	52
9	9.117	46	0.0020	62	0.2738	34	0.4399	23	0.5600	17	0.6542	14	0.7317	12	0.7978	10	0.8553	9	0.9063	8	51
10	9.163	41	0.0082	62	0.2772	33	0.4422	23	0.5617	18	0.6556	14	0.7329	12	0.7988	10	0.8562	9	0.9071	8	50
11	.204	38	.0144	60	.2805	33	.4445	23	.5635	17	.6570	14	.7341	12	.7998	10	.8571	9	.9079	8	49
12	.242	35	.0204	60	.2838	33	.4468	23	.5652	18	.6584	14	.7353	12	.8008	10	.8580	9	.9087	8	48
13	.277	32	.0264	59	.2871	33	.4491	22	.5670	17	.6598	14	.7365	11	.8018	11	.8589	9	.9095	8	47
14	9.309	30	0.0323	59	0.2904	32	0.4513	23	0.5687	17	0.6612	14	0.7376	12	0.8029	10	0.8598	9	0.9103	8	46
15	9.339	28	0.0382	57	0.2936	32	0.4536	22	0.5704	17	0.6626	14	0.7388	12	0.8039	10	0.8607	8	0.9111	8	45
16	.367	26	.0439	57	.2968	32	.4558	22	.5721	17	.6640	13	.7400	11	.8049	10	.8615	9	.9119	8	44
17	.393	25	.0496	56	.3000	32	.4580	22	.5738	17	.6653	14	.7411	12	.8059	10	.8624	9	.9127	8	43
18	.418	24	.0552	56	.3032	31	.4602	22	.5755	17	.6667	14	.7423	12	.8069	10	.8633	9	.9135	8	42
19	9.442	22	0.0608	54	0.3063	31	0.4624	22	0.5772	17	0.6681	14	0.7435	11	0.8079	10	0.8642	9	0.9143	8	41
20	9.464	21	0.0662	54	0.3094	31	0.4646	21	0.5789	16	0.6695	13	0.7446	12	0.8089	10	0.8651	9	0.9151	8	40
21	.485	20	.0716	53	.3125	31	.4667	22	.5805	17	.6708	14	.7458	11	.8099	10	.8660	8	.9159	8	39
22	.505	19	.0769	53	.3156	30	.4689	22	.5822	17	.6722	13	.7469	12	.8109	10	.8668	9	.9167	7	38
23	.524	19	.0822	52	.3186	31	.4711	21	.5839	16	.6735	14	.7481	11	.8119	10	.8677	9	.9174	8	37
24	9.543	18	0.0874	51	0.3217	30	0.4732	21	0.5855	17	0.6749	13	0.7492	11	0.8129	9	0.8686	9	0.9182	8	36
25	9.561	17	0.0925	51	0.3247	30	0.4753	21	0.5872	16	0.6762	14	0.7503	12	0.8138	10	0.8695	8	0.9190	8	35
26	.578	16	.0976	51	.3277	29	.4774	21	.5888	16	.6776	13	.7515	11	.8148	10	.8703	9	.9198	8	34
27	.594	16	.1027	49	.3306	30	.4795	21	.5904	17	.6789	13	.7526	11	.8158	10	.8712	9	.9206	8	33
28	.610	15	.1076	49	.3336	29	.4816	21	.5921	16	.6802	14	.7537	12	.8168	10	.8721	8	.9214	7	32
29	9.625	15	0.1125	49	0.3365	29	0.4837	21	0.5937	16	0.6816	13	0.7549	11	0.8178	9	0.8729	9	0.9221	8	31
30	9.640	14	0.1174	48	0.3394	29	0.4858	21	0.5953	16	0.6829	13	0.7560	11	0.8187	10	0.8738	9	0.9229	8	30
31	.654	14	.1222	47	.3423	29	.4879	20	.5969	16	.6842	13	.7571	11	.8197	10	.8747	8	.9237	8	29
32	.668	14	.1269	47	.3452	28	.4899	21	.5985	16	.6855	13	.7582	11	.8207	10	.8755	9	.9245	7	28
33	.682	13	.1316	47	.3480	29	.4920	20	.6001	16	.6868	14	.7593	12	.8217	9	.8764	9	.9252	8	27
34	9.695	12	0.1363	46	0.3509	28	0.4940	21	0.6017	16	0.6882	13	0.7605	11	0.8226	10	0.8773	8	0.9260	8	26
35	9.707	12	0.1409	45	0.3537	28	0.4961	20	0.6033	16	0.6895	13	0.7616	11	0.8236	10	0.8781	9	0.9268	7	25
36	.719	12	.1454	45	.3565	28	.4981	20	.6049	16	.6908	13	.7627	11	.8246	9	.8790	8	.9275	8	24
37	.731	12	.1499	45	.3593	27	.5001	20	.6065	15	.6921	13	.7638	11	.8255	10	.8798	9	.9283	8	23
38	.743	11	.1544	44	.3620	27	.5021	20	.6080	16	.6934	13	.7649	11	.8265	9	.8807	8	.9291	8	22
39	9.754	11	0.1588	44	0.3647	28	0.5041	20	0.6096	16	0.6947	12	0.7660	11	0.8274	10	0.8815	9	0.9299	7	21
40	9.765	11	0.1632	43	0.3675	27	0.5061	19	0.6112	15	0.6959	13	0.7671	11	0.8284	9	0.8824	8	0.9306	8	20
41	.776	10	.1675	43	.3702	27	.5080	20	.6127	16	.6972	13	.7682	11	.8293	10	.8832	9	.9314	7	19
42	.786	11	.1718	42	.3729	27	.5100	20	.6143	15	.6985	13	.7693	11	.8303	9	.8841	8	.9321	8	18
43	.797	10	.1760	42	.3756	26	.5120	19	.6158	16	.6998	13	.7704	10	.8312	10	.8849	8	.9329	8	17
44	9.807	9	0.1802	42	0.3782	27	0.5139	20	0.6174	15	0.7011	12	0.7714	11	0.8322	9	0.8857	9	0.9337	7	16
45	9.816	10	0.1844	41	0.3809	26	0.5159	19	0.6189	15	0.7023	13	0.7725	11	0.8331	10	0.8866	8	0.9344	8	15
46	.826	9	.1885	41	.3835	26	.5178	19	.6204	15	.7036	12	.7736	11	.8341	9	.8874	9	.9352	7	14
47	.835	9	.1926	40	.3861	26	.5197	19	.6219	16	.7048	13	.7747	10	.8350	10	.8883	8	.9359	8	13
48	.844	9	.1966	40	.3887	26	.5216	19	.6235	15	.7061	13	.7757	11	.8360	9	.8891	8	.9367	7	12
49	9.853	9	0.2006	40	0.3913	25	0.5235	19	0.6250	15	0.7074	12	0.7768	11	0.8369	10	0.8899	9	0.9374	8	11
50	9.862	9	0.2046	39	0.3938	26	0.5254	19	0.6265	15	0.7086	13	0.7779	11	0.8379	9	0.8908	8	0.9382	7	10
51	.871	8	.2085	39	.3964	25	.5273	19	.6280	15	.7099	12	.7790	10	.8388	9	.8916	8	.9389	8	9
52	.879	8	.2124	39	.3989	26	.5292	19	.6295	15	.7111	13	.7800	11	.8397	10	.8924	8	.9397	7	8
53	.887	8	.2163	38	.4015	25	.5311	18	.6310	14	.7124	12	.7811	10	.8407	9	.8932	9	.9404	8	7
54	9.895	8	0.2201	38	0.4040	25	0.5329	19	0.6324	15	0.7136	12	0.7821	11	0.8416	9	0.8941	8	0.9412	7	6
55	9.903	8	0.2239	38	0.4065	24	0.5348	18	0.6339	15	0.7148	13	0.7832	11	0.8425	9	0.8949	8	0.9419	8	5
56	.911	8	.2277	37	.4089	25	.5366	19	.6354	15	.7161	12	.7843	10	.8434	9	.8957	9	.9427	7	4
57	.919	8	.2314	37	.4114	25	.5385	18	.6369	14	.7173	12	.7853	11	.8443	10	.8966	8	.9434	8	3
58	.927	7	.2351	37	.4139	24	.5403	18	.6383	15	.7185	12	.7864	10	.8453	9	.8974	8	.9442	7	2
59	9.934	7	0.2388	36	0.4163	24	0.5421	19	0.6398	15	0.7197	12	0.7874	11	0.8462	9	0.8982	8	0.9449	7	1
60	9.941		0.2424		0.4187		0.5440		0.6413		0.7209		0.7885		0.8471		0.8990		0.9456		0
	359°		358°		357°		356°		355°		354°		353°		352°		351°		350°		App. Z. D.

TABLE XXVI.—*Log R*—Continued.

App. Z. D.	10°		11°		12°		13°		14°		15°		16°		17°		18°		19°		
0′	0.9456	8	0.9879	7	1.0268	6	1.0627	5	1.0961	5	1.1273	5	1.1568	4	1.1846	5	1 2111	4	1.2362	4	60′
1	.9464	7	.9886	7	.0274	6	.0632	6	.0966	5	.1278	6	.1572	5	.1851	4	.2115	4	.2366	5	59
2	.9471	7	.9893	7	.0280	6	.0638	6	.0971	6	.1284	5	.1577	5	.1855	5	.2119	4	.2371	4	58
3	.9478	8	.9900	6	.0286	6	.0644	6	.0977	5	.1289	5	.1582	5	.1860	4	.2123	5	.2375	4	57
4	0.9486	7	0.9906	7	1.0292	7	1.0650	5	1.0982	5	1.1294	5	1.1587	4	1.1864	5	1.2128	4	1.2379	4	56
5	0.9493	7	0.9913	7	1.0299	6	1.0655	6	1.0987	6	1.1299	5	1.1591	5	1.1869	4	1.2132	4	1.2383	4	55
6	.9500	8	.9920	6	.0305	6	.0661	6	.0993	5	.1304	5	.1596	5	.1873	5	.2136	5	.2387	4	54
7	.9508	7	.9926	7	.0311	6	.0667	5	.0998	5	.1309	5	.1601	5	.1878	4	.2141	4	.2391	4	53
8	.9515	7	.9933	7	.0317	6	.0672	6	.1003	6	.1314	5	.1606	5	.1882	5	.2145	4	.2395	4	52
9	0.9522	8	0.9940	6	1.0323	6	1.0678	6	1.1009	5	1.1319	5	1.1611	4	1.1887	4	1.2149	4	1.2399	4	51
10	0.9530	7	0.9946	7	1.0329	6	1.0684	6	1.1014	5	1.1324	5	1.1615	5	1.1891	5	1.2153	5	1.2403	4	50
11	.9537	7	.9953	7	.0335	7	.0690	5	.1019	6	.1329	5	.1620	5	.1896	4	.2158	4	.2407	4	49
12	.9544	7	.9960	6	.0342	6	.0695	6	.1025	5	.1334	5	.1625	4	.1900	5	.2162	4	.2411	4	48
13	.9551	8	.9966	7	.0348	6	.0701	6	.1030	5	.1339	5	.1629	5	.1905	4	.2166	4	.2415	5	47
14	0.9559	7	0.9973	7	1.0354	6	1.0707	5	1.1035	6	1.1344	5	1.1634	5	1.1909	4	1.2170	5	1.2420	4	46
15	0.9566	7	0.9980	6	1.0360	6	1.0712	6	1.1041	5	1.1349	5	1.1639	5	1.1913	5	1.2175	4	1.2424	4	45
16	.9573	7	.9986	7	.0366	6	.0718	6	.1046	5	.1354	5	.1644	4	.1918	4	.2179	4	.2428	4	44
17	.9580	7	.9993	6	.0372	6	.0724	5	.1051	6	.1359	5	.1648	5	.1922	5	.2183	4	.2432	4	43
18	.9587	8	.9999	7	.0378	6	.0729	6	.1057	5	.1364	5	.1653	5	.1927	4	.2187	5	.2436	4	42
19	0.9595	7	1.0006	7	1.0384	6	1.0735	6	1.1062	5	1.1369	5	1.1658	4	1.1931	5	1.2192	4	1.2440	4	41
20	0.9602	7	1.0013	6	1.0390	6	1.0741	5	1.1067	5	1.1374	4	1.1662	5	1.1936	4	1.2196	4	1.2444	4	40
21	.9609	7	.0019	7	.0396	6	.0746	6	.1072	6	.1378	5	.1667	5	.1940	5	.2200	4	.2448	4	39
22	.9616	7	.0026	6	.0402	6	.0752	5	.1078	5	.1383	5	.1672	4	.1945	4	.2204	4	.2452	4	38
23	.9623	7	.0032	7	.0408	6	.0757	6	.1083	5	.1388	5	.1676	5	.1949	4	.2208	5	.2456	4	37
24	0.9630	7	1.0039	6	1.0414	6	1.0763	6	1.1088	5	1.1393	5	1.1681	5	1.1953	5	1.2213	4	1.2460	4	36
25	0.9637	7	1.0045	7	1.0420	7	1.0769	5	1.1093	6	1.1398	5	1.1686	4	1.1958	4	1.2217	4	1.2464	4	35
26	.9644	7	.0052	6	.0427	6	.0774	6	.1099	5	.1403	5	.1690	5	.1962	5	.2221	4	.2468	4	34
27	.9651	7	.0058	7	.0433	6	.0780	5	.1104	5	.1408	5	.1695	5	.1967	4	.2225	5	.2472	4	33
28	.9658	8	.0065	6	.0439	6	.0785	6	.1109	5	.1413	5	.1700	4	.1971	5	.2230	4	.2476	4	32
29	0.9666	7	1.0071	7	1.0445	5	1.0791	5	1.1114	5	1.1418	5	1.1704	5	1.1976	4	1.2234	4	1.2480	4	31
30	0.9673	7	1.0078	6	1.0450	6	1.0796	6	1.1119	6	1.1423	5	1.1709	5	1.1980	4	1.2238	4	1.2484	4	30
31	.9680	7	.0084	7	.0456	6	.0802	6	.1125	5	.1428	5	.1714	4	.1984	5	.2242	4	.2488	4	29
32	.9687	7	.0091	6	.0462	6	.0808	5	.1130	5	.1433	4	.1718	5	.1989	4	.2246	5	.2492	4	28
33	.9694	7	.0097	6	.0468	6	.0813	6	.1135	5	.1437	5	.1723	4	.1993	5	.2251	4	.2496	4	27
34	0.9701	7	1.0103	7	1.0474	6	1.0819	5	1.1140	6	1.1442	5	1.1727	5	1.1998	4	1.2255	4	1.2500	4	26
35	0.9708	7	1.0110	6	1.0480	6	1.0824	6	1.1146	5	1.1447	5	1.1732	5	1.2002	4	1.2259	4	1.2504	4	25
36	.9715	7	.0116	7	.0486	6	.0830	5	.1151	5	.1452	5	.1737	4	.2006	5	.2263	4	.2508	4	24
37	.9722	7	.0123	6	.0492	6	.0835	6	.1156	5	.1457	5	.1741	5	.2011	4	.2267	4	.2512	4	23
38	.9729	7	.0129	6	.0498	6	.0841	5	.1161	5	.1462	5	.1746	4	.2015	4	.2271	5	.2516	4	22
39	0.9736	7	1.0135	7	1.0504	6	1.0846	6	1.1166	5	1.1467	5	1.1750	5	1.2019	5	1.2276	4	1.2520	4	21
40	0.9743	7	1.0142	6	1.0510	6	1.0852	5	1.1171	5	1.1472	4	1.1755	5	1.2024	4	1.2280	4	1.2524	4	20
41	.9750	7	.0148	7	.0516	6	.0857	6	.1176	6	.1476	5	.1760	4	.2028	5	.2284	4	.2528	4	19
42	.9757	6	.0155	6	.0522	6	.0863	5	.1182	5	.1481	5	.1764	5	.2033	4	.2288	4	.2532	4	18
43	.9763	7	.0161	6	.0528	5	.0868	6	.1187	5	.1486	5	.1769	4	.2037	4	.2292	4	.2536	4	17
44	0.9770	7	1.0167	7	1.0533	6	1.0874	5	1.1192	5	1.1491	5	1.1773	5	1.2041	5	1.2296	4	1.2540	4	16
45	0.9777	7	1.0174	6	1.0539	6	1.0879	6	1.1197	5	1.1496	5	1.1778	4	1.2046	4	1.2300	5	1.2544	4	15
46	.9784	7	.0180	6	.0545	6	.0885	5	.1202	5	.1501	4	.1782	5	.2050	4	.2305	4	.2548	4	14
47	.9791	7	.0186	7	.0551	6	.0890	6	.1207	5	.1505	5	.1787	5	.2054	5	.2309	4	.2552	4	13
48	.9798	7	.0193	6	.0557	6	.0896	5	.1212	5	.1510	5	.1792	4	.2059	4	.2313	4	.2556	4	12
49	0.9805	7	1.0199	6	1.0563	6	1.0901	6	1.1217	5	1.1515	5	1.1796	5	1.2063	4	1.2317	4	1.2560	4	11
50	0.9812	6	1.0205	6	1.0569	5	1.0907	5	1.1222	6	1.1520	5	1.1801	4	1.2067	5	1.2321	4	1.2564	4	10
51	.9818	7	.0211	7	.0574	6	.0912	5	.1228	5	.1525	5	.1805	5	.2072	4	.2325	4	.2568	4	9
52	.9825	7	.0218	6	.0580	6	.0917	6	.1233	5	.1530	4	.1810	4	.2076	4	.2329	5	.2572	4	8
53	.9832	7	.0224	6	.0586	6	.0923	5	.1238	5	.1534	5	.1814	5	.2080	5	.2334	4	.2576	3	7
54	0.9839	7	1.0230	7	1.0592	6	1.0928	6	1.1243	5	1.1539	5	1.1819	4	1.2085	4	1.2338	4	1.2579	4	6
55	0.9846	7	1.0237	6	1.0598	5	1.0934	5	1.1248	5	1.1544	5	1.1823	5	1.2089	4	1.2342	4	1.2583	4	5
56	.9853	6	.0243	6	.0603	6	.0939	5	.1253	5	.1549	4	.1828	4	.2093	4	.2346	4	.2587	4	4
57	.9859	7	.0249	6	.0609	6	.0944	6	.1258	5	.1553	5	.1832	5	.2097	5	.2350	4	.2591	4	3
58	.9866	7	.0255	6	.0615	6	.0950	5	.1263	5	.1558	5	.1837	5	.2102	4	.2354	4	.2595	4	2
59	0.9873	6	1.0261	7	1.0621	6	1.0955	6	1.1268	5	1.1563	5	1.1842	4	1.2106	5	1.2358	4	1.2599	4	1
60	0.9879		1.0268		1.0627		1.0961		1.1273		1.1568		1.1846		1.2111		1.2362		1.2603		0
	349°		348°		347°		346°		345°		344°		343°		342°		341°		340°		App. Z. D.

TABLE XXVI.—*Log R*—Continued.

App. Z. D.	20°		21°		22°		23°		24°		25°		26°		27°		28°		29°		
0′	1.2603	4	1.2834	4	1.3056	4	1.3270	3	1.3477	3	1.3678	3	1.3873	3	1.4063	3	1.4248	3	1.4428	3	60′
1	.2607	4	.2838	4	.3060	4	.3273	4	.3480	4	.3681	3	.3876	3	.4066	3	.4251	3	.4431	3	59
2	.2611	4	.2842	3	.3064	3	.3277	3	.3484	3	.3684	4	.3879	3	.4069	3	.4254	3	.4434	3	58
3	.2615	4	.2845	4	.3067	4	.3280	4	.3487	4	.3688	3	.3882	4	.4072	3	.4257	3	.4437	3	57
4	1.2619	4	1.2849	4	1.3071	4	1.3284	3	1.3491	3	1.3691	3	1.3886	3	1.4075	3	1.4260	3	1.4440	3	56
5	1.2623	4	1.2853	4	1.3075	3	1.3287	4	1.3494	3	1.3694	4	1.3889	3	1.4078	3	1.4263	3	1.4443	3	55
6	.2627	4	.2857	4	.3078	4	.3291	3	.3497	4	.3698	3	.3892	3	.4081	3	.4266	3	.4446	3	54
7	.2631	4	.2861	3	.3082	3	.3294	4	.3501	3	.3701	3	.3895	3	.4084	4	.4269	3	.4449	3	53
8	.2635	3	.2864	4	.3085	4	.3298	3	.3504	4	.3704	3	.3898	4	.4088	3	.4272	3	.4452	3	52
9	1.2638	4	1.2868	4	1.3089	4	1.3301	4	1.3508	3	1.3707	4	1.3902	3	1.4091	3	1.4275	3	1.4455	3	51
10	1.2642	4	1.2872	4	1.3093	3	1.3305	3	1.3511	3	1.3711	3	1.3905	3	1.4094	3	1.4278	3	1.4458	3	50
11	.2646	4	.2876	3	.3096	4	.3308	4	.3514	4	.3714	3	.3908	3	.4097	3	.4281	3	.4461	3	49
12	.2650	4	.2879	4	.3100	4	.3312	3	.3518	3	.3717	4	.3911	3	.4100	3	.4284	3	.4464	3	48
13	.2654	4	.2883	4	.3104	3	.3315	4	.3521	4	.3721	3	.3914	4	.4103	3	.4287	3	.4467	3	47
14	1.2658	4	1.2887	3	1.3107	4	1.3319	3	1.3525	3	1.3724	3	1.3918	3	1.4106	3	1.4290	3	1.4470	3	46
15	1.2662	4	1.2890	4	1.3111	3	1.3322	4	1.3528	3	1.3727	3	1.3921	3	1.4109	3	1.4293	3	1.4473	3	45
16	.2666	4	.2894	4	.3114	4	.3326	3	.3531	4	.3730	4	.3924	3	.4112	4	.4296	3	.4476	3	44
17	.2670	4	.2898	4	.3118	3	.3329	4	.3535	3	.3734	3	.3927	3	.4116	3	.4299	3	.4479	3	43
18	.2674	3	.2902	3	.3121	4	.3333	3	.3538	3	.3737	3	.3930	4	.4119	3	.4302	3	.4482	3	42
19	1.2677	4	1.2905	4	1.3125	4	1.3336	4	1.3541	4	1.3740	4	1.3934	3	1.4122	3	1.4305	3	1.4485	2	41
20	1.2681	4	1.2909	4	1.3129	3	1.3340	3	1.3545	3	1.3744	3	1.3937	3	1.4125	3	1.4308	3	1.4487	3	40
21	.2685	4	.2913	4	.3132	4	.3343	4	.3548	3	.3747	3	.3940	3	.4128	3	.4311	3	.4490	3	39
22	.2689	4	.2917	3	.3136	4	.3347	3	.3551	4	.3750	3	.3943	3	.4131	3	.4314	3	.4493	3	38
23	.2693	4	.2920	4	.3140	3	.3350	4	.3555	3	.3753	4	.3946	3	.4134	3	.4317	3	.4496	3	37
24	1.2697	4	1.2924	4	1.3143	4	1.3354	3	1.3558	4	1.3757	3	1.3949	3	1.4137	3	1.4320	3	1.4499	3	36
25	1.2701	4	1.2928	4	1.3147	3	1.3357	4	1.3562	3	1.3760	3	1.3952	4	1.4140	3	1.4323	3	1.4502	3	35
26	.2705	3	.2932	3	.3150	4	.3361	3	.3565	3	.3763	3	.3956	3	.4143	3	.4326	3	.4505	3	34
27	.2708	4	.2935	4	.3154	3	.3364	3	.3568	4	.3766	4	.3959	3	.4146	4	.4329	3	.4508	3	33
28	.2712	4	.2939	4	.3157	4	.3367	4	.3572	3	.3770	3	.3962	3	.4150	3	.4332	3	.4511	3	32
29	1.2716	4	1.2943	3	1.3161	3	1.3371	3	1.3575	3	1.3773	3	1.3965	3	1.4153	3	1.4335	3	1.4514	3	31
30	1.2720	4	1.2946	4	1.3164	4	1.3374	4	1.3578	4	1.3776	3	1.3968	4	1.4156	3	1.4338	3	1.4517	3	30
31	.2724	4	.2950	4	.3168	4	.3378	3	.3582	3	.3779	4	.3972	3	.4159	3	.4341	3	.4520	3	29
32	.2728	3	.2954	3	.3172	3	.3381	4	.3585	3	.3783	3	.3975	3	.4162	3	.4344	3	.4523	3	28
33	.2731	4	.2957	4	.3175	4	.3385	3	.3588	4	.3786	3	.3978	3	.4165	3	.4347	3	.4526	3	27
34	1.2735	4	1.2961	4	1.3179	3	1.3388	4	1.3592	3	1.3789	3	1.3981	3	1.4168	3	1.4350	3	1.4529	3	26
35	1.2739	4	1.2965	4	1.3182	4	1.3392	3	1.3595	3	1.3792	4	1.3984	3	1.4171	3	1.4353	3	1.4532	3	25
36	.2743	4	.2969	3	.3186	4	.3395	3	.3598	4	.3796	3	.3987	4	.4174	3	.4356	3	.4535	3	24
37	.2747	4	.2972	4	.3190	3	.3398	4	.3602	3	.3799	3	.3991	3	.4177	3	.4359	3	.4538	3	23
38	.2751	3	.2976	4	.3193	4	.3402	3	.3605	3	.3802	3	.3994	3	.4180	3	.4362	3	.4541	3	22
39	1.2754	4	1.2980	3	1.3197	3	1.3405	4	1.3608	4	1.3805	4	1.3997	3	1.4183	3	1.4365	3	1.4544	2	21
40	1.2758	4	1.2983	4	1.3200	4	1.3409	3	1.3612	3	1.3809	3	1.4000	3	1.4186	4	1.4368	3	1.4546	3	20
41	.2762	4	.2987	4	.3204	3	.3412	4	.3615	3	.3812	3	.4003	3	.4190	3	.4371	3	.4549	3	19
42	.2766	4	.2991	3	.3207	4	.3416	3	.3618	4	.3815	3	.4006	3	.4193	3	.4374	3	.4552	3	18
43	.2770	3	.2994	4	.3211	3	.3419	3	.3622	3	.3818	3	.4009	4	.4196	3	.4377	3	.4555	3	17
44	1.2773	4	1.2998	4	1.3214	4	1.3422	4	1.3625	3	1.3821	4	1.4013	3	1.4199	3	1.4380	3	1.4558	3	16
45	1.2777	4	1.3002	3	1.3218	4	1.3426	3	1.3628	4	1.3825	3	1.4016	3	1.4202	3	1.4383	3	1.4561	3	15
46	.2781	4	.3005	4	.3222	3	.3429	4	.3632	3	.3828	3	.4019	3	.4205	3	.4386	3	.4564	3	14
47	.2785	4	.3009	4	.3225	4	.3433	3	.3635	3	.3831	3	.4022	3	.4208	3	.4389	3	.4567	3	13
48	.2789	4	.3013	3	.3229	3	.3436	4	.3638	3	.3834	4	.4025	3	.4211	3	.4392	3	.4570	3	12
49	1.2793	3	1.3016	4	1.3232	4	1.3440	3	1.3641	4	1.3838	3	1.4028	3	1.4214	3	1.4395	3	1.4573	3	11
50	1.2796	4	1.3020	4	1.3236	3	1.3443	3	1.3645	3	1.3841	3	1.4031	4	1.4217	3	1.4398	3	1.4576	3	10
51	.2800	4	.3024	3	.3239	4	.3446	4	.3648	3	.3844	3	.4035	3	.4220	3	.4401	3	.4579	3	9
52	.2804	4	.3027	4	.3243	3	.3450	3	.3651	4	.3847	3	.4038	3	.4223	3	.4404	3	.4582	3	8
53	.2808	4	.3031	4	.3246	4	.3453	4	.3655	3	.3850	4	.4041	3	.4226	3	.4407	3	.4585	2	7
54	1.2812	3	1.3035	3	1.3250	3	1.3457	3	1.3658	3	1.3854	3	1.4044	3	1.4229	3	1.4410	3	1.4587	3	6
55	1.2815	4	1.3038	4	1.3253	4	1.3460	3	1.3661	4	1.3857	3	1.4047	3	1.4232	3	1.4413	3	1.4590	3	5
56	.2819	4	.3042	4	.3257	3	.3463	4	.3665	3	.3860	3	.4050	3	.4235	3	.4416	3	.4593	3	4
57	.2823	4	.3046	3	.3260	4	.3467	3	.3668	3	.3863	4	.4053	3	.4238	4	.4419	3	.4596	3	3
58	.2827	4	.3049	4	.3264	3	.3470	4	.3671	4	.3867	3	.4056	4	.4242	3	.4422	3	.4599	3	2
59	1.2831	3	1.3053	3	1.3267	3	1.3474	3	1.3675	3	1.3870	3	1.4060	3	1.4245	3	1.4425	3	1.4602	3	1
60	1.2834		1.3056		1.3270		1.3477		1.3678		1.3873		1.4063		1.4248		1.4428		1.4605		0
	339°		338°		337°		336°		335°		334°		333°		332°		331°		330°		App. Z. D.

TABLE XXVI.—*Log R*—Continued.

App. Z. D.	30°		31°		32°		33°		34°		35°		36°		37°		38°		39°		
0′	1.4605	3	1.4778	3	1.4948	3	1.5115	3	1.5280	2	1.5442	3	1.5602	3	1.5760	3	1.5917	3	1.6073	2	60′
1	.4608	3	.4781	3	.4951	3	.5118	3	.5282	3	.5445	2	.5605	2	.5763	3	.5920	2	.6075	3	59
2	.4611	3	.4784	3	.4954	3	.5121	3	.5285	3	.5447	3	.5607	3	.5766	2	.5922	3	.6078	2	58
3	.4614	3	.4787	3	.4957	2	.5124	2	.5288	3	.5450	3	.5610	3	.5768	3	.5925	3	.6080	3	57
4	1.4617	3	1.4790	2	1.4959	3	1.5126	3	1.5291	2	1.5453	2	1.5613	2	1.5771	3	1.5928	2	1.6083	2	56
5	1.4620	2	1.4792	3	1.4962	3	1.5129	3	1.5293	3	1.5455	3	1.5615	3	1.5774	2	1.5930	3	1.6085	3	55
6	.4622	3	.4795	3	.4965	3	.5132	3	.5296	3	.5458	3	.5618	3	.5776	3	.5933	2	.6088	3	54
7	.4625	3	.4798	3	.4968	3	.5135	2	.5299	2	.5461	2	.5621	2	.5779	2	.5935	3	.6091	2	53
8	.4628	3	.4801	3	.4971	2	.5137	3	.5301	3	.5463	3	.5623	3	.5781	3	.5938	3	.6093	3	52
9	1.4631	3	1.4804	3	1.4973	3	1.5140	3	1.5304	3	1.5466	3	1.5626	3	1.5784	3	1.5941	2	1.6096	2	51
10	1.4634	3	1.4807	3	1.4976	3	1.5143	3	1.5307	3	1.5469	2	1.5629	2	1.5787	2	1.5943	3	1.6098	3	50
11	.4637	3	.4810	2	.4979	3	.5146	2	.5310	2	.5471	3	.5631	3	.5789	3	.5946	2	.6101	2	49
12	.4640	3	.4812	3	.4982	3	.5148	3	.5312	3	.5474	3	.5634	3	.5792	3	.5948	3	.6103	3	48
13	.4643	3	.4815	3	.4985	2	.5151	3	.5315	3	.5477	3	.5637	2	.5795	2	.5951	3	.6106	3	47
14	1.4646	3	1.4818	3	1.4987	3	1.5154	3	1.5318	3	1.5480	2	1.5639	3	1.5797	3	1.5954	2	1.6109	2	46
15	1.4649	2	1.4821	3	1.4990	3	1.5157	2	1.5321	2	1.5482	3	1.5642	2	1.5800	2	1.5956	3	1.6111	3	45
16	.4651	3	.4824	3	.4993	3	.5159	3	.5323	3	.5485	2	.5644	3	.5802	3	.5959	2	.6114	2	44
17	.4654	3	.4827	3	.4996	3	.5162	3	.5326	3	.5487	3	.5647	3	.5805	3	.5961	3	.6116	3	43
18	.4657	3	.4830	2	.4999	2	.5165	3	.5329	2	.5490	3	.5650	3	.5808	2	.5964	2	.6119	2	42
19	1.4660	3	1.4832	3	1.5001	3	1.5168	2	1.5331	3	1.5493	2	1.5653	2	1.5810	3	1.5966	3	1.6121	3	41
20	1.4663	3	1.4835	3	1.5004	3	1.5170	3	1.5334	3	1.5495	3	1.5655	3	1.5813	2	1.5969	3	1.6124	3	40
21	.4666	3	.4838	3	.5007	3	.5173	3	.5337	2	.5498	3	.5658	2	.5815	3	.5972	2	.6127	2	39
22	.4669	3	.4841	3	.5010	2	.5176	3	.5339	3	.5501	3	.5660	3	.5818	3	.5974	3	.6129	3	38
23	.4672	3	.4844	3	.5012	3	.5179	2	.5342	2	.5504	2	.5663	3	.5821	2	.5977	2	.6132	2	37
24	1.4675	3	1.4847	2	1.5015	3	1.5181	3	1.5344	3	1.5506	3	1.5666	2	1.5823	3	1.5979	3	1.6134	3	36
25	1.4678	2	1.4849	3	1.5018	3	1.5184	3	1.5347	3	1.5509	3	1.5668	3	1.5826	3	1.5982	3	1.6137	2	35
26	.4680	3	.4852	3	.5021	3	.5187	3	.5350	3	.5512	2	.5671	3	.5829	2	.5985	2	.6139	3	34
27	.4683	3	.4855	3	.5024	2	.5190	2	.5353	3	.5514	3	.5674	2	.5831	3	.5987	3	.6142	3	33
28	.4686	3	.4858	3	.5026	3	.5192	3	.5356	2	.5517	3	.5676	3	.5834	2	.5990	2	.6145	2	32
29	1.4689	3	1.4861	3	1.5029	3	1.5195	3	1.5358	3	1.5520	2	1.5679	2	1.5836	3	1.5992	3	1.6147	3	31
30	1.4692	3	1.4864	2	1.5032	3	1.5198	3	1.5361	3	1.5522	3	1.5681	3	1.5839	3	1.5995	3	1.6150	2	30
31	.4695	3	.4866	3	.5035	2	.5201	2	.5364	2	.5525	3	.5684	3	.5842	2	.5998	2	.6152	3	29
32	.4698	3	.4869	3	.5037	3	.5203	3	.5366	3	.5528	2	.5687	2	.5844	3	.6000	3	.6155	2	28
33	.4701	3	.4872	3	.5040	3	.5206	3	.5369	3	.5530	3	.5689	3	.5847	2	.6003	2	.6157	3	27
34	1.4704	2	1.4875	3	1.5043	3	1.5209	2	1.5372	3	1.5533	3	1.5692	3	1.5849	3	1.6005	3	1.6160	3	26
35	1.4706	3	1.4878	3	1.5046	3	1.5211	3	1.5375	2	1.5536	2	1.5695	2	1.5852	3	1.6008	3	1.6163	2	25
36	.4709	3	.4881	2	.5049	3	.5214	3	.5377	3	.5538	3	.5697	3	.5855	2	.6011	2	.6165	3	24
37	.4712	3	.4883	3	.5052	2	.5217	3	.5380	3	.5541	3	.5700	3	.5857	3	.6013	3	.6168	2	23
38	.4715	3	.4886	3	.5054	3	.5220	2	.5383	2	.5544	2	.5703	2	.5860	2	.6016	2	.6170	3	22
39	1.4718	3	1.4889	3	1.5057	3	1.5222	3	1.5385	3	1.5546	3	1.5705	3	1.5862	3	1.6018	3	1.6173	2	21
40	1.4721	3	1.4892	3	1.5060	3	1.5225	3	1.5388	3	1.5549	3	1.5708	2	1.5865	3	1.6021	3	1.6175	3	20
41	.4724	3	.4895	3	.5063	2	.5228	3	.5391	3	.5552	2	.5710	3	.5868	2	.6024	2	.6178	3	19
42	.4727	2	.4898	2	.5065	3	.5231	2	.5394	2	.5554	3	.5713	3	.5870	3	.6026	3	.6181	2	18
43	.4729	3	.4900	3	.5068	3	.5233	3	.5396	3	.5557	2	.5716	2	.5873	3	.6029	2	.6183	3	17
44	1.4732	3	1.4903	3	1.5071	3	1.5236	3	1.5399	3	1.5559	3	1.5718	3	1.5876	2	1.6031	3	1.6186	2	16
45	1.4735	3	1.4906	3	1.5074	2	1.5239	3	1.5402	2	1.5562	3	1.5721	3	1.5878	3	1.6034	2	1.6188	3	15
46	.4738	3	.4909	3	.5076	3	.5242	2	.5404	3	.5565	2	.5724	2	.5881	2	.6036	3	.6191	2	14
47	.4741	3	.4912	2	.5079	3	.5244	3	.5407	3	.5567	3	.5726	3	.5883	3	.6039	3	.6193	3	13
48	.4744	3	.4914	3	.5082	3	.5247	3	.5410	2	.5570	3	.5729	2	.5886	2	.6042	2	.6196	3	12
49	1.4747	3	1.4917	3	1.5085	3	1.5250	2	1.5412	3	1.5573	2	1.5731	3	1.5888	3	1.6044	3	1.6199	2	11
50	1.4750	2	1.4920	3	1.5088	2	1.5252	3	1.5415	3	1.5575	3	1.5734	3	1.5891	3	1.6047	2	1.6201	3	10
51	.4752	3	.4923	3	.5090	3	.5255	3	.5418	2	.5578	3	.5737	2	.5894	3	.6049	3	.6204	2	9
52	.4755	3	.4926	2	.5093	3	.5258	3	.5420	3	.5581	2	.5739	3	.5897	2	.6052	2	.6206	3	8
53	.4758	3	.4928	3	.5096	3	.5261	2	.5423	3	.5583	3	.5742	3	.5899	3	.6054	3	.6209	2	7
54	1.4761	3	1.4931	3	1.5099	2	1.5263	3	1.5426	2	1.5586	3	1.5745	2	1.5902	2	1.6057	3	1.6211	3	6
55	1.4764	3	1.4934	3	1.5101	3	1.5266	3	1.5428	3	1.5589	2	1.5747	3	1.5904	3	1.6060	2	1.6214	2	5
56	.4767	3	.4937	3	.5104	3	.5269	3	.5431	3	.5591	3	.5750	3	.5907	2	.6062	3	.6216	3	4
57	.4770	2	.4940	3	.5107	3	.5272	2	.5434	3	.5594	3	.5753	2	.5909	3	.6065	2	.6219	2	3
58	.4772	3	.4943	2	.5110	2	.5274	3	.5437	2	.5597	2	.5755	3	.5912	3	.6067	3	.6221	3	2
59	1.4775	3	1.4945	3	1.5112	3	1.5277	3	1.5439	3	1.5599	3	1.5758	2	1.5915	2	1.6070	3	1.6224	3	1
60	1.4778		1.4948		1.5115		1.5280		1.5442		1.5602		1.5760		1.5917		1.6073		1.6227		0
	329°		328°		327°		326°		325°		324°		323°		322°		321°		320°		App. Z. D.

TABLE XXVI.—*Log R*—Continued.

App. Z. D.	40°		41°		42°		43°		44°		45°		46°		47°		48°		49°		
0′	1.6227	2	1.6380	3	1.6532	3	1.6684	3	1.6836	2	1.6987	3	1.7138	3	1.7290	2	1.7441	3	1.7594	2	60′
1	.6229	3	.6383	2	.6535	3	.6687	2	.6838	3	.6990	2	.7141	2	.7292	3	.7444	3	.7596	3	59
2	.6232	2	.6385	3	.6538	2	.6689	3	.6841	2	.6992	3	.7143	3	.7295	2	.7447	2	.7599	2	58
3	.6234	3	.6388	2	.6540	3	.6692	2	.6843	3	.6995	2	.7146	2	.7297	3	.7449	3	.7601	3	57
4	1.6237	3	1.6390	3	1.6543	2	1.6694	3	1.6846	2	1.6997	3	1.7148	3	1.7300	2	1.7452	2	1.7604	3	56
5	1.6240	2	1.6393	2	1.6545	3	1.6697	2	1.6848	3	1.7000	2	1.7151	2	1.7302	3	1.7454	3	1.7607	2	55
6	.6242	3	.6395	3	.6548	2	.6699	3	.6851	2	.7002	3	.7153	3	.7305	2	.7457	2	.7609	3	54
7	.6245	2	.6398	2	.6550	3	.6702	2	.6853	3	.7005	2	.7156	2	.7307	3	.7459	3	.7612	2	53
8	.6247	3	.6400	3	.6553	2	.6704	3	.6856	2	.7007	3	.7158	3	.7310	2	.7462	2	.7614	3	52
9	1.6250	2	1.6403	2	1.6555	3	1.6707	3	1.6858	3	1.7010	2	1.7161	2	1.7312	3	1.7464	3	1.7617	2	51
10	1.6252	3	1.6405	3	1.6558	2	1.6710	2	1.6861	2	1.7012	3	1.7163	3	1.7315	2	1.7467	2	1.7619	3	50
11	.6255	2	.6408	2	.6560	3	.6712	3	.6863	3	.7015	2	.7166	3	.7317	3	.7469	3	.7622	2	49
12	.6257	3	.6410	3	.6563	2	.6715	2	.6866	2	.7017	3	.7169	2	.7320	3	.7472	2	.7624	3	48
13	.6260	2	.6413	3	.6565	3	.6717	3	.6868	3	.7020	2	.7171	3	.7323	2	.7474	3	.7627	2	47
14	1.6262	3	1.6416	2	1.6568	2	1.6720	2	1.6871	3	1.7022	3	1.7174	2	1.7325	3	1.7477	3	1.7629	3	46
15	1.6265	3	1.6418	3	1.6570	3	1.6722	3	1.6874	2	1.7025	2	1.7176	3	1.7328	2	1.7480	2	1.7632	3	45
16	.6268	2	.6421	2	.6573	2	.6725	2	.6876	3	.7027	3	.7179	2	.7330	3	.7482	3	.7635	2	44
17	.6270	3	.6423	3	.6575	3	.6727	3	.6879	2	.7030	2	.7181	3	.7333	2	.7485	2	.7637	3	43
18	.6273	2	.6426	2	.6578	3	.6730	2	.6881	3	.7032	3	.7184	2	.7335	3	.7487	3	.7640	2	42
19	1.6275	3	1.6428	3	1.6581	2	1.6732	3	1.6884	2	1.7035	2	1.7186	3	1.7338	2	1.7490	2	1.7642	3	41
20	1.6278	2	1.6431	2	1.6583	3	1.6735	2	1.6886	3	1.7037	3	1.7189	2	1.7340	3	1.7492	3	1.7645	2	40
21	.6280	3	.6433	3	.6586	2	.6737	3	.6889	2	.7040	3	.7191	3	.7343	2	.7495	2	.7647	3	39
22	.6283	3	.6436	3	.6588	3	.6740	2	.6891	3	.7043	2	.7194	2	.7345	3	.7497	3	.7650	2	38
23	.6286	2	.6439	2	.6591	2	.6742	3	.6894	2	.7045	3	.7196	3	.7348	2	.7500	2	.7652	3	37
24	1.6288	3	1.6441	3	1.6593	3	1.6745	2	1.6896	3	1.7048	2	1.7199	2	1.7350	3	1.7502	3	1.7655	3	36
25	1.6291	2	1.6444	2	1.6596	2	1.6747	3	1.6899	2	1.7050	3	1.7201	3	1.7353	2	1.7505	2	1.7658	2	35
26	.6293	3	.6446	3	.6598	3	.6750	2	.6901	3	.7053	2	.7204	2	.7355	3	.7507	3	.7660	3	34
27	.6296	2	.6449	2	.6601	2	.6752	3	.6904	2	.7055	3	.7206	3	.7358	2	.7510	2	.7663	2	33
28	.6298	3	.6451	3	.6603	3	.6755	3	.6906	3	.7058	2	.7209	2	.7360	3	.7512	3	.7665	3	32
29	1.6301	2	1.6454	2	1.6606	2	1.6758	2	1.6909	2	1.7060	3	1.7211	3	1.7363	3	1.7515	3	1.7668	2	31
30	1.6303	3	1.6456	3	1.6608	3	1.6760	3	1.6911	3	1.7063	2	1.7214	2	1.7366	2	1.7518	2	1.7670	3	30
31	.6306	2	.6459	2	.6611	2	.6763	2	.6914	2	.7065	3	.7216	3	.7368	3	.7520	3	.7673	2	29
32	.6308	3	.6461	3	.6613	3	.6765	3	.6916	3	.7068	2	.7219	3	.7371	2	.7523	2	.7675	3	28
33	.6311	3	.6464	2	.6616	3	.6768	2	.6919	2	.7070	3	.7222	2	.7373	3	.7525	3	.7678	2	27
34	1.6314	2	1.6466	3	1.6619	2	1.6770	3	1.6921	3	1.7073	2	1.7224	3	1.7376	2	1.7528	2	1.7680	3	26
35	1.6316	3	1.6469	3	1.6621	3	1.6773	2	1.6924	3	1.7075	3	1.7227	2	1.7378	3	1.7530	3	1.7683	3	25
36	.6319	2	.6472	2	.6624	2	.6775	3	.6927	2	.7078	2	.7229	3	.7381	2	.7533	2	.7686	2	24
37	.6321	3	.6474	3	.6626	3	.6778	2	.6929	3	.7080	3	.7232	2	.7383	3	.7535	3	.7688	3	23
38	.6324	2	.6477	2	.6629	2	.6780	3	.6932	2	.7083	2	.7234	3	.7386	2	.7538	2	.7691	2	22
39	1.6326	3	1.6479	3	1.6631	3	1.6783	2	1.6934	3	1.7085	3	1.7237	2	1.7388	3	1.7540	3	1.7693	3	21
40	1.6329	2	1.6482	2	1.6634	2	1.6785	3	1.6937	2	1.7088	2	1.7239	3	1.7391	2	1.7543	2	1.7696	2	20
41	.6331	3	.6484	3	.6636	3	.6788	2	.6939	3	.7090	3	.7242	2	.7393	3	.7545	3	.7698	3	19
42	.6334	3	.6487	2	.6639	2	.6790	3	.6942	2	.7093	2	.7244	3	.7396	2	.7548	3	.7701	2	18
43	.6337	2	.6489	3	.6641	3	.6793	2	.6944	3	.7095	3	.7247	2	.7398	3	.7551	2	.7703	3	17
44	1.6339	3	1.6492	2	1.6644	2	1.6795	3	1.6947	2	1.7098	2	1.7249	3	1.7401	2	1.7553	3	1.7706	3	16
45	1.6342	2	1.6494	3	1.6646	3	1.6798	2	1.6949	3	1.7100	3	1.7252	2	1.7403	3	1.7556	2	1.7709	2	15
46	.6344	3	.6497	2	.6649	2	.6800	3	.6952	2	.7103	2	.7254	3	.7406	3	.7558	3	.7711	3	14
47	.6347	2	.6499	3	.6651	3	.6803	2	.6954	3	.7105	3	.7257	2	.7409	2	.7561	2	.7714	2	13
48	.6349	3	.6502	3	.6654	3	.6805	3	.6957	2	.7108	3	.7259	3	.7411	3	.7563	3	.7716	3	12
49	1.6352	2	1.6505	2	1.6657	2	1.6808	3	1.6959	3	1.7111	2	1.7262	2	1.7414	2	1.7566	2	1.7719	2	11
50	1.6354	3	1.6507	3	1.6659	3	1.6811	2	1.6962	2	1.7113	3	1.7264	3	1.7416	3	1.7568	3	1.7721	3	10
51	.6357	3	.6510	2	.6662	2	.6813	3	.6964	3	.7116	2	.7267	2	.7419	2	.7571	3	.7724	2	9
52	.6360	2	.6512	3	.6664	3	.6816	2	.6967	2	.7118	3	.7269	3	.7421	3	.7574	2	.7726	3	8
53	.6362	3	.6515	2	.6667	2	.6818	3	.6969	3	.7121	2	.7272	2	.7424	2	.7576	3	.7729	3	7
54	1.6365	2	1.6517	3	1.6669	3	1.6821	2	1.6972	2	1.7123	3	1.7274	3	1.7426	3	1.7579	2	1.7732	2	6
55	1.6367	3	1.6520	2	1.6672	2	1.6823	3	1.6974	3	1.7126	2	1.7277	3	1.7429	2	1.7581	3	1.7734	3	5
56	.6370	2	.6522	3	.6674	3	.6826	2	.6977	2	.7128	3	.7280	2	.7431	3	.7584	2	.7737	2	4
57	.6372	3	.6525	2	.6677	2	.6828	3	.6979	3	.7131	2	.7282	3	.7434	2	.7586	3	.7739	3	3
58	.6375	2	.6527	3	.6679	3	.6831	2	.6982	3	.7133	3	.7285	2	.7436	3	.7589	2	.7742	2	2
59	1.6377	3	1.6530	2	1.6682	2	1.6833	3	1.6985	2	1.7136	2	1.7287	3	1.7439	2	1.7591	3	1.7744	3	1
60	1.6380		1.6532		1.6684		1.6836		1.6987		1.7138		1.7290		1.7441		1.7594		1.7747		0
	319°		318°		317°		316°		315°		314°		313°		312°		311°		310°		App. Z. D.

Table XXVI.—*Log R*—Continued.

App. Z. D.	50°		51°		52°		53°		54°		55°		56°		57°		58°		
0′	1.7747	2	1.7901	2	1.8056	2	1.8212	3	1.8369	3	1.8529	2	1.86903	28	1.88542	27	1.90203	28	60′
1	.7749	3	.7903	3	.8058	3	.8215	2	.8372	2	.8531	3	.86931	27	.88569	28	.90231	28	59
2	.7752	3	.7906	3	.8061	3	.8217	3	.8374	3	.8534	3	.86958	27	.88597	27	.90259	28	58
3	.7755	2	.7909	2	.8064	2	.8220	3	.8377	3	.8537	2	.86985	27	.88624	28	.90287	28	57
4	1.7757	3	1.7911	3	1.8066	3	1.8223	2	1.8380	2	1.8539	3	1.87012	28	1.88652	27	1.90315	28	56
5	1.7760	2	1.7914	2	1.8069	2	1.8225	3	1.8382	3	1.8542	3	1.87040	27	1.88679	28	1.90343	28	55
6	.7762	3	.7916	3	.8071	3	.8228	3	.8385	3	.8545	2	.87067	27	.88707	27	.90371	28	54
7	.7765	2	.7919	2	.8074	3	.8231	2	.8388	2	.8547	3	.87094	27	.88734	28	.90399	28	53
8	.7767	3	.7921	3	.8077	2	.8233	3	.8390	3	.8550	3	.87121	27	.88762	27	.90427	28	52
9	1.7770	2	1.7924	3	1.8079	3	1.8236	2	1.8393	3	1.8553	2	1.87148	27	1.88789	28	1.90455	28	51
10	1.7772	3	1.7927	2	1.8082	2	1.8238	3	1.8396	2	1.8555	3	1.87175	27	1.88817	27	1.90483	28	50
11	.7775	3	.7929	3	.8084	3	.8241	3	.8398	3	.8558	3	.87202	28	.88844	28	.90511	28	49
12	.7778	2	.7932	2	.8087	3	.8244	2	.8401	2	.8561	2	.87230	27	.88872	27	.90539	28	48
13	.7780	3	.7934	3	.8090	2	.8246	3	.8403	3	.8563	3	.87257	27	.88899	28	.90567	28	47
14	1.7783	2	1.7937	3	1.8092	3	1.8249	3	1.8406	3	1.8566	3	1.87284	27	1.88927	27	1.90595	28	46
15	1.7785	3	1.7940	2	1.8095	2	1.8252	2	1.8409	2	1.8569	2	1.87311	27	1.88954	28	1.90623	28	45
16	.7788	2	.7942	3	.8097	3	.8254	3	.8411	3	.8571	3	.87338	28	.88982	27	.90651	28	44
17	.7790	3	.7945	2	.8100	3	.8257	2	.8414	3	.8574	3	.87366	27	.89009	28	.90679	28	43
18	.7793	3	.7947	3	.8103	2	.8259	3	.8417	2	.8577	3	.87393	27	.89037	27	.90707	28	42
19	1.7796	2	1.7950	2	1.8105	3.	1.8262	3	1.8419	3	1.8580	2	1.87420	28	1.89064	28	1.90735	28	41
20	1.7798	3	1.7952	3	1.8108	2	1.8265	2	1.8422	3	1.8582	3	1.87448	27	1.89092	28	1.90763	28	40
21	.7801	2	.7955	3	.8110	3	.8267	3	.8425	2	.8585	3	.87475	27	.89120	27	.90791	28	39
22	.7803	3	.7958	2	.8113	3	.8270	2	.8427	3	.8588	2	.87502	27	.89147	28	.90819	28	38
23	.7806	2	.7960	3	.8116	2	.8272	3	.8430	3	.8590	3	.87529	27	.89175	27	.90847	28	37
24	1.7808	3	1.7963	2	1.8118	3	1.8275	3	1.8433	2	1.8593	3	1.87556	27	1.89202	28	1.90875	28	36
25	1.7811	3	1.7965	3	1.8121	2	1.8278	2	1.8435	3	1.8596	2	1.87583	27	1.89230	28	1.90903	29	35
26	.7814	2	.7968	2	.8123	3	.8280	3	.8438	3	.8598	3	.87610	27	.89258	28	.90932	28	34
27	.7816	3	.7970	3	.8126	3	.8283	3	.8441	2	.8601	3	.87637	28	.89286	28	.90960	28	33
28	.7819	2	.7973	3	.8129	2	.8286	2	.8443	3	.8604	2	.87665	27	.89314	27	.90988	28	32
29	1.7821	3	1.7976	2	1.8131	3	1.8288	3	1.8446	3	1.8606	3	1.87692	27	1.89341	28	1.91016	28	31
30	1.7824	2	1.7978	3	1.8134	2	1.8291	2	1.8449	2	1.8609	3	1.87719	27	1.89369	27	1.91044	28	30
31	.7826	3	.7981	2	.8136	3	.8293	3	.8451	3	.8612	3	.87746	28	.89396	28	.91072	29	29
32	.7829	2	.7983	3	.8139	3	.8296	2	.8454	3	.8615	2	.87774	27	.89424	28	.91101	28	28
33	.7831	3	.7986	3	.8142	2	.8298	3	.8457	2	.8617	3	.87801	28	.89452	28	.91129	28	27
34	1.7834	3	1.7989	2	1.8144	3	1.8301	2	1.8459	3	1.8620	3	1.87829	27	1.89480	28	1.91157	28	26
35	1.7837	2	1.7991	3	1.8147	3	1.8303	3	1.8462	3	1.8623	2	1.87856	28	1.89508	28	1.91185	28	25
36	.7839	3	.7994	2	.8150	2	.8306	2	.8465	2	.8625	3	.87884	27	.89536	27	.91213	29	24
37	.7842	2	.7996	3	.8152	3	.8308	3	.8467	3	.8628	3	.87911	27	.89563	28	.91242	28	23
38	.7844	3	.7999	3	.8155	2	.8311	3	.8470	3	.8631	2	.87938	27	.89591	27	.91270	29	22
39	1.7847	2	1.8002	2	1.8157	3	1.8314	2	1.8473	2	1.8633	3	1.87965	28	1.89618	28	1.91299	28	21
40	1.7849	3	1.8004	3	1.8160	3	1.8316	3	1.8475	3	1.8636	3	1.87993	27	1.89646	28	1.91327	28	20
41	.7852	3	.8007	2	.8163	2	.8319	3	.8478	3	.8639	3	.88020	28	.89674	27	.91355	28	19
42	.7855	2	.8009	3	.8165	3	.8322	2	.8481	2	.8642	2	.88048	27	.89701	28	.91383	28	18
43	.7857	3	.8012	2	.8168	2	.8324	3	.8483	3	.8644	3	.88075	27	.89729	28	.91411	29	17
44	1.7860	2	1.8014	3	1.8170	3	1.8327	2	1.8486	3	1.8647	3	1.88102	27	1.89757	28	1.91440	28	16
45	1.7862	3	1.8017	3	1.8173	3	1.8329	3	1.8489	2	1.8650	2	1.88129	28	1.89785	28	1.91468	28	15
46	.7865	3	.8020	2	.8176	2	.8332	3	.8491	3	.8652	3	.88157	27	.89813	28	.91496	28	14
47	.7868	2	.8022	3	.8178	3	.8335	2	.8494	2	.8655	3	.88184	28	.89841	27	.91524	28	13
48	.7870	3	.8025	2	.8181	2	.8337	3	.8496	3	.8658	2	.88212	27	.89868	28	.91552	28	12
49	1.7873	2	1.8027	3	1.8183	3	1.8340	3	1.8499	3	1.8660	3	1.88239	28	1.89896	28	1.91580	29	11
50	1.7875	3	1.8030	3	1.8186	3	1.8343	2	1.8502	3	1.8663	3	1.88267	27	1.89924	28	1.91609	28	10
51	.7878	2	.8033	2	.8189	2	.8345	3	.8505	2	.8666	2	.88294	27	.89952	28	.91637	29	9
52	.7880	3	.8035	3	.8191	3	.8348	3	.8507	3	.8668	3	.88321	28	.89980	28	.91666	28	8
53	.7883	2	.8038	2	.8194	3	.8351	2	.8510	3	.8671	3	.88349	27	.90008	28	.91694	28	7
54	1.7885	3	1.8040	3	1.8197	2	1.8353	3	1.8513	2	1.8674	3	1.88376	28	1.90036	28	1.91722	29	6
55	1.7888	3	1.8043	2	1.8199	3	1.8356	2	1.8515	3	1.8677	2	1.88404	28	1.90064	28	1.91751	28	5
56	.7891	2	.8045	3	.8202	3	.8358	3	.8518	3	.8679	3	.88432	27	.90092	28	.91779	29	4
57	.7893	3	.8048	3	.8205	2	.8361	3	.8521	2	.8682	3	.88459	28	.90120	28	.91808	28	3
58	.7896	2	.8051	2	.8207	3	.8364	2	.8523	3	.8685	2	.88487	27	.90148	28	.91836	29	2
59	1.7898	3	1.8053	3	1.8210	2	1.8366	3	1.8526	3	1.8687	3	1.88514	28	1.90176	27	1.91865	28	1
60	1.7901		1.8056		1.8212		1.8369		1.8529		1.8690		1.88542		1.90203		1.91893		0
	309°		308°		307°		306°		305°		304°		303°		302°		301°		App. Z. D.

TABLE XXVI.—*Log R*—Continued.

App. Z. D.	59°		60°		61°		62°		63°		64°		65°		66°		67°		
0′	1.91893	28	1.93615	29	1.95368	30	1.97160	30	1.98993	31	2.00873	31	2.02802	33	2.04788	34	2.06833	35	60′
1	.91921	29	.93644	29	.95398	29	.97190	31	.99024	31	.00904	32	.02835	33	.04822	34	.06868	34	59
2	.91950	28	.93673	29	.95427	30	.97221	30	.99055	31	.00936	31	.02868	32	.04856	33	.06902	35	58
3	.91978	29	.93702	29	.95457	30	.97251	30	.99086	31	.00967	32	.02900	33	.04889	34	.06937	34	57
4	1.92007	28	1.93731	29	1.95487	29	1.97281	30	1.99117	31	2.00999	32	2.02933	33	2.04923	33	2.06971	35	56
5	1.92035	28	1.93760	29	1.95516	30	1.97311	31	1.99148	31	2.01031	32	2.02966	32	2.04956	33	2.07006	35	55
6	.92063	29	.93789	29	.95546	30	.97342	30	.99179	31	.01063	32	.02998	33	.04989	34	.07041	34	54
7	.92092	29	.93818	29	.95576	29	.97372	30	.99210	31	.01095	32	.03031	33	.05023	34	.07075	35	53
8	.92121	28	.93847	29	.95605	30	.97402	30	.99241	31	.01127	32	.03064	33	.05057	33	.07110	35	52
9	1.92149	29	1.93876	29	1.95635	30	1.97432	31	1.99272	31	2.01159	31	2.03097	33	2.05090	34	2.07145	35	51
10	1.92178	28	1.93905	29	1.95665	29	1.97463	30	1.99303	31	2.01190	32	2.03130	33	2.05124	34	2.07180	34	50
11	.92206	29	.93934	29	.95694	30	.97493	30	.99334	31	.01222	32	.03163	32	.05158	33	.07214	35	49
12	.92235	28	.93963	29	.95724	30	.97523	31	.99365	32	.01254	32	.03195	33	.05191	34	.07249	35	48
13	.92263	29	.93992	28	.95754	29	.97554	30	.99397	31	.01286	32	.03228	33	.05225	34	.07284	35	47
14	1.92292	29	1.94020	29	1.95783	30	1.97584	30	1.99428	31	2.01318	32	2.03261	33	2.05259	34	2.07319	35	46
15	1.92321	28	1.94049	29	1.95813	30	1.97614	30	1.99459	31	2.01350	32	2.03294	33	2.05293	34	2.07354	35	45
16	.92349	29	.94078	29	.95843	29	.97644	30	.99490	31	.01382	32	.03327	33	.05327	34	.07389	35	44
17	.92378	28	.94107	29	.95872	30	.97674	31	.99521	32	.01414	32	.03360	33	.05361	34	.07424	35	43
18	.92406	29	.94136	29	.95902	30	.97705	30	.99553	31	.01446	32	.03393	33	.05395	34	.07459	35	42
19	1.92435	29	1.94165	30	1.95932	29	1.97735	31	1.99584	31	2.01478	32	2.03426	33	2.05429	34	2.07494	35	41
20	1.92464	29	1.94195	29	1.95961	30	1.97766	30	1.99615	31	2.01510	32	2.03459	32	2.05463	34	2.07529	35	40
21	.92493	28	.94224	29	.95991	30	.97796	31	.99646	32	.01542	32	.03491	33	.05497	34	.07564	35	39
22	.92521	29	.94253	30	.96021	30	.97827	30	.99678	31	.01574	32	.03524	33	.05531	34	.07599	35	38
23	.92550	29	.94283	29	.96051	30	.97857	30	.99709	31	.01606	33	.03557	33	.05565	33	.07634	35	37
24	1.92579	28	1.94312	29	1.96081	30	1.97887	31	1.99740	31	2.01639	32	2.03590	33	2.05598	34	2.07669	35	36
25	1.92607	29	1.94341	29	1.96111	29	1.97918	30	1.99771	31	2.01671	32	2.03623	33	2.05632	34	2.07704	35	35
26	.92636	29	.94370	29	.96140	30	.97948	31	.99802	31	.01703	32	.03656	33	.05666	34	.07739	35	34
27	.92665	28	.94399	30	.96170	30	.97979	30	.99833	31	.01735	32	.03689	33	.05700	34	.07774	35	33
28	.92693	29	.94429	29	.96200	30	.98009	31	.99864	31	.01767	32	.03722	33	.05734	34	.07809	36	32
29	1.92722	28	1.94458	29	1.96230	30	1.98040	30	1.99895	31	2.01799	32	2.03755	33	2.05768	34	2.07845	35	31
30	1.92750	28	1.94487	29	1.96260	30	1.98070	31	1.99926	32	2.01831	32	2.03788	33	2.05802	34	2.07880	35	30
31	.92778	29	.94516	30	.96290	29	.98101	31	.99958	31	.01863	32	.03821	33	.05836	35	.07915	35	29
32	.92807	29	.94546	29	.96319	30	.98132	31	1.99989	31	.01895	32	.03854	33	.05871	34	.07950	36	28
33	.92836	29	.94575	29	.96349	30	.98163	30	2.00020	32	.01927	33	.03887	33	.05905	34	.07986	35	27
34	1.92865	28	1.94604	29	1.96379	30	1.98193	31	2.00052	31	2.01960	32	2.03920	33	2.05939	34	2.08021	35	26
35	1.92893	29	1.94633	30	1.96409	29	1.98224	30	2.00083	32	2.01992	32	2.03953	33	2.05973	34	2.08056	36	25
36	.92922	29	.94663	29	.96438	30	.98254	31	.00115	31	.02024	32	.03986	33	.06007	34	.08092	35	24
37	.92951	28	.94692	30	.96468	29	.98285	30	.00146	32	.02056	33	.04019	34	.06041	35	.08127	35	23
38	.92979	29	.94722	29	.96497	30	.98315	31	.00178	31	.02089	32	.04053	33	.06076	34	.08162	36	22
39	1.93008	29	1.94751	29	1.96527	30	1.98346	30	2.00209	31	2.02121	32	2.04086	33	2.06110	34	2.08198	35	21
40	1.93037	28	1.94780	30	1,96557	31	1.98376	31	2.00240	32	2.02153	33	2.04119	34	2.06144	35	2.08233	36	20
41	.93065	29	.94810	29	.96588	30	.98407	31	.00272	32	.02186	32	.04153	33	.06179	34	.08269	35	19
42	.93094	29	.94839	29	.96618	30	.98438	31	.00304	31	.02218	32	.04186	33	.06213	34	.08304	36	18
43	.93123	29	.94868	29	.96648	30	.98469	31	.00335	32	.02250	33	.04219	33	.06247	34	.08340	35	17
44	1.93152	29	1.94897	30	1.96678	31	1.98500	30	2.00367	31	2.02283	32	2.04252	33	2.06281	34	2.08375	36	16
45	1.93181	29	1.94927	29	1.96709	30	1.98530	31	2.00398	32	2.02315	33	2.04285	33	2.06315	35	2.08411	35	15
46	.93210	29	.94956	29	.96739	30	.98561	31	.00430	31	.02348	32	.04318	34	.06350	34	.08446	36	14
47	.93239	28	.94985	30	.96769	30	.98592	31	.00461	32	.02380	32	.04352	33	.06384	35	.08482	35	13
48	.93267	29	.95015	29	.96799	30	.98623	31	.00493	31	.02412	33	.04385	34	.06419	34	.08517	36	12
49	1.93296	29	1.95044	30	1.96829	30	1.98654	31	2.00524	32	2.02445	32	2.04419	34	2.06453	34	2.08553	35	11
50	1.93325	29	1.95074	29	1.96859	30	1.98685	31	2.00556	32	2.02477	33	2.04453	33	2.06487	35	2.08588	36	10
51	.93354	29	.95103	30	.96889	30	.98716	30	.00588	32	.02510	32	.04486	34	.06522	35	.08624	35	9
52	.93383	29	.95133	29	.96919	30	.98746	31	.00620	32	.02542	33	.04520	33	.06557	34	.08659	36	8
53	.93412	29	.95162	30	.96949	30	.98777	30	.00652	31	.02575	32	.04553	34	.06591	35	.08695	35	7
54	1.93441	29	1.95192	29	1.96979	30	1.98807	31	2.00683	32	2.02607	33	2.04587	33	2.06626	34	2.08730	36	6
55	1.93470	29	1.95221	29	1.97009	31	1.98838	31	2.00715	32	2.02640	32	2.04620	34	2.06660	35	2.08766	35	5
56	.93499	29	.95250	30	.97040	30	.98869	31	.00747	31	.02672	33	.04654	34	.06695	34	.08801	36	4
57	.93528	29	.95280	29	.97070	30	.98900	31	.00778	32	.02705	32	.04688	33	.06729	35	.08837	36	3
58	.93557	29	.95309	30	.97100	30	.98931	31	.00810	31	.02737	33	.04721	34	.06764	35	.08873	36	2
59	1.93586	29	1.95339	29	1.97130	30	1.98962	31	2.00841	32	2.02770	32	2.04755	33	2.06799	34	2.08909	36	1
60	1.93615		1.95368		1.97160		1.98993		2.00873		2.02802		2.04788		2.06833		2.08945		0
	300°		299°		298°		297°		296°		295°		294°		293°		292°		App. Z. D.

TABLE XXVI.—*Log R*—Continued.

App. Z. D.	68°		69°		70°		71°		72°		73°		74°		75°		76°		
0′	2.08945	36	2.11132	37	2.13401	39	2.15763	40	2.18225	42	2.20804	44	2.23511	47	2.26362	49	2.29377	52	60′
1	.08981	36	.11169	37	.13440	38	.15803	40	.18267	42	.20848	44	.23558	46	.26411	48	.29429	52	59
2	.09017	36	.11206	37	.13478	39	.15843	40	.18309	43	.20892	44	.23604	47	.26459	49	.29481	52	58
3	.09053	36	.11243	37	.13517	38	.15883	40	.18352	42	.20936	44	.23651	46	.26508	49	.29533	52	57
4	2.09089	36	2.11280	37	2.13555	39	2.15923	40	2.18394	42	2.20980	45	2.23697	47	2.26557	49	2.29585	52	56
5	2.09125	36	2.11317	37	2.13594	39	2.15963	41	2.18436	42	2.21025	44	2.23744	46	2.26606	50	2.29637	52	55
6	.09161	36	.11354	38	.13633	39	.16004	40	.18478	42	.21069	44	.23790	46	.26656	49	.29689	52	54
7	.09197	36	.11392	37	.13672	39	.16044	41	.18520	42	.21113	45	.23836	47	.26705	49	.29741	52	53
8	.09233	36	.11429	38	.13711	38	.16085	40	.18562	43	.21158	44	.23883	46	.26754	49	.29793	52	52
9	2.09269	35	2.11467	37	2.13749	39	2.16125	41	2.18605	42	2.21202	44	2.23929	47	2.26803	50	2.29845	53	51
10	2.09304	36	2.11504	37	2.13788	39	2.16166	40	2.18647	42	2.21246	44	2.23976	47	2.26853	49	2.29898	52	50
11	.09340	36	.11541	37	.13827	39	.16206	40	.18689	43	.21290	45	.24023	46	.26902	50	.29950	52	49
12	.09376	36	.11578	37	.13866	39	.16246	41	.18732	42	.21335	44	.24069	47	.26952	49	.30002	52	48
13	.09412	36	.11615	38	.13905	39	.16287	40	.18774	43	.21379	45	.24116	47	.27001	49	.30054	53	47
14	2.09448	36	2.11653	37	2.13944	39	2.16327	41	2.18817	42	2.21424	44	2.24163	47	2.27050	50	2.30107	52	46
15	2.09484	37	2.11690	38	2.13983	38	2.16368	41	2.18859	43	2.21468	45	2.24210	47	2.27100	50	2.30159	52	45
16	.09521	36	.11728	38	.14021	39	.16409	41	.18902	42	.21513	44	.24257	47	.27150	49	.30211	53	44
17	.09557	36	.11766	37	.14060	39	.16450	41	.18944	43	.21557	45	.24304	47	.27199	50	.30264	53	43
18	.09593	36	.11803	38	.14099	39	.16491	40	.18987	42	.21602	45	.24351	47	.27249	49	.30317	53	42
19	2.09629	36	2.11841	37	2.14138	39	2.16531	41	2.19029	43	2.21647	45	2.24398	47	2.27298	50	2.30370	53	41
20	2.09665	37	2.11878	38	2.14177	40	2.16572	41	2.19072	42	2.21692	45	2.24445	47	2.27348	50	2.30423	53	40
21	.09702	36	.11916	38	.14217	39	.16613	40	.19114	43	.21737	45	.24492	48	.27398	50	.30476	53	39
22	.09738	36	.11954	37	.14256	39	.16653	41	.19157	42	.21782	45	.24540	47	.27448	50	.30529	53	38
23	.09774	37	.11991	38	.14295	40	.16694	41	.19199	43	.21827	44	.24587	47	.27498	50	.30582	53	37
24	2.09811	36	2.12029	37	2.14335	39	2.16735	41	2.19242	43	2.21871	45	2.24634	47	2.27548	50	2.30635	53	36
25	2.09847	36	2.12066	38	2.14374	39	2.16776	41	2.19285	43	2.21916	45	2.24681	47	2.27598	50	2.30688	53	35
26	.09883	36	.12104	37	.14413	39	.16817	41	.19328	43	.21961	45	.24728	47	.27648	50	.30741	53	34
27	.09919	37	.12141	38	.14452	39	.16858	41	.19371	43	.22006	45	.24775	47	.27698	50	.30794	53	33
28	.09956	36	.12179	38	.14491	39	.16899	41	.19414	43	.22051	45	.24822	48	.27748	50	.30847	54	32
29	2.09992	36	2.12217	38	2.14530	39	2.16940	41	2.19457	43	2.22096	45	2.24870	47	2.27798	50	2.30901	53	31
30	2.10028	37	2.12255	38	2.14569	40	2.16981	41	2.19500	42	2.22141	45	2.24917	47	2.27848	51	2.30954	53	30
31	.10065	37	.12293	38	.14609	39	.17022	41	.19542	43	.22186	45	.24964	48	.27899	50	.31007	53	29
32	.10102	36	.12331	38	.14648	40	.17063	41	.19585	43	.22231	46	.25012	48	.27949	51	.31060	54	28
33	.10138	37	.12369	38	.14688	39	.17104	41	.19628	43	.22277	45	.25060	48	.28000	50	.31114	53	27
34	2.10175	37	2.12407	38	2.14727	40	2.17145	42	2.19671	43	2.22322	46	2.25108	48	2.28050	50	2.31167	54	26
35	2.10212	36	2.12445	38	2.14767	40	2.17187	41	2.19714	44	2.22368	45	2.25156	48	2.28100	51	2.31221	54	25
36	.10248	37	.12483	38	.14807	39	.17228	42	.19758	43	.22413	45	.25204	47	.28151	50	.31275	54	24
37	.10285	36	.12521	38	.14846	40	.17270	41	.19801	43	.22458	45	.25251	48	.28201	51	.31329	53	23
38	.10321	37	.12559	38	.14886	40	.17311	41	.19844	43	.22503	45	.25299	48	.28252	50	.31382	54	22
39	2.10358	36	2.12597	38	2.14926	39	2.17352	41	2.19887	43	2.22548	46	2.25347	48	2.28302	51	2.31436	54	21
40	2.10394	37	2.12635	38	2.14965	40	2.17393	41	2.19930	44	2.22594	45	2.25395	48	2.28353	51	2.31490	54	20
41	.10431	36	.12673	38	.15005	39	.17434	41	.19974	43	.22639	46	.25443	48	.28404	51	.31544	54	19
42	.10467	37	.12711	38	.15044	40	.17475	42	.20017	44	.22685	45	.25491	48	.28455	51	.31598	54	18
43	.10504	37	.12749	39	.15084	40	.17517	41	.20061	43	.22730	46	.25539	48	.28506	51	.31652	54	17
44	2.10541	37	2.12788	38	2.15124	40	2.17558	42	2.20104	44	2.22776	45	2.25587	48	2.28557	51	2.31706	54	16
45	2.10578	37	2.12826	38	2.15164	39	2.17600	42	2.20148	43	2.22821	46	2.25635	48	2.28608	51	2.31760	55	15
46	.10615	36	.12864	39	.15203	40	.17642	41	.20191	43	.22867	46	.25683	49	.28659	51	.31815	54	14
47	.10651	37	.12903	38	.15243	40	.17683	42	.20234	44	.22913	46	.25732	48	.28710	51	.31869	55	13
48	.10688	37	.12941	38	.15283	40	.17725	41	.20278	43	.22959	46	.25780	49	.28761	51	.31924	54	12
49	2.10725	37	2.12979	38	2.15323	40	2.17766	41	2.20321	44	2.23005	46	2.25829	48	2.28812	51	2.31978	54	11
50	2.10762	37	2.13017	38	2.15363	39	2.17807	42	2.20365	44	2.23051	46	2.25877	48	2.28863	51	2.32032	55	10
51	.10799	37	.13055	38	.15402	40	.17849	42	.20409	44	.23097	46	.25925	49	.28914	51	.32087	54	9
52	.10836	37	.13093	38	.15442	40	.17891	42	.20453	44	.23143	46	.25974	48	.28965	51	.32141	54	8
53	.10873	37	.13131	39	.15482	40	.17933	42	.20497	44	.23189	46	.26022	49	.29016	52	.32195	55	7
54	2.10910	37	2.13170	38	2.15522	40	2.17975	42	2.20541	43	2.23235	46	2.26071	48	2.29068	51	2.32250	55	6
55	2.10947	37	2.13208	39	2.15562	41	2.18017	41	2.20584	44	2.23281	46	2.26119	49	2.29119	52	2.32305	55	5
56	.10984	37	.13247	39	.15603	40	.18058	42	.20628	44	.23327	46	.26168	48	.29171	51	.32360	55	4
57	.11021	37	.13286	38	.15643	40	.18100	41	.20672	44	.23373	46	.26216	49	.29222	52	.32415	55	3
58	.11058	37	.13324	39	.15683	40	.18141	42	.20716	44	.23419	46	.26265	49	.29274	52	.32470	55	2
59	2.11095	37	2.13363	38	2.15723	40	2.18183	42	2.20760	44	2.23465	46	2.26314	48	2.29326	51	2.32525	55	1
60	2.11132		2.13401		2.15763		2.18225		2.20804		2.23511		2.26362		2.29377		2.32580		0
	291°		290°		289°		288°		287°		286°		285°		284°		283°		App. Z. D.

TABLE XXVI.—*Log R*—Continued.

App. Z. D.	77°		78°		79°		80°		81°		82°		83°		84°		
0′	2.32580	55	2.35997	59	2.39663	64	2.43618	69	2.47914	74	2.52612	82	2.57794	91	2.63568	102	60′
1	.32635	55	.36056	58	.39727	63	.43687	69	.47988	75	.52694	82	.57885	92	.63670	102	59
2	.32690	55	.36114	59	.39790	64	.43756	68	.48063	75	.52776	83	.57977	91	.63772	103	58
3	.32745	55	.36173	59	.39854	64	.43824	69	.48138	74	.52859	82	.58068	91	.63875	102	57
4	2.32800	56	2.36232	59	2.39918	63	2.43893	69	2.48212	75	2.52941	82	2.58159	92	2.63977	102	56
5	2.32856	55	2.36291	60	2.39981	64	2.43962	69	2.48287	76	2.53023	83	2.58251	92	2.64079	102	55
6	.32911	56	.36351	60	.40045	64	.44031	69	.48363	75	.53106	83	.58343	92	.64181	103	54
7	.32967	55	.36411	59	.40109	64	.44100	70	.48438	76	.53189	83	.58435	93	.64284	103	53
8	.33022	55	.36470	60	.40173	64	.44170	69	.48514	76	.53272	83	.58528	93	.64387	103	52
9	2.33077	56	2.36530	60	2.40237	64	2.44239	70	2.48590	76	2.53355	84	2.58621	92	2.64490	104	51
10	2.33133	56	2.36590	60	2.40301	64	2.44309	69	2.48666	76	2.53439	84	2.58713	93	2.64594	105	50
11	.33189	55	.36650	60	.40365	64	.44378	70	.48742	76	.53523	83	.58806	93	.64699	104	49
12	.33244	56	.36710	60	.40429	65	.44448	69	.48818	76	.53606	84	.58899	93	.64803	105	48
13	.33300	56	.36770	59	.40494	64	.44517	70	.48894	77	.53690	84	.58992	94	.64908	104	47
14	2.33356	56	2.36829	60	2.40558	65	2.44587	70	2.48971	76	2.53774	84	2.59086	94	2.65012	104	46
15	2.33412	56	2.36889	60	2.40623	65	2.44657	70	2.49047	77	2.53858	85	2.59180	94	2.65116	105	45
16	.33468	56	.36949	60	.40688	64	.44727	70	.49124	76	.53943	84	.59274	94	.65221	106	44
17	.33524	56	.37009	60	.40752	65	.44797	70	.49200	77	.54027	84	.59368	94	.65327	105	43
18	.33580	56	.37069	60	.40817	65	.44867	71	.49277	77	.54111	85	.59462	94	.65432	106	42
19	2.33636	57	2.37129	60	2.40882	65	2.44938	71	2.49354	76	2.54196	84	2.59556	95	2.65538	106	41
20	2.33693	56	2.37189	60	2.40947	65	2.45009	71	2.49430	77	2.54280	85	2.59651	95	2.65644	106	40
21	.33749	57	.37249	61	.41012	65	.45080	70	.49507	78	.54365	85	.59746	94	.65750	106	39
22	.33806	56	.37310	61	.41077	66	.45150	71	.49585	77	.54450	85	.59840	95	.65856	107	38
23	.33862	57	.37371	60	.41143	65	.45221	70	.49662	78	.54535	86	.59935	95	.65963	107	37
24	2.33919	57	2.37431	61	2.41208	65	2.45291	71	2.49740	77	2.54621	85	2.60030	95	2.66070	107	36
25	2.33976	56	2.37492	61	2.41273	65	2.45362	71	2.49817	78	2.54706	86	2.60125	95	2.66177	107	35
26	.34032	57	.37553	61	.41338	66	.45433	71	.49895	78	.54792	86	.60220	96	.66284	108	34
27	.34089	57	.37614	61	.41404	65	.45504	71	.49973	77	.54878	86	.60316	96	.66392	108	33
28	.34146	57	.37675	61	.41469	66	.45575	72	.50050	78	.54964	87	.60412	96	.66500	108	32
29	2.34203	56	2.37736	61	2.41535	65	2.45647	72	2.50128	79	2.55051	86	2.60508	96	2.66608	108	31
30	2.34259	57	2.37797	61	2.41600	66	2.45719	72	2.50207	79	2.55137	87	2.60604	96	2.66716	109	30
31	.34316	57	.37858	61	.41666	66	.45791	72	.50286	78	.55224	86	.60700	96	.66825	109	29
32	.34373	57	.37919	62	.41732	66	.45863	72	.50364	79	.55310	86	.60796	97	.66934	109	28
33	.34430	57	.37981	61	.41798	66	.45935	72	.50443	78	.55396	87	.60893	97	.67043	109	27
34	2.34487	58	2.38042	61	2.41864	67	2.46007	72	2.50521	79	2.55483	87	2.60990	96	2.67152	110	26
35	2.34545	57	2.38103	62	2.41931	66	2.46079	72	2.50600	79	2.55570	87	2.61086	97	2.67262	110	25
36	.34602	58	.38165	62	.41997	67	.46151	72	.50679	79	.55657	88	.61183	97	.67372	109	24
37	.34660	57	.38227	61	.42064	66	.46223	72	.50758	79	.55745	87	.61280	98	.67481	110	23
38	.34717	58	.38288	62	.42130	67	.46295	73	.50837	79	.55832	88	.61378	98	.67591	110	22
39	2.34775	57	2.38350	62	2.42197	67	2.46368	73	2.50916	80	2.55920	88	2.61476	98	2.67701	111	21
40	2.34832	57	2.38412	62	2.42264	67	2.46441	72	2.50996	79	2.56008	88	2.61574	97	2.67812	111	20
41	.34889	58	.38474	62	.42331	67	.46513	73	.51075	80	.56096	87	.61671	98	.67923	111	19
42	.34947	58	.38536	62	.42398	67	.46586	73	.51155	80	.56183	88	.61769	99	.68034	111	18
43	.35005	58	.38598	62	.42465	67	.46659	73	.51235	79	.56271	89	.61868	98	.68145	111	17
44	2.35063	58	2.38660	62	2.42532	67	2.46732	73	2.51314	80	2.56360	89	2.61966	98	2.68256	112	16
45	2.35121	58	2.38722	63	2.42599	67	2.46805	73	2.51394	80	2.56449	88	2.62064	99	2.68368	112	15
46	.35179	58	.38785	62	.42666	68	.46878	74	.51474	81	.56537	89	.62163	99	.68480	111	14
47	.35237	58	.38847	62	.42734	67	.46952	73	.51555	81	.56626	89	.62262	99	.68591	112	13
48	.35295	59	.38909	62	.42801	68	.47025	73	.51636	81	.56715	88	.62361	100	.68703	113	12
49	2.35354	58	2.38971	62	2.42869	68	2.47098	74	2.51717	80	2.56803	89	2.62461	99	2.68816	112	11
50	2.35412	58	2.39033	63	2.42937	68	2.47172	73	2.51797	81	2.56892	90	2.62560	100	2.68928	113	10
51	.35470	59	.39096	63	.43005	67	.47245	74	.51878	81	.56982	89	.62660	100	.69041	114	9
52	.35529	58	.39159	63	.43072	68	.47319	74	.51959	82	.57071	90	.62760	100	.69155	113	8
53	.35587	58	.39222	63	.43140	68	.47393	74	.52041	81	.57161	89	.62860	101	.69268	114	7
54	2.35645	59	2.39285	63	2.43208	68	2.47467	74	2.52122	82	2.57250	90	2.62961	100	2.69382	114	6
55	2.35704	58	2.39348	63	2.43276	68	2.47541	75	2.52204	82	2.57340	91	2.63061	101	2.69496	115	5
56	.35762	58	.39411	63	.43344	69	.47616	74	.52286	81	.57431	90	.63162	102	.69611	115	4
57	.35820	59	.39474	63	.43413	68	.47690	74	.52367	82	.57521	91	.63264	101	.69726	115	3
58	.35879	59	.39537	63	.43481	69	.47764	75	.52449	81	.57612	91	.63365	101	.69841	115	2
59	2.35938	59	2.39600	63	2.43550	68	2.47839	75	2.52530	82	2.57703	91	2.63466	102	2.69956	115	1
60	2.35997		2.39663		2.43618		2.47914		2.52612		2.57794		2.63568		2.70071		0
	282°		281°		280°		279°		278°		277°		276°		275°		App. Z. D.

TABLE XXVII.—*Log T.*

[Fahrenheit Scale.]

Ext. Ther.	0°.0	0°.1	0°.2	0°.3	0°.4	0°.5	0°.6	0°.7	0°.8	0°.9
°										
−19	0.10462	0.10472	0.10482	0.10492	0.10502	0.10512	0.10522	0.10532	0.10542	0.10552
18	.10363	.10373	.10383	.10393	.10403	.10413	.10423	.10433	.10443	.10453
17	.10264	.10274	.10284	.10294	.10304	.10313	.10323	.10333	.10343	.10353
16	.10165	.10175	.10185	.10195	.10205	.10214	.10224	.10234	.10244	.10254
−15	0.10066	0.10076	0.10086	0.10096	0.10106	0.10116	0.10126	0.10135	0.10145	0.10155
−14	0.09968	0.09978	0.09988	0.09998	0.10007	0.10017	0.10027	0.10037	0.10047	0.10057
13	.09870	.09880	.09890	.09899	.09909	.09919	.09929	.09939	.09948	.09958
12	.09772	.09782	.09792	.09801	.09811	.09821	.09831	.09841	.09850	.09860
11	.09674	.09684	.09694	.09704	.09713	.09723	.09733	.09743	.09752	.09762
−10	0.09577	0.09587	0.09597	0.09606	0.09616	0.09626	0.09635	0.09645	0.09655	0.09665
− 9	0.09479	0.09489	0.09499	0.09509	0.09518	0.09528	0.09538	0.09548	0.09557	0.09567
8	.09382	.09392	.09402	.09411	.09421	.09430	.09440	.09450	.09460	.09470
7	.09285	.09295	.09304	.09314	.09324	.09333	.09343	.09353	.09363	.09372
6	.09188	.09198	.09207	.09217	.09227	.09236	.09246	.09256	.09266	.09275
− 5	0.09092	0.09102	0.09111	0.09121	0.09130	0.09140	0.09150	0.09159	0.09169	0.09178
− 4	0.08996	0.09006	0.09015	0.09025	0.09034	0.09044	0.09054	0.09063	0.09073	0.09082
3	.08900	.08910	.08920	.08929	.08939	.08948	.08958	.08967	.08977	.08986
2	.08805	.08815	.08824	.08834	.08843	.08853	.08862	.08872	.08881	.08891
1	.08709	.08719	.08729	.08738	.08748	.08757	.08767	.08776	.08786	.08795
− 0	0.08614	0.08624	0.08633	0.08643	0.08652	0.08662	0.08671	0.08681	0.08690	0.08700
+ 0	0.08614	0.08604	0.08595	0.08585	0.08576	0.08566	0.08557	0.08547	0.08538	0.08528
1	.08518	.08509	.08499	.08490	.08480	.08471	.08461	.08452	.08442	.08433
2	.08423	.08413	.08404	.08394	.08385	.08375	.08366	.08356	.08347	.08337
3	.08328	.08318	.08309	.08299	.08290	.08280	.08271	.08261	.08252	.08242
+ 4	0.08233	0.08224	0.08214	0.08205	0.08195	0.08186	0.08177	0.08167	0.08158	0.08148
+ 5	0.08139	0.08130	0.08120	0.08111	0.08101	0.08092	0.08083	0.08073	0.08064	0.08054
6	.08045	.08036	.08026	.08017	.08008	.07998	.07989	.07980	.07970	.07961
7	.07951	.07942	.07933	.07923	.07914	.07905	.07895	.07886	.07877	.07867
8	.07858	.07849	.07839	.07830	.07821	.07811	.07802	.07793	.07783	.07774
+ 9	0.07764	0.07755	0.07746	0.07736	0.07727	0.07718	0.07708	0.07699	0.07690	0.07680
+10	0.07671	0.07662	0.07652	0.07643	0.07634	0.07625	0.07615	0.07606	0.07597	0.07587
11	.07578	.07569	.07559	.07550	.07541	.07531	.07522	.07513	.07504	.07494
12	.07485	.07476	.07467	.07457	.07448	.07439	.07429	.07420	.07411	.07402
13	.07393	.07383	.07374	.07365	.07355	.07346	.07337	.07328	.07319	.07309
+14	0.07300	0.07291	0.07282	0.07272	0.07263	0.07254	0.07244	0.07235	0.07226	0.07217
+15	0.07208	0.07198	0.07189	0.07180	0.07170	0.07161	0.07152	0.07143	0.07134	0.07124
16	.07115	.07106	.07097	.07088	.07078	.07069	.07060	.07051	.07042	.07033
17	.07023	.07014	.07005	.06996	.06987	.06978	.06969	.06959	.06950	.06941
18	.06932	.06923	.06914	.06905	.06895	.06886	.06877	.06868	.06859	.06850
+19	0.06840	0.06831	0.06822	0.06813	0.06804	0.06795	0.06786	0.06776	0.06767	0.06758
+20	0.06749	0.06740	0.06731	0.06721	0.06712	0.06703	0.06694	0.06685	0.06676	0.06666
21	.06657	.06648	.06639	.06630	.06621	.06612	.06603	.06594	.06584	.06575
22	.06566	.06557	.06548	.06539	.06530	.06521	.06511	.06502	.06493	.06484
23	.06475	.06466	.06457	.06448	.06439	.06430	.06421	.06412	.06403	.06394
+24	0.06385	0.06376	0.06367	0.06358	0.06349	0.06340	0.06331	0.06322	0.06313	0.06304
+25	0.06295	0.06286	0.06277	0.06268	0.06259	0.06250	0.06241	0.06232	0.06223	0.06214
26	.06205	.06196	.06187	.06178	.06169	.06160	.06151	.06142	.06133	.06124
27	.06115	.06106	.06097	.06088	.06079	.06070	.06061	.06052	.06043	.06034
28	.06025	.06016	.06007	.05998	.05989	.05980	.05971	.05962	.05953	.05944
+29	0.05935	0.05926	0.05917	0.05908	0.05899	0.05890	0.05881	0.05873	0.05864	0.05855
+30	0.05846	0.05837	0.05828	0.05819	0.05810	0.05801	0.05792	0.05783	0.05774	0.05765
31	.05756	.05747	.05738	.05729	.05720	.05711	.05703	.05694	.05685	.05676
32	.05667	.05658	.05649	.05640	.05631	.05623	.05614	.05605	.05596	.05587
33	.05578	.05569	.05560	.05551	.05542	.05533	.05525	.05516	.05507	.05498
+34	0.05489	0.05480	0.05471	0.05462	0.05454	0.05445	0.05436	0.05427	0.05418	0.05409
+35	0.05401	0.05392	0.05383	0.05374	0.05365	0.05357	0.05348	0.05339	0.05330	0.05321
36	.05312	.05304	.05295	.05286	.05277	.05268	.05259	.05251	.05242	.05233
37	.05224	.05215	.05207	.05198	.05189	.05180	.05171	.05162	.05154	.05145
38	.05136	.05127	.05118	.05110	.05101	.05092	.05084	.05075	.05066	.05057
+39	0.05048	0.05040	0.05031	0.05022	0.05014	0.05005	0.04996	0.04987	0.04978	0.04970

TABLE XXVII—*Log T*—Continued.

[Fahrenheit Scale.]

Ext. Ther.	0°.0	0°.1	0°.2	0°.3	0°.4	0°.5	0°.6	0°.7	0°.8	0°.9
°										
+40	0.04961	0.04952	0.04943	0.04935	0.04926	0.04917	0.04909	0.04900	0.04891	0.04882
41	.04873	.04865	.04856	.04847	.04839	.04830	.04821	.04812	.04803	.04794
42	.04786	.04777	.04769	.04760	.04751	.04742	.04734	.04725	.04716	.04708
43	.04699	.04690	.04682	.04673	.04664	.04656	.04647	.04638	.04629	.04621
+44	0.04612	0.04603	0.04595	0.04586	0.04577	0.04569	0.04560	0.04551	0.04543	0.04534
+45	0.04526	0.04517	0.04508	0.04500	0.04491	0.04482	0.04474	0.04465	0.04456	0.04448
46	.04439	.04430	.04422	.04413	.04404	.04396	.04387	.04378	.04370	.04361
47	.04352	.04344	.04335	.04326	.04318	.04309	.04301	.04292	.04283	.04274
48	.04265	.04257	.04248	.04240	.04232	.04223	.04214	.04206	.04197	.04188
+49	0.04179	0.04170	0.04162	0.04153	0.04145	0.04137	0.04128	0.04120	0.04111	0.04102
+50	0.04093	0.04085	0.04077	0.04068	0.04060	0.04051	0.04042	0.04034	0.04025	0.04016
51	.04008	.03999	.03991	.03982	.03974	.03965	.03956	.03948	.03939	.03931
52	.03922	.03913	.03905	.03896	.03888	.03879	.03871	.03862	.03854	.03845
53	.03836	.03828	.03819	.03811	.03802	.03794	.03786	.03777	.03768	.03760
+54	0.03751	0.03743	0.03734	0.03726	0.03717	0.03709	0.03700	0.03692	0.03683	0.03675
+55	0.03666	0.03658	0.03649	0.03641	0.03633	0.03624	0.03615	0.03607	0.03598	0.03590
56	.03581	.03573	.03564	.03556	.03547	.03539	.03530	.03522	.03513	.03505
57	.03497	.03488	.03480	.03471	.03463	.03454	.03446	.03437	.03429	.03420
58	.03412	.03404	.03395	.03387	.03378	.03370	.03362	.03353	.03345	.03336
+59	0.03328	0.03320	0.03311	0.03303	0.03294	0.03286	0.03278	0.03269	0.03261	0.03252
+60	0.03244	0.03236	0.03227	0.03219	0.03210	0.03202	0.03194	0.03185	0.03176	0.03168
61	.03160	.03152	.03143	.03135	.03126	.03118	.03109	.03100	.03092	.03084
62	.03076	.03068	.03059	.03051	.03042	.03034	.03025	.03017	.03009	.03000
63	.02992	.02984	.02975	.02967	.02958	.02950	.02942	.02933	.02925	.02916
+64	0.02908	0.02900	0.02891	0.02883	0.02875	0.02866	0.02858	0.02850	0.02841	0.02833
+65	0.02824	0.02816	0.02808	0.02800	0.02791	0.02783	0.02774	0.02766	0.02758	0.02749
66	.02741	.02733	.02725	.02716	.02708	.02699	.02691	.02683	.02675	.02666
67	.02658	.02650	.02641	.02633	.02625	.02617	.02608	.02600	.02592	.02583
68	.02575	.02567	.02559	.02550	.02542	.02534	.02525	.02517	.02509	.02500
+69	0.02492	0.02484	0.02476	0.02468	0.02459	0.02451	0.02443	0.02435	0.02426	0.02418
+70	0.02410	0.02402	0.02394	0.02385	0.02377	0.02369	0.02360	0.02352	0.02344	0.02336
71	.02328	.02319	.02311	.02303	.02294	.02286	.02278	.02270	.02262	.02253
72	.02245	.02237	.02229	.02220	.02212	.02204	.02195	.02187	.02179	.02171
73	.02163	.02154	.02146	.02138	.02130	.02121	.02113	.02105	.02097	.02088
+74	0.02080	0.02072	0.02064	0.02056	0.02047	0.02039	0.02031	0.02023	0.02015	0.02007
+75	0.01998	0.01990	0.01982	0.01974	0.01966	0.01958	0.01950	0.01941	0.01933	0.01925
76	.01917	.01908	.01900	.01892	.01884	.01876	.01868	.01860	.01852	.01844
77	.01835	.01827	.01819	.01811	.01803	.01795	.01787	.01778	.01770	.01762
78	.01754	.01746	.01738	.01730	.01722	.01714	.01705	.01697	.01689	.01681
+79	0.01673	0.01665	0.01657	0.01649	0.01641	0.01632	0.01624	0.01616	0.01608	0.01600
+80	0.01592	0.01584	0.01576	0.01568	0.01560	0.01552	0.01543	0.01535	0.01527	0.01519
81	.01511	.01503	.01495	.01487	.01479	.01470	.01462	.01454	.01446	.01438
82	.01430	.01422	.01414	.01406	.01398	.01390	.01382	.01374	.01366	.01358
83	.01350	.01341	.01333	.01325	.01317	.01309	.01301	.01293	.01285	.01277
+84	0.01269	0.01261	0.01253	0.01245	0.01237	0.01229	0.01221	0.01213	0.01205	0.01197
+85	0.01189	0.01180	0.01172	0.01164	0.01156	0.01148	0.01140	0.01132	0.01124	0.01116
86	.01108	.01100	.01092	.01084	.01076	.01068	.01060	.01052	.01044	.01036
87	.01028	.01020	.01012	.01004	.00996	.00988	.00980	.00972	.00964	.00956
88	.00948	.00940	.00932	.00924	.00916	.00908	.00900	.00892	.00884	.00876
+89	0.00868	0 00860	0.00852	0.00844	0.00836	0.00828	0.00820	0.00812	0.00804	0.00796
+90	0.00788	0.00780	0.00772	0.00764	0.00756	0.00748	0.00741	0.00733	0.00725	0.00717
91	.00709	.00701	.00693	.00685	.00677	.00669	.00661	.00653	.00645	.00637
92	.00630	.00622	.00614	.00606	.00598	.00590	.00583	.00575	.00567	.00559
93	.00551	.00543	.00535	.00527	.00519	.00512	.00504	.00496	.00488	.00480
+94	0.00472	0.00464	0.00456	0.00448	0.00440	0.00432	0.00425	0.00417	0.00409	0.00401
+95	0.00393	0.00385	0.00377	0.00369	0.00361	0.00354	0.00346	0.00338	0.00330	0.00322
96	.00314	.00306	.00298	.00290	.00283	.00275	.00267	.00259	.00251	.00243
97	.00235	.00227	.00219	.00212	.00204	.00196	.00188	.00180	.00172	.00164
98	.00157	.00149	.00141	.00133	.00126	.00118	.00110	.00102	.00094	.00086
+99	0.00079	0.00071	0.00063	0.00055	0.00047	0.00039	0.00031	0.00024	0.00016	0.00008

TABLE XXVIII—*Log T.*

[Centigrade Scale.]

Ext. Ther.	0°.0	0°.1	0°.2	0°.3	0°.4	0°.5	0°.6	0°.7	0°.8	0°.9
°										
−23	0.09518	0.09536	0.09553	0.09571	0.09588	0.09606	0.09624	0.09641	0.09659	0.09676
22	.09343	.09360	.09378	.09395	.09413	.09430	.09448	.09465	.09483	.09500
21	.09169	.09186	.09204	.09221	.09239	.09256	.09273	.09291	.09308	.09326
20	.08996	.09013	.09030	.09048	.09065	.09082	.09099	.09117	.09134	.09152
−19	0.08824	0.08841	0.08858	0.08876	0.08893	0.08910	0.08927	0.08944	0.08962	0.08979
−18	0.08652	0.08669	0.08686	0.08704	0.08721	0.08738	0.08755	0.08772	0.08790	0.08807
17	.08480	.08497	.08514	.08532	.08549	.08566	.08583	.08600	.08618	.08635
16	.08309	.08326	.08343	.08360	.08377	.08394	.08411	.08428	.08446	.08463
15	.08139	.08156	.08173	.08190	.08207	.08224	.08241	.08258	.08275	.08292
−14	0.07970	0.07987	0.08004	0.08020	0.08037	0.08054	0.08071	0.08088	0.08105	0.08122
−13	0.07802	0.07819	0.07836	0.07852	0.07869	0.07886	0.07903	0.07920	0.07936	0.07953
12	.07634	.07651	.07668	.07684	.07701	.07718	.07735	.07752	.07768	.07785
11	.07467	.07484	.07500	.07517	.07533	.07550	.07567	.07584	.07600	.07617
10	.07300	.07317	.07333	.07350	.07366	.07383	.07400	.07417	.07433	.07450
− 9	0.07134	0.07151	0.07167	0.07184	0.07200	0.07217	0.07234	0.07250	0.07267	0.07283
− 8	0.06969	0.06985	0.07002	0.07018	0.07035	0.07051	0.07068	0.07084	0.07101	0.07117
7	.06804	.06820	.06837	.06853	.06870	.06886	.06903	.06919	.06936	.06952
6	.06639	.06655	.06672	.06688	.06705	.06721	.06738	.06754	.06771	.06787
5	.06475	.06491	.06508	.06524	.06541	.06557	.06573	.06590	.06606	.06623
− 4	0.06313	0.06329	0.06345	0.06362	0.06378	0.06394	0.06410	0.06426	0.06443	0.06459
− 3	0.06151	0.06167	0.06183	0.06200	0.06216	0.06232	0.06248	0.06264	0.06281	0.06297
2	.05989	.06005	.06021	.06038	.06054	.06070	.06086	.06102	.06119	.06135
1	.05828	.05844	.05860	.05876	.05892	.05908	.05924	.05940	.05957	.05973
− 0	.05667	.05683	.05699	.05715	.05731	.05747	.05763	.05779	.05796	.05812
+ 0	0.05667	0.05651	0.05635	0.05619	0.05603	0.05587	0.05571	0.05555	0.05539	0.05523
+ 1	0.05507	0.05491	0.05475	0.05459	0.05443	0.05427	0.05411	0.05395	0.05380	0.05364
2	.05348	.05332	.05316	.05300	.05284	.05268	.05252	.05236	.05221	.05205
3	.05189	.05173	.05157	.05142	.05126	.05110	.05094	.05078	.05063	.05047
4	.05031	.05015	.04999	.04984	.04968	.04952	.04936	.04920	.04905	.04889
+ 5	0.04873	0.04857	0.04841	0.04826	0.04810	0.04794	0.04778	0.04763	0.04747	0.04732
+ 6	0.04716	0.04700	0.04685	0.04669	0.04654	0.04638	0.04622	0.04607	0.04591	0.04576
7	.04560	.04544	.04529	.04513	.04498	.04482	.04466	.04451	.04435	.04420
8	.04404	.04388	.04373	.04357	.04342	.04326	.04310	.04295	.04279	.04264
9	.04248	.04232	.04217	.04201	.04186	.04170	.04155	.04139	.04124	.04108
+10	0.04093	0.04078	0.04062	0.04047	0.04031	0.04016	0.04001	0.03985	0.03970	0.03954
+11	0.03939	0.03924	0.03908	0.03893	0.03877	0.03862	0.03847	0.03832	0.03816	0.03801
12	.03786	.03771	.03755	.03740	.03724	.03709	.03694	.03679	.03663	.03648
13	.03633	.03618	03602	.03587	.03572	.03556	.03541	.03526	.03510	.03495
14	.03480	.03465	.03450	.03434	.03419	.03404	.03389	.03374	.03358	.03343
+15	0.03328	0.03313	0.03298	0.03282	0.03267	0.03252	0.03237	0.03222	0.03206	0.03191
+16	0.03176	0.03161	0.03146	0.03130	0.03115	0.03100	0.03085	0.03070	0.03055	0.03040
17	.03025	.03010	.02995	.02980	.02965	.02950	.02935	.02920	.02905	.02890
18	.02875	.02860	.02845	.02830	.02815	.02800	.02785	.02770	.02755	.02740
19	.02725	.02710	.02695	.02680	.02665	.02650	.02635	.02620	.02605	.02590
+20	0.02575	0.02560	0.02545	0.02530	0.02515	0.02500	0.02485	0.02470	0.02456	0.02441
+21	0.02426	0.02411	0.02396	0.02382	0.02367	0.02352	0.02337	0.02322	0.02308	0.02293
22	.02278	.02263	.02248	.02234	.02219	.02204	.02189	.02174	.02160	.02145
23	.02130	.02115	.02100	.02086	.02071	.02056	.02041	.02026	.02012	.01997
24	.01982	.01967	.01952	.01938	.01923	.01908	.01893	.01879	.01864	.01850
+25	0.01835	0.01820	0.01806	0.01791	0.01777	0.01762	0.01747	0.01733	0.01718	0.01704
+26	0.01689	0.01674	0.01660	0.01645	0.01631	0.01616	0.01601	0.01587	0.01572	0.01558
27	.01543	.01528	.01514	.01499	.01485	.01470	.01456	.01441	.01427	.01412
28	.01398	.01383	.01369	.01354	.01340	.01325	.01311	.01296	.01282	.01267
29	.01253	.01238	.01224	.01209	.01195	.01180	.01166	.01151	.01137	.01122
+30	0.01108	0.01094	0.01079	0.01065	0.01050	0.01036	0.01022	0.01007	0.00993	0.00978
+31	0.00964	0.00950	0.00935	0.00921	0.00906	0.00892	0.00878	0.00863	0.00849	0.00834
32	.00820	.00806	.00791	.00777	.00762	.00748	.00734	.00720	.00705	.00691
33	.00677	.00663	.00649	.00634	.00620	.00606	.00592	.00578	.00563	.00549
34	.00535	.00521	.00507	.00492	.00478	.00464	.00450	.00436	.00421	.00407
+35	0.00393	0.00379	0.00365	0.00350	0.00336	0.00322	0.00308	0.00294	0.00279	0.00265
+36	0.00251	0.00237	0.00223	0.00208	0.00194	0.00180	0.00166	0.00152	0.00138	0.00124
+37	0.00110	0.00096	0.00082	0.00067	0.00053	0.00039	0.00025	0.00011	....	....

TABLE XXIX.—*Log t.*

[Fahrenheit Scale.]

Att. Ther.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
−10°	0.00424	0.00428	0.00432	0.00436	0.00440	0.00443	0.00447	0.00451	0.00455	0.00459
− 0	.00385	.00389	.00393	.00397	.00401	.00404	.00408	.00412	.00416	.00420
+ 0	.00385	.00381	.00377	.00374	.00370	.00366	.00362	.00358	.00355	.00351
10	.00347	.00343	.00339	.00335	.00331	.00328	.00324	.00320	.00317	.00313
20	.00309	.00305	.00301	.00297	.00293	.00290	.00286	.00282	.00278	.00274
+30	0.00270	0.00266	0.00262	0.00258	0.00254	0.00250	0.00247	0.00243	0.00239	0.00235
+40	0.00231	0.00227	0.00223	0.00220	0.00216	0.00212	0.00208	0.00204	0.00201	0.00197
50	.00193	.00189	.00185	.00181	.00177	.00173	.00170	.00166	.00162	.00158
60	.00154	.00150	.00146	.00143	.00139	.00135	.00131	.00127	.00124	.00120
70	.00116	.00112	.00108	.00105	.00101	.00097	.00093	.00089	.00086	.00082
80	.00078	.00074	.00070	.00066	.00062	.00059	.00055	.00051	.00047	.00043
+90	0.00039	0.00035	0.00031	0.00027	0.00023	0.00020	0.00016	0.00012	0.00008	0.00004

TABLE XXX.—*Log t.*

[Centigrade Scale.]

Att. Ther.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
−20°	0.00401	0.00408	0.00415	0.00422	0.00429	0.00436	0.00443	0.00450	0.00457	0.00464
10	.00331	.00338	.00345	.00352	.00359	.00366	.00373	.00380	.00387	.00394
− 0	0.00262	0.00269	0.00276	0.00283	0.00290	0.00297	0.00303	0.00310	0.00317	0.00324
+ 0	0.00262	0.00255	0.00248	0.00241	0.00234	0.00227	0.00221	0.00214	0.00207	0.00200
10	.00193	.00186	.00179	.00172	.00165	.00158	.00151	.00144	.00137	.00131
20	.00124	.00117	.00110	.00103	.00096	.00089	.00082	.00076	0.00069	0.00062
+30	0.00055	0.00048	0.00041	0.00034	0.00027	0.00020	0.00013	0.00006	....	....

TABLE XXXI.—*Log B.*

[English Scale.]

Barom.	$0^{\text{in}}.00$	$0^{\text{in}}.01$	$0^{\text{in}}.02$	$0^{\text{in}}.03$	$0^{\text{in}}.04$	$0^{\text{in}}.05$	$0^{\text{in}}.06$	$0^{\text{in}}.07$	$0^{\text{in}}.08$	$0^{\text{in}}.09$
in. 28.5	0.00000	0.00015	0.00030	0.00046	0.00061	0.00076	0.00092	0.00107	0.00122	0.00137
.6	.00152	.00168	.00183	.00198	.00213	.00228	.00244	.00259	.00274	.00289
.7	.00304	.00320	.00335	.00350	.00365	.00380	.00395	.00410	.00425	.00440
.8	.00455	.00470	.00485	.00500	.00515	.00530	.00545	.00560	.00575	.00590
28.9	0.00605	0.00620	0.00635	0.00650	0.00665	0.00680	0.00695	0.00710	0.00725	0.00740
29.0	0.00755	0.00770	0.00785	0.00800	0.00815	0.00830	0.00845	0.00860	0.00875	0.00890
.1	.00905	.00920	.00935	.00950	.00965	.00979	.00994	.01009	.01024	.01039
.2	.01054	.01069	.01084	.01099	.01113	.01128	.01143	.01158	01173	.01188
.3	.01202	.01217	.01232	.01247	.01262	.01276	.01291	.01306	.01321	.01336
29.4	0.01350	0.01365	0.01380	0.01395	0.01410	0.01424	0.01439	0.01454	0.01469	0.01484
29.5	0.01498	0.01513	0.01528	0.01543	0.01557	0.01571	0.01586	0.01601	0.01616	0.01631
.6	.01645	.01659	.01674	.01689	.01704	.01718	.01732	.01747	.01762	.01777
.7	.01791	.01805	.01820	.01835	.01850	.01864	.01878	.01893	.01908	.01923
.8	.01937	.01951	.01966	.01981	.01996	.02010	.02024	.02039	.02054	.02069
29.9	0.02083	0.02097	0.02112	0.02127	0.02142	0.02156	0.02170	0.02185	0.02199	0.02214
30.0	0.02228	0.02242	0.02257	0.02271	0.02286	0.02300	0.02314	0.02329	0.02343	0.02358
.1	.02372	.02386	.02401	.02415	.02430	.02444	.02458	.02473	.02487	.02502
.2	.02516	.02530	.02545	.02559	.02574	.02588	.02602	.02617	.02631	.02646
.3	.02660	.02674	.02689	.02703	.02718	.02732	.02746	.02761	.02775	.02789
30.4	0.02803	0.02817	0.02832	0.02846	0.02860	0.02875	0.02889	0.02904	0.02918	0.02932
30.5	0.02946	0.02960	0.02975	0.02989	0.03003	0.03017	0.03031	0.03046	0.03060	0.03074
.6	.03088	.03102	.03117	.03131	.03145	.03159	.03173	.03187	.03201	.03215
.7	.03229	.03243	.03257	.03271	.03286	.03300	.03314	.03328	.03342	.03356
.8	.03370	.03384	.03398	.03413	.03427	.03441	.03455	.03469	.03483	.03497
30.9	0.03511	0.03525	0.03539	0.03553	0.03568	0.03582	0.03596	0.03610	0.03624	0.03638

TABLE XXXII.—*Log B.*

[French Scale.]

Barom.	$0^{\text{mm}}.0$	$0^{\text{mm}}.1$	$0^{\text{mm}}.2$	$0^{\text{mm}}.3$	$0^{\text{mm}}.4$	$0^{\text{mm}}.5$	$0^{\text{mm}}.6$	$0^{\text{mm}}.7$	$0^{\text{mm}}.8$	$0^{\text{mm}}.9$
mm.										
725	0.00080	0.00086	0.00092	0.00098	0.00104	0.00110	0.00116	0.00122	0.00128	0.00134
726	.00140	.00146	.00152	.00158	.00164	.00170	.00176	.00182	.00188	.00194
727	.00200	.00206	.00212	.00218	.00224	.00230	.00236	.00242	.00248	.00254
728	.00260	.00266	.00272	.00278	.00284	.00290	.00295	.00301	.00307	.00313
729	0.00319	0.00325	0.00331	0.00337	0.00343	0.00349	0.00355	0.00361	0.00367	0.00373
730	0.00379	0.00385	0.00391	0.00397	0.00403	0.00409	0.00414	0.00420	0.00426	0.00432
731	.00438	.00444	.00450	.00456	.00462	.00468	.00474	.00480	.00486	.00492
732	.00498	.00504	.00510	.00516	.00522	.00528	.00533	.00539	.00545	.00551
733	.00557	.00563	.00569	.00575	.00581	.00587	.00592	.00598	.00604	.00610
734	0.00616	0.00622	0.00628	0.00634	0.00640	0.00646	0.00651	0.00657	0.00663	0.00669
735	0.00675	0 00681	0.00687	0.00693	0.00699	0.00705	0.00710	0.00716	0.00722	0.00728
736	.00734	.00740	.00746	.00752	.00758	.00764	.00769	.00775	.00781	.00787
737	.00793	.00799	.00805	.00811	.00817	.00823	.00828	.00834	.00840	.00846
738	.00852	.00858	.00864	.00870	.00876	.00882	.00887	.00893	.00899	.00905
739	0.00911	0.00917	0.00923	0.00929	0.00935	0.00941	0.00946	0.00952	0.00958	0.00964
740	0.00970	0.00976	0.00982	0.00987	0.00993	0.00999	0.01005	0.01011	0.01016	0.01022
741	.01028	.01034	.01040	.01046	.01052	.01058	.01063	.01069	.01075	.01081
742	.01087	.01093	.01099	.01105	.01111	.01117	.01122	.01128	.01134	.01140
743	.01146	.01152	.01158	.01163	.01169	.01175	.01181	.01187	.01192	.01198
744	0.01204	0.01210	0.01216	0.01221	0.01227	0.01233	0.01239	0.01245	0.01250	0.01256
745	0.01262	0.01268	0.01274	0.01280	0.01286	0.01292	0.01297	0.01303	0.01309	0.01315
746	.01321	.01327	.01333	.01338	.01344	.01350	.01356	.01362	.01367	.01373
747	.01379	.01385	.01391	.01396	.01402	.01408	.01414	.01420	.01425	.01431
748	.01437	.01443	.01449	.01454	.01460	.01466	.01472	.01478	.01483	.01489
749	0.01495	0.01501	0.01507	0.01512	0.01518	0.01524	0.01530	0.01536	0.01541	0.01547
750	0.01553	0.01559	0.01565	0.01570	0.01576	0.01582	0.01588	0.01594	0.01599	0.01605
751	.01611	.01617	.01622	.01628	.01634	.01640	.01645	.01651	.01657	.01662
752	.01668	.01674	.01680	.01685	.01691	.01697	.01703	.01709	.01714	.01720
753	.01726	.01732	.01738	.01743	.01749	.01755	.01761	.01767	.01772	.01778
754	0.01784	0.01790	0.01795	0.01801	0.01807	0.01813	0.01818	0.01824	0.01830	0.01835
755	0.01841	0.01847	0.01853	0.01858	0.01864	0.01870	0.01876	0.01882	0.01887	0.01893
756	.01899	.01905	.01910	.01916	.01922	.01928	.01933	.01939	.01945	.01950
757	.01956	.01962	.01968	.01973	.01979	.01985	.01991	.01997	.02002	.02008
758	.02014	.02020	.02025	.02031	.02037	.02043	.02048	.02054	.02060	.02065
759	0.02071	0.02077	0.02082	0.02088	0.02094	0.02100	0.02105	0.02111	0.02117	0.02122
760	0.02128	0.02134	0.02139	0.02145	0.02151	0.02157	0.02162	0.02168	0.02174	0.02179
761	.02185	.02191	.02196	.02202	.02208	.02214	.02219	.02225	.02231	.02236
762	.02242	.02248	.02253	.02259	.02265	.02271	.02276	.02282	.02288	.02293
763	.02299	.02305	.02310	.02316	.02322	.02328	.02333	.02339	.02345	.02350
764	0.02356	0.02362	0.02367	0.02373	0.02379	0.02385	0.02390	0.02396	0.02402	0.02407
765	0.02413	0.02419	0.02424	0.02430	0.02436	0.02442	0.02447	0.02453	0.02459	0.02464
766	.02470	.02476	.02481	.02487	.02492	.02498	.02504	.02509	.02515	.02520
767	.02526	.02532	.02537	.02543	.02549	.02555	.02560	.02566	.02572	.02577
768	.02583	.02589	.02594	.02600	.02605	.02611	.02617	.02622	.02628	.02633
769	0.02639	0.02645	0.02650	0.02656	0.02662	0.02668	0.02673	0.02679	0.02685	0.02690
770	0.02696	0.02702	0.02707	0.02713	0.02718	0.02724	0.02730	0.02735	0.02741	0.02746
771	.02752	.02758	.02763	.02769	.02774	.02780	.02786	.02791	.02797	.02802
772	.02808	.02814	.02819	.02825	.02831	.02837	.02842	.02848	.02854	.02859
773	.02865	.02871	.02876	.02882	.02887	.02893	.02899	.02904	.02910	.02915
774	0.02921	0.02927	0.02932	0.02938	0.02943	0.02949	0.02955	0.02960	0.02966	0.02971
775	0.02977	0.02983	0.02988	0.02994	0.02999	0.03005	0.03011	0.03016	0.03022	0.03027
776	.03033	.03039	.03044	.03050	.03055	.03061	.03067	.03072	.03078	.03083
777	.03089	.03095	.03100	.03106	.03111	.03117	.03123	.03128	.03134	.03139
778	.03145	.03151	.03156	.03162	.03167	.03173	.03178	.03184	.03189	.03195
779	0.03200	0.03206	0.03211	0.03217	0.03222	0.03228	0.03234	0.03239	0.03245	0.03250
780	0.03256	0.03262	0.03267	0.03273	0.03278	0.03284	0.03290	0.03295	0.03301	0.03306
781	.03312	.03318	.03323	.03329	.03334	.03340	.03345	.03351	.03356	.03362
782	.03367	.03373	.03378	.03384	.03389	.03395	.03401	.03406	.03412	.03417
783	.03423	.03429	.03434	.03440	.03445	.03451	.03456	.03462	.03467	.03473
784	0.03478	0.03484	0.03489	0.03495	0.03500	0.03506	0.03512	0.03517	0.03523	0.03528
785	0.03534	0.03540	0.03545	0.03551	0.03556	0.03562	0.03567	0.03573	0.03578	0.03584
786	0.03589	0.03595	0.03600	0.03606	0.03611	0.03617	0.03622	0.03628	0.03633	0.03639

TABLE XXXIII.—*Log b.*

Log *B*.	Apparent Zenith Distance.																				
	56°	60°	62°	64°	66°	68°	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	85°
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
.002	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	3
.003	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	3	4
0.004	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	4	5
0.005	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	4	5	6
.006	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3	4	5	6	8
.007	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3	4	4	5	7	9
.008	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3	4	4	5	6	8	10
0.009	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	4	5	6	7	9	11
0.010	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	4	4	5	6	8	10	13
.011	1	1	1	1	1	1	2	2	2	2	2	2	3	3	4	4	5	6	7	9	11	14
.012	1	1	1	1	1	2	2	2	2	2	2	3	3	3	4	5	5	6	8	9	12	15
.013	1	1	1	1	1	2	2	2	2	2	3	3	3	4	4	5	6	7	8	10	13	17
0.014	1	1	1	1	2	2	2	2	2	3	3	3	4	4	5	5	6	7	9	11	14	18
0.015	1	1	1	1	2	2	2	2	3	3	3	3	4	4	5	6	7	8	9	12	15	19
.016	1	1	1	2	2	2	2	2	3	3	3	4	4	5	5	6	7	8	10	12	16	20
.017	1	1	2	2	2	2	2	3	3	3	3	4	4	5	6	6	7	9	11	13	17	22
.018	1	2	2	2	2	2	3	3	3	3	4	4	5	5	6	7	8	9	11	14	18	23
0.019	1	2	2	2	2	2	3	3	3	4	4	4	5	5	6	7	8	10	12	15	19	24
0.020	1	2	2	2	2	3	3	3	3	4	4	5	5	6	7	8	9	10	13	16	20	25
.021	2	2	2	2	2	3	3	3	4	4	4	5	5	6	7	8	9	11	13	16	21	27
.022	2	2	2	2	2	3	3	3	4	4	4	5	6	6	7	8	10	11	14	17	22	28
.023	2	2	2	2	3	3	3	4	4	4	5	5	6	7	8	9	10	12	14	18	23	29
0.024	2	2	2	2	3	3	3	4	4	4	5	5	6	7	8	9	11	12	15	19	24	30
0.025	2	2	2	2	3	3	4	4	4	5	5	6	6	7	8	10	11	13	16	20	24	32
.026	2	2	2	3	3	3	4	4	4	5	5	6	7	7	9	10	11	14	16	20	25	33
.027	2	2	2	3	3	3	4	4	5	5	6	6	7	8	9	10	12	14	17	21	26	34
.028	2	2	3	3	3	4	4	4	5	5	6	6	7	8	9	11	12	15	18	22	27	36
0.029	2	2	3	3	3	4	4	5	5	5	6	7	7	8	10	11	13	15	18	23	28	37
0.030	2	3	3	3	3	4	4	5	5	6	6	7	8	9	10	11	13	16	19	23	29	38
.031	2	3	3	3	3	4	4	5	5	6	6	7	8	9	10	12	14	16	20	24	30	39
.032	2	3	3	3	4	4	5	5	5	6	7	7	8	9	11	12	14	17	20	25	31	41
.033	2	3	3	3	4	4	5	5	6	6	7	7	8	9	11	13	15	17	21	26	32	42
0.034	3	3	3	3	4	4	5	5	6	6	7	8	9	10	11	13	15	18	21	27	33	43
0.035	3	3	3	4	4	4	5	5	6	7	7	8	9	10	12	13	15	18	22	27	34	44
0.036	3	3	3	4	4	5	5	6	6	7	7	8	9	10	12	14	16	19	23	28	35	46

The tabular quantities are expressed in units of the fifth decimal.

TABLE XXXIV.—*Log t'.*

Log *T*.	Apparent Zenith Distance.																					
	35°	36°	37°	38°	39°	40°	41°	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°
0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
.03	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
.04	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0.05	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
0.06	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
.07	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
.08	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3
.09	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	3	3
.10	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3
0.11	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	4

The tabular quantities are expressed in units of the fourth decimal.

TABLE XXXIV.—*Log t′*—Continued.

Log *T*.	Apparent Zenith Distance.																			
	56°	57°	58°	59°	60°	61°	62°	63°	64°	65°	65°.5	66°	66°.5	67°	67°.5	68°	68°.5	69°	69°.5	70°
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.002	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
.004	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	4	4	4	4
.006	2	2	2	2	3	3	3	3	4	4	4	4	4	5	5	5	5	6	6	6
0.008	3	3	3	3	4	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8
0.010	3	4	4	4	4	5	5	6	6	6	7	7	8	8	8	9	9	9	10	10
.012	4	4	5	5	5	6	6	7	7	8	8	9	9	9	10	10	11	11	12	12
.014	4	5	5	6	6	7	7	8	8	9	10	10	10	11	11	12	13	13	14	15
.016	5	6	6	7	7	8	8	9	9	10	11	11	12	12	13	14	14	15	16	17
0.018	6	6	7	7	8	8	9	10	11	12	12	13	14	14	15	15	16	17	18	19
0.020	6	7	8	8	9	9	10	11	12	13	14	14	15	16	16	17	18	19	20	21
.022	7	8	8	9	10	10	11	12	13	14	15	16	16	17	18	19	20	21	22	23
.024	8	8	9	10	11	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
.026	8	9	10	11	11	12	13	14	15	17	18	18	20	20	21	22	23	24	26	27
0.028	9	10	11	11	12	13	14	15	17	18	19	20	21	22	23	24	25	26	28	29
0.030	10	10	11	12	13	14	15	16	18	19	20	21	22	23	25	26	27	28	30	31
.032	10	11	12	13	14	15	16	18	19	20	22	23	24	25	26	28	29	30	32	33
.034	11	12	13	14	15	16	17	19	20	22	23	24	26	27	28	29	31	32	34	35
.036	12	13	14	15	16	17	18	20	21	23	24	26	27	28	30	31	32	34	36	37
0.038	12	13	14	16	17	18	19	21	22	24	26	27	28	30	31	33	34	36	38	40
0.040	13	14	15	16	18	19	20	22	24	26	27	28	30	31	33	34	36	38	40	42
.042	13	15	16	17	18	20	21	23	25	27	29	30	32	33	34	36	38	40	42	44
.044	14	15	17	18	19	21	22	24	26	28	30	31	33	34	36	38	40	41	44	46
.046	15	16	17	19	20	22	23	25	27	29	31	33	34	36	38	40	41	43	46	48
0.048	15	17	18	20	21	23	24	26	28	31	33	34	36	37	39	41	43	45	48	50
0.050	16	18	19	20	22	24	26	28	30	32	34	36	38	39	41	43	45	47	50	52
.052	17	18	20	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	54
.054	17	19	21	22	24	26	28	30	32	35	37	38	40	42	44	46	49	51	53	56
.056	18	20	21	23	25	27	29	31	33	36	38	40	42	44	46	48	50	53	55	58
0.058	19	20	22	24	26	28	30	32	34	37	39	41	43	45	48	50	52	55	57	60
0.060	19	21	23	25	26	28	31	33	35	38	41	43	45	47	49	52	54	56	59	62
.062	20	22	24	25	27	29	32	34	37	40	42	44	46	48	51	53	56	58	61	64
.064	20	22	24	26	28	30	33	35	38	41	43	45	48	50	52	55	58	60	63	67
.066	21	23	25	27	29	31	34	36	39	42	45	47	50	52	54	57	59	62	65	69
0.068	22	24	26	28	30	32	35	37	40	44	46	48	51	53	56	58	61	64	67	71
0.070	22	24	27	29	31	33	36	38	41	45	48	50	52	55	57	60	63	66	69	73
.072	23	25	27	30	32	34	37	40	42	46	49	51	54	56	59	62	65	68	71	75
.074	24	26	28	30	33	35	38	41	44	47	50	53	56	58	61	64	67	70	73	77
.076	24	27	29	31	33	36	39	42	45	49	52	54	57	59	62	65	68	71	75	79
0.078	25	27	30	32	34	37	40	43	46	50	53	55	58	61	64	67	70	73	77	81
0.080	26	28	30	33	35	38	41	44	47	51	54	57	60	63	66	69	72	75	79	83
.082	26	29	31	34	36	39	42	45	48	52	55	58	61	64	67	71	74	77	81	85
.084	27	29	32	34	37	40	43	46	50	54	57	60	63	66	69	72	76	79	83	87
.086	28	30	33	35	38	41	44	47	51	55	58	61	64	67	71	74	77	81	85	89
0.088	28	31	33	36	39	42	45	48	52	56	60	63	66	69	72	76	79	83	87	92
0.090	29	32	34	37	40	43	46	50	53	58	61	64	68	70	74	77	81	85	89	94
.092	29	32	35	38	40	43	47	51	54	59	62	65	69	72	75	79	83	87	91	96
.094	30	33	36	39	41	44	48	52	55	60	64	67	70	73	77	81	85	88	93	98
.096	31	34	36	39	42	45	49	53	57	61	65	68	72	75	79	83	86	90	95	100
0.098	31	34	37	40	43	46	50	54	58	63	67	70	73	76	80	84	88	92	97	102
0.100	32	35	38	41	44	47	51	55	59	64	68	71	75	78	82	86	90	94	99	104
.102	33	36	39	42	45	48	52	56	60	65	69	72	76	80	84	88	92	96	101	106
.104	33	36	40	43	46	49	53	57	61	67	71	74	78	81	85	89	94	98	103	108
0.106	34	37	40	43	47	50	54	58	63	68	72	75	79	83	87	91	95	100	105	110

The tabular quantities are expressed in units of the fifth decimal.

TABLE XXXIV.—*Log t′*—Continued.

Log *T*.	Apparent Zenith Distance.															
	70° 0′	70° 20′	70° 40′	71° 0′	71° 20′	71° 40′	72° 0′	72° 20′	72° 40′	73° 0′	73° 10′	73° 20′	73° 30′	73° 40′	73° 50′	74° 0′
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.002	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
.004	4	4	4	5	5	5	5	5	6	6	6	6	6	6	7	7
.006	6	6	7	7	7	8	8	8	9	9	9	9	9	10	10	10
0.008	8	9	9	9	10	10	10	11	11	12	12	12	13	13	13	13
0.010	10	11	11	12	12	13	13	14	14	15	15	15	16	16	16	17
.012	12	13	13	14	15	15	16	16	17	18	18	18	19	19	20	20
.014	15	15	16	16	17	18	18	19	20	21	21	22	22	23	23	23
.016	17	17	18	19	19	20	21	22	23	24	24	25	25	26	26	27
0.018	19	19	20	21	22	23	24	25	26	27	27	28	28	29	30	30
0.020	21	22	22	23	24	25	26	27	28	30	30	31	32	32	33	33
.022	23	24	25	26	27	28	29	30	31	33	33	34	35	35	36	37
.024	25	26	27	28	29	30	31	33	34	36	36	37	38	39	39	40
.026	27	28	29	30	31	33	34	36	37	38	39	40	41	42	43	43
0.028	29	30	31	32	34	35	37	38	40	41	42	43	44	45	46	47
0.030	31	32	34	35	36	38	39	41	43	44	45	46	47	48	49	50
.032	33	35	36	37	39	40	42	44	45	47	48	49	51	52	52	53
.034	35	37	38	39	41	43	45	47	48	50	51	52	54	55	56	57
.036	37	39	40	42	44	45	47	49	51	53	54	55	57	58	59	60
0.038	40	41	43	44	46	48	50	52	54	56	57	59	60	61	62	63
0.040	42	43	45	46	48	50	52	55	57	59	60	62	63	64	66	67
.042	44	45	47	49	51	53	55	58	60	62	63	65	66	68	69	70
.044	46	48	49	51	53	55	58	60	62	65	66	68	70	71	72	73
.046	48	50	52	54	56	58	60	63	65	68	69	71	73	74	75	77
0.048	50	52	54	56	58	60	63	66	68	71	72	74	76	77	79	80
0.050	52	54	56	58	60	63	66	68	71	74	76	77	79	80	82	83
.052	54	56	58	60	63	66	68	71	74	77	79	80	82	84	85	87
.054	56	58	60	63	65	68	71	74	77	80	82	83	85	87	89	90
.056	58	60	63	65	68	71	73	77	80	83	85	86	88	90	92	93
0.058	60	63	65	67	70	73	76	79	82	86	88	90	92	93	95	97
0.060	62	65	67	70	73	76	79	82	85	89	91	93	95	97	98	100
.062	64	67	69	72	75	78	81	85	88	92	94	96	98	100	102	103
.064	67	69	72	74	77	81	84	88	91	95	97	99	101	103	105	107
.066	69	71	74	77	80	83	86	90	94	98	100	102	104	106	108	110
0.068	71	73	76	79	82	86	89	93	97	101	103	105	107	109	111	113
0.070	73	76	78	81	85	88	92	96	99	104	106	108	111	113	115	117
.072	75	78	81	84	87	91	94	98	102	107	109	111	114	116	118	120
.074	77	80	83	86	90	93	97	101	105	110	112	114	117	119	121	123
.076	79	82	85	88	92	96	100	104	108	112	115	117	120	122	125	127
0.078	81	84	87	90	94	98	102	107	111	115	118	120	123	126	128	130
0.080	83	86	90	93	97	101	105	110	114	118	121	123	126	129	131	133
.082	85	89	92	95	99	103	107	112	116	121	124	126	130	132	134	137
.084	87	91	94	98	102	106	110	115	119	124	127	129	133	135	138	140
.086	89	93	96	100	104	108	113	118	122	127	130	132	136	138	141	143
0.088	92	95	99	102	106	111	115	121	125	130	133	136	139	142	144	147
0.090	94	97	101	104	109	113	118	123	128	133	136	139	142	145	148	150
.092	96	99	103	107	111	116	121	126	131	136	139	142	145	148	151	153
.094	98	102	105	109	114	118	123	129	133	139	142	145	149	151	154	157
.096	100	104	108	111	116	121	126	132	136	142	145	148	152	155	157	160
0.098	102	106	110	114	119	123	128	134	139	145	148	151	155	158	161	163
0.100	104	108	112	116	121	126	131	137	142	148	151	154	158	161	164	167
.102	106	110	114	118	123	129	134	140	145	151	154	157	161	164	167	170
.104	108	112	116	121	126	131	136	142	148	154	157	160	164	167	171	173
0.106	110	114	119	123	128	134	139	145	151	157	160	163	167	171	174	177

The tabular quantities are expressed in units of the fifth decimal.

TABLE XXXIV.—*Log t′*—Continued.

Log *T*.	Apparent Zenith Distance.															
	74° 0′	74° 10′	74° 20′	74° 30′	74° 40′	74° 50′	75° 0′	75° 10′	75° 20′	75° 30′	75° 40′	75° 50′	76° 0′	76° 10′	76° 20′	76° 30′
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.002	3	3	3	4	4	4	4	4	4	4	4	4	4	4	5	5
.004	7	7	7	7	7	7	8	8	8	8	8	8	9	9	9	9
.006	10	10	10	11	11	11	11	12	12	12	12	13	13	13	14	14
0.008	13	14	14	14	15	15	15	15	16	16	16	17	17	18	18	19
0.010	17	17	17	18	18	18	19	19	20	20	21	21	22	22	23	24
.012	20	21	21	21	22	22	23	23	24	24	25	25	26	27	28	28
.014	23	24	24	25	25	26	26	27	27	28	29	30	31	31	32	33
.016	27	27	28	28	29	30	30	31	31	32	33	34	35	36	37	38
0.018	30	31	31	32	33	33	34	35	35	36	37	38	39	40	41	42
0.020	33	34	35	36	36	37	38	38	39	40	41	42	44	45	46	47
.022	37	38	38	39	40	41	42	42	43	44	45	47	48	49	51	52
.024	40	41	41	43	44	44	45	46	47	48	49	51	52	54	55	57
.026	43	44	45	46	47	48	49	50	51	52	54	55	57	58	60	61
0.028	47	48	48	50	51	52	53	54	55	56	58	59	61	63	64	66
0.030	50	51	52	53	55	56	57	58	59	60	62	64	65	67	69	71
.032	53	54	55	57	58	59	60	61	63	64	66	68	70	72	74	76
.034	57	58	59	61	62	63	64	65	67	68	70	72	74	76	78	80
.036	60	61	62	64	66	67	68	69	71	72	74	76	78	81	83	85
0.038	63	65	66	68	69	70	72	73	74	76	78	81	83	85	87	90
0.040	67	68	69	71	73	74	76	77	78	80	82	85	87	90	92	94
.042	70	72	73	75	76	78	79	81	82	84	87	89	92	94	97	99
.044	73	75	76	78	80	81	83	84	86	88	91	93	96	99	101	104
.046	77	79	80	82	84	85	87	88	90	92	95	98	100	103	106	109
0.048	80	82	83	85	87	89	91	92	94	96	99	102	105	108	110	113
0.050	83	86	87	89	91	92	94	96	98	100	103	106	109	112	115	118
.052	87	89	91	93	95	96	98	100	102	105	107	110	113	116	120	123
.054	90	92	94	96	98	100	102	104	106	109	111	114	118	121	124	127
.056	93	95	97	100	102	104	106	108	110	113	115	119	122	125	129	132
0.058	97	99	101	103	106	107	110	111	114	117	119	123	126	130	133	137
0.060	100	102	104	107	109	111	113	115	118	121	124	127	131	134	138	142
.062	103	106	108	110	113	115	117	119	122	125	128	131	135	139	143	146
.064	107	109	111	114	116	118	121	123	125	129	132	136	140	143	147	151
.066	110	113	115	117	120	122	125	127	129	133	136	140	144	148	152	156
0.068	113	116	118	121	124	126	129	131	133	137	140	144	148	152	156	160
0.070	117	120	122	125	127	130	132	134	137	141	144	148	153	157	161	165
.072	120	123	125	128	131	133	136	138	141	145	148	153	157	161	166	170
.074	123	126	129	132	135	137	140	142	145	149	152	157	161	166	170	175
.076	127	130	132	135	138	141	144	146	149	153	157	161	166	170	175	179
0.078	130	133	136	139	142	144	147	150	153	157	161	165	170	175	179	184
0.080	133	137	139	142	146	148	151	154	157	161	165	170	174	179	184	189
.082	137	140	143	146	149	152	155	157	161	165	169	174	179	184	189	194
.084	140	144	146	150	153	155	159	161	165	169	173	178	183	188	193	198
.086	143	147	150	153	157	159	163	165	169	173	177	182	187	193	198	203
0.088	147	150	153	157	160	163	166	169	172	177	181	187	192	197	202	208
0.090	150	154	157	160	164	166	170	173	176	181	185	191	196	202	207	212
.092	153	157	160	164	167	170	174	177	180	185	190	195	201	206	212	217
.094	157	161	164	167	171	174	178	180	184	189	194	199	205	211	216	222
.096	160	164	167	171	175	178	181	184	188	193	198	204	209	215	221	227
0.098	163	168	171	174	178	182	185	188	192	197	202	208	214	220	225	231
0.100	167	171	174	178	182	185	189	192	196	201	206	212	218	224	230	236
.102	170	174	177	182	186	189	193	196	200	205	210	216	222	228	235	241
.104	173	178	181	185	189	192	197	200	204	209	214	220	227	233	239	245
0.106	177	181	184	189	193	196	200	204	208	213	218	225	231	237	244	250

The tabular quantities are expressed in units of the fifth decimal.

TABLE XXXIV.—*Log t′*—Continued.

Log T.	Apparent Zenith Distance.														
	76° 30′	76° 40′	76° 50′	77° 0′	77° 10′	77° 20′	77° 30′	77° 40′	77° 50′	78° 0′	78° 10′	78° 20′	78° 30′	78° 40′	78° 50′
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.002	5	5	5	5	5	5	5	6	6	6	6	6	6	7	7
.004	9	10	10	10	10	11	11	11	11	12	12	12	13	13	13
.006	14	15	15	15	16	16	16	17	17	18	18	19	19	20	20
0.008	19	19	20	20	21	21	22	22	23	24	24	25	26	26	27
0.010	24	24	25	25	26	27	27	28	29	29	30	31	32	33	34
.012	28	29	30	30	31	32	33	33	34	35	36	37	38	39	40
.014	33	34	35	36	36	37	38	39	40	41	42	44	45	46	47
.016	38	39	40	41	42	43	44	45	46	47	48	50	51	53	54
0.018	42	44	45	46	47	48	49	50	51	53	54	56	58	59	61
0.020	47	48	50	51	52	53	54	56	57	59	60	62	64	66	67
.022	52	53	55	56	57	59	60	61	63	65	66	68	70	72	74
.024	57	58	60	61	62	64	65	67	69	71	72	75	77	79	81
.026	61	63	64	66	68	69	71	73	74	76	79	81	83	86	88
0.028	66	68	69	71	73	74	76	78	80	82	85	87	90	92	94
0.030	71	73	74	76	78	80	82	84	86	88	91	93	96	99	101
.032	76	77	79	81	83	85	87	89	92	94	97	100	102	105	108
.034	80	82	84	86	88	90	92	95	97	100	103	106	109	112	115
.036	85	87	89	91	94	96	98	100	103	106	109	112	115	118	121
0.038	90	92	94	97	99	101	103	106	109	112	115	118	122	125	128
0.040	94	97	99	102	104	106	109	112	114	118	121	124	128	132	135
.042	99	102	104	107	109	112	114	117	120	123	127	131	134	138	142
.044	104	106	109	112	114	117	120	123	126	129	133	137	141	145	148
.046	109	111	114	117	120	122	125	128	132	135	139	143	147	151	155
0.048	113	116	119	122	125	128	131	134	137	141	145	149	154	158	162
0.050	118	121	124	127	130	133	136	140	143	147	151	156	160	164	168
.052	123	126	129	132	135	138	141	145	149	153	157	162	166	171	175
.054	127	131	134	137	140	144	147	151	154	159	163	168	173	178	182
.056	132	136	139	142	146	149	152	156	160	165	169	174	179	184	189
0.058	137	140	144	147	151	154	158	162	166	171	175	180	186	191	195
0.060	142	145	149	152	156	160	163	167	172	176	181	187	192	197	202
.062	146	150	154	157	161	165	169	173	177	182	187	193	198	204	209
.064	151	155	159	163	166	170	174	179	183	188	193	199	205	211	216
.066	156	160	164	168	172	176	180	184	189	194	199	205	211	217	222
0.068	160	165	169	173	177	181	185	190	194	200	205	211	218	224	229
0.070	165	169	174	178	182	186	190	195	200	206	211	218	224	230	236
.072	170	174	179	183	187	192	196	201	206	212	217	224	230	237	243
.074	175	179	184	188	192	197	201	206	212	218	223	230	237	243	249
.076	179	184	188	193	198	202	207	212	217	223	230	236	243	250	256
0.078	184	189	193	198	203	207	212	218	223	229	236	243	250	257	263
0.080	189	194	198	203	208	213	218	223	229	235	242	249	256	263	270
.082	194	198	203	208	213	218	223	229	235	241	248	255	262	270	276
.084	198	203	208	213	218	223	228	234	240	247	254	261	269	276	283
.086	203	208	213	218	224	229	234	240	246	253	260	267	275	283	290
0.088	208	213	218	224	229	234	239	246	252	259	266	274	282	290	297
0.090	212	218	223	229	234	239	245	251	257	265	272	280	288	296	303
.092	217	223	228	234	239	245	250	257	263	270	278	286	294	303	310
.094	222	227	233	239	244	250	256	262	269	276	284	292	301	309	317
.096	227	232	238	244	250	255	261	268	275	282	290	299	307	316	324
0.098	231	237	243	249	255	261	267	273	280	288	296	305	314	322	330
0.100	236	242	248	254	260	266	272	279	286	294	302	311	320	329	337
.102	241	247	253	259	265	271	277	285	292	300	308	317	326	336	344
.104	245	252	258	264	270	277	283	290	297	306	314	323	333	342	350
0.106	250	257	263	269	276	282	288	296	303	312	320	330	339	349	357

The tabular quantities are expressed in units of the fifth decimal.

TABLE XXXIV.—*Log t′*—Continued.

Log *T*.	Apparent Zenith Distance.													
	78° 50′	79° 0′	79° 10′	79° 20′	79° 30′	79° 40′	79° 50′	80° 0′	80° 10′	80° 20′	80° 30′	80° 40′	80° 50′	81° 0′
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.002	7	7	7	7	8	8	8	8	8	9	9	9	10	10
.004	13	14	14	15	15	15	16	16	17	17	18	19	19	20
.006	20	21	21	22	23	23	24	25	25	26	27	28	29	30
0.008	27	28	28	29	30	31	32	33	34	35	36	37	38	39
0.010	34	35	36	37	38	39	40	41	42	44	45	46	48	49
.012	40	42	43	44	45	46	48	49	51	52	54	56	57	59
.014	47	48	50	51	53	54	56	58	59	61	63	65	67	69
.016	54	55	57	59	60	62	64	66	68	70	72	74	76	79
0.018	61	62	64	66	68	70	72	74	76	78	81	83	86	89
0.020	67	69	71	73	75	77	80	82	85	87	90	93	95	99
.022	74	76	78	81	83	85	88	90	93	96	99	102	105	108
.024	81	83	85	88	90	93	96	99	102	105	108	111	114	118
.026	88	90	93	95	98	101	104	107	110	113	117	120	124	128
0.028	94	97	100	102	105	108	112	115	118	122	126	130	134	138
0.030	101	104	107	110	113	116	120	123	127	131	135	139	143	148
.032	108	111	114	117	120	124	128	132	135	140	144	148	153	158
.034	115	118	121	124	128	132	136	140	144	148	153	157	162	168
.036	121	125	128	132	135	139	144	148	152	157	162	167	172	177
0.038	128	131	135	139	143	147	152	156	161	166	171	176	181	187
0.040	135	138	142	146	150	155	160	164	169	174	180	185	191	197
.042	142	145	150	154	158	163	168	173	178	183	189	194	200	207
.044	148	152	157	161	165	170	176	181	186	192	198	204	210	217
.046	155	159	164	168	173	178	184	189	195	201	207	213	219	227
0.048	162	166	171	176	180	186	192	197	203	209	216	222	229	237
0.050	168	173	178	183	188	194	200	206	212	218	224	232	238	246
.052	175	180	185	190	196	201	207	214	220	227	233	241	248	256
.054	182	187	192	198	203	209	215	222	228	235	242	250	258	266
.056	189	194	199	205	211	217	223	230	237	244	251	259	267	276
0.058	195	201	206	212	218	224	231	238	245	253	260	269	277	286
0.060	202	208	214	220	226	232	239	247	254	262	269	278	286	296
.062	209	215	221	227	233	240	247	255	262	270	278	287	296	306
.064	216	221	228	234	241	248	255	263	271	279	287	296	305	316
.066	222	228	235	242	248	255	263	271	279	288	296	306	315	325
0.068	229	235	242	249	256	263	271	279	288	296	305	315	324	335
0.070	236	242	249	256	263	271	279	288	296	305	314	324	334	345
.072	243	249	256	264	271	279	287	296	305	314	323	333	343	355
.074	249	256	263	271	278	286	295	304	313	323	332	343	353	365
.076	256	263	271	278	286	294	303	312	321	331	341	352	363	375
0.078	263	270	278	285	293	302	311	321	330	340	350	361	372	385
0.080	270	277	285	293	301	310	319	329	338	349	359	370	382	394
.082	276	284	292	300	308	317	327	337	347	358	368	380	391	404
.084	283	291	299	307	316	325	335	345	355	366	377	389	401	414
.086	290	298	306	315	323	333	343	353	364	375	386	398	410	424
0.088	297	304	313	322	331	341	351	362	372	384	395	407	420	434
0.090	303	311	320	329	338	348	359	370	381	392	404	417	429	444
.092	310	318	328	337	346	356	367	378	389	401	413	426	439	454
.094	317	325	335	344	353	364	375	386	398	410	422	435	448	463
.096	324	332	342	351	361	372	383	395	406	419	431	444	458	473
0.098	330	339	349	359	368	379	391	403	415	427	440	454	467	483
0.100	337	346	356	366	376	387	399	411	423	436	449	463	477	493
.102	344	353	363	373	384	395	407	419	431	445	458	472	487	503
.104	350	360	370	381	391	402	415	427	440	453	467	482	496	513
0.106	357	367	377	388	399	410	423	436	448	462	476	491	506	523

The tabular quantities are expressed in units of the fifth decimal.

TABLE XXXIV.—*Log t′*—Continued.

Log *T*.	Apparent Zenith Distance.												
	81° 0′	81° 5′	81° 10′	81° 15′	81° 20′	81° 25′	81° 30′	81° 35′	81° 40′	81° 45′	81° 50′	81° 55′	82° 0′
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0
.002	10	10	10	10	11	11	11	11	11	11	12	12	12
.004	20	20	20	21	21	21	22	22	23	23	23	24	24
.006	30	30	31	31	32	32	33	33	34	34	35	36	36
0.008	39	40	41	41	42	43	44	44	45	46	47	47	48
0.010	49	50	51	52	53	54	54	55	56	57	58	59	60
.012	59	60	61	62	63	64	65	66	68	69	70	71	72
.014	69	70	71	73	74	75	76	78	79	80	82	83	84
.016	79	80	82	83	84	86	87	89	90	92	93	95	96
0.018	89	90	92	93	95	96	98	100	102	103	105	107	109
0.020	99	100	102	104	105	107	109	111	113	115	117	119	121
.022	108	110	112	114	116	118	120	122	124	126	128	130	133
.024	118	120	122	124	126	129	131	133	135	138	140	142	145
.026	128	130	133	135	137	139	142	144	147	149	152	154	157
0.028	138	140	143	145	148	150	153	155	158	160	163	166	169
0.030	148	150	153	155	158	161	164	166	169	172	175	178	181
.032	158	160	163	166	169	172	174	177	180	183	187	190	193
.034	168	170	173	176	179	182	185	188	192	195	198	202	205
.036	177	180	183	186	190	193	196	199	203	206	210	213	217
0.038	187	190	194	197	200	204	207	211	214	218	222	225	229
0.040	197	200	204	207	211	214	218	222	226	229	233	237	241
.042	207	210	214	218	221	225	229	233	237	241	245	249	253
.044	217	220	224	228	232	236	240	244	248	252	257	261	265
.046	227	230	235	238	242	247	251	255	259	264	268	273	277
0.048	237	240	245	249	253	257	262	266	271	275	280	285	289
0.050	246	250	255	259	264	268	272	277	282	286	292	296	302
.052	256	261	265	269	274	279	283	288	293	298	303	308	314
.054	266	271	275	280	285	289	294	299	305	309	315	320	326
.056	276	281	286	290	295	300	305	310	316	321	326	332	338
0.058	286	291	296	301	306	311	316	321	327	332	338	344	350
0.060	296	301	306	311	316	322	327	332	338	344	350	356	362
.062	306	311	316	321	327	332	338	344	350	355	361	368	374
.064	316	321	326	332	337	343	349	355	361	367	373	380	386
.066	325	331	337	342	348	354	360	366	372	378	385	391	398
0.068	335	341	347	352	358	364	371	377	384	390	396	403	410
0.070	345	351	357	363	369	375	382	388	395	401	408	415	422
.072	355	361	367	373	379	386	392	399	406	413	420	427	434
.074	365	371	377	383	390	397	403	410	417	424	431	439	446
.076	375	381	388	394	401	407	414	421	429	435	443	451	458
0.078	385	391	398	404	411	418	425	432	440	447	455	463	470
0.080	394	401	408	414	422	429	436	443	451	458	466	474	482
.082	404	411	418	425	432	440	447	454	462	470	478	486	494
.084	414	421	428	435	443	450	458	465	474	481	490	498	507
.086	424	431	439	446	453	461	469	477	485	493	501	510	519
0.088	434	441	449	456	464	472	480	488	496	504	513	522	531
0.090	444	451	459	466	474	482	490	499	508	516	525	534	543
.092	454	461	469	477	485	493	501	510	519	527	536	546	555
.094	463	471	479	487	495	504	512	521	530	539	548	557	567
.096	473	481	489	497	506	515	523	532	541	550	560	569	579
0.098	483	491	500	508	516	525	534	543	553	562	571	581	591
0.100	493	501	510	518	527	536	545	554	564	573	583	593	603
.102	503	511	520	529	538	547	556	565	575	585	595	605	615
.104	513	521	530	539	548	557	567	576	587	596	606	617	627
.106	523	531	541	549	559	568	578	587	598	607	618	629	639

The tabular quantities are expressed in units of the fifth decimal.

TABLE XXXIV.—*Log t′*—Continued.

Log *T.*	Apparent Zenith Distance.												
	82° 0′	82° 5′	82° 10′	82° 15′	82° 20′	82° 25′	82° 30′	82° 35′	82° 40′	82° 45′	82° 50′	82° 55′	83° 0′
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0
.002	12	12	12	13	13	13	13	14	14	14	14	15	15
.004	24	25	25	25	26	26	27	27	28	28	29	29	30
.006	36	37	38	38	39	40	40	41	42	43	43	44	45
0.008	48	49	50	51	52	53	54	55	56	57	58	59	60
0.010	60	61	62	64	65	66	67	68	70	71	72	74	75
.012	72	74	75	76	78	79	81	82	84	85	87	88	90
.014	84	86	88	89	91	92	94	96	98	99	101	103	105
.016	96	98	100	102	104	106	108	109	112	114	116	118	120
0.018	109	111	112	114	117	119	121	123	125	128	130	133	135
0.020	121	123	125	127	130	132	134	137	139	142	145	147	150
.022	133	135	138	140	143	145	148	150	153	156	159	162	165
.024	145	147	150	153	156	158	161	164	167	170	174	177	180
.026	157	160	162	165	168	172	175	178	181	185	188	192	195
0.028	169	172	175	178	181	185	188	192	195	199	202	206	210
0.030	181	184	188	191	194	198	202	205	209	213	217	221	225
.032	193	196	200	204	207	211	215	219	223	227	231	236	240
.034	205	209	212	216	220	224	228	233	237	241	246	251	255
.036	217	221	225	229	233	238	242	246	251	256	260	265	270
0.038	229	233	238	242	246	251	255	260	265	270	275	280	285
0.040	241	246	250	254	259	264	269	274	279	284	289	295	300
.042	253	258	262	267	272	277	282	287	293	298	304	310	315
.044	265	270	275	280	285	290	296	301	307	312	318	324	330
.046	277	282	288	293	298	304	309	315	321	327	333	339	345
0.048	289	295	300	305	311	317	323	328	335	341	347	354	360
0.050	302	307	312	318	324	330	336	342	348	355	362	368	376
.052	314	319	325	331	337	343	349	356	362	369	376	383	391
.054	326	332	338	343	350	356	363	369	376	383	390	398	406
.056	338	344	350	356	363	370	376	383	390	398	405	413	421
0.058	350	356	362	369	376	383	390	397	404	412	419	427	436
0.060	362	368	375	382	389	396	403	410	418	426	434	442	451
.062	374	381	388	394	402	409	417	424	432	440	448	457	466
.064	386	393	400	407	415	422	430	438	446	454	463	472	481
.066	398	405	412	420	428	436	444	451	460	469	477	486	496
0.068	410	418	425	432	441	449	457	465	474	483	492	501	511
0.070	422	430	438	445	454	462	470	479	488	497	506	516	526
.072	434	442	450	458	467	475	484	492	502	511	521	531	541
.074	446	454	462	471	480	488	497	506	516	525	535	545	556
.076	458	467	475	483	492	502	511	520	530	540	549	560	571
0.078	470	479	488	496	505	515	524	534	544	554	564	575	586
0.080	482	491	500	509	518	528	538	547	558	568	578	590	601
.082	494	503	512	522	531	541	551	561	572	582	593	604	616
.084	507	516	525	534	544	554	564	575	586	596	607	619	631
.086	519	528	538	547	557	568	578	588	599	611	622	634	646
0.088	531	540	550	560	570	581	591	602	613	625	636	649	661
0.090	543	553	562	572	583	594	605	616	627	639	651	663	676
.092	555	565	575	585	596	607	618	629	641	653	665	678	691
.094	567	577	588	598	609	620	632	643	655	667	680	693	706
.096	579	589	600	611	622	634	645	657	669	682	694	708	721
0.098	591	602	612	623	635	647	659	670	683	696	709	722	736
0.100	603	614	625	636	648	660	672	684	697	710	723	737	751
.102	615	626	638	649	661	673	685	698	711	724	737	752	766
.104	627	639	650	661	674	686	699	711	725	738	752	766	781
0.106	639	651	662	674	687	700	712	725	739	753	766	781	796

The tabular quantities are expressed in units of the fifth decimal.

TABLE XXXIV.—*Log t′*—Continued.

Log *T*.	Apparent Zenith Distance.												
	83° 0′	83° 5′	83° 10′	83° 15′	83° 20′	83° 25′	83° 30′	83° 35′	83° 40′	83° 45′	83° 50′	83° 55′	84° 0′
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0
.002	15	15	16	16	16	17	17	17	18	18	18	19	19
.004	30	31	31	32	32	33	34	34	35	36	37	37	38
.006	45	46	47	48	49	50	51	52	53	54	55	56	57
0.008	60	61	62	64	65	66	67	69	70	72	73	75	76
0.010	75	77	78	80	81	83	84	86	88	90	92	93	95
.012	90	92	94	96	97	99	101	103	105	108	110	112	114
.014	105	107	109	111	114	116	118	120	123	126	128	131	133
.016	120	123	125	127	130	132	135	138	140	144	146	149	152
0.018	135	138	141	143	146	149	152	155	158	161	165	168	172
0.020	150	153	156	159	162	165	169	172	176	179	183	187	191
.022	165	169	172	175	178	182	185	189	193	197	201	205	210
.024	180	184	187	191	195	198	202	206	211	215	220	224	229
.026	195	199	203	207	211	215	219	224	228	233	238	243	248
0.028	210	214	219	223	227	232	236	241	246	251	256	262	267
0.030	225	230	234	239	243	248	253	258	263	269	274	280	286
.032	240	245	250	255	260	265	270	275	281	287	293	299	305
.034	255	260	266	271	276	281	287	292	299	305	311	318	324
.036	270	276	281	287	292	298	303	310	316	323	329	336	343
0.038	285	291	297	302	308	314	320	327	334	341	348	355	362
0.040	300	306	312	318	324	331	337	344	351	359	366	374	381
.042	315	322	328	334	341	347	354	361	369	377	384	392	400
.044	330	337	344	350	357	364	371	378	386	395	403	411	419
.046	345	352	359	366	373	380	388	396	404	413	421	430	438
0.048	360	368	375	382	389	397	405	413	421	431	439	448	457
0.050	376	383	390	398	406	414	422	430	439	448	458	467	476
.052	391	398	406	414	422	430	438	447	457	466	476	486	496
.054	406	414	422	430	438	447	455	464	474	484	494	504	515
.056	421	429	437	446	454	463	472	482	492	502	512	523	534
0.058	436	444	453	462	470	480	489	499	509	520	531	542	553
0.060	451	460	469	478	487	496	506	516	527	538	549	560	572
.062	466	475	484	494	503	513	523	533	544	556	567	579	591
.064	481	490	500	509	519	529	540	550	562	574	586	598	610
.066	496	506	515	525	535	546	556	568	579	592	604	616	629
0.068	511	521	531	541	551	562	573	585	597	610	622	635	648
0.070	526	536	547	557	568	579	590	602	615	628	640	654	667
.072	541	552	562	573	584	595	607	619	632	646	659	672	686
.074	556	567	578	589	600	612	624	636	650	664	677	691	705
.076	571	582	594	605	616	629	641	654	667	682	695	710	724
0.078	586	597	609	621	633	645	658	671	685	700	714	729	743
0.080	601	613	625	637	649	662	674	688	702	717	732	747	762
.082	616	628	640	653	665	678	691	705	720	735	750	766	781
.084	631	643	656	669	682	695	708	722	737	753	769	785	801
.086	646	659	672	685	698	711	725	740	755	771	787	803	820
0.088	661	674	687	700	714	728	742	757	773	789	805	822	839
0.090	676	689	703	716	730	744	759	774	790	807	824	841	858
.092	691	705	719	732	746	761	776	791	808	825	842	859	877
.094	706	720	734	748	762	777	792	808	825	843	860	878	896
.096	721	735	750	764	779	794	809	826	843	861	878	897	915
0.098	736	751	765	780	795	810	826	843	860	879	897	915	934
0.100	751	766	781	796	811	827	843	860	878	897	915	934	953
.102	766	781	797	812	827	844	860	877	896	915	933	953	972
.104	781	797	812	828	843	860	877	894	913	933	952	971	991
0.106	796	812	828	844	860	877	894	912	931	951	970	990	1010

The tabular quantities are expressed in units of the fifth decimal.

TABLE XXXIV.—*Log t′*—Continued.

Log *T*.	Apparent Zenith Distance.												
	84° 0′	84° 5′	84° 10′	84° 15′	84° 20′	84° 25′	84° 30′	84° 35′	84° 40′	84° 45′	84° 50′	84° 55′	85° 0′
0.000	0	0	0	0	0	0	0	0	0	0	0	0	0
.002	19	19	20	20	21	21	22	22	23	23	24	24	25
.004	38	39	40	41	42	42	43	44	45	46	47	49	50
.006	57	58	60	61	62	64	65	67	68	69	71	73	74
0.008	76	78	80	81	83	85	87	89	91	93	95	97	99
0.010	95	97	100	102	104	106	108	111	113	116	118	121	124
.012	114	117	119	122	125	127	130	133	136	139	142	146	149
.014	133	136	139	142	145	149	152	155	159	162	166	170	174
.016	152	156	159	163	166	170	174	177	181	185	190	194	199
0.018	172	175	179	183	187	191	195	200	204	208	213	218	223
0.020	191	195	199	203	208	212	217	222	227	232	237	243	248
.022	210	214	219	224	229	234	239	244	249	255	261	267	273
.024	229	234	239	244	249	255	260	266	272	278	284	291	298
.026	248	253	259	264	270	276	282	288	295	301	308	315	323
0.028	267	273	279	285	291	297	304	311	317	324	332	340	347
0.030	286	292	298	305	312	319	326	333	340	347	356	364	372
.032	305	312	318	325	332	340	347	355	363	371	379	388	397
.034	324	331	338	346	353	361	369	377	385	394	403	412	422
.036	343	351	358	366	374	382	391	399	408	417	427	437	447
0.038	362	370	378	386	395	404	412	421	431	440	450	461	472
0.040	381	390	398	407	416	425	434	444	453	463	474	485	496
.042	400	409	418	427	436	446	456	466	476	486	498	509	521
.044	419	429	438	447	457	467	477	488	499	510	521	534	546
.046	438	448	458	468	478	489	499	510	521	533	545	558	571
0.048	457	468	478	488	499	510	521	532	544	556	569	582	596
0.050	476	487	498	508	520	531	542	554	566	579	592	606	620
.052	496	506	517	529	540	552	564	577	589	602	616	631	645
.054	515	526	537	549	561	573	586	599	612	625	640	655	670
.056	534	545	557	570	582	595	608	621	634	649	664	679	695
0.058	553	565	577	590	603	616	629	643	657	672	688	704	720
0.060	572	584	597	610	623	637	651	665	680	695	711	728	745
.062	591	604	617	631	644	658	673	688	703	718	735	752	769
.064	610	623	637	651	665	680	695	710	725	741	758	776	794
.066	629	643	657	671	686	701	716	732	748	764	782	801	819
0.068	648	662	677	692	707	722	738	754	770	787	806	825	844
0.070	667	682	696	712	727	743	760	776	793	811	830	849	869
.072	686	701	716	732	748	765	781	798	816	834	853	873	894
.074	705	721	736	753	769	786	803	821	838	857	877	898	918
.076	724	740	756	773	790	807	825	843	861	880	901	922	943
0.078	743	760	776	793	810	828	846	865	884	903	924	946	968
0.080	762	779	796	814	831	850	868	887	906	926	948	970	993
.082	781	799	816	834	852	871	890	909	929	950	972	995	1018
.084	801	818	836	854	873	892	911	932	952	973	995	1019	1042
.086	820	838	856	875	894	913	933	954	974	996	1019	1043	1067
0.088	839	857	876	895	914	935	955	976	997	1019	1043	1067	1092
0.090	858	877	896	915	935	956	976	998	1020	1042	1066	1092	1117
.092	877	896	915	936	956	977	998	1020	1042	1065	1090	1116	1142
.094	896	916	935	956	977	998	1020	1042	1065	1089	1114	1140	1167
.096	915	935	955	976	997	1020	1042	1065	1088	1112	1138	1164	1191
0.098	934	955	975	997	1018	1041	1063	1087	1110	1135	1161	1189	1216
0.100	953	974	995	1017	1039	1062	1085	1109	1133	1158	1185	1213	1241
.102	972	994	1015	1037	1060	1083	1107	1131	1156	1181	1209	1237	1266
.104	991	1013	1035	1058	1081	1104	1128	1153	1178	1204	1232	1262	1291
0.106	1010	1033	1055	1078	1101	1126	1150	1176	1201	1227	1256	1286	1315

The tabular quantities are expressed in units of the fifth decimal.

APPENDIX III.

REDUCTION TABLES

FOR

EQUATORIAL OBSERVATIONS,

BY

C. W. FREDERICK,
Assistant on Equatorial.

TABLE OF CONTENTS.

INTRODUCTION.

DIFFERENTIAL REFRACTION.

The formulæ here to be developed are for the purpose of constructing tables of differential refraction for micrometer observations made with an equatorial. Only three cases will be considered: first, when observations are made by directly measuring both differences in right ascension and differences in declination with the micrometer; second, when differences in right ascension are determined by transits; and, third, when observations are made by measuring position angles and distances. For the first case formulæ were derived by Prof. GEORGE C. COMSTOCK in Circular No. 7, of the International Astrophotographic Conference of July, 1900. By methods suggested by his paper it is proposed to develop formulæ similar to those of Professor COMSTOCK, but with certain changes designed to increase their accuracy and convenience for the purpose in view.

Take any point c in the immediate vicinity of the measured objects, as the origin of a system of rectangular coordinates, in which the axis of y is the vertical circle through c, the positive direction being upward, or toward the zenith, z. Let the positive direction of the axis of x lie in position angle 90° from the zenith. Now the action of the micrometer is such that measurements in x and y are necessarily made along their respective axes; but we may here consider that these measurements are made along arcs of great circles perpendicular to the two axes, since the convergence of these circles is always negligible within the range of micrometer measurements.

With the above system let us determine the effect of refraction upon the measurements between any two stars. Let the following angular quantities be expressed in circular measure:

x'_0, x'=the horizontal distance, true and apparent, between the two stars.
y'_0, y'=the vertical distance, true and apparent, between the two stars.
ζ_1, ζ_2 and z_1, z_2=the true and apparent zenith distances of the stars.
ζ, z=their mean zenith distance, true and apparent.
r_1, r_2=their refractions.

where $r_1=k_1 \tan z_1$;
$r_2=k_2 \tan z_2$.

and $k=\alpha\,\beta^{A}\,\gamma^{\lambda}$ of BESSEL'S refraction formulæ.

Note.—After this appendix was ready for the press Assistant Astronomer H. L. RICE verified the mathematical formulæ, and made many valuable suggestions in the direction of simplicity which have been incorporated in the text.

The difference between x'_0 and x' is equal to the difference between the x components of r_1 and r_2. Then, the abscissas being small arcs, we obtain

$$x'_0=x'+x'\frac{k_1+k_2}{2}+x'_m(k_1-k_2).$$

In the last term of this equation x'_m is the mean apparent abscissa of the two stars and k_1 must refer to the star whose abscissa is algebraically the greater of the two. This term disappears if we take the origin midway between the stars; but it is inappreciable in any case, as the value of k changes very slowly with the zenith distance. Thus we may write

$$x'_0=x'+kx'. \tag{1}$$

In this equation k depends on the apparent zenith distance z.

Similarly the difference between y'_0 and y' is equal to the difference between the y components of r_1 and r_2. Thus if r_1 refers to the star having the lesser zenith distance, we have

$$y'_0=y'+r_2 \cos A_2 \sec x_2-r_1 \cos A_1 \sec x_1,$$

where A_1, A_2 are the azimuths of the two stars with reference to the origin c, and x_1, x_2 their abscissas. Since these are small arcs we may substitute unity for the cosines and secants in the above equation, which becomes

$$y'_0=y'+r_2-r_1.$$

A further substitution of $y'\frac{dr}{dz}$ for r_2-r_1 gives

$$y'_0=y'+y'\frac{dr}{dz}.$$

Differentiating the expression for refraction, namely,

$$r=k \tan z,$$

we obtain

$$\frac{dr}{dz}=k+k \tan^2 z+\frac{dk}{dz} \tan z,$$

which gives the rate of change of the refraction in terms of the apparent zenith distance. In micrometer observations it is generally the true zenith distance that is known; therefore it is necessary to make a transformation by introducing a new quantity κ which shall depend on the true zenith distance. See BESSEL'S Astronomische Untersuchungen, Bd. I, S. 160, or CHAUVENET'S Spherical and Practical Astronomy, Vol. II, p. 453. Thus putting

$$\kappa \tan^2 \zeta=k \tan^2 z+\frac{dk}{dz} \tan z,$$

we have

$$y'_0=y'+(k+\kappa \tan^2 \zeta)\, y', \tag{2}$$

where

$$\kappa=\alpha'' \beta^{A''}\gamma^{\lambda''},$$

the notation being that of Bessel. For convenience put

$$K=k+\kappa \tan^2 \zeta,$$

then (2) becomes

$$y'_0=y'+Ky'. \tag{3}$$

Let us now suppose the origin c of the foregoing investigation to be the point midway between the true positions of the stars in question; and let c' designate the point midway between their apparent positions. Then the equations (1) and (3) may be regarded as expressing the relations between two systems of rectangular coordinates, true and apparent, having c and c' for their respective origins, and the vertical circle through c for their common axis of y. Now take two new rectangular systems, true and apparent, of which also c, c' are the origins, the axis of y being an hour circle in each case.

Let y_0, y=true and apparent differences in declination, measured along an hour circle, the positive direction being northward.

x_0, x=true and apparent differences in right ascension as measured by the micrometer, and not reduced to the equator. They are positive when measured in the direction of increasing right ascensions.

q, q'=parallactic angles of c and c'.

Between the two systems of coordinates which have their common origin at c we have the following relations:

$$\left.\begin{aligned} x_0&=x'_0 \cos q+y'_0 \sin q, \\ y_0&=y'_0 \cos q-x'_0 \sin q. \end{aligned}\right\} \tag{4}$$

Substituting in (4) the values of x'_0 and y'_0 given by (1) and (3), we get,

$$\left.\begin{aligned} x_0&=x' (1+k) \cos q+y' (1+K) \sin q, \\ y_0&=y' (1+K) \cos q-x' (1+k) \sin q. \end{aligned}\right\} \tag{5}$$

The relations between the two systems of coordinates which have the common origin c' are—

$$\begin{aligned} x'&=x \cos q'-y \sin q', \\ y'&=y \cos q'+x \sin q'. \end{aligned}$$

Substituting these values in equation (5), we have

$$\left.\begin{aligned} x_0=x\ &[\cos (q'-q)+K \sin q \sin q'+k \cos q \cos q'] \\ &+y\ [K \sin q \cos q'-k \cos q \sin q'-\sin (q'-q)], \\ y_0=y\ &[\cos (q'-q)+K \cos q \cos q'+k \sin q \sin q'] \\ &+x\ [K \cos q \sin q'-k \sin q \cos q'+\sin (q'-q)]. \end{aligned}\right\} \tag{6}$$

These represent the relations between the two systems of rectangular coordinates, true and apparent, in which differences in right ascension and declination are directly measured with the micrometer.

Since the difference between the parallactic angles is small, we may put $\cos (q'-q)=1$. Also, applying Gauss's Equations to the triangle of which the vertices are the pole, c, and c', we have, approximately,

$$\sin (q'-q)=k' \tan \delta \tan \zeta \sin q,$$

in which, with Bessel, we let $k'=\alpha' \beta^{\lambda'} \gamma^{\lambda'}$.

The value of k' depends on the true zenith distance and must be expressed in circular measure, and δ is the declination of the point c. Furthermore, in the coefficients of K and k we may put $q'=q$, the error involving only terms of the order of the square of the small quantities K and k. Making these substitutions, equations (6) become

$$\left.\begin{aligned} x_0&=x+x[(K-k)\sin^2 q+k]+y[(K-k)\sin q\cos q-k'\tan\zeta\tan\delta\sin q],\\ y_0&=y+y[(K-k)\cos^2 q+k]+x[(K-k)\sin q\cos q+k'\tan\zeta\tan\delta\sin q].\end{aligned}\right\} \qquad (7)$$

Now introduce the following auxiliary quantities:

N, n=the sides adjacent to and opposite the pole in the right spherical triangle of which the vertices are the zenith, the north pole of the heavens, and the foot of a great circle drawn from the zenith perpendicular to the hour circle through c.

Then we have

$$\begin{aligned} \tan N&=\cot\varphi\cos\tau,\\ \tan n&=\tan\tau\sin N,\\ \cos n&=\sin\varphi\sec N,\\ \cos\zeta&=\sin(N+\delta)\cos n.\end{aligned}$$

Also put

$$\begin{aligned} X&=\tan n\csc(N+\delta),\\ Y&=\cot(N+\delta).\end{aligned}$$

In these φ is the latitude of the place, and τ is the hour angle of the origin c. For the values of the sine and cosine of q we have

$$\begin{aligned} \sin q&=X\cot\zeta,\\ \cos q&=Y\cot\zeta.\end{aligned}$$

Substituting these expressions and also the value of K, found at the top of page F 7 in equation (7), we obtain

$$\left.\begin{aligned} x_0&=x+[\kappa X^2+k]x+[\kappa XY-k'X\tan\delta]y,\\ y_0&=y+[\kappa Y^2+k]y+[\kappa XY+k'X\tan\delta]x.\end{aligned}\right\} \qquad (8)$$

The bracketed quantities in these formulæ are given in TABLE I for every degree in declination, from 70° north to 30° south, and for every 10^m in hour angle up to zenith distance, 75°. The quantities are there designated by letters, thus:

$$\left.\begin{aligned} M&=\kappa X^2+k; \quad m=\kappa XY-k'X\tan\delta;\\ W&=\kappa Y^2+k; \quad w=\kappa XY+k'X\tan\delta;\end{aligned}\right\} \qquad (9)$$

so that (8) becomes

$$\left.\begin{aligned} x_0&=x+Mx+my,\\ y_0&=y+Wy+wx.\end{aligned}\right\} \qquad (10)$$

The values of k and k' are nearly the same, and no appreciable error will be introduced if either one or the other is substituted throughout the formulæ. But as k' is sometimes multiplied by large numbers, and as it depends on the true zenith distance, we substitute k' rather than k in formulæ (8).

The state of the atmosphere assumed as a basis for the tables is temperature 50° Fahrenheit and barometric pressure 30 inches. The values of k' and κ might have been computed from BESSEL'S refraction tables, but it was thought more convenient to form new tables giving k' and κ for the assumed temperature and barometer, with the cosine of the true zenith distance as the argument. Thus the following were derived for use in the present case.

Log Cos ζ.	Log k'.		Log κ.	
0.000	6.4511	0	6.4499	2
9.980	6.4511	1	6.4497	2
9.960	6.4510	1	6.4495	2
9.940	6.4509	1	6.4493	2
9.920	6.4508	0	6.4491	2
9.900	6.4508	1	6.4489	2
9.880	6.4507	1	6.4487	3
9.860	6.4506	2	6.4484	4
9.840	6.4504	1	6.4480	4
9.820	6.4503	1	6.4476	3
9.800	6.4502	2	6.4473	4
9.780	6.4500	1	6.4469	5
9.760	6.4499	2	6.4464	6
9.740	6.4497	2	6.4458	6
9.720	6.4495	3	6.4452	7
9.700	6.4492	2	6.4445	6
9.680	6.4490	3	6.4439	7
9.660	6.4487	3	6.4432	8
9.640	6.4484	3	6.4424	8
9.620	6.4481	3	6.4416	10
9.600	6.4478	4	6.4406	11
9.580	6.4474	4	6.4395	12
9.560	6.4470	5	6.4383	12
9.540	6.4465	5	6.4371	14
9.520	6.4460	5	6.4357	16
9.500	6.4455	6	6.4341	18
9.480	6.4449	6	6.4323	17
9.460	6.4443	7	6.4306	19
9.440	6.4436	8	6.4287	20
9.420	6.4428	8	6.4267	20
9.400	6.4420	9	6.4247	23
9.380	6.4411		6.4224	

Cos ζ.	$10^5 k'$.
	28.3
0.927	
	28.2
0.524	
	28.1
0.406	
	28.0
0.343	
	27.9
0.300	
	27.8
0.270	
	27.7
0.247	
	27.6

Cos ζ.	$10^5 \kappa$.
	28.2
0.909	
	28.1
0.687	
	28.0
0.575	
	27.9
0.512	
	27.8
0.459	
	27.7
0.419	
	27.6
0.390	
	27.5
0.365	
	27.4
0.345	
	27.3
0.328	
	27.2
0.314	
	27.1
0.301	
	27.0
0.288	
	26.9
0.277	
	26.8
0.267	
	26.7
0.257	
	26.6
0.248	
	26.5
0.240	
	26.4

In forming TABLE I the quantities were computed in general at intervals of 2° in declination and 20^m of hour angle, though the intervals were increased at times to 4° and 40^m, and when it was thought advisable they were diminished to 1° and 10^m. The remaining quantities in the table were obtained by interpolation.

Natural numbers were used as long as three figures in the values of X, Y, and tan δ would give sufficient accuracy in the results, the computations being carried to the sixth decimal place. Thus in a general way natural numbers were used up to zenith distances of 50° or 60°. At greater zenith distances the multiplications were performed by the use of four place logarithms.

In order to check the table thus formed about seventy-five sets of the four quantities were independently computed at points well scattered throughout the table, and finally the entire table was differenced in both declination and hour angle. While no effort has been made to make the last digit exact, it is intended that the error shall in no case exceed one unit.

TABLES II, III, IV, V, and VI were checked in a similar manner.

When observations are made by transits each object is observed on the same hour circle, and therefore the corrections for refraction are the same as for two stars, directly measured, which have no difference in right ascension. Thus we have from (10), when x is zero,

$$\Delta x = my,$$
$$\Delta y = Wy.$$

These are to be applied respectively to the observed interval of time, $\Delta\alpha$, between the passages of the stars, and the measured difference in declination, $\Delta\delta$. But since $\Delta\alpha$ is the equatorial interval between the stars, the correction my must be reduced to the equator. Accordingly, if $\Delta\alpha$ and $\Delta\delta$, are expressed in seconds of time and seconds of arc, respectively, we have the following formulæ for the correction of observations made by transits:

$$\left.\begin{aligned}\Delta\alpha_0 &= \Delta\alpha + m'\Delta\delta,\\ \Delta\delta_0 &= \Delta\delta + W\Delta\delta,\end{aligned}\right\} \qquad (11)$$

where

$$m' = \frac{m}{15} \sec\ \delta.$$

The values of m' and W are given in TABLE II.

To derive the formulæ for the case where observations are made by measuring position angle p and distance s, we differentiate the relations between p, s, x, and y. Then, substituting for Δx and Δy the values of $x_0 - x$, and $y_0 - y$ from equations (10) we obtain

$$\left.\begin{aligned}\Delta p &= 57.3\left[\frac{w+m}{2}\cos 2p - \frac{W-M}{2}\sin 2p - \frac{w-m}{2}\right],\\ \Delta s &= s\left[\frac{w+m}{2}\sin 2p + \frac{W-M}{2}\cos 2p + \frac{W+M}{2}\right],\end{aligned}\right\} \qquad (12)$$

the numerical coefficient being introduced in order to give Δp in degrees.

Putting

$$h = \frac{w+m}{2}\sin 2p + \frac{W-M}{2}\cos 2p + \frac{W+M}{2}$$

we have

$$p_0 = p + \Delta p,$$
$$s_0 = s + hs,$$

where p_0 and s_0 are the true values of the position angle and distance.

The values of Δp and h are given in TABLE III.

Equations (12) represent BESSEL'S formulæ before the substitution of κ for k, see Astronomische Untersuchungen, Bd. I, S. 162. They are very convenient for computing tables of refraction after the values of M, m, W, w, have been computed for TABLE I. When carried to the sixth decimal place there will usually be only three significant figures in the natural values of M, m, W, w; and three figures are always sufficient in the sines and cosines of $2p$. Thus the formulæ in question are well suited to the use of natural numbers, and these were employed in computing the quantities given in TABLE III.

INSTRUMENTAL CONSTANTS.

Before investigating the effect of the instrumental constants in disturbing the orientation of the micrometer it may not be out of place to give a convenient method for determining them. Let the constants be defined as follows:

η=the distance of the instrumental pole westward from the true pole, measured along the six-hour circle.

ξ=the distance of the instrumental pole above the true pole, measured along the meridian.

i_{r}=the inclination of the axes. The angle between the polar axis produced northward and the declination axis produced through the telescope tube is $i_{\mathrm{r}}+90°$. This is the observed angle as affected by the flexure of the declination axis.

c=the collimation. The angle between the optical axis of the telescope produced through the objective and the declination axis produced through the tube is $c+90°$.

ε=the maximum flexure of the declination axis, positive when the end joining the tube bends downward.

e=the maximum flexure of the telescope tube, positive when the objective end of the tube bends the more.

The collimation, flexure of the declination axis, and flexure of the tube may be determined from observations of equatorial stars. For the collimation we take several transits of an equatorial star, half with the telescope east of the pier, and half with the telescope west, reading the verniers of the hour circle after each transit. The thread over which the transits are taken must be carefully placed in the optical axis of the telescope. This may be done by starting the driving clock and reversing the micrometer a few times upon a star. The collimation so determined will be diminished by a variable component of the flexure of the declination axis. In order to determine the true collimation we make an observation near the meridian, and at large hour angle, say between four and five hours, both west and east. For the meridian observation, let

c_{m}=the collimation as diminished by the flexure of the declination axis.

$\theta^{\mathrm{W}}_{\mathrm{m}}$, $\theta^{\mathrm{E}}_{\mathrm{m}}$=the mean of the sidereal times of transit taken telescope west and telescope east of the pier, respectively.

$\tau^{\mathrm{W}}_{\mathrm{m}}$, $\tau^{\mathrm{E}}_{\mathrm{m}}$=the mean of the readings of the hour circle plus the index correction for telescope west and east, respectively.

For the observations made at hour angles west and east, the corresponding quantities will be indicated by the subscripts w and e, respectively. We then have

$$\left.\begin{aligned}
c_{\mathrm{m}} &= \tfrac{1}{2}(\theta^{\mathrm{E}}_{\mathrm{m}}-\theta^{\mathrm{W}}_{\mathrm{m}})-\tfrac{1}{2}(\tau^{\mathrm{E}}_{\mathrm{m}}-\tau^{\mathrm{W}}_{\mathrm{m}})-0.0003\times\tfrac{1}{2}(\theta^{\mathrm{E}}_{\mathrm{m}}-\theta^{\mathrm{W}}_{\mathrm{m}}),\\
c_{\mathrm{w}} &= \tfrac{1}{2}(\theta^{\mathrm{E}}_{\mathrm{w}}-\theta^{\mathrm{W}}_{\mathrm{w}})-\tfrac{1}{2}(\tau^{\mathrm{E}}_{\mathrm{w}}-\tau^{\mathrm{W}}_{\mathrm{w}})-M\tfrac{1}{2}(\theta^{\mathrm{E}}_{\mathrm{w}}-\theta^{\mathrm{W}}_{\mathrm{w}}),\\
c_{\mathrm{e}} &= \tfrac{1}{2}(\theta^{\mathrm{E}}_{\mathrm{e}}-\theta^{\mathrm{W}}_{\mathrm{e}})-\tfrac{1}{2}(\tau^{\mathrm{E}}_{\mathrm{e}}-\tau^{\mathrm{W}}_{\mathrm{e}})-M\tfrac{1}{2}(\theta^{\mathrm{E}}_{\mathrm{e}}-\theta^{\mathrm{W}}_{\mathrm{e}}).
\end{aligned}\right\}\qquad(13)$$

The last term in each equation is a correction for refraction, the value of M being given in TABLE I. When observing for c_{m} we may wish to eliminate the differential effect of the flexure of the telescope tube. This may be accomplished by taking the transits, two with the telescope on one side of the pier, four on the opposite side, then two more in the first position. When observing for c_{w} and c_{e}, it is not necessary to reverse the telescope more than once, as the flexure of the tube may be sufficiently eliminated by making the observation at east hour angle in the reverse order from that at west hour angle. Thus, if at τ_w we observe in the order, telescope east, telescope west, at τ_e we would observe in the order, telescope west, telescope east. This is the natural procedure in manipulating the instrument.

The true collimation c, and the flexure of the declination axis, ε, may then be determined from the following relations:

$$\left.\begin{aligned} c-\varepsilon \cos \varphi \cos \tau_m &= c_m, \\ c-\varepsilon \cos \varphi \cos \tau_w &= c_w, \\ c-\varepsilon \cos \varphi \cos \tau_e &= c_e. \end{aligned}\right\} \tag{14}$$

In these equations

$$\begin{aligned} \tau_m &= \tau_m^E + \tau_m^W, \\ \tau_w &= \tau_w^E + \tau_w^W, \\ \tau_e &= \tau_e^E + \tau_e^W. \end{aligned}$$

For the flexure of the tube put

$$\begin{aligned} \theta_w &= \theta_w^E + \theta_w^W, \\ \theta_e &= \theta_e^E + \theta_e^W. \end{aligned}$$

Then we have

$$e \cos \varphi = \frac{\theta_w - \theta_e + \tau_e - \tau_w + \alpha_e - \alpha_w - r_w - r_e}{\sin \tau_w - \sin \tau_e} \tag{15}$$

Here α_e and α_w are the apparent right ascensions of the stars observed at east and west hour angles, respectively. Stars of the seventh or eighth magnitude within fifteen minutes of the equator may be picked up as required and their right ascensions obtained from the Nicolajew A. G. Catalogue. r_w and r_e are the refractions in right ascension at τ_w and τ_e, and are both assumed as positive. The values of M and r for use in equations (13) and (15) may be taken from the following table:

τ_w		M	r	τ_e	
h	m		s	h	m
4	0	0.0011	6.69	20	0
4	10	0.0013	7.41	19	50
4	20	0.0015	8.25	19	40
4	30	0.0019	9.27	19	30
4	40	0.0023	10.52	19	20
4	50	0.0029	12.09	19	10
5	0	0.0041	14.13	19	0

These quantities were computed for latitude 38° 55′ 14″, thermometer 50° Fahrenheit, and barometer 30 inches. To correct a given refraction for other temperatures subtract one per cent for each 5° above 50°, and for other pressures add one per cent for each three-tenths of an inch above 30 inches.

The quantities ξ, η, and $i_1 - c$ may be determined from observations on circumpolar stars. α and λ Ursæ Minoris are about six hours apart in right ascension, thus, one is near culmination when the other is near elongation. We may determine η from the star near culmination and ξ from the star near elongation.

Before making the observations we should determine the reading of the micrometer scale when the movable wire is in the optical axis of the telescope, or, better, place the fixed wire in the optical axis so that coincidence is the required reading. To determine η, clamp the telescope at one side of the pier so that the declination axis will lie in the plane of the six-hour circle. Also clamp the micrometer in a horizontal position. Then point the telescope at the star near culmination. As the star moves slowly across the field set the movable wire immediately ahead of it and note the time of transit; also note the setting of the thread. Two or more such transits should be taken to serve as a check on each other. Then reverse the telescope to the opposite side of the pier and repeat the operation. In setting the telescope for these observations allowance should be made for the bending of the declination axis. For the 26-inch equatorial at the United States Naval Observatory the bending in hour angle is $\varepsilon \cos \varphi = 95'' = 6^s +$. Therefore, when the telescope is east of the pier the hour circle is set 6^s past 0^h, and when it is west, 6^s less than 0^h in order to bring the declination axis into the plane of the meridian. To determine ξ, the star near elongation is observed in a similar manner, with the telescope above the pier and clamped so that the declination axis will lie in the plane of the meridian. The micrometer should remain clamped in position angle and not be disturbed during the observations.

For the reduction of these observations let us define the following quantities:

α_c, ρ_c, = the apparent right ascension and polar distance of the star at culmination.
α_e, ρ_e, = the apparent right ascension and polar distance of the star at elongation.
r = the refraction at the pole.
φ = the latitude of the observatory.
R_0 = the reading of the micrometer scale when the movable wire is in coincidence with the optical axis of the telescope.
R = the mean of the settings of the movable wire in a given position of the telescope.
θ = the mean of the transits, or the sidereal time corresponding to R.
$\tau = \theta - \alpha$.

The position of the telescope may be shown by indices E, W, U (east, west, up), and the position of the micrometer by subscripts E, W, U, D (east, west, up, down). These may refer to the positive direction of the micrometer scale, or to the micrometer head if it is opposite the zero of the scale. Thus R^E_W is the mean of the scale readings taken when the telescope is east of the pier, and the micrometer clamped so the scale increases westward, or head west.

The quantities η, ξ, and $i_1 - c$ are now determined by the following equations: When the micrometer is clamped head outward from the pier,

$$\left.\begin{aligned}\eta &= +\rho_c \sin \tfrac{1}{2} (\tau^W_W + \tau^E_E) + \tfrac{1}{2}(R^W_W - R^E_E),\\ i_1 - c &= \pm\rho_c \sin \tfrac{1}{2} (\tau^W_W - \tau^E_E) + \tfrac{1}{2}(R^W_W + R^E_E) - R_0,\\ \xi &= +\rho_e \cos \tau^U_U + R^U_U - R_0 - (i_1 - c) + c \cos \varphi + r.\end{aligned}\right\} \qquad (16)$$

When the micrometer is clamped head inward next the pier,

$$\left.\begin{aligned}\eta &= +\rho_c \sin \tfrac{1}{2} (\tau^W_E + \tau^E_W) + \tfrac{1}{2}(R^E_W - R^W_E),\\ i_1 - c &= \pm\rho_c \sin \tfrac{1}{2} (\tau^W_E - \tau^E_W) - \tfrac{1}{2}(R^W_E + R^E_W) + R_0,\\ \xi &= +\rho_e \cos \tau^U_D + R_0 - R^U_D - (i_1 - c) + c \cos \varphi + r.\end{aligned}\right\} \qquad (17)$$

If we wish to eliminate R_0 by reversing the micrometer during each observation we have for the reduction,

$$\left.\begin{aligned}\eta &= +\rho_c \sin \tfrac{1}{4} (\tau^W_W + \tau^E_W + \tau^E_E + \tau^W_E) + \tfrac{1}{4}(R^W_W + R^E_W - R^E_E - R^W_E),\\ i_1 - c &= \pm\rho_c \sin \tfrac{1}{4} (\tau^W_W - \tau^E_W - \tau^E_E + \tau^W_E) + \tfrac{1}{4}(R^W_W - R^E_W + R^E_E - R^W_E),\\ \xi &= +\rho_e \cos \tfrac{1}{2} (\tau^U_U + \tau^U_D) + \tfrac{1}{2}(R^U_U - R^U_D) - (i_1 - c) + c \cos \varphi + r.\end{aligned}\right\} \qquad (18)$$

In these equations the double sign is to be taken positive when the star is observed at upper culmination, and negative when at lower culmination.

In addition to the constants found above there is still another influence at work to disturb the orientation of the micrometer. This is the torsion of the telescope tube. It is probably caused by the distortion of the central casting of the tube under the weight of the telescope, its circular section becoming deformed. The effect is the same as if the declination axis were less rigid in a plane perpendicular to the tube than in one parallel to it. But for convenience let us assume the torsion is produced by the weight of a finder attached to the eye end of the telescope opposite the declination axis; also as a test of symmetry, suppose a second finder attached 90° in position angle from the declination axis.

Put

μ = the maximum torsion produced by the first finder,
μ' = the maximum torsion produced by the second finder.

The values of μ and μ' can be determined by means of levels placed on the micrometer box. Two small spirit levels may be secured to the micrometer box in such a way that their respective axes will be parallel and perpendicular to the telescope tube. Then when the level bubbles are in the center of their scales let

$p^{\mathrm{D}}_{\mathrm{e}}$ = the reading of the position circle when the telescope is beneath the pier and the object-glass east.
$p^{\mathrm{U}}_{\mathrm{w}}$ = the reading of the position circle when the telescope is above the pier and the object-glass west.
$p^{\mathrm{U}}_{\mathrm{e}}$ = the reading of the position circle when the telescope is above the pier and the object-glass east.
$p^{\mathrm{D}}_{\mathrm{w}}$ = the reading of the position circle when the telescope is beneath the pier and the object-glass west.

The telescope is set each time with the declination axis as nearly as possible in the instrumental meridian, and the tube as nearly as possible in the instrumental equator. In this position let

f = the component of the torsion due to the first finder, or $f = \mu \sin \varphi'$,
f' = the component of the torsion due to the second finder, or $f' = \mu' \cos \varphi'$,
φ' = the altitude of the instrumental pole.

To determine these quantities we have

$$\left.\begin{aligned} f &= \tfrac{1}{4}(p^{\mathrm{U}}_{\mathrm{e}} + p^{\mathrm{D}}_{\mathrm{w}} - p^{\mathrm{D}}_{\mathrm{e}} - p^{\mathrm{U}}_{\mathrm{w}}) - i_1. \\ f' &= \tfrac{1}{4}(p^{\mathrm{U}}_{\mathrm{e}} + p^{\mathrm{U}}_{\mathrm{w}} - p^{\mathrm{D}}_{\mathrm{e}} - p^{\mathrm{D}}_{\mathrm{w}}). \\ \varphi' &= \tfrac{1}{4}(p^{\mathrm{U}}_{\mathrm{e}} - p^{\mathrm{U}}_{\mathrm{w}} + p^{\mathrm{D}}_{\mathrm{e}} - p^{\mathrm{D}}_{\mathrm{w}}) + 90°. \\ \xi &= \varphi' - \varphi. \end{aligned}\right\} \qquad (19)$$

Thus incidentally we have an independent determination of ξ.

Having found the constants we proceed to investigate their effect in disturbing the orientation of the micrometer. Assume the micrometer of a perfect equatorial to be correctly oriented. Then if the constants are introduced they will cause the micrometer to deviate from the true parallel.

Put

λ = the deviation of the micrometer from its true parallel due to the instrumental constants, positive when the vertical wire strikes to the east of the true pole of the heavens.

The formula for λ may be obtained by considering each constant separately. Let s be a star at which the telescope is pointed, and p the pole of the heavens. Then for the effect of η and ξ we take the component of each perpendicular to sp and find the angle subtended at s,

$$\lambda=+\xi \sec \delta \sin \tau-\eta \sec \delta \cos \tau.$$

The deviation produced by the flexure of the tube is the difference of the parallactic angles at the extremities of the arc through which the line of sight is displaced by the bending of the tube,

$$\lambda=-e \cos \varphi \tan \delta \sin \tau.$$

For the inclination of the axes we construct a right triangle upon sp as an hypothenuse, and side i_1 adjacent to the pole, measured eastward when the telescope is east of the pier. The deviation is the angle at s.

$$\lambda=+i_1 \sec \delta.$$

This term becomes negative when the telescope is west of the pier.

For the collimation we construct a right triangle upon sp as an hypothenuse, and side c adjacent s, measured eastward when the telescope is east of the pier. The deviation is the complement of the angle at s,

$$\lambda=-c \tan \delta.$$

This term becomes positive when the telescope is west of the pier.

The flexure of the declination axis need not be considered, as its component in right ascension does not affect the parallel, and its component in declination is included in i_1.

The torsion of the tube we assume proportional to the component of gravity taken perpendicular to the plane of the tube and declination axis. When the telescope is east of the pier we have,

$$\lambda=+f \cos \delta-f \cot \varphi \sin \delta \cos \tau.$$

The signs are changed in this expression when the telescope is west of the pier.

If f' is appreciable we have

$$\lambda=\pm f' \sin \tau.$$

The sum of the above expressions for λ gives the deviation produced by the constants when it is assumed that the micrometer was oriented with the perfect equatorial before the introduction of the constants. Now with the actual instrument in which all the constants are present, let

p^e_m=the setting of the position circle determined by the trail of an equatorial star along one of the micrometer wires when the telescope is east of the pier and near the meridian.

If we take p^e_m as a fundamental parallel the value of λ is zero for this position of the telescope. But taking the sum of the above equations when δ and τ are zero,

$$\lambda_0=i_1+f-\eta.$$

Therefore, subtracting this quantity from the sum of the preceding expressions for λ, we have the deviation from the true parallel when the position circle of the micrometer is set at the reading p^{e}_{m}.

Putting λ_1 for the sum of the terms, the signs of which are independent of the position of the telescope, and λ_2 for the sum of the terms which change sign when the telescope is reversed in position, we have,

$$\left.\begin{aligned}\lambda_1&=\eta-i_1-f-\eta\sec\delta\cos\tau+(\xi\sec\delta-e\cos\varphi\tan\delta)\sin\tau,\\ \lambda_2&=i_1\sec\delta-c\tan\delta+f\cos\delta-f\cot\varphi\sin\delta\cos\tau\end{aligned}\right\}\qquad(20)$$

and

$$\left.\begin{aligned}\lambda^{E}&=\lambda_1+\lambda_2,\text{ for telescope east of pier,}\\ \lambda^{W}&=\lambda_1-\lambda_2,\text{ for telescope west of pier.}\end{aligned}\right\}\qquad(21)$$

These designations for the position of the telescope are not sufficiently general. But if we call the direction of increasing right ascensions, east, for any given part of the sky at which the telescope is pointed, they become general.

The value of p^{e}_{m} may be deduced from observations made in any part of the sky, or either position of the telescope, by adding λ and a correction for refraction to the observed parallel.

When observations are made by measuring rectangular coordinates with the micrometer the position circle is set at p^{e}_{m} and $90°+p^{e}_{m}$. Then we have

$$\left.\begin{aligned}\Delta a_0&=\Delta a+\Delta\delta\sin\lambda,\\ \Delta\delta_0&=\Delta\delta-\Delta a\sin\lambda,\end{aligned}\right\}\qquad(22)$$

in which Δa_0, Δa, are true and observed differences in right ascension not reduced to the equator, $\Delta\delta_0$, $\Delta\delta$, are true and observed differences in declination. For this reduction the values of the natural sine of λ in units of the fifth decimal place are given in TABLE IV. In this case the value of p^{e}_{m} should be the mean of parallel determinations made on the fixed and movable transverse wires of the micrometer.

When differences in right ascension are determined by transits the formulæ become,

$$\left.\begin{aligned}\Delta\alpha_0&=\Delta\alpha+\tfrac{1}{15}\,\Delta\delta\sin\lambda\sec\delta,\\ \Delta\delta_0&=\Delta\delta.\end{aligned}\right\}\qquad(23)$$

For this reduction the values of $^1/_{15}\sin\lambda\sec\delta$ are given in TABLE V. In this case the quantity p^{e}_{m} should be the mean of parallel determinations made on each of the longitudinal wires over which transits are taken. The position circle of the micrometer is set at the reading $p^{e}_{m}-90°$.

When observing position angles the parallel determinations should be made on the same wire used in measuring the angles. The index correction of the position circle will be $90°-p^{e}_{m}$. For the reduction of the observations we have,

$$p_0=p+\lambda-p^{e}_{m}+90°,\qquad(24)$$

in which p_0 and p are the true and observed position angles. The values of λ in thousandths of a degree are given in TABLE VI.

Within the last two years the constants of the 26-inch equatorial were determined from time to time by the methods given above, and the following results were obtained:

Date.	Temp.	η	i_1-c	ξ	c		$\varepsilon \cos \varphi$	$e \cos \varphi$ from Stars.	e from Coll's.
					From Stars.	From Coll's.			
1902	°	″	″	″	″	″	″	″	″
July 13	69*F*	+116	−54	−71	....	....	...	..	...
27	76	+113	−55	−73	....	....	...	..	...
Aug. 3	80	+115	−51	−73	....	....	...	..	...
11	70	+115	−55	−75	....	....	...	..	...
28	67	+121	- 55	−74	....	....	...	..	...
Sept. 23	70	+115	−52	−73	....	+113	...	..	...
Oct. 22	51	+116	−52	−73	+114	....	+94	..	...
27	64	....	...	...	....	+113	...	..	+10
Nov. 5	56	....	...	...	....	....	...	..	+ 4
28	35	+116	−52	−68	+107	+108	...	..	...
1903									
Jan. 9	27	....	...	...	+113	+119	+96	+2	− 2
9	20	+114	−57	−67	....	....	...	..	...
Feb. 17	14	+111	−56	−63	+115	....	+95	+4	...
Mar. 13	55	+114	−50	−70	....	....	...	..	...
Apr. 21	48	+113	−55	−65	+113	....	+98	+6	...
June 21	70	+113	−53	−74	+114	....	+96	+5	...
Oct. 13	60	+114	−55	−72	....	....	...	..	...
1904									
Feb. 3	24	+113	−57	−61	....	...	...	..	...
May 7	65	+115	−53	−72	+111	....	+92	+7	...

The collimators used in the determinations of *c* and *e* were attached to the dome in a vertical position and sighted into each other by means of mirrors. They were very unstable, the images of the wires moving as much as ten or fifteen seconds vertically and half as much horizontally during an observation.

The torsion of the telescope tube was determined from levels placed on the micrometer box, with the following results:

Date.	Temp.	f	f'	ξ
1903	°	°	°	″
May 5	..	+0.021	+0.001	−97
26	64*F*	+0.023	−0.001	−73
June 25	70	+0.017	−0.004	−81
26	68	+0.016	0.000	−80
July 13	74	+0.022	+0.004	−94
13	75	+0.013	+0.002	−69
24	72	+0.014	0.000	−78
24	72	+0.017	+0.002	−79
1904				
May 8	65	+0.020	+0.003	−81
8	65	+0.015	+0.002	−74

For these determinations the levels were fastened to the micrometer box with lead wire. The position circle was read by careful estimation to half hundredths of a degree, the verniers reading only to fiftieths.

It may be seen from these results that the constants of the 26-inch equatorial are very stable, and mean values may be used throughout the year. Thus we adopt the following constants:

$$
\begin{array}{rrl}
 & '' & \text{Radians.} \\
\eta = & +115 & = +0.000558 \\
\xi = & -\ \ 72 & = -0.000349 \\
c = & +113 & = +0.000548 \\
i_1 = & +\ \ 59 & = +0.000286 \\
e \cos \varphi = & +\ \ \ \ 5 & = +0.000024 \\
 & & \\
f = & +0^\circ.018 & = +0.000314
\end{array}
$$

Table IV was computed by substituting these values of the constants, expressed in radians, in equations (20) and (21). The computation was carried out by natural numbers, three figures being usually sufficient to express the quantities to the sixth decimal place. Table V was computed by multiplying the quantities in Table IV by $^1/_{15}$ sec δ. Table VI was computed by multiplying the quantities in Table IV by 0.573.

In view of the evidently stable condition of the constants it is probable that these tables will remain applicable to the reduction of observations for a considerable period of time.

USE OF TABLES.

Differential refraction.—Table I is for the correction of observations when differences in right ascension and declination are directly measured with the micrometer. Formulæ for the reductions are given at the foot of each page. In these, Δa_0, Δa, expressed in seconds of arc, are true and observed differences in right ascension as measured by the micrometer, and not reduced to the equator. They are positive when measured eastward from the origin. $\Delta\delta_0$, $\Delta\delta$ are true and observed differences in declination; positive when measured north from the origin.

M, m, W; w are coefficients, the expressions for which are given in equations (9). The natural values of these coefficients in units of the fifth decimal are given in the table. All four quantities are printed together for each argument in hour angle and declination, the two upper ones being M and m, the two lower W and w. This arrangement is shown to the left at the top of the page.

The signs of M and W are always positive. The sign of w is positive for positive hour angles and negative for negative hour angles. The sign of m is more involved. Draw the arc of a great circle from the zenith perpendicular to any given hour circle and take the middle point of that portion of the hour circle included between the foot of this perpendicular and the equator. Upon the locus of this middle point the value of m is zero. South of this locus the sign of m is positive for positive hour angles and negative for negative hour angles. North of this locus the sign of m is negative for positive hour angles, and positive for negative hour angles.

The effect of temperature may be allowed for by numerically diminishing a given correction for refraction by one per cent for each 5° Fahrenheit above 50°. And the effect of the barometric pressure may be allowed for by numerically increasing a given correction one per cent for each three-tenths of an inch above 30 inches. The tables were computed for temperature 50° Fahrenheit and barometric pressure 30 inches.

Example: Asteroid (371) Bohemia, October 26, 1903, Washington Mean Time $9^h\ 24^m\ 10^s$ is south following B. D.+25° 438.

$$\begin{array}{rl}
\Delta a = & +464.''06 \\
M = + & 0.\ 00042 \\
m = + & 0.\ 00001 \\ \hline
M\Delta a = + & 0.\ 195 \\
m\Delta\delta = - & 0.\ 006 \\ \hline
\text{Sum} = + & 0.\ 189 \\
\text{Temp. Corr.} = + & 0.\ 003 \\ \hline
\Delta a_0 - \Delta a = + & 0.''19
\end{array}
\qquad
\begin{array}{rl}
\Delta\delta = & -555.''49 \\
W = + & 0.\ 00033 \\
w = - & 0.\ 00017 \\ \hline
W\Delta\delta = - & 0.\ 183 \\
w\Delta a = - & 0.\ 079 \\ \hline
\text{Sum} = - & 0.\ 262 \\
\text{Temp. Corr.} = - & 0.\ 005 \\ \hline
\Delta\delta_0 - \Delta\delta = - & 0.''27
\end{array}
\qquad
\begin{array}{l}
T = 41^\circ\ F. \\
\\
\delta = +26^\circ\ 1' \\
\\
\tau = -2^h\ 56^m \\
\\
\\
\\
\end{array}$$

In case rectangular coordinates are measured with the micrometer set at position angles p, and $p+90°$, the measurements may be freed from differential refraction by the formulæ

$$\Delta a_0 = \Delta a + \left[\frac{M+W}{2} + \frac{M-W}{2}\cos 2p - \frac{m+w}{2}\sin 2p\right]\Delta a + \left[\frac{M-W}{2}\sin 2p + \frac{m+w}{2}\cos 2p + \frac{m-w}{2}\right]\Delta d,$$

$$\Delta d_0 = \Delta d + \left[\frac{M+W}{2} - \frac{M-W}{2}\cos 2p + \frac{m+w}{2}\sin 2p\right]\Delta d + \left[\frac{M-W}{2}\sin 2p + \frac{m+w}{2}\cos 2p - \frac{m-w}{2}\right]\Delta a,$$

in which Δd_0, Δd, are true and observed distances measured along the axis which lies at position angle p, and Δa_0, Δa, are true and observed distances measured along the axis which lies at position angle $p+90°$.

TABLE II is for the correction of observations when differences in right ascension are determined by transits, and differences in declination are measured with the micrometer. The use of this table is similar to that of TABLE I. It should be noted, however, that the product $m'\Delta\delta$ gives the correction to Δa in seconds of time when $\Delta\delta$ is given in seconds of arc—i. e.,

$$m' = \frac{m}{15}\sec\delta.$$

TABLE III is for the correction of observations when position angle and distance are measured. The correction Δp is to be added algebraically to an observed position angle to produce the true position angle. The signs of Δp are given for positive hour angles; they are to be changed for negative hour angles. The sign of h is always positive, and the correction $\Delta s = hs$ must always be added to the apparent distance to produce the true distance. Both Δp and h are printed together for each argument in hour angle and position angle. In entering the table with the measured position angle the left-hand column is to be used when the hour angle is positive, and the right-hand column when the hour angle is negative.

The rate of change of the tabular quantities for a change of 1° in declination is printed at intervals throughout the table. The sign of this change is not printed; but, for purposes of interpolation, it may be noted that both Δp and h increase numerically as one proceeds southward. Exceptions to this rule occur only when the change is small enough to be neglected.

Thermometer and barometer corrections for both position angle and distance may be made in exactly the same way as explained for TABLE I.

In case observations are made outside the limits of this table, differential refraction may be computed by formulæ (12) in which the quantities M, m, W, w are taken from TABLE I.

Instrumental corrections for the 26-inch equatorial.—These corrections have to do with the orientation of the micrometer. The parallel or reading of the position circle p^{e}_{m}, that would be determined by the trail of an equatorial star near the meridian when the telescope is east of the pier, is taken as fundamental. Then, when observing by rectangular coordinates or by transits, the position circle is always set at p^{e}_{m}, or $p^{e}_{m} \pm 90°$, for any part of the sky or either position of the telescope. The instrumental constants will usually cause this orientation of the micrometer to deviate slightly from the correct parallel.

TABLE IV gives the natural sine of the deviation, λ, produced by the constants. The sign of λ is positive when the vertical wire strikes to the east of true north, or the horizontal wire strikes to the south of true east. Formulae for the reduction of measurements made by rectangular coordinates are given at the foot of the table. In these $\varDelta a_0$, $\varDelta a$, are the true and observed distances in right ascension as measured by the micrometer and not reduced to the equator; $\varDelta\delta_0$, $\varDelta\delta$, are the true and observed distances in declination. If the position circle is set at the reading p, differing by a small angle from p^{e}_{m}, the quantity $\sin\,(p - p^{e}_{m})$ must be added to $\sin\lambda$ when computing corrections to the measured coordinates.

TABLE V is for the correction of observations when differences in right ascension are determined by transits. The tabular quantity, L, is such that when $\varDelta\delta$ is given in seconds of arc the product $L\varDelta\delta$ gives the correction to $\varDelta a$ in seconds of time, i. e.,

$$L = \frac{1}{15} \sin\lambda \sec\delta.$$

TABLE VI gives the values of λ in thousandths of a degree. At the foot of the table is given a formula for correcting measured position angles. In this p_0 and p are the true and observed position angles. The quantity $90° - p^{e}_{m}$ is the index correction of the position circle when parallel determinations are made on the same wire with which position angles are measured.

Parallel determinations.—These may be made in any part of the sky or either position of the telescope. For their reduction we have,

$$p^{e}_{m} = p_1 + \varDelta p_1 + \lambda.$$

in which p_1 is the observed parallel, $\varDelta p_1$ is a correction for differential refraction from TABLE III, and λ is taken from TABLE VI, or computed from TABLE IV ($\lambda = 57°.3 \sin\lambda$).

When rectangular coordinates are to be measured with the micrometer the value of p^{e}_{m} should be the mean of determinations made on both the fixed and movable transverse wires. But on account of the shortness of these wires it is difficult to make a good determination of the parallel by the usual method of trailing stars. A method used by Dr. HERMANN STRUVE in connection with his observations of Eros is described in the Königsberg Observations, vol. 41, p. 4. The micrometer is set approximately at the correct parallel and the reading of the position circle noted.

Then, with the driving clock of the telescope running, a star is placed in the following side of the field and bisected several times with the movable wire. The clockwork is then stopped or slowed down until the star drifts to the preceding side of the field, when several more bisections are made. From the difference of the bisections and the distance between the two positions of the star we obtain the sine of the small angle by which the setting of the position circle is to be corrected. However, if the fixed and movable wires are not exactly parallel a further correction must be made for half their mutual inclination.

TABLES

OF

DIFFERENTIAL REFRACTION

FOR LATITUDE

+ 38° 55′ 14″.

TABLE I.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

τ δ	0h												1h													
	0m		10m		20m		30m		40m		50m		0m		10m		20m		30m		40m		50m		60m	
	M	*m*																								
	W	*w*																								
° +70	28	0	28	−4	28	−8	29	−11	29	−15	29	−19	30	−22	30	−26	31	−30	32	−33	33	−37	34	−40	34	−44
	38	0	38	2	38	5	38	7	38	10	38	12	38	15	37	17	37	20	37	22	36	25	36	27	36	30
69	28	0	28	−4	28	−7	29	−10	29	−14	29	−17	30	−21	30	−24	31	−28	32	−31	33	−34	33	−38	34	−41
	38	0	38	2	38	4	38	7	37	9	37	11	37	14	37	16	36	18	36	21	36	23	35	26	35	28
68	28	0	28	−3	28	−7	29	−10	29	−13	29	−16	30	−20	30	−23	31	−26	32	−29	32	−32	33	−36	34	−39
	37	0	37	2	37	4	37	6	37	8	36	11	36	13	36	15	36	17	36	19	35	22	35	24	34	26
67	28	0	28	−3	28	−6	29	−9	29	−12	29	−16	30	−19	30	−22	31	−25	32	−28	32	−31	33	−34	34	−37
	36	0	36	2	36	4	36	6	36	8	36	10	36	12	35	14	35	16	35	18	35	20	34	23	34	25
+66	28	0	28	−3	28	−6	29	−9	29	−12	29	−15	30	−18	30	−21	31	−24	32	−26	32	−29	33	−32	34	−35
	36	0	36	2	35	4	35	6	35	8	35	9	35	11	35	13	34	15	34	17	34	19	34	22	33	24
+65	28	0	28	−3	28	−6	29	−8	29	−11	29	−14	30	−17	30	−19	31	−22	31	−25	32	−28	33	−30	34	−33
	35	0	35	2	35	4	35	5	35	7	35	9	34	11	34	13	34	14	34	16	33	18	33	20	33	22
64	28	0	28	−3	28	−5	29	−8	29	−10	29	−13	30	−16	30	−18	31	−21	31	−24	32	−26	33	−29	34	−31
	34	0	34	2	34	3	34	5	34	7	34	8	34	10	34	12	34	14	33	16	33	17	33	19	32	21
63	28	0	28	−2	28	−5	29	−8	29	−10	29	−12	30	−15	30	−18	31	−20	31	−22	32	−25	33	−27	34	−29
	34	0	34	2	34	3	34	5	34	6	34	8	33	10	33	11	33	13	33	15	32	16	32	18	32	20
62	28	0	28	−2	28	−5	29	−7	29	−10	29	−12	30	−14	30	−17	31	−19	31	−21	32	−24	33	−26	34	−28
	33	0	33	2	33	3	33	5	33	6	33	8	33	9	33	11	32	12	32	14	32	16	32	18	32	19
+61	28	0	28	−2	28	−5	29	−7	29	−9	29	−11	30	−14	30	−16	31	−18	31	−20	32	−22	33	−24	34	−27
	33	0	33	1	33	3	33	4	33	6	33	7	32	9	32	10	32	12	32	14	32	15	32	17	31	19
+60	28	0	28	−2	28	−4	29	−6	29	−8	29	−11	30	−13	30	−15	31	−17	31	−19	32	−21	33	−23	34	−25
	32	0	32	1	32	3	32	4	32	5	32	7	32	8	32	10	32	11	32	13	31	14	31	16	31	18
59	28	0	28	−2	28	−4	29	−6	29	−8	29	−10	30	−12	30	−14	31	−16	31	−18	32	−20	33	−22	34	−24
	32	0	32	1	32	3	32	4	32	5	32	7	32	8	31	10	31	11	31	12	31	14	31	16	31	17
58	28	0	28	−2	28	−4	29	−6	29	−8	29	−10	30	−12	30	−14	31	−16	31	−18	32	−19	33	−21	34	−23
	32	0	32	1	32	2	31	4	31	5	31	6	31	8	31	9	31	11	31	12	31	14	30	15	30	16
57	28	0	28	−2	28	−4	29	−6	29	−8	29	−9	30	−11	30	−13	31	−15	31	−17	32	−18	33	−20	34	−22
	31	0	31	1	31	2	31	4	31	5	31	6	31	7	31	9	31	10	31	12	30	13	30	15	30	16
+56	28	0	28	−2	28	−4	29	−5	29	−7	29	−9	30	−11	30	−12	31	−14	31	−16	32	−18	33	−19	34	−21
	31	0	31	1	31	2	31	4	31	5	31	6	31	7	30	8	30	10	30	11	30	12	30	14	30	15
+55	28	0	28	−2	28	−4	29	−5	29	−7	29	−8	30	−10	30	−12	31	−14	31	−15	32	−17	33	−18	33	−20
	31	0	31	1	31	2	30	3	30	5	30	6	30	7	30	8	30	10	30	11	30	12	30	13	30	15
54	28	0	28	−2	28	−3	29	−5	29	−6	29	−8	30	−10	30	−11	30	−13	31	−15	32	−16	33	−18	33	−19
	30	0	30	1	30	2	30	3	30	4	30	6	30	7	30	8	30	9	30	10	30	12	29	13	29	14
53	28	0	28	−2	28	−3	29	−5	29	−6	29	−8	30	−9	30	−11	30	−12	31	−14	32	−15	33	−17	33	−18
	30	0	30	1	30	2	30	3	30	4	30	5	30	7	30	8	30	9	30	10	29	11	29	13	29	14
52	28	0	28	−2	28	−3	29	−4	29	−6	29	−7	30	−9	30	−10	30	−12	31	−13	32	−14	33	−16	33	−17
	30	0	30	1	30	2	30	3	30	4	30	5	30	6	30	7	29	9	29	10	29	11	29	12	29	14
+51	28	0	28	−1	28	−3	29	−4	29	−6	29	−7	30	−8	30	−10	30	−11	31	−12	32	−14	33	−15	33	−16
	30	0	30	1	30	2	30	3	30	4	29	5	29	6	29	7	29	8	29	9	29	11	29	12	29	13
+50	28	0	28	−1	28	−3	29	−4	29	−5	29	−7	30	−8	30	−9	30	−11	31	−12	32	−13	33	−14	33	−16
	29	0	29	1	29	2	29	3	29	4	29	5	29	6	29	7	29	8	29	9	29	10	29	12	29	13

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$$\Delta a_0 = \Delta a + M\Delta a + m\Delta\delta.$$

$$\Delta\delta_0 = \Delta\delta + W\Delta\delta + w\Delta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

τ δ	IIh												IIIh													
	0m		10m		20m		30m		40m		50m		0m		10m		20m		30m		40m		50m		60m	
°	*M* *W*	*m* *w*																								
+70	34 36	−44 30	36 35	−47 33	37 35	−50 35	38 34	−54 38	39 34	−57 41	41 33	−60 44	42 33	−62 47	44 32	−65 50	45 31	−68 53	47 31	−71 56	49 30	−73 60	51 30	−75 63	53 29	−78 67
69	34 35	−41 28	35 34	−44 31	37 34	−47 33	38 34	−50 36	39 33	−53 39	41 33	−56 41	42 32	−59 44	44 32	−61 47	45 31	−64 50	47 31	−66 53	49 30	−69 57	51 30	−71 60	52 29	−73 63
68	34 34	−39 26	35 34	−42 29	36 34	−45 31	38 33	−47 34	39 33	−50 37	40 32	−53 39	42 32	−56 42	43 31	−58 45	45 31	−61 48	47 30	−63 51	49 30	−65 54	50 29	−67 57	52 29	−69 60
67	34 34	−37 25	35 33	−39 27	36 33	−42 30	38 33	−45 32	39 32	−47 35	40 32	−50 37	42 31	−53 40	43 31	−55 42	45 30	−57 45	47 30	−59 48	48 30	−61 51	50 29	−63 54	52 29	−65 57
+66	34 33	−35 24	35 33	−37 26	36 32	−40 28	38 32	−42 30	39 32	−45 33	40 31	−47 35	42 31	−50 38	43 30	−52 40	45 30	−54 43	46 30	−56 46	48 29	−58 49	50 29	−60 52	52 29	−62 55
+65	34 33	−33 22	35 32	−35 24	36 32	−38 26	37 32	−40 29	39 31	−42 31	40 31	−45 34	41 31	−47 36	43 30	−49 38	45 30	−51 41	46 30	−53 44	48 29	−55 47	50 29	−57 50	52 28	−59 53
64	34 32	−31 21	35 32	−33 23	36 32	−36 25	37 31	−38 28	39 31	−40 30	40 31	−43 32	41 30	−45 34	43 30	−47 37	44 30	−49 39	46 29	−51 42	48 29	−52 45	50 29	−54 48	52 28	−56 50
63	34 32	−29 20	35 32	−32 22	36 31	−34 24	37 31	−36 26	38 30	−38 28	40 30	−40 31	41 30	−42 33	43 30	−44 35	44 29	−46 38	46 29	−48 40	48 29	−50 43	50 29	−51 46	52 28	−53 48
62	34 32	−28 19	35 31	−30 21	36 31	−32 23	37 31	−34 25	38 30	−36 27	40 30	−38 29	41 30	−40 31	43 30	−42 34	44 29	−44 36	46 29	−46 39	48 29	−47 41	50 28	−49 44	52 28	−50 47
+61	34 31	−27 19	35 31	−29 20	36 31	−31 22	37 30	−33 24	38 30	−34 26	40 30	−36 28	41 30	−38 30	43 29	−40 32	44 29	−42 35	46 29	−43 37	48 29	−45 40	50 28	−46 42	52 28	−48 45
+60	34 31	−25 18	35 31	−27 20	36 30	−29 21	37 30	−31 23	38 30	−32 25	40 30	−34 27	41 29	−36 29	42 29	−38 31	44 29	−40 34	46 29	−41 36	48 29	−43 38	50 28	−44 41	52 28	−45 44
59	34 31	−24 17	35 30	−26 19	36 30	−28 20	37 30	−30 22	38 30	−31 24	39 29	−33 26	41 29	−35 28	42 29	−36 30	44 29	−38 32	46 29	−39 35	48 28	−41 37	50 28	−42 40	52 28	−43 43
58	34 30	−23 16	35 30	−25 18	36 30	−27 20	37 30	−28 21	38 29	−30 23	39 29	−32 25	41 29	−33 27	42 29	−35 29	44 29	−36 31	46 28	−38 34	48 28	−39 36	50 28	−40 39	52 28	−41 41
57	34 30	−22 16	35 30	−24 18	36 30	−25 19	37 29	−27 21	38 29	−29 22	39 29	−30 24	41 29	−32 26	42 29	−33 28	44 29	−34 30	46 28	−36 33	48 28	−37 35	50 28	−38 38	52 28	−39 40
+56	34 30	−21 15	34 30	−23 17	35 29	−24 18	37 29	−26 20	38 29	−27 22	39 29	−29 24	41 29	−30 25	42 28	−31 27	44 28	−33 30	46 28	−34 32	48 28	−35 34	50 28	−36 37	52 28	−37 39
+55	33 30	−20 15	34 29	−22 16	35 29	−23 18	37 29	−24 20	38 29	−26 21	39 29	−27 23	41 29	−29 25	42 28	−30 27	44 28	−31 29	46 28	−32 31	48 28	−33 33	50 28	−34 36	52 28	−35 38
54	33 29	−19 14	34 29	−21 16	35 29	−22 17	37 29	−23 19	38 29	−25 20	39 29	−26 22	40 28	−27 24	42 28	−29 26	44 28	−30 28	46 28	−31 30	48 28	−32 32	50 28	−33 35	52 28	−34 37
53	33 29	−18 14	34 29	−20 15	35 29	−21 17	37 29	−22 18	38 29	−24 20	39 29	−25 22	40 28	−26 23	42 28	−27 25	44 28	−28 27	46 28	−29 29	48 28	−30 32	50 28	−31 34	52 28	−32 37
52	33 29	−17 14	34 29	−19 15	35 29	−20 16	36 29	−21 18	38 28	−22 19	39 28	−24 21	40 28	−25 23	42 28	−26 25	44 28	−27 27	46 28	−28 29	48 28	−29 31	50 28	−30 33	52 28	−30 36
+51	33 29	−16 13	34 29	−18 14	35 29	−19 16	36 28	−20 17	38 28	−21 19	39 28	−23 21	40 28	−24 22	42 28	−25 24	44 28	−26 26	46 28	−26 28	48 28	−27 30	50 29	−28 33	52 29	−29 35
+50	33 29	−16 13	34 29	−17 14	35 28	−18 16	36 28	−19 17	38 28	−20 18	39 28	−22 20	40 28	−23 22	42 28	−24 24	44 28	−25 26	46 28	−25 28	48 28	−26 30	50 29	−27 32	52 29	−27 35

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$\varDelta a_{\circ}=\varDelta a+M\varDelta a+m\varDelta\delta.$

$\varDelta\delta_{\circ}=\varDelta\delta+W\varDelta\delta+w\varDelta a.$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

δ \ τ	IVh						Vh						
	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	60m
	M *m* *W* *w*												
+70°	53 — 78 29 67	54 — 80 29 70	56 — 81 29 74	58 — 83 28 78	60 — 85 28 82	62 — 86 28 86	65 — 87 28 90	67 — 88 28 94	69 — 88 29 98	71 — 88 29 102	73 — 88 30 106	75 — 88 31 111	76 — 88 32 116
69	52 — 73 29 63	54 — 75 29 67	56 — 76 29 70	58 — 78 28 74	60 — 80 28 78	62 — 81 28 82	65 — 82 28 86	67 — 83 29 90	69 — 83 29 94	71 — 83 30 98	74 — 83 30 102	76 — 83 31 107	77 — 83 32 112
68	52 — 69 29 60	54 — 71 29 64	56 — 72 28 67	58 — 74 28 71	60 — 76 28 75	62 — 76 28 78	65 — 77 28 82	67 — 78 29 86	69 — 78 29 90	72 — 78 30 95	74 — 78 31 99	76 — 78 32 104	78 — 78 33 109
67	52 — 65 29 57	54 — 67 28 61	56 — 68 28 64	58 — 70 28 68	60 — 72 28 72	63 — 72 28 75	65 — 73 28 79	67 — 74 29 83	69 — 74 29 87	72 — 74 30 92	74 — 74 31 96	77 — 74 32 101	79 — 73 33 106
+66	52 — 62 29 55	54 — 63 28 58	56 — 65 28 61	58 — 66 28 65	60 — 68 28 69	63 — 69 28 72	65 — 69 28 76	67 — 70 29 80	70 — 70 29 84	72 — 70 30 89	75 — 70 31 93	77 — 70 32 98	79 — 69 34 103
+65	52 — 59 28 53	54 — 60 28 56	56 — 61 28 59	58 — 63 28 63	60 — 64 28 66	63 — 65 28 70	65 — 65 29 74	68 — 66 29 78	70 — 66 30 82	73 — 66 31 87	75 — 66 32 91	78 — 66 33 96	80 — 65 34 101
64	52 — 56 28 50	54 — 57 28 53	56 — 58 28 56	58 — 59 28 60	60 — 60 28 64	63 — 61 28 68	65 — 62 29 71	68 — 62 29 75	70 — 62 30 80	73 — 62 31 84	76 — 62 32 89	79 — 62 33 94	81 — 61 35 99
63	52 — 53 28 48	54 — 54 28 51	56 — 55 28 54	58 — 56 28 58	61 — 57 28 62	63 — 58 29 66	65 — 59 29 69	68 — 59 30 73	71 — 59 30 78	74 — 59 31 82	77 — 59 32 87	79 — 58 34 92	82 — 57 36 97
62	52 — 50 28 47	54 — 51 28 50	56 — 52 28 53	58 — 53 28 56	61 — 54 28 60	63 — 55 29 64	66 — 56 29 67	68 — 56 30 71	71 — 56 31 76	74 — 55 32 80	77 — 55 33 85	80 — 54 34 90	83 — 53 36 95
+61	52 — 48 28 45	54 — 49 28 48	56 — 50 28 51	58 — 51 28 55	61 — 52 28 58	63 — 52 29 62	66 — 53 29 66	69 — 53 30 70	72 — 53 31 74	75 — 52 32 79	78 — 52 33 84	81 — 51 35 89	84 — 50 37 94
+60	52 — 45 28 44	54 — 46 28 47	56 — 47 28 50	58 — 48 28 53	61 — 49 28 56	64 — 50 29 60	66 — 50 29 64	69 — 50 30 68	72 — 50 31 72	75 — 49 32 77	79 — 49 34 82	82 — 48 36 87	85 — 47 38 93
59	52 — 43 28 43	54 — 44 28 46	56 — 45 28 49	58 — 46 29 52	61 — 47 29 55	64 — 47 29 59	67 — 47 30 63	70 — 47 31 67	73 — 47 32 71	76 — 46 33 76	79 — 46 34 81	83 — 45 36 86	86 — 44 38 92
58	52 — 41 28 41	54 — 42 28 44	56 — 43 28 47	58 — 43 29 50	61 — 44 29 54	64 — 44 29 58	67 — 44 30 62	70 — 44 31 66	73 — 44 32 70	77 — 44 33 75	80 — 43 35 80	84 — 42 37 86	88 — 41 39 92
57	52 — 39 28 40	54 — 40 28 43	56 — 41 28 46	59 — 41 29 49	61 — 42 29 53	64 — 42 30 57	67 — 42 30 61	71 — 42 31 65	74 — 42 32 69	78 — 41 34 74	81 — 40 36 79	85 — 39 38 85	89 — 37 40 91
+56	52 — 37 28 39	54 — 38 28 42	56 — 39 28 45	59 — 39 29 48	62 — 40 29 52	65 — 40 30 56	68 — 40 31 60	71 — 40 32 64	74 — 39 33 68	78 — 38 34 73	82 — 37 36 79	86 — 36 38 85	90 — 34 41 91
+55	52 — 35 28 38	54 — 36 28 41	56 — 37 29 44	59 — 37 29 47	62 — 38 29 51	65 — 38 30 55	68 — 38 31 59	72 — 38 32 63	75 — 37 33 67	79 — 36 35 72	83 — 35 37 78	88 — 33 39 84	92 — 31 42 90
54	52 — 34 28 37	54 — 34 28 40	56 — 35 29 43	59 — 35 29 46	62 — 36 30 50	65 — 36 30 54	68 — 36 31 58	72 — 36 32 62	76 — 35 34 67	80 — 34 36 72	85 — 33 38 78	89 — 31 40 84	93 — 28 43 91
53	52 — 32 28 37	54 — 32 29 39	57 — 33 29 42	60 — 33 29 46	62 — 34 30 49	66 — 34 31 53	69 — 33 32 57	73 — 33 33 62	76 — 32 34 67	81 — 31 36 72	86 — 30 38 78	90 — 28 41 84	95 — 25 44 91
52	52 — 30 28 36	54 — 31 29 39	57 — 31 29 42	60 — 31 30 45	63 — 32 30 48	66 — 32 31 52	70 — 31 32 56	73 — 31 33 61	77 — 30 35 66	82 — 29 37 72	87 — 27 39 78	92 — 25 42 84	97 — 22 45 91
+51	52 — 29 29 35	54 — 29 29 38	57 — 29 29 41	60 — 30 30 44	63 — 30 30 48	66 — 30 31 52	70 — 29 32 56	74 — 28 34 61	78 — 27 36 66	83 — 26 38 71	88 — 24 40 77	93 — 22 43 84	99 — 19 47 92
+50	52 — 27 29 35	54 — 27 29 37	57 — 28 29 40	60 — 28 30 44	64 — 28 31 47	67 — 28 32 51	71 — 27 33 56	75 — 26 34 60	79 — 25 36 65	84 — 24 38 71	89 — 22 41 77	94 — 19 44 84	101 — 16 48 92

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$\Delta a_0 = \Delta a + M\Delta a + m\Delta\delta.$

$\Delta\delta_0 = \Delta\delta + W\Delta\delta + w\Delta a.$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

δ \ τ	VI^{h}						VII^{h}						
	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	60^{m}
	M m												
	W w												
+70°	76 − 88	78 − 88	80 − 87	81 − 86	83 − 84	84 − 82	85 − 80	86 − 77	88 − 75	88 − 72	89 − 68	88 − 66	88 − 62
	32 116	33 120	35 125	37 129	39 133	42 137	45 141	49 146	53 151	57 155	62 158	67 162	73 165
69	77 − 83	79 − 82	81 − 81	82 − 80	84 − 78	85 − 76	87 − 74	88 − 71	90 − 69	91 − 66	91 − 62	91 − 59	91 − 55
	32 112	34 116	36 121	38 126	40 130	43 134	46 139	50 144	54 149	59 154	64 158	70 162	76 165
68	78 − 78	80 − 77	82 − 76	83 − 75	85 − 73	87 − 71	89 − 69	90 − 66	92 − 63	93 − 60	94 − 56	94 − 53	94 − 49
	33 109	34 113	36 118	39 123	41 128	44 132	48 137	52 142	56 147	61 152	67 157	73 161	80 165
67	79 − 73	81 − 72	83 − 71	85 − 70	87 − 68	89 − 66	91 − 64	93 − 61	94 − 58	95 − 54	96 − 51	97 − 47	97 − 42
	33 106	35 110	37 115	39 120	42 125	45 131	49 136	53 141	58 146	63 152	70 157	77 162	84 166
+66	79 − 69	82 − 68	84 − 67	87 − 65	89 − 63	91 − 61	93 − 59	95 − 56	97 − 52	98 − 49	99 − 45	100 − 41	101 − 36
	34 103	36 108	38 113	40 118	43 123	47 129	51 135	55 140	60 146	66 151	73 157	80 163	88 168
+65	80 − 65	83 − 64	86 − 62	88 − 60	90 − 58	93 − 56	95 − 54	97 − 51	99 − 47	101 − 43	102 − 39	104 − 35	105 − 30
	34 101	36 106	38 111	41 116	44 122	48 128	52 134	57 140	62 146	68 152	76 158	84 164	92 170
64	81 − 61	84 − 60	87 − 58	89 − 56	92 − 54	95 − 52	97 − 49	100 − 46	102 − 42	104 − 38	106 − 34	107 − 29	109 − 24
	35 99	37 104	39 109	42 115	45 121	49 127	54 133	59 140	65 146	71 153	79 160	88 166	97 173
63	82 − 57	85 − 56	88 − 54	91 − 52	94 − 50	97 − 47	100 − 44	102 − 41	105 − 37	107 − 33	109 − 28	111 − 23	113 − 17
	36 97	38 102	40 107	43 113	47 120	51 126	55 133	61 140	67 147	74 154	83 162	93 169	103 177
62	83 − 53	86 − 52	89 − 50	92 − 48	96 − 46	99 − 43	102 − 40	105 − 36	108 − 32	111 − 27	114 − 22	116 − 16	118 − 10
	36 95	38 100	41 106	44 112	48 119	52 126	57 133	63 141	70 148	78 156	87 164	97 173	109 181
+61	84 − 50	87 − 48	91 − 46	94 − 44	98 − 42	101 − 39	105 − 35	108 − 31	112 − 27	115 − 21	118 − 16	121 − 10	124 − 2
	37 94	39 100	42 106	46 112	50 119	54 126	59 133	66 141	73 149	82 158	92 167	103 177	116 186
+60	85 − 47	89 − 45	92 − 43	96 − 40	100 − 38	104 − 34	108 − 30	112 − 26	116 − 21	119 − 16	123 − 10	127 − 3	130 + 5
	38 93	40 99	43 105	47 112	51 119	56 126	62 134	69 143	77 151	86 161	97 171	109 181	123 192
59	86 − 44	90 − 42	94 − 40	98 − 37	102 − 34	107 − 30	111 − 26	115 − 21	120 − 16	124 − 10	128 − 3	133 + 5	137 + 13
	38 92	41 98	44 105	48 112	53 119	58 127	64 136	72 145	80 154	90 164	102 175	115 186	131 198
58	88 − 41	92 − 39	96 − 36	100 − 33	105 − 30	109 − 26	114 − 21	119 − 16	124 − 10	129 − 4	134 + 4	139 + 13	144 + 22
	39 92	42 98	46 105	50 112	54 120	60 128	67 137	75 147	84 157	95 168	108 180	123 193	140 206
57	89 − 37	93 − 35	98 − 32	103 − 29	107 − 26	112 − 22	118 − 17	123 − 11	129 − 4	135 + 3	140 + 11	146 + 21	152 + 32
	40 91	43 98	47 105	51 112	56 120	62 129	70 139	78 150	88 161	100 173	114 186	131 200	150 215
+56	90 − 34	95 − 32	100 − 29	105 − 26	110 − 22	116 − 17	122 − 12	128 − 6	134 + 2	141 + 10	147 + 19	154 + 30	162 + 42
	41 91	44 98	48 105	53 112	58 121	65 131	73 141	82 153	93 165	106 178	122 192	140 208	161 226
+55	92 − 31	97 − 29	102 − 26	107 − 22	113 − 18	119 − 13	126 − 7	133 0	140 + 8	147 + 17	155 + 27	164 + 39	172 + 53
	42 90	45 97	49 105	54 113	60 123	67 133	76 144	86 156	98 169	112 184	129 200	150 218	174 238
54	93 − 28	99 − 26	104 − 23	110 − 19	116 − 14	123 − 8	131 − 2	138 + 6	146 + 15	155 + 25	164 + 36	174 + 50	184 + 66
	43 91	47 98	51 106	56 115	62 125	70 135	79 147	90 160	104 174	119 191	138 209	161 229	189 251
53	95 − 25	101 − 22	107 − 19	113 − 15	120 − 10	128 − 3	136 + 4	144 + 12	153 + 22	163 + 33	174 + 47	185 + 62	198 + 80
	44 91	48 98	52 107	58 116	65 127	73 138	83 151	95 165	110 180	127 198	148 218	174 241	205 266
52	97 − 22	103 − 19	109 − 16	116 − 11	124 − 5	132 + 2	141 + 9	150 + 19	161 + 30	172 + 43	184 + 58	198 + 76	213 + 97
	45 91	49 99	54 108	60 117	67 129	76 141	87 155	101 170	117 188	136 207	159 229	188 255	224 284
+51	99 − 19	105 − 16	112 − 12	120 − 7	128 − 1	137 + 7	147 + 15	157 + 26	169 + 38	182 + 53	197 + 70	213 + 91	
	47 92	51 100	56 109	63 119	70 131	80 144	92 159	107 176	124 196	145 217	172 242	204 271	
+50	101 − 16	108 − 13	115 − 8	123 − 2	132 + 4	142 + 12	153 + 21	165 + 33	179 + 47	194 + 64	211 + 84	230 + 108	
	48 92	52 100	58 110	65 121	74 134	84 148	97 164	113 183	132 204	156 228	186 256	223 289	

The tabular quantities are expressed in units of the fifth decimal.
M and W are always positive.
m and w change signs for negative hour angles.

$$\Delta a_{\circ}=\Delta a+M\Delta a+m\Delta\delta.$$

$$\Delta\delta_{\circ}=\Delta\delta+W\Delta\delta+w\Delta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

τ / δ	0h												1h													
	0m		10m		20m		30m		40m		50m		0m		10m		20m		30m		40m		50m		60m	
	M	*m*																								
	W	*w*																								
+50°	28	0	28	−1	28	−3	29	−4	29	−5	29	−7	30	−8	30	−9	30	−11	31	−12	32	−13	33	−14	33	−16
	29	0	29	1	29	2	29	3	29	4	29	5	29	6	29	7	29	8	29	9	29	10	29	12	29	13
49	28	0	28	−1	28	−3	29	−4	29	−5	29	−6	30	−8	30	−9	30	−10	31	−12	32	−13	33	−14	33	−15
	29	0	29	1	29	2	29	3	29	4	29	5	29	6	29	7	29	8	29	9	29	10	29	11	29	13
48	28	0	28	−1	28	−3	29	−4	29	−5	29	−6	30	−7	30	−9	30	−10	31	−11	32	−12	33	−13	33	−14
	29	0	29	1	29	2	29	3	29	4	29	5	29	6	29	7	29	8	29	9	29	10	29	11	29	12
47	28	0	28	−1	28	−2	29	−3	29	−5	29	−6	30	−7	30	−8	30	−9	31	−10	32	−11	33	−12	33	−14
	29	0	29	1	29	2	29	3	29	4	29	5	29	6	29	7	29	8	29	9	29	10	29	11	28	12
+46	28	0	28	−1	28	−2	29	−3	29	−4	29	−6	30	−7	30	−8	30	−9	31	−10	32	−11	33	−12	33	−13
	29	0	29	1	29	2	29	3	29	4	29	4	29	5	29	6	28	7	28	8	28	10	28	11	28	12
+45	28	0	28	−1	28	−2	29	−3	29	−4	29	−5	30	−6	30	−7	30	−8	31	−9	32	−10	33	−11	33	−12
	29	0	29	1	29	2	29	3	29	3	29	4	29	5	28	6	28	7	28	8	28	9	28	10	28	12
44	28	0	28	−1	28	−2	29	−3	29	−4	29	−5	30	−6	30	−7	30	−8	31	−9	32	−10	33	−11	33	−12
	29	0	29	1	29	2	29	2	29	3	28	4	28	5	28	6	28	7	28	8	28	9	28	10	28	11
43	28	0	28	−1	28	−2	29	−3	29	−4	29	−5	30	−6	30	−7	30	−8	31	−9	32	−9	33	−10	33	−11
	28	0	28	1	28	2	28	2	28	3	28	4	28	5	28	6	28	7	28	8	28	9	28	10	28	11
42	28	0	28	−1	28	−2	29	−3	29	−4	29	−5	30	−6	30	−6	30	−7	31	−8	32	−9	33	−10	33	−10
	28	0	28	1	28	2	28	2	28	3	28	4	28	5	28	6	28	7	28	8	28	9	28	10	28	11
+41	28	0	28	−1	28	−2	29	−3	29	−4	29	−4	30	−5	30	−6	30	−7	31	−8	32	−9	33	−9	33	−10
	28	0	28	1	28	2	28	2	28	3	28	4	28	5	28	6	28	7	28	8	28	9	28	10	28	11
+40	28	0	28	−1	28	−2	29	−2	29	−3	29	−4	30	−5	30	−6	30	−6	31	−7	32	−8	33	−9	33	−9
	28	0	28	1	28	2	28	2	28	3	28	4	28	5	28	6	28	7	28	8	28	9	28	10	28	11
39	28	0	28	−1	28	−2	29	−2	29	−3	29	−4	30	−5	30	−5	30	−6	31	−7	32	−8	33	−8	33	−9
	28	0	28	1	28	2	28	2	28	3	28	4	28	5	28	6	28	7	28	8	28	9	28	10	28	11
38	28	0	28	−1	28	−1	29	−2	29	−3	29	−4	30	−4	30	−5	30	−6	31	−6	32	−7	33	−8	33	−8
	28	0	28	1	28	2	28	2	28	3	28	4	28	5	28	6	28	6	28	7	28	8	28	9	28	10
37	28	0	28	−1	28	−1	29	−2	29	−3	29	−3	30	−4	30	−5	30.	−5	31	−6	32	−7	33	−7	33	−8
	28	0	28	1	28	1	28	2	28	3	28	4	28	5	28	6	28	6	28	7	28	8	29	9	29	10
+36	28	0	28	−1	28	−1	29	−2	29	−3	29	−3	30	−4	30	−4	30	−5	31	−6	32	−6	33	−7	33	−7
	28	0	28	1	28	1	28	2	28	3	28	4	28	5	28	5	29	6	29	7	29	8	29	9	29	10
+35	28	0	28	−1	28	−1	29	−2	29	−2	29	−3	30	−4	30	−4	30	−5	31	−5	32	−6	33	−6	33	−7
	28	0	28	1	28	1	28	2	28	3	28	4	28	5	29	5	29	6	29	7	29	8	29	9	29	10
34	28	0	28	0	28	−1	29	−2	29	−2	29	−3	30	−3	30	−4	30	−4	31	−5	32	−5	33	−6	34	−6
	28	0	28	1	28	1	28	2	28	3	29	4	29	4	29	5	29	6	29	7	29	8	29	9	29	10
33	28	0	28	0	28	−1	29	−2	29	−2	29	−3	30	−3	30	−3	30	−4	31	−4	32	−5	33	−5	34	−6
	29	0	29	1	29	1	29	2	29	3	29	4	29	4	29	5	29	6	29	7	29	8	29	9	29	10
32	28	0	28	0	28	−1	29	−1	29	−2	29	−2	30	−3	30	−3	30	−4	31	−4	32	−4	33	−5	34	−5
	29	0	29	1	29	1	29	2	29	3	29	4	29	4	29	5	29	6	29	7	29	8	29	9	29	10
+31	28	0	28	0	28	−1	29	−1	29	−2	29	−2	30	−3	30	−3	30	−3	31	−4	32	−4	33	−4	34	−5
	29	0	29	1	29	1	29	2	29	3	29	4	29	4	29	5	29	6	29	7	29	8	29	9	30	10
+30	28	0	28	0	28	−1	29	−1	29	−2	29	−2	30	−2	30	−3	30	−3	31	−3	32	−4	33	−4	34	−4
	29	0	29	1	29	1	29	2	29	3	29	4	29	4	29	5	29	6	29	7	29	8	30	9	30	10

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$$\Delta a_\circ = \Delta a + M\Delta a + m\Delta\delta.$$

$$\Delta\delta_\circ = \Delta\delta + W\Delta\delta + w\Delta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

δ \ τ	II^{h}												$\mathrm{III}^{\mathrm{h}}$													
	0^{m}		10^{m}		20^{m}		30^{m}		40^{m}		50^{m}		0^{m}		10^{m}		20^{m}		30^{m}		40^{m}		50^{m}		60^{m}	
	M *W*	*m* *w*																								
+50°	33	−16	34	−17	35	−18	36	−19	38	−20	39	−22	40	−23	42	−24	44	−25	46	−25	48	−26	50	−27	52	−27
	29	13	29	14	28	16	28	17	28	18	28	20	28	22	28	24	28	26	28	28	28	30	29	32	29	35
49	33	−15	34	−16	35	−17	36	−19	38	−20	39	−20	40	−22	42	−22	44	−23	46	−24	48	−25	50	−25	52	−26
	29	13	29	14	28	15	28	17	28	18	28	20	28	21	28	23	28	25	28	27	29	29	29	32	29	34
48	33	−14	34	−16	35	−17	36	−18	38	−19	39	−19	40	−20	42	−21	44	−22	46	−23	48	−23	50	−24	52	−25
	29	12	28	13	28	15	28	16	28	18	28	19	28	21	28	23	28	25	28	27	29	29	29	31	29	34
47	33	−14	34	−15	35	−16	36	−17	38	−18	39	−18	40	−19	42	−20	44	−21	46	−21	48	−22	50	−22	52	−23
	28	12	28	13	28	15	28	16	28	17	28	19	28	20	28	22	28	24	29	26	29	28	29	31	29	33
+46	33	−13	34	−14	35	−15	36	−16	38	−17	39	−18	40	−18	42	−19	44	−20	46	−20	48	−21	50	−21	53	−22
	28	12	28	13	28	14	28	16	28	17	28	18	28	20	28	22	28	24	29	26	29	28	29	30	30	33
+45	33	−12	34	−13	35	−14	36	−15	38	−16	39	−17	40	−17	42	−18	44	−19	46	−19	48	−20	50	−20	53	−20
	28	12	28	13	28	14	28	15	28	16	28	18	28	20	28	22	29	24	29	26	29	28	29	30	30	33
44	33	−12	34	−13	35	−14	36	−14	38	−15	39	−16	40	−16	42	−17	44	−18	46	−18	48	−19	50	−19	53	−19
	28	11	28	13	28	14	28	15	28	16	28	18	28	20	29	21	29	23	29	25	29	27	30	30	30	32
43	33	−11	34	−12	35	−13	36	−13	38	−14	39	−15	40	−16	42	−16	44	−17	46	−17	48	−18	51	−18	53	−18
	28	11	28	12	28	14	28	15	28	16	28	18	29	19	29	21	29	23	29	25	30	27	30	29	30	32
42	33	−10	34	−11	35	−12	36	−13	38	−13	39	−14	40	−15	42	−15	44	−16	46	−16	48	−16	51	−16	54	−16
	28	11	28	12	28	13	28	15	28	16	28	18	29	19	29	21	29	23	29	25	30	27	30	29	31	32
+41	33	−10	34	−11	35	−11	36	−12	38	−13	39	−13	41	−14	42	−14	44	−15	46	−15	49	−15	51	−15	54	−15
	28	11	28	12	28	13	28	14	28	16	29	17	29	19	29	21	29	23	30	25	30	27	30	29	31	32
+40	33	− 9	34	−10	35	−11	36	−11	38	−12	39	−12	41	−13	42	−13	44	−14	46	−14	49	−14	51	−14	54	−14
	28	11	28	12	29	13	29	14	29	16	29	17	29	19	29	20	29	22	30	24	30	26	31	29	31	32
39	33	− 9	34	−10	35	−10	36	−11	38	−11	39	−12	41	−12	43	−12	45	−13	47	−13	49	−13	52	−13	54	−13
	28	11	28	12	29	13	29	14	29	16	29	17	29	18	29	20	30	22	30	24	30	26	31	29	31	32
38	33	− 8	34	− 9	35	− 9	36	−10	38	−10	39	−11	41	−11	43	−12	45	−12	47	−12	49	−12	52	−12	55	−11
	28	10	28	12	29	13	29	14	29	15	29	17	29	18	30	20	30	22	30	24	31	26	31	29	32	32
37	33	− 8	34	− 8	35	− 9	37	− 9	38	−10	39	−10	41	−10	43	−11	45	−11	47	−11	49	−11	52	−10	55	−10
	29	10	29	11	29	13	29	14	29	15	29	17	29	18	30	20	30	22	31	24	31	26	32	29	32	32
+36	33	− 7	34	− 8	35	− 8	37	− 9	38	− 9	39	− 9	41	−10	43	−10	45	−10	47	−10	50	−10	52	− 9	55	− 9
	29	10	29	11	29	12	29	14	29	15	29	17	30	18	30	20	30	22	31	24	31	26	32	29	33	32
+35	33	− 7	34	− 7	36	− 8	37	− 8	38	− 8	40	− 8	41	− 9	43	− 9	45	− 9	47	− 9	50	− 8	53	− 8	56	− 8
	29	10	29	11	29	12	29	14	29	15	30	17	30	18	30	20	31	22	31	24	32	26	33	29	33	32
34	34	− 6	35	− 7	36	− 7	37	− 7	38	− 8	40	− 8	41	− 8	43	− 8	45	− 8	48	− 8	50	− 7	53	− 7	56	− 6
	29	10	29	11	29	12	29	14	30	15	30	16	30	18	31	20	31	22	32	24	32	26	33	29	34	32
33	34	− 6	35	− 6	36	− 6	37	− 7	38	− 7	40	− 7	41	− 7	43	− 7	45	− 7	48	− 7	51	− 6	53	− 6	57	− 5
	29	10	29	11	29	12	30	14	30	15	30	16	30	18	31	20	31	22	32	24	33	26	34	29	35	32
32	34	− 5	35	− 6	36	− 6	37	− 6	38	− 6	40	− 6	42	− 6	44	− 6	46	− 6	48	− 6	51	− 5	54	− 5	57	− 4
	29	10	30	11	30	12	30	14	30	15	30	16	31	18	31	20	32	22	32	24	33	26	34	29	35	32
+31	34	− 5	35	− 5	36	− 5	37	− 5	38	− 6	40	− 6	42	− 6	44	− 5	46	− 5	48	− 5	51	− 4	54	− 3	58	− 2
	30	10	30	11	30	12	30	14	30	15	31	16	31	18	32	20	32	22	33	24	34	26	35	29	36	32
+30	34	− 4	35	− 4	36	− 5	37	− 5	38	− 5	40	− 5	42	− 5	44	− 4	46	− 4	49	− 4	52	− 3	55	− 2	58	− 1
	30	10	30	11	30	12	30	14	31	15	31	16	32	18	32	20	33	22	33	24	34	26	35	29	36	32

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$$\Delta a_{\circ}=\Delta a+M\Delta a+m\Delta\delta.$$

$$\Delta\delta_{\circ}=\Delta\delta+W\Delta\delta+w\Delta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

δ \ τ	IV^{h}						V^{h}						
	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	60^{m}
	M *m* *W* *w*												
+50°	52 — 27 29 35	54 — 27 29 37	57 — 28 29 40	60 — 28 30 44	64 — 28 31 47	67 — 28 32 51	71 — 27 33 56	75 — 26 34 60	79 — 25 36 65	84 — 24 38 71	89 — 22 41 77	94 — 19 44 84	101 — 16 48 92
49	52 — 26 29 34	55 — 26 29 37	57 — 26 30 40	60 — 26 30 43	64 — 26 31 47	68 — 26 32 51	72 — 25 33 55	76 — 24 35 60	80 — 23 37 65	85 — 21 39 71	90 — 19 42 77	96 — 16 45 84	103 — 13 49 93
48	52 — 25 29 34	55 — 25 30 36	57 — 25 30 39	61 — 25 31 43	64 — 25 32 46	68 — 24 33 50	72 — 23 34 55	76 — 22 36 60	81 — 21 38 65	86 — 19 40 71	92 — 17 43 78	98 — 14 47 85	105 — 10 51 94
47	52 — 23 29 33	55 — 23 30 36	58 — 23 30 39	61 — 23 31 42	64 — 23 32 46	68 — 22 33 50	73 — 21 34 55	77 — 20 36 60	82 — 19 38 65	87 — 17 41 71	93 — 14 44 78	100 — 11 48 86	108 — 7 53 95
+46	53 — 22 30 33	55 — 22 30 36	58 — 22 30 39	61 — 21 31 42	65 — 21 32 46	69 — 20 33 50	73 — 19 35 55	78 — 18 37 60	83 — 17 39 65	89 — 15 42 71	95 — 12 45 79	102 — 8 49 87	110 — 4 54 96
+45	53 — 20 30 33	56 — 20 30 35	58 — 20 31 38	62 — 20 32 42	66 — 19 33 46	70 — 18 34 50	74 — 17 36 55	79 — 16 38 60	84 — 14 40 66	90 — 12 43 72	97 — 9 46 80	104 — 5 50 88	113 0 56 97
44	53 — 19 30 32	56 — 19 31 35	59 — 19 31 38	62 — 18 32 42	66 — 18 33 46	71 — 17 34 50	75 — 16 36 55	80 — 14 38 60	86 — 12 41 66	92 — 9 44 73	99 — 6 48 81	107 — 2 52 89	116 + 3 58 99
43	53 — 18 30 32	56 — 18 31 35	59 — 17 32 38	63 — 17 33 42	67 — 16 34 46	71 — 15 35 50	76 — 14 37 55	81 — 12 39 60	87 — 10 42 66	93 — 7 45 74	102 — 3 49 82	110 + 1 54 90	120 + 7 60 101
42	54 — 16 31 32	57 — 16 31 35	60 — 16 32 38	63 — 15 33 42	67 — 14 34 46	72 — 13 36 50	77 — 12 38 55	82 — 10 40 61	88 — 7 43 67	95 — 4 46 74	104 0 50 83	113 + 4 56 92	123 + 10 63 103
+41	54 — 15 31 32	57 — 15 32 35	60 — 14 33 38	64 — 14 34 42	68 — 13 35 46	73 — 12 36 50	78 — 10 38 55	84 — 8 41 61	90 — 5 44 67	97 — 2 47 75	106 + 2 52 84	116 + 7 58 94	127 + 14 65 106
+40	54 — 14 31 32	57 — 13 32 35	60 — 13 33 38	64 — 12 34 42	68 — 11 35 46	74 — 10 37 51	79 — 8 39 56	85 — 6 42 62	92 — 3 45 68	99 + 1 49 76	108 + 5 54 86	119 + 11 60 96	131 + 18 67 109
39	54 — 13 31 32	58 — 12 32 35	61 — 12 33 38	65 — 11 35 42	69 — 10 36 46	75 — 8 38 51	80 — 6 40 56	86 — 4 43 62	94 — 1 46 69	102 + 3 50 77	111 + 8 56 87	122 + 15 62 98	135 + 22 70 112
38	55 — 11 32 32	58 — 11 33 35	62 — 10 34 38	66 — 9 35 42	70 — 8 37 46	76 — 6 39 51	81 — 4 41 57	88 — 1 44 63	96 + 2 48 70	104 + 6 52 79	114 + 12 58 89	125 + 19 64 101	139 + 27 73 115
37	55 — 10 32 32	58 — 10 33 35	62 — 9 34 38	66 — 8 36 42	71 — 6 38 47	77 — 4 40 52	83 — 2 42 58	90 + 1 45 64	98 + 4 49 71	106 + 9 54 80	117 + 15 60 91	129 + 23 67 103	144 + 32 76 119
+36	55 — 9 33 32	59 — 8 34 35	63 — 7 35 38	67 — 6 36 42	72 — 4 38 47	78 — 2 40 52	84 0 43 58	92 + 3 46 65	100 + 7 50 72	109 + 12 56 82	121 + 18 62 93	134 + 27 70 106	150 + 37 80 123
+35	56 — 8 33 32	60 — 7 34 35	64 — 6 35 38	68 — 4 37 42	73 — 2 39 47	79 0 41 53	85 + 2 44 59	93 + 6 48 66	102 + 10 52 74	112 + 15 58 84	125 + 22 64 96	139 + 31 73 110	156 + 42 84 127
34	56 — 6 34 32	60 — 5 35 35	64 — 4 36 39	69 — 3 38 43	74 — 1 40 48	80 + 1 42 53	87 + 4 45 59	95 + 8 49 67	104 + 13 54 75	115 + 19 60 86	129 + 26 67 98	144 + 36 76 113	163 + 48 88 132
33	57 — 5 35 32	61 — 4 36 35	65 — 3 37 39	69 — 2 39 43	75 0 41 48	81 + 3 44 54	88 + 7 47 60	97 + 11 51 68	106 + 16 56 77	118 + 22 62 88	133 + 31 70 101	149 + 41 80 117	170 + 54 93 137
32	57 — 4 35 32	61 — 3 36 36	65 — 1 38 40	70 0 40 44	76 + 2 42 49	83 + 5 45 55	90 + 9 48 61	99 + 13 52 69	109 + 19 58 79	122 + 26 65 90	137 + 35 73 104	155 + 46 84 121	178 + 61 98 143
+31	58 — 2 36 32	62 — 1 37 36	66 0 39 40	71 + 2 41 44	77 + 4 43 50	84 + 7 46 56	92 + 11 49 63	101 + 16 54 71	112 + 22 60 81	125 + 30 67 93	142 + 40 76 107	161 + 52 88 126	186 + 69 104 150
+30	58 — 1 36 32	62 0 38 36	67 + 1 40 40	72 + 3 42 45	78 + 6 44 50	85 + 10 47 57	94 + 14 51 64	104 + 19 56 73	115 + 25 62 83	129 + 34 70 96	147 + 45 79 112	168 + 59 92 132	195 + 77 110 157

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$$\varDelta a_{\circ}=\varDelta a+M\varDelta a+m\varDelta\delta.$$

$$\varDelta\delta_{\circ}=\varDelta\delta+W\varDelta\delta+w\varDelta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

τ / δ	$\mathrm{VI^h}$						$\mathrm{VII^h}$						
	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	60^{m}
	M m W w												
+50°	101 − 16 48 92	108 − 13 52 100	115 − 8 58 110	123 − 2 65 121	132 + 4 74 134	142 + 12 84 148	153 + 21 97 164	165 + 33 113 183	179 + 47 132 204	194 + 64 156 228	211 + 84 186 256	230 +108 223 289	
49	103 − 13 49 93	110 − 9 54 102	118 − 4 60 113	127 + 2 68 124	137 + 9 77 137	148 + 18 88 152	160 + 28 102 170	174 + 41 120 190	189 + 57 141 213	206 + 76 168 240	126 + 99 202 273		
48	105 − 10 51 94	113 − 6 56 103	122 0 63 115	131 + 6 71 127	142 + 14 80 141	154 + 24 93 157	168 + 36 108 176	183 + 50 128 198	200 + 68 152 224	220 + 90 182 255	244 +116 220 291		
47	108 − 7 53 95	116 − 2 58 105	126 + 4 65 117	136 + 11 74 130	148 + 19 84 145	161 + 30 98 163	176 + 44 115 184	193 + 60 136 208	213 + 80 163 237	236 +105 197 272			
+46	110 − 4 54 96	119 + 1 60 107	130 + 8 68 119	141 + 16 77 133	154 + 25 89 150	168 + 37 103 169	185 + 52 122 192	204 + 70 146 218	228 + 93 176 251	255 +123 214 291			
+45	113 0 56 97	123 + 5 62 109	134 + 12 71 122	146 + 21 81 137	160 + 32 94 155	176 + 45 109 176	196 + 61 130 201	217 + 82 156 230	245 +108 190 267				
44	116 + 3 58 99	126 + 9 65 111	138 + 17 74 125	152 + 27 85 141	167 + 39 99 160	186 + 53 116 183	208 + 72 139 211	232 + 95 168 244	264 +126 207 286				
43	120 + 7 60 101	130 + 13 68 114	143 + 22 77 129	158 + 32 89 146	175 + 46 104 166	196 + 62 124 191	220 + 83 149 222	249 +110 182 259					
42	123 + 10 63 103	135 + 18 71 117	149 + 27 81 133	165 + 38 94 151	184 + 53 110 173	206 + 72 132 200	234 + 96 160 235	269 +127 197 277					
+41	127 + 14 65 106	140 + 22 74 120	155 + 32 85 137	172 + 45 99 157	194 + 61 117 181	219 + 82 141 211	251 +110 173 249						
+40	131 + 18 67 109	145 + 27 77 124	161 + 38 89 142	180 + 52 104 164	204 + 70 124 190	233 + 94 151 223	269 +126 187 266						
39	135 + 22 70 112	150 + 32 80 128	168 + 45 94 147	189 + 60 111 171	216 + 80 133 200	248 +107 163 236							
38	139 + 27 73 115	156 + 38 84 132	176 + 52 99 153	199 + 69 118 179	229 + 92 142 211	266 +122 176 252							
37	144 + 32 76 119	162 + 44 88 137	184 + 59 104 159	210 + 79 125 188	244 +105 152 223								
+36	150 + 37 80 123	169 + 50 93 142	193 + 67 110 167	222 + 90 133 198	260 +119 164 236								
+35	156 + 42 84 127	177 + 56 98 148	203 + 75 117 175	236 +101 142 209	276 +134 176 252								
34	163 + 48 88 132	186 + 64 104 155	214 + 85 125 184	251 +113 153 221									
33	170 + 54 93 137	195 + 72 110 162	227 + 96 133 194	268 +127 164 235									
32	178 + 61 98 143	205 + 81 117 170	241 +107 142 205	287 +143 177 251									
+31	186 + 69 104 150	216 + 91 125 179	256 +120 152 217										
+30	195 + 77 110 157	228 +102 133 189	273 +135 164 232										

The tabular quantities are expressed in units of the fifth decimal.
M and W are always positive.
m and w change signs for negative hour angles.

$$\Delta\alpha_0 = \Delta\alpha + M\Delta\alpha + m\Delta\delta.$$

$$\Delta\delta_0 = \Delta\delta + W\Delta\delta + w\Delta\alpha.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

δ \ τ	0h												1h													
	0m		10m		20m		30m		40m		50m		0m		10m		20m		30m		40m		50m		60m	
°	M	m																								
	W	w																								
+30	28	0	28	0	28	−1	29	−1	29	−2	29	−2	30	−2	30	−3	30	−3	31	−3	32	−4	33	−4	34	−4
	29	0	29	1	29	1	29	2	29	3	29	4	29	4	29	5	29	6	29	7	29	8	30	9	30	10
29	28	0	28	0	28	−1	29	−1	29	−1	29	−2	30	−2	30	−2	30	−3	31	−3	32	−3	33	−4	34	−4
	29	0	29	1	29	1	29	2	29	3	29	4	29	4	29	5	29	6	30	7	30	8	30	9	30	10
28	28	0	28	0	28	−1	29	−1	29	−1	29	−2	30	−2	30	−2	30	−2	31	−3	32	−3	33	−3	34	−3
	29	0	29	1	29	1	29	2	29	3	29	4	30	4	30	5	30	6	30	7	30	8	30	9	30	10
27	28	0	28	0	28	−1	29	−1	29	−1	29	−1	30	−2	30	−2	30	−2	31	−2	32	−2	33	−3	34	−3
	30	0	30	1	30	1	30	2	30	3	30	4	30	4	30	5	30	6	30	7	30	8	30	9	31	10
+26	28	0	28	0	28	0	29	−1	29	−1	29	−1	30	−1	30	−2	30	−2	31	−2	32	−2	33	−2	34	−2
	30	0	30	1	30	1	30	2	30	3	30	4	30	4	30	5	30	6	30	7	30	8	31	9	31	10
+25	28	0	28	0	28	0	29	−1	29	−1	29	−1	30	−1	30	−1	30	−1	31	−2	32	−2	33	−2	34	−2
	30	0	30	1	30	1	30	2	30	3	30	4	30	4	30	5	30	6	31	7	31	8	31	9	31	10
24	28	0	28	0	28	0	29	−1	29	−1	29	−1	30	−1	30	−1	30	−1	31	−1	32	−1	33	−1	34	−1
	30	0	30	1	30	1	30	2	30	3	30	4	30	4	31	5	31	6	31	7	31	8	31	9	32	10
23	28	0	28	0	28	0	29	0	29	0	29	−1	30	−1	30	−1	31	−1	31	−1	32	−1	33	−1	34	−1
	31	0	31	1	31	1	31	2	31	3	31	4	31	4	31	5	31	6	31	7	31	8	32	9	32	10
22	28	0	28	0	28	0	29	0	29	0	29	0	30	−1	30	−1	31	0	31	0	32	0	33	0	34	0
	31	0	31	1	31	1	31	2	31	3	31	4	31	4	31	5	31	6	32	7	32	8	32	9	32	10
+21	28	0	28	0	28	0	29	0	29	0	29	0	30	0	30	0	31	0	31	0	32	0	33	0	34	0
	31	0	31	1	31	1	31	2	31	3	31	4	32	4	32	5	32	6	32	7	32	8	32	9	33	10
+20	28	0	28	0	28	0	29	0	29	0	29	0	30	0	30	0	31	0	31	0	32	0	33	0	34	+1
	32	0	32	1	32	1	32	2	32	3	32	4	32	4	32	5	32	6	32	7	33	8	33	9	33	10
19	28	0	28	0	28	0	29	0	29	0	29	0	30	0	30	0	31	0	31	+1	32	+1	33	+1	34	+1
	32	0	32	1	32	1	32	2	32	3	32	4	32	4	32	5	33	6	33	7	33	8	33	9	34	10
18	28	0	28	0	28	0	29	0	29	0	29	0	30	0	30	+1	31	+1	31	+1	32	+1	33	+1	34	+2
	32	0	32	1	32	2	32	2	32	3	33	4	33	4	33	5	33	6	33	7	34	8	34	9	34	10
17	28	0	28	0	28	0	29	0	29	0	29	+1	30	+1	30	+1	31	+1	32	+1	32	+2	33	+2	34	+2
	33	0	33	1	33	2	33	2	33	3	33	4	33	5	33	5	34	6	34	7	34	8	34	9	35	10
+16	28	0	28	0	28	0	29	0	29	+1	29	+1	30	+1	30	+1	31	+1	32	+2	32	+2	33	+2	34	+3
	33	0	33	1	33	2	33	2	33	3	34	4	34	5	34	6	34	6	34	7	35	8	35	9	36	11
+15	28	0	28	0	28	0	29	+1	29	+1	29	+1	30	+1	30	+2	31	+2	32	+2	33	+3	34	+3	35	+4
	34	0	34	1	34	2	34	2	34	3	34	4	34	5	34	6	35	6	35	7	35	8	36	10	36	11
14	28	0	28	0	28	0	29	+1	29	+1	29	+1	30	+2	30	+2	31	+2	32	+3	33	+3	34	+4	35	+4
	34	0	34	1	34	2	34	2	34	3	35	4	35	5	35	6	35	7	36	8	36	9	36	10	37	11
13	28	0	28	0	28	+1	29	+1	29	+1	29	+1	30	+2	30	+2	31	+2	32	+3	33	+4	34	+4	35	+5
	35	0	35	1	35	2	35	2	35	3	35	4	35	5	36	6	36	7	36	8	37	9	37	10	38	11
12	28	0	28	0	28	+1	29	+1	29	+1	29	+2	30	+2	30	+2	31	+3	32	+3	33	+4	34	+5	35	+5
	36	0	36	1	36	2	36	2	36	3	36	4	36	5	36	6	37	7	37	8	37	9	38	10	38	11
+11	28	0	28	0	28	+1	29	+1	29	+2	29	+2	30	+2	30	+3	31	+3	32	+4	33	+5	34	+5	35	+6
	36	0	36	1	36	2	36	2	36	3	37	4	37	5	37	6	37	7	38	8	38	9	39	10	39	12
+10	28	0	28	0	28	+1	29	+1	29	+2	29	+2	30	+3	30	+3	31	+4	32	+4	33	+5	34	+6	35	+7
	37	0	37	1	37	2	37	2	37	3	37	4	38	5	38	6	38	7	38	8	39	9	39	10	40	12

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$$\Delta a_0 = \Delta a + M\Delta a + m\Delta\delta.$$

$$\Delta\delta_0 = \Delta\delta + W\Delta\delta + w\Delta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

δ \ τ	II^{h}												III^{h}													
	0^{m}		10^{m}		20^{m}		30^{m}		40^{m}		50^{m}		0^{m}		10^{m}		20^{m}		30^{m}		40^{m}		50^{m}		60^{m}	
°	*M* *W*	*m* *w*																								
+30	34 30	− 4 10	35 30	− 4 11	36 30	− 5 12	37 30	− 5 14	38 31	− 5 15	40 31	− 5 16	42 32	− 5 18	44 32	− 4 20	46 33	− 4 22	49 33	− 4 24	52 34	− 3 26	55 35	− 2 29	58 36	− 1 32
29	34 30	− 4 10	35 30	− 4 11	36 30	− 4 12	37 31	− 4 13	38 31	− 4 15	40 31	− 4 16	42 32	− 4 18	44 32	− 4 20	46 33	− 3 22	49 34	− 3 24	52 35	− 2 27	55 36	− 1 30	59 37	0 33
28	34 30	− 3 10	35 30	− 3 11	36 31	− 3 12	37 31	− 3 13	39 31	− 3 15	40 32	− 3 16	42 32	− 3 18	44 33	− 3 20	47 34	− 2 22	49 35	− 2 24	52 36	− 1 27	56 37	0 30	59 38	+ 1 33
27	34 31	− 3 10	35 31	− 3 11	36 31	− 3 12	37 31	− 3 14	39 32	− 3 15	40 32	− 2 16	42 33	− 2 18	45 33	− 2 20	47 34	− 1 22	50 35	− 1 24	53 36	0 27	56 37	+ 1 30	60 38	+ 2 33
+26	34 31	− 2 10	35 31	− 2 11	36 31	− 2 12	37 32	− 2 14	39 32	− 2 15	41 33	− 2 16	43 33	− 1 18	45 34	− 1 20	47 35	0 22	50 36	0 24	53 37	+ 2 27	57 38	+ 3 30	61 39	+ 4 34
+25	34 31	− 2 10	35 31	− 2 11	36 32	− 2 12	38 32	− 1 14	39 33	− 1 15	41 33	− 1 16	43 34	− 1 18	45 34	0 20	48 35	+ 1 22	51 36	+ 2 25	54 37	+ 3 28	57 38	+ 4 31	61 40	+ 6 34
24	34 32	− 1 10	35 32	− 1 11	36 32	− 1 12	38 33	− 1 14	39 33	− 1 15	41 34	0 17	43 34	0 18	45 35	+ 1 20	48 36	+ 2 22	51 37	+ 3 25	54 38	+ 4 28	58 39	+ 5 31	62 41	+ 7 35
23	34 32	− 1 10	35 32	− 1 11	36 33	− 1 12	38 33	0 14	39 34	0 15	41 34	+ 1 17	43 35	+ 1 19	46 36	+ 2 21	48 37	+ 3 23	51 38	+ 4 26	55 39	+ 5 29	59 40	+ 7 32	63 42	+ 9 36
22	34 32	0 10	35 33	0 11	36 33	0 12	38 34	0 14	40 34	+ 1 15	41 35	+ 1 17	44 35	+ 2 19	46 36	+ 3 21	49 37	+ 4 23	52 38	+ 5 26	55 40	+ 6 29	59 41	+ 8 32	64 43	+10 36
+21	34 33	0 10	35 33	+ 1 11	37 34	+ 1 13	38 34	+ 1 14	40 35	+ 2 16	42 35	+ 2 17	44 36	+ 3 19	46 37	+ 4 21	49 38	+ 5 23	52 39	+ 6 26	56 41	+ 8 29	60 42	+10 33	65 44	+12 37
+20	34 33	+ 1 10	35 34	+ 1 11	37 34	+ 2 13	38 35	+ 2 14	40 35	+ 2 16	42 36	+ 3 17	44 37	+ 4 19	47 38	+ 5 21	49 39	+ 6 24	53 40	+ 7 27	57 42	+ 9 30	61 44	+11 34	66 46	+14 38
19	34 34	+ 1 10	35 34	+ 2 12	37 35	+ 2 13	38 35	+ 3 14	40 36	+ 3 16	42 37	+ 4 18	44 38	+ 5 20	47 39	+ 6 22	50 40	+ 7 24	53 41	+ 9 27	57 43	+11 30	62 45	+13 34	67 47	+16 38
18	34 34	+ 2 10	36 35	+ 2 12	37 35	+ 3 13	38 36	+ 3 14	40 36	+ 4 16	42 37	+ 5 18	45 38	+ 6 20	48 39	+ 7 22	50 40	+ 8 25	54 42	+10 28	58 44	+12 31	63 46	+14 35	68 48	+17 39
17	34 35	+ 2 10	36 35	+ 3 12	37 36	+ 3 13	39 37	+ 4 15	41 37	+ 5 16	43 38	+ 6 18	45 39	+ 7 20	48 40	+ 8 22	51 41	+10 25	55 43	+12 28	59 45	+14 32	63 47	+16 36	69 50	+19 40
+16	34 36	+ 3 11	36 36	+ 4 12	37 37	+ 4 13	39 37	+ 5 15	41 38	+ 6 16	43 39	+ 7 18	45 40	+ 8 20	48 41	+ 9 23	52 42	+11 26	56 44	+13 29	60 46	+15 32	64 48	+18 36	70 51	+21 41
+15	35 36	+ 4 11	36 37	+ 4 12	37 37	+ 5 14	39 38	+ 6 15	41 39	+ 7 17	43 40	+ 8 19	46 41	+ 9 21	49 42	+10 23	52 44	+12 26	56 45	+14 29	60 47	+17 33	65 50	+20 37	72 53	+23 42
14	35 37	+ 4 11	36 37	+ 5 12	38 38	+ 6 14	39 39	+ 7 15	41 40	+ 8 17	44 41	+ 9 19	46 42	+10 21	49 43	+12 24	53 45	+14 27	57 47	+16 30	61 49	+18 34	67 52	+22 38	73 55	+26 43
13	35 38	+ 5 11	36 38	+ 5 12	38 39	+ 6 14	40 40	+ 7 16	42 41	+ 8 17	44 42	+10 19	47 43	+11 22	50 44	+13 24	53 46	+15 27	57 48	+17 31	62 50	+20 35	68 53	+24 39	75 57	+28 45
12	35 38	+ 5 11	36 39	+ 6 13	38 40	+ 7 14	40 41	+ 8 16	42 42	+ 9 18	44 43	+11 20	47 44	+12 22	50 45	+14 25	54 47	+16 28	58 49	+19 32	64 52	+22 36	70 55	+26 40	77 59	+30 46
+11	35 39	+ 6 12	37 40	+ 7 13	38 41	+ 8 14	40 42	+ 9 16	42 43	+10 18	45 44	+12 20	48 45	+14 23	51 47	+16 26	55 49	+18 29	59 51	+21 33	65 54	+24 37	71 57	+28 42	78 61	+33 48
+10	35 40	+ 7 12	37 41	+ 8 13	39 42	+ 9 15	41 43	+10 17	43 44	+11 19	45 45	+13 21	48 46	+15 23	52 48	+17 26	56 50	+20 29	60 52	+23 33	66 55	+26 38	72 59	+31 43	80 63	+36 49

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$$\Delta a_0=\Delta a+M\Delta a+m\Delta\delta.$$

$$\Delta\delta_0=\Delta\delta+W\Delta\delta+w\Delta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

δ \ τ	$\mathrm{IV^h}$												$\mathrm{V^h}$													
	0^{m}		10^{m}		20^{m}		30^{m}		40^{m}		50^{m}		0^{m}		10^{m}		20^{m}		30^{m}		40^{m}		50^{m}		60^{m}	
	M *W*	*m* *w*																								
+30°	58	− 1	62	0	67	1	72	3	78	6	85	10	94	14	104	19	115	25	129	34	147	45	168	59	195	77
	36	32	38	36	40	40	42	45	44	50	47	57	51	64	56	73	62	83	70	96	79	112	92	132	110	157
29	59	0	63	1	68	3	73	5	80	8	87	12	96	16	106	22	119	29	134	38	153	50	176	65	205	85
	37	33	38	36	40	40	43	45	46	51	49	58	53	66	58	75	64	86	73	99	83	116	97	138	116	165
28	59	1	64	3	69	5	75	7	81	10	89	14	98	19	109	25	123	33	139	43	159	56	184	72	216	94
	38	33	39	37	41	41	44	46	47	52	50	59	54	67	60	77	67	88	76	103	87	121	103	144	124	173
27	60	2	65	4	70	6	76	9	83	13	91	17	101	22	112	29	127	37	144	48	166	62	193	80	228	105
	38	33	40	37	42	42	45	47	48	53	52	60	56	68	62	79	70	91	79	107	92	126	109	151	132	183
+26	61	4	65	6	71	8	77	11	84	15	93	19	103	25	116	32	131	41	149	53	173	69	203	89	242	117
	39	34	41	38	43	43	46	48	49	54	53	61	58	70	65	81	73	94	83	111	97	132	116	158	141	194
+25	61	6	66	8	72	10	78	13	86	17	95	22	106	28	119	36	135	46	155	59	181	76	214	99	257	130
	40	34	42	38	44	43	47	49	51	55	55	63	60	72	67	84	76	98	87	115	102	138	123	167	151	206
24	62	7	67	9	73	12	80	16	88	20	98	25	109	32	123	40	140	51	162	65	190	84	226	109	275	145
	41	35	43	39	46	44	49	50	52	57	57	65	63	74	70	86	80	101	92	120	108	144	131	176	162	220
23	63	9	68	11	74	14	81	18	90	22	100	28	112	35	127	44	146	56	169	72	200	92	240	121	294	161
	42	36	44	40	47	45	50	51	54	58	59	66	65	77	73	90	84	106	97	126	115	152	140	187	175	235
22	64	10	69	13	76	16	83	20	92	25	103	31	116	39	132	49	152	62	177	79	210	102	255	134		
	43	36	45	41	48	46	52	52	56	59	61	68	68	79	77	93	88	110	102	132	122	160	150	199		
+21	65	12	70	15	77	18	85	22	94	28	106	34	120	43	137	54	158	68	186	87	222	112	272	148		
	44	37	47	42	50	47	53	53	58	61	64	70	71	82	80	97	92	115	108	139	130	170	161	212		
+20	66	14	72	17	79	20	87	25	97	31	109	38	124	47	142	59	165	75	196	96	236	124	291	164		
	46	38	48	42	51	48	55	55	60	63	66	73	74	85	84	101	97	120	115	146	139	180	174	227		
19	67	16	73	19	80	23	89	28	99	34	112	42	128	52	148	65	173	82	206	105	250	137	312	182		
	47	38	50	43	53	49	57	56	62	65	69	75	77	88	88	105	103	126	122	154	149	191	188	245		
18	68	17	74	21	82	25	91	30	102	37	116	46	133	57	154	71	181	90	218	115	267	151				
	48	39	51	44	55	51	59	58	65	67	72	78	81	92	93	110	109	133	130	163	160	205				
17	69	19	76	23	84	28	94	34	105	41	120	50	138	62	161	78	190	99	231	127	286	167				
	50	40	53	46	57	52	62	60	68	69	75	81	85	96	98	115	115	140	139	174	173	220				
+16	70	21	78	25	86	30	96	37	108	45	124	55	143	68	168	85	201	108	245	140	307	185				
	51	41	54	47	59	54	64	62	71	72	79	85	89	101	103	121	123	148	149	185	187	237				
+15	72	23	79	28	88	33	99	40	112	49	128	60	149	74	176	93	212	118	261	154						
	53	42	56	48	61	55	66	64	74	75	83	88	94	105	109	128	131	157	160	198						
14	73	26	81	30	90	36	102	44	116	53	133	65	156	81	185	102	225	129	279	170						
	55	43	58	50	63	57	69	66	77	78	87	92	99	111	116	135	140	167	173	212						
13	75	28	83	33	93	40	105	48	120	58	139	71	163	88	195	111	239	142	300	188						
	57	45	61	51	66	59	72	69	80	81	91	97	105	117	124	143	150	178	187	229						
12	77	30	85	36	95	43	108	52	124	63	145	77	171	96	206	121	255	157								
	59	46	63	53	69	62	76	72	84	85	96	102	111	123	132	152	161	191								
+11	78	33	87	39	98	46	112	56	129	68	151	84	180	105	219	132	273	173								
	61	48	66	55	72	64	79	75	88	89	101	107	118	130	141	161	174	205								
+10	80	36	90	42	102	50	116	61	134	74	158	91	190	114	233	145	293	191								
	63	49	68	57	75	67	83	78	93	93	107	112	126	138	151	172	188	221								

δ \ τ	$\mathrm{VI^h}$	
	10^{m}	
	M *W*	*m* *w*
+30°	228	102
	133	189
29	242	113
	142	200
28	258	126
	151	212
+27	275	140
	163	226

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$$\Delta a_{o} = \Delta a + M\Delta a + m\Delta\delta.$$

$$\Delta\delta_{o} = \Delta\delta + W\Delta\delta + w\Delta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer

δ \ τ	0h												1h													
	0m		10m		20m		30m		40m		50m		0m		10m		20m		30m		40m		50m		60m	
	M	*m*																								
	W	*w*																								
+10°	28	0	28	0	28	1	29	1	29	2	29	2	30	3	30	3	31	4	32	4	33	5	34	6	35	7
	37	0	37	1	37	2	37	2	37	3	37	4	38	5	38	6	38	7	38	8	39	9	39	10	40	12
9	28	0	28	0	28	1	29	1	29	2	29	2	30	3	30	4	31	4	32	5	33	6	34	6	36	7
	38	0	38	1	38	2	38	2	38	3	38	4	38	5	39	6	39	7	39	8	40	9	40	10	41	12
8	28	0	28	1	28	1	29	2	29	2	29	3	30	3	30	4	31	5	32	5	33	6	34	7	36	8
	38	0	38	1	38	2	38	2	39	3	39	4	39	5	39	6	40	7	40	8	41	9	41	11	42	12
7	28	0	28	1	28	1	29	2	29	2	29	3	30	4	30	4	31	5	32	6	33	7	34	8	36	9
	39	0	39	1	39	2	39	2	40	3	40	4	40	5	40	6	41	7	41	8	42	10	42	11	43	12
+ 6	28	0	28	1	28	1	29	2	29	2	29	3	30	4	31	5	31	6	32	7	33	8	35	9	36	10
	40	0	40	1	40	2	40	3	41	3	41	4	41	5	41	6	42	8	42	9	43	10	43	11	44	13
+ 5	28	0	28	1	28	1	29	2	29	3	29	3	30	4	31	5	32	6	33	7	34	8	35	9	36	10
	41	0	41	1	41	2	41	3	42	3	42	4	42	6	42	7	43	8	43	9	44	10	44	11	45	13
4	28	0	28	1	28	1	29	2	29	3	29	4	30	5	31	6	32	7	33	8	34	9	35	10	36	11
	42	0	42	1	42	2	42	3	43	4	43	5	43	6	43	7	44	8	44	9	45	10	46	12	47	14
3	28	0	28	1	28	2	29	2	29	3	29	4	30	5	31	6	32	7	33	8	34	9	35	10	37	12
	43	0	43	1	43	2	43	3	44	4	44	5	44	6	44	7	45	8	46	9	46	11	47	12	48	14
2	28	0	28	1	28	2	29	3	29	3	30	4	30	5	31	6	32	8	33	9	34	10	35	11	37	13
	44	0	44	1	44	2	44	3	45	4	45	5	45	6	46	7	46	8	47	10	48	11	48	12	49	14
+ 1	28	0	28	1	28	2	29	3	29	4	30	5	30	6	31	7	32	8	33	10	34	11	36	12	37	14
	45	0	45	1	45	2	46	3	46	4	46	5	46	6	47	7	47	9	48	10	49	11	50	13	51	15
0	28	0	28	1	28	2	29	3	29	4	30	5	30	6	31	7	32	9	33	10	34	12	36	13	38	15
	47	0	47	1	47	2	47	3	47	4	47	5	48	6	48	7	49	9	50	10	51	12	52	13	53	15
− 1	28	0	28	1	28	2	29	3	29	4	30	6	30	7	31	8	32	9	33	11	34	13	36	14	38	16
	48	0	48	1	48	2	48	3	49	4	49	5	49	6	50	8	50	9	51	10	52	12	53	14	54	16
2	28	0	28	1	28	2	29	3	29	5	30	6	30	7	31	9	32	10	33	12	35	13	36	15	38	17
	49	0	49	1	49	2	50	3	50	4	50	5	51	7	51	8	52	9	53	11	54	12	55	14	56	16
3	28	0	28	1	28	2	29	4	29	5	30	6	30	8	31	9	32	11	34	13	35	14	37	16	39	18
	51	0	51	1	51	2	51	3	52	4	52	6	52	7	53	8	54	10	55	11	56	13	57	15	58	17
4	28	0	28	1	28	3	29	4	29	5	30	7	30	8	31	10	32	12	34	13	35	15	37	17	39	19
	52	0	53	1	53	2	53	3	53	5	54	6	54	7	55	8	56	10	57	12	58	13	59	15	60	17
− 5	28	0	28	1	28	3	29	4	29	6	30	7	31	9	32	11	33	12	34	14	35	16	37	18	39	21
	54	0	54	1	54	2	55	4	55	5	56	6	56	7	57	9	58	10	59	12	60	14	61	16	63	18
− 6	28	0	28	1	28	3	29	5	29	6	30	8	31	10	32	11	33	13	34	15	36	17	38	20	40	23
	56	0	56	1	56	2	57	4	57	5	58	6	58	8	59	9	60	11	61	12	62	14	63	16	65	19
7	28	0	28	2	28	3	29	5	29	6	30	8	31	10	32	12	33	14	34	16	36	18	38	21	40	24
	58	0	58	1	58	2	59	4	59	5	60	7	60	8	61	10	62	11	63	13	64	15	66	17	68	20
8	28	0	28	2	28	3	29	5	29	7	30	9	31	11	32	13	33	15	35	17	36	20	38	23	41	26
	60	0	60	1	60	3	61	4	61	5	62	7	62	8	63	10	64	12	65	14	67	16	69	18	71	20
9	28	0	28	2	28	4	29	6	29	8	30	10	31	12	32	14	33	16	35	18	37	21	39	24	41	28
	63	0	63	1	63	3	63	4	63	6	64	7	65	9	66	10	67	12	68	14	70	16	72	19	74	21
−10	28	0	28	2	28	4	29	6	29	8	30	10	31	12	32	14	34	17	35	20	37	23	39	26	42	30
	65	0	65	1	65	3	66	4	66	6	67	7	68	9	69	11	70	13	71	15	73	17	75	20	77	23

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$\Delta a_{0}=\Delta a+M\Delta a+m\Delta\delta.$

$\Delta\delta_{0}=\Delta\delta+W\Delta\delta+w\Delta a.$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

τ / δ	II^{h}												$\mathrm{III}^{\mathrm{h}}$													
	0^{m}		10^{m}		20^{m}		30^{m}		40^{m}		50^{m}		0^{m}		10^{m}		20^{m}		30^{m}		40^{m}		50^{m}		60^{m}	
°	M W	m w																								
+10	35	7	37	8	39	9	41	10	43	11	45	13	48	15	52	17	56	20	60	23	66	26	72	31	80	36
	40	12	41	13	42	15	43	17	44	19	45	21	46	23	48	26	50	29	52	33	55	38	59	43	63	49
9	36	7	37	8	39	10	41	11	43	12	46	14	49	16	52	19	57	22	62	25	67	28	74	33	82	39
	41	12	42	13	43	15	44	17	45	19	46	21	48	24	50	27	52	30	54	34	57	39	61	45	66	51
8	36	8	37	9	39	10	41	12	44	14	46	16	49	18	53	20	58	23	63	27	69	31	76	36	84	42
	42	12	43	14	44	15	45	17	46	19	47	22	49	25	51	28	53	31	56	35	59	40	63	46	68	53
7	36	9	37	10	39	11	41	13	44	15	47	17	50	19	54	22	59	25	64	29	70	33	78	39	87	46
	43	12	44	14	45	16	46	18	47	20	49	22	51	25	53	28	55	32	58	37	62	42	66	48	71	55
+ 6	36	10	38	11	40	12	42	14	44	16	47	18	51	21	55	24	60	27	65	31	72	36	80	42	90	49
	44	13	45	14	46	16	47	18	49	20	50	23	52	26	54	29	57	33	60	38	64	43	69	50	74	58
+ 5	36	10	38	12	40	13	42	15	45	17	48	19	52	22	56	25	61	29	67	33	74	39	82	45	93	53
	45	13	46	15	47	17	48	19	50	21	52	24	54	27	56	30	59	34	63	39	67	45	72	52	78	60
4	36	11	38	13	40	14	43	16	46	18	49	21	53	24	57	27	62	31	68	36	75	42	84	49	96	57
	47	14	48	15	49	17	50	19	52	22	54	25	56	28	58	32	61	36	65	41	69	47	75	54	82	63
3	37	12	39	14	41	16	43	18	46	20	49	23	53	26	58	29	63	34	69	39	77	45	87	53	99	62
	48	14	49	16	50	18	52	20	54	22	56	25	58	29	61	33	64	37	68	42	72	49	78	57	86	66
2	37	13	39	15	41	17	44	19	47	21	50	24	54	28	59	32	65	37	71	42	80	48	90	57	102	67
	49	14	50	16	52	18	54	20	56	23	58	26	60	30	63	34	66	38	71	44	76	51	82	59	90	69
+ 1	37	14	39	16	42	18	44	20	47	23	51	26	55	30	60	34	66	39	73	45	82	52	93	61	107	72
	51	15	52	17	53	19	55	21	57	24	60	27	62	31	65	35	69	40	74	46	79	53	86	62	95	73
0	38	15	40	17	42	19	45	22	48	25	52	28	56	32	61	37	67	42	75	48	85	56	96	66	111	78
	53	15	54	17	55	19	57	22	59	25	62	28	65	32	68	37	72	42	77	48	83	56	91	65	100	77
− 1	38	16	40	18	42	21	45	24	49	27	53	30	57	34	63	39	69	45	78	52	88	60	100	71	115	84
	54	16	56	18	57	20	59	23	61	26	64	29	67	33	71	38	75	44	81	50	87	59	96	69	106	81
2	38	17	40	19	43	22	46	25	50	28	54	32	58	37	64	42	71	48	80	56	91	65	104	76	120	90
	56	16	58	18	60	21	62	24	64	27	67	31	70	35	74	40	79	46	85	53	92	62	101	73	112	86
3	39	18	41	21	44	24	47	27	51	30	55	34	60	39	66	45	74	52	83	60	94	70	108	82	126	97
	58	17	60	19	62	22	64	25	67	28	70	32	73	37	78	42	83	48	89	56	97	65	107	77	119	92
4	39	19	41	22	44	25	47	29	51	33	56	37	61	42	68	48	76	56	86	64	98	75	113	88	133	105
	60	17	62	20	64	22	66	25	69	29	72	33	76	38	81	44	87	50	94	59	102	69	113	81	127	98
− 5	39	21	42	24	45	27	48	31	52	35	57	39	63	45	70	52	78	60	89	69	102	81	118	95	140	114
	63	18	65	21	67	23	69	26	72	30	76	35	80	40	85	46	91	53	99	62	108	73	120	86	135	104
− 6	40	23	42	26	45	29	49	33	53	37	58	42	64	48	72	56	81	64	92	74	106	87	124	103	148	124
	65	19	67	21	70	24	72	28	75	32	79	36	84	42	89	48	96	56	104	65	115	77	128	92	145	112
7	40	24	43	28	46	31	50	35	54	40	60	46	66	52	74	60	84	69	96	80	111	94	131	112	156	135
	68	20	70	22	73	26	76	29	79	33	83	38	88	44	94	51	102	59	111	70	122	82	136	99	155	121
8	41	26	44	30	47	34	51	38	56	43	61	49	68	56	77	64	87	74	101	87	117	102	138	122	166	148
	71	20	73	23	76	27	79	31	83	35	87	40	93	46	100	54	108	63	118	74	130	88	146	106	167	130
9	41	28	44	32	48	36	52	40	57	46	63	52	71	60	80	69	91	80	105	94	123	111	146	133	177	162
	74	21	77	24	80	28	83	32	87	37	92	42	98	49	105	57	114	67	125	79	139	94	157	114	181	141
−10	42	30	45	34	49	38	53	43	58	49	65	56	73	64	82	74	94	86	109	101	129	120	155	144	190	177
	77	23	80	26	84	29	88	34	92	39	97	45	104	52	111	60	121	71	133	84	149	101	169	123	196	153

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$$\varDelta a_{\circ}=\varDelta a+M\varDelta a+m\varDelta\delta.$$

$$\varDelta\delta_{\circ}=\varDelta\delta+W\varDelta\delta+w\varDelta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

τ δ	IV^h						V^h						
	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	60^m
	M m W w												
$+10°$	80 36 63 49	90 42 68 57	102 50 75 67	116 61 83 78	134 74 93 93	158 91 107 112	190 114 126 138	233 145 151 172	293 191 188 221				
9	82 39 66 51	92 46 71 59	105 55 78 70	120 66 87 82	140 80 98 98	166 99 113 119	201 124 134 147	248 160 162 185					
8	84 42 68 53	95 50 74 62	109 59 82 73	125 71 92 86	147 87 104 103	175 108 120 126	213 136 143 156	265 176 175 199					
7	87 46 71 55	98 54 78 65	112 64 86 76	131 77 97 90	154 94 110 109	184 117 128 134	226 149 154 168	285 194 190 215					
$+6$	90 49 74 58	102 58 81 68	117 69 90 80	137 84 102 95	162 103 117 116	195 128 137 143	241 163 166 180						
$+5$	93 53 78 60	105 62 86 71	122 75 95 84	143 91 108 101	170 112 124 123	207 140 147 153	258 179 179 194						
4	96 57 82 63	109 67 90 74	127 81 100 88	150 99 114 107	179 122 133 131	220 153 158 164	278 198 194 210						
3	99 62 86 66	114 73 95 78	132 88 106 93	157 107 122 113	190 133 143 140	235 168 170 176							
2	102 67 90 69	118 79 100 82	139 95 113 99	166 116 130 121	202 145 153 150	252 184 184 190							
$+1$	107 72 95 73	124 85 106 87	146 103 120 105	175 127 138 129	215 158 164 161	271 202 200 206							
0	111 78 100 77	129 92 112 92	153 111 127 112	185 137 148 138	229 173 177 173	293 224 218 224							
-1	115 84 106 81	135 100 119 98	162 121 136 120	197 150 159 148	246 190 192 187								
2	120 90 112 86	142 108 127 104	171 132 146 128	210 165 172 160	265 210 208 204								
3	126 97 119 92	150 117 135 111	182 144 156 137	225 181 186 173									
4	133 105 127 98	159 128 145 119	194 158 168 148	242 199 202 188									
-5	140 114 135 104	168 139 155 128	207 173 182 160	262 219 220 205									
-6	148 124 145 112	179 152 167 138	222 190 198 174										
7	156 135 155 121	191 166 180 149	240 209 215 190										
8	166 148 167 130	205 182 196 162											
9	177 162 181 141	220 201 213 177											
-10	190 177 196 153												

The tabular quantities are expressed in units of the fifth decimal.
M and W are always positive.
m and w change signs for negative hour angles.

$$\Delta a_0 = \Delta a + M \Delta a + m \Delta \delta.$$

$$\Delta \delta_0 = \Delta \delta + W \Delta \delta + w \Delta a.$$

TABLE I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

τ / δ	0h												1h													
	0m		10m		20m		30m		40m		50m		0m		10m		20m		30m		40m		50m		60m	
	M	*m*																								
	W	*w*																								
°																										
−10	28	0	28	2	28	4	29	6	29	8	30	10	31	12	32	14	34	17	35	20	37	23	39	26	42	30
	65	0	65	1	65	3	66	4	66	6	67	7	68	9	69	11	70	13	71	15	73	17	75	20	77	23
11	28	0	28	2	28	4	29	6	29	8	30	11	31	13	32	15	34	18	35	21	37	24	40	28	43	32
	68	0	68	1	68	3	69	4	69	6	70	8	71	9	72	11	73	13	74	16	76	18	79	21	81	24
12	28	0	28	2	28	4	29	7	30	9	30	11	31	14	32	16	34	19	36	22	38	26	40	30	43	34
	71	0	71	2	71	3	72	5	72	6	73	8	74	10	75	12	76	14	78	16	80	19	83	22	85	25
13	28	0	28	2	29	5	29	7	30	10	30	12	31	15	33	18	34	21	36	24	38	28	41	32	44	36
	74	0	74	2	74	3	75	5	75	7	76	8	77	10	78	12	80	15	82	17	84	20	87	23	90	26
−14	28	0	28	2	29	5	29	8	30	10	31	13	32	16	33	19	35	22	37	26	39	30	42	34	45	39
	77	0	77	2	78	3	78	5	79	7	80	9	81	11	82	13	84	15	86	18	88	21	91	24	94	28
−15	28	0	28	3	29	5	29	8	30	11	31	14	32	17	33	20	35	24	37	28	39	32	42	37	46	42
	81	0	81	2	81	4	82	5	83	7	84	9	85	12	86	14	88	16	90	19	93	22	96	26	100	30
16	28	0	28	3	29	6	29	9	30	12	31	15	32	18	33	22	35	26	37	30	40	34	43	39	47	45
	85	0	85	2	85	4	86	6	87	8	88	10	89	12	91	15	93	17	95	20	98	23	101	27	105	31
17	28	0	28	3	29	6	29	9	30	12	31	16	32	19	34	23	36	27	38	32	41	37	44	42	48	48
	90	0	90	2	90	4	90	6	91	8	92	10	94	13	96	16	98	18	101	21	104	25	107	29	111	33
18	28	0	28	3	29	6	29	10	30	13	31	17	32	21	34	25	36	29	38	34	41	39	45	45	49	52
	95	0	95	2	95	4	95	6	96	9	97	11	99	14	101	17	104	20	107	23	110	26	114	31	118	36
−19	28	0	28	3	29	7	29	10	30	14	31	18	33	23	34	27	36	32	39	37	42	42	46	48	50	56
	100	0	100	2	100	4	101	7	102	9	103	12	105	15	107	18	110	21	113	24	117	28	121	33	126	38
−20	28	0	28	4	29	8	29	11	30	15	31	19	33	24	35	29	37	34	40	39	43	45	47	52	52	60
	105	0	105	2	106	5	107	7	108	10	109	13	111	16	113	19	116	22	120	26	124	30	129	35	135	41
21	28	0	28	4	29	8	29	12	30	16	32	21	33	26	35	31	37	36	40	42	44	49	48	56	54	65
	111	0	111	3	112	5	113	8	114	10	116	13	118	16	120	20	123	24	127	28	132	32	138	38	144	44
22	28	0	28	4	29	9	29	13	30	18	32	23	33	28	35	33	38	39	41	46	45	53	50	61	56	70
	118	0	118	3	119	5	120	8	121	11	123	14	125	18	128	21	132	25	136	30	141	35	148	41	155	48
23	28	0	28	5	29	9	29	14	30	19	32	24	34	30	36	36	39	42	42	49	46	57	51	66	58	76
	126	0	126	3	127	6	128	9	129	12	131	15	134	19	137	23	141	27	146	32	152	38	159	44	167	52
−24	28	0	28	5	29	10	30	15	31	21	32	26	34	32	37	39	40	46	43	54	48	62	53	72	60	83
	135	0	135	3	135	6	136	10	138	13	140	17	143	21	147	25	152	30	157	35	163	41	171	48	180	56
−25	28	0	28	5	29	11	30	16	31	22	33	28	35	35	37	42	40	50	44	58	49	68	55	79	63	91
	144	0	144	3	145	7	146	10	148	14	151	18	154	22	158	27	163	32	169	38	176	45	185	53	195	62
26	28	0	28	6	29	12	30	18	31	24	33	31	35	38	38	45	41	54	46	63	51	74	58	86	66	100
	154	0	155	4	156	7	157	11	159	15	162	20	166	24	170	29	176	35	183	41	191	49	201	58	213	68
27	28	0	28	6	29	13	30	19	31	26	33	34	36	41	39	49	42	58	47	69	53	81	60	94	69	110
	166	0	167	4	168	8	170	12	172	16	175	21	179	26	184	32	191	38	198	45	208	54	219	64	233	75
28	28	0	28	7	29	14	30	21	32	29	34	37	36	45	40	54	44	64	49	76	55	89	63	104	73	121
	180	0	180	4	181	9	183	13	186	18	190	23	194	29	200	35	208	42	216	50	227	59	240	70	256	83
−29	28	0	28	8	29	15	30	23	32	31	34	40	37	49	41	60	45	71	51	84	58	98	67	114	78	134
	195	0	196	5	197	10	199	15	202	20	207	25	212	32	219	39	227	46	237	55	249	65	264	78	283	92
−30	28	0	28	8	29	17	30	25	32	34	35	44	38	54	42	66	47	78	53	92	61	108	71	127	84	150
	212	0	213	5	214	10	217	16	221	22	226	28	232	35	239	43	249	51	261	61	275	73	292	87	314	103

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$\Delta a_{\circ} = \Delta a + M\Delta a + m\Delta\delta.$

$\Delta\delta_{\circ} = \Delta\delta + W\Delta\delta + w\Delta a.$

Table I—Continued.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

τ δ	IIh												IIIh													
	0m		10m		20m		30m		40m		50m		0m		10m		20m		30m		40m		50m		60m	
°	*M* *W*	*m* *w*																								
—10	42 77	30 23	45 80	34 26	49 84	38 29	53 88	43 34	58 92	49 39	65 97	56 45	73 104	64 52	82 111	74 60	94 121	86 71	109 133	101 84	129 149	120 101	155 169	144 123	190 196	177 153
11	43 81	32 24	46 84	36 27	50 88	41 31	55 92	47 36	60 97	53 41	67 103	60 48	76 110	69 55	86 118	80 64	99 129	93 76	115. 143	110 90	137 160	131 109	165 183	158 134		
12	43 85	34 25	47 88	38 29	51 92	44 33	56 97	50 38	62 102	57 43	69 109	65 50	78 117	75 59	89 126	87 69	104 138	101 81	122 153	119 97	146 173	143 118	177 199	173 146		
13	44 90	36 26	48 93	41 30	52 97	47 35	58 102	54 40	64 108	61 46	72 115	70 54	82 124	81 63	94 135	94 74	109 148	110 88	129 165	130 105	155 187	156 128				
—14	45 94	39 28	49 98	44 32	54 103	50 37	59 108	58 42	66 115	66 49	74 122	75 57	85 132	87 67	98 144	101 79	115 159	119 94	137 178	142 114	166 203	171 140				
—15	46 100	42 30	50 104	47 34	55 109	54 39	61 115	62 45	69 122	71 52	78 131	81 61	89 141	94 72	103 154	110 85	122 171	130 102	146 193	155 124	179 222	188 153				
16	47 105	45 31	52 110	51 36	57 116	58 42	63 122	67 48	71 130	77 56	81 140	88 66	94 151	102 78	109 166	120 92	130 185	142 111	156 210	170 136	193 243	208 169				
17	48 111	48 33	53 117	55 39	59 123	63 45	66 130	72 52	74 139	83 61	85 150	96 71	99 163	112 84	116 180	131 100	138 202	156 121	168 229	188 149						
18	49 118	52 36	54 124	59 41	60 131	68 48	68 139	78 55	78 149	90 65	89 161	104 77	104 176	122 91	123 195	143 109	148 220	171 133	182 252	208 164						
—19	50 126	56 38	56 132	64 44	63 140	73 51	71 149	84 60	81 160	98 71	94 174	114 83	111 191	133 99	131 212	157 120	160 241	189 146								
—20	52 135	60 41	58 142	69 48	65 150	79 56	74 160	91 65	86 173	106 76	100 188	124 91	118 208	146 109	141 232	173 132	173 265	209 162								
21	54 144	65 44	60 152	75 52	68 161	86 60	78 173	100 70	90 187	116 83	106 205	135 99	126 227	160 119	152 255	192 146	188 293	233 181								
22	56 155	70 48	62 164	81 56	71 174	94 65	82 187	109 77	95 203	127 91	113 223	149 109	135 249	177 132	166 282	213 162										
23	58 167	76 52	65 177	88 61	75 189	102 71	86 203	119 84	102 221	139 100	121 245	164 120	146 274	196 147												
—24	60 180	83 56	68 191	96 66	79 205	112 78	92 222	131 92	109 243	153 110	130 270	182 133	159 304	218 164												
—25	63 195	91 62	72 208	106 73	83 224	123 86	98 243	144 102	117 268	170 122	141 299	202 149														
26	66 213	100 68	76 228	116 80	89 246	136 95	105 268	160 113	126 296	189 137																
27	69 233	110 75	80 250	128 89	95 271	150 106	113 297	178 126																		
28	73 256	121 83	86 276	142 98	102 300	167 118	123 331	198 142																		
—29	78 283	134 92	92 306	158 110	111 335	187 132																				
—30	84 314	150 103	100 341	177 124																						

The tabular quantities are expressed in units of the fifth decimal.
M and *W* are always positive.
m and *w* change signs for negative hour angles.

$\Delta a_0 = \Delta a + M\Delta a + m\Delta\delta.$

$\Delta\delta_0 = \Delta\delta + W\Delta\delta + w\Delta a.$

TABLE II.

To be used when differences in Right Ascension are determined by Transits.

δ \ τ	0^{h}						I^{h}						II^{h}						$\mathrm{III}^{\mathrm{h}}$						
	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	60^{m}
	m' W																								
$+70^\circ$	0 38	−1 38	−2 38	−2 38	−3 38	−4 38	−4 38	−5 37	−6 37	−6 37	−7 36	−8 36	−9 36	−9 35	−10 35	−11 34	−11 34	−12 33	−12 33	−13 32	−13 31	−14 31	−14 30	−15 30	−15 29
69	0 38	−1 38	−1 38	−2 38	−3 37	−3 37	−4 37	−4 37	−5 36	−6 36	−6 36	−7 35	−8 35	−8 34	−9 34	−9 34	−10 33	−10 33	−11 32	−11 32	−12 31	−12 31	−13 30	−13 30	−14 29
68	0 37	−1 37	−1 37	−2 37	−2 37	−3 36	−4 36	−4 36	−5 36	−5 36	−6 35	−6 35	−7 34	−7 34	−8 34	−8 33	−9 33	−9 32	−10 32	−10 31	−11 31	−11 30	−12 30	−12 29	−12 29
67	0 36	−1 36	−1 36	−2 36	−2 36	−3 36	−3 36	−4 35	−4 35	−5 35	−5 35	−6 34	−6 34	−7 33	−7 33	−8 33	−8 32	−9 32	−9 31	−9 31	−10 30	−10 30	−11 30	−11 29	−11 29
+66	0 36	0 36	−1 35	−1 35	−2 35	−2 35	−3 35	−3 35	−4 34	−4 34	−5 34	−5 34	−6 33	−6 33	−7 32	−7 32	−7 32	−8 31	−8 31	−9 30	−9 30	−9 30	−10 29	−10 29	−10 29
+65	0 35	0 35	−1 35	−1 35	−2 35	−2 35	−3 34	−3 34	−3 34	−4 34	−4 33	−5 33	−5 33	−6 32	−6 32	−6 32	−7 31	−7 31	−7 31	−8 30	−8 30	−8 30	−9 29	−9 29	−9 28
64	0 34	0 34	−1 34	−1 34	−2 34	−2 34	−2 34	−3 34	−3 34	−4 33	−4 33	−4 33	−5 32	−5 32	−5 32	−6 31	−6 31	−7 31	−7 30	−7 30	−7 30	−8 29	−8 29	−8 29	−9 28
63	0 34	0 34	−1 34	−1 34	−1 34	−2 34	−2 33	−3 33	−3 33	−3 33	−4 32	−4 32	−4 32	−5 32	−5 31	−5 31	−6 30	−6 30	−6 30	−6 30	−7 29	−7 29	−7 29	−7 29	−8 28
62	0 33	0 33	−1 33	−1 33	−1 33	−2 33	−2 33	−2 33	−3 32	−3 32	−3 32	−4 32	−4 32	−4 31	−5 31	−5 31	−5 30	−5 30	−6 30	−6 30	−6 29	−7 29	−7 29	−7 28	−7 28
+61	0 33	0 33	−1 33	−1 33	−1 33	−2 33	−2 32	−2 32	−2 32	−3 32	−3 32	−3 32	−4 31	−4 31	−4 31	−5 30	−5 30	−5 30	−5 30	−5 29	−6 29	−6 29	−6 29	−6 28	−7 28
+60	0 32	0 32	−1 32	−1 32	−1 32	−1 32	−2 32	−2 32	−2 32	−3 32	−3 31	−3 31	−3 31	−4 31	−4 30	−4 30	−4 30	−5 30	−5 29	−5 29	−5 29	−5 29	−6 29	−6 28	−6 28
59	0 32	0 32	−1 32	−1 32	−1 32	−1 32	−2 32	−2 31	−2 31	−2 31	−3 31	−3 31	−3 31	−3 30	−4 30	−4 30	−4 30	−4 29	−5 29	−5 29	−5 29	−5 29	−5 28	−5 28	−6 28
58	0 32	0 32	−1 32	−1 31	−1 31	−1 31	−2 31	−2 31	−2 31	−2 31	−2 31	−3 30	−3 30	−3 30	−3 30	−4 30	−4 29	−4 29	−4 29	−4 29	−5 29	−5 28	−5 28	−5 28	−5 28
57	0 31	0 31	0 31	−1 31	−1 31	−1 31	−1 31	−2 31	−2 31	−2 31	−2 30	−2 30	−3 30	−3 30	−3 30	−3 29	−4 29	−4 29	−4 29	−4 29	−4 29	−4 28	−5 28	−5 28	−5 28
+56	0 31	0 31	0 31	−1 31	−1 31	−1 31	−1 31	−1 30	−2 30	−2 30	−2 30	−2 30	−2 30	−3 30	−3 29	−3 29	−3 29	−3 29	−4 29	−4 28	−4 28	−4 28	−4 28	−4 28	−4 28
+55	0 31	0 31	0 31	−1 30	−1 30	−1 30	−1 30	−1 30	−2 30	−2 30	−2 30	−2 30	−2 30	−3 29	−3 29	−3 29	−3 29	−3 29	−3 29	−3 28	−4 28	−4 28	−4 28	−4 28	−4 28
54	0 30	0 30	0 30	−1 30	−1 30	−1 30	−1 30	−1 30	−1 30	−2 30	−2 30	−2 29	−2 29	−2 29	−2 29	−3 29	−3 29	−3 29	−3 28	−3 28	−3 28	−4 28	−4 28	−4 28	−4 28
53	0 30	0 30	0 30	−1 30	−1 30	−1 30	−1 30	−1 30	−1 30	−2 30	−2 29	−2 29	−2 29	−2 29	−2 29	−2 29	−3 29	−3 29	−3 28	−3 28	−3 28	−3 28	−3 28	−3 28	−4 28
52	0 30	0 30	0 30	0 30	−1 30	−1 30	−1 30	−1 30	−1 29	−1 29	−2 29	−2 29	−2 29	−2 29	−2 29	−2 29	−2 28	−3 28	−3 28	−3 28	−3 28	−3 28	−3 28	−3 28	−3 28
+51	0 30	0 30	0 30	0 30	−1 30	−1 29	−1 29	−1 29	−1 29	−1 29	−2 29	−2 29	−2 29	−2 29	−2 29	−2 28	−2 28	−2 28	−3 28	−3 28	−3 28	−3 28	−3 28	−3 28	−3 29
+50	0 29	0 29	0 29	0 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−2 29	−2 29	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−3 28	−3 28	−3 29	−3 29

The tabular quantities are expressed in units of the fifth decimal.
m' changes sign for negative hour angles.
W is always positive.

$$\varDelta\alpha^{s}_{0}=\varDelta\alpha^{s}+m'\varDelta\delta''.$$

$$\varDelta\delta_{0}=\varDelta\delta+W\varDelta\delta.$$

Table II—Continued.

To be used when differences in Right Ascension are determined by Transits.

τ / δ	IV^h						V^h						VI^h						VII^h						
	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	60^m
	m′ W																								
+70°	−15 29	−15 29	−16 29	−16 28	−17 28	−17 28	−17 28	−17 28	−17 29	−17 29	−17 30	−17 31	−17 32	−17 33	−17 35	−17 37	−16 39	−16 42	−15 45	−15 49	−15 53	−14 57	−13 62	−13 67	−12 73
69	−14 29	−14 29	−14 29	−14 28	−15 28	−15 28	−15 28	−15 29	−15 29	−15 30	−15 30	−15 31	−15 32	−15 34	−15 36	−15 38	−15 40	−14 43	−14 46	−13 50	−13 54	−12 59	−12 64	−11 70	−10 76
68	−12 29	−13 29	−13 28	−13 28	−14 28	−14 28	−14 28	−14 29	−14 29	−14 30	−14 31	−14 32	−14 33	−14 34	−14 36	−13 39	−13 41	−13 44	−12 48	−12 52	−11 56	−11 61	−10 67	− 9 73	− 9 80
67	−11 29	−11 28	−12 28	−12 28	−12 28	−12 28	−12 28	−13 29	−13 29	−13 30	−13 31	−13 32	−13 33	−12 35	−12 37	−12 39	−12 42	−11 45	−11 49	−10 53	−10 58	− 9 63	− 9 70	− 8 77	− 7 84
+66	−10 29	−10 28	−11 28	−11 28	−11 28	−11 28	−11 28	−11 29	−11 29	−11 30	−11 31	−11 32	−11 34	−11 36	−11 38	−11 40	−10 43	−10 47	−10 51	− 9 55	− 9 60	− 8 66	− 7 73	− 7 80	− 6 88
+65	− 9 28	− 9 28	−10 28	−10 28	−10 28	−10 28	−10 29	−10 29	−10 30	−10 31	−10 32	−10 33	−10 34	−10 36	−10 38	−10 41	− 9 44	− 9 48	− 9 52	− 8 57	− 7 62	− 7 68	− 6 76	− 6 84	− 5 92
64	− 9 28	− 9 28	− 9 28	− 9 28	− 9 28	− 9 28	− 9 29	− 9 29	−10 30	−10 31	−10 32	− 9 33	− 9 35	− 9 37	− 9 39	− 9 42	− 8 45	− 8 49	− 7 54	− 7 59	− 6 65	− 6 71	− 5 79	− 4 88	− 4 97
63	− 8 28	− 8 28	− 8 28	− 8 28	− 9 28	− 9 29	− 9 29	− 9 30	− 9 30	− 9 31	− 9 32	− 9 34	− 8 36	− 8 38	− 8 40	− 8 43	− 7 47	− 7 51	− 6 55	− 6 61	− 5 67	− 5 74	− 4 83	− 3 93	− 3 103
62	− 7 28	− 7 28	− 7 28	− 8 28	− 8 28	− 8 29	− 8 29	− 8 30	− 8 31	− 8 32	− 8 33	− 8 34	− 8 36	− 7 38	− 7 41	− 7 44	− 7 48	− 6 52	− 6 57	− 5 63	− 5 70	− 4 78	− 3 87	− 2 97	− 2 109
+61	− 7 28	− 7 28	− 7 28	− 7 28	− 7 28	− 7 29	− 7 29	− 7 30	− 7 31	− 7 32	− 7 33	− 7 35	− 7 37	− 7 39	− 6 42	− 6 46	− 6 50	− 5 54	− 5 59	− 4 66	− 4 73	− 3 82	− 2 92	− 1 103	0 116
+60	− 6 28	− 6 28	− 6 28	− 6 28	− 7 28	− 7 29	− 7 29	− 7 30	− 7 31	− 7 32	− 7 34	− 6 36	− 6 38	− 6 40	− 6 43	− 5 47	− 5 51	− 5 56	− 4 62	− 3 69	− 3 77	− 2 86	− 1 97	0 109	+ 1 123
59	− 6 28	− 6 28	− 6 28	− 6 29	− 6 29	− 6 29	− 6 30	− 6 31	− 6 32	− 6 33	− 6 34	− 6 36	− 6 38	− 5 41	− 5 44	− 5 48	− 4 53	− 4 58	− 3 64	− 3 72	− 2 80	− 1 90	0 102	+ 1 115	+ 2 131
58	− 5 28	− 5 28	− 5 28	− 5 29	− 6 29	− 6 29	− 6 30	− 6 31	− 6 32	− 6 33	− 5 35	− 5 37	− 5 39	− 5 42	− 5 46	− 4 50	− 4 54	− 3 60	− 3 67	− 2 75	− 1 84	0 95	+ 1 108	+ 2 123	+ 3 140
57	− 5 28	− 5 28	− 5 28	− 5 29	− 5 29	− 5 30	− 5 30	− 5 31	− 5 32	− 5 34	− 5 36	− 5 38	− 5 40	− 4 43	− 4 47	− 4 51	− 3 56	− 3 62	− 2 70	− 1 78	0 88	0 100	+ 1 114	+ 3 131	+ 4 150
+56	− 4 28	− 5 28	− 5 28	− 5 29	− 5 29	− 5 30	− 5 31	− 5 32	− 5 33	− 5 34	− 5 36	− 4 38	− 4 41	− 4 44	− 3 48	− 3 53	− 3 58	− 2 65	− 1 73	− 1 82	0 93	+ 1 106	+ 2 122	+ 4 140	+ 5 161
+55	− 4 28	− 4 28	− 4 29	− 4 29	− 4 29	− 4 30	− 4 31	− 4 32	− 4 33	− 4 35	− 4 37	− 4 39	− 4 42	− 3 45	− 3 49	− 3 54	− 2 60	− 2 67	− 1 76	0 86	+ 1 98	+ 2 112	+ 3 129	+ 5 150	+ 6 174
54	− 4 28	− 4 28	− 4 29	− 4 29	− 4 30	− 4 30	− 4 31	− 4 32	− 4 34	− 4 36	− 4 38	− 3 40	− 3 43	− 3 47	− 3 51	− 2 56	− 2 62	− 1 70	0 79	+ 1 90	+ 2 104	+ 3 119	+ 4 138	+ 6 161	+ 7 189
53	− 4 28	− 4 29	− 4 29	− 4 29	− 4 30	− 4 31	− 4 32	− 4 33	− 4 34	− 3 36	− 3 38	− 3 41	− 3 44	− 2 48	− 2 52	− 2 58	− 1 65	0 73	0 83	+ 1 95	+ 2 110	+ 4 127	+ 5 148	+ 7 174	+ 9 205
52	− 3 28	− 3 29	− 3 29	− 3 30	− 3 30	− 3 31	− 3 32	− 3 33	− 3 35	− 3 37	− 3 39	− 3 42	− 2 45	− 2 49	− 2 54	− 1 60	− 1 67	0 76	+ 1 87	+ 2 101	+ 3 117	+ 5 136	+ 6 159	+ 8 188	+10 224
+51	− 3 29	− 3 29	− 3 29	− 3 30	− 3 30	− 3 31	− 3 32	− 3 34	− 3 36	− 3 38	− 3 40	− 2 43	− 2 47	− 2 51	− 1 56	− 1 63	0 70	+ 1 80	+ 2 92	+ 3 107	+ 4 124	+ 6 145	+ 8 172	+10 204	
+50	− 3 29	− 3 29	− 3 29	− 3 30	− 3 31	− 3 32	− 3 33	− 3 34	− 3 36	− 2 38	− 2 41	− 2 44	− 2 48	− 1 52	− 1 58	0 65	0 74	+ 1 84	+ 2 97	+ 3 113	+ 5 132	+ 7 156	+ 9 186	+11 223	

The tabular quantities are expressed in units of the fifth decimal.
m′ changes sign for negative hour angles.
W is always positive.

$$\Delta\alpha^s_0 = \Delta\alpha^s + m'\Delta\delta''.$$

$$\Delta\delta_0 = \Delta\delta + W'\Delta\delta.$$

TABLE II—Continued.

To be used when differences in Right Ascension are determined by Transits.

τ δ	0h						Ih						IIh						IIIh						
	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	60m
°	m' W																								
+50	0 29	0 29	0 29	0 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−2 29	−2 29	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−3 28	−3 28	−3 29	−3 29
49	0 29	0 29	0 29	0 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−2 29	−2 29	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−3 29	−3 29	−3 29
48	0 29	0 29	0 29	0 29	0 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 29	−2 29	−2 29
47	0 29	0 29	0 29	0 29	0 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 28	−1 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 29	−2 29	−2 29	−2 29
+46	0 29	0 29	0 29	0 29	0 29	−1 29	−1 29	−1 29	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 28	−2 29	−2 29	−2 29	−2 30
+45	0 29	0 29	0 29	0 29	0 29	0 29	−1 29	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−2 28	−2 28	−2 28	−2 29	−2 29	−2 29	−2 29	−2 30
44	0 29	0 29	0 29	0 29	0 29	0 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−2 29	−2 29	−2 29	−2 29	−2 30	−2 30
43	0 28	0 28	0 28	0 28	0 28	0 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 29	−1 29	−2 29	−2 29	−2 30	−2 30	−2 30
42	0 28	0 28	0 28	0 28	0 28	0 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 29	−1 29	−1 29	−1 29	−1 30	−1 30	−1 31
+41	0 28	0 28	0 28	0 28	0 28	0 28	0 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 29	−1 29	−1 29	−1 29	−1 30	−1 30	−1 30	−1 31
+40	0 28	0 28	0 28	0 28	0 28	0 28	0 28	0 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 30	−1 30	−1 31	−1 31
39	0 28	0 28	0 28	0 28	0 28	0 28	0 28	0 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 30	−1 30	−1 30	−1 31	−1 31
38	0 28	0 28	0 28	0 28	0 28	0 28	0 28	0 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 28	−1 29	−1 29	−1 29	−1 29	−1 29	−1 30	−1 30	−1 30	−1 31	−1 31	−1 32
37	0 28	0 28	0 28	0 28	0 28	0 28	0 28	0 28	0 28	−1 28	−1 28	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 30	−1 30	−1 31	−1 31	−1 32	−1 32
+36	0 28	0 28	0 28	0 28	0 28	0 28	0 28	0 28	0 29	0 29	0 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 30	−1 30	−1 30	−1 31	−1 31	−1 32	−1 33
+35	0 28	0 28	0 28	0 28	0 28	0 28	0 28	0 29	0 29	0 29	0 29	0 29	−1 29	−1 29	−1 29	−1 29	−1 29	−1 30	−1 30	−1 30	−1 31	−1 31	−1 32	−1 33	−1 33
34	0 28	0 28	0 28	0 28	0 28	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	−1 29	−1 29	−1 29	−1 30	−1 30	−1 30	−1 31	−1 31	−1 32	−1 32	−1 33	0 34
33	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	−1 30	−1 30	−1 30	−1 30	−1 31	−1 31	−1 32	0 33	0 34	0 35
32	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 32	0 32	0 33	0 34	0 35
+31	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 32	0 32	0 33	0 34	0 35	0 36
+30	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 32	0 32	0 33	0 33	0 34	0 35	0 36

The tabular quantities are expressed in units of the fifth decimal.
m' changes sign for negative hour angles.
W is always positive.

$$\Delta\alpha^s_0=\Delta\alpha^s+m'\Delta\delta''.$$

$$\Delta\delta_0=\Delta\delta+W\Delta\delta.$$

TABLE II—Continued.

To be used when differences in Right Ascension are determined by Transits.

δ \ τ	IV^h						V^h						VI^h						VII^h						
	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	60^m
°	m' W																								
+50	−3 29	−3 29	−3 29	−3 30	−3 31	−3 32	−3 33	−3 34	−3 36	−2 38	−2 41	−2 44	−2 48	−1 52	−1 58	0 65	0 74	+1 84	+2 97	+3 113	+5 132	+7 156	+9 186	+11 223	
49	−3 29	−3 29	−3 30	−3 30	−3 31	−3 32	−3 33	−2 35	−2 37	−2 39	−2 42	−2 45	−1 49	−1 54	0 60	0 68	+1 77	+2 88	+3 102	+4 120	+6 141	+8 168	+10 202		
48	−2 29	−2 30	−2 30	−2 31	−2 32	−2 33	−2 34	−2 36	−2 38	−2 40	−2 43	−1 47	−1 51	−1 56	0 63	+1 71	+1 80	+2 93	+4 108	+5 128	+7 152	+9 182	+12 220		
47	−2 29	−2 30	−2 30	−2 31	−2 32	−2 33	−2 34	−2 36	−2 38	−2 41	−1 44	−1 48	−1 53	0 58	0 65	+1 74	+2 84	+3 98	+4 115	+6 136	+8 163	+10 197			
+46	−2 30	−2 30	−2 30	−2 31	−2 32	−2 33	−2 35	−2 37	−2 39	−1 42	−1 45	−1 49	0 54	0 60	+1 68	+1 77	+2 89	+4 103	+5 122	+7 146	+9 176	+12 214			
+45	−2 30	−2 30	−2 31	−2 32	−2 33	−2 34	−2 36	−2 38	−1 40	−1 43	−1 46	0 50	0 56	0 62	+1 71	+2 81	+3 94	+4 109	+6 130	+8 156	+10 190				
44	−2 30	−2 31	−2 31	−2 32	−2 33	−2 34	−1 36	−1 38	−1 41	−1 44	−1 48	0 52	0 58	+1 65	+2 74	+3 85	+4 99	+5 116	+7 139	+9 168	+12 207				
43	−2 30	−2 31	−2 32	−2 33	−1 34	−1 35	−1 37	−1 39	−1 42	−1 45	0 49	0 54	+1 60	+1 68	+2 77	+3 89	+4 104	+6 124	+8 149	+10 182					
42	−1 31	−1 31	−1 32	−1 33	−1 34	−1 36	−1 38	−1 40	−1 43	0 46	0 50	0 56	+1 63	+2 71	+2 81	+3 94	+5 110	+7 132	+9 160	+11 197					
+41	−1 31	−1 32	−1 33	−1 34	−1 35	−1 36	−1 38	−1 41	0 44	0 47	0 52	+1 58	+1 65	+2 74	+3 85	+4 99	+5 117	+7 141	+10 173						
+40	−1 31	−1 32	−1 33	−1 34	−1 35	−1 37	−1 39	−1 42	0 45	0 49	0 54	+1 60	+2 67	+2 77	+3 89	+5 104	+6 124	+8 151	+11 187						
39	−1 31	−1 32	−1 33	−1 35	−1 36	−1 38	−1 40	0 43	0 46	0 50	+1 56	+1 62	+2 70	+3 80	+4 94	+5 111	+7 133	+9 163							
38	−1 32	−1 33	−1 34	−1 35	−1 37	−1 39	0 41	0 44	0 48	+1 52	+1 58	+2 64	+2 73	+3 84	+4 99	+6 118	+8 142	+10 176							
37	−1 32	−1 33	−1 34	−1 36	−1 38	0 40	0 42	0 45	0 49	+1 54	+1 60	+2 67	+3 76	+4 88	+5 104	+7 125	+9 152								
+36	−1 33	−1 34	−1 35	0 36	0 38	0 40	0 43	0 46	+1 50	+1 56	+1 62	+2 70	+3 80	+4 93	+5 110	+7 133	+10 164								
+35	−1 33	−1 34	0 35	0 37	0 39	0 41	0 44	0 48	+1 52	+1 58	+2 64	+2 73	+3 84	+5 98	+6 117	+8 142	+11 176								
34	0 34	0 35	0 36	0 38	0 40	0 42	0 45	+1 49	+1 54	+1 60	+2 67	+3 76	+4 88	+5 104	+7 125	+9 153									
33	0 35	0 36	0 37	0 39	0 41	0 44	0 47	+1 51	+1 56	+2 62	+2 70	+3 80	+4 93	+6 110	+8 133	+10 164									
32	0 35	0 36	0 38	0 40	0 42	0 45	+1 48	+1 52	+2 58	+2 65	+3 73	+4 84	+5 98	+6 117	+8 142	+11 177									
+31	0 36	0 37	0 39	0 41	0 43	+1 46	+1 49	+1 54	+2 60	+2 67	+3 76	+4 88	+5 104	+7 125	+9 152										
+30	0 36	0 38	0 40	0 42	0 44	+1 47	+1 51	+1 56	+2 62	+3 70	+3 79	+4 92	+6 110	+8 133	+10 164										

The tabular quantities are expressed in units of the fifth decimal.
m′ changes sign for negative hour angles.
W is always positive.

$\varDelta\alpha^s_0 = \varDelta\alpha^s + m'\varDelta\delta''$.

$\varDelta\delta_0 = \varDelta\delta + W\varDelta\delta$.

TABLE II—Continued.

To be used when differences in Right Ascension are determined by Transits.

τ / δ	0h						1h						2h						3h						
	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	60m
°	m′ W																								
+30	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 32	0 32	0 33	0 33	0 34	0 35	0 36
29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 29	0 30	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 31	0 32	0 32	0 33	0 34	0 35	0 36	0 37
28	0 29	0 29	0 29	0 29	0 29	0 29	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 31	0 32	0 32	0 33	0 34	0 35	0 36	0 37	0 38
27	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 31	0 31	0 32	0 32	0 33	0 33	0 34	0 35	0 36	0 37	0 38
+26	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 31	0 31	0 32	0 32	0 33	0 33	0 34	0 35	0 36	0 37	0 38	0 39
+25	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 31	0 31	0 31	0 32	0 32	0 33	0 33	0 34	0 34	0 35	0 36	0 37	0 38	0 40
24	0 30	0 30	0 30	0 30	0 30	0 30	0 30	0 31	0 31	0 31	0 31	0 31	0 32	0 32	0 32	0 33	0 33	0 34	0 34	0 35	0 36	0 37	0 38	0 39	1 41
23	0 31	0 31	0 31	0 31	0 31	0 31	0 31	0 31	0 31	0 31	0 31	0 32	0 32	0 32	0 33	0 33	0 34	0 34	0 35	0 36	0 37	0 38	0 39	1 40	1 42
22	0 31	0 31	0 31	0 31	0 31	0 31	0 31	0 31	0 31	0 32	0 32	0 32	0 32	0 33	0 33	0 34	0 34	0 35	0 35	0 36	0 37	0 38	0 40	1 41	1 43
+21	0 31	0 31	0 31	0 31	0 31	0 31	0 32	0 32	0 32	0 32	0 32	0 32	0 33	0 33	0 34	0 34	0 35	0 35	0 36	0 37	0 38	0 39	1 41	1 42	1 44
+20	0 32	0 32	0 32	0 32	0 32	0 32	0 32	0 32	0 32	0 32	0 33	0 33	0 33	0 34	0 34	0 35	0 35	0 36	0 37	0 38	0 39	0 40	1 42	1 44	1 46
19	0 32	0 32	0 32	0 32	0 32	0 32	0 32	0 32	0 33	0 33	0 33	0 33	0 34	0 34	0 35	0 35	0 36	0 37	0 38	0 39	0 40	1 41	1 43	1 45	1 47
18	0 32	0 32	0 32	0 32	0 32	0 33	0 33	0 33	0 33	0 33	0 34	0 34	0 34	0 35	0 35	0 36	0 36	0 37	0 38	0 39	1 40	1 42	1 44	1 46	1 48
17	0 33	0 33	0 33	0 33	0 33	0 33	0 33	0 33	0 34	0 34	0 34	0 34	0 35	0 35	0 36	0 37	0 37	0 38	0 39	1 40	1 41	1 43	1 45	1 47	1 50
+16	0 33	0 33	0 33	0 33	0 33	0 34	0 34	0 34	0 34	0 34	0 35	0 35	0 36	0 36	0 37	0 37	0 38	0 39	1 40	1 41	1 42	1 44	1 46	1 48	1 51
+15	0 34	0 34	0 34	0 34	0 34	0 34	0 34	0 34	0 35	0 35	0 35	0 36	0 36	0 37	0 37	0 38	0 39	1 40	1 41	1 42	1 44	1 45	1 47	1 50	2 53
14	0 34	0 34	0 34	0 34	0 34	0 35	0 35	0 35	0 35	0 36	0 36	0 36	0 37	0 37	0 38	0 39	1 40	1 41	1 42	1 43	1 45	1 47	1 49	2 52	2 55
13	0 35	0 35	0 35	0 35	0 35	0 35	0 35	0 36	0 36	0 36	0 37	0 37	0 38	0 38	0 39	0 40	1 41	1 42	1 43	1 44	1 46	1 48	1 50	2 53	2 57
12	0 36	0 36	0 36	0 36	0 36	0 36	0 36	0 36	0 37	0 37	0 37	0 38	0 38	0 39	0 40	1 41	1 42	1 43	1 44	1 45	1 47	1 49	1 52	2 55	2 59
+11	0 36	0 36	0 36	0 36	0 36	0 37	0 37	0 37	0 37	0 38	0 38	0 39	0 39	0 40	1 41	1 42	1 43	1 44	1 45	1 47	1 49	1 51	2 54	2 57	2 61
+10	0 37	0 37	0 37	0 37	0 37	0 37	0 38	0 38	0 38	0 38	0 39	0 39	0 40	1 41	1 42	1 43	1 44	1 45	1 46	1 48	1 50	2 52	2 55	2 59	2 63

The tabular quantities are expressed in units of the fifth decimal.
m′ changes sign for negative hour angles.
W is always positive.

$$\varDelta\alpha^s_0 = \varDelta\alpha^s + m'\varDelta\delta''.$$

$$\varDelta\delta_0 = \varDelta\delta + W\varDelta\delta.$$

TABLE II—Continued.

To be used when differences in Right Ascension are determined by Transits.

τ	IV^{h}						V^{h}						VI^{h}						VII^{h}						
δ	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	60^{m}
°	m' W																								
+30	0 36	0 38	0 40	0 42	0 44	1 47	1 51	1 56	2 62	3 70	3 79	4 92	6 110	8 133	10 164										
29	0 37	0 38	0 40	0 43	1 46	1 49	1 53	2 58	2 64	3 73	4 83	5 97	7 116	9 142											
28	0 38	0 39	0 41	1 44	1 47	1 50	1 54	2 60	2 67	3 76	4 87	5 103	7 124	10 151											
27	0 38	0 40	0 42	1 45	1 48	1 52	2 56	2 62	3 70	4 79	5 92	6 109	8 132	11 163											
+26	0 39	0 41	1 43	1 46	1 49	1 53	2 58	2 65	3 73	4 83	5 97	7 116	9 141												
+25	0 40	0 42	1 44	1 47	1 51	1 55	2 60	2 67	3 76	4 87	5 102	7 123	9 151												
24	1 41	1 43	1 46	1 49	1 52	2 57	2 63	3 70	4 80	5 92	6 108	8 131	10 162												
23	1 42	1 44	1 47	1 50	2 54	2 59	3 65	3 73	4 84	5 97	7 115	9 140	12 175												
22	1 43	1 45	1 48	1 52	2 56	2 61	3 68	4 77	5 88	6 102	8 122	10 150													
+21	1 44	1 47	1 50	2 53	2 58	2 64	3 71	4 80	5 92	6 108	8 130	11 161													
+20	1 46	1 48	1 51	2 55	2 60	3 66	3 74	4 84	5 97	7 115	9 139	12 174													
19	1 47	1 50	2 53	2 57	2 62	3 69	4 77	5 88	6 103	7 122	10 149	13 188													
18	1 48	1 51	2 55	2 59	3 65	3 72	4 81	5 93	6 109	8 130	11 160														
17	1 50	2 53	2 57	2 62	3 68	3 75	4 85	5 98	7 115	9 139	12 173														
+16	1 51	2 54	2 59	3 64	3 71	4 79	5 89	6 103	7 123	10 149	13 187														
+15	2 53	2 56	2 61	3 66	3 74	4 83	5 94	6 109	8 131	11 160															
14	2 55	2 58	2 63	3 69	4 77	4 87	5 99	7 116	9 140	12 173															
13	2 57	2 61	3 66	[illegible]	4 80	5 91	6 105	8 124	10 150	13 187															
12	2 59	2 63	3 69	4 76	4 84	5 96	7 111	8 132	11 161																
+11	2 61	3 66	3 72	4 79	5 88	6 101	7 118	9 141	12 174																
+10	2 63	3 68	3 75	4 83	5 93	6 107	8 126	10 151	13 188																

The tabular quantities are expressed in units of the fifth decimal.
m' changes sign for negative hour angles.
W' is always positive.

$$\Delta\alpha^{s}_{0}=\Delta\alpha^{s}+m'\Delta\delta''.$$

$$\Delta\delta_{0}=\Delta\delta+W'\Delta\delta.$$

TABLE II—Continued.

To be used when differences in Right Ascension are determined by Transits.

τ	0^h						I^h						II^h						III^h						
δ	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	60^m
	m' W																								
+10°	0 37	0 37	0 37	0 37	0 37	0 37	0 38	0 38	0 38	0 38	0 39	0 39	0 40	1 41	1 42	1 43	1 44	1 45	1 46	1 48	1 50	2 52	2 55	2 59	2 63
9	0 38	0 38	0 38	0 38	0 38	0 38	0 38	0 39	0 39	0 39	0 40	0 40	0 41	1 42	1 43	1 44	1 45	1 46	1 48	1 50	1 52	2 54	2 57	2 61	3 66
8	0 38	0 38	0 38	0 38	0 39	0 39	0 39	0 39	0 40	0 40	0 41	0 41	1 42	1 43	1 44	1 45	1 46	1 47	1 49	1 51	2 53	2 56	2 59	2 63	3 68
7	0 39	0 39	0 39	0 39	0 40	0 40	0 40	0 40	0 41	0 41	0 42	1 42	1 43	1 44	1 45	1 46	1 47	1 49	1 51	1 53	2 55	2 58	2 62	3 66	3 71
+ 6	0 40	0 40	0 40	0 40	0 41	0 41	0 41	0 41	0 42	0 42	0 43	1 43	1 44	1 45	1 46	1 47	1 49	1 50	1 52	2 54	2 57	2 60	2 64	3 69	3 74
+ 5	0 41	0 41	0 41	0 41	0 42	0 42	0 42	0 42	0 43	0 43	1 44	1 44	1 45	1 46	1 47	1 48	1 50	1 52	1 54	2 56	2 59	2 63	3 67	3 72	4 78
4	0 42	0 42	0 42	0 42	0 43	0 43	0 43	0 43	0 44	1 44	1 45	1 46	1 47	1 48	1 49	1 50	1 52	1 54	2 56	2 58	2 61	2 65	3 69	3 75	4 82
3	0 43	0 43	0 43	0 43	0 44	0 44	0 44	0 44	0 45	1 46	1 46	1 47	1 48	1 49	1 50	1 52	1 54	2 56	2 58	2 61	2 64	3 68	3 72	3 78	4 86
2	0 44	0 44	0 44	0 44	0 45	0 45	0 45	0 46	1 46	1 47	1 48	1 48	1 49	1 50	1 52	1 54	1 56	2 58	2 60	2 63	2 66	3 71	3 76	4 82	4 90
+ 1	0 45	0 45	0 45	0 46	0 46	0 46	0 46	0 47	1 47	1 48	1 49	1 50	1 51	1 52	1 53	1 55	2 57	2 60	2 62	2 65	3 69	3 74	3 79	4 86	5 95
0	0 47	0 47	0 47	0 47	0 47	0 47	0 48	0 48	1 49	1 50	1 51	1 52	1 53	1 54	1 55	1 57	2 59	2 62	2 65	2 68	3 72	3 77	4 83	4 91	5 100
− 1	0 48	0 48	0 48	0 48	0 49	0 49	0 49	1 50	1 50	1 51	1 52	1 53	1 54	1 56	1 57	2 59	2 61	2 64	2 67	3 71	3 75	3 81	4 87	5 96	6 106
2	0 49	0 49	0 49	0 50	0 50	0 50	0 51	1 51	1 52	1 53	1 54	1 55	1 56	1 58	1 60	2 62	2 64	2 67	2 70	3 74	3 79	4 85	4 92	5 101	6 112
3	0 51	0 51	0 51	0 51	0 52	0 52	1 52	1 53	1 54	1 55	1 56	1 57	1 58	1 60	2 62	2 64	2 67	2 70	3 73	3 78	3 83	4 89	5 97	5 107	6 119
4	0 52	0 53	0 53	0 53	0 53	0 54	1 54	1 55	1 56	1 57	1 58	1 59	1 60	1 62	2 64	2 66	2 69	2 72	3 76	3 81	4 87	4 94	5 102	6 113	7 127
− 5	0 54	0 54	0 54	0 55	0 55	0 56	1 56	1 57	1 58	1 59	1 60	1 61	1 63	2 65	2 67	2 69	2 72	3 76	3 80	3 85	4 91	5 99	5 108	6 120	7 135
− 6	0 56	0 56	0 56	0 57	0 57	1 58	1 58	1 59	1 60	1 61	1 62	1 63	2 65	2 67	2 70	2 72	3 75	3 79	3 84	4 89	4 96	5 104	6 115	7 128	8 145
7	0 58	0 58	0 58	0 59	0 59	1 60	1 60	1 61	1 62	1 63	1 64	1 66	2 68	2 70	2 73	2 76	3 79	3 83	3 88	4 94	5 102	5 111	6 122	8 136	9 155
8	0 60	0 60	0 60	0 61	0 61	1 62	1 62	1 63	1 65	1 66	1 67	2 69	2 71	2 73	2 76	3 79	3 83	3 87	4 93	4 100	5 108	6 118	7 130	8 146	10 167
9	0 63	0 63	0 63	0 63	0 63	1 64	1 65	1 66	1 67	1 68	1 70	2 72	2 74	2 77	2 80	3 83	3 87	3 92	4 98	5 105	5 114	6 125	7 139	9 157	11 181
−10	0 65	0 65	0 65	0 66	1 66	1 67	1 68	1 69	1 70	1 71	2 73	2 75	2 77	2 80	3 84	3 88	3 92	4 97	4 104	5 111	6 121	7 133	8 149	10 169	12 196

The tabular quantities are expressed in units of the fifth decimal.
m' changes sign for negative hour angles.
W is always positive.

$$\Delta\alpha^s_0 = \Delta\alpha^s + m'\Delta\delta''.$$

$$\Delta\delta_0 = \Delta\delta + W\Delta\delta.$$

TABLE II—Continued.

To be used when differences in Right Ascension are determined by Transits.

δ \ τ	IV^h						V^h						VI^h						VII^h						
	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	60^m
°	m' W																								
+10	2 63	3 68	3 75	4 83	5 93	6 107	8 126	10 151	13 188																
9	3 66	3 71	4 78	4 87	5 98	7 113	8 134	11 162																	
8	3 68	3 74	4 82	5 92	6 104	7 120	9 143	12 175																	
7	3 71	4 78	4 86	5 97	6 110	8 128	10 154	13 190																	
+ 6	3 74	4 81	5 90	6 102	7 117	9 137	11 166																		
+ 5	4 78	4 86	5 95	6 108	7 124	9 147	12 179																		
4	4 82	4 90	5 100	7 114	8 133	10 158	13 194																		
3	4 86	5 95	6 106	7 122	9 143	11 170																			
2	4 90	5 100	6 113	8 130	10 153	12 184																			
+ 1	5 95	6 106	7 120	9 138	11 164	14 200																			
0	5 100	6 112	7 127	9 148	12 177	15 218																			
− 1	6 106	7 119	8 136	10 159	13 192																				
2	6 112	7 126	9 146	11 172	14 208																				
3	6 119	8 135	10 156	12 186																					
4	7 127	9 145	11 168	13 202																					
− 5	7 135	9 155	12 182	15 220																					
− 6	8 145	10 167	12 198																						
7	9 155	11 180	14 215																						
8	10 167	12 196																							
9	11 181	14 213																							
−10	12 196																								

The tabular quantities are expressed in units of the fifth decimal.
m′ changes sign for negative hour angles.
W is always positive.

$$\Delta\alpha^s_0 = \Delta\alpha^s + m'\Delta\delta''.$$

$$\Delta\delta_0 = \Delta\delta + W\Delta\delta.$$

TABLE II—Continued.

To be used when differences in Right Ascension are determined by Transits.

τ / δ	0^{h}						I^{h}						II^{h}						$\mathrm{III}^{\mathrm{h}}$						
	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	60^{m}
°	m' W																								
—10	0 65	0 65	0 65	0 66	1 66	1 67	1 68	1 69	1 70	1 71	2 73	2 75	2 77	2 80	3 84	3 88	3 92	4 97	4 104	5 111	6 121	7 133	8 149	10 169	12 196
11	0 68	0 68	0 68	0 69	1 69	1 70	1 71	1 72	1 73	1 74	2 76	2 79	2 81	2 84	3 88	3 92	4 97	4 103	5 110	5 118	6 129	7 143	9 160	11 183	
12	0 71	0 71	0 71	0 72	1 72	1 73	1 74	1 75	1 76	2 78	2 80	2 83	2 85	3 88	3 92	3 97	4 102	5 109	5 117	6 126	7 138	8 153	10 173	12 199	
13	0 74	0 74	0 74	0 75	1 75	1 76	1 77	1 78	1 80	2 82	2 84	2 87	2 90	3 93	3 97	4 102	4 108	5 115	6 124	7 135	8 148	9 165	11 187		
—14	0 77	0 77	0 78	1 78	1 79	1 80	1 81	1 82	2 84	2 86	2 88	2 91	3 94	3 98	3 103	4 108	5 115	5 122	6 132	7 144	8 159	10 178	12 203		
—15	0 81	0 81	0 81	1 82	1 83	1 84	1 85	1 86	2 88	2 90	2 93	2 96	3 100	3 104	4 109	4 115	5 122	6 131	7 141	8 154	9 171	11 193	13 222		
16	0 85	0 85	0 85	1 86	1 87	1 88	1 89	2 91	2 93	2 95	2 98	3 101	3 105	4 110	4 116	5 122	5 130	6 140	7 151	8 166	10 185	12 210	14 243		
17	0 90	0 90	0 90	1 90	1 91	1 92	1 94	2 96	2 98	2 101	3 104	3 107	3 111	4 117	4 123	5 130	6 139	7 150	8 163	9 180	11 202	13 229			
18	0 95	0 95	0 95	1 95	1 96	1 97	1 99	2 101	2 104	2 107	3 110	3 114	4 118	4 124	5 131	5 139	6 149	7 161	9 176	10 195	12 220	15 252			
—19	0 100	0 100	0 100	1 101	1 102	1 103	2 105	2 107	2 110	3 113	3 117	3 121	4 126	5 132	5 140	6 149	7 160	8 174	9 191	11 212	13 241				
—20	0 105	0 105	1 106	1 107	1 108	1 109	2 111	2 113	2 116	3 120	3 124	4 129	4 135	5 142	6 150	7 160	8 173	9 188	10 208	12 232	15 265				
21	0 111	0 111	1 112	1 113	1 114	1 116	2 118	2 120	3 123	3 127	4 132	4 138	5 144	5 152	6 161	7 173	8 187	10 205	12 227	14 255	17 293				
22	0 118	0 118	1 119	1 120	1 121	2 123	2 125	2 128	3 132	3 136	4 141	4 148	5 155	6 164	7 174	8 187	9 203	11 223	13 249	15 282					
23	0 126	0 126	1 127	1 128	1 129	2 131	2 134	3 137	3 141	4 146	4 152	5 159	5 167	6 177	7 189	9 203	10 221	12 245	14 274						
—24	0 135	0 135	1 135	1 136	2 138	2 140	2 143	3 147	3 152	4 157	5 163	5 171	6 180	7 191	8 205	9 222	11 243	13 270	16 304						
—25	0 144	0 144	1 145	1 146	2 148	2 151	3 154	3 158	4 163	4 169	5 176	6 185	7 195	8 208	9 224	11 243	13 268	15 299							
26	0 154	0 155	1 156	1 157	2 159	2 162	3 166	3 170	4 176	5 183	5 191	6 201	7 213	9 228	10 246	12 268	14 296								
27	0 166	0 167	1 168	1 170	2 172	3 175	3 179	4 184	4 191	5 198	6 208	7 219	8 233	10 250	11 271	13 297									
28	0 180	0 180	1 181	2 183	2 186	3 190	3 194	4 200	5 208	6 216	7 227	8 240	9 256	11 276	13 300	15 331									
—29	0 195	0 196	1 197	2 199	2 202	3 206	4 212	4 219	5 227	6 237	7 249	9 264	10 283	12 306	14 335										
—30	0 212	0 213	1 214	2 217	3 221	3 226	4 232	5 239	6 249	7 261	8 275	10 292	12 314	14 341											

The tabular quantities are expressed in units of the fifth decimal.
m' changes sign for negative hour angles.
W is always positive.

$$\Delta\alpha^{s}_{0}=\Delta\alpha^{s}+m'\Delta\delta''.$$

$$\Delta\delta_{0}=\Delta\delta+W\Delta\delta.$$

TABLE III.

To be used when Position Angle and Distance are determined.

$\delta=+24°$

τ		0h			Ih			IIh			IIIh				τ	
$p_{+\tau}$		0m	20m	40m	0m	20m	40m	0m	20m	40m	0m	20m	40m	60m		$p_{-\tau}$
°	°	Δp h													°	°
0	180	0 30	0 30	0 30	−1 30	−1 31	−1 31	−1 32	−1 32	0 33	0 34	+1 36	+2 38	+4 41	360	180
15	195	0 30	−1 30	−1 31	−1 31	−1 32	−1 33	−1 34	−1 35	0 37	+1 40	+2 43	+3 47	+6 53	345	165
30	210	−1 30	−1 30	−1 31	−1 32	−1 33	−1 34	−2 36	−2 38	−1 41	0 44	+1 49	+2 56	+3 65	330	150
45	225	−1 29	−1 30	−1 31	−2 32	−2 33	−2 35	−3 37	−3 40	−3 43	−3 48	−3 54	−2 62	−2 73	315	135
60	240	−1 29	−1 29	−2 30	−2 31	−3 33	−3 35	−4 37	−4 40	−5 44	−6 49	−6 55	−8 64	−9 75	300	120
75	255	0 28	−1 29	−2 29	−3 30	−3 32	−4 34	−5 36	−6 39	−7 42	−9 47	−10 53	−12 61	−15 71	285	105
90	270	0 28	−1 28	−2 29	−3 30	−3 31	−4 32	−6 34	−7 36	−9 39	−11 43	−13 48	−16 54	−20 62	270	90
105	285	0 28	−1 28	−1 28	−2 29	−3 29	−4 30	−6 31	−7 33	−9 35	−11 38	−14 41	−17 45	−21 50	255	75
120	300	+1 29	0 29	−1 28	−2 28	−3 28	−4 29	−5 29	−6 30	−8 31	−10 33	−12 34	−15 36	−19 39	240	60
135	315	+1 29	0 29	−1 28	−1 28	−2 28	−3 28	−4 28	−5 29	−6 29	−8 29	−10 30	−12 30	−14 31	225	45
150	330	+1 30	0 30	0 29	−1 29	−1 29	−2 29	−3 29	−3 28	−4 28	−5 28	−6 28	−6 28	−7 28	210	30
165	345	0 30	0 30	0 30	−1 30	−1 30	−1 30	−2 30	−2 30	−2 30	−2 30	−2 30	−1 31	0 32	195	15
180	360	0 30	0 30	0 30	−1 30	−1 31	−1 31	−1 32	−1 32	0 33	0 34	+1 36	+2 38	+4 41	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta=+22°$

τ $p_{+\tau}$		0^h			I^h			II^h			III^h				τ $p_{-\tau}$	
		0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	60^m		
		Δp h														
0°	180°	0 31	0 31	0 31	0 31	0 32	0 32	0 32	0 33	0 34	+ 1 35	+ 2 37	+ 4 40	+ 6 43	360°	180°
15	195	0 31	− 1 31	− 1 31	− 1 32	− 1 33	− 1 34	0 35	0 36	+ 1 38	+ 2 41	+ 3 45	+ 5 50	+ 7 56	345	165
30	210	− 1 30	− 1 31	− 1 32	− 1 33	− 1 34	− 1 35	− 1 37	− 1 39	− 1 42	0 46	+ 1 52	+ 3 59	+ 4 69	330	150
45	225	− 1 30	− 1 30	− 1 31	− 2 32	− 2 34	− 2 36	− 3 38	− 3 41	− 3 45	− 3 50	− 2 56	− 2 65	− 1 77	315	135
60	240	− 1 29	− 1 30	− 2 31	− 2 32	− 3 33	− 3 35	− 4 38	− 4 41	− 5 45	− 6 50	− 7 57	− 8 67	− 9 79	300	120
75	255	0 28	− 1 29	− 2 30	− 3 31	− 3 32	− 4 34	− 5 36	− 6 39	− 7 43	− 9 48	−11 54	−13 63	−16 74	285	105
90	270	0 28	− 1 28	− 2 29	− 3 30	− 4 31	− 5 32	− 6 34	− 7 36	− 9 39	−11 44	−13 49	−17 55	−21 64	270	90
105	285	0 28	0 28	− 1 28	− 2 29	− 3 29	− 4 30	− 6 31	− 7 33	− 9 35	−11 38	−14 42	−17 46	−22 51	255	75
120	300	+ 1 29	0 28	− 1 28	− 2 28	− 3 28	− 4 29	− 5 29	− 6 30	− 8 31	−10 32	−12 34	−15 36	−19 38	240	60
135	315	+ 1 30	0 29	0 29	− 1 28	− 2 28	− 2 28	− 3 28	− 4 28	− 6 29	− 7 29	− 9 29	−11 30	−13 30	225	45
150	330	+ 1 30	0 30	0 29	− 1 29	− 1 29	− 1 29	− 2 28	− 3 28	− 3 28	− 4 28	− 5 28	− 5 28	− 6 28	210	30
165	345	0 31	0 30	0 30	0 30	0 30	− 1 30	− 1 30	− 1 30	− 1 30	− 1 31	− 1 31	0 32	+ 1 33	195	15
180	360	0 31	0 31	0 31	0 31	0 32	0 32	0 32	0 33	0 34	+ 1 35	+ 2 37	+ 4 40	+ 6 43	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = +20°$

$p_{+\tau}$ \ τ		0^h			I^h			II^h			III^h				τ / $p_{-\tau}$	
		0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	60^m		
°	°	Δp h													°	°
0	180	0 32	0 32	0 32	0 32	0 32	0 33	0 33	+ 1 34	+ 1 35	+ 2 37	+ 3 39	+ 5 42	+ 8 46	360	180
15	195	0 31	− 1 32	− 1 32	− 1 33	0 34	0 35	0 36	0 38	+ 1 40	+ 2 43	+ 4 47	+ 6 52	+ 9 60	345	165
30	210	− 1 31	− 1 31	− 1 32	− 1 33	− 1 34	− 1 36	− 1 38	− 1 41	0 44	+ 1 49	+ 2 54	+ 3 62	+ 5 73	330	150
45	225	− 1 30	− 1 31	− 2 32	− 2 33	− 2 34	− 2 37	− 2 39	− 2 42	− 2 46	− 2 52	− 2 59	− 2 68	− 1 81	315	135
60	240	− 1 29	− 1 30	− 2 31	− 2 32	− 3 34	− 3 36	− 4 39	− 4 42	− 5 46	− 6 52	− 7 60	− 8 70	− 9 83	300	120
75	255	0 28	− 1 29	− 2 30	− 3 31	− 3 32	− 4 34	− 5 37	− 6 40	− 8 44	− 9 49	−11 56	−13 65	−17 77	285	105
90	270	0 28	− 1 28	− 2 29	− 3 30	− 4 31	− 5 32	− 6 34	− 7 37	− 9 40	−11 44	−14 50	−17 57	−21 66	270	90
105	285	0 28	0 28	− 1 28	− 2 29	− 3 29	− 4 30	− 6 31	− 7 33	− 9 35	−11 38	−14 41	−18 46	−22 52	255	75
120	300	+ 1 29	0 28	− 1 28	− 1 28	− 2 28	− 3 29	− 4 29	− 6 30	− 8 31	−10 32	−12 34	−15 36	−19 39	240	60
135	315	+ 1 30	+ 1 29	0 29	− 1 28	− 1 28	− 2 28	− 3 28	− 4 28	− 5 28	− 7 29	− 8 29	−10 30	−13 30	225	45
150	330	+ 1 31	+ 1 30	0 30	0 29	0 29	− 1 29	− 1 29	− 2 29	− 2 29	− 3 29	− 4 28	− 4 28	− 5 28	210	30
165	345	0 31	0 31	0 31	0 31	0 30	0 31	0 31	0 31	0 31	0 31	+ 1 32	+ 2 33	+ 3 34	195	15
180	360	0 32	0 32	0 32	0 32	0 32	0 33	0 33	+ 1 34	+ 1 35	+ 2 37	+ 3 39	+ 5 42	+ 8 46	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta=+18°$

τ $p_{+\tau}$		0^h			I^h			II^h			III^h				τ $p_{-\tau}$	
		0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	60^m		
°	°	Δp h													°	°
0	180	0 32	0 32	0 32	0 33	0 33	+1 34	+1 34	+2 35	+3 36	+4 38	+5 40	+7 44	+10 48	360	180
15	195	−1 32	−1 32	0 33	0 34	0 35	0 36	0 37	+1 39	+2 42	+3 45	+5 49	+7 55	+11 64	345	165
30	210	−1 31	−1 32	−1 33	−1 34	−1 36	−1 38	−1 40	0 42	0 46	+1 51	+2 57	+4 66	+7 78	330	150
45	225	−1 30	−2 31	−2 32	−2 34	−2 36	−2 38	−2 40	−2 44	−2 48	−2 54	−2 62	−1 72	−1 86	315	135
60	240	−1 29	−2 30	−2 31	−3 33	−3 35	−4 37	−4 40	−5 43	−5 48	−6 54	−7 62	−8 73	−9 87	300	120
75	255	−1 28	−1 29	−2 30	−3 31	−4 33	−5 35	−6 37	−7 41	−8 45	−9 51	−11 58	−14 68	−17 81	285	105
90	270	0 28	−1 28	−2 29	−3 30	−4 31	−5 32	−6 34	−7 37	−9 41	−11 45	−14 50	−18 58	−22 68	270	90
105	285	+1 28	0 28	−1 28	−2 29	−3 29	−4 30	−6 31	−7 33	−9 35	−11 38	−14 41	−18 46	−23 53	255	75
120	300	+1 29	0 29	0 28	−1 28	−2 28	−3 29	−4 29	−5 30	−7 31	−9 32	−12 34	−15 36	−19 39	240	60
135	315	+1 30	+1 30	0 29	0 29	−1 28	−2 28	−2 28	−3 28	−5 28	−6 29	−8 29	−9 29	−11 30	225	45
150	330	+1 31	+1 31	+1 30	0 30	0 30	0 29	−1 29	−1 29	−1 29	−2 29	−2 29	−3 29	−3 29	210	30
165	345	+1 32	+1 32	+1 31	+1 31	+1 31	+1 31	+1 31	+1 31	+1 32	+1 32	+2 33	+3 34	+5 35	195	15
180	360	0 32	0 32	0 32	0 33	0 33	+1 34	+1 34	+2 35	+3 36	+4 38	+5 40	+7 44	+10 48	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = +16°$															
τ / $p_{+\tau}$		0^{h}			I^{h}			II^{h}			$\mathrm{III}^{\mathrm{h}}$			τ / $p_{-\tau}$	
		0^{m}	20^{m}	40^{m}	0^{m}	20^{m}	40^{m}	0^{m}	20^{m}	40^{m}	0^{m}	20^{m}	40^{m}	60^{m}		
		Δp h														
0°	180°	0 33	0 33	0 33	+1 34	+1 34	+1 35	+2 36	+2 37	+3 38	+5 40	+6 42	+9 46	+12 51	360°	180°
15	195	−1 33	−1 33	0 34	0 35	0 36	0 37	+1 39	+2 41	+3 44	+4 47	+6 52	+9 59	+13 68	345	165
30	210	−1 32	−1 33	−1 34	−1 35	−1 37	−1 39	0 41	0 44	+1 48	+2 54	+3 60	+5 70	+8 83	330	150
45	225	−1 31	−2 32	−2 33	−2 34	−2 36	−2 39	−2 42	−2 46	−2 50	−2 57	−2 65	−1 76	0 92	315	135
60	240	−1 30	−2 31	−2 32	−3 33	−3 35	−4 37	−4 41	−5 45	−6 50	−6 56	−7 65	−8 77	−10 93	300	120
75	255	−1 29	−1 29	−2 30	−3 31	−4 33	−5 35	−6 38	−7 42	−8 46	−10 52	−12 60	−15 70	−18 85	285	105
90	270	0 28	−1 28	−2 29	−3 30	−4 31	−5 32	−6 34	−8 37	−9 41	−12 46	−15 52	−18 60	−24 70	270	90
105	285	+1 29	0 28	−1 28	−2 29	−3 29	−4 30	−5 31	−7 33	−9 35	−11 38	−15 42	−19 47	−24 54	255	75
120	300	+1 30	+1 29	0 28	−1 28	−2 28	−3 28	−4 29	−5 30	−7 31	−9 32	−12 34	−15 36	−19 39	240	60
135	315	+1 31	+1 30	+1 29	0 29	−1 28	−1 28	−2 28	−3 28	−4 28	−5 28	−7 29	−9 29	−11 30	225	45
150	330	+1 32	+1 31	+1 30	+1 30	0 30	0 30	0 29	0 29	−1 29	−1 29	−1 29	−2 29	−2 29	210	30
165	345	+1 33	+1 32	+1 32	+1 32	+1 32	+1 32	+1 32	+2 32	+2 33	+3 33	+4 34	+5 35	+7 37	195	15
180	360	0 33	0 33	0 33	+1 34	+1 34	+1 35	+2 36	+2 37	+3 38	+5 40	+6 42	+9 46	+12 51	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = +14°$

τ		0^h			I^h			II^h			III^h				τ	
$p_{+\tau}$		0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	60^m	$p_{-\tau}$	
°	°	Δp h													°	°
0	180	0 34	0 34	+ 1 34	+ 1 35	+ 1 35	+ 2 36	+ 2 37	+ 3 38	+ 4 40	+ 6 42	+ 8 45	+11 49	+15 55	360	180
15	195	− 1 34	− 1 34	0 35	0 36	0 37	+ 1 39	+ 1 40	+ 2 43	+ 3 46	+ 5 50	+ 7 55	+10 63	+15 73	345	165
30	210	− 2 33	− 1 34	− 1 35	− 1 36	− 1 38	− 1 40	0 43	0 46	+ 1 51	+ 2 56	+ 4 64	+ 6 75	+ 9 89	330	150
45	225	− 2 31	− 2 32	− 2 34	− 2 36	− 3 38	− 3 40	− 3 43	− 2 47	− 2 53	− 2 60	− 1 69	− 1 81	0 98	315	135
60	240	− 2 30	− 2 31	− 3 32	− 3 34	− 4 36	− 4 39	− 5 42	− 5 46	− 6 52	− 7 59	− 8 68	− 9 81	−10 99	300	120
75	255	− 1 28	− 2 29	− 2 30	− 3 32	− 4 34	− 5 36	− 6 39	− 7 42	− 9 47	−11 54	−13 63	−16 74	−19 89	285	105
90	270	0 28	− 1 28	− 2 29	− 3 30	− 4 31	− 5 33	− 6 35	− 8 38	−10 41	−12 46	−15 53	−19 62	−25 73	270	90
105	285	+ 1 28	0 28	− 1 28	− 2 28	− 3 29	− 4 30	− 5 31	− 7 33	− 9 35	−12 38	−15 42	−19 48	−25 55	255	75
120	300	+ 2 30	+ 1 29	0 28	− 1 28	− 1 28	− 2 28	− 4 29	− 5 29	− 7 30	− 9 32	−12 34	−15 36	−20 39	240	60
135	315	+ 2 31	+ 1 30	+ 1 30	0 29	0 29	− 1 28	− 1 28	− 2 28	− 3 28	− 5 28	− 6 29	− 8 29	−10 30	225	45
150	330	+ 2 33	+ 1 32	+ 1 31	+ 1 31	+ 1 31	+ 1 30	+ 1 30	+ 1 30	0 29	0 29	0 29	0 29	0 29	210	30
165	345	+ 1 34	+ 1 33	+ 1 33	+ 1 33	+ 2 33	+ 2 33	+ 2 33	+ 2 33	+ 3 34	+ 4 34	+ 5 35	+ 7 37	+ 9 39	195	15
180	360	0 34	0 34	+ 1 34	+ 1 35	+ 1 35	+ 2 36	+ 2 37	+ 3 38	+ 4 40	+ 6 42	+ 8 45	+11 49	+15 55	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta=+12°$

$p_{+\tau}$	τ	0h			Ih			IIh			IIIh				τ	$p_{-\tau}$
		0m	20m	40m	0m	20m	40m	0m	20m	40m	0m	20m	40m	60m		
°	°	Δp h													°	°
0	180	0 36	0 36	+1 36	+1 36	+2 36	+3 37	+3 38	+4 40	+5 42	+7 44	+10 47	+13 52	+17 58	360	180
15	195	−1 35	−1 36	0 36	0 37	+1 38	+1 40	+2 42	+3 45	+4 48	+6 53	+9 59	+12 67	+17 79	345	165
30	210	−2 34	−2 35	−1 36	−1 37	−1 39	−1 42	0 45	+1 48	+2 53	+3 60	+5 68	+7 80	+11 96	330	150
45	225	−2 32	−2 33	−2 34	−3 36	−3 38	−3 41	−3 45	−3 50	−2 55	−2 63	−1 73	0 86	+1 105	315	135
60	240	−2 30	−2 31	−3 32	−3 34	−4 36	−4 39	−5 43	−6 48	−6 54	−7 62	−8 72	−9 86	−11 105	300	120
75	255	−1 29	−2 30	−3 31	−3 32	−4 34	−5 36	−6 39	−7 43	−9 49	−11 56	−13 65	−16 78	−21 94	285	105
90	270	0 28	−1 28	−2 29	−3 30	−4 31	−5 33	−6 35	−8 38	−10 42	−13 47	−16 54	−20 64	−26 76	270	90
105	285	+1 29	0 28	−1 28	−2 28	−3 29	−4 30	−5 31	−7 33	−9 35	−12 38	−15 42	−20 48	−26 56	255	75
120	300	+2 30	+1 29	0 29	0 28	−1 28	−2 28	−3 29	−5 29	−6 30	−8 31	−11 33	−15 36	−20 39	240	60
135	315	+2 32	+2 31	+1 30	+1 30	+1 29	0 29	−1 28	−2 28	−3 28	−4 28	−5 28	−7 29	−10 29	225	45
150	330	+2 34	+2 33	+2 32	+2 32	+2 31	+1 31	+1 30	+1 30	+1 30	+1 30	+1 30	+2 30	+2 30	210	30
165	345	+1 35	+1 34	+2 34	+2 34	+2 34	+2 34	+3 34	+3 34	+4 35	+5 36	+7 37	+9 38	+12 40	195	15
180	360	0 36	0 36	+1 36	+1 36	+2 36	+3 37	+3 38	+4 40	+5 42	+7 44	+10 47	+13 52	+17 58	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = +10°$

$p_{+\tau}$	τ	0^h			I^h			II^h			III^h				τ	$p_{-\tau}$
		0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	60^m		
		Δp h														
0°	180°	0 37	0 37	+ 1 37	+ 1 38	+ 2 38	+ 3 39	+ 4 40	+ 5 42	+ 6 44	+ 8 47	+11 50	+15 55	+21 63	360°	180°
15	195	− 1 36	− 1 37	0 38	0 39	0 40	+ 1 42	+ 2 44	+ 3 47	+ 5 51	+ 7 56	+10 63	+14 72	+20 85	345	165
30	210	− 2 34	− 2 36	− 2 37	− 2 39	− 1 41	− 1 44	0 47	+ 1 51	+ 2 56	+ 3 63	+ 6 73	+ 9 86	+13 104	330	150
45	225	− 2 32	− 3 34	− 3 36	− 3 38	− 3 40	− 3 43	− 3 47	− 3 52	− 2 58	− 2 66	− 1 77	0 93	+ 1 114	315	135
60	240	− 2 30	− 3 32	− 3 33	− 4 35	− 4 37	− 5 40	− 5 44	− 6 49	− 6 56	− 7 65	− 8 76	−10 91	−12 113	300	120
75	255	− 1 29	− 2 30	− 3 31	− 4 32	− 5 34	− 6 37	− 7 40	− 8 44	−10 50	−12 58	−14 68	−18 82	−23 100	285	105
90	270	0 28	− 1 28	− 2 29	− 3 30	− 4 31	− 5 33	− 7 35	− 9 38	−11 43	−13 48	−17 56	−22 66	−28 80	270	90
105	285	+ 1 29	0 28	− 1 28	− 2 28	− 3 29	− 4 30	− 5 31	− 7 33	− 9 35	−12 38	−16 43	−21 49	−27 58	255	75
120	300	+ 2 30	+ 1 30	0 29	0 28	− 1 28	− 2 28	− 3 28	− 4 29	− 6 30	− 8 31	−11 33	−15 36	−20 39	240	60
135	315	+ 2 32	+ 2 32	+ 1 31	+ 1 30	+ 1 29	0 29	0 28	− 1 28	− 2 28	− 3 28	− 4 28	− 6 29	− 9 29	225	45
150	330	+ 2 34	+ 2 34	+ 2 33	+ 2 32	+ 2 32	+ 2 31	+ 2 31	+ 2 31	+ 2 30	+ 3 30	+ 3 30	+ 3 30	+ 4 30	210	30
165	345	+ 1 36	+ 1 36	+ 2 35	+ 2 35	+ 3 35	+ 3 35	+ 4 35	+ 4 36	+ 5 36	+ 7 37	+ 9 38	+11 40	+15 43	195	15
180	360	0 37	0 37	+ 1 37	+ 1 38	+ 2 38	+ 3 39	+ 4 40	+ 5 42	+ 6 44	+ 8 47	+11 50	+15 55	+21 63	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p$.
$s_0 = s + hs$.

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta=+8°$																
$p_{+\tau}$ \ τ		0^{h}			I^{h}			II^{h}			$\mathrm{III}^{\mathrm{h}}$				τ / $p_{-\tau}$	
		0^{m}	20^{m}	40^{m}	0^{m}	20^{m}	40^{m}	0^{m}	20^{m}	40^{m}	0	20^{m}	40^{m}	60^{m}		
°	°	Δp h													°	°
0	180	0 38	+1 38	+1 39	+2 39	+3 40	+4 41	+5 42	+6 44	+8 46	+10 49	+13 53	+18 59	+24 68	360	180
15	195	−2 38	−1 38	0 39	0 40	+1 42	+2 44	+3 47	+4 50	+6 54	+8 60	+11 68	+16 79	+23 93	345	165
30	210	−3 36	−2 37	−2 38	−2 40	−1 43	−1 46	0 49	+1 54	+2 60	+4 68	+6 78	+9 93	+15 113	330	150
45	225	−3 33	−3 35	−3 37	−3 39	−3 41	−3 45	−3 49	−3 54	−2 61	−2 70	−1 82	0 100	+1 124	315	135
60	240	−2 31	−3 32	−3 34	−4 36	−4 38	−5 42	−5 46	−6 51	−7 58	−8 68	−9 80	−11 97	−13 122	300	120
75	255	−1 29	−2 30	−3 31	−4 33	−5 35	−6 37	−7 41	−8 46	−10 52	−12 60	−15 71	−19 86	−25 107	285	105
90	270	0 28	−1 28	−2 29	−3 30	−4 31	−5 33	−7 36	−9 39	−11 44	−14 49	−18 57	−23 69	−30 85	270	90
105	285	+1 29	+1 28	0 28	−1 28	−2 29	−3 30	−5 31	−7 33	−9 36	−12 39	−16 44	−22 50	−29 60	255	75
120	300	+2 31	+2 30	+1 29	+1 28	0 28	−1 28	−2 28	−4 29	−6 30	−8 31	−11 33	−15 36	−21 39	240	60
135	315	+3 33	+3 32	+2 31	+2 30	+2 30	+1 29	+1 29	0 28	−1 28	−2 28	−3 28	−5 28	−8 29	225	45
150	330	+3 36	+3 35	+3 34	+3 33	+3 33	+3 32	+3 32	+3 31	+4 31	+4 31	+4 31	+5 31	+7 31	210	30
165	345	+1 38	+2 37	+2 37	+3 36	+3 36	+4 37	+5 37	+6 37	+7 38	+8 38	+10 40	+13 42	+18 46	195	15
180	360	0 38	+1 38	+1 39	+2 39	+3 40	+4 41	+5 42	+6 44	+8 46	+10 49	+13 53	+18 59	+24 68	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

Table III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = +6°$

τ $p_{+\tau}$		0^h			I^h			II^h			III^h				τ $p_{-\tau}$	
		0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	60^m		
°	°	Δp h													°	°
0	180	0 40	+ 1 40	+ 1 40	+ 2 41	+ 3 42	+ 4 43	+ 6 44	+ 7 46	+ 9 49	+12 52	+16 57	+21 64	+28 74	360	180
15	195	− 2 39	− 1 40	0 41	0 42	+ 1 44	+ 2 46	+ 3 49	+ 5 53	+ 7 58	+10 64	+14 72	+19 84	+26 102	345	165
30	210	− 3 37	− 2 38	− 2 40	− 2 42	− 1 45	− 1 48	0 52	+ 1 57	+ 3 63	+ 5 72	+ 7 84	+11 100	+17 124	330	150
45	225	− 3 34	− 3 36	− 3 38	− 4 40	− 3 43	− 3 47	− 3 51	− 3 57	− 2 65	− 2 75	− 1 88	0 107	+ 2 135	315	135
60	240	− 3 31	− 3 32	− 4 34	− 5 37	− 5 40	− 5 43	− 6 48	− 7 54	− 8 61	− 9 71	−10 85	−12 104	−14 132	300	120
75	255	− 2 29	− 2 30	− 3 31	− 4 33	− 5 35	− 6 38	− 7 42	− 9 47	−11 54	−13 63	−16 74	−21 91	−27 115	285	105
90	270	0 28	− 1 28	− 2 29	− 3 30	− 4 31	− 5 33	− 7 36	− 9 40	−12 44	−15 51	−19 60	−25 72	−33 90	270	90
105	285	+ 2 29	+ 1 28	0 28	− 1 28	− 2 29	− 3 30	− 5 31	− 7 33	−10 36	−13 39	−17 44	−23 51	−31 62	255	75
120	300	+ 3 31	+ 2 30	+ 2 29	+ 1 28	0 28	− 1 28	− 2 28	− 4 29	− 6 30	− 8 31	−11 33	−15 36	−22 40	240	60
135	315	+ 3 34	+ 3 33	+ 3 32	+ 3 31	+ 2 30	+ 2 29	+ 1 29	+ 1 28	0 28	− 1 28	− 2 28	− 4 28	− 7 29	225	45
150	330	+ 3 37	+ 3 36	+ 3 35	+ 4 34	+ 4 34	+ 4 33	+ 4 32	+ 5 32	+ 5 32	+ 5 32	+ 6 32	+ 7 32	+ 9 32	210	30
165	345	+ 2 39	+ 2 38	+ 2 38	+ 3 38	+ 4 38	+ 5 38	+ 6 38	+ 7 39	+ 8 39	+10 40	+12 42	+16 45	+22 49	195	15
180	360	0 40	+ 1 40	+ 1 40	+ 2 41	+ 3 42	+ 4 43	+ 6 44	+ 7 46	+ 9 49	+12 52	+16 57	+21 64	+28 74	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta=+4°$

τ $p_{+\tau}$		0h			Ih			IIh			IIIh				τ $p_{-\tau}$	
		0m	20m	40m	0m	20m	40m	0m	20m	40m	0m	20m	40m	60m		
		Δp h														
0°	180°	0 42	+1 42	+2 42	+3 43	+4 44	+5 45	+7 47	+8 49	+11 52	+14 56	+18 61	+24 69	+33 82	360°	180°
15	195	−2 41	−1 42	0 43	+1 45	+2 47	+3 49	+4 52	+6 56	+8 61	+11 68	+15 78	+21 92	+30 112	345	165
30	210	−3 38	−3 40	−3 42	−2 44	−1 47	0 51	+1 55	+2 60	+3 67	+5 77	+8 90	+13 109	+19 137	330	150
45	225	−4 35	−4 37	−4 39	−4 42	−4 45	−4 49	−3 54	−3 60	−3 69	−2 80	−1 95	0 117	+2 148	315	135
60	240	−3 32	−4 33	−4 35	−5 38	−5 41	−6 45	−6 50	−7 56	−8 64	−9 75	−11 90	−13 112	−15 144	300	120
75	255	−2 29	−3 30	−4 32	−5 34	−6 36	−7 39	−8 44	−10 49	−12 56	−14 65	−18 78	−23 97	−30 125	285	105
90	270	0 28	−1 28	−2 29	−3 30	−4 32	−6 34	−8 37	−10 40	−13 45	−16 52	−20 62	−27 76	−36 96	270	90
105	285	+2 29	+1 28	0 28	−1 28	−2 29	−4 30	−5 31	−7 33	−10 36	−13 40	−18 45	−24 53	−34 65	255	75
120	300	+3 32	+3 30	+2 29	+1 29	0 28	−1 28	−2 28	−3 29	−5 30	−8 31	−11 33	−16 36	−22 40	240	60
135	315	+4 35	+4 33	+4 32	+3 31	+3 30	+3 30	+2 29	+2 29	+1 28	0 28	−1 28	−3 28	−6 28	225	45
150	330	+3 38	+4 37	+4 36	+4 35	+5 34	+5 34	+5 33	+6 33	+6 33	+7 33	+8 33	+10 33	+12 33	210	30
165	345	+2 41	+3 40	+3 40	+4 39	+5 39	+6 39	+7 40	+8 40	+10 41	+12 43	+15 45	+20 48	+26 52	195	15
180	360	0 42	+1 42	+2 42	+3 43	+4 44	+5 45	+7 47	+8 49	+11 52	+14 56	+18 61	+24 69	+33 82	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = +2°$

$p_{+\tau}$ \ τ		0^h			I^h			II^h			III^h				τ / $p_{-\tau}$	
		0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	0^m	20^m	40^m	60^m		
°	°	Δp h													°	°
0	180	0 44	+1 44	+2 45	+3 45	+4 46	+6 48	+8 50	+10 52	+12 55	+16 60	+21 66	+28 76	+38 90	360	180
15	195	−2 43	−1 44	0 45	+1 47	+2 49	+3 52	+5 55	+7 60	+9 66	+13 74	+18 85	+24 101	+34 125	345	165
30	210	−4 40	−3 42	−3 44	−2 46	−1 49	0 53	+1 58	+2 64	+4 72	+6 83	+10 98	+15 119	+21 152	330	150
45	225	−5 36	−5 38	−5 40	−5 43	−4 47	−4 51	−4 57	−3 64	−3 73	−2 86	−1 103	0 127	+3 164	315	135
60	240	−4 32	−4 34	−5 36	−6 39	−6 42	−7 46	−7 52	−8 59	−9 68	−10 80	−12 97	−14 121	−17 158	300	120
75	255	−2 29	−3 30	−4 32	−5 34	−6 37	−7 40	−9 45	−11 50	−13 58	−16 69	−20 83	−25 104	−33 136	285	105
90	270	0 28	−1 28	−2 29	−3 30	−4 32	−6 34	−8 37	−10 41	−13 47	−17 54	−22 65	−29 80	−40 102	270	90
105	285	+2 29	+1 29	0 28	−1 28	−2 29	−3 30	−5 31	−8 33	−10 36	−14 40	−19 46	−26 54	−36 68	255	75
120	300	+4 32	+3 31	+3 30	+2 29	+1 28	0 28	−1 28	−3 29	−5 30	−7 31	−11 33	−16 36	−23 41	240	60
135	315	+5 36	+4 34	+4 33	+4 32	+4 31	+4 30	+3 30	+3 29	+2 29	+1 28	0 28	−2 28	−5 28	225	45
150	330	+4 40	+4 39	+5 38	+5 37	+6 36	+6 35	+7 34	+7 34	+8 34	+9 34	+10 34	+12 34	+15 34	210	30
165	345	+2 43	+3 42	+4 42	+5 41	+6 41	+7 42	+8 42	+10 43	+12 44	+15 46	+18 48	+23 51	+31 57	195	15
180	360	0 44	+1 44	+2 45	+3 45	+4 46	+6 48	+8 50	+10 52	+12 55	+16 60	+21 66	+28 76	+38 90	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_\circ = p + \Delta p.$
$s_\circ = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = 0°$

$p_{+\tau}$ \ τ		0^h						I^h						II^h							τ / $p_{-\tau}$	
		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	60^m		
°	°	Δp h																			°	°
0	180	0_0 46_1	+1 47	+1 47	+2 47	+2 47	+3 47	$+4_0$ 48_1	+4 48	+5 49	+6 50	+7 51	+8 52	$+9_1$ 53_2	+10 54	+11 55	+12 57	+14 59	+16 62	$+18_1$ 65_3	360	180
5	185	−1 46	0 47	0 47	+1 47	+1 48	+2 48	+3 49	+3 49	+4 50	+5 51	+6 52	+7 54	+8 56	+9 57	+10 59	+11 61	+13 63	+15 66	+17 70	355	175
10	190	−2 46	−1 46	−1 47	0 47	0 48	+1 49	+2 49	+2 50	+3 51	+4 52	+5 54	+6 56	+7 58	+8 60	+9 62	+10 64	+12 67	+14 71	+16 75	350	170
15	195	−3 45	−2 46	−2 46	−1 47	−1 48	0 49	+1 50	+1 51	+2 52	+3 54	+3 56	+4 58	+5 60	+6 62	+8 64	+9 67	+11 71	+13 75	+15 80	345	165
20	200	−3 44	−3 45	−2 46	−2 47	−2 48	−1 49	0 50	0 51	+1 53	+1 55	+2 57	+3 59	+4 61	+5 63	+6 66	+7 70	+9 74	+11 79	+13 84	340	160
25	205	−4 43	−4 44	−3 45	−3 46	−2 47	−2 48	−1 50	−1 51	0 53	0 55	+1 57	+1 59	+2 61	+3 64	+4 68	+5 72	+7 77	+8 82	+10 87	335	155
30	210	-5_0 42_1	−4 43	−4 44	−4 45	−3 46	−3 47	-2_0 49_1	−2 50	−2 52	−1 54	−1 56	0 59	$+1_0$ 62_2	+1 65	+2 69	+3 73	+4 78	+6 84	$+7_0$ 90_4	330	150
35	215	−5 41	−5 42	−4 43	−4 44	−4 45	−4 46	−3 48	−3 50	−3 52	−2 54	−2 56	−2 59	−1 62	0 65	0 69	+1 73	+2 78	+3 85	+4 92	325	145
40	220	−5 39	−5 40	−5 41	−5 42	−5 44	−4 45	−4 47	−4 49	−4 51	−4 53	−3 55	−3 58	−3 61	−2 65	−2 69	−1 74	−1 79	0 85	+1 92	320	140
45	225	−5 37	−5 38	−5 40	−5 41	−5 42	−5 44	−5 45	−5 47	−5 49	−5 52	−5 54	−4 57	−4 60	−4 64	−4 68	−4 73	−3 78	−3 85	−2 92	315	135
50	230	−5 36	−5 37	−5 38	−5 39	−6 40	−6 42	−6 44	−6 46	−6 48	−6 50	−6 52	−6 55	−6 58	−6 62	−6 66	−6 71	−6 77	−6 84	−6 91	310	130
55	235	−5 34	−5 35	−5 36	−5 38	−6 39	−6 40	−6 42	−6 44	−6 46	−6 48	−7 50	−7 53	−7 56	−7 60	−7 64	−8 69	−8 75	−8 82	−8 89	305	125
60	240	-5_0 33_0	−5 34	−5 35	−5 36	−6 37	−6 39	-6_0 40_1	−6 42	−7 44	−7 46	−7 48	−8 51	-8_0 54_1	−8 58	−9 62	−9 67	−10 72	−11 79	-11_1 86_3	300	120
65	245	−4 31	−4 32	−5 33	−5 34	−5 35	−6 37	−6 38	−6 40	−7 42	−7 44	−8 46	−8 49	−9 52	−9 55	−10 59	−11 64	−12 69	−13 75	−14 82	295	115
70	250	−3 30	−4 31	−4 32	−5 33	−5 34	−6 35	−6 36	−6 38	−7 40	−8 42	−8 44	−9 46	−9 49	−10 52	−11 56	−12 60	−13 65	−14 71	−16 78	290	110
75	255	−3 30	−3 30	−4 31	−4 32	−5 33	−5 34	−6 35	−6 36	−7 38	−7 40	−8 42	−9 44	−10 46	−11 49	−12 52	−13 56	−14 61	−15 67	−17 73	285	105
80	260	−2 29	−2 29	−3 30	−3 30	−4 31	−4 32	−5 33	−6 34	−6 36	−7 37	−8 39	−9 41	−10 43	−11 46	−12 49	−13 53	−14 57	−16 62	−18 67	280	100
85	265	−1 28	−1 29	−2 29	−3 29	−3 30	−4 31	−4 32	−5 33	−6 34	−7 35	−7 36	−8 38	−9 40	−10 43	−11 46	−12 49	−14 53	−16 57	−18 62	275	95
90	270	0_0 28_0	−1 28	−1 29	−2 29	−2 29	−3 30	-4_0 30_0	−4 31	−5 32	−6 33	−7 34	−8 36	-9_0 38_0	−10 40	−11 42	−12 45	−14 48	−16 52	-18_1 56_1	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta=0°$

	τ	0^h						I^h						II^h							τ	
$p_{+\tau}$		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	60^m		$p_{-\tau}$
°	°	Δp h																			°	°
90	270	0_0 28_0	−1 28	−1 29	−2 29	−2 29	−3 30	-4_0 30_0	−4 31	−5 32	−6 33	−7 34	−8 36	-9_0 38_0	−10 40	−11 42	−12 45	−14 48	−16 52	-18_1 56_1	270	90
95	275	+1 28	0 28	0 28	−1 28	−1 28	−2 29	−3 29	−3 30	−4 31	−5 31	−6 32	−7 34	−8 35	−9 37	−10 39	−11 41	−13 44	−15 47	−17 51	265	85
100	280	+2 29	+1 29	+1 29	0 28	0 28	−1 29	−2 29	−2 29	−3 30	−4 30	−5 31	−6 32	−7 33	−8 34	−9 36	−10 38	−12 40	−14 43	−16 46	260	80
105	285	+3 30	+2 29	+2 29	+1 29	+1 28	0 28	−1 28	−1 29	−2 29	−3 29	−3 30	−4 30	−5 31	−6 32	−8 33	−9 35	−11 37	−13 39	−15 41	255	75
110	290	+3 30	+3 30	+2 30	+2 29	+2 29	+1 29	0 28	0 28	−1 28	−1 28	−2 29	−3 29	−4 30	−5 30	−6 31	−7 32	−9 34	−11 35	−13 37	250	70
115	295	+4 32	+4 31	+3 31	+3 30	+2 29	+2 29	+1 28	+1 28	0 28	0 28	−1 28	−1 28	−2 29	−3 29	−4 29	−5 30	−7 31	−8 32	−10 34	245	65
120	300	$+5_0$ 33_0	+4 32	+4 32	+4 31	+3 30	+3 30	$+2_0$ 29_0	+2 29	+2 29	+1 28	+1 28	0 28	-1_0 28_0	−1 28	−2 28	−3 29	−4 30	−6 30	-7_0 31_0	240	60
125	305	+5 34	+5 34	+4 33	+4 32	+4 31	+4 31	+3 30	+3 30	+3 29	+2 29	+2 29	+2 28	+1 28	0 28	0 28	−1 29	−2 29	−3 29	−4 29	235	55
130	310	+5 36	+5 35	+5 34	+5 33	+5 32	+4 32	+4 31	+4 31	+4 30	+4 30	+3 30	+3 29	+3 29	+2 29	+2 28	+1 28	+1 28	0 28	−1 28	230	50
135	315	+5 37	+5 36	+5 36	+5 35	+5 34	+5 33	+5 33	+5 32	+5 31	+5 31	+5 31	+4 30	+4 30	+4 30	+4 29	+4 29	+3 29	+3 29	+2 28	225	45
140	320	+5 39	+5 38	+5 37	+5 36	+6 36	+6 35	+6 34	+6 34	+6 33	+6 33	+6 32	+6 32	+6 32	+6 31	+6 31	+6 31	+6 30	+6 30	+6 30	220	40
145	325	+5 40	+5 40	+5 39	+5 38	+6 37	+6 37	+6 36	+6 36	+6 35	+6 35	+7 34	+7 34	+7 34	+7 33	+7 33	+8 33	+8 32	+8 32	+8 32	215	35
150	330	$+5_0$ 42_1	+5 41	+5 40	+5 40	+6 39	+6 38	$+6_0$ 38_1	+6 38	+7 37	+7 37	+7 36	+8 36	$+8_1$ 36_1	+8 36	+9 35	+9 35	+10 35	+11 35	$+11_1$ 35_1	210	30
155	335	+4 43	+4 43	+5 42	+5 41	+5 41	+6 40	+6 40	+6 40	+7 39	+7 39	+8 39	+8 38	+9 38	+9 38	+10 38	+11 38	+12 38	+13 38	+14 39	205	25
160	340	+3 44	+4 44	+4 43	+5 43	+5 42	+6 42	+6 42	+6 42	+7 41	+8 41	+8 41	+9 41	+9 41	+10 41	+11 41	+12 42	+13 42	+14 42	+16 43	200	20
165	345	+3 45	+3 45	+4 44	+4 44	+5 44	+5 44	+6 43	+6 43	+7 43	+7 43	+8 44	+9 44	+10 44	+11 44	+12 45	+13 46	+14 46	+15 47	+17 48	195	15
170	350	+2 46	+2 46	+3 45	+3 45	+4 45	+4 45	+5 45	+6 45	+6 45	+7 46	+8 46	+9 46	+10 47	+11 48	+12 48	+13 49	+14 50	+16 52	+18 53	190	10
175	355	+1 46	+1 46	+2 46	+3 46	+3 46	+4 46	+4 47	+5 47	+6 47	+7 48	+7 48	+8 49	+9 50	+10 51	+11 52	+12 53	+14 55	+16 57	+18 59	185	5
180	360	0_0 46_1	+1 47	+1 47	+2 47	+2 47	+3 47	$+4_0$ 48_1	+4 48	+5 49	+6 50	+7 51	+8 52	$+9_1$ 53_2	+10 54	+11 55	+12 57	+14 59	+16 62	$+18_1$ 65_3	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -2^\circ$

τ / $p_{+\tau}$	0^h						I^h						II^h						τ / $p_{-\tau}$
	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	
° °	Δp h																		° °
0 180	0_0 49_1	+1 49	+1 49	+2 50	+2 50	+3 50	$+4_0$ 51_2	+5 52	+6 52	+7 53	+8 54	+9 55	$+10_1$ 56_2	+11 58	+13 60	+14 62	+16 64	$+18_1$ 67_3	360 180
5 185	−1 49	0 49	0 50	+1 50	+1 51	+2 51	+3 52	+4 53	+5 54	+6 55	+7 56	+8 57	+9 59	+10 61	+12 63	+13 66	+15 69	+17 72	355 175
10 190	−2 49	−1 49	−1 50	0 50	0 51	+1 52	+2 53	+3 54	+3 55	+4 56	+5 58	+6 59	+8 61	+9 64	+10 66	+12 70	+14 73	+16 77	350 170
15 195	−3 48	−2 48	−2 49	−1 50	−1 51	0 52	0 53	+1 54	+2 56	+3 57	+4 59	+5 61	+6 63	+7 66	+9 69	+10 73	+12 77	+14 81	345 165
20 200	−4 47	−3 47	−3 48	−2 49	−2 50	−1 52	−1 53	0 54	+1 56	+2 58	+2 60	+3 62	+4 65	+5 68	+7 71	+8 75	+10 80	+12 85	340 160
25 205	−5 46	−4 46	−4 47	−3 48	−3 49	−2 51	−2 52	−1 54	−1 56	0 58	+1 60	+2 63	+3 66	+3 69	+5 73	+6 77	+8 82	+9 88	335 155
30 210	-5_0 44_1	−5 45	−5 46	−4 47	−4 48	−3 50	-3_0 52_2	−2 54	−2 56	−1 58	−1 60	0 63	$+1_0$ 66_2	+1 70	+2 74	+4 79	+5 84	$+6_0$ 90_4	330 150
35 215	−6 42	−5 43	−5 45	−5 46	−5 47	−4 49	−4 51	−4 53	−3 55	−3 57	−2 60	−2 63	−1 66	−1 70	0 74	+1 79	+2 85	+3 91	325 145
40 220	−6 41	−6 42	−6 43	−6 44	−5 46	−5 48	−5 50	−5 52	−4 54	−4 56	−4 59	−3 62	−3 65	−3 69	−2 74	−2 79	−1 85	0 92	320 140
45 225	−6 39	−6 40	−6 41	−6 42	−6 44	−6 46	−6 48	−6 50	−5 52	−5 54	−5 57	−5 60	−5 64	−5 68	−4 73	−4 78	−4 84	−3 91	315 135
50 230	−6 37	−6 38	−6 39	−6 41	−6 42	−6 44	−6 46	−6 48	−6 50	−6 52	−6 55	−6 58	−6 62	−6 66	−6 71	−6 76	−6 82	−6 89	310 130
55 235	−6 35	−6 36	−6 37	−6 39	−6 40	−7 42	−7 44	−7 46	−7 48	−7 50	−7 53	−8 56	−8 60	−8 64	−8 69	−8 74	−9 80	−9 87	305 125
60 240	-5_0 34_0	−6 35	−6 36	−6 37	−6 38	−7 40	-7_0 42_1	−7 44	−8 46	−8 48	−8 51	−9 54	-9_0 57_1	−9 61	−10 66	−10 71	−11 77	-12_1 84_3	300 120
65 245	−5 32	−5 33	−5 34	−6 35	−6 36	−7 38	−7 39	−7 41	−8 43	−8 46	−9 48	−9 51	−10 54	−10 58	−11 62	−12 67	−13 73	−14 80	295 115
70 250	−4 31	−4 32	−5 32	−5 33	−6 34	−6 36	−7 37	−7 39	−8 41	−8 43	−9 45	−10 48	−10 51	−11 55	−12 59	−13 63	−14 69	−16 75	290 110
75 255	−3 30	−3 30	−4 31	−5 32	−5 33	−6 34	−6 35	−7 37	−7 38	−8 40	−9 42	−10 45	−11 48	−12 51	−13 55	−14 59	−15 64	−17 70	285 105
80 260	−2 29	−3 29	−3 30	−4 31	−4 31	−5 32	−6 33	−6 35	−7 36	−8 38	−8 40	−9 42	−10 44	−12 47	−13 51	−14 55	−16 59	−18 64	280 100
85 265	−1 28	−2 29	−2 29	−3 30	−3 30	−4 31	−5 32	−6 33	−6 34	−7 35	−8 37	−9 39	−10 41	−11 44	−13 47	−14 50	−16 54	−18 59	275 95
90 270	0_0 28_0	−1 28	−1 28	−2 29	−2 29	−3 30	-4_0 30_0	−5 31	−5 32	−6 33	−7 35	−8 36	-9_0 38_0	−11 40	−12 43	−13 46	−15 49	-17_1 53_1	270 90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -2°$

$p_{+\tau}$ \ τ		0h						Ih						IIh						τ / $p_{-\tau}$	
		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		
°	°	Δp h																		°	°
90	270	0_0 28_0	−1 28	−1 28	−2 29	−2 29	−3 30	-4_0 30_0	−5 31	−5 32	−6 33	−7 35	−8 36	-9_0 38_0	−11 40	−12 43	−13 46	−15 49	-17_1 53_1	270	90
95	275	+1 28	0 28	0 28	−1 28	−1 29	−2 29	−3 29	−3 30	−4 31	−5 32	−6 33	−7 34	−8 35	−10 37	−11 39	−12 42	−14 45	−16 48	265	85
100	280	+2 29	+1 28	+1 28	0 28	0 28	−1 28	−2 28	−2 29	−3 30	−4 30	−5 31	−6 32	−7 33	−8 34	−10 36	−11 38	−13 41	−15 43	260	80
105	285	+3 30	+2 29	+2 29	+1 28	+1 28	0 28	0 28	−1 28	−2 29	−3 29	−3 30	−4 30	−5 31	−7 32	−8 33	−9 35	−11 37	−13 39	255	75
110	290	+4 31	+3 30	+3 30	+2 29	+2 29	+1 28	+1 28	0 28	0 28	−1 28	−2 29	−3 29	−4 30	−5 30	−6 31	−7 32	−9 33	−11 35	250	70
115	295	+5 32	+4 31	+4 31	+3 30	+3 30	+2 29	+2 28	+2 28	+1 28	0 28	0 28	−1 28	−2 29	−3 29	−4 29	−5 30	−6 31	−8 32	245	65
120	300	$+5_0$ 34_0	+5 33	+5 32	+4 31	+4 31	+3 30	$+3_0$ 29_0	+3 29	+2 29	+2 29	+1 28	+1 28	0_0 28_0	−1 28	−2 28	−3 29	−4 29	-5_0 30_0	240	60
125	305	+6 35	+5 34	+5 33	+5 32	+5 32	+4 31	+4 30	+4 30	+4 30	+3 29	+3 29	+2 28	+2 28	+1 28	+1 28	0 28	−1 28	−2 29	235	55
130	310	+6 37	+6 36	+6 35	+6 34	+5 33	+5 32	+5 32	+5 31	+5 31	+5 30	+4 30	+4 29	+4 29	+3 29	+3 29	+2 28	+2 28	+1 28	230	50
135	315	+6 39	+6 38	+6 37	+6 36	+6 35	+6 34	+6 34	+6 33	+6 32	+6 32	+6 31	+6 31	+6 30	+5 30	+5 30	+5 29	+5 29	+4 29	225	45
140	320	+6 41	+6 40	+6 39	+6 38	+6 37	+6 36	+7 35	+7 35	+7 34	+7 34	+7 33	+7 33	+7 32	+7 32	+7 32	+7 31	+7 31	+7 31	220	40
145	325	+6 42	+6 41	+6 40	+6 40	+7 39	+7 38	+7 37	+7 37	+8 36	+8 36	+8 35	+8 35	+8 34	+9 34	+9 34	+9 34	+10 33	+10 33	215	35
150	330	$+5_0$ 44_1	+6 43	+6 42	+6 42	+6 41	+7 40	$+7_1$ 40_1	+8 39	+8 39	+8 38	+9 38	+9 37	$+9_1$ 37_1	+10 37	+11 37	+11 37	+12 36	$+13_1$ 36_1	210	30
155	335	+5 46	+5 45	+6 44	+6 44	+6 43	+7 42	+7 42	+8 41	+8 41	+9 41	+9 40	+10 40	+10 40	+11 40	+12 40	+13 40	+14 40	+15 40	205	25
160	340	+4 47	+4 46	+5 46	+5 45	+6 45	+6 44	+7 44	+8 44	+8 44	+9 44	+9 43	+10 43	+11 43	+12 44	+13 44	+14 44	+15 44	+17 45	200	20
165	345	+3 48	+3 47	+4 47	+5 47	+5 46	+6 46	+7 46	+7 46	+8 46	+9 46	+9 46	+10 46	+11 47	+12 47	+13 48	+15 48	+16 49	+18 50	195	15
170	350	+2 49	+3 48	+3 48	+4 48	+5 48	+5 48	+6 48	+7 48	+7 48	+8 49	+9 49	+10 49	+11 50	+12 51	+14 52	+15 53	+17 54	+19 56	190	10
175	355	+1 49	+2 49	+2 49	+3 49	+4 49	+4 49	+5 50	+6 50	+7 50	+8 51	+9 51	+10 52	+11 53	+12 54	+13 56	+15 57	+17 59	+19 61	185	5
180	360	0_0 49_1	+1 49	+1 49	+2 50	+2 50	+3 50	$+4_0$ 51_2	+5 52	+6 52	+7 53	+8 54	+9 55	$+10_1$ 56_2	+11 58	+13 60	+14 62	+16 64	$+18_1$ 67_3	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determinea.

$\delta=-4^\circ$

τ		0^h						I^h						II^h						τ	
$p_{+\tau}$		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	$p_{-\tau}$	
°	°	Δp h																		°	°
0	180	0_0 52_2	0 52	+1 53	+2 53	+3 53	+4 54	$+5_0$ 54_2	+6 55	+7 56	+8 57	+9 58	+10 59	$+11_1$ 60_2	+13 62	+15 64	+17 66	+19 69	$+21_2$ 72_3	360	180
5	185	−1 52	−1 52	0 53	+1 53	+2 54	+3 55	+3 55	+4 56	+5 57	+6 59	+8 60	+9 61	+10 63	+12 66	+13 68	+15 71	+17 74	+20 78	355	175
10	190	−2 52	−2 52	−1 53	0 54	+1 54	+1 55	+2 56	+3 57	+4 58	+5 60	+6 62	+7 64	+8 66	+10 69	+12 72	+14 75	+16 79	+18 83	350	170
15	195	−3 51	−3 51	−2 52	−1 53	−1 54	0 55	+1 56	+2 58	+3 59	+4 61	+5 63	+6 66	+7 68	+8 71	+10 75	+12 79	+14 83	+16 88	345	165
20	200	−4 50	−4 50	−3 51	−3 52	−2 54	−1 55	−1 56	0 58	+1 60	+2 62	+3 64	+4 67	+5 70	+6 73	+8 77	+9 82	+11 87	+13 92	340	160
25	205	−5 48	−5 49	−4 50	−4 51	−3 53	−3 54	−2 56	−1 58	−1 60	0 62	+1 65	+2 68	+3 71	+4 75	+5 79	+7 84	+8 90	+10 96	335	155
30	210	-6_0 46_1	−6 47	−5 49	−5 50	−4 52	−4 53	-3_0 55_2	−3 57	−2 59	−2 62	−1 65	0 68	$+1_0$ 71_3	+2 75	+3 80	+4 85	+5 91	$+7_0$ 98_4	330	150
35	215	−7 44	−6 46	−6 47	−6 48	−5 50	−5 52	−4 54	−4 56	−4 58	−3 61	−3 64	−2 67	−1 71	−1 75	0 80	+1 86	+2 92	+3 99	325	145
40	220	−7 42	−7 44	−6 45	−6 46	−6 48	−6 50	−5 52	−5 54	−5 57	−5 60	−4 63	−4 66	−3 70	−3 74	−2 79	−2 85	−1 92	0 100	320	140
45	225	−7 40	−7 42	−7 43	−7 44	−7 46	−7 48	−6 50	−6 52	−6 55	−6 58	−6 61	−6 64	−5 68	−5 73	−5 78	−5 84	−4 91	−4 99	315	135
50	230	−7 38	−7 40	−7 41	−7 42	−7 44	−7 46	−7 48	−7 50	−7 53	−7 56	−7 59	−7 62	−7 66	−7 71	−7 76	−7 82	−7 89	−7 97	310	130
55	235	−7 36	−7 38	−7 39	−7 40	−7 42	−7 44	−8 46	−8 48	−8 50	−8 53	−8 56	−8 60	−9 64	−9 68	−9 73	−9 79	−10 86	−10 94	305	125
60	240	-6_0 34_0	−6 36	−7 37	−7 38	−7 40	−7 41	-8_0 43_1	−8 45	−8 47	−9 50	−9 53	−9 57	-10_1 61_2	−10 65	−11 70	−11 76	−12 82	-13_1 90_4	300	120
65	245	−5 33	−6 34	−6 35	−7 36	−7 37	−7 39	−8 41	−8 43	−9 45	−9 47	−10 50	−10 54	−11 57	−11 61	−12 66	−13 72	−14 78	−15 85	295	115
70	250	−4 31	−5 32	−5 33	−6 34	−6 35	−7 37	−7 38	−8 40	−9 42	−9 44	−10 47	−11 50	−11 53	−12 57	−13 62	−14 67	−16 73	−17 80	290	110
75	255	−3 30	−4 30	−4 31	−5 32	−6 33	−6 35	−7 36	−7 37	−8 39	−9 41	−10 44	−11 47	−12 50	−13 53	−14 57	−15 62	−17 68	−18 74	285	105
80	260	−2 29	−3 29	−3 30	−4 31	−5 32	−5 33	−6 34	−7 35	−8 37	−8 39	−9 41	−10 43	−11 46	−13 49	−14 53	−15 57	−17 62	−19 68	280	100
85	265	−1 28	−2 29	−2 29	−3 30	−4 30	−4 31	−5 32	−6 33	−7 35	−8 36	−9 38	−10 40	−11 42	−12 45	−14 48	−15 52	−17 57	−19 62	275	95
90	270	0_0 28_0	−1 28	−1 28	−2 29	−3 29	−3 30	-4_0 31_0	−5 32	−6 33	−7 34	−8 35	−9 37	-10_0 39_0	−11 41	−13 44	−15 47	−17 51	-19_1 56_1	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -4°$

τ $p_{+\tau}$	0h						Ih						IIh						τ $p_{-\tau}$
	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	
	Δp h																		
° ° 90 270	0_0 28_0	−1 28	−1 28	−2 29	−3 29	−3 30	-4_0 31_0	−5 32	6 33	−7 34	−8 35	−9 37	-10_0 39_0	−11 41	−13 44	−15 47	−17 51	-19_1 56_1	° ° 270 90
95 275	+1 28	+1 28	0 28	−1 28	−1 28	−2 29	−3 30	−4 30	−4 31	−5 32	−6 33	−8 34	−9 36	−10 38	−12 40	−14 43	−16 46	−18 50	265 85
100 280	+2 29	+2 28	+1 28	+1 28	0 28	−1 28	−1 29	−2 29	−3 30	−4 30	−5 31	−6 32	−7 33	−8 35	−10 37	−12 39	−14 41	−16 44	260 80
105 285	+3 30	+3 29	+2 29	+2 28	+1 28	+1 28	0 28	−1 28	−2 29	−2 29	−3 30	−4 30	−5 31	−6 32	−8 34	−10 35	−12 37	−14 39	255 75
110 290	+4 31	+4 30	+3 30	+3 29	+2 29	+2 29	+1 28	+1 28	0 28	−1 28	−2 29	−3 29	−4 29	−5 30	−6 31	−7 32	−9 34	−11 35	250 70
115 295	+5 33	+5 32	+4 31	+4 30	+3 30	+3 29	+3 29	+2 29	+2 28	+1 28	0 28	−1 28	−2 28	−3 29	−4 29	−5 30	−6 31	−8 32	245 65
120 300	$+6_0$ 34_0	+6 33	+5 32	+5 32	+4 31	+4 30	$+4_0$ 30_0	+4 30	+3 29	+3 29	+2 28	+1 28	0_0 28_0	0 28	−1 28	−2 29	−3 29	-5_0 30_0	240 60
125 305	+7 36	+6 35	+6 34	+6 33	+5 32	+5 32	+5 31	+5 31	+5 30	+4 30	+4 29	+3 29	+3 28	+2 28	+2 28	+1 28	0 28	−1 29	235 55
130 310	+7 38	+7 37	+7 36	+7 35	+6 34	+6 34	+6 33	+6 32	+6 31	+6 31	+5 30	+5 30	+5 29	+5 29	+4 29	+4 29	+3 29	+2 28	230 50
135 315	+7 40	+7 39	+7 38	+7 37	+7 36	+7 36	+7 35	+7 34	+7 33	+7 33	+7 32	+7 32	+7 31	+7 31	+7 30	+6 30	+6 30	+6 29	225 45
140 320	+7 42	+7 41	+7 40	+7 39	+8 38	+8 38	+8 37	+8 36	+8 35	+8 35	+8 34	+9 34	+9 33	+9 33	+9 32	+9 32	+9 32	+9 31	220 40
145 325	+7 44	+7 43	+7 42	+7 41	+8 41	+8 40	+8 39	+8 39	+9 38	+9 37	+9 37	+10 36	+10 36	+11 36	+11 35	+11 35	+12 35	+12 34	215 35
150 330	$+6_0$ 46_1	+6 45	+7 44	+7 44	+8 43	+8 42	$+8_1$ 42_1	+9 41	+9 40	+10 40	+10 40	+11 39	$+11_1$ 39_1	+12 39	+13 38	+13 38	+14 38	$+15_1$ 38_1	210 30
155 335	+5 48	+6 47	+6 46	+7 46	+7 45	+8 45	+8 44	+9 44	+10 43	+10 43	+11 43	+11 42	+12 42	+13 42	+14 42	+15 42	+16 42	+18 43	205 25
160 340	+4 50	+5 49	+6 48	+6 48	+7 47	+7 47	+8 46	+9 46	+10 46	+10 46	+11 46	+12 46	+13 46	+14 46	+15 46	+16 47	+18 47	+20 48	200 20
165 345	+3 51	+4 50	+5 50	+5 50	+6 49	+7 49	+8 49	+8 49	+9 49	+10 49	+11 49	+12 49	+13 50	+14 50	+16 51	+17 52	+19 53	+21 54	195 15
170 350	+2 52	+3 51	+4 51	+4 51	+5 51	+6 51	+7 51	+8 51	+9 51	+10 52	+11 52	+12 53	+13 53	+14 54	+16 55	+17 57	+19 58	+21 60	190 10
175 355	+1 52	+2 52	+3 52	+3 52	+4 52	+5 53	+6 53	+7 53	+8 54	+9 55	+10 55	+11 56	+12 57	+14 58	+15 60	+17 62	+19 64	+21 66	185 5
180 360	0_0 52_2	0 52	+1 53	+2 53	+3 53	+4 54	$+5_0$ 54_2	+6 55	+7 56	+8 57	+9 58	+10 59	$+11_1$ 60_2	+13 62	+15 64	+17 66	+19 69	$+21_2$ 72_3	180 0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -6°$

τ		0^h						I^h						II^h						τ	
$p_{+\tau}$		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	$p_{-\tau}$	
		Δp h																			
0°	180°	0_0 56_2	+1 56	+2 56	+3 57	+3 57	+4 57	$+5_0$ 58_2	+6 59	+8 60	+9 61	+10 62	+11 64	$+13_1$ 65_3	+15 67	+17 69	+19 72	+21 76	$+24_2$ 80_4	360°	180°
5	185	−1 56	−1 56	0 57	+1 57	+2 58	+3 58	+4 59	+5 60	+6 62	+7 63	+8 65	+9 67	+11 69	+13 71	+15 74	+17 77	+20 81	+23 86	355	175
10	190	−3 55	−2 56	−1 57	0 57	+1 58	+2 59	+3 60	+4 61	+5 63	+6 65	+7 67	+8 69	+9 72	+11 74	+13 78	+15 82	+18 86	+21 92	350	170
15	195	−4 54	−3 55	−2 56	−2 57	−1 58	0 59	+1 60	+2 62	+3 64	+4 66	+5 68	+6 71	+7 74	+9 77	+11 81	+13 86	+15 91	+18 97	345	165
20	200	−5 53	−4 54	−4 55	−3 56	−2 57	−2 59	−1 60	0 62	+1 64	+2 67	+3 69	+4 72	+5 76	+6 80	+8 84	+10 89	+12 95	+15 102	340	160
25	205	−6 51	−5 52	−5 53	−4 55	−4 56	−3 58	−2 60	−2 62	−1 64	0 67	+1 70	+2 73	+3 77	+4 81	+5 86	+7 91	+9 98	+12 106	335	155
30	210	-7_0 49_1	−6 50	−6 52	−5 53	−5 55	−4 57	-4_0 59_2	−3 61	−3 63	−2 66	−1 69	0 73	$+1_0$ 77_3	+2 82	+3 87	+4 93	+6 100	$+8_0$ 108_5	330	150
35	215	−8 47	−7 48	−7 50	−6 51	−6 53	−6 55	−5 57	−5 59	−4 62	−4 65	−3 68	−2 72	−2 76	−1 81	0 87	+1 93	+2 101	+4 110	325	145
40	220	−8 44	−8 46	−7 48	−7 49	−7 51	−7 53	−6 55	−6 57	−6 60	−5 63	−5 67	−4 71	−4 75	−3 80	−3 86	−2 92	−1 100	0 110	320	140
45	225	−8 42	−8 44	−8 45	−8 47	−8 49	−8 51	−7 53	−7 55	−7 58	−7 61	−7 65	−6 69	−6 73	−6 78	−6 84	−5 90	−5 98	−4 108	315	135
50	230	−8 40	−8 41	−8 43	−8 44	−8 46	−8 48	−8 50	−8 53	−8 56	−8 59	−8 62	−8 66	−8 71	−8 76	−8 82	−8 88	−8 96	−8 106	310	130
55	235	−8 37	−8 39	−8 40	−8 42	−8 44	−8 46	−9 48	−9 50	−9 53	−9 56	−9 59	−10 63	−10 68	−10 73	−10 79	−11 85	−11 93	−12 103	305	125
60	240	-7_0 35_0	−7 36	−8 38	−8 39	−8 41	−8 43	-9_1 45_1	−9 47	−10 50	−10 53	−10 56	−11 60	-11_1 64_2	−12 69	−12 75	−13 81	−14 89	-15_1 98_4	300	120
65	245	−6 33	−6 34	−7 36	−7 37	−8 38	−8 40	−9 42	−9 44	−10 47	−10 49	−11 52	−11 56	−12 60	−13 65	−14 70	−15 76	−16 84	−18 93	295	115
70	250	−5 31	−5 32	−6 34	−7 35	−7 36	−8 38	−8 39	−9 41	−10 44	−10 46	−11 49	−12 52	−13 56	−14 60	−15 65	−16 71	−18 78	−20 87	290	110
75	255	−4 30	−4 31	−5 32	−6 33	−6 34	−7 35	−8 37	−8 39	−9 41	−10 43	−11 45	−12 48	−13 52	−14 56	−15 60	−17 66	−19 72	−21 80	285	105
80	260	−3 29	−3 30	−4 30	−5 31	−5 32	−6 33	−7 34	−8 36	−8 38	−9 40	−10 42	−11 45	−12 48	−14 51	−15 55	−17 60	−19 66	−21 73	280	100
85	265	−1 28	−2 29	−3 29	−3 30	−4 30	−5 31	−6 32	−7 34	−7 35	−8 37	−9 39	−10 41	−11 44	−13 47	−15 50	−17 54	−19 60	−21 66	275	95
90	270	0_0 28_0	0 28	−1 28	−2 29	−3 29	−4 30	-4_0 31_0	−5 32	−6 33	−7 34	−8 36	−9 38	-10_0 40_0	−12 42	−14 45	−16 49	−18 54	-21_1 59_1	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

Table III—Continued.

To be used when Position Angle and Distance are determined.

$\delta=-6°$

τ / $p_{+\tau}$		0h						Ih						IIh						τ / $p_{-\tau}$	
		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		
°	°	Δp h																		°	°
90	270	0_0 28_0	0 28	−1 28	−2 29	−3 29	−4 30	-4_0 31_0	−5 32	−6 33	−7 34	−8 36	−9 38	-10_0 40_0	−12 42	−14 45	−16 49	−18 54	-21_1 59_1	270	90
95	275	+1 28	+1 28	0 28	−1 28	−1 28	−2 29	−3 30	−4 30	−5 31	−6 32	−7 33	−8 35	−9 36	−11 38	−13 41	−15 44	−17 48	−19 52	265	85
100	280	+3 29	+2 29	+1 28	+1 28	0 28	−1 28	−1 29	−2 29	−3 29	−4 30	−5 31	−6 32	−8 33	−9 35	−11 37	−13 39	−15 42	−17 46	260	80
105	285	+4 30	+3 30	+3 29	+2 29	+2 28	+1 28	0 28	−1 28	−1 28	−2 29	−3 29	−4 30	−6 31	−7 32	−8 34	−10 35	−12 38	−15 41	255	75
110	290	+5 31	+5 31	+4 30	+4 30	+3 29	+2 28	+2 28	+1 28	0 28	0 28	−1 28	−2 29	−3 29	−5 30	−6 31	−7 32	−9 34	−12 36	250	70
115	295	+6 33	+6 32	+5 31	+5 31	+4 30	+4 29	+3 29	+3 29	+2 28	+2 28	+1 28	0 28	−1 28	−2 29	−3 29	−4 30	−6 31	−8 32	245	65
120	300	$+7_0$ 35_0	+7 34	+6 33	+6 32	+6 31	+5 30	$+5_0$ 30_0	+4 30	+4 29	+3 29	+3 28	+2 28	$+1_0$ 28_0	+1 28	0 28	−1 29	−2 29	-4_0 30_0	240	60
125	305	+8 37	+7 36	+7 35	+7 34	+7 33	+6 32	+6 32	+6 31	+6 30	+5 30	+5 29	+4 29	+4 29	+3 28	+3 28	+2 28	+1 28	0 29	235	55
130	310	+8 39	+8 38	+8 37	+8 36	+8 35	+7 34	+7 34	+7 33	+7 32	+7 31	+7 31	+6 30	+6 30	+6 29	+6 29	+5 29	+4 29	+4 29	230	50
135	315	+8 42	+8 41	+8 40	+8 39	+8 38	+8 37	+8 36	+8 35	+8 34	+8 33	+8 33	+8 32	+8 32	+8 31	+8 31	+8 31	+8 30	+8 30	225	45
140	320	+8 44	+8 43	+8 42	+9 41	+9 40	+9 39	+9 38	+9 38	+9 37	+10 36	+10 35	+10 35	+10 34	+10 34	+11 33	+11 33	+11 32	+12 32	220	40
145	325	+8 47	+8 46	+8 45	+9 44	+9 43	+9 42	+10 41	+10 40	+10 40	+11 39	+11 38	+12 38	+12 37	+12 37	+13 36	+14 36	+14 36	+15 36	215	35
150	330	$+7_0$ 49_1	+7 48	+8 47	+8 46	+9 45	+9 44	$+10_1$ 44_1	+10 43	+11 43	+12 42	+12 42	+13 41	$+13_1$ 41_1	+14 41	+15 40	+16 40	+17 40	$+18_2$ 41_1	210	30
155	335	+6 51	+7 50	+7 49	+8 49	+8 48	+9 47	+10 47	+10 46	+11 46	+12 45	+13 45	+13 45	+14 45	+15 45	+16 45	+18 45	+19 45	+21 46	205	25
160	340	+5 53	+6 52	+6 51	+7 51	+8 50	+9 50	+9 49	+10 49	+11 49	+12 49	+13 49	+14 49	+15 49	+16 49	+17 50	+19 50	+21 51	+23 52	200	20
165	345	+4 54	+5 54	+5 53	+6 53	+7 52	+8 52	+9 52	+10 52	+11 52	+12 52	+13 52	+14 53	+15 53	+16 54	+18 55	+20 56	+22 57	+24 59	195	15
170	350	+3 55	+3 55	+4 55	+5 55	+6 54	+7 54	+8 54	+9 55	+10 55	+11 55	+12 56	+13 57	+15 57	+16 58	+18 60	+20 61	+22 63	+25 66	190	10
175	355	+1 56	+2 56	+3 56	+4 56	+5 56	+6 56	+7 56	+8 57	+9 58	+10 58	+11 59	+12 60	+14 61	+16 63	+18 65	+20 67	+22 70	+25 73	185	5
180	360	0_0 56_2	+1 56	+2 56	+3 57	+3 57	+4 57	$+5_0$ 58_2	+6 59	+8 60	+9 61	+10 62	+11 64	$+13_1$ 65_3	+15 67	+17 69	+19 72	+21 76	$+24_2$ 80_4	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -8°$

$p_{+\tau}$ \ τ		0^h						I^h						II^h						τ / $p_{-\tau}$	
		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m		
°	°	Δp h																		°	°
0	180	0_0 60_2	+1 60	+2 61	+3 61	+4 61	+5 62	$+6_0$ 62_2	+7 63	+9 64	+10 66	+11 67	+13 69	$+15_1$ 71_3	+17 74	+19 76	+21 79	+24 83	$+28_2$ 87_4	360	180
5	185	−2 60	−1 60	0 61	+1 61	+2 62	+3 63	+5 64	+6 65	+7 66	+8 68	+10 70	+11 72	+13 75	+15 78	+17 81	+20 85	+23 89	+26 95	355	175
10	190	−3 59	−2 60	−1 60	0 61	+1 62	+2 64	+3 65	+4 66	+5 68	+6 70	+8 72	+9 75	+11 78	+13 81	+15 85	+18 90	+21 95	+24 102	350	170
15	195	−5 58	−4 59	−3 60	−2 61	−1 62	0 64	+1 65	+2 67	+3 69	+4 71	+6 74	+7 77	+9 80	+11 84	+13 89	+15 94	+18 100	+21 108	345	165
20	200	−6 57	−5 58	−4 59	−4 60	−3 61	−2 63	−1 65	0 67	+1 69	+2 72	+3 75	+5 78	+6 82	+8 87	+10 92	+12 98	+14 104	+17 113	340	160
25	205	−7 55	−6 56	−6 57	−5 58	−4 60	−4 62	−3 64	−2 66	−1 69	0 72	+1 75	+2 79	+3 83	+5 88	+7 94	+9 100	+11 107	+13 117	335	155
30	210	-8_1 52_2	−7 54	−7 55	−6 57	−6 59	−5 61	-4_0 63_2	−4 65	−3 68	−2 71	−1 75	0 79	$+1_0$ 84_4	+2 89	+3 95	+5 101	+7 109	$+9_0$ 119_6	330	150
35	215	−9 50	−8 51	−8 53	−7 55	−7 57	−7 59	−6 61	−6 64	−5 67	−4 70	−4 74	−3 78	−2 83	−1 88	0 94	+1 101	+3 110	+5 120	325	145
40	220	−9 47	−9 49	−9 50	−8 52	−8 54	−8 56	−7 59	−7 62	−6 65	−6 68	−6 72	−5 76	−5 81	−4 87	−3 93	−3 101	−2 110	0 120	320	140
45	225	−9 44	−9 46	−9 48	−9 49	−9 51	−9 54	−8 56	−8 59	−8 62	−8 66	−8 70	−7 74	−7 79	−7 85	−6 91	−6 99	−6 108	−5 119	315	135
50	230	−9 42	−9 43	−9 45	−9 46	−9 48	−9 51	−9 53	−9 56	−9 59	−9 63	−9 67	−9 71	−9 76	−9 82	−9 88	−9 96	−9 105	−9 116	310	130
55	235	−9 39	−9 40	−9 42	−9 44	−9 46	−10 48	−10 50	−10 53	−10 56	−10 59	−10 63	−11 67	−11 72	−11 78	−12 84	−12 92	−13 101	−13 112	305	125
60	240	-8_1 36_1	−8 38	−9 39	−9 41	−9 43	−10 45	-10_1 47_1	−10 50	−11 53	−11 56	−11 59	−12 63	-12_1 68_2	−13 74	−14 80	−15 87	−16 96	-17_1 106_5	300	120
65	245	−7 34	−7 35	−8 36	−8 38	−9 40	−9 42	−10 44	−10 46	−11 49	−12 52	−12 55	−13 59	−13 64	−14 69	−15 75	−17 82	−18 90	−20 100	295	115
70	250	−6 32	−6 33	−7 34	−7 35	−8 37	−9 39	−9 41	−10 43	−11 45	−11 48	−12 51	−13 55	−14 59	−15 64	−16 70	−18 76	−20 84	−22 93	290	110
75	255	−5 30	−5 31	−6 32	−6 33	−7 34	−8 36	−9 38	−9 40	−10 42	−11 44	−12 47	−13 50	−14 54	−16 59	−17 64	−19 70	−21 77	−23 85	285	105
80	260	−3 29	−4 30	−5 30	−5 31	−6 32	−7 34	−8 35	−8 37	−9 39	−10 41	−11 43	−13 46	−14 49	−15 53	−17 58	−19 64	−21 70	−24 77	280	100
85	265	−2 28	−2 29	−3 29	−4 30	−5 31	−5 32	−6 33	−7 34	−8 36	−9 38	−10 40	−12 42	−13 45	−15 48	−17 52	−19 57	−21 63	−24 69	275	95
90	270	0_0 28_0	−1 28	−1 28	−2 29	−3 30	−4 30	-5_0 31_0	−6 32	−7 33	−8 35	−9 36	−10 38	-12_1 41_0	−14 44	−16 47	−18 51	−20 56	-23_1 61_1	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -8°$

$p_{+\tau}$	τ	0^h						I^h						II^h						τ	$p_{-\tau}$
		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m		
°	°	Δp h																		°	°
90	270	0_0 28_0	−1 28	−1 28	−2 29	−3 30	−4 30	-5_0 31_0	−6 32	−7 33	−8 35	−9 36	−10 38	-12_1 41_0	−14 44	−16 47	−18 51	−20 56	-23_1 61_1	270	90
95	275	+2 28	+1 28	0 28	−1 28	−1 29	−2 29	−3 29	−4 30	−5 31	−6 32	−7 33	−8 35	−10 37	−12 39	−14 42	−16 45	−18 49	−21 54	265	85
100	280	+3 29	+3 29	+2 28	+1 28	0 28	−1 28	−1 28	−2 29	−3 30	−4 30	−5 31	−6 32	−8 34	−10 35	−12 38	−14 40	−16 43	−19 47	260	80
105	285	+5 30	+4 30	+3 29	+3 29	+2 28	+1 28	0 28	0 28	−1 29	−2 29	−3 30	−4 30	−6 31	−7 32	−9 34	−11 36	−13 38	−16 41	255	75
110	290	+6 32	+5 31	+5 30	+4 30	+4 29	+3 29	+2 28	+2 28	+1 28	0 28	−1 29	−2 29	−3 29	−4 30	−6 31	−8 33	−10 34	−12 36	250	70
115	295	+7 34	+6 33	+6 32	+6 31	+5 30	+5 30	+4 29	+4 29	+3 29	+2 28	+1 28	0 28	−1 28	−2 29	−3 29	−4 30	−6 31	−8 32	245	65
120	300	$+8_1$ 36_1	+7 35	+7 34	+7 33	+7 32	+6 31	$+6_1$ 30_0	+5 30	+5 30	+4 29	+4 29	+3 28	$+2_0$ 28_0	+1 28	0 28	−1 28	−2 29	-4_0 29_0	240	60
125	305	+9 39	+8 38	+8 36	+8 35	+8 34	+8 33	+7 32	+7 32	+7 31	+6 30	+6 30	+6 29	+5 29	+4 28	+4 28	+3 28	+2 28	+1 28	235	55
130	310	+9 42	+9 40	+9 39	+9 38	+9 36	+9 35	+9 34	+9 34	+8 33	+8 32	+8 32	+8 31	+8 31	+7 30	+7 29	+7 29	+6 29	+5 28	230	50
135	315	+9 44	+9 43	+9 42	+10 40	+10 39	+10 38	+10 37	+10 36	+10 36	+10 35	+10 34	+10 33	+10 33	+10 32	+10 31	+10 31	+10 30	+10 30	225	45
140	320	+9 47	+9 46	+10 44	+10 43	+10 42	+10 41	+11 40	+11 39	+11 39	+11 38	+12 37	+12 36	+12 36	+13 35	+13 34	+13 34	+14 33	+14 33	220	40
145	325	+9 50	+9 48	+9 47	+10 46	+10 45	+11 44	+11 43	+12 42	+12 42	+12 41	+13 40	+14 40	+14 39	+15 39	+16 38	+16 38	+17 37	+18 37	215	35
150	330	$+8_1$ 52_2	+9 51	+9 50	+10 49	+10 48	+11 47	$+11_1$ 46_1	+12 46	+12 45	+13 44	+14 44	+15 44	$+16_1$ 43_1	+17 43	+18 43	+19 43	+20 42	$+22_2$ 42_1	210	30
155	335	+7 55	+8 54	+8 53	+9 52	+10 51	+10 50	+11 49	+12 49	+13 49	+14 48	+15 48	+16 48	+17 48	+18 48	+19 48	+21 48	+23 48	+25 49	205	25
160	340	+6 57	+7 56	+7 55	+8 54	+9 54	+10 53	+11 52	+12 52	+13 52	+14 52	+15 52	+16 52	+17 52	+19 53	+20 53	+22 54	+24 55	+27 56	200	20
165	345	+5 58	+5 58	+6 57	+7 56	+8 56	+9 56	+10 55	+11 55	+12 56	+13 56	+14 56	+16 57	+17 57	+19 58	+21 59	+23 60	+25 62	+28 63	195	15
170	350	+3 59	+4 59	+5 59	+6 58	+7 58	+8 58	+9 58	+10 58	+11 59	+12 59	+14 60	+15 61	+17 62	+19 63	+21 65	+23 67	+26 69	+29 71	190	10
175	355	+2 60	+3 60	+4 60	+5 60	+6 60	+7 60	+8 60	+9 61	+10 62	+11 63	+13 64	+14 65	+16 67	+18 69	+20 71	+22 73	+25 76	+29 79	185	5
180	360	0_0 60_2	+1 60	+2 61	+3 61	+4 61	+5 62	$+6_0$ 62_2	+7 63	+9 64	+10 66	+11 67	+13 69	$+15_1$ 71_3	+17 74	+19 76	+21 79	+24 83	$+28_2$ 87_4	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -10°$

τ / $p_{+\tau}$	0^h						I^h						II^h						τ / $p_{-\tau}$
	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	
° °	Δp h																		° °
0 180	0_0 65_3	+1 65	+2 66	+3 66	+4 66	+6 67	$+7_0$ 68_3	+8 69	+9 70	+11 71	+13 73	+15 75	$+17_1$ 77_4	+19 80	+22 83	+25 87	+28 92	$+32_2$ 97_5	360 180
5 185	−2 65	−1 65	0 66	+1 66	+3 67	+4 68	+5 69	+6 71	+8 72	+9 74	+11 76	+13 79	+15 81	+17 85	+20 89	+23 93	+26 99	+30 106	355 175
10 190	−4 64	−3 64	−2 65	0 66	+1 67	+2 69	+3 70	+4 72	+6 74	+7 76	+8 79	+10 82	+12 85	+15 89	+17 94	+20 99	+23 105	+27 114	350 170
15 195	−5 62	−4 63	−3 64	−2 66	−1 67	0 69	+1 71	+2 73	+3 75	+5 78	+6 81	+8 84	+10 88	+12 92	+14 98	+17 104	+20 111	+24 120	345 165
20 200	−7 60	−6 61	−5 63	−4 65	−3 66	−2 68	−1 70	0 73	+1 76	+2 79	+4 82	+5 85	+7 90	+9 95	+11 101	+13 108	+16 116	+20 126	340 160
25 205	−8 58	−8 59	−7 61	−6 63	−5 65	−4 67	−3 69	−2 72	−1 75	0 78	+1 82	+2 86	+4 91	+5 97	+7 103	+9 110	+12 119	+15 130	335 155
30 210	-9_1 56_2	−9 57	−8 59	−7 61	−7 63	−6 65	-5_0 68_2	−4 71	−4 74	−3 77	−2 81	−1 86	$+1_0$ 91_4	+2 97	+4 104	+5 112	+7 121	$+10_1$ 133_7	330 150
35 215	−10 53	−10 55	−9 57	−8 59	−8 61	−7 63	−7 66	−6 69	−6 72	−5 76	−4 80	−3 85	−2 90	−1 96	0 104	+1 112	+3 122	+4 134	325 145
40 220	−10 50	−10 52	−10 54	−9 56	−9 58	−9 60	−8 63	−8 66	−8 70	−7 74	−7 78	−6 83	−5 88	−5 94	−4 102	−3 111	−2 121	−1 133	320 140
45 225	−11 47	−10 48	−10 50	−10 52	−10 54	−10 57	−9 60	−9 63	−9 67	−9 71	−9 75	−9 80	−8 85	−8 91	−7 99	−7 108	−6 119	−6 131	315 135
50 230	−10 43	−10 45	−10 47	−10 49	−10 51	−10 54	−10 57	−10 60	−10 63	−10 67	−10 71	−11 76	−11 82	−11 88	−11 96	−11 104	−11 115	−11 128	310 130
55 235	−10 40	−10 42	−10 44	−10 46	−11 48	−11 50	−11 53	−11 56	−11 59	−11 63	−12 67	−12 72	−13 78	−13 84	−14 92	−14 100	−15 110	−15 123	305 125
60 240	-9_1 37_1	−9 39	−10 41	−10 43	−10 45	−11 47	-11_1 49_1	−12 52	−12 55	−12 59	−13 63	−13 68	-14_1 73_3	−15 79	−16 87	−17 95	−18 104	-19_1 116_6	300 120
65 245	−8 35	−8 36	−9 38	−9 39	−10 41	−10 43	−11 45	−12 48	−12 51	−13 55	−14 59	−14 63	−15 68	−16 74	−17 81	−19 89	−20 98	−22 109	295 115
70 250	−7 33	−7 34	−8 35	−8 36	−9 38	−10 40	−10 42	−11 44	−12 47	−13 50	−14 54	−15 58	−16 63	−17 68	−18 74	−20 82	−22 91	−24 101	290 110
75 255	−5 31	−6 32	−7 33	−7 34	−8 35	−9 37	−9 39	−10 41	−11 43	−12 46	−13 49	−15 53	−16 57	−17 62	−19 68	−21 75	−23 83	−26 92	285 105
80 260	−4 29	−4 30	−5 31	−6 32	−7 33	−8 34	−8 36	−9 38	−10 40	−11 42	−12 45	−14 48	−15 52	−17 56	−19 61	−21 67	−24 74	−27 83	280 100
85 265	−2 28	−3 29	−3 30	−4 30	−5 31	−6 32	−7 33	−8 35	−9 37	−10 39	−11 41	−13 44	−14 47	−16 51	−18 55	−20 60	−23 66	−27 74	275 95
90 270	0_0 28_0	−1 28	−2 29	−2 29	−3 29	−4 30	-5_0 31_0	−6 32	−7 34	−8 35	−9 37	−11 39	-13_1 42_1	−15 45	−17 49	−19 53	−22 58	-26_1 65_2	270 90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

Table III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -10°$

τ / $p_{+\tau}$	0^h						I^h						II^h						τ / $p_{-\tau}$
	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	
° °	Δp h																		° °
90 270	0_0 28_0	−1 28	−2 29	−2 29	−3 29	−4 30	-5_0 31_0	−6 32	−7 34	−8 35	−9 37	−11 39	-13_1 42_1	−15 45	−17 49	−19 53	−22 58	-26_1 65_2	270 90
95 275	+2 28	+1 28	0 28	−1 28	−1 28	−2 29	−3 30	−4 30	−5 31	−6 32	−7 34	−9 35	−11 37	−13 40	−15 43	−17 47	−20 51	−23 56	265 85
100 280	+4 29	+3 29	+2 29	+1 28	0 28	0 28	−1 29	−2 29	−3 30	−4 30	−5 31	−7 32	−8 34	−10 36	−12 38	−14 41	−17 44	−20 48	260 80
105 285	+5 31	+5 30	+4 30	+3 29	+2 28	+2 28	+1 28	0 28	−1 29	−2 29	−3 29	−4 30	−6 31	−7 32	−9 34	−11 36	−14 39	−17 42	255 75
110 290	+7 33	+6 32	+6 31	+5 30	+4 29	+4 29	+3 28	+2 28	+1 28	0 28	−1 28	−2 29	−3 29	−4 30	−6 31	−8 32	−10 34	−13 36	250 70
115 295	+8 35	+8 34	+7 33	+7 32	+6 31	+6 30	+5 29	+4 29	+4 29	+3 28	+2 28	+1 28	0 28	−1 29	−2 29	−4 30	−6 31	−3 32	245 65
120 300	$+9_1$ 37_1	+9 36	+8 35	+8 34	+8 33	+7 32	$+7_1$ 31_0	+6 30	+6 30	+6 29	+5 29	+4 29	$+3_1$ 28_0	+2 28	+1 28	0 29	−1 29	-3_0 29_0	240 60
125 305	+10 40	+10 39	+9 37	+9 36	+9 35	+9 34	+9 33	+8 32	+8 32	+8 31	+7 30	+7 30	+6 29	+6 29	+5 28	+4 28	+3 28	+2 28	235 55
130 310	+10 43	+10 42	+10 40	+10 39	+10 38	+10 37	+10 36	+10 35	+10 34	+10 33	+10 32	+10 32	+9 31	+9 31	+9 30	+8 30	+8 29	+8 29	230 50
135 315	+11 47	+11 45	+11 44	+11 42	+11 41	+11 40	+11 39	+12 38	+12 37	+12 36	+12 35	+12 35	+12 34	+12 33	+12 33	+12 32	+12 31	+13 31	225 45
140 320	+10 50	+11 48	+11 47	+11 46	+12 44	+12 43	+12 42	+13 41	+13 40	+13 39	+14 38	+14 38	+15 37	+15 36	+15 36	+16 35	+17 35	+18 34	220 40
145 325	+10 53	+10 51	+11 50	+11 49	+12 48	+12 47	+13 46	+13 45	+14 44	+14 43	+15 42	+16 42	+17 41	+17 40	+18 40	+19 40	+21 40	+22 39	215 35
150 330	$+9_1$ 56_2	+10 54	+10 53	+11 52	+12 51	+12 50	$+13_1$ 49_2	+14 49	+14 48	+15 47	+16 47	+17 46	$+18_1$ 46_1	+19 45	+20 45	+22 46	+24 46	$+26_2$ 46_2	210 30
155 335	+8 58	+9 57	+9 56	+10 55	+11 54	+12 54	+13 53	+14 53	+15 52	+16 52	+17 51	+18 51	+19 51	+21 51	+22 51	+24 52	+26 52	+29 53	205 25
160 340	+7 60	+8 60	+8 59	+9 58	+10 57	+11 57	+12 57	+13 57	+14 56	+16 56	+17 56	+18 56	+20 56	+22 57	+23 58	+25 59	+28 60	+31 61	200 20
165 345	+5 62	+6 62	+7 61	+8 61	+9 60	+10 60	+11 60	+12 60	+13 60	+15 60	+17 61	+18 61	+20 62	+22 63	+24 64	+26 66	+29 68	+33 70	195 15
170 350	+4 64	+5 64	+6 63	+7 63	+8 63	+9 63	+10 63	+11 63	+12 64	+14 64	+16 65	+17 66	+19 67	+21 69	+24 71	+27 73	+30 76	+34 79	190 10
175 355	+2 65	+3 65	+4 65	+5 65	+6 65	+7 65	+9 66	+10 66	+11 67	+13 68	+15 69	+16 71	+18 73	+20 75	+23 77	+26 80	+29 84	+33 88	185 5
180 360	0_0 65_3	+1 65	+2 66	+3 66	+4 66	+6 67	$+7_0$ 68_3	+8 69	+9 70	+11 71	+13 73	+15 75	$+17_1$ 77_4	+19 80	+22 83	+25 87	+28 92	$+32_2$ 97_5	180 0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -12°$

τ		0^h						I^h						II^h						τ	
$p_{+\tau}$		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m		$p_{-\tau}$
°	°	Δp h																		°	°
0	180	0_0 71_3	+1 71	+2 71	+4 71	+5 72	+6 73	$+8_1$ 74_3	+9 75	+11 76	+13 78	+15 80	+17 82	$+19_1$ 85_4	+22 88	+25 92	+28 97	+32 102	$+37_3$ 108_6	360	180
5	185	−2 70	−1 71	0 71	+2 72	+3 73	+4 74	+6 75	+7 77	+9 79	+11 81	+13 83	+15 86	+17 90	+20 94	+23 98	+26 104	+30 111	+35 118	355	175
10	190	−4 69	−3 70	−2 71	−1 72	+1 73	+2 75	+3 76	+5 78	+6 81	+8 83	+10 86	+12 90	+14 94	+17 98	+20 104	+23 110	+27 118	+32 127	350	170
15	195	−6 68	−5 69	−4 70	−3 71	−2 73	0 75	+1 77	+2 79	+4 82	+5 85	+7 88	+9 92	+11 97	+13 102	+16 108	+19 115	+23 124	+27 135	345	165
20	200	−8 66	−7 67	−6 68	−5 70	−4 72	−3 74	−1 76	0 79	+1 82	+3 85	+4 89	+6 94	+8 99	+10 105	+12 112	+15 120	+18 129	+22 141	340	160
25	205	−9 63	−8 64	−8 66	−7 68	−6 70	−5 72	−4 75	−3 78	−2 81	0 85	+1 90	+3 95	+4 100	+6 106	+8 114	+11 123	+13 133	+16 145	335	155
30	210	-10_1 60_2	−9 62	−9 64	−8 66	−8 68	−7 70	-6_0 73_3	−5 76	−4 80	−3 84	−2 89	−1 94	$+1_0$ 100_5	+2 107	+4 115	+6 124	+8 135	$+11_1$ 148_9	330	150
35	215	−11 57	−10 59	−10 61	−10 63	−9 65	−9 68	−8 71	−7 74	−7 78	−6 82	−5 87	−4 93	−3 99	−2 106	0 114	+1 124	+3 136	+5 150	325	145
40	220	−12 53	−11 55	−11 57	−11 59	−10 62	−10 65	−10 68	−9 71	−9 75	−8 79	−8 84	−7 90	−6 97	−6 104	−5 113	−4 123	−3 135	−1 149	320	140
45	225	−12 49	−12 51	−12 54	−12 56	−11 58	−11 61	−11 64	−11 68	−11 72	−10 76	−10 81	−10 87	−9 94	−9 101	−9 110	−8 120	−8 132	−7 146	315	135
50	230	−12 46	−12 48	−12 50	−12 52	−12 54	−12 57	−12 60	−12 64	−12 68	−12 72	−12 77	−12 83	−12 90	−12 97	−12 106	−12 116	−12 128	−13 142	310	130
55	235	−11 42	−11 44	−12 46	−12 48	−12 50	−12 53	−13 56	−13 60	−13 64	−13 68	−14 73	−14 78	−14 85	−15 92	−15 100	−16 110	−17 122	−18 136	305	125
60	240	-10_1 39_1	−10 40	−11 42	−12 44	−12 46	−12 49	-13_1 52_2	−13 55	−14 59	−14 63	−15 68	−15 73	-16_1 79_3	−17 86	−18 94	−19 103	−21 115	-22_2 129_7	300	120
65	245	−9 36	−9 37	−10 39	−11 41	−11 43	−12 45	−13 48	−13 51	−14 54	−15 58	−15 63	−16 68	−17 73	−18 80	−20 87	−22 96	−24 107	−26 120	295	115
70	250	−8 33	−8 34	−9 36	−10 38	−10 40	−11 42	−12 44	−13 47	−14 50	−15 53	−16 57	−17 62	−18 67	−19 73	−21 80	−23 88	−26 99	−29 111	290	110
75	255	−6 31	−7 32	−8 33	−8 35	−9 36	−10 38	−11 40	−12 42	−13 45	−14 48	−15 52	−16 56	−18 61	−20 66	−22 72	−24 80	−27 90	−30 101	285	105
80	260	−4 29	−5 30	−6 31	−7 32	−8 33	−9 35	−10 36	−11 38	−12 41	−13 44	−14 47	−15 51	−17 55	−19 59	−21 65	−24 72	−27 80	−31 90	280	100
85	265	−2 28	−3 29	−4 30	−5 30	−6 31	−7 32	−8 33	−9 35	−10 37	−11 40	−13 42	−14 45	−16 49	−18 53	−20 58	−23 64	−26 71	−30 79	275	95
90	270	0_0 28_0	−1 28	−2 29	−3 29	−4 30	−5 30	-6_0 31_0	−7 32	−8 34	−9 36	−11 38	−12 40	-14_1 43_1	−16 47	−18 51	−22 56	−25 62	-29_2 69_2	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

Table III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -12°$

		0^h						I^h						II^h							
$p_{+\tau}$	τ	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	τ	$p_{-\tau}$
°	°	Δp h																		°	°
90	270	0_0 28_0	−1 28	−2 29	−3 29	−4 30	−5 30	-6_0 31_0	−7 32	−8 34	−9 36	−11 38	−12 40	-14_1 43_1	−16 47	−18 51	−22 56	−25 62	-29_2 69_2	270	90
95	275	+2 28	+1 28	0 28	−1 28	−1 29	−2 29	−3 29	−5 30	−6 31	−7 33	−9 34	−10 36	−12 39	−14 42	−16 45	−19 49	−22 54	−26 60	265	85
100	280	+4 29	+3 29	+2 28	+2 28	+1 28	0 28	−1 28	−2 29	−3 30	−4 31	−6 32	−7 33	−9 35	−11 37	−13 39	−16 42	−19 46	−23 51	260	80
105	285	+6 31	+5 30	+4 29	+4 29	+3 29	+2 28	+1 28	0 28	−1 29	−2 29	−3 30	−4 31	−6 32	−8 33	−10 35	−12 37	−15 40	−19 43	255	75
110	290	+8 33	+7 32	+6 31	+6 30	+5 30	+4 29	+4 28	+3 28	+2 28	+1 28	0 29	−1 29	−3 30	−4 30	−6 31	−8 33	−11 35	−14 37	250	70
115	295	+9 36	+9 34	+8 33	+8 32	+7 31	+6 30	+6 29	+5 29	+5 29	+4 28	+3 28	+2 28	+1 29	0 29	−2 29	−4 30	−6 31	−8 32	245	65
120	300	$+10_1$ 39_1	+10 37	+10 36	+9 35	+9 33	+8 32	$+8_1$ 31_0	+8 31	+7 30	+7 29	+6 29	+5 29	$+4_1$ 29_0	+3 28	+2 28	+1 28	−1 29	-3_0 29_0	240	60
125	305	+11 42	+11 40	+11 39	+11 38	+11 36	+10 35	+10 34	+10 33	+10 32	+9 31	+9 31	+8 31	+8 30	+7 29	+7 28	+6 28	+5 28	+3 28	235	55
130	310	+12 46	+12 44	+12 42	+12 41	+12 40	+12 38	+12 37	+12 36	+12 35	+12 34	+12 33	+11 33	+11 32	+11 31	+11 30	+11 30	+10 29	+9 29	230	50
135	315	+12 49	+12 48	+12 46	+13 45	+13 43	+13 42	+13 40	+14 39	+14 38	+14 37	+14 36	+14 36	+14 35	+15 34	+15 33	+15 33	+15 32	+15 32	225	45
140	320	+12 53	+12 51	+13 50	+13 48	+13 47	+14 46	+14 44	+15 43	+15 42	+16 41	+16 40	+17 40	+17 39	+18 38	+18 37	+19 37	+20 36	+21 36	220	40
145	325	+11 57	+12 55	+13 54	+13 52	+14 51	+14 50	+15 49	+16 48	+16 47	+17 46	+18 45	+19 45	+19 44	+20 43	+21 42	+23 42	+24 42	+26 42	215	35
150	330	$+10_1$ 60_2	+11 58	+12 57	+13 56	+13 55	+14 54	$+15_1$ 53_2	+16 52	+17 51	+18 51	+19 50	+20 50	$+21_2$ 49_2	+22 49	+24 48	+26 49	+28 49	$+30_3$ 49_2	210	30
155	335	+9 63	+10 62	+11 61	+12 60	+13 59	+14 58	+15 57	+16 56	+17 56	+18 56	+20 55	+21 55	+22 55	+24 55	+26 55	+28 56	+31 57	+34 57	205	25
160	340	+8 66	+9 65	+10 64	+11 63	+12 62	+13 61	+14 61	+15 61	+17 61	+18 61	+20 61	+21 61	+23 61	+25 62	+27 63	+30 64	+33 65	+37 67	200	20
165	345	+6 68	+7 67	+8 66	+9 66	+11 65	+12 65	+13 65	+14 65	+16 65	+17 66	+19 66	+21 67	+23 68	+25 69	+28 70	+31 72	+34 74	+38 77	195	15
170	350	+4 69	+5 69	+6 68	+8 68	+9 68	+10 68	+12 69	+13 69	+15 69	+16 70	+18 71	+20 72	+22 74	+25 76	+28 78	+31 81	+35 84	+39 88	190	10
175	355	+2 70	+3 70	+4 70	+6 70	+7 70	+8 71	+10 72	+11 72	+13 73	+15 74	+17 76	+19 77	+21 79	+24 82	+27 85	+30 89	+34 93	+39 98	185	5
180	360	0_0 71_3	+1 71	+2 71	+4 71	+5 72	+6 73	$+8_1$ 74_3	+9 75	+11 76	+13 78	+15 80	+17 82	$+19_1$ 85_4	+22 88	+25 92	+28 97	+32 102	$+37_3$ 108_6	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -14°$																					
$p_{+\tau}$ \ τ		0h						Ih						IIh						τ / $p_{-\tau}$	
		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		
°	°	Δp h																		°	°
0	180	0_0 77_4	+1 77	+3 77	+4 78	+6 79	+7 80	$+9_1$ 81_4	+11 82	+13 84	+15 86	+17 88	+19 91	$+22_2$ 94_5	+25 98	+29 103	+33 108	+38 114	$+43_3$ $122_{8,}$	360	180
5	185	−2 77	−1 77	0 78	+2 79	+3 80	+5 81	+7 83	+8 85	+10 87	+12 89	+14 92	+17 95	+19 99	+22 104	+26 110	+30 116	+35 124	+40 134	355	175
10	190	−5 76	−3 76	−2 77	−1 79	+1 80	+2 82	+4 84	+6 86	+7 89	+9 92	+11 95	+14 99	+16 104	+19 110	+22 116	+26 124	+31 133	+36 144	350	170
15	195	−7 74	−6 75	−4 76	−3 78	−2 80	−1 82	+1 84	+3 87	+4 90	+6 93	+8 97	+10 102	+12 108	+15 114	+18 121	+22 130	+26 140	+31 152	345	165
20	200	−9 71	−8 73	−7 74	−6 76	−4 78	−3 81	−2 84	0 87	+1 90	+3 94	+5 99	+6 104	+8 110	+11 117	+14 125	+17 135	+21 146	+25 159	340	160
25	205	−11 68	−10 70	−9 72	−8 74	−7 76	−6 79	−5 82	−3 86	−2 90	−1 94	+1 99	+3 105	+5 111	+7 118	+9 127	+12 138	+15 150	+19 164	335	155
30	210	-12_1 65_3	−11 67	−10 69	−10 71	−9 74	−8 77	-7_1 80_4	−6 84	−5 88	−4 93	−3 98	−1 104	0_0 110_6	+2 118	+4 128	+6 139	+9 152	$+12_1$ 167_{11}	330	150
35	215	−13 61	−12 63	−12 65	−11 68	−11 71	−10 74	−9 77	−8 81	−8 85	−7 90	−6 96	−5 102	−4 109	−2 117	−1 127	+1 139	+3 153	+5 169	325	145
40	220	−14 57	−13 59	−13 61	−12 64	−12 67	−12 70	−11 74	−10 78	−10 82	−9 87	−9 93	−8 99	−7 106	−7 115	−6 125	−5 137	−3 151	−2 168	320	140
45	225	−14 53	−14 55	−14 57	−13 60	−13 63	−13 66	−13 70	−12 74	−12 78	−12 83	−12 89	−11 95	−11 103	−11 111	−10 121	−10 133	−9 148	−8 165	315	135
50	230	−14 48	−14 50	−14 53	−14 56	−14 59	−14 62	−14 65	−14 69	−14 73	−14 78	−14 84	−14 90	−14 98	−14 106	−14 116	−15 128	−15 143	−15 159	310	130
55	235	−13 44	−13 46	−14 48	−14 51	−14 54	−14 57	−14 60	−15 64	−15 68	−15 73	−16 79	−16 85	−17 92	−17 100	−18 110	−19 122	−20 136	−21 152	305	125
60	240	-12_1 40_1	−12 42	−13 44	−13 47	−14 50	−14 52	-15_1 55_2	−15 59	−16 63	−16 68	−17 73	−18 79	-19_1 86_4	−20 94	−21 103	−22 114	−24 128	-26_2 144_8	300	120
65	245	−11 37	−11 38	−12 40	−12 43	−13 46	−14 48	−14 51	−15 54	−16 58	−17 62	−18 67	−19 73	−20 79	−21 87	−23 95	−25 106	−27 119	−30 134	295	115
70	250	−9 34	−10 35	−11 37	−11 39	−12 41	−13 43	−14 46	−14 49	−15 52	−16 56	−18 61	−19 66	−21 72	−22 79	−24 87	−27 97	−30 109	−33 123	290	110
75	255	−7 31	−8 32	−9 34	−10 36	−11 37	−12 39	−13 42	−13 44	−14 47	−15 51	−17 55	−19 60	−21 65	−23 71	−25 78	−28 87	−31 98	−34 111	285	105
80	260	−5 29	−6 30	−7 31	−8 33	−9 34	−10 36	−11 38	−12 40	−13 42	−14 46	−16 49	−18 53	−20 58	−22 63	−24 70	−27 78	−31 87	−35 98	280	100
85	265	−2 28	−3 29	−4 30	−5 31	−6 32	−7 33	−9 34	−10 36	−11 38	−12 41	−14 44	−16 47	−18 51	−20 56	−23 61	−26 68	−30 76	−34 86	275	95
90	270	0_0 28_0	−1 28	−2 29	−3 29	−4 30	−5 31	-6_0 32_0	−7 33	−9 35	−10 37	−12 39	−14 42	-16_1 45_1	−18 49	−21 53	−24 59	−28 66	-33_2 74_3	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -14°$

	τ	0^{h}						I^{h}						II^{h}						τ	
$p_{+\tau}$		0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}	0^{m}	10^{m}	20^{m}	30^{m}	40^{m}	50^{m}		$p_{-\tau}$
°	°	Δp h																		°	°
90	270	0_0	−1	−2	−3	−4	−5	-6_0	−7	−9	−10	−12	−14	-16_1	−18	−21	−24	−28	-33_2	270	90
		28_0	28	29	29	30	31	32_0	33	35	37	39	42	45_1	49	53	59	66	74_3		
95	275	+2	+1	0	−1	−2	−3	−4	−5	−6	−8	−9	−11	−13	−15	−18	−21	−25	−29	265	85
		28	28	28	28	29	29	30	31	32	34	35	37	40	43	46	51	57	63		
100	280	+5	+4	+3	+2	+1	0	−1	−2	−3	−5	−6	−8	−10	−12	−15	−18	−21	−25	260	80
		29	29	28	28	28	28	29	29	30	31	32	33	35	37	40	44	48	53		
105	285	+7	+6	+5	+5	+4	+3	+2	+1	0	−2	−3	−5	−6	−8	−11	−14	−17	−20	255	75
		31	30	29	29	29	28	28	28	29	29	30	30	31	33	35	38	41	44		
110	290	+9	+8	+8	+7	+6	+5	+5	+4	+3	+2	0	−1	−2	−4	−6	−9	−12	−15	250	70
		34	32	31	31	30	29	29	29	28	28	28	29	29	30	31	33	35	37		
115	295	+11	+10	+10	+9	+9	+8	+7	+7	+6	+5	+4	+3	+2	0	−1	−3	−6	−9	245	65
		37	35	34	33	32	31	30	30	29	29	28	28	28	29	29	30	31	32		
120	300	$+12_1$	+12	+11	+11	+11	+10	$+10_1$	+9	+9	+8	+7	+7	$+6_1$	+5	+4	+2	0	-2_0	240	60
		40_1	39	37	36	35	33	32_0	31	31	30	29	29	28_0	28	28	28	29	29_0		
125	305	+13	+13	+13	+13	+13	+12	+12	+12	+12	+11	+11	+10	+10	+9	+9	+8	+7	+5	235	55
		44	42	40	39	38	36	35	34	33	32	31	30	29	29	29	28	28	28		
130	310	+14	+14	+14	+14	+14	+14	+14	+14	+14	+14	+14	+14	+14	+14	+13	+13	+13	+12	230	50
		48	46	44	43	41	40	39	38	36	35	34	33	32	31	31	30	30	29		
135	315	+14	+14	+14	+15	+15	+15	+16	+16	+16	+16	+17	+17	+17	+18	+18	+18	+19	+19	225	45
		53	51	49	47	45	44	43	42	40	39	38	37	36	35	35	34	33	32		
140	320	+14	+14	+15	+15	+16	+16	+17	+17	+18	+18	+19	+19	+20	+21	+22	+23	+24	+25	220	40
		57	55	53	52	50	49	47	46	45	44	43	42	41	40	40	39	38	37		
145	325	+13	+14	+14	+15	+16	+16	+17	+18	+19	+20	+21	+22	+23	+24	+26	+27	+29	+31	215	35
		61	59	57	56	54	53	52	51	50	49	48	47	47	46	46	45	45	44		
150	330	$+12_1$	+13	+14	+15	+16	+16	$+17_1$	+18	+20	+21	+22	+23	$+25_2$	+27	+29	+31	+33	$+36_3$	210	30
		65_3	63	61	60	59	58	57_2	56	55	54	54	53	53_2	53	53	53	53	53_2		
155	335	+11	+12	+13	+14	+15	+16	+17	+18	+20	+21	+23	+24	+26	+28	+31	+33	+36	+40	205	25
		68	67	65	64	63	63	62	61	61	60	60	60	60	60	61	61	62	63		
160	340	+9	+10	+11	+13	+14	+15	+16	+18	+19	+21	+23	+25	+27	+29	+32	+35	+39	+43	200	20
		71	70	69	68	67	67	66	66	66	66	66	66	67	68	69	70	72	74		
165	345	+7	+8	+9	+11	+12	+14	+15	+17	+18	+20	+22	+24	+27	+29	+32	+36	+40	+45	195	15
		74	73	72	71	71	71	71	71	71	72	72	73	74	76	78	80	83	86		
170	350	+5	+6	+7	+9	+10	+12	+13	+15	+17	+19	+21	+23	+26	+29	+32	+36	+40	+45	190	10
		76	75	74	74	74	74	75	75	76	77	78	79	81	83	86	90	94	98		
175	355	+2	+4	+5	+7	+8	+10	+11	+13	+15	+17	+19	+21	+24	+27	+31	+35	+39	+44	185	5
		77	76	76	76	77	77	78	79	80	82	83	85	88	91	95	99	104	110		
180	360	0_0	+1	+3	+4	+6	+7	$+9_1$	+11	+13	+15	+17	+19	$+22_2$	+25	+29	+33	+38	$+43_3$	180	0
		77_4	77	77	78	79	80	81_4	82	84	86	88	91	94_5	98	103	108	114	122_8		

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -16°$

$p_{+\tau}$	τ	0h						Ih						IIh						τ	$p_{-\tau}$
		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		
°	°	Δp h																		°	°
0	180	0_0 84_4	+2 85	+3 85	+5 86	+7 87	+9 88	$+10_1$ 89_4	+12 91	+15 93	+17 95	+19 98	+22 101	$+25_2$ 105_6	+29 110	+33 115	+38 122	+44 130	$+51_4$ 140_9	360	180
5	185	−3 84	−1 85	0 86	+2 87	+4 88	+6 89	+7 91	+9 93	+12 96	+14 99	+16 102	+19 106	+22 111	+26 117	+30 124	+35 132	+40 141	+47 153	355	175
10	190	−6 83	−4 84	−2 85	−1 87	+1 88	+3 90	+4 92	+6 95	+8 98	+10 102	+13 106	+16 111	+18 116	+22 123	+26 131	+30 140	+35 151	+42 164	350	170
15	195	−8 81	−7 82	−5 84	−4 86	−2 88	−1 90	+1 93	+3 96	+5 100	+7 104	+9 109	+12 114	+14 120	+17 127	+21 136	+25 147	+30 159	+36 174	345	165
20	200	−10 78	−9 80	−8 82	−7 84	−5 86	−4 89	−2 92	−1 96	+1 100	+3 105	+5 110	+7 116	+9 123	+12 130	+16 140	+20 152	+24 166	+29 182	340	160
25	205	−12 75	−11 77	−10 79	−9 81	−8 84	−6 87	−5 90	−4 94	−2 99	−1 104	+1 109	+3 116	+5 124	+7 133	+10 143	+13 155	+17 170	+22 188	335	155
30	210	-14_1 71_3	−13 73	−12 75	−11 78	−10 81	−9 84	-8_1 88_5	−7 92	−6 97	−5 102	−3 108	−1 115	0_0 123_7	+2 133	+4 144	+7 157	+10 173	$+14_1$ 192_{13}	330	150
35	215	−15 66	−14 69	−14 71	−13 74	−12 77	−11 80	−11 84	−10 89	−9 94	−8 100	−7 106	−6 113	−5 121	−3 131	−1 143	+1 157	+3 173	+6 193	325	145
40	220	−16 62	−15 64	−15 66	−14 69	−14 72	−13 76	−13 80	−12 85	−12 90	−11 96	−10 103	−10 110	−9 118	−8 128	−7 140	−6 154	−4 171	−2 191	320	140
45	225	−16 57	−16 59	−16 62	−15 65	−15 68	−15 71	−15 75	−14 80	−14 85	−14 91	−13 98	−13 105	−13 114	−12 124	−12 136	−12 150	−11 167	−10 187	315	135
50	230	−16 52	−16 54	−16 57	−16 60	−16 63	−16 66	−16 70	−16 75	−16 80	−16 86	−16 92	−16 99	−16 108	−16 118	−17 130	−17 144	−17 161	−17 181	310	130
55	235	−15 47	−15 49	−16 52	−16 55	−16 58	−16 61	−17 65	−17 69	−17 74	−18 80	−18 86	−18 93	−19 101	−20 111	−21 123	−22 137	−23 153	−24 173	305	125
60	240	-14_1 42_1	−14 44	−15 47	−15 50	−16 53	−16 56	-17_1 59_2	−17 63	−18 68	−19 73	−19 79	−20 86	-21_2 94_5	−23 103	−24 115	−26 128	−28 143	-30_2 162_{10}	300	120
65	245	−12 38	−13 40	−14 42	−14 45	−15 48	−15 51	−16 54	−17 58	−18 62	−19 67	−20 72	−21 79	−23 86	−25 95	−27 106	−29 118	−32 132	−35 151	295	115
70	250	−10 35	−11 36	−12 38	−13 41	−14 43	−14 46	−15 49	−16 52	−17 56	−19 60	−20 65	−22 71	−24 78	−26 86	−28 96	−31 107	−34 121	−38 138	290	110
75	255	−8 32	−9 33	−10 35	−11 37	−12 39	−13 41	−14 44	−15 47	−16 50	−18 54	−19 58	−21 63	−23 70	−26 77	−29 86	−32 96	−36 108	−40 124	285	105
80	260	−6 30	−7 31	−8 32	−9 34	−10 35	−11 37	−12 39	−13 42	−15 45	−16 48	−18 52	−20 56	−22 62	−25 68	−28 76	−32 85	−36 96	−41 109	280	100
85	265	−3 29	−4 29	−5 30	−6 31	−7 32	−8 34	−10 35	−11 37	−13 40	−14 43	−16 46	−18 49	−20 54	−23 60	−26 66	−30 74	−35 83	−40 95	275	95
90	270	0_0 28_0	−1 28	−2 29	−3 29	−4 30	−6 31	-7_0 32_0	−8 34	−10 36	−11 38	−13 40	−15 43	-18_1 47_1	−21 52	−24 57	−28 63	−33 71	-38_3 81_3	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -16°$

	τ	0^h						I^h						II^h						τ	
$p_{+\tau}$		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m		$p_{-\tau}$
°	°	Δp h																		°	°
90	270	0_0 28_0	−1 28	−2 29	−3 29	−4 30	−6 31	-7_0 32_0	−8 34	−10 36	−11 38	−13 40	−15 43	-18_1 47_1	−21 52	−24 57	−28 63	−33 71	-38_3 81_3	270	90
95	275	+3 29	+2 28	+1 28	0 28	−2 29	−3 29	−4 30	−5 31	−7 32	−8 34	−10 36	−12 38	−15 41	−17 44	−20 48	−24 54	−29 60	−34 68	265	85
100	280	+6 30	+5 29	+4 29	+3 28	+1 28	0 28	−1 29	−2 29	−4 30	−5 31	−7 32	−9 33	−11 35	−13 38	−16 41	−20 45	−24 50	−29 57	260	80
105	285	+8 32	+7 31	+6 30	+5 29	+4 29	+3 28	+2 28	+1 28	0 29	−1 29	−3 29	−5 30	−7 31	−9 33	−12 35	−15 38	−18 42	−23 47	255	75
110	290	+10 35	+10 34	+9 32	+8 31	+7 31	+6 30	+6 29	+5 28	+4 28	+2 28	+1 28	0 29	−2 29	−4 30	−6 31	−9 33	−12 35	−16 39	250	70
115	295	+12 38	+12 37	+11 35	+11 34	+10 33	+9 32	+9 31	+8 30	+7 29	+6 28	+5 28	+4 28	+3 28	+1 28	−1 29	−3 30	−6 31	−9 33	245	65
120	300	$+14_1$ 42_1	+14 41	+13 39	+13 37	+12 36	+12 35	$+12_1$ 33_0	+11 32	+11 31	+10 30	+9 29	+8 29	$+7_1$ 29_0	+6 28	+5 28	+3 28	+1 28	-1_0 29_0	240	60
125	305	+15 47	+15 45	+15 43	+15 41	+14 40	+14 38	+14 36	+14 35	+14 34	+13 33	+13 32	+13 31	+12 31	+11 30	+11 29	+10 28	+9 28	+7 28	235	55
130	310	+16 52	+16 50	+16 48	+16 46	+16 44	+16 42	+16 40	+16 39	+16 38	+16 37	+17 36	+17 35	+17 34	+16 33	+16 32	+16 31	+16 30	+15 30	230	50
135	315	+16 57	+17 54	+17 52	+17 50	+17 49	+18 47	+18 45	+18 44	+19 43	+19 42	+20 41	+20 39	+21 38	+21 37	+21 36	+22 35	+23 34	+23 34	225	45
140	320	+16 62	+17 59	+17 57	+18 55	+18 54	+19 52	+19 51	+20 49	+21 48	+21 47	+22 46	+23 45	+24 44	+25 43	+26 42	+27 41	+29 40	+31 40	220	40
145	325	+15 66	+16 64	+17 62	+18 60	+18 59	+19 57	+20 56	+21 55	+22 54	+23 53	+24 52	+25 51	+27 51	+28 50	+30 49	+32 49	+34 48	+37 48	215	35
150	330	$+14_1$ 71_3	+15 69	+16 67	+17 65	+18 64	+19 63	$+20_1$ 62_3	+21 61	+23 60	+24 59	+25 58	+27 58	$+29_2$ 58_2	+31 58	+34 57	+36 58	+39 58	$+43_4$ 58_3	210	30
155	335	+13 75	+14 73	+15 72	+16 70	+17 69	+18 68	+20 67	+21 67	+23 66	+25 66	+26 65	+28 65	+30 66	+33 66	+36 67	+39 68	+43 69	+48 70	205	25
160	340	+11 78	+12 77	+13 76	+14 75	+16 74	+17 73	+19 73	+20 72	+22 72	+24 72	+26 73	+28 73	+31 74	+34 75	+37 76	+41 78	+46 80	+51 83	200	20
165	345	+9 81	+10 80	+11 79	+12 79	+14 78	+16 78	+17 78	+19 78	+21 78	+23 79	+25 80	+28 81	+31 82	+34 84	+38 86	+42 89	+47 93	+53 97	195	15
170	350	+6 83	+7 82	+9 82	+10 82	+12 82	+14 82	+15 82	+17 83	+19 84	+22 85	+24 86	+27 88	+30 90	+33 93	+37 96	+42 100	+47 105	+54 112	190	10
175	355	+3 84	+4 84	+6 84	+8 84	+9 85	+11 85	+13 86	+15 87	+17 89	+20 90	+22 92	+25 95	+28 98	+31 102	+36 106	+41 111	+46 118	+53 126	185	5
180	360	0_0 84_4	+2 85	+3 85	+5 86	+7 87	+9 88	$+10_1$ 89_4	+12 91	+15 93	+17 95	+19 98	+22 101	$+25_2$ 105_6	+29 110	+33 115	+38 122	+44 130	$+51_4$ 140_9	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -17°$

τ $p_{+\tau}$		0h						Ih						IIh						τ $p_{-\tau}$	
		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		
°	°	Δp h																		°	°
0	180	0_0 89_5	+ 2 89	+ 3 89	+ 5 90	+ 7 91	+ 9 92	$+11_1$ 94_5	+13 96	+15 98	+18 100	+21 103	+24 107	$+27_2$ 111_7	+31 116	+36 123	+41 130	+47 139	$+55_4$ 150_{11}	360	180
5	185	− 3 88	− 1 89	0 90	+ 2 91	+ 4 92	+ 6 94	+ 8 96	+10 98	+12 101	+15 104	+18 108	+21 113	+24 118	+28 124	+32 132	+37 140	+43 151	+51 164	355	175
10	190	− 6 87	− 4 88	− 3 89	− 1 91	+ 1 93	+ 3 95	+ 5 97	+ 7 100	+ 9 103	+11 107	+14 112	+17 117	+20 123	+24 130	+28 139	+33 149	+39 161	+46 176	350	170
15	195	− 9 85	− 7 87	− 6 88	− 4 90	− 2 92	− 1 95	+ 1 98	+ 3 101	+ 5 105	+ 7 109	+10 114	+12 120	+15 127	+19 135	+23 145	+28 157	+33 170	+39 187	345	165
20	200	−11 82	−10 84	− 9 86	− 7 88	− 5 90	− 4 93	− 2 97	− 1 101	+ 1 105	+ 3 110	+ 5 116	+ 8 122	+10 130	+13 139	+17 150	+21 162	+26 177	+32 196	340	160
25	205	−13 78	−12 80	−11 83	−10 85	− 8 88	− 7 91	− 6 95	− 4 99	− 3 104	− 1 110	+ 1 116	+ 3 123	+ 5 131	+ 8 141	+11 152	+15 165	+19 182	+24 202	335	155
30	210	-15_1 74_3	−14 76	−13 79	−12 82	−11 85	−10 88	-9_1 92_5	− 8 97	− 6 102	− 5 108	− 3 114	− 2 122	0_0 131_8	+ 2 142	+ 5 153	+ 8 167	+11 185	$+15_1$ 206_{15}	330	150
35	215	−16 69	−16 72	−15 74	−14 77	−13 81	−12 85	−12 89	−11 93	−10 98	− 9 105	− 7 112	− 6 119	− 5 129	− 4 140	− 2 152	0 167	+ 3 185	+ 6 206	325	145
40	220	−17 64	−17 67	−16 69	−16 72	−15 76	−14 80	−14 84	−13 89	−13 94	−12 101	−11 108	−10 116	−10 125	− 9 136	− 8 149	− 6 164	− 5 182	− 3 205	320	140
45	225	−17 59	−17 61	−17 64	−17 67	−16 71	−16 75	−16 79	−15 84	−15 90	−15 96	−14 103	−14 111	−14 120	−14 131	−13 144	−13 159	−12 177	−11 200	315	135
50	230	−17 53	−17 56	−17 59	−17 62	−17 65	−17 69	−17 73	−17 78	−17 84	−17 90	−17 97	−17 105	−18 114	−18 125	−18 138	−19 153	−19 171	−19 193	310	130
55	235	−16 48	−17 51	−17 53	−17 56	−17 60	−18 64	−18 68	−18 72	−19 77	−19 83	−19 90	−20 98	−21 107	−22 117	−23 130	−24 145	−25 163	−27 184	305	125
60	240	-15_1 44_1	−16 46	−16 48	−16 51	−17 54	−17 58	-18_1 62_2	−19 66	−20 71	−20 76	−21 83	−22 90	-23_2 99_5	−25 109	−26 121	−28 135	−30 152	-33_3 173_{11}	300	120
65	245	−13 39	−14 41	−15 43	−15 46	−16 49	−17 52	−18 56	−19 60	−20 64	−21 69	−22 75	−23 82	−25 90	−27 100	−29 111	−31 124	−34 140	−38 160	295	115
70	250	−11 35	−12 37	−13 39	−14 41	−15 44	−16 47	−17 50	−18 54	−19 58	−20 62	−22 68	−24 74	−26 81	−28 90	−30 100	−33 113	−37 128	−41 146	290	110
75	255	− 9 32	−10 34	−11 35	−12 37	−13 39	−14 42	−15 45	−16 48	−18 51	−19 55	−21 60	−23 66	−25 72	−28 80	−31 90	−34 101	−38 115	−43 131	285	105
80	260	− 6 30	− 7 31	− 8 32	− 9 34	−10 35	−12 37	−13 40	−14 42	−16 45	−17 49	−19 53	−21 58	−24 64	−27 71	−30 79	−34 89	−38 101	−44 115	280	100
85	265	− 3 29	− 4 29	− 5 30	− 6 31	− 8 32	− 9 34	−10 36	−12 38	−13 40	−15 43	−17 46	−19 50	−22 55	−25 61	−28 68	−32 77	−37 87	−43 100	275	95
90	270	0_0 28_0	− 1 28	− 2 29	− 3 29	− 5 30	− 6 31	-7_0 33_0	− 9 34	−10 36	−12 38	−14 41	−16 44	-19_1 48_1	−22 52	−26 58	−30 65	−35 74	-41_3 85_4	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -17°$

$p_{+\tau}$	τ	0h 0m	0h 10m	0h 20m	0h 30m	0h 40m	0h 50m	Ih 0m	Ih 10m	Ih 20m	Ih 30m	Ih 40m	Ih 50m	IIh 0m	IIh 10m	IIh 20m	IIh 30m	IIh 40m	IIh 50m	τ	$p_{-\tau}$
°	°	Δp h																		°	°
90	270	0_0 28_0	−1 28	−2 29	−3 29	−5 30	−6 31	-7_0 33_0	−9 34	−10 36	−12 38	−14 41	−16 44	-19_1 48_1	−22 52	−26 58	−30 65	−35 74	-41_3 85_4	270	90
95	275	+3 29	+2 28	+1 28	0 28	−2 29	−3 29	−4 30	−6 31	−7 33	−9 34	−11 36	−13 38	−15 41	−18 45	−22 50	−26 55	−31 62	−37 71	265	85
100	280	+6 30	+5 29	+4 29	+3 28	+2 28	+1 28	−1 28	−2 29	−4 30	−5 31	−7 32	−9 34	−11 36	−14 39	−17 42	−21 46	−26 52	−31 58	260	80
105	285	+9 32	+8 31	+7 30	+6 30	+5 29	+4 28	+3 28	+1 28	0 28	−1 29	−3 30	−5 31	−7 32	−9 34	−12 36	−16 39	−20 43	−25 48	255	75
110	290	+11 35	+10 34	+10 33	+9 32	+8 31	+7 30	+6 29	+5 28	+4 28	+3 28	+1 28	0 29	−2 30	−4 31	−7 32	−10 34	−13 36	−17 39	250	70
115	295	+13 39	+13 38	+12 36	+12 34	+11 33	+10 32	+9 31	+9 30	+8 29	+7 29	+6 28	+5 28	+3 28	+1 28	−1 29	−3 30	−6 31	−9 33	245	65
120	300	$+15_1$ 44_1	+15 42	+14 40	+14 38	+14 36	+13 35	$+12_1$ 34_0	+12 33	+11 32	+11 31	+10 30	+9 29	$+8_1$ 29_0	+7 28	+6 28	+4 28	+2 28	-1_0 29_0	240	60
125	305	+16 48	+16 46	+16 44	+16 42	+16 40	+16 39	+15 38	+15 36	+15 35	+14 33	+14 32	+14 31	+13 31	+13 30	+12 29	+11 29	+10 28	+8 28	235	55
130	310	+17 53	+17 51	+17 49	+17 47	+18 45	+18 43	+18 42	+18 40	+18 39	+18 37	+18 36	+18 35	+18 34	+18 33	+18 32	+18 31	+18 30	+17 30	230	50
135	315	+17 59	+18 57	+18 54	+18 52	+19 50	+19 48	+20 47	+20 45	+20 44	+21 42	+21 41	+22 40	+22 39	+23 38	+24 37	+24 36	+25 35	+26 34	225	45
140	320	+17 64	+18 62	+18 60	+19 58	+20 56	+20 54	+21 52	+22 51	+22 50	+23 48	+24 47	+25 46	+26 45	+27 44	+29 43	+30 43	+32 42	+34 41	220	40
145	325	+16 69	+17 67	+18 65	+19 63	+20 61	+21 60	+22 58	+23 57	+24 56	+25 55	+26 54	+28 53	+29 52	+31 52	+33 51	+35 51	+38 50	+41 50	215	35
150	330	$+15_1$ 74_3	+16 72	+17 70	+18 68	+19 67	+21 66	$+22_2$ 64_3	+23 63	+25 62	+26 62	+28 61	+30 61	$+32_3$ 60_3	+34 60	+36 60	+39 60	+43 61	$+47_4$ 61_3	210	30
155	335	+14 78	+15 77	+16 75	+17 73	+18 72	+20 71	+21 70	+23 70	+25 69	+27 69	+29 69	+31 69	+33 69	+36 69	+39 70	+43 71	+47 72	+52 74	205	25
160	340	+12 82	+13 81	+14 79	+15 78	+17 77	+19 77	+20 76	+22 76	+24 76	+26 76	+28 76	+31 77	+34 78	+37 79	+41 81	+45 83	+50 85	+56 88	200	20
165	345	+9 85	+10 84	+12 83	+13 82	+15 82	+17 82	+19 81	+21 82	+23 82	+25 83	+27 84	+30 85	+33 87	+37 89	+41 92	+46 95	+51 99	+57 104	195	15
170	350	+6 87	+8 87	+9 86	+11 86	+13 86	+15 86	+17 86	+19 87	+21 88	+23 89	+26 91	+29 93	+32 96	+36 99	+40 103	+45 107	+51 112	+58 119	190	10
175	355	+3 89	+5 89	+6 88	+8 88	+10 89	+12 90	+14 91	+16 92	+18 93	+21 95	+24 97	+27 100	+30 104	+34 108	+39 113	+44 119	+50 126	+57 135	185	5
180	360	0_0 89_5	+2 89	+3 89	+5 90	+7 91	+9 92	$+11_1$ 94_5	+13 96	+15 98	+18 100	+21 103	+24 107	$+27_2$ 111_7	+31 116	+36 123	+41 130	+47 139	$+55_4$ 150_{11}	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -18°$

$p_{+\tau}$ \ τ	0h						Ih						IIh						τ / $p_{-\tau}$
	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	
° °	Δp h																		° °
0 180	0_0 94_5	+ 2 94	+ 4 95	+ 6 95	+ 8 96	+10 97	$+12_1$ 99_5	+14 101	+16 103	+19 106	+22 110	+26 114	$+30_2$ 118_7	+34 124	+39 131	+45 139	+51 149	$+59_5$ 161_{12}	360 180
5 185	− 3 93	− 1 94	0 95	+ 2 96	+ 4 97	+ 6 99	+ 8 101	+11 104	+13 107	+16 111	+19 115	+22 120	+26 125	+30 132	+35 140	+40 150	+47 162	+55 176	355 175
10 190	− 6 92	− 5 93	− 3 94	− 1 96	+ 1 98	+ 3 100	+ 5 103	+ 7 106	+ 9 110	+12 114	+15 119	+18 124	+21 131	+25 139	+30 148	+35 160	+42 173	+50 190	350 170
15 195	− 9 90	− 8 91	− 6 93	− 5 95	− 3 97	− 1 100	+ 1 103	+ 3 107	+ 5 111	+ 7 116	+10 121	+13 128	+16 136	+20 144	+24 155	+29 168	+35 183	+42 201	345 165
20 200	−12 86	−11 88	− 9 90	− 8 93	− 6 96	− 5 99	− 3 102	− 1 106	+ 1 111	+ 3 116	+ 5 122	+ 8 130	+11 138	+14 148	+18 160	+22 174	+28 190	+34 210	340 160
25 205	−14 82	−13 84	−12 87	−10 90	− 9 93	− 8 96	− 7 100	− 5 105	− 3 110	− 1 116	+ 1 122	+ 3 130	+ 5 139	+ 8 150	+11 162	+15 177	+20 195	+25 217	335 155
30 210	-16_1 77_4	−15 80	−14 83	−13 86	−12 89	−11 93	-10_1 97_5	− 8 102	− 7 108	− 5 114	− 4 121	− 2 129	0_0 138_9	+ 2 150	+ 5 163	+ 8 179	+12 198	$+16_1$ 221_{17}	330 150
35 215	−17 72	−17 75	−16 78	−15 81	−14 85	−13 89	−12 93	−11 98	−10 104	− 9 111	− 8 118	− 7 126	− 5 136	− 4 148	− 2 162	0 178	+ 3 198	+ 6 222	325 145
40 220	−18 67	−18 70	−17 73	−17 76	−16 80	−15 84	−15 88	−14 93	−13 99	−13 106	−12 114	−11 122	−10 133	− 9 144	− 8 158	− 7 175	− 5 196	− 3 220	320 140
45 225	−19 61	−18 64	−18 67	−18 70	−17 74	−17 78	−17 83	−17 88	−16 94	−16 101	−16 108	−15 117	−15 127	−14 139	−14 153	−14 170	−13 191	−13 215	315 135
50 230	−18 55	−18 58	−18 61	−18 64	−18 68	−18 72	−18 77	−18 82	−18 88	−19 94	−19 101	−19 110	−19 121	−19 132	−20 146	−20 163	−21 183	−22 208	310 130
55 235	−17 50	−18 52	−18 55	−18 58	−18 62	−19 66	−19 70	−19 75	−20 81	−21 87	−21 94	−22 103	−22 113	−23 124	−25 138	−26 154	−28 173	−29 197	305 125
60 240	-16_1 45_1	−17 47	−17 50	−18 53	−18 56	−19 60	-19_1 64_2	−20 69	−21 74	−22 80	−23 87	−24 95	-25_2 104_5	−27 115	−29 128	−31 143	−33 162	-36_3 185_{13}	300 120
65 245	−14 40	−15 42	−16 45	−17 47	−17 50	−18 54	−19 58	−20 62	−21 66	−22 72	−23 79	−25 86	−27 95	−29 105	−31 117	−34 132	−37 149	−41 171	295 115
70 250	−12 36	−13 38	−14 40	−15 42	−16 45	−17 48	−18 51	−19 55	−20 59	−22 64	−23 70	−25 77	−28 85	−30 94	−33 106	−36 119	−40 136	−45 156	290 110
75 255	− 9 33	−10 34	−11 36	−12 38	−13 40	−15 42	−16 45	−17 48	−19 52	−21 57	−22 62	−24 68	−27 76	−30 84	−33 94	−37 106	−42 121	−47 139	285 105
80 260	− 6 30	− 7 31	− 8 32	− 9 34	−10 36	−12 38	−14 40	−15 43	−17 46	−19 50	−21 55	−23 60	−26 66	−29 73	−33 82	−37 93	−42 106	−48 122	280 100
85 265	− 3 29	− 4 29	− 5 30	− 6 31	− 7 32	− 9 34	−11 36	−13 38	−14 41	−16 44	−18 48	−21 52	−24 57	−27 63	−31 71	−35 80	−40 92	−47 105	275 95
90 270	0_0 28_0	− 1 28	− 2 29	− 3 29	− 5 30	− 6 31	-8_0 33_0	−10 34	−11 36	−13 38	−15 41	−18 45	-21_1 49_1	−24 54	−28 60	−32 68	−37 78	-44_4 89_5	270 90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -18°$

τ / $p_{+\tau}$		0^h						I^h						II^h						τ / $p_{-\tau}$	
		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m		
°	°	Δp h																		°	°
90	270	0_0 28_0	−1 28	−2 29	−3 29	−5 30	−6 31	-8_0 33_0	−10 34	−11 36	−13 38	−15 41	−18 45	-21_1 49_1	−24 54	−28 60	−32 68	−37 78	-44_4 89_5	270	90
95	275	+3 29	+2 28	+1 28	0 28	−2 29	−3 29	−4 30	−6 31	−8 32	−10 34	−12 36	−14 39	−17 42	−20 46	−24 51	−28 57	−33 64	−40 74	265	85
100	280	+6 30	+5 30	+4 29	+3 28	+2 28	+1 28	−1 28	−2 29	−4 30	−6 31	−8 32	−10 34	−12 36	−15 39	−19 43	−23 48	−28 53	−34 60	260	80
105	285	+9 33	+8 32	+7 31	+6 30	+5 29	+4 28	+3 28	+2 28	0 28	−1 29	−3 30	−5 31	−7 32	−10 34	−13 36	−17 40	−22 44	−27 49	255	75
110	290	+12 36	+11 34	+10 33	+10 32	+9 31	+8 30	+7 29	+6 29	+4 28	+3 28	+2 28	0 29	−2 29	−4 30	−7 32	−10 34	−14 36	−19 40	250	70
115	295	+14 40	+14 38	+13 37	+13 35	+12 34	+11 32	+10 31	+10 30	+9 29	+7 29	+6 28	+5 28	+4 28	+2 28	0 29	−3 30	−6 31	−10 33	245	65
120	300	$+16_1$ 45_1	+16 43	+15 41	+15 39	+14 37	+14 35	$+14_1$ 34_0	+13 33	+13 32	+12 31	+11 30	+10 29	$+9_1$ 29_0	+8 28	+7 28	+5 28	+3 28	0_0 29_0	240	60
125	305	+18 50	+18 48	+17 45	+17 43	+17 41	+17 39	+17 38	+16 37	+16 36	+16 34	+15 33	+15 32	+14 31	+14 30	+13 30	+12 29	+11 28	+9 28	235	55
130	310	+19 55	+19 53	+19 50	+19 48	+19 46	+19 44	+19 43	+19 42	+19 40	+19 38	+19 37	+20 36	+20 35	+20 34	+20 33	+20 32	+19 31	+19 30	230	50
135	315	+19 61	+19 59	+20 56	+20 54	+20 52	+21 50	+21 48	+21 47	+22 45	+22 44	+23 43	+24 41	+25 40	+25 39	+26 38	+27 37	+27 36	+28 35	225	45
140	320	+19 67	+19 64	+20 62	+20 60	+21 58	+22 56	+22 54	+23 53	+24 51	+25 50	+26 49	+27 48	+29 47	+30 46	+31 45	+33 44	+35 43	+37 42	220	40
145	325	+18 72	+18 70	+19 68	+20 66	+21 64	+22 62	+23 61	+24 59	+25 58	+27 57	+28 56	+30 56	+32 55	+34 54	+36 54	+38 53	+41 53	+45 53	215	35
150	330	$+16_1$ 77_4	+17 75	+18 73	+19 72	+21 70	+22 68	$+23_2$ 67_3	+25 66	+26 65	+28 64	+30 64	+32 64	$+34_3$ 63_3	+37 63	+40 63	+43 64	+47 64	$+52_5$ 65_4	210	30
155	335	+14 82	+16 80	+17 79	+18 77	+20 76	+21 75	+23 74	+25 73	+27 72	+29 72	+31 72	+33 72	+36 72	+39 73	+42 74	+46 75	+51 77	+57 79	205	25
160	340	+12 86	+14 85	+15 84	+16 82	+18 81	+20 81	+22 80	+24 80	+26 80	+28 80	+30 80	+33 81	+36 82	+40 84	+44 86	+49 88	+54 91	+60 94	200	20
165	345	+9 90	+11 89	+13 88	+14 87	+16 86	+18 86	+20 86	+22 86	+24 87	+27 87	+30 88	+33 90	+36 92	+40 94	+45 97	+50 101	+56 105	+62 111	195	15
170	350	+6 92	+8 91	+10 91	+12 90	+14 90	+16 90	+18 91	+20 92	+22 93	+25 94	+28 96	+31 98	+35 101	+39 105	+44 109	+50 114	+56 120	+63 128	190	10
175	355	+3 93	+5 93	+7 93	+9 93	+11 94	+13 94	+15 95	+17 97	+19 98	+22 100	+25 103	+29 106	+33 110	+37 115	+42 120	+48 127	+54 135	+62 145	185	5
180	360	0_0 94_5	+2 94	+4 95	+6 95	+8 96	+10 97	$+12_1$ 99_5	+14 101	+16 103	+19 106	+22 110	+26 114	$+30_2$ 118_7	+34 124	+39 131	+45 139	+51 149	$+59_5$ 161_{12}	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -19°$

τ $p_{+\tau}$		0h						Ih						IIh						τ $p_{-\tau}$	
		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		
°	°	Δp h																		°	°
0	180	0_0 99_5	+2 99	+4 100	+6 101	+8 102	+10 103	$+13_1$ 105_6	+15 107	+18 109	+21 112	+24 116	+28 121	$+32_2$ 126_8	+37 132	+42 140	+48 149	+56 160	$+65_6$ 174_{14}	360	180
5	185	−4 99	−2 99	0 100	+2 101	+5 103	+7 105	+9 107	+11 110	+14 113	+17 117	+20 122	+24 127	+28 134	+32 141	+37 150	+44 161	+51 174	+60 190	355	175
10	190	−7 97	−5 98	−3 99	−1 101	+1 103	+3 106	+5 109	+7 112	+10 116	+13 121	+16 126	+19 132	+23 140	+27 148	+32 159	+38 172	+45 187	+54 205	350	170
15	195	−10 94	−9 96	−7 98	−5 100	−3 102	−1 105	+1 109	+3 113	+5 117	+8 123	+11 129	+14 136	+17 144	+21 154	+26 166	+32 180	+38 197	+46 218	345	165
20	200	−13 91	−12 93	−10 95	−8 98	−7 101	−5 104	−3 108	−1 112	+1 117	+3 123	+6 130	+9 138	+12 147	+15 158	+19 171	+24 186	+30 205	+37 228	340	160
25	205	−16 86	−15 89	−13 92	−11 95	−10 98	−8 102	−7 106	−5 111	−3 116	−1 122	+1 130	+3 138	+6 148	+9 160	+12 174	+16 190	+21 210	+27 235	335	155
30	210	-18_1 81_4	−17 84	−15 87	−14 90	−13 94	−12 98	-11_1 103_6	−9 108	−8 114	−6 120	−4 128	−2 137	0_0 148_9	+2 160	+5 174	+8 192	+12 213	$+17_1$ 239_{19}	330	150
35	215	−19 76	−18 79	−17 82	−16 85	−16 89	−15 93	−14 98	−13 104	−12 110	−10 117	−9 125	−7 134	−6 145	−4 158	−2 173	0 191	+3 213	+6 240	325	145
40	220	−20 70	−19 73	−19 76	−18 80	−18 84	−17 88	−16 93	−16 99	−15 105	−14 112	−13 120	−12 130	−11 141	−10 154	−9 169	−8 188	−6 211	−4 237	320	140
45	225	−20 64	−20 67	−20 70	−19 74	−19 78	−19 82	−18 87	−18 93	−18 99	−17 106	−17 114	−17 124	−16 135	−16 148	−16 164	−15 182	−15 205	−14 232	315	135
50	230	−20 57	−20 60	−20 63	−20 67	−20 71	−20 76	−20 81	−20 86	−20 92	−20 99	−20 107	−21 117	−21 128	−21 141	−22 156	−22 174	−23 196	−24 224	310	130
55	235	−19 51	−19 54	−20 57	−20 61	−20 65	−20 69	−21 74	−21 79	−22 85	−22 92	−23 100	−24 109	−25 119	−26 132	−27 147	−28 164	−30 186	−32 213	305	125
60	240	-18_1 46_1	−18 48	−19 51	−19 54	−20 58	−20 62	-21_2 66_3	−22 71	−23 77	−24 84	−25 91	−26 100	-27_2 110_6	−29 122	−31 136	−33 153	−36 174	-39_4 199_{15}	300	120
65	245	−16 41	−16 43	−17 46	−18 49	−19 52	−19 55	−20 59	−21 64	−23 69	−24 75	−25 82	−27 90	−29 100	−31 111	−34 124	−37 140	−41 160	−45 183	295	115
70	250	−13 36	−14 38	−15 41	−16 43	−17 46	−18 49	−19 53	−20 57	−22 61	−23 67	−25 74	−27 81	−29 89	−32 100	−35 112	−39 126	−44 144	−49 166	290	110
75	255	−10 33	−11 34	−12 36	−13 38	−15 41	−16 44	−17 47	−18 50	−20 54	−22 59	−24 65	−26 71	−29 79	−32 88	−36 99	−40 112	−45 128	−51 148	285	105
80	260	−7 30	−8 31	−9 32	−10 34	−12 36	−13 39	−15 41	−16 44	−18 48	−20 52	−22 57	−25 62	−28 69	−31 77	−35 86	−40 98	−45 112	−52 130	280	100
85	265	−4 29	−5 29	−6 30	−7 31	−9 32	−10 34	−12 36	−13 39	−15 42	−17 45	−19 49	−22 54	−25 59	−29 66	−33 74	−38 84	−44 96	−51 112	275	95
90	270	0_0 28_0	−1 28	−3 29	−4 29	−5 30	−7 31	-8_0 32_0	−10 34	−12 36	−14 39	−16 42	−19 46	-22_2 50_1	−25 56	−29 63	−34 71	−40 81	-48_4 94_5	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -19°$

τ $p_{+\tau}$		0h						Ih						IIh						τ $p_{-\tau}$	
		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		
°	°	Δp h																		°	°
90	270	0_0 28_0	−1 28	−3 29	−4 29	−5 30	−7 31	-8_0 32_0	−10 34	−12 36	−14 39	−16 42	−19 46	-22_2 50_1	−25 56	−29 63	−34 71	−40 81	-48_4 94_5	270	90
95	275	+4 29	+2 28	+1 28	0 28	−2 28	−3 29	−5 30	−6 31	−8 32	−10 34	−12 36	−15 39	−18 43	−21 47	−25 52	−30 59	−36 67	−43 77	265	85
100	280	+7 30	+6 29	+5 29	+3 28	+2 28	+1 28	−1 28	−2 29	−4 30	−6 31	−8 32	−10 34	−13 37	−16 40	−20 44	−25 49	−30 55	−36 63	260	80
105	285	+10 33	+9 32	+8 31	+7 30	+6 29	+5 29	+3 28	+2 28	+1 28	−1 29	−3 30	−5 31	−7 32	−10 34	−14 37	−18 40	−23 44	−29 50	255	75
110	290	+13 37	+12 35	+11 33	+10 32	+9 31	+8 30	+7 29	+6 29	+5 28	+4 28	+2 28	0 29	−2 29	−4 30	−7 32	−11 34	−15 36	−20 40	250	70
115	295	+16 41	+15 39	+14 37	+14 35	+13 34	+12 32	+11 31	+10 31	+9 30	+8 29	+7 28	+6 28	+4 28	+2 28	0 29	−3 30	−6 31	−10 33	245	65
120	300	$+18_1$ 46_1	+17 44	+17 42	+17 40	+16 38	+15 36	$+15_1$ 35_0	+14 34	+14 32	+13 31	+12 30	+11 29	$+10_1$ 29_0	+9 28	+8 28	+6 28	+3 28	0_0 29_0	240	60
125	305	+19 52	+19 49	+19 47	+19 45	+18 43	+18 41	+18 39	+18 38	+18 36	+17 34	+17 33	+17 32	+16 31	+16 30	+15 29	+14 29	+13 28	+11 28	235	55
130	310	+20 58	+20 55	+20 52	+20 50	+20 48	+20 46	+21 44	+21 43	+21 41	+21 39	+21 38	+22 37	+22 35	+22 34	+22 33	+22 32	+22 31	+21 30	230	50
135	315	+20 64	+21 61	+21 58	+21 56	+22 54	+22 52	+23 50	+23 49	+24 47	+24 45	+25 44	+26 43	+27 41	+27 40	+28 39	+29 38	+30 37	+31 36	225	45
140	320	+20 70	+21 67	+21 65	+22 62	+23 60	+23 58	+24 57	+25 55	+26 54	+27 52	+28 51	+30 50	+31 49	+32 48	+34 47	+36 46	+38 45	+41 44	220	40
145	325	+19 76	+20 73	+21 71	+22 69	+23 67	+24 65	+25 64	+26 62	+28 61	+29 60	+31 59	+33 58	+34 57	+36 56	+39 56	+42 56	+45 55	+49 55	215	35
150	330	$+18_1$ 81_4	+19 79	+20 77	+21 75	+22 73	+24 72	$+25_2$ 71_3	+27 70	+29 69	+30 68	+32 67	+35 67	$+37_3$ 66_4	+40 66	+43 67	+47 67	+51 68	$+56_5$ 69_4	210	30
155	335	+16 86	+17 84	+18 83	+20 81	+21 80	+23 79	+25 78	+27 77	+29 76	+31 76	+33 76	+36 76	+39 76	+42 77	+46 78	+51 80	+56 82	+62 84	205	25
160	340	+13 90	+15 89	+16 88	+18 87	+20 86	+22 85	+24 85	+26 84	+28 84	+30 84	+33 85	+36 86	+39 87	+43 89	+48 91	+53 94	+59 97	+66 101	200	20
165	345	+10 94	+12 93	+14 92	+16 91	+18 91	+20 91	+22 91	+24 91	+26 91	+29 92	+32 94	+35 96	+39 98	+43 101	+48 104	+54 108	+61 113	+69 119	195	15
170	350	+7 97	+9 96	+11 95	+13 95	+15 95	+17 96	+19 96	+21 97	+24 98	+27 100	+30 102	+34 105	+38 108	+42 112	+47 116	+53 122	+61 129	+69 138	190	10
175	355	+4 99	+6 98	+8 98	+10 98	+12 99	+14 100	+16 101	+18 102	+21 104	+24 107	+27 110	+31 113	+35 117	+40 122	+45 128	+51 136	+59 145	+68 156	185	5
180	360	0_0 99_5	+2 99	+4 100	+6 101	+8 102	+10 103	$+13_1$ 105_6	+15 107	+18 109	+21 112	+24 116	+28 121	$+32_2$ 126_8	+37 132	+42 140	+48 149	+56 160	$+65_6$ 174_{14}	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -20°$

τ \ $p_{+\tau}$		0^h						I^h						II^h						τ / $p_{-\tau}$	
		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m		
°	°	Δp h																		°	°
0	180	0_0 105_6	+2 105	+4 105	+6 106	+9 107	+11 109	$+13_1$ 111_6	+16 113	+19 116	+22 120	+26 124	+30 129	$+34_3$ 135_9	+39 142	+45 150	+52 160	+61 173	$+71_6$ 188_{15}	360	180
5	185	−4 104	−2 105	0 106	+3 107	+5 109	+7 111	+9 114	+12 117	+15 121	+18 125	+22 130	+26 136	+30 143	+35 151	+40 161	+47 173	+56 188	+65 206	355	175
10	190	−8 102	−6 104	−3 105	−1 107	+1 109	+3 112	+5 115	+8 119	+11 123	+14 128	+17 134	+21 141	+25 149	+29 159	+34 170	+41 184	+49 201	+58 222	350	170
15	195	−11 100	−9 101	−7 103	−5 106	−3 109	−1 112	+1 116	+4 120	+6 125	+9 130	+12 137	+15 144	+19 154	+23 165	+28 178	+34 193	+41 212	+50 236	345	165
20	200	−14 96	−13 98	−11 100	−9 103	−7 106	−5 110	−3 115	−1 120	+1 125	+3 131	+6 138	+9 147	+12 157	+16 169	+21 183	+26 200	+32 221	+40 247	340	160
25	205	−17 91	−16 93	−14 96	−12 99	−11 103	−9 107	−7 112	−5 117	−4 123	−2 130	0 138	+3 148	+6 159	+9 171	+13 186	+18 204	+23 227	+29 254	335	155
30	210	-19_1 86_4	−18 88	−17 91	−15 95	−14 99	−13 104	-11_1 109_6	−9 114	−8 120	−7 128	−5 136	−3 146	-1_0 158_{10}	+2 171	+5 187	+9 206	+13 230	$+18_1$ 259_{21}	330	150
35	215	−21 80	−20 82	−19 86	−18 90	−17 94	−16 99	−14 104	−13 110	−12 116	−11 124	−10 133	−9 143	−7 155	−5 169	−3 185	0 205	+3 230	+7 260	325	145
40	220	−22 73	−21 76	−20 80	−20 84	−19 88	−18 93	−17 98	−16 104	−16 111	−15 119	−15 128	−14 138	−13 150	−12 164	−10 181	−9 201	−7 226	−5 257	320	140
45	225	−22 66	−22 70	−21 73	−21 77	−20 81	−20 86	−20 92	−19 98	−19 105	−19 112	−19 121	−18 132	−18 144	−18 158	−17 175	−17 195	−16 220	−16 251	315	135
50	230	−22 60	−22 63	−21 66	−21 70	−21 74	−21 79	−21 85	−21 91	−21 97	−22 105	−22 114	−22 124	−23 136	−23 150	−24 166	−25 186	−25 211	−26 242	310	130
55	235	−21 53	−21 56	−21 59	−21 63	−22 67	−22 72	−22 77	−22 83	−23 89	−24 97	−25 105	−26 115	−27 127	−28 140	−29 156	−31 176	−33 200	−35 229	305	125
60	240	-19_1 47_1	−19 50	−20 53	−20 57	−21 61	−22 65	-22_2 70_3	−23 75	−24 81	−25 88	−26 96	−28 105	-30_2 116_7	−32 129	−34 145	−36 163	−39 186	-43_4 214_{18}	300	120
65	245	−17 42	−17 44	−18 47	−19 50	−20 54	−21 58	−22 62	−23 67	−25 73	−26 79	−27 86	−29 95	−31 105	−34 117	−37 132	−40 149	−44 171	−50 197	295	115
70	250	−14 37	−15 39	−16 41	−17 44	−18 47	−19 51	−21 55	−22 59	−24 64	−25 70	−27 77	−29 85	−32 94	−35 105	−39 118	−43 134	−48 154	−54 179	290	110
75	255	−11 33	−12 35	−13 37	−14 39	−16 42	−17 45	−19 48	−20 52	−22 56	−24 61	−26 67	−28 74	−31 83	−35 93	−39 104	−44 119	−49 137	−56 159	285	105
80	260	−8 30	−9 31	−10 33	−11 35	−13 37	−14 39	−16 42	−18 45	−20 49	−22 53	−24 58	−27 64	−30 72	−34 80	−38 91	−43 104	−49 119	−57 139	280	100
85	265	−4 29	−5 29	−6 30	−8 31	−9 33	−11 35	−13 37	−15 40	−17 43	−19 46	−21 50	−24 55	−27 61	−31 69	−36 78	−41 89	−47 102	−55 119	275	95
90	270	0_0 28_0	−1 28	−3 29	−4 29	−6 30	−7 31	-9_0 33_0	−11 35	−13 37	−15 40	−17 43	−20 47	-23_2 52_2	−27 58	−32 65	−37 74	−44 85	-52_5 99_6	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -20^\circ$

	τ	0h						Ih						IIh						τ	
$p_{+\tau}$		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		$p_{-\tau}$
°	°	Δp h																		°	°
90	270	0_0 28_0	−1 28	−3 29	−4 29	−6 30	−7 31	-9_0 33_0	−11 35	−13 37	−15 40	−17 43	−20 47	-23_2 52_2	−27 58	−32 65	−37 74	−44 85	-52_5 99_6	270	90
95	275	+4 29	+2 28	+1 28	0 28	−2 29	−3 29	−5 30	−7 31	−9 33	−11 35	−13 37	−16 40	−19 44	−23 49	−27 54	−32 61	−39 70	−47 81	265	85
100	280	+7 30	+6 29	+5 29	+4 28	+2 28	+1 28	−1 28	−2 29	−4 30	−6 31	−8 33	−11 35	−14 37	−17 41	−21 45	−26 50	−32 57	−40 65	260	80
105	285	+11 33	+10 32	+9 31	+7 30	+6 29	+5 28	+4 28	+2 28	+1 28	−1 29	−3 30	−5 31	−8 32	−11 34	−14 37	−19 41	−24 46	−31 52	255	75
110	290	+14 37	+13 36	+12 34	+11 33	+10 31	+9 30	+8 29	+7 29	+5 28	+4 28	+3 28	+1 28	−1 29	−4 30	−7 32	−11 34	−15 37	−21 41	250	70
115	295	+17 42	+16 40	+15 38	+15 36	+14 34	+13 33	+12 32	+11 31	+10 30	+9 29	+8 28	+7 28	+5 28	+3 28	+1 29	−2 30	−6 31	−11 33	245	65
120	300	$+19_1$ 47_1	+18 45	+18 42	+18 40	+17 38	+17 37	$+16_1$ 35_0	+15 34	+15 33	+14 31	+14 30	+13 30	$+12_1$ 29_0	+10 28	+9 28	+7 28	+4 28	0_0 29_0	240	60
125	305	+21 53	+20 51	+20 48	+20 46	+20 44	+20 42	+19 40	+19 38	+19 37	+19 35	+19 34	+18 33	+18 32	+17 31	+16 30	+15 29	+14 28	+12 28	235	55
130	310	+22 60	+22 57	+22 54	+22 52	+22 50	+22 48	+22 46	+22 44	+23 42	+23 41	+23 39	+23 38	+24 36	+24 35	+24 34	+24 33	+24 32	+24 31	230	50
135	315	+22 66	+22 64	+23 61	+23 58	+24 56	+24 54	+25 52	+25 50	+26 48	+27 47	+27 46	+28 44	+29 43	+30 42	+31 40	+32 39	+33 38	+35 37	225	45
140	320	+22 73	+22 70	+23 68	+24 65	+25 63	+26 61	+27 59	+28 57	+29 56	+30 54	+31 53	+32 52	+33 51	+35 50	+37 49	+39 48	+42 47	+45 46	220	40
145	325	+21 80	+22 77	+23 74	+24 72	+25 70	+26 68	+28 67	+29 65	+30 64	+32 63	+33 62	+35 61	+37 60	+40 59	+43 59	+46 59	+50 58	+54 58	215	35
150	330	$+19_1$ 86_4	+20 83	+22 81	+23 79	+24 77	+26 76	$+28_2$ 74_4	+29 73	+31 72	+33 71	+35 71	+37 71	$+40_3$ 70_4	+43 70	+47 70	+51 71	+56 72	$+62_6$ 73_5	210	30
155	335	+17 91	+18 89	+20 87	+22 85	+23 84	+25 83	+27 82	+29 81	+31 80	+33 80	+36 80	+39 81	+42 81	+46 82	+50 83	+55 85	+61 87	+68 90	205	25
160	340	+14 96	+16 94	+18 92	+19 91	+21 90	+23 90	+26 89	+28 89	+30 89	+33 89	+36 90	+39 91	+43 92	+47 94	+52 97	+58 100	+65 104	+73 109	200	20
165	345	+11 100	+13 98	+15 97	+17 96	+19 96	+21 96	+23 96	+26 96	+29 97	+32 98	+35 99	+38 101	+42 104	+47 107	+52 111	+59 116	+66 122	+75 129	195	15
170	350	+8 102	+10 102	+12 101	+14 101	+16 101	+18 101	+20 102	+23 103	+26 104	+29 106	+33 108	+37 111	+41 115	+46 119	+51 125	+58 131	+66 139	+76 149	190	10
175	355	+4 104	+6 104	+8 104	+10 104	+13 105	+15 106	+17 107	+20 108	+23 110	+26 113	+30 117	+34 121	+38 125	+43 131	+49 138	+56 146	+64 156	+74 169	185	5
180	360	0_0 105_6	+2 105	+4 105	+6 106	+9 107	+11 109	$+13_1$ 111_6	+16 113	+19 116	+22 120	+26 124	+30 129	$+34_3$ 135_9	+39 142	+45 150	+52 160	+61 173	$+71_6$ 188_{15}	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -21°$

$p_{+\tau}$ \ τ	0h						Ih						IIh						τ / $p_{-\tau}$
	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	
° °	Δp h																		° °
0 180	0_0 111_6	+2 111	+5 112	+7 113	+9 114	+12 116	$+15_1$ 118_6	+18 120	+21 123	+24 127	+28 132	+32 138	$+37_3$ 144_{10}	+43 152	+49 161	+57 173	+66 187	$+78_7$ 205_{18}	360 180
5 185	−4 110	−2 111	+1 112	+3 114	+5 116	+7 118	+10 121	+13 124	+16 128	+19 133	+23 138	+27 145	+32 153	+38 162	+44 173	+51 187	+60 204	+72 224	355 175
10 190	−8 109	−6 110	−4 112	−2 114	+1 116	+3 119	+5 122	+8 126	+11 131	+14 137	+18 143	+22 151	+26 160	+32 171	+38 184	+45 199	+53 218	+64 242	350 170
15 195	−12 106	−10 108	−8 110	−6 112	−3 115	−1 119	+1 123	+3 127	+6 133	+9 139	+12 146	+16 155	+20 165	+25 177	+30 192	+37 209	+45 230	+54 257	345 165
20 200	−15 101	−14 104	−12 106	−10 109	−8 113	−6 117	−4 122	−2 127	+1 133	+3 140	+6 148	+10 157	+13 168	+17 182	+22 198	+28 216	+35 239	+44 268	340 160
25 205	−18 96	−17 99	−15 102	−13 105	−12 109	−10 114	−8 119	−6 125	−4 131	−2 139	+1 148	+3 158	+6 170	+10 184	+14 201	+19 221	+25 246	+32 277	335 155
30 210	-20_2 90_5	−19 93	−18 97	−16 101	−15 105	−14 110	-12_1 115_7	−11 121	−9 128	−7 136	−5 145	−3 156	-1_0 169_{12}	+2 184	+5 201	+9 222	+14 249	$+19_1$ 281_{24}	330 150
35 215	−22 84	−21 87	−20 91	−19 95	−18 99	−17 104	−16 110	−15 116	−14 124	−12 132	−11 141	−9 153	−8 166	−6 181	−4 199	−1 221	+3 249	+7 282	325 145
40 220	−23 77	−22 80	−22 84	−21 88	−20 93	−20 98	−19 104	−18 111	−18 118	−17 126	−16 136	−15 147	−14 160	−13 176	−12 195	−10 217	−8 245	−6 279	320 140
45 225	−24 70	−23 73	−23 77	−22 81	−22 86	−22 91	−21 97	−21 104	−21 111	−21 119	−20 129	−20 140	−20 153	−20 169	−19 188	−19 210	−18 238	−18 272	315 135
50 230	−23 62	−23 66	−23 70	−23 74	−23 78	−23 83	−23 89	−23 96	−23 103	−24 111	−24 120	−25 131	−25 144	−26 160	−26 179	−27 201	−28 228	−29 262	310 130
55 235	−22 55	−22 59	−23 62	−23 66	−23 70	−24 75	−24 81	−24 87	−25 94	−26 102	−27 111	−28 122	−29 134	−30 149	−32 167	−34 189	−36 215	−39 248	305 125
60 240	-20_2 49_2	−21 52	−22 55	−22 59	−23 63	−24 68	-25_2 73_3	−25 78	−26 85	−27 93	−29 101	−30 111	-32_2 123_8	−34 137	−37 154	−40 175	−43 200	-48_5 232_{19}	300 120
65 245	−18 43	−19 46	−20 49	−21 52	−22 56	−23 60	−24 65	−25 70	−26 76	−28 83	−30 91	−32 100	−34 111	−37 125	−40 141	−44 160	−49 183	−55 213	295 115
70 250	−15 38	−16 41	−17 43	−18 46	−19 49	−21 53	−22 57	−24 62	−26 67	−28 73	−30 80	−32 89	−35 99	−38 111	−42 126	−47 144	−53 165	−59 193	290 110
75 255	−12 34	−13 36	−14 38	−15 40	−16 43	−18 46	−20 50	−22 54	−24 58	−26 64	−28 70	−31 78	−34 87	−38 98	−42 111	−48 127	−54 146	−62 171	285 105
80 260	−8 31	−9 32	−11 33	−12 35	−13 37	−15 40	−17 43	−19 46	−21 50	−23 55	−26 61	−29 67	−32 75	−36 85	−41 96	−47 110	−54 127	−62 149	280 100
85 265	−4 29	−6 29	−7 30	−9 31	−10 33	−12 35	−14 37	−16 40	−18 43	−20 47	−23 52	−26 57	−29 64	−33 72	−38 81	−44 93	−52 108	−61 127	275 95
90 270	0_0 28_0	−2 28	−3 29	−5 29	−6 30	−8 31	-10_1 33_0	−12 35	−14 38	−16 41	−19 44	−22 48	-25_2 54_2	−29 60	−34 68	−40 78	−48 90	-57_5 106_7	270 90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -21°$

$p_{+\tau}$	τ	0h						1h						2h						τ	$p_{-\tau}$
		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		
°	°	Δp h																		°	°
90	270	0_0 28_0	− 2 28	− 3 29	− 5 29	− 6 30	− 8 31	-10_1 33_0	−12 35	−14 38	−16 41	−19 44	−22 48	-25_2 54_2	−29 60	−34 68	−40 78	−48 90	-57_5 106_7	270	90
95	275	+ 4 29	+ 3 28	+ 1 28	0 28	− 2 28	− 3 29	− 5 30	− 7 31	− 9 33	−11 35	−14 38	−17 41	−20 45	−24 50	−29 56	−35 64	−42 74	−51 86	265	85
100	280	+ 8 31	+ 7 30	+ 6 29	+ 4 28	+ 3 28	+ 1 28	− 1 28	− 2 29	− 4 30	− 6 31	− 8 33	−11 35	−14 38	−18 41	−23 46	−28 52	−35 59	−43 68	260	80
105	285	+12 34	+11 32	+10 31	+ 8 30	+ 7 29	+ 6 29	+ 4 28	+ 3 28	+ 1 28	− 1 29	− 3 30	− 5 31	− 8 33	−11 35	−15 38	−20 42	−26 47	−34 54	255	75
110	290	+15 38	+14 36	+13 34	+12 33	+11 31	+10 30	+ 9 29	+ 8 29	+ 6 28	+ 5 28	+ 3 28	+ 1 28	− 1 29	− 4 30	− 7 32	−11 34	−16 38	−23 43	250	70
115	295	+18 43	+17 40	+16 38	+16 37	+15 35	+14 33	+13 32	+12 31	+11 30	+10 29	+ 9 28	+ 8 28	+ 6 28	+ 4 28	+ 1 29	− 2 30	− 6 31	−11 33	245	65
120	300	$+20_2$ 49_2	+20 46	+19 44	+19 42	+18 40	+18 38	$+17_1$ 36_1	+17 35	+16 33	+15 32	+15 31	+14 30	$+13_1$ 29_0	+12 28	+10 28	+ 8 28	+ 5 28	$+ 1_1$ 29_0	240	60
125	305	+22 55	+22 52	+22 50	+22 47	+21 45	+21 43	+21 41	+21 40	+21 38	+20 36	+20 35	+20 34	+20 32	+19 31	+18 30	+17 29	+16 29	+14 28	235	55
130	310	+23 62	+23 59	+24 57	+24 54	+24 51	+24 49	+24 47	+25 46	+25 44	+25 42	+25 40	+26 39	+26 37	+26 36	+26 35	+27 33	+27 32	+27 31	230	50
135	315	+24 70	+24 66	+25 64	+25 61	+26 58	+26 56	+27 54	+28 53	+28 51	+29 49	+30 47	+31 46	+32 44	+33 43	+34 42	+36 40	+37 39	+39 38	225	45
140	320	+23 77	+24 74	+25 71	+26 68	+27 66	+28 64	+29 62	+30 60	+31 58	+32 57	+34 56	+35 54	+37 53	+39 52	+41 51	+44 50	+47 49	+50 48	220	40
145	325	+22 84	+23 81	+24 78	+26 76	+27 74	+28 72	+30 70	+31 68	+33 67	+34 66	+36 65	+38 64	+41 63	+44 62	+47 62	+51 62	+55 62	+60 62	215	35
150	330	$+21_2$ 90_5	+22 88	+23 85	+25 83	+26 81	+28 80	$+30_2$ 78_4	+32 77	+34 76	+36 75	+38 75	+41 75	$+44_4$ 74_4	+48 74	+52 75	+57 76	+62 77	$+68_7$ 78_5	210	30
155	335	+18 96	+20 94	+22 92	+23 90	+25 88	+27 87	+29 86	+31 86	+34 85	+36 85	+39 85	+42 86	+46 86	+50 87	+55 89	+61 91	+67 94	+75 97	205	25
160	340	+15 101	+17 99	+19 98	+21 96	+23 95	+25 94	+27 94	+30 94	+33 94	+36 95	+39 96	+42 97	+46 99	+51 101	+57 104	+63 107	+71 112	+80 118	200	20
165	345	+12 106	+14 104	+16 103	+18 102	+20 101	+22 101	+25 101	+28 102	+31 103	+34 104	+37 106	+41 108	+46 111	+51 115	+57 119	+64 124	+72 131	+83 140	195	15
170	350	+ 8 109	+10 108	+13 107	+15 107	+17 107	+19 107	+22 108	+25 109	+28 111	+31 113	+35 116	+39 119	+44 123	+50 128	+56 134	+63 141	+72 150	+83 162	190	10
175	355	+ 4 110	+ 6 110	+ 9 110	+11 110	+13 111	+16 112	+19 113	+22 115	+25 118	+28 121	+32 125	+36 129	+41 134	+47 140	53 148	+61 157	+70 169	+81 184	185	5
180	360	0_0 111_6	+ 2 111	+ 5 112	+ 7 113	+ 9 114	+12 116	$+15_1$ 118_6	+18 120	+21 123	+24 127	+28 132	+32 138	$+37_3$ 144_{10}	+43 152	+49 161	+57 173	+66 187	$+78_7$ 205_{18}	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -22°$

τ / $p_{+\tau}$	0h						Ih						IIh						τ / $p_{-\tau}$
	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	
	Δp h																		
0° 180°	0_0 118_7	+2 118	+5 119	+7 120	+10 121	+13 123	$+16_1$ 125_8	+19 128	+22 132	+26 136	+30 141	+35 147	$+40_3$ 155_{11}	+46 164	+54 174	+62 187	+72 203	$+85_8$ 223_{20}	360° 180°
5 185	−5 117	−2 118	+1 119	+3 121	+6 123	+8 126	+11 129	+14 132	+17 137	+21 142	+25 148	+30 155	+35 164	+41 175	+48 187	+56 202	+66 221	+78 245	355 175
10 190	−9 115	−6 116	−4 118	−2 120	+1 123	+3 127	+6 131	+9 135	+12 140	+15 146	+19 153	+24 162	+29 172	+34 184	+41 198	+49 215	+58 237	+70 264	350 170
15 195	−13 112	−11 114	−9 116	−7 119	−4 122	−2 126	+1 131	+3 136	+6 142	+9 149	+13 157	+17 166	+22 178	+27 191	+33 207	+40 226	+49 250	+60 280	345 165
20 200	−17 108	−15 110	−13 113	−11 116	−9 120	−6 124	−4 129	−2 135	+1 142	+4 149	+7 158	+10 169	+14 181	+19 196	+24 213	+30 234	+38 261	+48 293	340 160
25 205	−20 102	−18 105	−16 108	−15 112	−13 116	−11 121	−9 126	−7 133	−5 140	−2 148	0 158	+3 169	+6 182	+10 198	+15 217	+20 239	+27 267	+35 302	335 155
30 210	-22_2 96_5	−21 99	−19 102	−18 106	−17 111	−15 116	-14_1 122_8	−12 129	−10 136	−8 145	−6 155	−4 167	-1_0 181_{13}	+2 197	+6 217	+10 241	+15 270	$+21_2$ 307_{28}	330 150
35 215	−24 89	−23 92	−22 96	−21 100	−20 105	−19 110	−18 116	−16 123	−15 131	−13 140	−12 151	−10 163	−8 178	−6 195	−4 215	−1 240	+3 270	+7 308	325 145
40 220	−25 81	−24 85	−24 89	−23 93	−22 98	−22 103	−21 109	−20 117	−19 125	−18 134	−17 145	−16 157	−15 172	−14 189	−13 210	−11 235	−9 266	−7 304	320 140
45 225	−26 73	−25 77	−25 81	−24 85	−24 90	−24 96	−23 102	−23 109	−23 117	−23 126	−22 137	−22 149	−22 164	−22 181	−21 202	−21 227	−21 258	−20 296	315 135
50 230	−25 65	−25 69	−25 73	−25 77	−25 82	−25 88	−25 94	−25 101	−26 108	−26 117	−26 128	−27 140	−28 155	−28 172	−29 192	−30 217	−31 247	−33 285	310 130
55 235	−24 58	−24 61	−24 65	−25 69	−25 74	−26 79	−26 85	−27 92	−28 99	−29 108	−30 118	−31 130	−32 144	−33 160	−35 180	−37 204	−40 233	−44 270	305 125
60 240	-22_2 51_2	−23 54	−23 57	−24 61	−24 66	−25 71	-26_2 76_4	−28 82	−29 90	−30 98	−32 107	−33 118	-35_3 131_9	−37 147	−40 166	−44 188	−48 216	-53_6 252_{22}	300 120
65 245	−20 44	−21 47	−21 50	−22 54	−23 58	−24 62	−25 67	−27 73	−29 80	−30 87	−32 96	−34 106	−37 118	−40 133	−44 150	−48 172	−54 198	−60 231	295 115
70 250	−17 38	−18 41	−19 44	−20 47	−21 50	−22 54	−24 59	−26 64	−28 70	−30 77	−32 85	−34 94	−37 105	−41 118	−46 134	−51 154	−57 178	−65 208	290 110
75 255	−13 34	−14 36	−15 38	−17 41	−18 44	−20 47	−22 51	−24 56	−26 61	−28 67	−30 74	−33 82	−37 92	−41 104	−46 118	−52 135	−59 157	−68 184	285 105
80 260	−9 31	−10 32	−11 34	−13 36	−15 38	−17 41	−19 44	−21 48	−23 52	−25 57	−28 63	−31 70	−35 79	−40 89	−45 101	−51 117	−59 136	−69 160	280 100
85 265	−5 29	−6 30	−7 31	−9 32	−11 34	−13 36	−15 38	−17 41	−19 44	−22 49	−25 54	−28 59	−32 66	−37 75	−42 86	−49 99	−57 115	−67 136	275 95
90 270	0_0 28_0	−2 28	−3 29	−5 30	−6 31	−8 32	-10_1 34_0	−12 36	−14 38	−17 41	−20 45	−23 50	-27_2 55_2	−32 62	−37 71	−44 82	−52 95	-62_6 113_8	270 90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -22°$

τ / $p_{+\tau}$		0^h						I^h						II^h						τ / $p_{-\tau}$	
		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m		
°	°	Δp h																		°	°
90	270	0_0 28_0	−2 28	−3 29	−5 30	−6 31	−8 32	-10_1 34_0	−12 36	−14 38	−17 41	−20 45	−23 50	-27_2 55_2	−32 62	−37 71	−44 82	−52 95	-62_6 113_8	270	90
95	275	+5 29	+3 28	+2 28	0 28	−1 28	−3 29	−5 30	−7 32	−9 33	−12 35	−15 38	−18 42	−22 46	−27 51	−32 58	−38 67	−46 77	−55 91	265	85
100	280	+9 31	+7 30	+6 29	+5 28	+3 28	+2 28	0 28	−2 29	−4 30	−7 31	−9 33	−12 35	−16 38	−20 42	−25 47	−31 53	−38 61	−47 72	260	80
105	285	+13 34	+11 32	+10 31	+9 30	+7 29	+6 29	+5 28	+3 28	+1 28	−1 29	−3 30	−6 31	−9 33	−12 35	−17 38	−22 42	−28 48	−37 56	255	75
110	290	+16 38	+15 36	+14 35	+13 33	+12 32	+11 31	+10 30	+9 29	+7 28	+5 28	+3 28	+1 28	−1 29	−4 30	−8 32	−12 35	−17 38	−25 43	250	70
115	295	+19 44	+19 42	+18 40	+17 38	+16 36	+15 34	+15 33	+14 31	+13 30	+11 29	+10 29	+8 28	+6 28	+4 28	+1 29	−2 30	−6 32	−12 34	245	65
120	300	$+22_2$ 50_2	+22 48	+21 46	+21 43	+20 41	+19 39	$+19_2$ 37_1	+19 35	+18 34	+17 32	+16 31	+15 30	$+14_1$ 30_0	+13 29	+11 28	+9 28	+6 28	$+2_1$ 29_0	240	60
125	305	+24 57	+24 55	+24 52	+24 49	+23 47	+23 44	+23 42	+23 40	+23 39	+23 37	+22 35	+22 34	+22 33	+21 32	+20 30	+19 30	+18 29	+16 28	235	55
130	310	+25 65	+25 62	+26 59	+26 56	+26 53	+26 51	+26 49	+27 47	+27 45	+28 43	+28 41	+28 40	+29 38	+29 37	+29 35	+29 34	+30 33	+30 32	230	50
135	315	+26 73	+26 70	+27 67	+27 64	+28 61	+28 59	+29 57	+30 55	+31 53	+32 51	+33 49	+34 48	+35 46	+36 45	+37 43	+39 42	+41 41	+43 40	225	45
140	320	+25 81	+26 78	+27 75	+28 72	+29 69	+30 67	+31 65	+32 63	+34 62	+35 60	+37 58	+38 57	+40 56	+42 54	+45 53	+48 52	+51 51	+55 51	220	40
145	325	+24 88	+25 85	+26 83	+28 80	+29 78	+30 76	+32 74	+34 72	+36 71	+38 70	+40 68	+42 67	+45 67	+48 66	+52 66	+56 65	+60 65	+66 66	215	35
150	330	$+22_2$ 95_5	+24 93	+25 90	+27 88	+28 86	+30 85	$+32_3$ 83_5	+34 82	+37 81	+39 80	+41 79	+44 79	$+48_4$ 79_5	+52 79	+57 80	+62 81	+68 82	$+76_8$ 84_6	210	30
155	335	+20 102	+22 100	+23 97	+25 95	+27 94	+29 93	+31 92	+34 91	+36 90	+39 90	+42 90	+46 91	+50 92	+55 93	+60 95	+66 98	+74 101	+83 105	205	25
160	340	+17 107	+19 105	+21 103	+23 102	+25 101	+27 100	+30 100	+33 100	+36 100	+39 101	+42 102	+46 103	+51 105	+56 108	+62 111	+69 115	+78 121	+88 128	200	20
165	345	+13 112	+15 110	+17 109	+20 108	+22 107	+25 107	+28 108	+31 108	+34 109	+37 111	+41 113	+45 115	+50 118	+56 122	+62 128	+70 134	+79 142	+91 152	195	15
170	350	+9 115	+11 114	+13 114	+16 113	+18 113	+21 114	+24 115	+27 116	+30 118	+34 120	+38 123	+43 127	+48 132	+54 137	+61 144	+69 152	+79 163	+92 176	190	10
175	355	+5 117	+7 117	+9 117	+12 117	+14 118	+17 119	+20 121	+23 123	+26 126	+30 129	+35 133	+40 138	+45 144	+51 151	+58 160	+67 170	+77 183	+90 200	185	5
180	360	0_0 118_7	+2 118	+5 119	+7 120	+10 121	+13 123	$+16_1$ 125_8	+19 128	+22 132	+26 136	+30 141	+35 147	$+40_3$ 155_{11}	+46 164	+54 174	+62 187	+72 203	$+85_8$ 223_{20}	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -23°$

$p_{+\tau}$	τ	0^h						I^h						II^h						τ	$p_{-\tau}$
		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m		
°	°	Δp h																		°	°
0	180	0_0 126_8	+3 126	+5 127	+8 128	+11 129	+14 131	$+17_1$ 134_9	+20 137	+24 141	+28 146	+33 151	+38 158	$+44_4$ 167_{13}	+51 177	+59 189	+68 203	+80 222	$+94_9$ 245_{23}	360	180
5	185	−5 125	−2 126	0 127	+3 129	+6 131	+9 134	+12 137	+15 141	+19 146	+23 152	+27 159	+32 167	+38 177	+44 189	+52 203	+61 220	+72 242	+87 269	355	175
10	190	−10 123	−7 124	−5 126	−2 129	+1 132	+4 135	+7 139	+10 144	+13 150	+17 157	+21 165	+26 174	+31 185	+37 199	+44 215	+53 235	+63 259	+77 290	350	170
15	195	−14 119	−12 121	−9 124	−7 127	−4 130	−2 134	+1 139	+4 145	+7 152	+10 159	+14 168	+18 179	+23 191	+29 206	+36 224	+44 246	+53 273	+65 308	345	165
20	200	−18 114	−16 117	−14 120	−12 124	−9 128	−7 132	−5 138	−2 145	+1 152	+4 160	+7 170	+11 182	+15 195	+20 211	+26 231	+33 255	+42 284	+52 322	340	160
25	205	−21 108	−20 111	−18 115	−16 119	−14 124	−12 129	−10 135	−7 142	−5 150	−3 159	0 169	+3 181	+7 196	+11 214	+16 235	+22 260	+29 292	+37 332	335	155
30	210	-24_2 101_6	−23 105	−21 109	−20 113	−18 118	−17 124	-15_1 130_8	−13 137	−11 146	−9 155	−7 166	−5 179	-2_0 195_{15}	+2 213	+6 235	+10 262	+16 295	$+22_2$ 337_{32}	330	150
35	215	−26 93	−25 97	−24 101	−23 106	−22 111	−21 117	−19 124	−18 131	−16 140	−15 150	−13 162	−12 175	−10 191	−8 210	−5 233	−2 260	+2 295	+7 338	325	145
40	220	−28 85	−27 89	−26 93	−25 98	−24 103	−24 109	−23 116	−22 124	−21 133	−20 143	−19 155	−18 169	−17 185	−16 204	−15 227	−13 255	−11 290	−8 334	320	140
45	225	−28 77	−28 81	−27 85	−27 90	−26 95	−26 101	−26 108	−25 116	−25 125	−25 135	−25 147	−24 160	−24 176	−24 195	−24 218	−23 246	−23 281	−23 325	315	135
50	230	−28 68	−28 72	−28 76	−28 81	−28 86	−28 92	−28 99	−28 107	−28 115	−29 125	−29 137	−29 150	−30 166	−31 185	−32 207	−33 235	−35 269	−37 312	310	130
55	235	−26 60	−27 64	−27 68	−28 72	−28 77	−28 83	−29 90	−29 97	−30 105	−31 115	−32 126	−33 139	−35 154	−37 172	−39 194	−41 220	−45 253	−49 295	305	125
60	240	-24_2 53_2	−25 56	−25 60	−26 64	−27 69	−28 74	-29_2 80_4	−30 87	−31 94	−32 103	−34 114	−36 126	-39_4 140_{10}	−41 157	−44 178	−48 204	−53 235	-59_6 275_{25}	300	120
65	245	−21 46	−22 49	−23 52	−24 56	−25 60	−26 65	−28 71	−29 77	−31 84	−33 92	−35 102	−38 113	−41 126	−44 142	−48 161	−53 185	−59 215	−67 252	295	115
70	250	−18 40	−19 42	−20 45	−21 48	−23 52	−24 57	−26 62	−28 67	−30 73	−32 80	−35 89	−38 99	−41 111	−45 126	−50 144	−56 166	−63 193	−73 227	290	110
75	255	−14 35	−15 37	−17 39	−18 42	−20 45	−21 49	−23 53	−25 58	−27 63	−30 69	−33 77	−36 86	−40 97	−45 110	−50 126	−57 145	−65 170	−76 200	285	105
80	260	−10 31	−11 33	−13 34	−14 36	−16 39	−18 42	−20 45	−22 49	−24 54	−27 59	−30 66	−34 74	−38 83	−43 94	−49 108	−56 125	−65 146	−76 173	280	100
85	265	−5 29	−6 30	−8 31	−10 32	−12 34	−14 36	−16 39	−18 42	−20 46	−23 50	−26 55	−30 62	−35 70	−40 79	−46 91	−53 105	−62 123	−74 146	275	95
90	270	0_0 28_0	−2 28	−3 29	−5 30	−7 31	−9 32	-11_1 34_0	−13 36	−15 39	−18 42	−21 46	−25 51	-30_2 58_2	−35 65	−41 75	−48 87	−57 102	-69_7 121_9	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -23°$

τ / $p_{+\tau}$		0^h						I^h						II^h						τ / $p_{-\tau}$	
		0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m		
°	°	Δp h																		°	°
90	270	0_0 28_0	− 2 28	− 3 29	− 5 30	− 7 31	− 9 32	-11_1 34_0	−13 36	−15 39	−18 42	−21 46	−25 51	-30_2 58_2	−35 65	−41 75	−48 87	−57 102	$-\ 69_7$ 121_9	270	90
95	275	+ 5 29	+ 3 28	+ 2 28	0 28	− 2 28	− 4 29	− 6 30	− 8 32	−10 34	−13 36	−16 39	−19 43	−24 47	−29 53	−34 61	−41 70	−50 82	− 61 97	265	85
100	280	+10 31	+ 8 30	+ 6 29	+ 5 28	+ 3 28	+ 2 28	0 28	− 2 29	− 5 30	− 7 31	−10 33	−13 36	−17 39	−22 43	−27 49	−33 55	−41 64	− 52 76	260	80
105	285	+14 35	+13 33	+11 31	+10 30	+ 8 29	+ 7 29	+ 5 28	+ 3 28	+ 1 28	− 1 29	− 3 30	− 6 31	− 9 33	−13 36	−18 39	−24 44	−31 50	− 40 58	255	75
110	290	+18 40	+17 37	+16 35	+15 34	+13 32	+12 31	+11 30	+ 9 29	+ 8 28	+ 6 28	+ 4 28	+ 2 28	− 1 29	− 4 31	− 8 33	−13 35	−19 39	− 27 44	250	70
115	295	+21 46	+20 43	+20 40	+19 38	+18 36	+17 35	+16 33	+15 32	+14 30	+13 29	+11 28	+ 9 28	+ 7 28	+ 5 28	+ 2 29	− 2 30	− 7 32	− 13 34	245	65
120	300	$+24_2$ 53_2	+23 50	+23 47	+23 44	+22 42	+21 40	$+21_2$ 38_1	+20 36	+20 34	+19 33	+18 31	+17 30	$+16_2$ 30_0	+14 29	+12 28	+10 28	+ 7 28	$+\ 3_1$ 29_0	240	60
125	305	+26 60	+26 57	+26 54	+26 51	+25 48	+25 46	+25 44	+25 42	+25 40	+25 38	+24 36	+24 35	+24 34	+23 32	+23 31	+22 30	+20 29	+ 18 28	235	55
130	310	+28 68	+28 65	+28 62	+28 59	+28 56	+28 53	+29 51	+29 49	+30 47	+30 45	+30 43	+31 41	+31 40	+32 38	+32 36	+33 35	+33 33	+ 33 32	230	50
135	315	+28 77	+29 73	+29 70	+29 67	+30 64	+31 61	+32 59	+33 57	+34 55	+35 53	+36 51	+37 50	+38 48	+40 46	+41 45	+43 44	+45 42	+ 48 41	225	45
140	320	+28 86	+29 82	+29 79	+30 76	+31 73	+32 70	+34 68	+35 66	+37 65	+38 63	+40 61	+42 60	+44 59	+47 57	+50 56	+53 55	+57 54	+ 62 54	220	40
145	325	+26 94	+28 90	+29 87	+30 84	+32 82	+33 80	+35 78	+37 76	+39 75	+41 74	+43 72	+46 71	+49 71	+52 70	+57 70	+61 70	+67 70	+ 74 70	215	35
150	330	$+24_2$ 101_6	+26 98	+28 95	+29 93	+31 91	+33 89	$+35_3$ 88_5	+37 87	+40 86	+42 85	+45 84	+49 84	$+53_5$ 84_5	+57 84	+62 85	+68 86	+75 88	$+\ 84_9$ 91_7	210	30
155	335	+21 108	+23 105	+25 103	+27 101	+29 100	+32 98	+34 97	+37 97	+40 96	+43 96	+46 96	+50 97	+55 98	+60 100	+66 102	+73 105	+82 109	+ 92 114	205	25
160	340	+18 114	+20 112	+22 110	+25 109	+27 108	+30 107	+32 106	+35 107	+38 107	+42 108	+46 109	+50 111	+55 113	+61 116	+68 120	+76 125	+86 131	+ 98 139	200	20
165	345	+14 119	+16 117	+19 116	+21 115	+24 115	+27 115	+30 115	+33 116	+36 117	+40 119	+44 121	+49 124	+54 128	+61 132	+68 138	+77 145	+87 154	+101 166	195	15
170	350	+10 123	+12 122	+15 121	+17 121	+29 121	+23 122	+26 123	+29 124	+33 126	+37 129	+41 132	+46 136	+52 142	+59 148	+67 156	+76 165	+87 177	+101 192	190	10
175	355	+ 5 125	+ 7 125	+10 125	+13 125	+16 126	+19 127	+22 129	+25 131	+29 134	+33 138	+38 142	+43 148	+49 155	+56 163	+64 173	+73 185	+85 200	+ 99 219	185	5
180	360	0_0 126_8	+ 3 126	+ 5 127	+ 8 128	+11 129	+14 131	$+17_1$ 134_9	+20 137	+24 141	+28 146	+33 151	+38 158	$+44_4$ 167_{13}	+51 177	+59 189	+68 203	+80 222	$+\ 94_9$ 245_{23}	180	0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles. $p_0 = p + \Delta p$.
h is expressed in units of the fifth decimal and its sign is always positive. $s_0 = s + hs$.

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta = -24°$

$p_{+\tau}$ \ τ		0h						1h						2h						τ / $p_{-\tau}$	
		0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m	0m	10m	20m	30m	40m	50m		
°	°	Δp h																		°	°
0	180	0_0 134_9	+ 3 134	+ 6 135	+ 9 136	+12 138	+15 140	$+18_1$ 143_{10}	+22 147	+26 152	+31 157	+36 163	+42 171	$+48_4$ 180_{14}	+55 191	+64 205	+75 222	+88 243	$+104_{11}$ 270_{27}	360	180
5	185	− 5 134	− 2 135	0 136	+ 3 138	+ 6 140	+ 9 143	+13 147	+17 152	+21 157	+25 163	+30 171	+35 180	+41 191	+48 205	+56 221	+67 240	+80 265	+ 96 296	355	175
10	190	−10 131	− 7 133	− 5 135	− 2 138	+ 1 141	+ 4 145	+ 7 150	+10 155	+14 161	+18 168	+23 177	+28 188	+34 201	+40 216	+48 234	+58 256	+70 284	+ 85 319	350	170
15	195	−15 127	−12 129	−10 132	− 8 135	− 5 139	− 2 144	+ 1 150	+ 4 156	+ 7 163	+11 171	+15 181	+20 193	+25 207	+31 224	+39 244	+48 269	+58 300	+ 71 339	345	165
20	200	−19 122	−17 125	−15 128	−13 132	−10 136	− 8 142	− 5 148	− 2 155	+ 1 163	+ 4 172	+ 7 183	+11 196	+16 211	+22 229	+28 251	+36 279	+45 312	+ 57 355	340	160
25	205	−23 115	−21 119	−19 123	−17 127	−15 132	−13 138	−11 144	− 8 152	− 6 160	− 3 170	0 182	+ 3 196	+ 7 212	+12 231	+17 255	+23 284	+31 320	+ 41 365	335	155
30	210	-26_2 108_7	−25 112	−23 116	−21 121	−19 126	−18 132	-16_1 139_{10}	−14 147	−12 156	−10 167	− 8 179	− 5 193	-2_0 210_{17}	+ 2 231	+ 6 256	+11 286	+17 324	$+24_2$ 371_{37}	330	150
35	215	−29 100	−28 104	−26 108	−25 113	−23 119	−22 125	−21 132	−19 141	−18 150	−16 161	−15 174	−13 189	−11 206	− 8 227	− 5 253	− 2 284	+ 2 323	+ 7 372	325	145
40	220	−30 91	−29 95	−28 99	−27 104	−26 110	−25 117	−25 124	−24 133	−23 142	−22 153	−21 166	−20 181	−19 199	−18 220	−16 246	−14 278	−12 317	− 10 368	320	140
45	225	−30 82	−30 86	−29 90	−29 95	−29 101	−28 108	−28 115	−28 124	−28 133	−27 144	−27 157	−27 172	−27 190	−27 211	−26 237	−26 268	−26 307	− 26 358	315	135
50	230	−30 72	−30 76	−30 81	−30 86	−30 92	−30 98	−30 105	−30 114	−31 123	−31 134	−32 146	−32 161	−33 178	−34 199	−35 224	−37 255	−39 294	− 41 343	310	130
55	235	−29 63	−29 67	−29 72	−30 77	−30 82	−30 88	−31 95	−32 103	−33 112	−34 122	−35 134	−36 148	−38 165	−40 185	−43 209	−46 239	−50 277	− 55 324	305	125
60	240	-26_2 55_2	−27 58	−28 62	−29 67	−29 72	−30 78	-31_3 85_5	−32 92	−34 100	−35 110	−37 121	−39 134	-42_4 150_{11}	−45 170	−49 193	−53 221	−59 256	-66_8 302_{29}	300	120
65	245	−23 47	−24 50	−25 54	−26 58	−28 63	−29 68	−30 74	−32 81	−34 88	−36 97	−38 108	−41 120	−44 135	−48 153	−53 174	−59 200	−66 234	− 75 277	295	115
70	250	−19 40	−21 43	−22 46	−23 50	−25 54	−27 59	−29 64	−31 70	−33 77	−35 85	−38 94	−41 105	−45 119	−50 135	−55 155	−62 179	−70 209	− 81 248	290	110
75	255	−15 35	−17 37	−18 40	−20 43	−22 46	−24 50	−26 55	−28 60	−30 66	−33 73	−36 81	−40 91	−44 103	−49 117	−55 135	−63 157	−72 184	− 84 218	285	105
80	260	−10 31	−12 33	−14 35	−16 37	−18 40	−20 43	−22 47	−24 51	−26 56	−30 62	−33 69	−37 78	−42 88	−47 100	−54 115	−62 134	−72 158	− 84 188	280	100
85	265	− 5 29	− 7 30	− 9 31	−11 33	−13 35	−15 37	−17 40	−19 43	−22 47	−25 52	−29 58	−33 65	−38 73	−43 84	−50 96	−58 112	−69 133	− 82 159	275	95
90	270	0_0 28_0	− 2 28	− 3 29	− 5 30	− 7 31	−10 32	-12_1 34_0	−14 37	−17 40	−20 43	−24 48	−28 54	-32_3 60_2	−38 68	−45 79	−53 92	−63 109	-76_8 130_{10}	270	90

Δp is expressed in thousandths of a degree and changes sign for negative hour angles.
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0 = p + \Delta p.$
$s_0 = s + hs.$

TABLE III—Continued.

To be used when Position Angle and Distance are determined.

$\delta=-24°$

τ / $p_{+\tau}$	0^h						I^h						II^h						τ / $p_{-\tau}$
	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	0^m	10^m	20^m	30^m	40^m	50^m	
° °	Δp h																		° °
90 270	0_0 28_0	−2 28	−3 29	−5 30	−7 31	−10 32	-12_1 34_0	−14 37	−17 40	−20 43	−24 48	−28 54	-32_3 60_2	−38 68	−45 79	−53 92	−63 109	-76_8 130_{10}	270 90
95 275	+5 29	+3 28	+2 28	0 28	−2 29	−4 29	−6 30	−8 32	−11 34	−14 36	−17 39	−21 44	−25 49	−31 55	−38 63	−45 73	−55 87	−67 104	265 85
100 280	+10 31	+9 30	+7 29	+5 29	+3 28	+2 28	0 28	−2 29	−5 30	−7 32	−10 34	−14 37	−18 40	−23 44	−29 50	−36 58	−45 68	−56 81	260 80
105 285	+15 35	+14 33	+12 32	+11 31	+9 30	+7 29	+6 28	+4 28	+2 28	0 29	−3 30	−6 31	−10 33	−14 36	−19 40	−26 45	−34 52	−44 61	255 75
110 290	+19 40	+18 38	+17 36	+16 34	+14 33	+13 31	+12 30	+10 29	+9 28	+7 28	+5 28	+2 28	−1 29	−4 31	−8 33	−14 36	−21 40	−30 45	250 70
115 295	+23 47	+22 44	+21 41	+20 39	+19 37	+18 35	+17 34	+16 32	+15 31	+14 30	+13 29	+11 28	+8 28	+6 28	+3 29	−1 30	−7 32	−14 34	245 65
120 300	$+26_2$ 55_2	+25 51	+25 48	+24 45	+24 43	+23 41	$+23_2$ 39_1	+22 37	+22 35	+21 33	+20 32	+19 31	$+18_2$ 30_0	+16 29	+14 28	+11 28	+8 28	$+3_1$ 29_0	240 60
125 305	+29 63	+28 59	+28 56	+28 53	+28 50	+28 48	+28 45	+28 43	+28 41	+27 39	+27 37	+27 36	+26 34	+26 33	+25 31	+24 30	+23 29	+21 28	235 55
130 310	+30 72	+30 68	+30 65	+30 62	+31 59	+31 56	+32 53	+32 51	+33 49	+33 47	+33 45	+34 43	+34 41	+35 39	+36 37	+36 36	+37 34	+38 32	230 50
135 315	+30 81	+31 77	+31 74	+32 71	+33 68	+34 65	+35 62	+36 60	+37 58	+38 56	+39 54	+40 52	+42 50	+44 49	+46 47	+48 46	+51 44	+54 42	225 45
140 320	+30 90	+31 86	+32 83	+33 80	+34 77	+36 75	+37 72	+38 70	+40 68	+42 66	+44 65	+46 63	+49 62	+52 61	+55 60	+59 59	+63 58	+69 57	220 40
145 325	+29 99	+30 95	+31 92	+33 89	+34 87	+36 85	+38 83	+40 81	+42 79	+44 78	+47 77	+50 76	+54 75	+58 75	+62 74	+68 74	+74 75	+82 76	215 35
150 330	$+26_2$ 107_7	+28 104	+30 101	+32 99	+34 97	+36 95	$+38_3$ 93_6	+41 92	+43 91	+46 90	+49 90	+53 90	$+57_5$ 90_6	+62 90	+68 91	+75 93	+83 95	$+94_{10}$ 98_8	210 30
155 335	+23 115	+25 112	+27 110	+30 108	+32 106	+34 105	+37 104	+40 103	+43 103	+46 103	+50 103	+54 104	+59 105	+65 107	+72 110	+80 114	+90 118	+102 123	205 25
160 340	+19 122	+22 119	+24 117	+27 116	+29 115	+32 114	+35 114	+38 114	+42 114	+46 115	+50 116	+55 118	+60 121	+67 125	+75 129	+84 135	+95 143	+109 152	200 20
165 345	+15 127	+18 125	+20 124	+23 123	+26 123	+29 123	+32 123	+36 124	+40 125	+44 127	+48 130	+53 133	+59 137	+66 143	+75 149	+85 157	+97 168	+112 182	195 15
170 350	+10 131	+13 130	+16 129	+19 129	+22 129	+25 130	+28 131	+32 133	+36 135	+40 138	+45 142	+51 147	+57 153	+64 160	+73 169	+84 180	+96 194	+112 212	190 10
175 355	+5 134	+8 133	+11 133	+14 133	+17 134	+20 136	+23 138	+27 141	+31 144	+36 148	+41 153	+47 160	+53 167	+60 176	+69 188	+80 202	+93 219	+109 241	185 5
180 360	0_0 134_9	+3 134	+6 135	+9 136	+12 138	+15 140	$+18_1$ 143_{10}	+22 147	+26 152	+31 157	+36 163	+42 171	$+48_4$ 180_{14}	+55 191	+64 205	+75 222	+88 243	$+104_{11}$ 270_{27}	180 0

Δp is expressed in thousandths of a degree and changes sign for negative hour angles
h is expressed in units of the fifth decimal and its sign is always positive.

$p_0=p+\Delta p.$
$s_0=s+hs.$

TABLES

OF

INSTRUMENTAL CORRECTIONS

FOR THE

TWENTY-SIX-INCH EQUATORIAL.

TABLE IV—Sin λ.

To be used when differences in Right Ascension and Declination are determined by the Micrometer.

TELESCOPE EAST OF PIER.

τ / δ	$-\mathrm{VI}^{h}$	$-\mathrm{V}^{h}$		$-\mathrm{IV}^{h}$		$-\mathrm{III}^{h}$		$-\mathrm{II}^{h}$		$-\mathrm{I}^{h}$		O^{h}			$+\mathrm{I}^{h}$		$+\mathrm{II}^{h}$		$+\mathrm{III}^{h}$		$+\mathrm{IV}^{h}$		$+\mathrm{V}^{h}$		$+\mathrm{VI}^{h}$
	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}
°																									
+60													−172	−180	−186	−189	−189	−186	−181	−173	−163	−150	−135	−118	−100
55													−144	−151	−156	−158	−158	−156	−151	−144	−135	−123	−110	− 95	− 79
50													−121	−128	−132	−134	−134	−132	−128	−121	−112	−102	− 90	− 77	− 62
45													−103	−109	−113	−114	−114	−112	−108	−102	− 94	− 85	− 74	− 62	− 48
40													− 87	− 92	− 96	− 97	− 97	− 95	− 91	− 86	− 79	− 70	− 60	− 49	− 36
+35													− 72	− 77	− 81	− 82	− 82	− 80	− 77	− 72	− 66	− 58	− 48	− 38	− 26
+30													− 59	− 64	− 67	− 69	− 69	− 67	− 64	− 60	− 54	− 47	− 38	− 28	− 17
25													− 48	− 52	− 55	− 57	− 57	− 56	− 53	− 49	− 43	− 36	− 28	− 19	− 9
20													− 37	− 41	− 44	− 46	− 46	− 45	− 42	− 38	− 33	− 27	− 20	− 11	− 2
15		+68	+59	+ 49	+ 39	+ 29	+ 19	+ 10	+ 1	− 7	− 15	− 21	− 27	− 31	− 34	− 36	− 36	− 35	− 33	− 29	− 24	− 19	− 12	− 4	
10		+73	+64	+ 55	+ 45	+ 36	+ 27	+ 18	+ 9	+ 1	− 6	− 12	− 17	− 21	− 24	− 26	− 27	− 26	− 24	− 21	− 16	− 11	− 5	+ 2	
+ 5			+70	+ 61	+ 52	+ 43	+ 34	+ 25	+ 17	+ 10	+ 3	− 3	− 8	− 12	− 15	− 17	− 18	− 18	− 16	− 13	− 9	− 4	+ 2		
0			+75	+ 67	+ 58	+ 50	+ 41	+ 33	+ 25	+ 18	+ 11	+ 5	0	− 4	− 7	− 9	− 10	− 10	− 8	− 6	− 2	+ 2	+ 8		
− 5				+ 72	+ 64	+ 56	+ 48	+ 40	+ 32	+ 25	+ 19	+ 13	+ 8	+ 4	+ 1	− 1	− 2	− 2	− 1	+ 1	+ 4	+ 8			
10					+ 71	+ 63	+ 55	+ 47	+ 40	+ 33	+ 27	+ 21	+ 16	+ 11	+ 8	+ 6	+ 5	+ 5	+ 6	+ 7	+ 10				
15						+ 70	+ 62	+ 54	+ 47	+ 40	+ 34	+ 28	+ 23	+ 18	+ 15	+ 13	+ 11	+ 11	+ 12	+ 13					
20						+ 76	+ 69	+ 61	+ 54	+ 47	+ 41	+ 35	+ 30	+ 25	+ 22	+ 19	+ 17	+ 17	+ 18	+ 19					
25							+ 76	+ 68	+ 61	+ 54	+ 48	+ 42	+ 37	+ 32	+ 28	+ 25	+ 23	+ 23	+ 23						
−30							+ 83	+ 76	+ 68	+ 61	+ 54	+ 48	+ 43	+ 38	+ 34	+ 31	+ 29	+ 28	+ 28						

TELESCOPE WEST OF PIER.

τ / δ	$-\mathrm{VI}^{h}$	$-\mathrm{V}^{h}$		$-\mathrm{IV}^{h}$		$-\mathrm{III}^{h}$		$-\mathrm{II}^{h}$		$-\mathrm{I}^{h}$		O^{h}			$+\mathrm{I}^{h}$		$+\mathrm{II}^{h}$		$+\mathrm{III}^{h}$		$+\mathrm{IV}^{h}$		$+\mathrm{V}^{h}$		$+\mathrm{VI}^{h}$
	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}
°																									
+60	+92	+81	+69	+ 56	+ 43	+ 29	+ 15	+ 1	− 13	− 26	− 38	− 49	− 60												
55	+70	+61	+51	+ 40	+ 29	+ 17	+ 5	− 6	− 18	− 29	− 40	− 50	− 60												
50	+54	+46	+37	+ 27	+ 17	+ 7	− 4	− 14	− 24	− 34	− 44	− 53	− 61												
45	+40	+32	+25	+ 16	+ 7	− 2	− 12	− 21	− 31	− 39	− 48	− 56	− 63												
40	+28	+21	+14	+ 6	− 2	− 11	− 20	− 29	− 37	− 45	− 53	− 60	− 67												
+35	+18	+12	+ 5	− 3	− 11	− 19	− 27	− 36	− 44	− 52	− 59	− 66	− 72												
+30	+ 9	+ 3	− 4	− 11	− 19	− 27	− 35	− 43	− 51	− 58	− 65	− 72	− 78												
25	+ 1	− 5	−12	− 19	− 27	− 35	− 42	− 50	− 58	− 65	− 72	− 78	− 84												
20	− 6	−13	−20	− 27	− 34	− 42	− 50	− 58	− 65	− 72	− 79	− 85	− 90												
15		−20	−27	− 34	− 41	− 49	− 57	− 65	− 72	− 79	− 86	− 92	− 97	−101	−105	−108	−109	−110	−109	−107	−104	−101	− 97	− 92	
10		−26	−33	− 40	− 48	− 56	− 64	− 72	− 80	− 87	− 93	− 99	−104	−108	−112	−114	−116	−116	−115	−113	−110	−106	−102	− 96	
+ 5			−39	− 47	− 55	− 64	− 72	− 80	− 87	− 94	−101	−107	−112	−116	−119	−121	−123	−123	−122	−119	−116	−112	−107		
0			−45	− 53	− 62	− 70	− 79	− 87	− 95	−102	−109	−115	−120	−124	−127	−129	−130	−130	−129	−126	−122	−118	−112		
− 5				− 59	− 69	− 78	− 87	− 95	−103	−110	−117	−123	−128	−132	−135	−137	−138	−137	−136	−133	−129	−124			
10					− 75	− 84	− 94	−103	−111	−119	−126	−132	−137	−141	−144	−146	−146	−145	−143	−140	−136				
15						− 92	−102	−111	−120	−128	−135	−141	−147	−151	−154	−155	−155	−154	−152	−148					
20						−100	−110	−120	−129	−137	−144	−151	−157	−161	−164	−165	−165	−164	−161	−157					
25							−119	−129	−138	−147	−155	−162	−168	−172	−175	−176	−176	−174	−171						
−30							−128	−139	−149	−158	−167	−174	−180	−184	−187	−188	−188	−186	−183						

TELESCOPE ABOVE PIER.

τ / δ			$-\mathrm{IX}^{h}$		$-\mathrm{VIII}^{h}$		$-\mathrm{VII}^{h}$		$-\mathrm{VI}^{h}$			$+\mathrm{VI}^{h}$		$+\mathrm{VII}^{h}$		$+\mathrm{VIII}^{h}$		$+\mathrm{IX}^{h}$			
			30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}		0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}	0^{m}	30^{m}		
°																					
+60			+125	+125	+124	+121	+116	+109	+101	+ 92		−100	− 80	− 60	− 39	− 18	+ 3	+ 24	+ 44		
55					+ 97	+ 94	+ 90	+ 85	+ 78	+ 70		− 79	− 61	− 43	− 24	− 6	+ 13				
50						+ 74	+ 71	+ 66	+ 61	+ 54		− 62	− 46	− 30	− 13	+ 4					
45							+ 56	+ 51	+ 46	+ 40		− 48	− 34	− 19	− 4						
40								+ 39	+ 34	+ 28		− 36	− 23	− 9							
35									+ 24	+ 18		− 26	− 14								
+30									+ 14	+ 9		− 17	− 6								

The tabular quantities are expressed in units of the fifth decimal.

$$\Delta a_0 = \Delta a + \Delta\delta \sin \lambda.$$
$$\Delta\delta_0 = \Delta\delta - \Delta a \sin \lambda.$$

This table is based upon the adopted values of the instrumental constants found on page F18.

TABLE V—L.

To be used when differences in Right Ascension are determined by Transits.

TELESCOPE EAST OF PIER.

δ \ τ	−VI^h	−V^h		−IV^h		−III^h		−II^h		−I^h		0^h			+I^h		+II^h		+III^h		+IV^h		+V^h		+VI^h
	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m
°																									
+60													−23	−24	−25	−25	−25	−25	−24	−23	−22	−20	−18	−16	−13
55													−17	−18	−18	−18	−18	−18	−18	−17	−16	−15	−13	−11	−9
50													−13	−13	−14	−14	−14	−14	−13	−13	−12	−11	−9	−8	−6
45													−10	−10	−11	−11	−11	−11	−10	−10	−9	−8	−7	−6	−4
40													−8	−8	−8	−8	−8	−8	−8	−8	−7	−6	−5	−4	−3
+35													−6	−6	−7	−7	−7	−6	−6	−6	−5	−5	−4	−3	−2
+30													−5	−5	−5	−5	−5	−5	−5	−5	−4	−4	−3	−2	−1
25													−4	−4	−4	−4	−4	−4	−4	−4	−3	−3	−2	−1	−1
20													−3	−3	−3	−3	−3	−3	−3	−3	−2	−2	−1	−1	0
15		+5	+4	+3	+3	+2	+1	+1	0	0	−1	−1	−2	−2	−2	−2	−2	−2	−2	−2	−2	−1	−1	0	
10		+5	+4	+4	+3	+2	+2	+1	+1	0	0	−1	−1	−1	−2	−2	−2	−2	−2	−1	−1	−1	0	0	
+5			+5	+4	+4	+3	+2	+2	+1	+1	0	0	−1	−1	−1	−1	−1	−1	−1	−1	−1	0	0		
0			+5	+4	+4	+3	+3	+2	+2	+1	+1	0	0	0	0	−1	−1	−1	−1	0	0	0	+1		
−5				+5	+4	+4	+3	+3	+2	+2	+1	+1	+1	0	0	0	0	0	0	0	0	+1			
10					+5	+4	+4	+3	+3	+2	+2	+1	+1	+1	+1	0	0	0	0	0	+1				
15						+5	+4	+4	+3	+3	+2	+2	+2	+1	+1	+1	+1	+1	+1	+1					
20						+5	+5	+4	+4	+3	+3	+2	+2	+2	+2	+1	+1	+1	+1	+1					
25							+6	+5	+4	+4	+3	+3	+3	+2	+2	+2	+2	+2	+2						
−30							+6	+6	+5	+5	+4	+4	+3	+3	+3	+2	+2	+2	+2						

TELESCOPE WEST OF PIER.

δ \ τ	−VI^h	−V^h		−IV^h		−III^h		−II^h		−I^h		0^h			+I^h		+II^h		+III^h		+IV^h		+V^h		+VI^h
	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m
°																									
+60	+12	+11	+9	+7	+6	+4	+2	0	−2	−3	−5	−7	−8												
55	+8	+7	+6	+5	+3	+2	+1	−1	−2	−3	−5	−6	−7												
50	+6	+5	+4	+3	+2	+1	0	−1	−2	−4	−5	−6	−6												
45	+4	+3	+2	+2	+1	0	−1	−2	−3	−4	−5	−5	−6												
40	+2	+2	+1	+1	0	−1	−2	−3	−3	−4	−5	−5	−6												
+35	+1	+1	0	0	−1	−2	−2	−3	−4	−4	−5	−5	−6												
+30	+1	0	0	−1	−1	−2	−3	−3	−4	−4	−5	−6	−6												
25	0	0	−1	−1	−2	−3	−3	−4	−4	−5	−5	−6	−6												
20	0	−1	−1	−2	−2	−3	−4	−4	−5	−5	−6	−6	−6												
15		−1	−2	−2	−3	−3	−4	−4	−5	−5	−6	−6	−7	−7	−7	−7	−8	−8	−8	−7	−7	−7	−7	−6	
10		−2	−2	−3	−3	−4	−4	−5	−5	−6	−6	−7	−7	−7	−8	−8	−8	−8	−8	−8	−7	−7	−7	−6	
+5			−3	−3	−4	−4	−5	−5	−6	−6	−7	−7	−7	−8	−8	−8	−8	−8	−8	−8	−8	−7	−7		
0			−3	−4	−4	−5	−5	−6	−6	−7	−7	−8	−8	−8	−8	−9	−9	−9	−9	−8	−8	−8	−7		
−5				−4	−5	−5	−6	−6	−7	−7	−8	−8	−9	−9	−9	−9	−9	−9	−9	−9	−9	−8			
10					−5	−6	−6	−7	−8	−8	−9	−9	−9	−10	−10	−10	−10	−10	−10	−9	−9				
15						−6	−7	−8	−8	−9	−9	−10	−10	−10	−11	−11	−11	−11	−10	−10					
20						−7	−8	−8	−9	−10	−10	−11	−11	−11	−12	−12	−12	−12	−11	−11					
25							−9	−9	−10	−11	−11	−12	−12	−13	−13	−13	−13	−13	−13						
−30							−10	−11	−11	−12	−13	−13	−14	−14	−14	−14	−14	−14	−14						

TELESCOPE ABOVE PIER.

δ \ τ	−IX^h		−VIII^h		−VII^h		−VI^h		+VI^h		+VII^h		+VIII^h		+IX^h	
	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m
°																
+60	+17	+17	+16	+16	+15	+15	+13	+12	−13	−11	−8	−5	−2	+1	+3	+6
55			+11	+11	+10	+10	+9	+8	−9	−7	−5	−3	−1	+2		
50				+8	+7	+7	+6	+6	−6	−5	−3	−1	0			
45					+5	+5	+4	+4	−4	−3	−2	0				
40						+3	+3	+2	−3	−2	−1					
35							+2	+1	−2	−1						
+30							+1	+1	−1	0						

The tabular quantities are expressed in units of the fifth decimal.

$\Delta\alpha^s_0 = \Delta\alpha^s + L\Delta\delta''$.

This table is based upon the adopted values of the instrumental constants found on page F18.

TABLE VI—λ.

To be used when Position Angle and Distance are determined.

TELESCOPE EAST OF PIER.

δ \ τ	−VI^h	−V^h		−IV^h		−III^h		−II^h		−I^h		0^h			+I^h		+II^h		+III^h		+IV^h		+V^h		+VI^h
	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m
°																									
+25													−27	−30	−32	−33	−33	−32	−30	−28	−25	−21	−16	−11	−5
20													−21	−23	−25	−26	−26	−26	−24	−22	−19	−16	−11	−6	−1
15		+39	+34	+28	+22	+17	+11	+6	+1	−4	−8	−12	−15	−17	−19	−20	−20	−20	−19	−17	−14	−11	−7	−2	
10		+42	+37	+31	+26	+21	+15	+10	+5	+1	−3	−7	−10	−12	−14	−15	−15	−15	−14	−12	−9	−6	−3	+1	
+5			+40	+35	+30	+25	+19	+14	+10	+6	+2	−2	−5	−7	−9	−10	−10	−10	−9	−7	−5	−2	+1		
0			+43	+38	+33	+28	+23	+19	+14	+10	+6	+3	0	−2	−4	−5	−6	−6	−5	−3	−1	+1	+4		
−5				+41	+37	+32	+27	+23	+18	+14	+11	+8	+5	+2	0	−1	−1	−2	−1	0	+2	+4			
10					+41	+36	+31	+27	+23	+19	+15	+12	+9	+6	+5	+3	+3	+2	+3	+4	+6				
15						+40	+36	+31	+27	+23	+19	+16	+13	+10	+9	+7	+6	+6	+7	+8					
20						+44	+39	+35	+31	+27	+23	+20	+17	+14	+12	+11	+10	+10	+10	+11					
−25							+43	+39	+35	+31	+27	+24	+21	+18	+16	+14	+13	+13	+13						

TELESCOPE WEST OF PIER.

δ \ τ	−VI^h	−V^h		−IV^h		−III^h		−II^h		−I^h		0^h			+I^h		+II^h		+III^h		+IV^h		+V^h		+VI^h
	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m	30^m	0^m
°																									
+25	0	−3	−7	−11	−16	−20	−24	−29	−33	−37	−41	−45	−48												
20	−4	−7	−11	−15	−20	−24	−29	−33	−37	−41	−45	−49	−52												
15		−11	−15	−19	−24	−28	−33	−37	−41	−45	−49	−53	−56	−58	−60	−62	−63	−63	−63	−62	−60	−58	−56	−53	
10		−15	−19	−23	−28	−32	−37	−41	−46	−50	−53	−57	−60	−62	−64	−65	−66	−66	−66	−65	−63	−61	−58	−55	
+5			−22	−27	−32	−36	−41	−46	−50	−54	−58	−61	−64	−66	−68	−69	−70	−70	−70	−68	−66	−64	−61		
0			−26	−31	−36	−40	−45	−50	−54	−58	−62	−66	−69	−71	−73	−74	−74	−74	−74	−72	−70	−68	−64		
−5				−34	−39	−44	−49	−54	−59	−63	−67	−71	−74	−76	−78	−79	−79	−79	−78	−76	−74	−71			
10					−43	−48	−54	−59	−64	−68	−72	−76	−79	−81	−83	−84	−84	−83	−82	−80	−78				
15						−53	−58	−64	−69	−73	−77	−81	−84	−86	−88	−89	−89	−88	−87	−85					
20						−57	−63	−69	−74	−79	−83	−87	−90	−92	−93	−94	−95	−94	−92	−90					
−25							−68	−74	−79	−84	−89	−93	−96	−98	−99	−100	−101	−100	−98						

The tabular quantities are expressed in thousandths of a degree.

$p_0 = p + \lambda + (90^\circ - p^\circ_m)$.

This table is based upon the adopted values of the instrumental constants found on page F 18.

APPENDIX IV.

THE PRESENT STATUS
OF THE
USE OF STANDARD TIME

BY

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Head of the Department of Chronometers and Time Service.

TABLE OF CONTENTS.

THE PRESENT STATUS OF THE USE OF STANDARD TIME.

STANDARD TIME.

Standard time may be defined as time based upon a certain definite meridian that is adopted by law or usage as the time meridian for a more or less wide extent of country, in place of the various meridians upon which local mean. time is based. Its advantage is that neighboring places then keep exactly the same time, instead of differing by a few minutes or seconds according to their differences of longitude, a matter of especial importance in connection with the operation of railroads and telegraphs, or the transaction of any business wherein contracts involve any definite time limits.

In the selection of standard time meridians it is of course desirable not to have them so far apart as to cause any very marked variation from true local mean time at any point, and the plan usually adopted is to have them exactly one hour of time, or 15 degrees of longitude, apart. It is also desirable, for the sake of international convenience and harmony, to base them upon the prime meridian that is in most common use throughout the world, namely, that of Greenwich, England.

The United States adopted standard time in 1883, on the initiative of the American Railway Association, and at noon of November 18 of that year the telegraphic time signals sent out daily from the Naval Observatory at Washington were changed to the new system, according to which the meridians of 75°, 90°, 105°, and 120° west from Greenwich became the time meridians of Eastern, Central, Mountain, and Pacific standard time, respectively. When it is noon at Washington, Baltimore, Philadelphia, New York, and Boston it is precisely 11 a. m. at Chicago, Minneapolis, St. Louis, and New Orleans; 10 a. m. from Dakota to Arizona and New Mexico, and 9 a. m. at all points on the Pacific coast. The same system has been extended to our remotest possessions, and has spread over the greater portion of the civilized world, although a few nations still use their own prime meridians instead of that of Greenwich.

THE INTERNATIONAL DATE LINE.

The meridian, 180° east and west from Greenwich, which crosses the Pacific Ocean from the Aleutian to the Fiji islands, is called the international date line. Here each new day has its birth at the instant when it is exactly noon of *the preceding date* at Greenwich; 7 a. m. at Washington; 4 a. m. at San Francisco, and 1.30 a. m.

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[*] Note.—In order that this appendix might be ready for distribution at the meeting of the International Railway Congress to be held at Washington in May, 1905, it has been necessary to hurry it through the press. Whatever inaccuracies may occur, it is hoped to remove in a future edition, and it is requested that notice of any corrections or additions be reported promptly to the Superintendent of the Naval Observatory.

at Honolulu. It is thus evident that if a vessel west bound across the Pacific were to continue her old calendar, without change, she would find upon arrival in Japan, Australia, or New Zealand, that she was one day behind in the day of the week and month. To avoid this it is customary, upon crossing the one hundred and eightieth meridian, to drop a day when bound west; to repeat a day when bound east. For instance, in the first case, Monday, October 24, would be followed in the log book by Wednesday, October 26, and in the second case, Monday, October 24, would be followed by another Monday, October 24.

The date line does not coincide with the one hundred and eightieth meridian everywhere, because as a mere matter of convenience it is better for all of eastern Siberia to have the same date, for all of the extreme Aleutian and Hawaiian islands to have the same date as the other islands of those groups and as the United States, and for all of the Fiji and Chatham islands to have the same date as Australia and New Zealand, with which they are closely connected politically and geographically. The date line is thus slightly irregular, but follows very closely the one hundred and eightieth meridian. The following ordinance was enacted in order to insure the use of the same day of the week and month in the Fiji Islands, through which the one hundred and eightieth meridian passes:

> Fiji, No. XIV, 1879: An ordinance enacted by the governor of the colony of Fiji, with the advice and consent of the legislative council thereof, to provide for a universal day throughout the colony.
>
> Whereas according to the ordinary rule of noting time, any given time would in that part of the colony lying to the east of the meridian of 180 degrees from Greenwich be noted as of a day of the week and month different from the day by which the same time would be noted in the part of the colony lying to the west of such meridian; and
>
> Whereas, by custom the ordinary rule has been set aside and time has been noted throughout the colony as though the whole were situated to the west of such meridian; and
>
> Whereas in order to preclude uncertainty for the future it is expedient that the above custom should be legalized; *Therefore*
>
> *Be it enacted by the governor, with the advice and consent of the legislative council, as follows:*
>
> I. Time in this colony shall be noted as if the whole colony were situated to the west of the meridian of 180 degrees from Greenwich.
>
> (Exempli gratia—To-day, which according to the ordinary rule for noting time is on the island of Ovalau the 5th day of June, and on the island of Vanua-Balevu the 4th day of June, would by this ordinance be deemed as the 5th day of June, 1879, in the whole colony.)
>
> II. This ordinance may be cited as the "Uniform date ordinance, 1879."
>
> Passed in council this 5th day of June in the year of our Lord 1879.

A curious thing brought out by a consideration of this date line is the fact that the total duration or life of each day, if you consider the entire globe and not merely a single locality, is 48 instead of 24 hours. For example, imagine yourself close to but west of this line, near the equator, at midnight, when the new day begins. Remain there until noon and the day will then have lasted 12 hours. Now suppose that you move west, with the Sun overhead all the time, until you return close to, but east of, the date line. During this rapid trip of 900 knots (nautical miles) per hour, you will have passed 24 hours, all the time at noon of the same day, making 36 hours in all. Finally, if you wait there until the day ends, at midnight, it will add 12 hours more, making 48 hours for the total duration of that single day.

THE CONVERSION OF THE TIME OF ONE COUNTRY INTO THAT OF ANOTHER.

The following table is arranged for use in converting the time of one country into that of another, without any confusion regarding the proper date. It gives the hours, minutes, and seconds earlier or later than Washington or eastern standard time, which is in use everywhere from Maine to South Carolina, and also the same data for Greenwich time. Thus, when it is noon at Washington it is also noon at New York, Philadelphia, and Boston; one hour earlier, or 11 a. m., at Chicago, St. Louis, and New Orleans; 10 a. m. at Denver; 9 a. m. at San Francisco; 6.30 a. m. at Honolulu; and thirteen hours later, or 1 a. m. the next day, at Manila.

One more example will serve to make the use of the table still clearer. When it is 6 p. m. at Chicago, what time is it at Manila? The table shows that Chicago is one hour earlier (—) than Washington, so that it is then 7 p. m. at Washington, and as Manila is thirteen hours later (+) than Washington it must then be 8 a. m. the next day at Manila. In other words, to convert Chicago time into Manila time add 14 hours, and to convert Manila time into Chicago time subtract 14 hours.

Table for the Conversion of Time.

[To the nearest second.]

Place.	Earlier (—) or Later (+) than,					
	Washington			Greenwich		
United States—	*h*	*m*	*s*	*h*	*m*	*s*
From Maine to South Carolina	0	0	0	— 5	0	0
From Dakota and Michigan to Texas and Florida	— 1	0	0	— 6	0	0
From Montana to Arizona and New Mexico	— 2	0	0	— 7	0	0
Pacific Coast States and Nevada	— 3	0	0	— 8	0	0
Sitka, Alaska	— 4	0	0	— 9	0	0
Hawaiian Islands	— 5	30	0	—10	30	0
Tutuila, Samoa	— 6	30	0	—11	30	0
Guam	+14	30	0	+ 9	30	0
Philippine Islands	+13	0	0	+ 8	0	0
Porto Rico	+ 1	0	0	— 4	0	0
Panama Canal Zone	0	0	0	— 5	0	0
Algeria	+ 5	9	21	+ 0	9	21
Argentina	+ 0	43	12	— 4	16	48
Australia, western	+13	0	0	+ 8	0	0
Australia, central	+14	30	0	+ 9	30	0
Australia, eastern	+15	0	0	+10	0	0
Austria-Hungary	+ 6	0	0	+ 1	0	0
Belgium	+ 5	0	0	0	0	0
Borneo (British North) and Labuan	+13	0	0	+ 8	0	0
Brazil (Rio Janeiro)	+ 2	7	19	— 2	52	41
British Columbia	— 3	0	0	— 8	0	0
Canada, eastern	0	0	0	— 5	0	0
Canada, central	— 1	0	0	— 6	0	0
Chile	+ 0	17	14	— 4	42	46
China (Shanghai)	+13	5	43	+ 8	5	43
China (Saigon)	+12	6	49	+ 7	6	49
Colombia	+ 0	3	6	— 4	56	54
Costa Rica	— 0	36	17	— 5	36	17
Cuba	— 0	29	26	— 5	29	26
Denmark	+ 6	0	0	+ 1	0	0
Ecuador	— 0	14	7	— 5	14	7
Egypt	+ 7	0	0	+ 2	0	0
England	+ 5	0	0	0	0	0
Fiji Islands (Suva)	+16	53	44	+11	53	44
France	+ 5	9	21	+ 0	9	21
Germany	+ 6	0	0	+ 1	0	0
Gibraltar	+ 5	0	0	0	0	0

Table for the Conversion of Time—Continued.

Place.	Earlier (−) or Later (+) than,					
	Washington			Greenwich		
	h	*m*	*s*	*h*	*m*	*s*
Greece	+ 6	34	53	+ 1	34	53
Holland	+ 5	0	0	0	0	0
Honduras	− 1	0	0	− 6	0	0
Hongkong	+13	0	0	+ 8	0	0
India (Madras)	+10	20	59	+ 5	20	59
Ireland	+ 4	34	39	− 0	25	21
Italy	+ 6	0	0	+ 1	0	0
Jamaica (Kingston)	− 0	7	11	− 5	7	11
Japan	+14	0	0	+ 9	0	0
Java	+12	7	14	+ 7	7	14
Kiaochau	+13	0	0	+ 8	0	0
Korea	+14	0	0	+ 9	0	0
Madagascar (Tananarivo)	+ 8	10	7	+ 3	10	7
Malta	+ 6	0	0	+ 1	0	0
Mauritius	+ 8	50	13	+ 3	50	13
Mexico	− 1	36	27	− 6	36	27
Newfoundland (St. Johns)	+ 1	29	16	− 3	30	44
New Zealand	+16	30	0	+11	30	0
Nicaragua	− 0	45	10	− 5	45	10
Norway	+ 6	0	0	+ 1	0	0
Nova Scotia	+ 1	0	0	− 4	0	0
Panama (Colon)	− 0	19	39	− 5	19	39
Peru	− 0	9	3	− 5	9	3
Portugal	+ 4	23	40	− 0	36	20
Russia (Pulkowa)	+ 7	1	19	+ 2	1	19
Russia (Irkutsk)	+11	57	5	+ 6	57	5
Russia (Vladivostok)	+13	47	31	+ 8	47	31
Salvador	− 0	56	32	− 5	56	32
Servia	+ 6	0	0	+ 1	0	0
Singapore	+11	55	25	+ 6	55	25
South Africa (British)	+ 7	0	0	+ 2	0	0
Spain	+ 5	0	0	0	0	0
Sweden	+ 6	0	0	+ 1	0	0
Switzerland	+ 6	0	0	+ 1	0	0
Tunis	+ 5	9	21	+ 0	9	21
Turkey	+ 7	0	0	+ 2	0	0
Uruguay	+ 1	15	11	− 3	44	49
Venezuela	+ 0	32	16	− 4	27	44

It may be added that England proposes to adopt for India and Ceylon the time meridian of $10^h\ 30^m\ 0^s$ later than Washington ($5^h\ 30^m\ 0^s$ later than Greenwich), and for Burma $11^h\ 30^m\ 0^s$ later than Washington ($6^h\ 30^m\ 0^s$ later than Greenwich), thus adding that vast region to the long list of countries that use standard time based upon the meridian of Greenwich.

THE UNIVERSAL TIME SYSTEM.

The need of a common and harmonious international system of time becomes greater every year by reason of the rapid extension of railroads, telegraphs, and cables, and the increase of international, diplomatic, and business relations that are conducted by telegraph. When a telegram is sent it is of course important to know the corresponding date and time of day at its destination, and confusion and errors may be avoided if the difference of time is only a question of hours or half hours, instead of hours, minutes, and seconds. Moreover, this question of the best common standard of time is merely part of the still more important question of the best common standard of longitude, as longitude and time are practically the same. By far the greater part of all the charts and maps are based upon the prime meridian of Greenwich, and it is of great importance in navigation and geographic work for all charts, maps, sailing directions and notices to mariners to reckon longitudes from the same prime meridian, exactly as they already reckon latitudes from the equator.

The following quotation from The Observatory for November, 1904, supplies a graphic illustration of how this universal time system is spreading over the world by reason of the same self-evident advantages that induced the American people to accept it by common consent when it was first adopted and sent out from the United States Naval Observatory at noon of November 18, 1883:

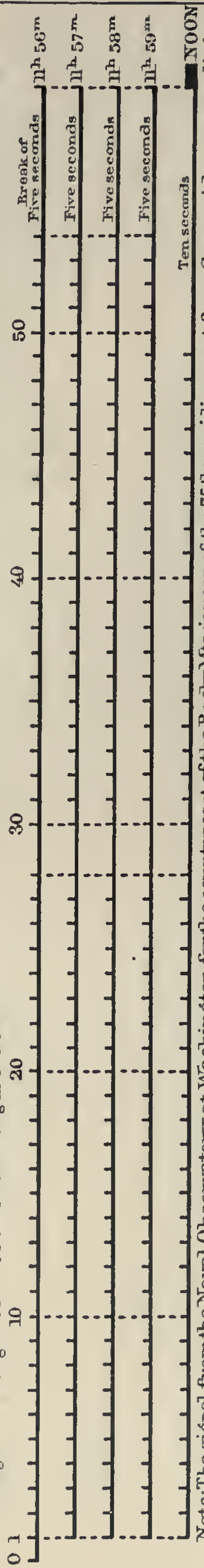
> Gradually, and without any public notification, the standard time 8 hours fast on Greenwich has crept into use along the coast of China from Newchwang, in the north, to Swatow, nearly the southernmost point; also up the Yangtsekiang as far as Hankau, and at Wei-hai-Wei and Tsingtau. It will be noted that, with the exception of Wei-hai-Wei, this territory is all non-British. There is an observatory at Hongkong, under the colonial government, in longitude 7^h 37^m east of Greenwich, and this local time is used in the colony; but it seemed good to the Hongkong Chamber of Commerce that the port, and consequently the west river ports and Canton, who use the same time, should fall into line with the rest of the country and adopt the times of the 8-hour zone. The main reason urged for the adoption was that the railway systems in China are now being developed, and that it is better that the change should be made now, before the Hongkong lines are connected with those of the rest of China. Another point, perhaps a minor one, in favor of the change is that, if the business time-tables remain the same, there will be more daylight after office hours than at present. The authorities at the colonial office, having been approached by the governor of Hongkong, gave their consent to the change of time system, which will therefore soon be made. The court of directors of the British North Borneo Company, having been communicated with, expressed their willingness to join the scheme, and gave instructions for the adoption of the 8-hour zone time in British North Borneo and the island of Labuan.

DAILY TELEGRAPHIC TIME SIGNALS.

Some philosopher has said that the appreciation of the value of correct time is a good index to the civilization of a nation, and in this respect the United States is among the very foremost. Since August, 1865, telegraphic time signals have been sent out daily from the Naval Observatory, and they now reach every part of the country, as well as Habana and Panama. The Pacific coast states and Alaska receive their time signals from the observatory at the Mare Island Navy-Yard, and it is proposed soon to extend them to Honolulu. Nineteen time-balls are dropped by these signals in the principal ports of our Atlantic, Pacific, Gulf of Mexico, and Great Lake coasts, and probably in no other country do any such signals cover such a large extent of territory or render such great service to both water-borne and inland commerce. They have, in fact, become an essential part of our everyday life, as transmitted by the voluntary cooperation of the Western Union Telegraph Company, the Postal Telegraph Company, and the American Telephone and Telegraph Company, all of whom receive the signals over special wires connected directly with the transmitting clock at the Naval Observatory.

The series of noon signals sent out daily is shown graphically in the accompanying diagram. This represents the signals as they would be recorded on a chronograph, where a pen draws a line upon a sheet of paper moving along at a

U.S. Naval Observatory Telegraphic Time Signals begin at 11:55 A.M., standard time, and continue for five minutes. During this interval every tick of the clock is transmitted over the wires except the 29th second of each minute, the last five seconds of each of the first four minutes, and finally the last ten seconds of the last minute. The noon signal is a longer contact after this longer break.



Note: The signal from the Naval Observatory at Washington, for the country east of the Rocky Mts., is noon of the 75th meridian west from Greenwich, corresponding to 11 A.M., 90th meridian, and 10 A.M., 105th meridian. From the Observatory at Mare Id. Navy Yd., for the Pacific Coast, it is 120th meridian time.

uniform rate, and is actuated by an electro-magnet so as to make a jog at every tick of the transmitting clock. The electric connections of the clock are such as to omit certain seconds, as shown by the breaks in the record. These breaks enable anyone who is listening to a sounder in a telegraph or telephone office to recognize the middle and end of each minute, especially the end of the last minute, when there is a longer interval followed by the noon signal. During this last long interval, or 10-second break, those who are in charge of time-balls and of clocks that are corrected electrically at noon throw their local lines into circuit so that the noon signal drops the time-balls and corrects the clocks.

This series of noon signals is sent continuously over the wires all over the United States for an interval of five minutes immediately preceding noon. For the country east of the Rocky Mountains the signals are sent out by the Naval Observatory at Washington and end at noon of the seventy-fifth meridian, standard time, corresponding to 11 a. m. of the ninetieth meridian and 10 a. m. of the one hundred and fifth meridian. For the country west of the Rocky Mountains they are sent out by the observatory at the Mare Island Navy-Yard, and end at noon of the one hundred and twentieth meridian, the standard time meridian of the Pacific coast. The transmitting clock that sends out the signals is corrected very accurately, shortly before noon, from the mean of three standard clocks that are rated by star sights with a meridian transit instrument. The noon signal is seldom in error to an amount greater than one or two tenths of a second, although a tenth more may be added by the relays in use on long telegraph lines. Electric transmission over a continuous wire is practically instantaneous. At other times than noon, similar signals can be sent out by telegraph or telephone from the same clock that sends out the noon signal.

SPECIAL TELEGRAPHIC TIME SIGNALS.

A plan that was inaugurated on December 31, 1902, of sending out a special series of midnight New Year's Eve time signals to mark the exact instant of the beginning of the new year for each of the four great standard time belts of the United States met with such great success that it has become a regular feature of the time service, and bids fair to have an important influence toward the universal adoption of the Greenwich meridian as the international basis of longitude and time.

The plan referred to has been taken up so energetically by telegraph and cable companies, not only on New Year's Eve, but whenever similar special series of midnight signals are sent out, that upon such occasions our standard clock may fairly be said to be heard in "the remotest ends of the earth," thus anticipating the day when wireless telegraphy will perhaps allow of a daily international time signal that will reach every continent and ocean in a small fraction of a second.

These midnight signals have reached such distant points as Madras, Mauritius, Cape Town, Pulkowa, Rome, Lisbon, Madrid, Sitka, Buenos Ayres, Wellington, Sydney, and Guam. Upon one occasion they extended from Greenwich to Adelaide, and from Sitka to Buenos Ayres, thus covering about three-quarters of the civilized world, and at Adelaide they have met from the east and from the west, thus compassing the entire globe, all within a very few seconds. They have been reported as having been received at the Lick Observatory in $0^s.05$; Montreal, $0^s.10$; City of Mexico, $0^s.11$; Manila, $0^s.37$; Greenwich, $1^s.33$; Sydney, $2^s.25$; Wellington, New Zealand, $4^s.00$; and Cordoba, Argentina, $7^s.70$.

The voluntary cooperation required to transmit, note, and report such signals proves the widespread interest and public attention that they elicit, while the fact that they are based on Greenwich standard time involves its use in calculating intervals occupied by their transmission and thus emphasizes the value of a common standard.

It may be explained that to measure accurately such brief differences of time requires exact astronomical observations for time at the observatories at each end of the line and the use of fine clocks and chronographs. It also involves, of course, an exact knowledge of the longitude of each observatory, as any error in the longitude enters directly into the determination of the time of transmission of the signal. This will be readily understood by remembering the fact that the best method of determining differences of longitude is by exchanging telegraphic time signals in connection with accurate astronomical star sights at each station. The object then is to eliminate the delay in transmission of the signals and thus find the exact difference of time, which at once gives the difference of longitude—four seconds of time being equal to one minute of longitude.

In the present case, where the object is to observe the exact delay in transmission of the signals from Washington to another observatory, the details are briefly as follows:

First, the exact error of the clock at each observatory is ascertained, usually by comparing its time with sidereal or star time, obtained by observing the meridian transit of one or more stars. This involves the use of a meridian transit instrument, a sidereal clock, and usually a chronograph. The observer starts the chronograph, adjusts the pen and ink, and closes the clock circuit. The pen then begins to mark seconds (clock time) on the moving chronograph cylinder, making a record somewhat as shown by the diagram on page G 10. The observer then sets his telescope, which swings in the plane of the meridian, and waits, with electric key in hand, until the expected star enters the field. As soon as he sees it he gives a rattle on the key, followed by a quick tap as the star crosses each of the transit wires, or fine spider threads, and then a rattle again as it passes out of the field. He can then easily read on the chronograph sheet the *clock time* of the star's transit over each wire, reduce these to the middle wire and then to the meridian, get the *star time*, or right ascension, from the Almanac, and the difference between the two is the *error of the clock*. By making a mark on the diagram, page G 10, between any two of the seconds, and reading the corresponding clock time from the scale, it will be readily seen how the clock time of a star's transit can be marked and read with an accuracy within even less than a tenth of a second.

Next, it remains only to convert this accurate sidereal time into mean solar and finally into standard time, and to arrange for the accurate transmission and receipt of the midnight signals, which are due in Chicago at precisely 11 p. m., Denver at 10 p. m., San Francisco at 9 p. m., and so on around the world.

THE PRESENT STATUS OF STANDARD TIME.

It is gratifying to note that the following resolution, proposed by the writer, was adopted at a recent meeting of the Eighth International Geographic Congress, in whose honor a special midnight time signal was sent out on the occasion of a reception to that distinguished body by the Superintendent of the Naval Observatory, Rear-Admiral C. M. Chester, U. S. Navy, on September 8, 1904:

> *Resolved*, in view of the fact that a large majority of the nations of the world have already adopted systems of standard time based upon the meridian of Greenwich as prime meridian, that this Congress is in favor of the universal adoption of the meridian of Greenwich as the basis of all systems of standard time.

The following table gives a list of the nations that have adopted and now use standard time. It shows also the meridian that is used as the basis of each system and the number of hours, minutes, and seconds earlier or later than the Washington standard, or seventy-fifth meridian time, and the same data for Greenwich standard time.

The table shows that 36 nations have adopted standard time; that 20 of these, including a very large majority as regards population and extent of territory, use systems based on the meridian of Greenwich; and that no two other nations agree. This table is thus conclusive in showing the strength of the argument in favor of what is appropriately called the Universal Time System, which may fairly be said to have as much in its favor as the Gregorian calendar itself.

Summary of Nations that use Standard Time.

Nation.	Basis of System.	Earlier (—) or Later (+) than,					
		Washington			Greenwich		
		h	*m*	*s*	*h*	*m*	*s*
Argentina	Cordoba	+ 0	43	11. 8	— 4	16	48. 2
Austria-Hungary	Greenwich	+ 6	0	0	+ 1	0	0
Belgium	Greenwich	+ 5	0	0	0	0	0
British Empire:							
Ireland	Dublin	+ 4	34	38. 9	— 0	25	21. 1
England and Scotland	Greenwich	+ 5	0	0	0	0	0
Cape Colony, Transvaal, Orange River Colony, Rhodesia, Natal.	Greenwich	+ 7	0	0	+ 2	0	0
India and Ceylon	Madras	+10	20	59. 1	+ 5	20	59. 1
Straits Settlements	Singapore	+11	55	25	+ 6	55	25

Summary of Nations that use Standard Time—Continued.

Nation.	Basis of System.	Earlier (—) or Later (+) than,					
		Washington			Greenwich		
		h	*m*	*s*	*h*	*m*	*s*
British Empire—Continued.							
Hongkong	Greenwich	+13	0	0	+8	0	0
West Australia, British North Borneo, and Labuan.	Greenwich	+13	0	0	+8	0	0
South Australia	Greenwich	+14	30	0	+9	30	0
New South Wales, Queensland, Tasmania, Victoria.	Greenwich	+15	0	0	+10	0	0
New Zealand	Greenwich	+16	30	0	+11	30	0
Newfoundland	St. Johns	+1	29	16.4	—3	30	43.6
Nova Scotia and Prince Edward Island.	Greenwich	+1	0	0	—4	0	0
New Brunswick, Ontario, Quebec	Greenwich	0	0	0	—5	0	0
Keewatin, Manitoba	Greenwich	—1	0	0	—6	0	0
Alberta, Assiniboia, Athabasca	Greenwich	—2	0	0	—7	0	0
British Columbia	Greenwich	—3	0	0	—8	0	0
Chile (except Valparaiso)	Santiago	+0	17	13.9	—4	42	46.1
China (east coast)	Greenwich	+13	0	0	+8	0	0
Colombia	Bogotá	+0	3	5.8	—4	56	54.2
Costa Rica	San José	—0	36	16.9	—5	36	16.9
Cuba	Habana	—0	29	26.0	—5	29	26.0
Denmark	Greenwich	+6	0	0	+1	0	0
Ecuador	Quito	—0	14	6.7	—5	14	6.7
Egypt	Greenwich	+7	0	0	+2	0	0
France, including Algeria and Tunis	Paris	+5	9	21.0	+0	9	21.0
German Empire:							
Germany	Greenwich	+6	0	0	+1	0	0
Southwest Africa (German)	Greenwich	+6	0	0	+1	0	0
Kiaochau	Greenwich	+13	0	0	+8	0	0
Greece	Athens	+6	34	52.9	+1	34	52.9
Holland	Greenwich	+5	0	0	0	0	0
Grand Duchy of Luxembourg	Greenwich	+6	0	0	+1	0	0
Honduras	Greenwich	—1	0	0	—6	0	0
Italy	Greenwich	+6	0	0	+1	0	0
Japan	Greenwich	+14	0	0	+9	0	0
Formosa, Pescadores, etc	Greenwich	+13	0	0	+8	0	0
Korea	Greenwich	+14	0	0	+9	0	0
Mexico	City of Mexico	—1	36	26.7	—6	36	26.7
Nicaragua	Managua	—0	45	10.0	—5	45	10.0
Norway	Greenwich	+6	0	0	+1	0	0
Panama	Greenwich	0	0	0	—5	0	0
Peru	Callao.	—0	9	3.0	—5	9	3.0
Portugal	Lisbon	+4	23	39.5	—0	36	20.5
Russia (western)	Pulkowa	+7	1	18.6	+2	1	18.6
Salvador	San Salvador	—0	56	32.0	—5	56	32.0
Servia	Greenwich	+6	0	0	+1	0	0
Spain	Greenwich	+5	0	0	0	0	0
Sweden	Greenwich	+6	0	0	+1	0	0
Switzerland	Greenwich	+6	0	0	+1	0	0
Turkey	Greenwich	+7	0	0	+2	0	0
United States:							
Eastern standard time	Greenwich	0	0	0	—5	0	0
Central standard time	Greenwich	—1	0	0	—6	0	0
Mountain standard time	Greenwich	—2	0	0	—7	0	0
Pacific standard time	Greenwich	—3	0	0	—8	0	0
Alaska standard time	Greenwich	—4	0	0	—9	0	0
Hawaiian standard time	Greenwich	—5	30	0	—10	30	0
Samoan standard time	Greenwich	—6	30	0	—11	30	0
Porto Rico standard time	Greenwich	+1	0	0	—4	0	0
Philippine standard time	Greenwich	+13	0	0	+8	0	0
Guam standard time	Greenwich	+14	30	0	+9	30	0
Uruguay	Montevideo	+1	15	11.1	—3	44	48.9
Venezuela	Caracas	+0	32	16.4	—4	27	43.6

LEGAL ACTS, DECREES, AND DECISIONS.

The legal use of standard or other kind of time is a question partly of statute and partly of common law, or custom. In some countries the legal standard is defined explicitly by statute law or by royal decree, either for the entire country or for certain definite parts thereof, but in other countries or parts of countries no statute law has as yet been adopted and there is only custom, supported by occasional precedents, consisting of legal decisions made in certain specific cases.

The following are good examples of statute laws, ordinances, and decrees:

[Great Britain, act of 1880.]

A BILL to remove doubts as to the meaning of expressions relative to time occurring in acts of Parliament, deeds, and other legal instruments.

Whereas it is expedient to remove certain doubts as to whether expressions of time occurring in acts of Parliament, deeds, and other legal instruments relate in England and Scotland to Greenwich time, and in Ireland to Dublin time, or to the mean astronomical time in each locality:

Be it therefore enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords, spiritual and temporal, and Commons, in the present Parliament assembled, and by the authority of the same, as follows (that is to say):

1. That whenever any expression of time occurs in any act of Parliament, deed, or other legal instrument, the time referred shall, unless it is otherwise specifically stated, be held in the case of Great Britain to be Greenwich mean time and in the case of Ireland Dublin mean time.
2. This act may be cited as the statutes (definition of time) act, 1880.

AN ACT to establish a standard of time in the District of Columbia.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the legal standard of time in the District of Columbia shall hereafter be the mean time of the seventy-fifth meridian of longitude west from Greenwich.

SECTION 2. That this act shall not be so construed as to affect existing contracts.

Approved, March 13, 1884.

AN ACT to declare the time known as "standard central time" the legal time within and for the State of Minnesota for all public and private purposes.

Be it enacted by the legislature of the State of Minnesota:

SECTION 1. That the time known as "standard central time," the same being the mean solar time of 90° longitude west of Greenwich is hereby declared to be the legal time within and for the State of Minnesota for all public and private purposes.

SECTION 2. This act shall take effect and be in force from and after its passage.

Approved, February 26, 1901.

[Empire of Japan. Imperial ordinance No. 51 of 1886.]

The meridian that passes through the observatory at Greenwich, England, shall be the zero (0) meridian.

Longitudes shall be counted from the above meridian east and west up to 180 degrees, the east being positive and the west negative.

From January 1, 1888, the time of the one hundred and thirty-fifth degree east longitude shall be the standard time of Japan.

[Imperial ordinance No. 167 of 1895.]

ARTICLE I. The standard time hitherto used in Japan shall henceforth be called central standard time.

ARTICLE II. The time of 120° east longitude shall be the standard time of Formosa, the Pescadores, the Yaeyama, and the Miyako groups, and shall be called western standard time.

ARTICLE III. This ordinance shall take effect from the 1st of January, 1896.

[Empire of Germany. Imperial decree of March 12, 1893.]

We, Wilhelm, by the grace of God German Emperor, King of Prussia, decree in the name of the Empire, the Bundesrath and Reichstag concurring, as follows:

The legal time in Germany is the mean solar time of longitude 15° east from Greenwich.

Although such statutes seem and are intended to be clear and mandatory, yet, like other written laws, they are subject to official interpretation by the courts. For example, the British statutory definition, quoted above, is limited to the word "time" in any act of Parliament, deed, or other legal instrument, and a subsequent decision is referred to as follows:

In the case of Curtis *v.* March, reported in volume 3 of Hurlestone and Norman's Exchequer Reports, page 866 (1858), it was held that the time appointed for the sitting of a court must be understood as the mean time at the place where the court sits, and not Greenwich time, unless it be so expressed, and a new trial was granted to a defendant who arrived at the local (Carlisle) time appointed by the court to sit, but found that the court had met by Greenwich time, and the case had been decided against him.

Similarly, in a decision by a court in the State of Georgia, U. S. A., in 1889, the following opinion was rendered:

The only standard of time in computation of a day, or hours of a day, recognized by the laws of Georgia is the meridian of the sun; and a legal day begins and ends at midnight, the mean time between meridan and meridian, or 12 o'clock *post meridiem*. An arbitrary and artificial standard of time, fixed by persons in a certain line of business, can not be substituted at will in a certain locality for the standard recognized by the law.

These laws and decisions will serve to illustrate that it is desirable, for many reasons, to fix a legal standard of time everywhere, and it seems evident that such standard should in every case be based upon Greenwich as the prime meridian. The nearest hour meridian, 15 degrees of longitude or multiple thereof, east or west from Greenwich, should be adopted as the standard time meridian of each wide adjacent region, the exact limits to be defined accurately by law. The result would then be, with the universal adoption of this system, that the minute and second hands of all chronometers, clocks, and watches set to ordinary solar, not sidereal, time would be exactly the same all over the world, only the hour differing, so that a single international noon signal by wireless telegraphy would be due at an exact hour on board of every vessel and at every city, town and village in the world.

ABSTRACTS OF OFFICIAL REPORTS OF THE KINDS OF TIME IN USE BY VARIOUS NATIONS.

The following abstracts have been prepared from official reports collected and forwarded to the Superintendent of the United States Naval Observatory by the Department of State, through the Diplomatic and Consular Service, and the Department of the Navy, through the Bureau of Navigation and the Office of Naval Intelligence:

Country.	System of Time in Actual Use.	Earlier (—) or Later (+) than,		Authority.
		Washington	Greenwich	
		h m s	h m s	
Alaska	See United States.			
Algeria	See France.			
Anam	See France.			
Argentina	The official time in use throughout Argentina is referred to the meridian of Cordoba, $4^h 16^m 48^s.2$ west from Greenwich. At 11 a. m. a daily signal is telegraphed from the Cordoba Observatory. The greatest deviation of local mean time from the official time would not exceed 26 minutes. La Plata is $25^m 45^s$ east from Cordoba, and Mendoza, the most western town of importance, is $18^m 32^s$ west from Cordoba.	+ 0 43 11.8	— 4 16 48.2	A. E.[a]
Australia	See British Empire.			
Austria-Hungary.	Standard time does not exist in Austria except for the service of the railroads. Central European time, 15° east from Greenwich, is required to be used by all the railways. This is not a matter of law, but is in force by order of the proper authorities.	+ 6 0 0	+ 1 0 0	
Bahamas	See British Empire.			
Belgium	Official time in Belgium is calculated from 0 to 24 hours, zero corresponding to mean midnight at Greenwich. The Royal Observatory at Brussels communicates daily the precise hour to the Central Telegraphic Administration and Government offices; also to important corporations. The Telegraphic Administration transmits it to the towns in Belgium.	+ 5 0 0	0 0 0	
Bermudas	See British Empire.			
Bismarck Archipelago.	See German Empire.			
Borneo	See British Empire.			
British Empire	Great Britain: The meridian of Greenwich is the standard time meridian for— England, Isle of Man, Orkneys, Shetland Islands, Scotland.	+ 5 0 0	0 0 0	
	Ireland: The meridian of Dublin $0^h 25^m 21^s.1$ west from Greenwich is the standard time meridian.	+ 4 34 38.9	— 0 25 21.1	A. E.
	Colonies:			
	Africa: The meridian of longitude 30° east from Greenwich is the standard time meridian for— Cape Colony, Natal, Orange River Colony, Rhodesia, Transvaal.	+ 7 0 0	+ 2 0 0	
	Australia: The standard time meridian is for—			
	New South Wales, Queensland, } longitude 150° east from Greenwich.	+15 0 0	+10 0 0	
	South Australia, including Northern Territory, longitude 142°.5 east from Greenwich.	+14 30 0	+ 9 30 0	
	Tasmania, Victoria, } longitude 150° east from Greenwich.	+15 0 0	+10 0 0	
	West Australia, longitude 120° east from Greenwich.	+13 0 0	+ 8 0 0	

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[a] American Ephemeris.

Abstracts of Official Reports of the Kinds of Time in Use by Various Nations—Continued.

Country.	System of Time in Actual Use.	Earlier (−) or Later (+) than,						Authority.
		Washington			Greenwich			
		h	m	s	h	m	s	
British Empire	Colonies—Continued.							
	Canada: The standard time meridian is for—							
	Alberta, Assiniboia, Athabasca, longitude 105° west from Greenwich.	− 2	0	0	− 7	0	0	
	British Columbia, longitude 120° west from Greenwich.	− 3	0	0	− 8	0	0	
	Keewatin, Manitoba, longitude 90° west from Greenwich.	− 1	0	0	− 6	0	0	
	New Brunswick, longitude 75° west from Greenwich.	0	0	0	− 5	0	0	
	Nova Scotia, longitude 60° west from Greenwich.	+ 1	0	0	− 4	0	0	
	Ontario, longitude 75° west from Greenwich .	0	0	0	− 5	0	0	
	Prince Edward Island, longitude 60° west from Greenwich.	+ 1	0	0	− 4	0	0	
	Quebec, longitude 75° west from Greenwich .	0	0	0	− 5	0	0	
	Chatham Island, longitude 172°.5 east from Greenwich.	+16	30	0	+11	30	0	
	Gibraltar, longitude of Greenwich..............	+ 5	0	0	0	0	0	
	Hongkong, longitude 120° east from Greenwich..	+13	0	0	+ 8	0	0	
	Malta, longitude 15° east from Greenwich........	+ 6	0	0	+ 1	0	0	
	New Zealand, longitude 172°.5 east from Greenwich.	+16	30	0	+11	30	0	
	Straits Settlements, longitude of Fort Fullerton, Singapore, $6^h\ 55^m\ 25^s$ east from Greenwich.	+11	55	25.0	+ 6	55	25.0	B.[a]
	Assuming local mean time for other British colonies gives the following results:							
	Antigua (St. John)...........................	+ 0	52	38.1	− 4	7	21.9	B.
	Arabia (Aden)................................	+ 7	59	55.9	+ 2	59	55.9	B.
	Bahamas (Nassau).............................	− 0	9	27.9	− 5	9	27.9	B.
	Barbados (Bridgetown)........................	+ 1	1	30.8	− 3	58	29.2	C. T.[b]
	Bermudas (Hamilton)..........................	+ 0	40	33.6	− 4	19	26.4	B.
	Borneo (Labuan)..............................	+12	41	1.0	+ 7	41	1.0	B.
	NOTE.—It is reported unofficially that standard time has been adopted in British North Borneo and Labuan.	+13	0	0	+ 8	0	0	
	Falkland Islands (Port Stanley)...............	+ 1	8	34.0	− 3	51	26.0	B.
	Fiji Islands (Suva)..........................	+16	53	44.3	+11	53	44.3	B.
	Guiana (Demerara)............................	+ 1	7	14.0	− 3	52	46.0	B.
	Honduras (Belize)............................	− 0	52	46.7	− 5	52	46.7	B.
	India (Madras)...............................	+10	20	59.1	+ 5	20	59.1	A. E.
	India (Calcutta).............................	+10	53	20.8	+ 5	53	20.8	B.
	India (Bombay)...............................	+ 9	51	15.7	+ 4	51	15.7	A. E.
	NOTE.—Local mean time of the Madras Observatory is practically used as standard time for India and Ceylon, being telegraphed daily all over the country; but for strictly local use it is generally converted into local mean time. It is proposed soon to adopt the standard time meridian of $5^h\ 30^m\ 0^s$ east from Greenwich for India and Ceylon and the standard time meridian of $6^h\ 30^m\ 0^s$ east from Greenwich for Burma.							
	Jamaica (Kingston)...........................	− 0	7	10.7	− 5	7	10.7	B.
	Mauritius (Royal Alfred Observatory)..........	+ 8	50	12.6	+ 3	50	12.6	A. E.
	Newfoundland (St. Johns).....................	+ 1	29	16.4	− 3	30	43.6	B.
	NOTE.—Local mean time of St. Johns is practically used as standard time for the entire island.							
	Trinidad (Port of Spain)......................	+ 0	53	57.5	− 4	6	2.5	C. T.
Cambodia	See France.							
Canada.......	See British Empire.							
Carolines.....	See German Empire.							
Chatham Island.	See British Empire.							

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[a] Bowditch's American Practical Navigator.

[b] Connaissance des Temps.

Abstracts of Official Reports of the Kinds of Time in Use by Various Nations—Continued.

Country.	System of Time in Actual Use.	Earlier (−) or Later (+) than,						Author-ity.
		Washington			Greenwich			
		h	*m*	*s*	*h*	*m*	*s*	
Chile.........	The official railroad time is that of the meridian of Santiago furnished the central railway station in that city by the Santiago Observatory. This time is telegraphed over the country daily at 7 a. m.	+ 0	17	13. 9	− 4	42	46. 1	A. E.
	The city of Valparaiso uses local time furnished by the observatory at the Naval School located there.	+ 0	13	25. 9	− 4	46	34. 1	C. T.
China........	An observatory is maintained by the Jesuit mission at Zikawei near Shanghai, and a time-ball suspended from a mast on the French Bund in Shanghai is dropped electrically precisely at noon each day. This furnishes the local time at the port of Shanghai, which is adopted by the railway and telegraph companies represented there, as well as by the coastwise shipping. From Shanghai the time is telegraphed to other ports. The cable companies represented in Peking receive this time from Chefoo; the Imperial Chinese Telegraphs from the office of that company at Tientsin. The Imperial Railways of North China use the same time, taking it from the British gun at Tientsin and passing it on to the stations of the railway twice each day, at 8 a. m. and 8 p. m. No information yet from the Peking-Hankau Railway.	+13	5	43. 3	+ 8	5	43. 3	C. T.
	NOTE.—Standard time is coming into use all along the east coast of China, from Newchwang to Hongkong, and in the interior as far as Hankau.	+13	0	0	+ 8	0	0	
Cochin-China.	See France.							
Colombia.....	At Bogotá the time used is that of the meridian of Bogotá. This time is taken every day at noon in the observatory, but there is no method employed in correcting it daily by signal from a central observatory. Some few people, such as jewelers, go to the observatory daily, but the great mass of business men, railroad officials, etc., let their timepieces run sometimes for weeks without correcting them, until the inconveniences caused thereby compel them to make the necessary corrections. So far as communicating the time as corrected in Bogotá to other parts of the country is concerned, this is rendered impossible by the very poor telegraphic service, it frequently taking 4 and 5 days to send messages a distance of from 50 to 100 miles.	+ 0	3	5. 8	− 4	56	54. 2	A. E.
Costa Rica....	The Government has established an observatory at the capital, San José, in latitude 9° 56′ north, longitude 84° 4′ 14″ west from Greenwich; altitude 3,800 feet above sea level. The Greenwich meridian is used exclusively to regulate observatory time, which is corrected by observation and reduced to mean time. This time is issued to public offices, railway and telegraph offices, churches, and to all residents whose occupations necessitate correct time. There is no method employed to correct time by signal from the observatory, the corrected time being taken by applicants from the standard chronometer at the observatory.	− 0	36	16. 9	− 5	36	16. 9	
Cuba.........	The official time of the Republic is civil mean time of the meridian of Habana and is used by the railroads and telegraphic lines of the government. The Central Meteorological Station gives the time daily to the port and city of Habana as well as to all the telegraph offices of the Republic.	− 0	29	26. 0	− 5	29	26. 0	B.
Danish West Indies.	See Denmark.							
Denmark.....	"Standard time is fixed at one hour earlier than that of Greenwich, corresponding to mean solar time of the 15th degree of longitude east from Greenwich." In Iceland, the Faroe Islands, and the Danish West Indies, local mean time is used.	+ 6	0	0	+ 1	0	0	
	Local mean time for the Danish West Indies gives							
	Curaçao................................	+ 0	24	13. 1	− 4	35	46. 9	B.
	St. Thomas................................	+ 0	40	16. 5	− 4	19	43. 5	B.
	Local mean time for Iceland gives for Reikiavik..	+ 3	32	20. 0	− 1	27	40. 0	B.

Abstracts of Official Reports of the Kinds of Time in Use by Various Nations—Continued.

Country.	System of Time in Actual Use.	Earlier (−) or Later (+) than,						Authority.
		Washington			Greenwich			
		h	*m*	*s*	*h*	*m*	*s*	
Ecuador	The official time is that of the meridian of Quito. It is corrected daily from the National Observatory of Quito.	− 0	14	6.7	− 5	14	6.7	A. E.
Egypt	Standard time is that of the 30th degree of longitude east from Greenwich, eastern European time, and is therefore 2 hours fast of Greenwich or western European time. It is sent out electrically by the standard clock of the observatory to the citadel at Cairo, to Alexandria, Port Said, and Wady-Halfa.	+ 7	0	0	+ 2	0	0	
England	See British Empire.							
Faroe Islands	See Denmark.							
Fiji Islands	See British Empire.							
Formosa	See Japan.							
France	Legal time in France, Algeria, and Tunis, is local mean time of the Paris Observatory. Local mean time is considered as legal in other French colonies. This gives the following results:	+ 5	9	20.9	+ 0	9	20.9	C. T.
	Cochin-China, Cambodia, and Anam (Saigon)	+12	6	48.2	+ 7	6	48.2	C. T.
	Corsica (Ajaccio)	+ 5	34	57.3	+ 0	34	57.3	B.
	Guadaloupe (Basse-Terre)	+ 0	53	3.4	− 4	6	56.6	C. T.
	Madagascar (Tananarivo)	+ 8	10	7.0	+ 3	10	7.0	C. T.
	Marquesas Islands (Port Resolution)	− 4	16	36.0	− 9	16	36.0	B.
	Martinique (St. Pierre)	+ 0	55	15.2	− 4	4	44.8	C. T.
	Miquelon (St. Pierre)	+ 1	15	17.5	− 3	44	42.5	C. T.
	New Caledonia (Nouméa)	+16	5	48.4	+11	5	48.4	C. T.
	Paumotu Archipelago (Pitcairn Island)	− 3	40	23.2	− 8	40	23.2	C. T.
	Senegal (Port Dakar)	+ 3	50	18.0	− 1	9	42.0	B.
	Tongking (Hai-Phong)	+12	6	39.5	+ 7	6	39.5	C. T.
German Empire.	Germany: The standard time is the mean solar time of the meridian of longitude 15° east from Greenwich.	+ 6	0	0	+ 1	0	0	
	Colonies: Mean solar time has been adopted for the following—							
	Kiaochau, based on the meridian of longitude 120° east from Greenwich.	+13	0	0	+ 8	0	0	
	Southwest Africa (German), based on the meridian of longitude 15° east from Greenwich.	+ 6	0	0	+ 1	0	0	
	It is proposed to adopt standard time for the following:							
	Bismarck Archipelago, Carolines, based on the meridian of longitude 150° east from Greenwich.	+15	0	0	+10	0	0	
	East Africa (German), based on the meridian of longitude 30° east or possibly 37°.5 east from Greenwich.	+ 7 + 7	0 30	0 0	+ 2 + 2	0 30	0 0	
	Kamerun, based on the meridian of longitude 15° east from Greenwich.	+ 6	0	0	+ 1	0	0	
	Mariane Islands, New Guinea, based on the meridian of longitude 150° east from Greenwich.	+15	0	0	+10	0	0	
	Samoa, based on the meridian of longitude 180° east from Greenwich, but only after an understanding with the Government at Washington.	+17	0	0	+12	0	0	
	Toga, based on the meridian of Greenwich	+ 5	0	0	0	0	0	
Gibraltar	See British Empire.							
Greece	By royal decree of September 14, 1895, the time in common use is that of the mean time of Athens, which is transmitted every day from the observatory by telegraph to the towns of the Kingdom.	+ 6	34	52.9	+ 1	34	52.9	A. E.
Hawaiian Islands.	See United States.							
Holland	The local time of Amsterdam is generally used, but Greenwich time is used by the post and telegraph administration and the railways and other transportation companies. The observatory at Leyden communicates the time twice a week to Amsterdam, The Hague, Rotterdam, and other cities, and the telegraph bureau at Amsterdam signals the time to all the other telegraph bureaus every morning.	+ 5 + 5	19 0	32.3 0	+ 0 0	19 0	32.3 0	B.
	In the Grand Duchy of Luxembourg central European time is the legal and uniform time.	+ 6	0	0	+ 1	0	0	

Abstracts of Official Reports of the Kinds of Time in Use by Various Nations—Continued.

Country.	System of Time in Actual Use.	Earlier (—) or Later (+) than,		Authority.
		Washington	Greenwich	
		h m s	h m s	
Holland	Local mean time for the colonies gives—			
	Java (Batavia)	+12 7 13.7	+ 7 7 13.7	B.
	Sumatra (Padang)	+11 41 20.9	+ 6 41 20.9	B.
Honduras	"In Honduras the half hour nearest to the meridian of Tegucigalpa, longitude 87° 12′ west from Greenwich, is generally used. Said hour is frequently determined at the National Institute by means of a solar chronometer and communicated by telephone to the Industrial School, where in turn it is indicated to the public by a steam whistle. The central telegraph office communicates it to the various sub-offices of the Republic, whose clocks generally serve as a basis for the time of the villages, and in this manner an approximately uniform time is established throughout the Republic."	— 1 0 0	— 6 0 0	
	Belize. See British Empire.			
Hongkong	See British Empire.			
Iceland	See Denmark.			
India	See British Empire.			
Italy	Mean solar time of the meridian of longitude 15° east from Greenwich is the standard time adopted by royal decree of August 10, 1893, for the Kingdom of Italy. This time is to be kept in all government establishments, offices, dockyards, and is to be used by all ships of the Italian Navy in the ports of or doing duty on the coast of Italy. All railroads, post and telegraph offices, and Italian coasting steamers, are to use this time and regulate their business and time-tables in accordance therewith. The hours run from midnight to midnight—that is to say, in Italy 1 p. m. is 13 hours, 5 p. m. is 17 hours, etc.	+ 6 0 0	+ 1 0 0	
Jamaica	See British Empire.			
Japan	Imperial ordinance No. 51, of 1886: The meridian that passes through the observatory at Greenwich, England, shall be the zero (0) meridian. Longitude shall be counted from the above meridian east and west up to 180 degrees, the east being positive and the west negative. From January 1, 1888, the time of the 135th degree east longitude shall be the standard time of Japan.	+14 0 0	+ 9 0 0	
	Imperial ordinance No. 167, of 1895: The standard time hitherto used in Japan shall henceforth be called Central Standard time. The time of the 120th degree east longitude shall be the standard time of Formosa, the Pescadores, the Yaeyama, and the Miyako groups, and shall be called western standard time. This ordinance shall take effect from the 1st of January, 1896.	+14 0 0 +13 0 0	+ 9 0 0 + 8 0 0	
Java	See Holland.			
Kamerun	See German Empire.			
Kiaochau	See German Empire.			
Korea	Tokyo time, 135° east from Greenwich, is telegraphed daily to the Imperial Japanese Post and Telegraph Office at Seoul. Before December 1, 1904, this was corrected by subtracting 30 minutes, which nearly represents the difference in longitude, and was then used by the railroads, street railways, and post and telegraph offices, and most of the better classes. Since December 1, 1904, the Japanese post-offices and railways in Korea have begun to use Tokyo time. In the country districts the people use sun dials to some extent.	+13 30 0 +14 0 0	+8 30 0 +9 0 0	
Madagascar	See France.			
Malta	See British Empire.			
Marquesas Islands.	See France.			

Abstracts of Official Reports of the Kinds of Time in Use by Various Nations—Continued.

Country.	System of Time in Actual Use.	Earlier (—) or Later (+) than,		Author-ity.
		Washington	Greenwich	
		h m s	h m s	
Mariane Islands.	See German Empire.			
Mauritius	See British Empire.			
Mexico.......	The National Astronomical Observatory of Tacubaya regulates a clock twice a day which marks the local mean time of the City of Mexico, 6h 36m 26s.7 west from Greenwich, and a signal is raised twice a week at noon upon the roof of the national palace, such signal being used to regulate the city's public clocks. This signal, the clock at the central telegraph office, and the public clock on the cathedral, serve as a basis for the time used commonly by the people. The general telegraph office transmits this time daily to all of its branch offices. Not every city in the country uses this time, however, since a local time, very imperfectly determined, is more commonly observed. The following railroad companies use standard City of Mexico time corrected daily by telegraph: Central, Hidalgo, Xico and San Rafael, National and Mexican. The Central and National railroads correct their clocks to City of Mexico time daily by means of the noon signal sent out from the Naval Observatory at Washington, and by a similar signal from the observatory at St. Louis, Mo.	— 1 36 26.7	—6 36 26.7	A. E.
Miquelon.....	See France.			
New Caledonia.	See France.			
Newfoundland	See British Empire.			
New Guinea ..	See German Empire.			
New Zealand .	See British Empire.			
Nicaragua	Managua time is issued to all public offices, railways, telegraph offices, and churches, in a zone that extends from San Juan del Sur, latitude 11° 15′ 44″ north, to El Ocotal, latitude 12° 46′ north, and from El Castillo, longitude 84° 22′ 37″ west from Greenwich, to Corinto, longitude 87° 12′ 31″ west from Greenwich. The time of the Atlantic ports is usually obtained from the captains of ships.	— 0 45 10.0	—5 45 10.0	
Norway	Central European time, longitude 15° east from Greenwich, is the standard and, as far as known, is used everywhere in the country. Telegraphic time signals are sent out once a week to the telegraph stations throughout the country from the observatory of the Christiania University.	+ 6 0 0	+1 0 0	
Panama	The railroad company uses the local mean time of Colon, 5h 19m 39s west from Greenwich. This time is obtained from the chronometers of the company's New York steamers. The Central and South American Cable Co. now cables 75th meridian time, 5h west from Greenwich, daily from Washington, and this will probably be adopted as the standard.	— 0 19 39.0 0 0 0	—5 19 39.0 —5 0 0	B.
Panama Canal Zone.	See United States.			
Paumotu Archipelago.	See France.			
Peru	There is no official time. The railroad from Callao to Oroya takes its time by telegraph from the noon signal at the naval school at Callao, which may be said to be the standard time for Callao, Lima, and the whole of Central Peru. The railroad from Mollendo to Lake Titicaca, in southern Peru, takes its time from ships in the Bay of Mollendo.	— 0 9 3.0	—5 9 3.0	B.
Pescadores....	See Japan.			
Philippine Islands.	See United States.			
Porto Rico....	See United States.			

Abstracts of Official Reports of the Kinds of Time in Use by Various Nations—Continued.

Country.	System of Time in Actual Use.	Earlier (−) or Later (+) than,						Authority.
		Washington			Greenwich			
		h	*m*	*s*	*h*	*m*	*s*	
Portugal	Standard time is in use throughout Portugal, and is based upon the meridian of Lisbon (9° 5′ 7″). It is established by the Naval Observatory in the Royal Gardens at Lisbon, and from there sent by telegraph to every railway station throughout Portugal having telegraphic communication. Clocks on railway station platforms are 5 minutes behind, while clocks outside of stations are 2 minutes ahead of standard time.	+ 4	23	39.5	−0	36	20.5	
Russia	All telegraph stations use the time of Pulkowa (St. Petersburg). At railroad stations both local and Pulkowa time are given, from which it is to be inferred that for all local purposes local time is used. Local mean time gives for—	+ 7	1	18.6	+2	1	18.6	A. E.
	Nicolaeff	+ 7	7	53.8	+2	7	53.8	A. E.
	Riga	+ 6	36	28.2	+1	36	28.2	A. E.
	Irkutsk..	+10	57	4.7	+5	57	4.7	C. T.
	Vladivostok	+13	47	30.9	+8	47	30.9	C. T.
Salvador	The Government has established a national observatory at San Salvador which issues time on Wednesdays and Saturdays, at noon, to all public offices, telegraph offices, railways, etc., throughout the Republic.	− 0	56	32.0	−5	56	32.0	
Samoa	See German Empire and United States.							
Santo Domingo.	Local mean time is used, but there is no central observatory and no means of correcting the time. The time differs from that of naval vessels in these waters by about 30 minutes.							
	Local mean time gives, for Santo Domingo City......	+ 0	20	28.0	−4	39	32.0	C. T.
Senegal	See France.							
Servia........	Central European time, longitude 15° east from Greenwich, is used by the railroad, telegraph companies, and the people generally. Clocks are regulated by telegraph from Budapest every day at noon.	+ 6	0	0	+1	0	0	
Siberia (Irkutsk and Vladivostok).	See Russia.							
Singapore	See British Empire.							
South Africa..	See British Empire.							
Spain	Official time is the mean time of the meridian of Greenwich, obtained from the Madrid Observatory. It is used by the railroad and telegraph companies and the people of Madrid and provinces generally, in some of which, however, local time is still used for private matters.	+ 5	0	0	0	0	0	
Straits Settlements.	See British Empire.							
Sumatra......	See Holland.							
Sweden	Central European time, 15° east from Greenwich, is the standard. It is sent out every week by telegraph from the Stockholm Observatory.	+ 6	0	0	+1	0	0	
Switzerland ..	Central European time is at present the only legal time. It is sent out daily by telegraph from the Cantonal Observatory at Neuchâtel.	+ 6	0	0	+1	0	0	
Toga.........	See German Empire.							
Tongking	See France.							
Trinidad	See British Empire.							
Tunis	See France.							

Abstracts of Official Reports of the Kinds of Time in Use by Various Nations—Continued.

Country.	System of Time in Actual Use.	Earlier (—) or Later (+) than,		Authority.
		Washington	Greenwich	
		h m s	h m s	
Turkey.......	Two kinds of time are used, i. e., Turkish and eastern European time, the former for the natives and the latter for Europeans. The railroads generally use both, the latter for the actual running of trains and Turkish time-tables for the benefit of the natives. Standard Turkish time is used generally by the people, sunset being the base and 12 hours being added for a theoretical sunrise. The official clocks are set daily so as to read 12 o'clock at the theoretical sunrise, but the tower clocks are set only two or three times a week. The Government telegraph lines use Turkish time throughout the Empire and St. Sophia time, 1^h 47^m 32^s ahead of Paris, for telegrams sent out of the country.	+ 7 0 0 + 6 56 53.0	+2 0 0 +1 56 53.0	
United States .	Standard time based on the meridian of Greenwich is universally used and is sent out daily by telegraph to most of the country and to Habana and Panama from the Naval Observatory at Washington; and to the Pacific coast, from the observatory at Mare Island Navy-Yard, California. Standard times used are as follows:			
	Porto Rico, Atlantic standard time, meridian of longitude 60° west from Greenwich.	+ 1 0 0	— 4 0 0	
	Atlantic coast and Panama Canal Zone, eastern standard time, meridian of longitude 75° west from Greenwich.	0 0 0	— 5 0 0	
	Mississippi Valley, central standard time, meridian of longitude 90° west from Greenwich.	— 1 0 0	— 6 0 0	
	Rocky Mountain Region, mountain standard time, meridian of longitude 105° west from Greenwich.	— 2 0 0	— 7 0 0	
	Pacific coast, Pacific standard time, meridian of longitude 120° west from Greenwich.	— 3 0 0	— 8 0 0	
	Sitka, Alaska standard time, meridian of longitude 135° west from Greenwich.	— 4 0 0	— 9 0 0	
	Hawaiian Islands, Hawaiian standard time, meridian of longitude 157°.5 west from Greenwich.	— 5 30 0	—10 30 0	
	Tutuila, Samoa, Samoan standard time, meridian of longitude 172°.5 west from Greenwich.	— 6 30 0	—11 30 0	
	Guam, Guam standard time, meridian of longitude 142°.5 east from Greenwich.	+14 30 0	+ 9 30 0	
	Philippine Islands, Philippine standard time, meridian of longitude 120° east from Greenwich.	+13 0 0	+ 8 0 0	
Uruguay	The time in common use for railways, telegraph companies, and the public in general, is mean time of the meridian of the dome of the Metropolitan Church of Montevideo. The correct time is indicated by a striking clock in the tower of that church. An astronomical geodetic observatory, with meridian telescope and chronometers, has now been established and will in the future furnish the time It is proposed to install a time-ball for the benefit of navigators at the port of Montevideo. An electric time service will be extended throughout the country, using at first the meridian of the church and afterwards that of the national observatory, when constructed.	+1 15 11.1	— 3 44 48.9	C. T.
Venezuela	The time is computed daily at the Caracas Observatory, longitude 66° 55′ 53.6″ west from Greenwich, from observations of the sun and is occasionally telegraphed to other parts of Venezuela. The cathedral clock at Caracas is corrected by means of these observations. Railway time is at least 5 minutes later than that indicated by the cathedral clock, which is accepted as standard by the entire people. Some people take time from the observatory flag, which always falls at noon.	+0 32 16.4	— 4 27 43.6	C. T.

List of the Dividing Points, North American Standard Time Sections, with the Time in Use at Each, as Adopted by the American Railway Association.

BETWEEN ATLANTIC OR INTERCOLONIAL AND EASTERN SECTIONS.

CAMPBELLTON, N. B.

Atlantic time.—Intercolonial Railway (east of Campbellton).
Eastern time.—Intercolonial Railway (west of Campbellton).

VANCEBORO, ME.

Atlantic time.—Canadian Pacific Railway (east of Vanceboro).
Eastern time.—Canadian Pacific Railway (west of Vanceboro).
Maine Central Railway.

BETWEEN EASTERN AND CENTRAL SECTIONS.

ASHEVILLE, N. C.

(Eastern time is used locally.)

Eastern time.—Southern (except Asheville and Morristown Line).
Central time.—Southern (Asheville and Morristown Line).

ATHENS, GA.

(The city uses Central time.)

Eastern time.—Southern.
Seaboard Air Line.
Central time.—Georgia.
Central of Georgia.

ATLANTA, GA.

(The city uses Central time.)

Eastern time.—Seaboard Air Line.
Southern, main line (east of Atlanta).
Central time.—Atlanta and West Point.
Central of Georgia.
Georgia.
Southern (west and south of Atlanta).
Western and Atlantic.

AUGUSTA, GA.

(The city uses Eastern time.)

Eastern time.—Atlantic Coast Line.
Charleston and Western Carolina.
Southern.
Central time.—Central of Georgia.
Georgia.

BENWOOD, W. VA.

(Eastern time is used locally.)

Eastern time.—Baltimore and Ohio (east of Benwood).
Central time.—Baltimore and Ohio (west of Benwood).

BRISTOL, TENN.

(Eastern time is used locally.)

Eastern time.—Norfolk and Western.
Virginia and Southwestern.
Central time.—Southern.

BUFFALO, N. Y.

(The city uses Eastern time.)

Eastern time.—Buffalo, Rochester and Pittsburg.
Delaware, Lackawanna and Western.
Erie.
Grand Trunk.
Lehigh Valley.
New York Central and Hudson River.
Pennsylvania.
Wabash.
West Shore.
Central time.—Lake Shore and Michigan Southern.
Michigan Central.
New York, Chicago and St. Louis.

CARTIER, ONT.

(Central time is used locally.)

Eastern time.—Canadian Pacific (east of Cartier).
Central time.—Canadian Pacific (west of Cartier).

CENTRAL JUNCTION, GA.

Eastern time.—Atlantic Coast Line (north of Junction).
Central time.—Atlantic Coast Line (south of Junction).

CLIFTON FORGE, VA.

(See also West Clifton Forge.)

(Eastern time is used locally.)

Eastern time.—Chesapeake and Ohio (east of Clifton Forge).
Central time.—Chesapeake and Ohio (west of Clifton Forge).

COLUMBIA, S. C.

(Eastern time is used locally.)

Eastern time.—Atlantic Coast Line.
Columbia, Newberry and Laurens.
Seaboard Air Line (north of Columbia).
Southern.
Central time.—Seaboard Air Line (south of Columbia).

CORRY, PA.

(Eastern time is used locally.)

Eastern time.—Pennsylvania.
Central time.—Erie.

List of the Dividing Points, North American Standard Time Sections, etc.—Continued.

BETWEEN EASTERN AND CENTRAL SECTIONS—Continued.

DETROIT, MICH.

(See Windsor.)

(Central time is legal time for the State of Michigan, but local time, twenty-eight minutes faster than Central time, is also used in the city of Detroit.)

Eastern time.—Canadian Pacific.
Grand Trunk (in Canada).
Central time.—Grand Trunk (in Michigan).
Lake Shore and Michigan Southern.
Michigan Central.
Pere Marquette.
Wabash.

DUNKIRK, N. Y.

(The city uses Eastern time.)

Eastern time.—Erie.
Pennsylvania.
Central time.—Dunkirk, Allegheny Valley and Pittsburg.
Lake Shore and Michigan Southern.
New York, Chicago and St. Louis.

ERIE, PA.

(The city uses Eastern time.)

Eastern time.—Pennsylvania (P. and E. Div.).
Bessemer and Lake Erie.
Central time.—Pennsylvania Company.
Lake Shore and Michigan Southern.
New York, Chicago and St. Louis.

FRANKLIN, PA.

(Eastern time is used locally.)

Eastern time.—Pennsylvania.
Central time.—Erie.
Lake Shore and Michigan Southern.

GAINESVILLE, GA.

(The city uses local mean time.)

Eastern time.—Southern.
Central time.—Georgia.

JAMESTOWN, N. Y.

(Eastern time is used locally.)

Eastern time.—Erie (B. and S. W. Div.).
Jamestown and Chautauqua.
Central time.—Erie (main line).

KENOVA, W. VA.

(Central time is used locally.)

Eastern time.—Baltimore and Ohio.
Central time.—Chesapeake and Ohio.
Norfolk and Western.

NEW CASTLE JUNCTION, PA.

Eastern time.—Baltimore and Ohio (east of New Castle Junction).
Central time.—Baltimore and Ohio (west of New Castle Junction).

NORTON, VA.

Eastern time.—Norfolk and Western.
Central time.—Louisville and Nashville.

OIL CITY, PA.

(Eastern time is used locally.)

Eastern time.—Pennsylvania.
Central time.—Erie.
Lake Shore and Michigan Southern.

PARKERSBURG, W. VA.

(The city uses Eastern time.)

Eastern time.—Baltimore and Ohio.
Central time.—Baltimore and Ohio Southwestern.

PITTSBURG, PA.

(The city uses Eastern time.)

Eastern time.—Baltimore and Ohio.
Buffalo, Rochester and Pittsburg.
Pennsylvania.
Pittsburg and Castle Shannon.
Pittsburg and Western.
Central time.—Pennsylvania Company.
Pittsburg, Chartiers and Youghiogheny.
Pittsburg and Lake Erie.
Pittsburg, Cincinnati, Chicago and St. Louis.

PORT HURON, MICH.

(The city uses Central time.)

Eastern time.—Grand Trunk (in Canada).
Central time.—Grand Trunk (in Michigan).
Pere Marquette.

ST. THOMAS, ONT.

(The city uses Eastern time.)

Eastern time.—Canadian Pacific.
Grand Trunk.
Central time.—Michigan Central.

SALAMANCA, N. Y.

(Eastern time is used locally.)

Eastern time.—Buffalo, Rochester and Pittsburg.
Erie (east of Salamanca).
Pennsylvania.
Central time.—Erie (west of Salamanca).

SARNIA, ONT.

(See Port Huron.)

(The city uses Eastern time.)

SAULT STE. MARIE, MICH.

(Central time is used locally.)

Central time.—Duluth, South Shore and Atlantic.
Minneapolis, St. Paul and Sault Ste. Marie.

List of the Dividing Points, North Amcrican Standard Time Sections, etc.—Continued.

BETWEEN EASTERN AND CENTRAL SECTIONS—Continued.

SAULT STE. MARIE, ONT.

(Eastern time is used locally.)

Eastern time.—Algoma Central and Hudson Bay Canadian Pacific.

TITUSVILLE, PA.

(Eastern time is used locally.)

Eastern time.—Pennsylvania.
Central time.—Dunkirk, Allegheny Valley and Pittsburg.

UNION CITY, PA.

(Eastern time is used locally.)

Eastern time.—Pennsylvania.
Central time.—Erie.

WASHINGTON (WASHINGTON COUNTY), PA.

(The city uses Eastern time.)

Eastern time.—Baltimore and Ohio.
Central time.—Pennsylvania Company.
Pittsburg, Cincinnati, Chicago and St. Louis.
Waynesburg and Washington.

WELLAND, ONT.

Eastern time.—Grand Trunk.
Wabash.
Central time.—Michigan Central.
Toronto, Hamilton and Buffalo.

WEST CLIFTON FORGE, VA.

(See also Clifton Forge.)

(Eastern time is used locally.)

Eastern time.—Chesapeake and Ohio (east of West Clifton Forge).
Central time.—Chesapeake and Ohio (west of West Clifton Forge).

WESTFIELD, N. Y.

Eastern time.—Jamestown, Chautauqua and Lake Erie.
Central time.—Lake Shore and Michigan Southern.

WHEELING, W. VA.

(The city uses Eastern time.)

Eastern time.—Baltimore and Ohio.
Central time.—Cleveland, Lorain and Wheeling.
Pittsburg, Cincinnati, Chicago and St. Louis.
Wheeling and Lake Erie.

WILLIAMSON, W. VA.

(Central time is used locally.)

Eastern time.—Norfolk and Western (east of Williamson).
Central time.—Norfolk and Western (west of Williamson).

WINDSOR, ONT.

(See Detroit.)

Eastern time.—Canadian Pacific.
Grand Trunk (in Canada).
Central time.—Michigan Central.

BETWEEN CENTRAL AND MOUNTAIN SECTIONS.

ALLIANCE, NEB.

(Mountain time is used locally.)

Central time.—Chicago, Burlington and Quincy.
Lines west of the Missouri River (east of Alliance).
Mountain time.—Chicago, Burlington and Quincy.
Lines west of the Missouri River (west of Alliance).

BROADVIEW, ASSINIBOIA.

(Central time is used locally.)

Central time.—Canadian Pacific (east of Broadview).
Mountain time.—Canadian Pacific (west of Broadview).

DODGE CITY, KAN.

(The city uses Central time.)

Central time.—Atchison, Topeka and Santa Fé (east of Dodge City).
Chicago, Rock Island and Pacific.
Mountain time.—Atchison, Topeka and Santa Fé (west of Dodge City).

ELLIS, KAN.

(Central time is used locally.)

Central time.—Union Pacific, Kansas Division (east of Ellis).
Mountain time.—Union Pacific, Colorado Division (west of Ellis).

EL PASO, TEX.

(Mountain time is used locally.)

Central time.—Galveston, Harrisburg and San Antonio, Texas and Pacific.
Mountain time.—Atchison, Topeka and Santa Fé.
El Paso and Northeastern.
City of Mexico time.—Mexican Central.

HOLYOKE, COLO.

(Central time is used locally.)

Central time.—Chicago, Burlington and Quincy.
Lines west of the Missouri River (east of Holyoke).
Mountain time.—Chicago, Burlington and Quincy.
Lines west of the Missouri River (west of Holyoke).

List of the Dividing Points, North American Standard Time Sections, etc.—Continued.

BETWEEN CENTRAL AND MOUNTAIN SECTIONS—Continued.

HOISINGTON, KAN.

(Central time is used locally.)

Central time.—Missouri Pacific (east of Hoisington).
Mountain time.—Missouri Pacific (west of Hoisington).

LONG PINE, NEB

(Central time is used locally).

Central time.—Fremont, Elkhorn and Missouri Valley (east of Long Pine).
Mountain time.—Fremont, Elkhorn and Missouri Valley (west of Long Pine).

MANDAN, N. DAK.

(Mountain time is used locally).

Central time.—Northern Pacific (east of Mandan).
Mountain time.—Northern Pacific (west of Mandan).

McCOOK, NEB.

(Mountain time is used locally).

Central time.—Chicago, Burlington and Quincy. Lines west of the Missouri River (east of McCook).
Mountain time.—Chicago, Burlington and Quincy. Lines west of the Missouri River (west of McCook).

MINOT, N. DAK.

(Central time is used locally).

Central time.—Great Northern (east of Minot). Minnesota, St. Paul and Sault Ste. Marie.
Mountain time.—Great Northern (west of Minot).

NORTH PLATTE, NEB.

(Central time is used locally.)

Central time.—Union Pacific (east of North Platte).
Mountain time.—Union Pacific (west of North Platte).

PORTAL, N. DAK.

(Central time is used locally.)

Central time.—Minneapolis, St. Paul and Sault Ste. Marie.
Mountain time.—Canadian Pacific.

PHILLIPSBURG, KAN.

(Central time is used locally).

Central time.—Chicago, Rock Island and Pacific (east of Phillipsburg).
Mountain time.—Chicago, Rock Island and Pacific (west of Phillipsburg).

PLAINVILLE, KAN.

Central time.—Union Pacific, Oakley Branch (east of Plainville).
Mountain time.—Union Pacific, Oakley Branch (west of Plainville).

RIO GRANDE, TEX.

Central time.—Galveston, Harrisburg and San Antonio.
Pacific time.—Southern Pacific.

SANTA ROSA, N. MEX.

(Central time is used locally.)

Central time.—Chicago, Rock Island and El Paso.
Mountain time.—El Paso and Rock Island Railway.

TEXLINE, TEX.

(Mountain time is used locally.)

Central time.—Fort Worth and Denver City.
Mountain time.—Colorado and Southern.

BETWEEN MOUNTAIN AND PACIFIC SECTIONS.

DEMING, N. MEX.

(Mountain time is used locally.)

Mountain time.—Atchison, Topeka and Santa Fé.
Pacific time.—Southern Pacific.

HUNTINGTON, ORE.

(Pacific time is used locally.)

Mountain time.—Oregon Short Line.
Pacific time.—Oregon Railroad and Navigation Company.

LAGGAN, BRITISH COLUMBIA.

(Pacific time is used locally.)

Mountain time.—Canadian Pacific (east of Laggan).
Pacific time.—Canadian Pacific (west of Laggan).

RIO GRANDE, TEX.

Central time.—Galveston, Harrisburg and San Antonio.
Pacific time.—Southern Pacific.

SELIGMAN, ARIZ.

(Mountain time is used locally.)

Mountain time.—Santa Fé Route (east of Seligman).
Pacific time.—Santa Fé Route (west of Seligman).

SPARKS, NEV.

(Mountain time is used locally.)

Mountain time.—Southern Pacific (east of Sparks).
Pacific time.—Southern Pacific (west of Sparks).

TROUT CREEK, MONT.

(Mountain time is used locally.)

Mountain time.—Northern Pacific (east of Trout Creek).
Pacific time.—Northern Pacific (west of Trout Creek).

TROY, MONT.

(Mountain time is used locally.)

Mountain time.—Great Northern (east of Troy).
Pacific time.—Great Northern (west of Troy).

NOTICE OF A SPECIAL SERIES OF MIDNIGHT TELEGRAPHIC TIME SIGNALS, MAY 3, 1905, IN HONOR OF THE INTERNATIONAL RAILWAY CONGRESS.

As this Appendix is going to press, the following notice has been issued of a special series of midnight telegraphic time signals in honor of the International Railway Congress, which is about to meet in Washington:

NAVY DEPARTMENT, BUREAU OF EQUIPMENT,
U. S. NAVAL OBSERVATORY,
Washington, D. C., March 31, 1905.

NOTICE OF A SPECIAL SERIES OF MIDNIGHT TELEGRAPHIC TIME SIGNALS TO BE SENT OUT BY THE U. S. NAVAL OBSERVATORY ON MAY 3, 1905.

It is proposed to send out a special series of telegraphic time signals beginning at 11.55 p. m., United States Eastern Standard Time (mean time of the 75th meridian west from Greenwich), May 3, 1905, and ending at midnight, according to the plan followed daily at noon, as shown by the accompanying text and diagram. [*See text and diagram, page G10.*]

These special time signals will be sent out by request of the American Railway Association, with the cordial approval of the Secretary of the Navy, in honor of the International Railway Congress, which is to meet in the Capital of the United States on the following day.

It is hoped to obtain such complete voluntary cooperation on the part of all telegraph, cable, and telephone companies as to secure for the signals quick, accurate, world-wide distribution, as far as electricity can carry them, and possibly to make the circuit of the globe.

It is hoped also that the principal observatories of the world will make efforts to receive and time these signals accurately, and reports of such observations may be made at once, without expense, through the courtesy of the various telegraph and cable companies. This has been done already in the case of the international New Year's Eve time signals from this Observatory, which are reported to have reached the Toronto Observatory in $0^s.00$; Lick Observatory, $0^s.05$; City of Mexico, $0^s.11$; Manilla, $0^s.37$; Greenwich, $1^s.33$; Sydney, Australia, $2^s.25$; Wellington, New Zealand, $4^s.00$, and Cordoba, Argentina, $7^s.70$.

From the rapidity and accuracy with which these time signals are transmitted over connecting land lines, as a result of long experience in transmitting the daily noon signals, it seems very probable, if the telegraph companies will take especial care in their transmission and not interpose any secondary clocks or human relays, that they may serve to give fairly accurate determinations of longitude at any telegraph station on this continent where they can be noted exactly and compared with accurate local time. For this purpose also, as a check on such observations, it is very desirable for their exact time of receipt to be noted and reported at all observatories in North America whose longitudes are already accurately known.

It is understood that the members of the International Railway Congress regard this feature of their meeting with great interest, both by reason of the close affiliations between railroads and telegraphs and because of the practical importance of accurate standard time, and this Observatory is anxious to secure the widest possible cooperation in making the experiment successful.

It is respectfully requested that all who are interested and willing to cooperate in this plan will take up the matter with the telegraph or cable companies and arrange the necessary details, in order that they may be able to receive the signals and report the results.

C. M. CHESTER,
Rear-Admiral, U. S. N., Superintendent Naval Observatory.

It is proposed to publish, as soon as practicable, the results of the plan outlined in the above notice, and to send a copy of such publication to all those who may have cooperated in carrying it out.

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