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Determination of The Constant of Refraction from Observations made with The Repsold Meridian Circle of The Lick Observatory

DISSERTATION IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE UNIVERSITY OF CALIFORNIA PRESENTED IN 1901 BY

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DETERMINATION OF THE CONSTANT OF REFRACTION FROM OBSERVATIONS MADE WITH THE REPSOLD MERIDIAN CIRCLE OF THE LICK OBSERVATORY.

BY RUSSELL TRACY CRAWFORD.

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INTRODUCTION.

1. The Meridian Circle.—The instrument with which these observations for refraction were made has been fully described by Astronomer Tucker in Volume IV of the "Publications of the Lick Observatory, 1900." For the sake of completeness, however, it will be described again in this paper.

The instrument was made by Messrs. Repsold and Sons, and was described by Professors Auwers and Krueger to be "in its construction in every way suited to be the chief instrument in an observatory of the first class." (cf. Vol. I, "Publications of the Lick Observatory.")

The aperture of the object glass, which was made by Clark and Sons, is 6.4 inches. Its focal length is 6 feet

4 inches. The tube of the telescope is in two parts, each of which is attached to a central cube. Their diameters decrease from 8.1 inches at the cube to 6.5 inches near their outer ends. An eyepiece giving a power of 90 and a field of 12′ was used for these observations. The star images formed are not exactly round, but are slightly elongated in a direction parallel to the horizontal (declination) thread. There being no component of this elongation parallel to the vertical threads, it can have no effect upon observations for zenith distance.

The axis is 3 feet 2½ inches long, the distance between the counterpoises being 2 feet 2 inches. The pivots are 3.6 inches in diameter and are protected by brass covers. The telescope is furnished with clamps which, however, were never used during these observations. After the telescope was once set for a star it was not moved again to make the bisection, this being done by means of the declination micrometer. The value of one revolution of the screw of this micrometer is 48″.10. This value has been adopted as the result of many determinations made in past years. The micrometer thread is single.

The instrument has two circles, one of which can be rotated about the axis of the instrument while the other is rigidly fixed to it. They are both graduated to 2′. The degrees, as numbered, increase counter-clockwise. The diameter of the silver circle, upon which the graduations are marked, is 26 inches. There are 130 graduations to the inch. The fixed circle was used throughout these observations.

The four reading microscopes on each side are alike in all respects. They are 26.5 inches long and have clear apertures of 0.55 of an inch. Their powers are 40 and their fields are nearly one degree. The objectives are 5 inches from the circle and their eye ends project 8 inches from the frame holding them. The micrometer heads are divided into 60 parts. One revolution of a micrometer head carries the threads over one minute of arc of the circle. There are two pairs of threads in every micrometer, but one of which is generally used.

There is a separate broken telescope for setting. This is supported on wyes attached to either pier and is at the level of the lower rim of the circle. By means of this the circle can be seen either from the north or from the south, so that the settings can be made very conveniently.

The illumination for both the field of view and for the circles under the microscopes is furnished by a Rochester lamp placed in a cylindrical case 9 feet from the axis of the instrument. This light also illuminates the heads of the microscope micrometers. Most of the heat from this lamp is carried out of the room by a pipe which extends from directly over the lamp through the roof to the outside air.

A simple mechanism enables the observer to change the system of illumination from a bright field with dark wires to a dark field with bright wires and *vice versa;* he can also reduce the amount of illumination at will.

The brick piers supporting the instrument are 34 inches by 44 inches at the floor of the room and 22 inches square at the top. The sides next to the telescope are vertical. They are cased in wood with a layer of felt between the surfaces. The platforms for the microscope reader are entirely disconnected from the casing of the piers.

The microscope bearers are 23 inches in diameter and 17 inches long. The wyes for the pivots of the instrument are attached to the inner faces of these frames.

The weights of the counterpoises hang from levers 26 inches long. The fulcra are in the centers of the levers and are 6 inches from the inner faces of the microscope bearers.

Two collimators, of same aperture and focal length as the Meridian Circle, are suitably mounted. The collimator micrometers are 35 feet 6 inches apart.

2. *The Room.*—The Meridian Circle house on Mount Hamilton has been most admirably designed. Its efficiency will become apparent from the meteorological data to be given later.

The observing room is 43 feet long (north and south) and 38 feet wide. All of the walls are double. The outer of the two is a louvre-work of galvanized iron which prevents the sunlight from touching any part of the building proper. The inner wall is of California redwood, and is separated from the outer by a two foot air space. The ceiling is also of redwood. It is about 16 feet above the floor. Above the ceiling is an air space 8 feet high at the observing slit and sloping to meet the east and the west walls.

The observing slit is slightly over three feet in width. The covering for the slit is in four parts which open outward. The ends are closed by shutters, each of which is in two parts opening inwards. Each end is also provided with a single shutter which slides up and down. For stars at zenith distances greater than 72 degrees these shutters have to be lifted. When down they are very efficient wind breaks.

There is a large canopy which can be rolled over the instrument to serve as an additional protection in stormy weather or when the instrument is not in use.

For a more detailed account of the instrument and room see Astronomer Tucker's account of them in Volume IV of the "Publications of the Lick Observatory, 1900."

3. Meteorology.—To make quite sure of the condition of the atmosphere at any time during the observations, the thermometers were read, on the average, three times an hour (at nearly equal intervals); and the barometer was observed every hour. The reading of the wet bulb thermometer was also taken when the dry was read. The relative humidity has not been introduced into the reductions, but it was thought desirable to have it for possible future reductions.

The barometer, Green 2839, hangs on the north wall of the observing room. It reads to one two-hundredth of an inch. The dry and the wet bulb thermometers (F) hang in the air space between the north walls. The dry bulb thermometer, used to indicate the external temperatures, is Green 494. This thermometer has been calibrated at the

Yale Observatory. The corrections which have been applied to all the readings have been taken from the following table sent from Yale Observatory:—

t (F)	*Cor.*
0°	+0°.1
32	—0 .2
52	—0 .1
72	—0 .2
112	—0 .1

The table which follows contains the *uncorrected* temperatures *(t)*, the readings of the attached thermometer *(T)*, of the barometer *(B)*, and the times at which they were taken. The readings of the wet bulb thermometer are not given here.

TABLE OF BAROMETER AND THERMOMETER READINGS.

Sid.	June 7			June 8			June 9			June 12			June 13		
T	*t*	*T*	*B*	*t*	*T*	*B*	*t*	*T*	*B*	*t*	*T*	*B*	*t*	*T*	*B*
h															
14.7	60.2°	60°	5169	66.0°	65½°	5175	69.0°	68°	5178	55.1°	57°	5147	61.8°	62°	5165
15.0	62.9			66.0			69.8			56.0			62.5		
.3	62.8			66.6			69.2			57.0			63.0		
.6	63.8			66.7			69.4			58.8			62.9		
.9	.0 63.8	62	5170	.0 66.5	66	5174	69.7	69	5178	58.2	58	5148	63.2	62½	5164
16.3				.4 66.2			.4 68.8			.4 58.3			.4 63.0		
.6	.7 63.9			.7 66.0			.7 68.7			.7 58.2			62.9		
17.0	63.8	62½	5169	66.0	66	5172	67.2	68½	5177	58.6	58½	5148	62.5	62½	5165
.4	63.8			.5 66.1			68.0			57.8			62.8		
.7	.8 64.0			.8 66.0			67.5			.8 57.5	58	5145	62.8		
18.1	63.3	63	5167	65.9	66	5170	67.5	68	5176				62.8	62½	5163
.4	61.0			.5 65.8			67.5						62.8		
.7							68.0						62.6		
19.0	61.0	62	5166	65.5	65½	5169	67.9	68	5174				62.0	62½	5163

Sid.	June 14			June 19			June 21			June 22			June 27		
T	*t*	*T*	*B*	*t*	*T*	*B*	*t*	*T*	*B*	*t*	*T*	*B*	*t*	*T*	*B*
h															
14.7	70.1°	69½°	5194	.8 57.7°	59°	5185	64.9°	65½°	5178	.8 68.2°	68½°	5170	66.0°	67½°	5187
15.0	70.6			57.8			65.8			68.4			66.7		
.3	70.8			56.4			65.3			68.0			66.7		
.6	70.4			.7 56.3			66.4			67.5			66.9		
.9	70.9	70	5194	56.3	57½	5182	65.8	65½	5178	67.0	68	5167	66.8	67½	5187
16.3	.4 70.9			55.9			66.2			67.2			66.8		
.6	70.9			55.5			66.0			67.2			66.8		
17.0	70.9	70	5194	55.4	56½	5179	66.2	65½	5178	66.0	68	5166	66.1	67	5187
.4	70.6			55.8			66.0			65.9			65.0		
.7	69.5			56.2			66.1			66.1			65.0		
18.1	69.2	70	5193	56.0	56½	5177	66.2	66	5176	66.1	67	5163	65.6	66	5185
.4	68.9			56.2			66.2			66.4			65.8		
.7	69.5			57.0			66.1			66.6			65.8		
19.0	68.8	69	5193	56.4	56½	5175	66.2	66½	5173	66.3	66½	5161	65.8	66½	5184

TABLE OF BAROMETER AND THERMOMETER READINGS.—(*Con.*)

Sid.	June 28			June 29			June 30			July 3			July 4		
T	*t*	*T*	*B*	*t*	*T*	*B*	*t*	*T*	*B*	*t*	*T*	*B*	*t*	*T*	*B*
h	°	°		°	°		°	°		°	°		°	°	
14.7	68.2	70	5188	69.0	69	5191	66.5	70½	5178	74.0	76½	5164	71.2	71½	5167
15.0	68.0			69.0			67.2			73.7			70.0		
.3	67.0			68.2			66.8			73.7			67.9		
.6	67.2			68.8			66.8			72.8			69.0		
.9	67.2	67½	5189	69.3	68½	5193	65.8	68	5176	72.0	74	5165	69.0	70	5167
16.3	66.2			69.6			66.3			71.2			68.9		
.6	66.8			69.3			66.3			70.6			68.8		
17.0	67.6	67	5186	70.5	68½	5191	66.2	67½	5174	72.3	72½	5161	67.7	69	5167
.4	68.4			70.8			66.3			72.2			67.8		
.7	68.4			70.0			66.5			71.8			67.3		
18.1	68.2	67½	5187	69.4	69	5190	66.4	67	5172	71.6	72½	5160	67.0	67½	5165
.4	67.3			69.2			66.4			72.0			67.8		
.7	67.2			69.1			66.8			72.0			68.1		
19.0	67.6	67	5187	68.7	69	5188	66.6	67	5169	71.3	72½	5158	68.4	68	5163

Sid.	July 5			July 6		
T	*t*	*T*	*B*	*t*	*T*	*B*
h	°	°		°	°	
14.7	62.8	66	5166	58.0	62	5170
15.0	61.8			58.4		
.3	62.2			57.6		
.6	61.8			57.1		
.9	61.0	68	5167	57.2	59½	5170
16.3	61.0			57.8		
.6	61.0			57.8		
17.0	61.0	62	5166	58.2	59	5168
.4	61.0			58.2		
.7	60.9			58.2		
18.1	60.5	61½	5165	58.3	59	5168
.4	60.5			58.3		
.7	60.7			58.2		
19.0	60.4	61	5163	58.0	58½	5167

NOTE.—On the nights of June 7, 8, 9, 12, 13, 14, 19 and 22 some of the observations were made at times a little different from those given in the column *Sid. T.* The actual times of such observations are indicated just before the column *t.* Thus, on June 7 before the column *t* occur the numbers .0, .7, and .8, which indicate that the times of the corresponding observations were 16.0 instead of 15.9, as given in the column *Sid. T.*, 16.7 instead of 16.6, 17.8 instead of 17.7, etc.

In this table the unit of B is one two-hundredth of an inch.

From this table the following data have been taken:

Maximum temperature	=	74°.0, July 3
Minimum temperature	=	55°.1, June 12
Maximum range	=	18°.9
Maximum barometer	=	5194, June 14
Minimum barometer	=	5145, June 12
Maximum range	=	49.

During this period of observing, the maximum difference between the dry and the wet bulb thermometers was 75°.5 — 48°.0 = 22°.5. This was on June 29. The minimum was 65°.0 — 56°.0 = 9°.0, which occurred June 27.

Concerning the maximum temperature noted above, 74°.0, it should be remarked that this was the first reading of the period, and was taken several minutes before the sun had set.

Besides the regular thermometers in the air space between the north walls, three other thermometers were suspended from the ceiling of the observing room. All three were swung under the observing slit, near the plane of the meridian. One was directly over the instrument, and three or four feet from the ceiling. The other two were hung, one north and one south, about half way between the instrument and the north and south walls respectively, and at such a distance above the floor that the plane of the axis of the instrument and the line of sight of the telescope, pointed at about 83° zenith distance (north and south respectively), would intersect the thermometers near their bulbs.

Before being thus placed, these thermometers were compared with Green 494, so that their readings could be reduced for comparison with those of the external thermometer (Green 494).

During the course of an evening's observations these three thermometers were read just after reading the regular thermometer. The average difference between the inside and the outside thermometers was found to be the same for all three, and is 0°.3 (F). It is nearly always the case (in this hemisphere) that the southern part of a room is a trifle warmer than the northern. But this is not the case on Mount Hamilton. The temperature of the air inside is, on the average, very uniform and but very little (0°.3) warmer than the air outside. In his "Untersuchung über die Astronomische Refraction u. s. w.," Dr. Bauschinger notes that the southern part of his observing room in Munich was warmer than the northern, and that at night the average difference between the inside and the outside temperatures is 1°.3 (C). From his investigation, he concludes that the temperature of the air *within* the observing room should be taken into account.

Because of these difficulties, many observers have seriously considered the idea of mounting their instruments under a movable house, so that when at work the instrument will be entirely out of doors, and thus completely obviate this difficulty. But this would needlessly endanger the instrument. To accomplish the same purpose, the Meridian Circle house being built at Kiel is to be constructed in the shape of a cylinder whose axis coïncides with the axis of the instrument. This is undoubtedly the best form of construction.

For the efficiency of the Meridian Circle house on Mount Hamilton, the difference between the inside and the outside thermometers can speak. As has been said, the average difference (in the sense Inside–Outside) is + 0°.3 (F). The *maximum* difference noted was one evening, a few minutes before the sun had set, when the difference was + 1°.1 (F). *The maximum difference noted here is less than half the average at Munich.* After this Meridian Circle house has been completely opened for an hour and a half, the temperature inside is practically the same as it is outside.

During the months October to December, inclusive, a similar set of observations was secured. For these months the average difference between the inside and the outside temperatures is even less than for the summer months. But the range of the difference is much greater for the fall and the winter months. The maximum differences observed were — 2°.0 (F) and + 2°.1 (F). There was one still larger difference, viz. — 3°.7 (F), which can hardly be counted in the series, for it occurred on a poor night, immediately after observing had been suspended because of clouds and poor "seeing." The hot wave, which caused the outside temperature to rise suddenly, undoubtedly destroyed the "seeing." Although the winter months present conditions not so favorable as those of the summer months, nevertheless they also speak well for the efficiency of the Lick Observatory Meridian Circle house.

4. Plan for Observing.—The method of determining the refractions here may be stated as being a quasi converse to Talcott's method of determining the latitude. Instead of eliminating the refractions to get the latitude, the method is to determine the refractions by eliminating the latitude, as follows:

Let

z_s = the zenith distance of a southern star,
z_n = the zenith distance of a northern star,
z'_s = the apparent zenith distance of the southern star,
z'_n = the apparent zenith distance of the northern star,
δ_s = the declination of the southern star,
δ_n = the declination of the northern star,
r_s = the refraction of the southern star,
r_n = the refraction of the northern star,
φ = the latitude of the Meridian Circle.

Then

$$\delta_n = \varphi + z_n = \varphi + (z'_n + r_n) \quad (1)$$
$$\delta_s = \varphi - z_s = \varphi - (z'_s + r_s) \quad (2)$$
$$\delta_n - \delta_s = z'_s + z'_n + r_s + r_n \quad (3)$$

Let

$$A = \delta_n - \delta_s \quad (4)$$
$$B = z'_s + z'_n \quad (5)$$

Then

$$A = B + r_s + r_n \quad (6)$$

or

$$r_s + r_n = A - B \quad (7)$$

If now, the southern and northern zenith distances were the same, and if, at the times of observing them, the conditions of the atmosphere were the same, the two refractions would be the same, *i. e.*,

$$r_s = r_n.$$

In this case we have

$$2r = A - B \qquad (I)$$

In practice these ideal conditions are only approximately satisfied. We therefore proceed as follows:

From (7) we have

$$2r_s - r_s + r_n = A - B \qquad (8)$$

whence

$$2r_s = (A - B) + (r_s - r_n)$$

and

also

$$\left.\begin{aligned} r_s &= \tfrac{1}{2}(A - B) + \tfrac{1}{2}(r_s - r_n) \\ r_n &= \tfrac{1}{2}(A - B) + \tfrac{1}{2}(r_n - r_s) \end{aligned}\right\} \qquad (II)$$

In case the northern star is at lower culmination we shall have:

$$\delta_n = 180^\circ - z_n - \varphi \qquad (9)$$

$$\delta_s = \varphi - z_s \qquad (10)$$

$$\delta_n + \delta_s = 180^\circ - z_n - z_s \qquad (11)$$

$$= 180^\circ - [z'_n + r_n + z'_s + r_s]. \qquad (12)$$

Hence

$$r_n + r_s = 180^\circ - [z'_n + z'_s] - [\delta_n + \delta_s] \qquad (13)$$

and

$$2r_s = 180^\circ - [z'_n + z'_s] - [\delta_n + \delta_s] + [r_s - r_n]. \qquad (14)$$

Calling

$$A' = \delta_n + \delta_s \qquad (15)$$

and since

$$B = z'_s + z'_n \qquad (5)$$

we have

and

$$\left.\begin{aligned} r_s &= 90^\circ - \tfrac{1}{2}[A' + B] + \tfrac{1}{2}[r_s - r_n] \\ r_n &= 90^\circ - \tfrac{1}{2}[A' + B] + \tfrac{1}{2}[r_n - r_s] \end{aligned}\right\} \qquad (III)$$

In order to obtain the refractions from (II) and (III) it is necessary to know the declinations of the stars, their apparent zenith distances (or rather the sums of the zenith distances of the pairs of north and south stars), and the differences between the refractions of the pairs. The stars chosen for this work are all fundamental, and in a first approximation their declinations are to be considered absolute. The list of stars, given later, has been taken from Professor Newcomb's "Catalogue of Fundamental Stars for 1875 and 1900, reduced to an absolute System." The apparent zenith distances, or the sums of the zenith distances of the several pairs, are obtained from the Meridian Circle observations; and the differences in the refractions are found by computing the refractions from some standard table. In this work the Pulkowa tables have been used. The term $\frac{1}{2}(r_s - r_n)$ being of the nature of a differential refraction, any error in the constant of refraction of the table used will have practically no effect upon this difference. The more nearly ideal conditions (*i. e.*, when $r_s = r_n$) are approached, of course, the better the determination of the refractions will be.

This method has both its advantages and its disadvantages. Among the former, the most important are: first, the total elimination of the latitude and hence also of its variation; second, the elimination of the nadir, since $(z'_s + z'_n)$ is nothing more nor less than the difference between the circle readings, and is therefore independent of the zenith point; third, there is no wait of twelve hours or of six months in order to observe a star at both culminations, as is usually done; and fourth, the simplicity of the reductions.

The greatest disadvantage in this method lies in the fact that the declinations of the stars have to be considered known. But by taking fundamental stars, such as those whose places are given by Professor Newcomb's new Fundamental Catalogue, and by taking a large number of these stars, this difficulty will be nearly completely eliminated.

Having now the new refractions, the correction to the constant of the table used (Pulkowa) is found from the following equation [eq. (701) pg. 672, Vol. I, Chauvenet, "Spherical and Practical Astronomy"]:

$$dr = A d\alpha + B d\beta,$$

where

$$A = \frac{r}{\alpha}$$

and

$$B = \sin^2 z \sqrt{\frac{2}{\beta}} \left(\frac{dQ}{d\beta} - \frac{Q}{2\beta} \right).$$

For this observatory, whose altitude is 4,209 feet and where the mean annual pressure is less than 26 inches, an investigation into the effect of the higher powers of $\triangle\beta$ involved in the factor $\beta = \frac{b}{B} = 1 + \frac{b-B}{B} = 1 + \frac{\triangle b}{B}$ (in Bessel's notation for r) was necessary. In his memoir, "Untersuchungen über die Constitution der Atmosphäre und die Strahlenbrechung in Derselben," St. Petersburg, 1866, Gyldén has neglected the squares and higher powers of $\frac{\triangle b}{B}$, since for places at low altitudes $\frac{\triangle b}{B}$ is a very small quantity. This investigation was made by Professor Comstock (Vol. I, "Publications of the Lick Observatory"). From his investigation the conclusion is drawn that "the Pulkowa Refraction Tables may be used for atmospheric pressures as low as 25 inches without taking into account the squares and higher powers of $\triangle b$, and the quantities so neglected will not be sensible at zenith distances less than 80°." The minimum reading of the barometer during these observations was 25.72 inches, so that in these reductions no modification of the factor of the refraction depending upon the barometer need be made.

This question having been disposed of, the assumption is here made that all of the error in the refractions is due to an error in the constant of refraction. This amounts to assuming the constant β to be correct or that $d\beta = 0$. The equation above then reduces to the very simple expression

$$dr = A d\alpha = \frac{r}{\alpha} d\alpha ;$$

hence

$$\frac{d\alpha}{\alpha} = \frac{dr}{r},$$

or

$$d\log\alpha = d\log r.$$

Having $d\log r$ from the reductions, we thus have $d\log\alpha$, and hence $d\alpha$.

This assumption would perhaps seem somewhat risky for stars whose zenith distances are greater than 80°. But at the conclusion of the reductions, the value of $d\log\alpha$ deduced from such stars was found to fit in very well with those deduced from the other stars. Furthermore, down to 85° zenith distance the observing was very good. In consequence of these facts it was decided to take into account all the stars observed. The zenith distances of the stars in this list range from 21° 21′ to 89° 12′ (apparent).

From 85° zenith distance down, the quality of the "seeing" decreases quite rapidly. This can be seen from the following table of average weights. These weights were derived from the probable errors of the individual determinations of dlog$a$.

Z. D.	*Av. Wt.*
20° to 30°	2.0
50 to 60	7.5
60 to 70	7.5
70 to 80	11.8
80 to 85	14.8
85 to 90	3.6

The small weight for the small zenith distances is due to the fact that in the expression for da the refraction occurs in the denominator. The small weight for the stars at zenith distances greater than 85° is, of course, due to uncertainties in observing at such low altitudes.

Observations.

1. List.—The following list of 31 stars was observed on seventeen nights, from 1899 June 7 to 1899 July 6, inclusive, and have been reduced according to the plan outlined in the preceding section. Eleven other stars were on the same observing list, but they have not been used here. They were put on to obtain data for determining bisection error, and for other purposes.

The numbers of the stars are those of Newcomb's "Catalogue of Fundamental Stars for 1875 and 1900, reduced to an Absolute System."

No.	α (1900)			δ (1900)		
948	14*h*	51*m*	59*s*	−42°	43′	52″.30
190	2	57	33	+53	6	53 .92
959	15	5	6	−51	43	6 .62
968	15	13	29	+67	43	35 .08
977	15	21	9	+15	46	46 .45
984	15	28	28	−40	49	50 .61
225	3	33	28	+62	53	33 .74
997	15	39	21	+ 6	44	24 .53
1005	15	47	32	−19	52	5 .65
1009	15	51	50	+15	59	16 .46
1019	16	0	1	+58	49	56 .19
264	4	5	6	+85	17	29 .06
1032	16	12	21	−49	54	36 .79
282	4	24	6	+53	41	37 .37
1084	16	52	56	+ 9	31	49 .32
1094	17	8	30	+65	50	15 .88
1105	17	15	52	−24	53	59 .07
1110	17	20	58	−29	46	35 .61
349	5	26	21	+74	58	39 .95
356	5	29	54	+85	8	49 .60
1135	17	40	35	−40	5	17 .65
377	5	46	28	+55	41	1 .68
1156	17	58	51	−50	5	53 .20
1162	18	3	48	−45	58	18 .07
406	6	10	48	+59	2	50 .18
1179	18	19	34	−46	1	24 .50
1182	18	21	48	−25	28	37 .40
424	6	29	10	+79	40	22 .10
438	6	45	29	+77	6	17 .47
444	6	48	37	+58	33	14 .18
1225	19	0	42	−27	48	59 .80

2. *Details of Observations.*—A night's program consisted in observing the above list, together with three nadirs, one before, one during, and one after the observing of the stars. As has been pointed out, the nadirs are not necessary for the refraction determinations, but were taken for the reduction of the latitude, which is a problem practically inseparable from the main one undertaken here.

No transits were observed during these observations, the whole attention being devoted to the observations for zenith distance. The telescope was set to the nearest 2′ and not disturbed until the observation had been completed. The bisection was made (with but a very few exceptions) at the central transit wire, by means of the declination micrometer. For the sake of uniformity every star was bisected but once during its transit. Because of unavoidable circumstances a few of the stars had passed the meridian before the bisection could have been made. In these cases the readings have been reduced to the meridian.

For the position of the circle four microscopes were read. Settings were made upon two scratches under every microscope. The circle microscopes were usually read after the star had been bisected. In a few cases, because of a following star culminating very soon, the microscopes were read before the bisection. In such cases the position of the circle was quickly checked after the bisection.

The correction for runs for a night was obtained from all of the microscope readings of the night. This correction has been applied to all of the observations. Its values for the several nights of observing are given in the following table:—

Date	R	Date	R	Date	R
June 7	+0".06	June 19	+0".02	June 30	+0".06
8	+0 .08	21	+0 .03	July 3	+0 .07
9	+0 .08	22	+0 .03	4	+0 .08
12	+0 .05	27	+0 .04	5	+0 .05
13	+0 .03	28	+0 .07	6	+0 .08
14	+0 .07	29	+0 .06		

These corrections were applied to the circle readings to reduce them to the mean position of the two scratches; so that for a reading of 0" the correction is +R, for 60" it is 0, and for 120" it is —R.

In the few cases where the bisections were made a little late the reductions to the meridian were computed from the formula,

$$\delta = \delta' - \frac{\sin^2 \frac{1}{2}(\tau - m)}{\sin 1''} \sin 2\delta'$$

The horizontal flexure in this instrument is very small. In his work published in Vol. IV, "Publications of the Lick Observatory," Astronomer Tucker adopts the correction 0".1sin Z. D., which was determined from a series of observations extending over two and a half years. In this work but two observations for flexure were made, one on 1899 June 3, and the other, 1899 July 8. The mean of the two gives the correction —0″.01sin Z. D.; so that for these observations the flexure correction has been considered zero. The mean of the values of one revolution of the declination micrometer, determined at the same time, is 48″.05. The value adopted, as noted before, is 48″.10.

For the computation of the preliminary refractions (called r′ in the reductions) the Pulkowa tables have been used. The reductions for the barometer, for the attached, and for the external thermometers were taken from Vol. I, "Publications of the Lick Observatory."

The graduation errors of the 1° divisions of the fixed circle have been determined by Astronomer Tucker. His results are given in Vol. IV, "Publications of the Lick Observatory." He says there, in part: "The probable error of a reading upon four divisions of the fixed circle due to graduation may be adopted as ±0″.15. * * * There is some evidence of periodic character in the errors, and it may be assumed, in absence of further data, that the probable error due to errors of graduation is not diminished by reading upon two adjoining divisions under each microscope. * * * The largest error measured is 0″.7 for the mean of four divisions."

The errors are not sufficiently systematic to warrant interpolating for undetermined divisions, so that no correction for division error has been applied.

Three nadirs were observed every night. The changes during a night were usually very small. The following table gives the means of the three determinations on the several nights:

Date	*Nadir 134° 57′*	*t*	*Date*	*Nadir 134° 57′*	*t*
June 7	22″.87	62°	June 27	20″.95	66°
8	22 .18	66	28	21 .32	67
9	22 .14	69	29	21 .40	69
12	24 .41	57	30	21 .70	66
13	22 .70	62	July 3	21 .43	72
14	21 .61	70	4	21 .46	69
19	23 .81	57	5	22 .91	61
21	22 .36	66	6	22 .10	58
22	21 .59	67			

All of the observations were taken with the fixed circle west. Had more time been available the instrument would have been reversed.

Weights, ranging from 5, the highest, to 1 (occasionally ½), the lowest, were arbitrarily assigned to all the observations. Judgment on a weight was formed from the steadiness of the image during the observation. These weights have been applied all through the reductions.

3. Reduction of Observations.— The first thing done on the reductions was to take the means of the microscope readings and to apply the micrometer corrections, giving the circle readings (called C′ in the tables following). The means of the microscopes were checked by taking the difference of every microscope reading from the mean of the four. If the sums of these differences for the two opposite pairs of microscopes was the same, the mean was correct. The corrections for the micrometers were checked by duplicating this part of the work.

From the readings C′ the quantity B [equations (II) and (III)] is obtained. The terms A and A′ of these equations are obtained from the declinations.

The declinations have been reduced to 1899.0 by means of the data furnished in Newcomb's Catalogue. The reductions to apparent places were computed by using the Besselian Star Numbers from the American Ephemeris. The factors a′, b′, c′ and d′ were computed from the American Ephemeris data. The reductions to apparent places for the first night (June 7) were computed by means of the Independent Star Numbers also. The places for the remaining nights were checked by differences. The apparent declinations are placed in the columns δ of the tables given later.

The following table exhibits the stars' approximate zenith distances and the stars with which they are grouped in the reductions for the refractions:

Star No.	Z. D. South		Z. D. North		Grouped with Star No.
	°	′	°	′	
948	79	59.9			225 *l. c.*
190 *l. c.*			89	12.0	959
959	88	45.5			190 *l. c.*, 282 *l. c.*
968			30	22.9	997
977	21	33.2			1019
984	78	6.6			225 *l. c.*
225 *l. c.*			79	41.9	948, 984, 1135
997	30	35.5			968
1005	57	11.3			264 *l. c.*, 356 *l. c.*
1009	21	20.7			1019
1019			21	29.3	977, 1009
264 *l. c.*			57	21.0	1005
1032	87	3.1			377 *l. c.*
282 *l. c.*			88	40.0	959
1084	27	48.1			1094
1094			28	29.4	1084
1105	62	12.9			424 *l. c.*
1110	67	5.1			349 *l. c.*
349 *l. c.*			67	39.0	1110
356 *l. c.*			57	29.5	1005
1135	77	22.1			225 *l. c.*
377 *l. c.*			86	47.2	1032, 1156
1156	87	13.9			377 *l. c.*
1162	83	12.4			406 *l. c.*, 444 *l. c.*
406 *l. c.*			83	30.2	1162, 1179
1179	83	15.5			406 *l. c.*, 444 *l. c.*
1182	62	47.5			424 *l. c.*
424 *l. c.*			62	57.5	1105, 1182
438 *l. c.*			65	31.4	1225
444 *l. c.*			83	59.3	1162, 1179
1225	65	7.7			438 *l. c.*

It will be noticed from this table that some of the stars are grouped with two others and that one is grouped with three others.

The following tables show the reductions for the new refractions. The column p contains the means of the weights of the pairs of stars. The other columns have already been explained. In the grouping of the pairs on the several dates the northern star is written first and the southern star below it. The numbers of the stars given at the tops are arranged in this same order. The pairs which have their northern stars at upper culmination are placed first. It will be noticed that the headings of the columns for these pairs are slightly different from the later ones containing the lower culmination stars.

Because of very bad "seeing" or of occasional accidents, some of the stars were not observed on some nights. In such cases blanks appear after the dates. No observations have been rejected.

Stars No. $\left\{\begin{matrix}968\\997\end{matrix}\right.$

Date	δ	*A*	*C′*	*B*	r'	$\frac{1}{2}(r'_s - r'_n)$	$\frac{1}{2}(A-B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 67 43 47.61		284 34 29.57		0 28.61			0 28.96	4
	+ 6 44 26.73	60 59 20.88	345 32 52.32	60 58 22.75	0 28.80	+ 0.10	0 29.06	0 29.16	4
8	47.88		28.48		28.43			29.21	4
	26.87	21.01	50.84	22.36	28.65	+ 0.11	29.32	29.43	4
9	48.12		27.26		28.28			28.60	3
	26.98	21.14	50.97	23.71	28.51	+ 0.11	28.71	28.82	3
12	48.80		30.50		28.83			29 37	1
	27.29	21.51	53.14	22.64	28.96	+ 0.06	29.43	29.49	1
13	49.04		28.03		28.58			28.99	1½
	27.41	21.63	51.46	23.43	28.81	+ 0.11	29.10	29.21	1½
14	49.31		26.24		28.30			28.68	3
	27.55	21.76	50.39	24.15	28.54	+ 0.12	28.80	28.92	3
19	50.67		28.00		29.02			29.43	3
	28.36	22.31	51.19	23.19	29.29	+ 0.13	29.56	29.69	3
21	51.13		25.83		28.50			29.09	3½
	28.64	22.49	49.95	24.12	28.69	+ 0.09	29.18	29.27	3½
22	51.35		24.44		28.30			28.92	5
	28.76	22.59	48.93	24.49	28.57	+ 0.13	29.05	29.18	5
27	52.22		22.44		28.48			28.61	2½
	29.23	22.99	48.00	25.56	28.70	+ 0.11	28 72	28.83	2½
28	52.41		23.76		28.45			28.88	3½
	29.34	23.07	48.82	25.06	28.70	+ 0.12	29.00	29.12	3½

STARS No. $\left\{ \begin{matrix} 968 \\ 997 \end{matrix} \right\}$ (*Con.*)

Date	δ	A	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$\frac{1}{2}(A-B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 67 43 52.62		284 34 22.98		0 28.40			0 28.83	3½
	+ 6 44 29.48	60 59 23.14	345 32 48.24	60 58 25.26	0 28.62	+ 0.11	0 28.94	0 29.05	3½
30									
July 3	53.48		21.77		27.96			28.41	3
	30.08	23.40	48.07	26.30	28.25	+ 0.14	28.55	28.69	3
4	53.66		22.04		28.26			28.45	5
	30.22	23.44	48.38	26.34	28.47	+ 0.10	28.55	28.65	5
5	53.83		24.63		28.61			29.40	3
	30.34	23.49	49.05	24.42	28.87	+ 0.13	29.53	29.66	3
6	53.96		23.27		28.88			29.41	1½
	30.44	23.52	47.69	24.42	29.17	+ 0.14	29.55	29.69	1½

Stars No. { 1019 / 977 }

Date	δ	A	C′	B	r′	½ $(r'_s - r'_n)$	½(A—B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 58 50 3.28		293 28 3.46		0 19.18			0 19.19	4
	+ 15 46 50.66	43 3 12.62	336 30 37.61	43 2 34.15	0 19.27	+ 0.04	0 19.23	0 19.27	4
8	3.57		3.07		19.09			19.39	4
	50.83	12.74	36.96	33.89	19.15	+ 0.03	19.42	19.45	4
9	3.84		2.73		18.99			19.05	3
	50.98	12.86	37.43	34.70	19.06	+ 0.03	19.08	19.11	3
12	4.64		4.79		19.31			19.52	1
	51.39	13.25	38.89	34.10	19.41	+ 0.05	19.57	19.62	1
13	4.91		3.14		19.18			19.66	1½
	51.54	13.37	37.13	33.99	19.25	+ 0.03	19.69	19.72	1½
14	5.20		1.52		19.00			19.48	3
	51.70	13.50	36.00	34.48	19.06	+ 0.03	19.51	19.54	3
19	6.79		28 1.98		19.51			19.59	3
	52.67	14.12	36.86	34.88	19.57	+ 0.03	19.62	19.65	3
21	7.35		27 59.71		19.13			19.33	3½
	53.00	14.35	35.33	35.62	19.20	+ 0.03	19.36	19 39	3½
22	7.62		58.28		19.04			19.10	3½
	53.14	14.48	34.54	36.26	19.07	+ 0.01	19.11	19.12	3½
27	8.75		56.75		19.12			19.33	5
	53.72	15.03	33.05	36.30	19.19	+ 0.03	19.36	19.39	5
28	9.00		57.16		19.12			19.23	2½
	53.87	15.13	33.76	36.60	19.18	+ 0.03	19.26	19.29	2½

STARS NO. { 1019 / 977 } (*Con.*)

Date	δ	A	C′	B	r′	½ $(r'_s - r'_n)$	½ (A—B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 58 50 9.25		293 27 56.55		0 19.05			0 19.26	3½
	54.02	43 3 15.23	336 30 33.15	43 2 36.60	0 19.15	+ 0.05	0 19.31	0 19.36	3½
30	9.53		56.74		19.12			19.32	4
	54.20	15.33	33.41	36 67	19.14	+ 0.01	19.33	19.34	4
July 3	10.33		55.76		18.85			19.13	3
	54.71	15.62	33.11	37.35	18.84	± 0.00	19.13	19.13	3
4	10.59		55.62		18.97			19.31	5
	54.85	15.74	32.66	37.04	19.06	+ 0.04	19.35	19.39	5
5	10.80		58 01		19.26			19.76	3
	54.99	15.81	34.28	36.27	19.28	+ 0.01	19.77	19.78	3
6	11.01		55.72		19.43			19.40	2
	55.09	15.92	32.80	37.08	19.47	+ 0.02	19.42	19.44	2

Stars No. { 1019 / 1009

Date	δ	A	C′	B	r′	½ $(r'_s - r'_n)$	½ (A—B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 58 50 3.28		293 28 3.46		0 19.18			0 19.02	4
	+ 15 59 20.28	42 50 43.00	336 18 8.55	42 50 5.09	0 19.04	— 0.07	0 18.95	0 18.88	4
8	3.57		3.07		19 09			19.26	4
	20.45	43.12	7.81	4.74	18.95	— 0.07	19.19	19.12	4
9	3.84		2.73		18.99			19.26	3
	20.61	43.23	7.58	4.85	18.84	— 0.07	19.19	19.12	3
12	4.64		4.79		19.31			19.30	1
	21.06	43.58	9.90	5.11	19.16	— 0.07	19.23	19.16	1
13	4.91		3.13		19.18			19.33	2
	21.22	43.69	8.30	5.16	19.04	— 0.07	19.26	19.19	2
14	5.20		1.52		19.00			19.31	3
	21.38	43.82	6.86	5.34	18.86	— 0.07	19.24	19.17	3
19	6.79		28 1.98		19.51			19.56	3
	22.41	44.38	7 38	5.40	19.37	— 0.07	19.49	19.42	3
21	7.35		27 59.71		19.13			19.19	4
	22.72	44.63	6.09	6.38	18 99	— 0.07	19.12	19.05	4
22	7.62		58.28		19.04			18.91	4
	22.93	44.69	5.29	7.01	18.90	— 0.07	18.84	18.77	4
27	8.75		56 75		19.12			19.42	5
	23.56	45.19	3.24	6.49	18.98	— 0.07	19 35	19.28	5
28	9.00		57.16		19.12			19.25	2
	23.73	45.27	4.07	6.91	18 98	— 0.07	19.18	19.11	2

STARS NO. {1019 / 1009} (*Con.*)

Date	δ	A	C′	B	r′	½ $(r'_s - r'_n)$	½ (A—B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 58 50 9.25		293 27 56.55		0 19.05			0 19.26	4
	+ 15 59 23.88	42 50 45.37	336 18 3.53	42 50 6.98	0 18.91	— 0.07	0 19.19	0 19.12	4
30	9.53		56.74		19.12			19.36	4
	24.07	45.46	3.61	6.87	18.97	— 0.07	19.29	19.22	4
July 3	10.33		55.76		18.85			18.89	3
	24.61	45.72	3.83	8.07	18.70	— 0.07	18.82	18.75	3
4	10.59		55.62		18.97			19.11	5
	24.78	45.81	3.34	7.72	18.82	— 0.07	19.04	18.97	5
5	10.80		58.01		19.26			19.40	3
	24.94	45.86	5.21	7.20	19.11	— 0.07	19.33	19.26	3
6	11.01		55.72		19.43			19.64	2
	25.07	45.94	2.51	6.79	19.28	— 0.07	19.57	19.50	2

Stars No. { 1094 / 1084

Date	δ	A	C′	B	r′	½ $(r'_s - r'_n)$	½ (A−B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 65 50 17.02		286 27 57.43		0 26.43			0 26.60	5
	+ 9 31 49.64	56 18 27.38	342 45 32.35	56 17 34.92	0 25.68	— 0.37	0 26.23	0 25.86	5
8	17.36		56.49		26.32			25.95	4
	49.83	27.53	32.86	36.37	25.58	— 0.37	25.58	25.21	4
9	17.69		56.30		26.27			26.34	3
	49.99	27.70	32.08	35.78	25.51	— 0.38	25.96	25.58	3
12	18.60		57.58		26.60			26.56	1
	50.41	28.19	33.41	35.83	25.84	— 0.38	26.18	25.80	1
13	18.91		56.18		26.47			26.53	2
	50.56	28.35	32.20	36.02	25.72	— 0.37	26.16	25.79	2
14	19.23		53.84		26.19			26.08	3
	50.73	28.50	30.92	37.08	25.44	— 0.37	25.71	25.34	3
19	21.00		54.58		26.92			26.85	3
	51.71	29.29	30.91	36.33	26.17	— 0.37	26.48	26.11	3
21	21.68		52.55		26.35			26.43	4
	52.10	29.58	30.00	37.45	25.60	— 0.37	26.06	25.69	4
22	22.03		50.95		26.29			26.13	4
	52.27	29.76	29.20	38.25	25.53	— 0.38	25.75	25.37	4
27	23.44		49.29		26.41			26.44	5
	52.93	30.51	27.70	38.41	25.63	— 0.39	26.05	25.66	5
28	23.74		49.58		26.30			26.36	2
	53.08	30.66	28.23	38.65	25.58	— 0.36	26.00	25.64	2

STARS NO. { 1094 / 1084 } (*Con.*)

Date	δ	*A*	*C'*	*B*	r'	½ $(r'_s - r'_n)$	½ $(A-B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 65 50 24.05		286 27 49 17		0 26.19			0 26.13	3
	+ 9 31 53.25	56 18 30.80	342 45 28.42	56 17 39.25	0 25.46	— 0.36	0 25.77	0 25.41	3
30	24.38		49.41		26.32			26.45	4
	53.44	30.94	28.18	38.77	25.57	— 0.37	26.08	25.71	4
July 3	25.38		47.32		25.94			25.76	3
	54.01	31.37	27.88	40.56	5.22	— 0.36	25.40	25.04	3
4	25.70		47.75		26.21			26.20	5
	54.19	31.51	27.61	39.86	25.45	— 0.38	25.82	25.44	5
5	26.01		47.90		26.56			26.14	4
	54.36	31.65	28.03	40.13	25.80	— 0.38	25.76	25.38	4
6	26.29		47.79		26.72			26.46	3
	54.50	31.79	27.42	39.63	25.96	— 0.38	26.08	25.70	3

STARS No. { 225 *l. c.* / 948 }

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90^\circ - \frac{1}{2}(A'+B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 62 53 22.12		235 15 29.18		4 19.13			4 18.37	4
	− 42 43 57.82	20 9 24.30	394 57 19.73	159 41 50.55	4 27.56	+ 4.21	4 22.58	4 26.79	4
8	21.96		25.86		17.63			15.93	4
	57.96	24.00	22.21	56.35	25.46	+ 3.91	19.84	23.75	4
9	21.81		23.88		16.42			14.23	3
	58.10	23.71	24.35	60.47	23.79	+ 3.68	17.91	21.59	3
12	21.44		30.10		20.72			18.45	1
	58.54	22.90	21.28	51.18	29.74	+ 4.51	22.96	27.47	1
13	21.30		27.85		19.17			18.15	2
	58.65	22.65	21.04	53.19	27.04	+ 3.93	22.08	26.01	2
14	21.15		22.87		16.62			14.63	3
	58.75	22.40	23.80	60.93	24.05	+ 3.71	18.34	22.05	3
19	20.31		31.55		23.64			21.63	3
	59.10	21.21	20.24	48.69	30.48	+ 3.42	25.05	28.47	3
21	20.04		24.63		18.11			16.33	4
	59.28	20.76	23.39	58.76	25.94	+ 3.91	20.24	24.15	4
22	19.93		22.86		16.84			16.20	3½
	59.39	20.54	22.84	59.98	23.93	+ 3.54	19.74	23.28	3½
27	19.54		22.57		18.15			16.84	5
	43 59.95	19.59	21.64	59.07	25.82	+ 3.83	20.67	24.50	5
28	19.45		24.60		18.08			17.08	2½
	44 0.03	19.42	24.18	59.58	24.93	+ 3.42	20.50	23.92	2½

STARS NO. { 225 *l.c.* / 948 } (*Con.*)

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90^\circ - \frac{1}{2}(A'+B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 62 53 19.34		235 15 21.40		4 17.46			4 15.95	3½
	− 42 44 0.07	20 9 19.27	394 57 23.07	159 41 61.67	4 24.62	+ 3.58	4 19.53	4 23.11	3½
30									
July 3	18 86		20.47		13.88			14.34	2½
	0.20	18.66	26.39	65.92	20.62	+ 3.37	17.71	21.08	2½
4	18.76		21.15		16.12			15.51	5
	0.25	18.51	25.22	64.07	22.52	+ 3.20	18.71	21.91	5
5	18.69		26.87		19.66			19.42	3
	0.32	18.37	22.36	55.49	26.96	+ 3.65	23.07	26.72	3
6	18.63		27.04		22.46			19.76	1½
	0.38	18.25	22.34	55.30	29.41	+ 3.47	23.23	26.70	1½

Stars No. { 190 *l. c.*
959

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90^\circ - \frac{1}{2}(A' + B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	′ ″	′ ″	′ ″	
June 7									
8									
9	+ 53 6 39.95 − 51 43 12.97	1 23 26.98	225 44 42.86 403 43 8.96	177 58 26.10	20 47.65 18 11.02	−1 18.31	19 3.46	20 21.77 17 45.15	3 3
12	39.80 13.54	26.26	45 53.72 43 34.42	57 40.70	21 23.85 18 42.23	−1 20.81	26.52	20 47.33 18 5.71	1 1
13	39.74 13.72	26.02	45 33.61 42 31.90	56 58.29	21 5.65 18 25.95	−1 19.85	47.85	21 7.70 18 28.00	1½ 1½
14	39.66 13.86	25.80	44 45.18 42 49.63	58 4.45	20 47.94 18 9.87	−1 19.03	14.88	20 33.91 17 55.85	3 3
19									
21	39.08 14.70	24.38	45 4.24 42 56.99	57 52.75	20 59.18 18 21.67	−1 18.75	21.44	20 40.19 18 2.69	4 4
22	39.05 14.86	24.19	45 8.65 42 56.61	57 47.96	20 45.74 18 11.00	−1 17.37	23.93	20 41.30 18 6.56	3½ 3½
27	39.05 15.65	23.40	45 25.81 43 0.57	57 34.76	20 54.62 18 19.97	−1 17.32	30.92	20 48.24 18 13.60	5 5
28	39.02 15.76	23.26	44 55.03 43 4.29	58 9.26	20 52.94 18 17.28	−1 17.83	13.74	20 31.57 17 55.91	3 3

STARS NO. { 190 *l. c.* / 959 } (*Con.*)

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90° − ½ (A′ + B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	′ ″	′ ″	′ ″	
June 19	+ 53 6 38.98		225 44 40.97		20 51.65			20 19.29	3
	− 51 43 15.85	1 23 23.13	403 43 14.79	177 58 33.82	18 16.12	−1 17.76	19 1.53	17 43.77	3
30	38.94		45 18.75		20 51.06			20 46.33	4
	15.93	23.03	42 58.07	57 39.32	18 16.05	−1 17.50	28.83	18 11.33	4
July 3									
4	38.82		45 1.07		20 38.49			20 28.14	5
	16.23	22.59	43 12.58	58 11.51	18 8.10	−1 15.19	12.95	17 57.76	5
5	38.82		45 13.44		21 6.51			20 50.64	3
	16.33	22.49	42 48.50	57 35.06	18 27.69	−1 19.41	31.23	18 11.82	3
6									

Stars No. $\begin{cases} 282\ l.\ c. \\ 959 \end{cases}$

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90°−½(A′+B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 53 41 30.49		226 17 17.18		17 57 70			17 47.23	4½
	− 51 43 12.60	1 58 17.89	403 42 53.57	177 25 36.39	18 28.97	+ 15.63	18 2.86	18 18.49	4½
8	30.34		17 20.57		17 50.61			17 43.70	3½
	12 78	17.56	43 5.72	25 45.15	18 20.52	+ 14.95	17 58.65	18 13.60	3½
9	30.20		16 47.39		17 46.70			17 28.44	3
	12.97	17.23	43 8.96	26 21.57	18 11.02	+ 12.16	17 40.60	17 52.76	3
12	29.85		17 25.93		18 8.67			18 0.82	1
	13.54	16.31	42 34.42	25 8.49	18 42.23	+ 16.78	18 17.60	18 34.38	1
13									
14	29.60		16 53.23		17 43.20			17 40.60	3
	13.86	15.74	42 49.63	25 56.40	18 9.87	+ 13.33	17 53.93	18 7.26	3
19	28.76		17 31.26		18 22.57			18 12.83	3
	14.44	14.32	42 27.57	24 56.31	18 46.29	+ 11.86	18 24.69	18 36.55	3
21	28.48		17 2.06		17 53.07			17 41.35	4
	14.70	13.78	42 56.99	25 54.93	18 21.67	+ 14 30	17 55.65	18 9.95	4
22	28.36		17 1.17		17 46.95			17 43.51	3½
	14.86	13.50	42 56.61	25 55.44	18 11.00	+ 12.02	17 55.53	18 7.55	3½
27	27.94		17 3.58		17 51.97			17 41.36	5
	15.65	12.29	43 0.57	25 56.99	18 19.97	+ 14.00	17 55 36	18 9.36	5
28	27.84		16 48.37		17 54.98			17 34.85	2½
	15.76	12.08	43 4.29	26 15.92	18 17.28	+ 11.15	17 46.00	17 57.15	2½

STARS No. { 282 *l. c.* / 959 } (*Con.*)

Date	δ	A′	C′	B	r′	½ (r′ₛ − r′ₙ)	90° − ½ (A′ + B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 53 41 27.72		226 16 42.70		17 46.97			17 23.45	3
	− 51 43 15.85	1 58 11.87	403 43 14.79	177 26 32.09	18 16.12	+ 14.57	17 38.02	17 52.59	3
30	27.59		16 58.31		17 51.25			17 41.89	4½
	15.93	11.66	42 58.07	25 59.76	18 16.05	+ 12.40	17 54.29	18 6.69	4½
July 3									
4	27.06		16 46.51		17 42.59			17 28.79	5
	16.23	10.83	43 12.60	26 26.09	18 8.10	+ 12.75	17 41.54	17 54.29	5
5	26.97		17 4.06		18 4.20			17 50.72	3½
	16.33	10.64	42 48.50	25 44.44	18 27.69	+ 11.74	18 2.46	18 14.20	3½
6	26.89		17 10.44		18 14.13			17 59.45	2½
	16.45	10.44	42 35.29	25 24.85	18 39.95	+ 12.91	18 12.36	18 25.27	2½

Stars No. { 225 *l. c.* / 984 }

Date	δ	*A′*	*C′*	*B*	*r′*	½ $(r'_s - r'_n)$	90°—½(*A′*+*B*)	*r*	*p*
June 7									
8									
9									
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
12	+ 62 53 21.44		235 15 30.10		4 20.72			4 18.50	1
	− 40 49 55.27	22 3 26.17	390 4 0.54	157 48 30.44	3 47.12	− 16.80	4 1.70	3 44.90	1
13	21.30		15 27.85		4 19.17			4 18.02	2½
	55.40	25.90	3 59.47	31.62	3 45.61	− 16.78	4 1.24	3 44.46	2½
14	21.15		15 22.87		4 16.62			4 15.14	3
	55.52	25.63	4 0.20	37.33	3 43.37	− 16.62	3 58.52	3 41.90	3
19	20.31		15 31.55		4 23.64			4 23.11	3
	55.86	24.45	3 55.07	23.52	3 49.46	− 17.09	4 6.02	3 48.93	3
21	20.04		15 26.63		4 18.11			4 17.43	3
	56.03	24.01	3 59.11	34.48	3 44.77	− 16.67	4 0.76	3 44.09	3
22	19.93		15 22.86		4 16.84			4 16.15	3½
	56.15	23.78	4 0.07	37.21	3 43.55	− 16.64	3 59.51	3 42.87	3½
27	19.54		15 22.57		4 18.15			4 17.00	5
	56.75	22.79	3 59.16	36.59	3 44.77	− 16.69	4 0.31	3 43.62	5
28	19.45		15 24.60		4 18.08			4 18.14	2
	56.83	22.62	3 59.07	34.47	3 44.71	− 16.68	4 1.46	3 44.78	2

May 7, 1903.

STARS NO. { 225 *l.c.* / 984 } (*Con.*)

Date	δ	*A′*	*C′*	*B*	*r′*	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A'+B)$	*r*	*p*
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 62 53 19.34		235 15 21.40		4 17.46			4 16.53	4
	− 40 49 56.91	22 3 22.43	393 3 59.20	157 48 37.80	3 44.18	− 16.64	3 59.89	3 43.25	4
30									
July 3	18.86		15 20.47		4 13.88			4 14.90	3
	57.07	21.79	4 1.88	41.41	3 40.88	− 16.50	3 58.40	3 41.90	3
4	18.76		15 21.15		4 16.12			4 15.44	5
	57.12	21.64	4 1.68	40.53	3 43.07	− 16.52	3 58.92	3 42.40	5
5	18.69		15 26.87		4 19.66			4 19.16	3
	57.18	21.51	4 0.69	33.82	3 46.02	− 16.82	4 2.34	3 45.52	3
6	18.63		15 27.04		4 22.46			4 20.93	1½
	57.29	21.34	3 57.89	30.85	3 48.41	− 17.02	4 3.91	3 46.89	1½

STARS No. { 225 *l. c.* / 1135

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A' + B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 62 53 22.12		235 15 29.18		4 19.13			4 18.82	4½
	− 40 5 16.59	22 48 5.53	392 19 32.82	157 4 3.64	3 32.32	− 23.40	3 55.42	3 32.02	4½
8	21.96		25.86		4 17.63			4 16.61	4
	16.68	5.28	33.46	7.60	3 31.52	− 23.05	53.56	3 30.51	4
9	21.81		23.88		4 16.42			4 14.69	3
	16.78	5.03	34.82	10.94	3 31.07	− 22.67	52.02	3 29.35	3
12	21.44		30.10		4 20.72			4 19.51	1
	17.15	4.29	33.42	3.32	3 34.09	− 23.31	56.20	3 32.89	1
13	21.30		27.85		4 19.17			4 17.66	2
	17.27	4.03	35.03	7.18	3 32.65	− 23.26	54.40	3 31.14	2
14	21.15		22.87		4 16.62			4 15.41	3
	17.39	3.76	34.06	11.19	3 30.86	− 22.88	52.53	3 29.65	3
19	20.31		31.55		4 23.64			4 22.17	3
	17.74	2.57	32.18	0.63	3 36.10	− 23.77	58.40	3 34.63	3
21	20.04		24.63		4 18.11			4 17.63	4
	17.87	2.17	33.59	8.96	3 31.73	− 23.19	54.44	3 31.25	4
22	19.93		22.86		4 16.84			4 16.34	4
	17.96	1.97	33.87	11.01	3 31.17	− 22.83	53.51	3 30.68	4
27	19.54		22.57		4 18.15			4 16.93	5
	18.59	0.95	33.37	10.80	3 32.55	− 22.80	54.13	3 31.33	5
28	19.45		24.60		4 18.08			4 17.63	2½
	18.71	0.74	35.52	10.92	3 31.16	− 23.46	54.17	3 30.71	2½

STARS No. { 225 *l. c.* / 1135 } (*Con.*)

Date	δ	*A′*	*C′*	*B*	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A' + B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+62 53 19.34		235 15 21.40		4 17.46			4 15.53	4
	−40 5 18.81	22 48 0.53	392 19 36.68	157 4 15.28	3 30.60	−23.43	3 52.10	3 28.67	4
30									
July 3	18.86		20.47		4 13.88			4 14 03	3
	19.06	47 59.80	37.90	17.43	3 28.60	−22.64	51.39	3 28.75	3
4	18.76		21.15		4 16.12			4 15.22	5
	19.13	59.63	36.45	15.30	3 30.76	−22.68	52.54	3 29.86	5
5	18.69		26.87		4 19.66			4 19.64	3½
	19.20	59 49	34.31	7 44	3 33.46	−23.10	56.54	3 33.44	3½
6	18.63		27.04		4 22.46			4 20.30	2
	19.30	59.33	34.80	7.76	3 34.78	−23.84	56.46	3 32.62	2

Stars No. { 264 *l. c.* / 1005 }

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90^\circ - \frac{1}{2}(A'+B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 85 17 20.29		257 31 33.27		1 15.82			1 15 48	4
	— 19 52 6.90	65 25 13.39	372 8 39.39	114 32 16.12	1 15.35	— 0.23	1 15.25	1 15 02	4
8	20.01		21.80		15.47			14.93	4
	6.90	13.11	39.32	17.52	14 98	— 0.24	14.69	14.45	4
9	19.77		20.20		15.10			14.12	3
	6 93	12.84	39.62	19.42	14.59	— 0.25	13.87	13 62	3
12	19.08		24.35		16.36			15.85	1
	7.02	12.06	41.12	16.77	15.84	— 0.26	15.59	15.33	1
13	18.84		21.88		15.84			15.21	2
	7.04	11 80	40.15	18.24	15.37	— 0.23	14.98	14.75	2
14	18.60		20.42		15.09			15.33	3
	7.05	11.55	38.63	18.21	14.66	— 0.21	15.12	14.91	3
19	17.22		22.04		17.17			16.60	3
	6.87	10.35	38.99	16.95	16.66	— 0.25	16.35	16.10	3
21	16.72		18 55		15.60			14 99	4
	6.84	9.88	39.15	20.60	15.13	— 0.23	14.76	14.53	4
22	16.49		16.97		15.26			14.55	4
	6.85	9.64	38 72	21.75	14.78	— 0.24	14.31	14.07	4
27	15.56		16.45		15.60			15.43	5
	6.97	8 59	37.47	21.02	15.13	— 0.23	15.20	14.97	5
28	15.36		16.32		15.64			14.83	2
	6.96	8.40	38.81	22.49	15.10	— 0.27	14.56	14.29	2

STARS NO. { 264 *l. c.* / 1005 } (*Con.*)

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90°−½(A′+B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 85 17 15.14		257 36 16.07		1 15.29			1 14.97	4
	− 19 52 6.93	65 25 8.21	372 8 38.32	114 32 22.25	1 14.88	− 0.20	1 14.77	1 14.57	4
30	14.92		16.33		15.55			15.45	4
	6.89	8.03	37.88	21.55	15.07	− 0.24	15.21	14.97	4
July 3	14.23		14.94		14.54			14.41	3
	6.76	7.47	39.19	24.25	13.99	− 0.27	14.14	13.87	3
4	14.02		15.35		14.98			14.86	5
	6.72	7.30	38.80	23.45	14.51	− 0.23	14.63	14.40	5
5	13.84		18.17		16.14			16.07	3
	6.71	7.13	39.43	21.26	15.62	− 0.26	15.81	15.55	3
6	13.66		16.36		16.77			16.09	2
	6.71	6.95	37.68	21.32	16.33	− 0 22	15.87	15.65	2

Stars No. { 356 *l. c.* / 1005 }

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A' + B)$	r	p
June 7									
8									
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
9	+ 85 8 49.23		257 27 52.09		1 15.72			1 15.65	3
	− 19 52 6.93	65 16 42.30	372 8 39.62	114 40 47.53	1 14.59	− 0.56	1 15.09	1 14.53	3
12	48.41		54.49		16.80			16.47	1
	7.02	41.39	41.12	46.63	15.84	− 0.48	15.99	15.51	1
13	48.16		52.30		16.29			15.99	2½
	7.04	41.12	40.12	47.82	15.37	− 0.46	15.53	15.07	2½
14	47.87		49.87		15.60			15.68	3
	7.05	40.82	38.63	48.78	14.66	− 0.47	15.21	14.74	3
19	46.25		52.74		17.56			17.64	3
	6.87	39.38	38.99	46.25	16.66	− 0.45	17.19	16.74	3
21	45.63		48.47		15.99			15.70	4
	6.84	38.79	39.15	50.68	15.13	− 0.43	15.27	14.84	4
22	45.30		47.37		15.80			15.61	4
	6.85	38.45	38.72	51.35	14.78	− 0.51	15.10	14.59	4
27	44.02		46.47		16.27			16.55	5
	6.97	37.05	37.47	51.00	15.13	− 0.57	15.98	15.41	5
28	43.77		45.99		15.77			15.52	2
	6.96	36.81	38.81	52.82	15.10	− 0.33	15.19	14.86	2

STARS NO. { 356 *l. c.* / 1005 } (*Con.*)

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90°−½(A′+B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 85 8 43.48		257 27 45.52		1 15.53			1 15.65	4
	− 19 52 6.93	65 16 36.55	372 8 38 32	114 40 52.80	1 14.88	− 0.32	1 15.33	1 15.01	4
30	43.19		45.70		15.87			16.16	4
	6.89	36.30	37.88	52.18	15.07	− 0.40	15.76	15.36	4
July 3	42.25		43.05		14.84			14.61	3
	6.76	35.49	39.19	56.14	13.99	− 0.42	14.19	13.77	3
4	41.94		44.46		15.58			15.75	5
	6.72	35 22	38.80	54.34	14.51	− 0.53	15.22	14.69	5
5	41.67		45.48		16.58			16.03	3½
	6.71	34.96	39 43	53.95	15.62	− 0.48	15.55	15.07	3½
6	41 41		45.04		17.05			16.69	2½
	6.71	34.70	37 68	52.64	16.33	− 0.36	16.33	15.97	2½

Stars No. { 377 *l. c.* / 1032 }

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A' + B)$	r	p
June 7									
8									
9									
12									
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
13	+ 55 41 1.33		228 10 14.90		11 22.33			11 27 15	1
	− 49 54 40.61	5 46 20.72	402 0 21.c8	173 50 6.18	12 1.13	+ 19.40	11 46.55	12 5.95	1
14	1.16		10 0.34		11 15.85			11 11.99	3½
	40.77	20.39	0 39.28	38.94	11 52.53	+ 18.34	30.33	11 48.67	3½
19	41 0.12		10 14.46		11 35.13			11 27.08	3
	41.39	18.73	0 21.24	6.78	12 15.48	+ 20.17	47.25	12 7.42	3
21	40 59.71		10 5.27		11 18.89			11 15.69	4
	41 65	18.06	0 36.34	31.07	11 58.40	+ 19.75	35.44	11 55.19	4
22	59 50		9 58.22		11 17.25			11 14.74	4
	41.82	17.68	0 33.65	35.43	11 54.68	+ 18.71	33.45	11 52.16	4
27	58.75		10 2.48		11 21.65			11 18.39	5
	42.72	16.03	0 33.09	30.61	11 58.23	+ 18.29	36.68	11 54.97	5
28	58 60		9 59 26		11 16.63			11 9.88	2½
	42.86	15.74	0 41.03	41.77	11 59.38	+ 21.37	31.25	11 52.62	2½

STARS No. { 377 *l. c.* / 1032 } (*Con.*)

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90° − ½(A′ + B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 55 40 58.43		228 9 49.65		11 15.01			11 5.21	3½
	− 49 54 42.99	5 46 15.44	402 0 43.98	173 50 54.33	11 54.84	+ 19.91	11 25.12	11 45.03	3½
30	58.23		10 0.13		11 17.75			11 7.19	4
	43.10	15.13	0 39.43	39.30	11 57.80	+ 20.02	27.21	11 47.23	4
July 3	57.61		9 44.08		11 8.03			11 2.16	3
	43.38	14.43	0 46.11	62.03	11 47.25	+ 19.61	21.77	11 41.38	3
4	57.41		10 0.23		11 15.58			11 14.53	4½
	43.48	13.93	0 40.99	40.76	11 51.85	+ 18.13	32.66	11 50.79	4½
5	57.23		10 6.49		11 25.62			11 20.73	4
	43.61	13.62	0 32.18	25.69	12 4.80	+ 19.59	40.32	11 59.91	4
6	57.05		10 4.93		11 30.43			11 20.21	2½
	43.74	13.31	0 30.21	25.28	12 11 43	+ 20.50	40.71	12 1.21	2½

Stars No. { 424 *l. c.* / 1105 }

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A' + B)$	r	p
June 7									
8									
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
9	+ 79 40 28.16		251 59 50.10		1 34.35			1 33.79	3½
	− 24 53 59.26	54 46 28.90	377 10 16.51	125 10 26.41	1 31.46	− 1.44	1 32.35	1 30.91	3½
12									
13	27.13		50.13		35.10			34.56	2
	59.44	27.69	16.24	26.11	32.18	− 1.46	33.10	31.64	2
14	26.85		50.49		34.41			35.37	3½
	59.47	27.38	15.56	25.07	31.22	− 1.59	33 78	32.19	3½
19	25.26		52 35		36.54			36.68	3
	59.40	25.86	15.94	23.59	33.73	− 1.40	35.28	33.88	3
21	24.64		47.26		34.64			34.33	4
	59.38	25.26	16.19	28.93	31.80	− 1.42	32.91	31.49	4
22	24.31		45.67		34.35			34.22	4
	59.39	24.92	15.10	29.43	31.56	− 1.39	32.83	31.44	4
27	22.95		43.76		34.90			34.38	5
	59.61	23.34	14.50	30.74	32.05	− 1.42	32.96	31.54	5
28	22.69		44.93		34.65			34.75	3
	59 65	23.04	15.48	30.55	31.56	− 1.54	33.21	31.67	3

STARS NO. { 424 *l. c.* / 1105 } (*Con.*)

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A' + B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 79 40 22.40		251 59 43.75		1 34.34			1 34.33	3
	− 24 53 59.65	54 46 22.75	377 10 15.50	125 10 31.75	1 31.18	− 1.58	1 32.75	1 31.17	3
30	22.10		43.70		34.51			34.34	4½
	59.65	22.45	15 41	31.71	31.66	− 1.42	32.92	31.50	4½
July 3	21.10		41.68		33.26			33 37	3
	59.57	21.53	16.32	34.64	30.36	− 1.45	31.92	30.47	3
4	20.77		42.48		34.13			34.27	5
	59.56	21.21	15.59	33.11	31.26	− 1.43	32.84	31.41	5
5	20.46		44.05		35.50			35.42	4
	59.56	20.90	15.31	31.26	32.49	− 1.50	33.92	32.42	4
6	20.16		44.16		36.02			36.02	3
	59.57	20.59	14.49	30.33	33.05	− 1.48	34.54	33.06	3

Stars No. { 349 *l. c.* / 1110 }

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A' + B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 74 58 39.46		247 18 25.85		1 57.63			1 57.97	5
	— 29 46 35.49	45 12 3.97	382 2 29.10	134 44 3.25	1 54.46	— 1.58	1 56.39	1 54 81	5
8	39.17		24.48		57.14			57.42	4
	35.53	3.64	29.16	4.68	53.98	— 1.58	55.84	54.26	4
9	38.91		23.19		56.85			56.25	3
	35.58	3.33	30.52	7.33	53.69	— 1.58	54.67	53.09	3
12	38.19		26.02		58.54			58.06	1
	35.79	2.40	30.71	4.69	55.33	— 1.60	56.46	54.86	1
13	37.96		23.58		57.77			57.70	1
	35.86	2.10	29 27	5.69	54.59	— 1.59	56 11	54.52	1
14	37.71		22.15		56 65			57.41	3
	35 92	1.79	28.72	6.57	53.46	— 1.59	55.82	54.23	3
19	36.26		24.88		59.74			59.16	3
	35.99	12 0.27	29.45	4.57	56.57	— 1.58	57.58	56.00	3
21	35.71		20.63		57.31			57.02	4
	36.02	11 59.69	30.07	9.44	54.14	— 1.58	55 44	53.86	4
22	35.43		18.12		57.04			56 19	4
	36.07	59.36	29.55	11.43	53.88	— 1.58	54.61	53.03	4
27	34 32		17.95		57.74			57.42	5
	36.43	57.89	28.42	10.47	54 53	— 1.60	55.82	54 22	5
28	34.09		18.10		56.96			56.90	2
	36.47	57.62	29.82	11.72	53 82	— 1.57	55.33	53.76	2

STARS NO. { 349 *l. c.* / 1110 } (*Con.*)

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90° − ½ (A′ + B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 74 58 33.85		247 18 17.41		1 56.54			1 56.36	4
	− 29 46 36.51	45 11 57.34	382 2 30.52	134 44 13.11	1 53.37	− 1.58	1 54.78	1 53.20	4
30	33.59		16.93		57.14			56.47	4½
	36.54	57.05	30.10	13.17	53 97	− 1.58	54.89	53.31	4½
July 3	32.75		13 92		55.53			55.09	2½
	36.55	56.20	30.71	16.79	52.37	− 1.58	53.51	51.93	2½
4	32.49		16.55		56.65			56.64	5
	36.55	55.94	30 51	13.96	53.47	− 1.59	55.05	53.46	5
5	32.23		17.98		58.23			57.92	4
	36.57	55.66	29.69	11.71	55.02	− 1.60	56.32	54.72	4
6	32.01		18.15		58.95			58.35	3
	36.62	55.39	29.29	11.14	55.73	− 1.61	56.74	55.13	3

Stars No. { 377 *l. c.* / 1156 }

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90°—½(A′+B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 55 41 2.34		228 10 11.24		11 21.21			11 17.87	5
	− 50 5 50.75	5 35 11.59	402 11 14.82	174 1 3.58	12 30.32	+ 34.55	11 52.42	12 26.97	5
8	2.14		4.37		11 18.45			11 13.56	4
	50.88	11.26	18.07	13.70	12 26.38	+ 33.96	47.52	12 21.48	4
9	1.96		0.28		11 16.78			11 11.74	3
	51.03	10.93	18.41	18.13	12 24.25	+ 33.73	45.47	12 19.20	3
12									
13	1.33		14.90		11 22.33			11 20.86	½
	51.71	9.62	15.03	0.13	12 30.88	+ 34.27	55.13	12 29.40	½
14	1.16		0.34		11 15.85			11 10.00	3½
	51.89	9.27	23.26	22.92	12 23.67	+ 33.91	43.91	12 17.82	3½
19	41 0.12		14.46		11 35.13			11 23.35	3
	52.49	7.63	10.18	0 55.72	12 45.10	+ 34.98	58.33	12 33.31	3
21	40 59.71		5.27		11 18.89			11 16.84	4
	52.70	7.01	17.01	1 11.74	12 26.48	+ 33.79	50.63	12 24.42	4
22	59.50		9 58.22		11 17.25			11 13.60	4
	52.86	6.64	17.03	18.81	12 24.62	+ 33.68	47.28	12 20.96	4
27	58.75		10 2.48		11 21.65			11 17.34	5
	53.73	5.02	14.45	12.97	12 29.00	+ 33.67	51.01	12 24.68	5
28	58.60		9 59 26		11 16.63			11 10.61	3
	53.90	4.70	25.42	26.16	12 24.55	+ 33.96	44.57	12 18.53	3

STARS NO. { 377 *l. c.* / 1156 } (*Con.*)

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90° − ½ (A′ + B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 55 40 58.43		228 9 49.65		11 15.01			11 5.46	4
	− 50 5 54.05	5 35 4.38	402 11 26.72	174 1 37.07	12 22.65	+ 33.82	11 39.28	12 13 10	4
30	58.23		10 0.13		11 17.75			11 13.49	4
	54.19	4.04	21.35	21.22	12 25.52	+ 33.88	47.37	12 21.25	4
July 3	57.61		9 44.08		11 8.03			11 2.59	3
	54.52	3.09	29.44	45.36	12 14.42	+ 33.19	35.78	12 8.97	3
4	57.41		10 0.23		11 15.58			11 11.90	5
	54.64	2.77	25.64	25.41	12 23.60	+ 34.01	45.91	12 19.92	5
5	57.23		6.49		11 25.62			11 19.81	3½
	54.77	2.46	15.42	8.93	12 34.62	+ 34.50	54.31	12 28.81	3½
6	57.05		4.93		11 30.43			11 23.95	2½
	54.92	2.13	6.26	1.33	12 39.07	+ 34.32	58.27	12 32.59	2½

Stars No. { 406 *l. c.* / 1162 }

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A' + B)$	r	p
June 7									
8									
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
9	+ 59 2 52.90		231 27 10.27		6 32.25			6 29.51	3½
	− 45 58 15.92	13 4 36.98	398 9 49.26	166 42 38.99	6 17.27	− 7.49	6 22.02	6 14.53	3½
12									
13	52.19		17.29		35.21			34.33	½
	16.50	35.69	47.98	30.69	20.17	− 7.52	26.81	19.29	½
14	52.02		7.78		32.19			29.51	3½
	16.65	35.37	48.45	40.67	17.13	− 7.53	21.98	14.45	3½
19	50.86		18.62		42.02			37.19	3
	17.15	33.71	45.82	27.20	26.74	− 7.64	29.55	21.91	3
21	50.39		8.82		33.35			30.76	4
	17.30	33.09	49.21	40.39	18.35	− 7.50	23.26	15.76	4
22	50.16		6.33		32.34			30.53	4
	17.43	32.73	47.46	41.13	17.41	− 7.46	23.07	15.61	4
27	49.28		8 18		34.47			32.76	5
	18.20	31.08	46.52	38.34	19.52	− 7.47	25 29	17.82	5
28	49.10		5.95		32.83			29.92	3½
	18.34	30.76	50.61	44.66	17.56	− 7.63	22.29	14.66	3½

STARS NO. { 406 *l. c.* / 1162 } (*Con.*)

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90° − ½ (A′ + B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 59 2 48.90		231 27 5.26		6 31.87			6 29 25	4
	− 45 58 18.47	13 4 30.43	398 9 51.46	166 42 46.20	6 16.74	− 7.56	6 21.69	6 14.13	4
30	48.67		5.28		32.94			28.50	4
	18.57	30.10	53.21	47.93	17.91	− 7.51	20.99	13.48	4
July 3	47.97		26 59.31		27.63			24.51	3½
	18.86	29.11	55.94	56.63	12.87	− 7.38	17.13	9.75	3½
4	47.74		27 4.37		31.72			29 02	5
	18.94	28.80	51.44	47.07	17.81	− 6.95	22.07	15.12	5
5	47.53		11.77		37.27			35.46	3½
	19.05	28.48	47.60	35.83	22.05	− 7.61	27.85	20.24	3½
6	47.32		9.39		39.46			34.68	3
	19.18	28.14	47.22	37.83	24.13	− 7.66	27.02	19.36	3

STARS No. { 444 *l. c.* / 1162

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90° − ½ (A′ + B)	r	p
June 7									
8									
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
9	+ 58 33 20.44		230 58 2.07		6 58.73			6 54.88	3½
	− 45 58 15.92	12 35 4.52	398 9 49.26	167 11 47.19	6 17.27	− 20 73	6 34.15	6 13 42	3½
12									
13	19.74		8.16		7 2.88			6 59.82	½
	16.50	3.24	47.98	39.82	6 20.17	− 21.35	38.47	6 17.12	½
14	19.57		5 71		6 59.02			6 58.11	2½
	16.65	2.92	48.45	42.74	6 17.13	− 20.94	37.17	6 16.23	2½
19	18.44		12.84		7 8.99			7 3.99	3
	17.15	1.29	45.82	32.98	6 26.74	− 21.12	42.87	6 21.75	3
21	17.97		3.92		7 0.41			6 58.05	4
	17.30	0.67	49.21	45.29	6 18.35	− 21.03	37.02	6 15.99	4
22	17.72		2.44		6 58.99			6 58.14	4
	17.43	35 0.29	47.46	45.02	6 17.41	− 20.79	37.35	6 16.56	4
27	16.78		2.10		7 1.48			6 59.48	5
	18.20	34 58.58	46.52	44.42	6 19.52	− 20.98	38.50	6 17.52	5
28	16.61		0.05		7 0.43			6 57.02	
	18.34	58.27	50.61	50.56	6 17.56	− 21.43	35.59	6 14.16	4

STARS NO. { 444 *l. c.* / 1162 } (*Con.*)

Date	δ			A'			C'			B			r'		$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A'+B)$		r		p
	°	′	″	°	′	″	°	′	″	°	′	″	′	″	″	′	″	′	″	
June 29	+ 58	33	16.40				230	58	0.79				6	58.92				6	56.79	3½
	− 45	58	18.47	12	34	57.93	398	9	51.46	167	11	50.67	6	16.74	− 21.09	6	35.70	6	14.61	3½
30			16.17						0.83				6	59 55				6	55.83	4
			18.57			57.60			53.21			52.38	6	17.91	— 20.82		35.01	6	14.19	4
July 3			15.41					57	55.07				6	54.01				6	51.86	3
			18.86			56.55			55.94			60.87	6	12.87	— 20.57		31.29	6	10.72	3
4			15.17					57	58.10				6	57.66				6	55.14	5
			18.94			56.23			51.44			53.34	6	17.81	— 19.92		35.22	6	15.30	5
5			14.94					58	6.86				7	4.44				7	2.88	3½
			19.05			55.89			47.60			40.74	6	22.05	— 21.19		41.69	6	20.50	3½
6			14.71					58	6.84				7	7.10				7	3.53	2
			19.18			55.53			47.22			40.38	6	24.13	— 21.48		42.05	6	20.57	2

Stars No. { 406 *l. c.* / 1179 }

Date	δ	*A'*	*C'*	*B*	*r'*	½ $(r'_s - r'_n)$	90°—½ (*A'*+*B*)	*r*	*p*
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 59 2 53.33		231 27 14.32		6 35.64			6 33.88	4
	— 46 1 21.48	13 1 31.85	398 12 46.55	166 45 32.23	6 23.79	— 5.92	6 27.96	6 22.04	4
8	53.10		12 30		33.15			31.01	4
	21.57	31.53	50.25	37.95	21.65	— 5.75	25.26	19.51	4
9	52.90		10.27		32.25			29.06	4
	21 68	31.22	53.38	43.11	19.80	— 6.22	22.84	16.62	4
12									
13	52.19		17.29		35.21			35.28	½
	22.22	29.97	49.30	32.01	22.67	— 6.27	29.01	12.74	½
14	52.02		7.78		32.19			29.39	4
	22.37	29.65	51.76	43.98	19.78	— 6.20	23.19	16.99	4
19	50.86		18 62		42.02			38.14	3
	22.83	28.03	47.21	28.59	29.11	— 6.45	31.69	25.24	3
21	50.39		8.82		33.35			29.98	4
	22.99	27.40	54.02	45.20	20.79	— 6.28	23.70	17.42	4
22	50.16		6.33		32.34			29.74	4
	23.10	27.06	52.34	46.01	19.80	— 6.27	23.47	17.20	4
27	49.28		8.18		34.47			32.76	5
	23.84	25.44	49.89	41.71	21.81	— 6.33	26.43	20.10	5
28	49.10		5.95		32.83			29.80	3½
	23.98	25.12	53.43	47.48	20.62	— 6.10	23.70	17.60	3½

STARS NO. { 406 *l. c.* / 1179 } (*Con.*)

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90° − ½ (A′ + B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 59 2 48.90		231 27 5.26		6 31.87			6 29.41	3½
	− 46 1 24.10	13 1 24.80	398 12 54 05	166 45 48.79	6 19.47	− 6.20	6 23.21	6 17.01	3½
30	48 67		5.28		32.94			29.06	3½
	24.22	24.45	55.33	50.05	20.32	− 6.31	22.75	16.44	3½
July 3	47.97		26 59.31		27.63			25.25	3½
	24.48	23.49	57.83	58.52	15.12	− 6.25	19.00	12.75	3½
4	47.74		27 4.37		31.72			30.05	4½
	24.58	23.16	53 94	49.57	18.90	− 6.41	23.64	17.23	4½
5	47.53		11.77		37.27			35.24	4
	24.68	22.85	51.19	39.42	24.53	− 6.37	28.87	22.50	4
6	47.32		9.39		39.46			35.21	3
	24.81	22.51	49.24	39.85	26.68	− 6.39	28.82	22.43	3

Stars No. { 444 *l. c.* / 1179 }

Date	δ	A′	C′	B	r′	½ $(r'_s - r'_n)$	90°−½(A′+B)	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 58 33 20.87		230 58 12.93		7 4.25			7 3.73	3
	− 46 1 21.48	12 31 59.39	398 12 46.55	167 14 33.62	6 23.79	− 20.23	6 43.50	6 23.27	3
8	20.64		5.04		7 0.37			6 57.22	4
	21.57	59.07	50.25	45.21	6 21.65	− 19.36	37.86	6 18.50	4
9	20.44		2.07		6 58.73			6 54.43	4
	21.68	58.76	53.38	51.31	6 19.80	− 19.46	34.97	6 15.51	4
12									
13	19.74		8.16		7 2.88			7 0.77	½
	22.22	57.52	49.30	41.14	6 22.67	− 20.10	40.67	6 20.57	½
14	19.57		5.71		6 59.02			6 58.00	3
	22.37	57.20	51.76	46.05	6 19.78	− 19.62	38.38	6 18.76	3
19	18.44		12.84		7 8.99			7 4.95	3
	22.83	55.61	47.21	34.37	6 29.11	− 19.94	45.01	6 25.07	3
21	17.97		3.92		7 0.41			6 57.27	4
	22.99	54.98	54.02	50.10	6 20.79	− 19.81	37.46	6 17.65	4
22	17.72		2.44		6 58.99			6 57.33	4
	23.10	54.62	52.34	49.90	6 19.80	− 19.59	37.74	6 18.15	4
27	16.78		2.10		7 1.48			6 59.47	5
	23.84	52.94	49.89	47.79	6 21.81	− 19.83	39.64	6 19.81	5
28	16.61		0.05		7 0.43			6 56.90	4
	23.98	52.63	53.43	53.38	6 20.62	− 19.90	37.00	6 17.10	4

STARS NO. { 444 *l. c.* / 1179 } (*Con.*)

Date	δ	*A'*	*C'*	*B*	*r'*	½ $(r'_s - r'_n)$	90°−½ (*A'*+*B*)	*r*	*p*
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 58 33 16.40		230 58 0.79		6 58.92			6 56.94	3
	− 46 1 24.10	12 31 52.30	398 12 54.05	167 14 53.26	6 19.47	− 19.72	6 37.22	6 17.50	3
30	16.17		0.83		6 59.55			6 56.39	3½
	24.22	51.95	55.33	54.50	6 20.32	− 19.61	36.78	6 17.17	3½
July 3	15.41		57 55.07		6 54.01			6 52.60	3
	24.48	50.93	57.83	62.76	6 15.12	− 19.44	33.16	6 13.72	3
4	15.17		57 58.10		6 57.66			6 56.17	4½
	24.58	50.59	53.94	55.84	6 18.90	− 19.38	36.79	6 17.41	4½
5	14.94		58 6.86		7 4.44			7 2.66	4
	24.68	50.26	51.19	44.33	6 24.53	− 19.95	42.71	6 22.76	4
6	14.71		58 6.84		7 7.10			7 4.06	2
	24.81	49.90	49.24	42.40	6 26.68	− 20.21	43.85	6 23.64	2

Stars No. { 424 *l. c.* / 1182 }

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A'+B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 79 40 28.77		251 59 52.60		1 35.46			1 35.24	3
	− 25 28 36.31	54 11 52.46	377 44 50.41	125 44 57.81	1 34.72	− 0.37	1 34.87	1 34.50	3
8	28.47		51.05		34.62			34.48	4
	36.27	52.20	50.55	59.50	33.95	− 0.33	34.15	33.82	4
9	28.16		50.10		34.35			33.80	4
	36.27	51.89	51.25	61.15	33.71	− 0.32	33.48	33.16	4
12									
13	27.13		50.13		35.10			35.15	2½
	36.36	50.77	49.76	59.63	34.40	− 0.35	34.80	34.45	2½
14	26.85		5c.49		34.41			35.46	4
	36.38	50.47	49.74	59.25	33.77	− 0.32	35.14	34.82	4
19	25.26		52.35		36.54			36.73	3
	36.25	49.01	50.53	44 58.18	35.89	− 0.32	36.41	36.09	3
21	24.64		47.26		34.64			34.78	4
	36.19	48.45	49.93	45 2.67	33.96	− 0.34	34.44	34.10	4
22	24.31		45.67		34.35			34.52	4
	36.17	48.14	49.16	3.49	33.68	− 0.33	34.19	33.86	4
27	22.95		43.76		34.90			34.83	5
	36.32	46.63	48.15	4.39	34.22	− 0.34	34.49	34.15	5
28	22.69		44.93		34.65			34.70	4
	36.35	46.34	49.90	4.97	33.95	− 0.35	34.35	34.00	4

STARS No. { 424 *l. c.* / 1182 } (*Con.*)

Date	δ			A′			C′			B			r′		½ $(r'_s - r'_n)$	90° − ½(A′ + B)		r		p
	°	′	″	°	′	″	°	′	″	°	′	″	′	″	″	′	″	′	″	
June 29	+ 79	40	22.40				251	59	43.75				1	34.34				1	34.39	3
	− 25	28	36.37	54	11	46.03	377	44	49.62	125	45	5.87	1	33.65	− 0.34	1	34.05	1	33.71	3
30			22.10						43.70					34.51					34.26	3½
			36.35			45.75			50.09			6.39		33.85	− 0.33		33.93		33.60	3½
July 3			21.10						41.10					33.26					33.81	3
			36.26			44.84			49.89			8.21		32.59	− 0.33		33.48		33.15	3
4			20.77						42.48					34.13					34.09	5
			36.25			44.52			50.42			7.94		33.48	− 0.32		33.77		33.45	5
5			20.46						44.05					35.50					35.11	4
			36.23			44.23			50.27			6.22		34.83	− 0.33		34.78		34.45	4
6			20.16						44.16					36.02					35.86	3
			36.24			43.92			49.21			5.05		35.33	− 0.34		35.52		35.18	3

Stars No. { 438 *l. c.* / 1225 }

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A'+B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 7	+ 77 6 25.30		249 26 0.93		1 46.90			1 46.86	3
	− 27 48 57.74	49 17 27.56	380 5 1.55	130 39 0.62	1 44.99	− 0.95	1 45.91	1 44.96	3
8	25.00		25 58.08		46.00			45.41	4
	57.70	27.30	1.82	3.74	44.13	− 0.93	44.48	43.55	4
9	24.73		58.05		45.61			45.35	4
	57.67	27.06	2.17	4.12	43.73	− 0.94	44.41	43.47	4
12									
13	23.73		58.23		46.54			46.48	1½
	57.72	26.01	1.09	2.86	44.72	− 0.91	45.57	44.66	1½
14	23.46		58.61		45.68			46.76	2½
	57.75	25.71	1.15	2.54	43.91	− 0.88	45.88	45.00	2½
19	21.96		59.53		48.02			47.73	3
	57.63	24.33	1.59	2.06	46.17	− 0.92	46.81	45.89	3
21	21.34		54.93		46.00			46.39	4
	57.55	23.79	0.30	5.37	44.06	− 0.97	45.42	44.45	4
22	21.01		53.62		45.65			45.73	4
	57.54	23.47	5 0.57	6.95	43.77	− 0.94	44.79	43.85	4
27	19.69		51.56		46.27			46.15	5
	57.65	22.04	4 59.12	7.56	44.36	− 0.95	45.20	44.25	5
28	19.44		52.52		46.01			46.42	4
	57.68	21.76	4 59.89	7.37	44.05	− 0.98	45.44	44.46	4

STARS NO. { 438 *l. c.* / 1225 } (*Con.*)

Date	δ	A'	C'	B	r'	$\frac{1}{2}(r'_s - r'_n)$	$90° - \frac{1}{2}(A'+B)$	r	p
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	″	′ ″	′ ″	
June 29	+ 77 6 19.15		249 25 51.85		1 45.69			1 45.72	3½
	− 27 48 57.70	49 17 21.45	380 5 0.82	130 39 8.97	1 43.83	− 0.93	1 44.79	1 43.86	3½
30	18.85		52.23		45.77			46.04	4
	57.71	21.14	0.90	8.67	43.89	− 0.94	45.10	44.16	4
July 3	17.88		49.50		44.47			44.85	3
	57.63	20.25	1.31	11.81	42.70	− 0.88	43.97	43.09	3
4	17.56		49.72		45.38			45.52	5
	57.61	19.95	0.72	11.00	43.40	− 0.99	44.53	43.54	5
5	17.24		52.23		46.94			47.05	4
	57.59	19.65	5 0.39	8.16	45.04	− 0.95	46.10	45.15	4
6	16.94		52.81		47.55			47.99	2
	57.60	19.34	4 59.38	6.57	45.66	− 0.94	47.05	46.11	2

The following tables contain the reductions for dlogr or its equivalent dlog*a*. The second column contains the logarithms of the computed refractions; the next column contains the logarithms of the observed refractions; the fourth the difference between the two preceding, in the sense of Observed—Computed; the column *p* contains the weights and the last column the weighted differences. The residuals and their weighted squares are not given. Log [*pvv*] is given in every case, as is also the resulting probable error of the weighted mean of every set. All of the results in the following tables have been checked.

STAR NO. 948.

Date	*log. r′*	*log. r*	△	*p*	*p* △
June 7	2.42742	2.42617	— 0.00125	4	— 0.00500
8	2.42399	2.42119	— 280	4	— 1120
9	2.42126	2.41762	— 364	3	— 1092
12	2.43095	2.42727	— 368	1	— 368
13	2.42658	2.42490	— 168	2	— 336
14	2.42169	2.41838	— 331	3	— 993
19	2.43214	2.42889	— 325	3	— 975
21	2.42478	2.42185	— 293	4	— 1172
22	2.42149	2.42042	— 107	3½	— 375
27	2.42459	2.42243	— 216	5	— 1080
28	2.42313	2.42147	— 166	2½	— 415
29	2.42262	2.42014	— 248	3½	— 868
30					
July 3	2.41600	2.41678	+ 78	2½	+ 195
4	2.41916	2.41816	— 100	5	— 500
5	2.42644	2.42605	— 39	3	— 117
6	2.43042	2.42602	— 440	1½	— 660
				△	— 0.00205

[*p*] = 50½ ; *log* [*pvv*] = 5.8653

p. e. = ± 0.00015

STAR No. 190 *l. c.*

Date	log. r′	log. r	△	p	p △
June 7					
8					
9	3.09609	3.08699	— 0.00910	3	— 0.02730
12	3.10852	3.09598	— 1254	1	— 1254
13	3.10231	3.10302	+ 71	½	+ 35
14	3.09619	3.09129	— 490	3	— 1470
19					
21	3.10009	3.09349	— 660	4	— 2640
22	3.09543	3.09387	— 156	3½	— 546
27	3.09851	3.09629	— 222	5	— 1110
28	3.09793	3.09046	— 747	3	— 2241
29	3.09748	3.08610	— 1138	3	— 3414
30	3.09728	3.09563	— 165	4	— 660
July 3					
4	3.09289	3.08925	— 364	5	— 1820
5	3.10261	3.09713	— 548	3	— 1644
6					
				△	— 0.00513

[*p*] = 38; *log* [*pvv*] = 6.6112

p. e. = ± 0.00047

STAR No. 959.—(With 190 *l. c.*)

Date	log. r′	log. r	△	p	p △
June 7					
8					
9	3.03783	3.02741	— 0.01042	3	— 0.03126
12	3.05008	3.03571	— 1437	1	— 1437
13	3.04374	3.04454	+ 80	½	+ 40
14	3.03714	3.03175	— 539	3	— 1617
19					
21	3.04205	3.03451	— 754	4	— 3016
22	3.03782	3.03605	— 177	3½	— 619
27	3.04138	3.03886	— 252	5	— 1260
28	3.04032	3.03177	— 855	3	— 2565
29	3.03986	3.02685	— 1301	3	— 3903
30	3.03983	3.03795	— 188	4	— 752
July 3					
4	3.03667	3.03252	— 415	5	— 2075
5	3.04442	3.03815	— 627	3	— 1881
6					
				△	— 0.00584

[*p*] = 38; *log* [*pvv*] = 6.7298

p. e. = ± 0.00053

Star No. 959.—(With 282 *l. c.*)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	3.04492	3.04068	— 0.00424	4½	— 0.01908
8	3.04160	3.03886	— 274	3½	— 959
9	3.03783	3.03050	— 733	3	— 2199
12	3.05008	3.04703	— 305	1	— 305
13					
14	3.03714	3.03633	— 81	3	— 243
19	3.05165	3.04787	— 378	3	— 1134
21	3.04205	3.03741	— 464	4	— 1856
22	3.03782	3.03645	— 137	3½	— 479
27	3.04138	3.03717	— 421	5	— 2105
28	3.04032	3.03228	— 804	2½	— 2010
29	3.03986	3.03043	— 943	3	— 2829
30	3.03983	3.03611	— 372	4½	— 1674
July 3					
4	3.03667	3.03112	— 555	5	— 2775
5	3.04442	3.03910	— 532	3½	— 1862
6	3.04920	3.04347	— 573	2½	— 1432
				△	— 0.00462

[*p*] = 51½ ; *log* [*pvv*] = 6.3662

p. e. = ± 0.00027

Star No. 968.

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	1.45651	1.46180	+ 0.00529	4	+ 0.02116
8	1.45383	1.46553	+ 1170	4	+ 4680
9	1.45149	1.45637	+ 488	3	+ 1464
12	1.45985	1.46790	+ 805	1	+ 805
13	1.45614	1.46225	+ 611	1½	+ 916
14	1.45172	1.45758	+ 586	3	+ 1758
19	1.46276	1.46879	+ 603	3	+ 1809
21	1.45485	1.46374	+ 889	3½	+ 3111
22	1.45181	1.46120	+ 939	3½	+ 3286
27	1.45453	1.45652	+ 199	5	+ 995
28	1.45407	1.46060	+ 653	2½	+ 1632
29	1.45340	1.45984	+ 644	3½	+ 2254
30					
July 2	1.44653	1.45347	+ 694	3	+ 2082
4	1.45114	1.45408	+ 294	5	+ 1470
5	1.45656	1.46835	+ 1179	3	+ 3537
6	1.46066	1.46850	+ 784	1½	+ 1176
				△	+ 0.00662

[*p*] = 50 ; *log* [*pvv*] = 6.6307

p. e. = ± 0.00036

STAR NO. 977.

Date	log. r′	log. r	△	p	p △
June 7	1.28488	1.28488	± 0.00000	4	± 0.00000
8	1.28218	1.28892	+ 674	4	+ 2696
9	1.28019	1.28126	+ 107	3	+ 321
12	1.28796	1.29270	+ 474	1	+ 474
13	1.28439	1.29491	+ 1052	1½	+ 1578
14	1.28022	1.29092	+ 1070	3	+ 3210
19	1.29163	1.29336	+ 173	3	+ 519
21	1.28336	1.28758	+ 422	3½	+ 1477
22	1.28043	1.28149	+ 106	3½	+ 371
27	1.28302	1.28758	+ 456	5	+ 2280
28	1.28288	1.28533	+ 245	2½	+ 612
29	1.28206	1.28691	+ 485	3½	+ 1697
30	1.28204	1.28648	+ 444	4	+ 1776
July 3	1.27518	1.28171	+ 653	3	+ 1959
4	1.28003	1.28758	+ 755	5	+ 3775
5	1.28512	1.29623	+ 1111	3	+ 3333
6	1.28948	1.28870	— 78	2	— 156
				△	+ 0.00476

[p] = 54½ ; *log* [pvv] = 6.7951

p. e. = ± 0.00040

STAR NO. 984.

Date	log. r′	log. r	△	p	p △
June 7					
8					
9					
12	2.35626	2.35199	— 0.00427	1	— 0.00427
13	2.35336	2.35114	— 222	2½	— 555
14	2.34902	2.34616	— 286	3	— 858
19	2.36071	2.35971	— 100	3	— 300
21	2.35175	2.35042	— 133	3	— 399
22	2.34937	2.34805	— 132	3½	— 462
27	2.35175	2.34951	— 224	5	— 1120
28	2.35162	2.35176	+ 14	2	+ 28
29	2.35060	2.34874	— 186	4	— 744
30					
July 3	2.34417	2.34616	+ 199	3	+ 597
4	2.34844	2.34713	— 131	5	— 655
5	2.35414	2.35319	— 95	3	— 285
6	2.35871	2.35581	— 290	1½	— 435
				△	— 0.00142

[p] = 39½ ; *log* [pvv] = 5.8091

p. e. = ± 0.00017

STAR NO. 225 *l. c.*—(With 948.)

Date	log. r′	log. r	△	p	p △
June 7	2.41352	2.41224	— 0.00128	4	— 0.00512
8	2.41100	2.40812	— 288	4	— 1152
9	2.40895	2.40523	— 372	3	— 1116
12	2.41618	2.41237	— 381	1	— 381
13	2.41359	2.41187	— 172	2	— 344
14	2.40930	2.40591	— 339	3	— 1017
19	2.42102	2.41769	— 333	3	— 999
21	2.41181	2.40880	— 301	4	— 1204
22	2.40967	2.40858	— 109	3½	— 381
27	2.41188	2.40966	— 222	5	— 1110
28	2.41175	2.41007	— 168	2½	— 420
29	2.41072	2.40815	— 257	3½	— 899
30					
July 3	2.40463	2.40542	+ 79	2½	+ 197
4	2.40845	2.40741	— 104	5	— 520
5	2.41441	2.41400	— 41	3	— 123
6	2.41907	2.41457	— 450	1½	— 675
				△	— 0.00211

[*p*] = 50½ ; *log* [*pvv*] = 5.8809

p. e. = ± 0.00015

STAR NO. 225 *l. c.*—(With 984.)

Date	log. r′	log. r	△	p	p △
June 7					
8					
9					
12	2.41618	2.41246	— 0.00372	1	— 0.00372
13	2.41359	2.41165	— 194	2½	— 485
14	2.40930	2.40678	— 252	3	— 756
19	2.42102	2.42014	— 88	3	— 264
21	2.41181	2.41066	— 115	3	— 345
22	2.40967	2.40849	— 118	3½	— 413
27	2.41188	2.40983	— 205	5	— 1025
28	2.41175	2.41186	+ 11	2	+ 22
29	2.41072	2.40914	— 158	4	— 632
30					
July 3	2.40463	2.40637	+ 174	3	+ 522
4	2.40845	2.40729	— 116	5	— 580
5	2.41441	2.41357	— 84	3	— 252
6	2.41907	2.41652	— 255	1½	— 382
				△	— 0.00126

[*p*] = 39½ ; *log* [*pvv*] = 5.6934

p. e. = ± 0.00015

STAR NO. 225 *l. c.*—(With 1135.)

Date	log. r′	log. r	△	p	p △
June 7	2.41352	2.41299	— 0.00053	4½	— 0.00238
8	2.41100	2.40928	— 172	4	— 688
9	2.40895	2.40601	— 294	3	— 882
12	2.41618	2.41416	— 202	1	— 202
13	2.41359	2.41105	— 254	2	— 508
14	2.40930	2.40724	— 206	3	— 618
19	2.42102	2.41858	— 244	3	— 732
21	2.41181	2.41100	— 81	4	— 324
22	2.40967	2.40882	— 85	4	— 340
27	2.41188	2.40981	— 207	5	— 1035
28	2.41175	2.41100	— 75	2½	— 187
29	2.41072	2.40744	— 328	4	— 1312
30					
July 3	2.40463	2.40488	+ 25	3	+ 75
4	2.40845	2.40691	— 154	5	— 770
5	2.41441	2.41437	— 4	3½	— 14
6	2.41907	2.41547	— 360	2	— 720
				△	— 0.00159

[*p*] = 53½ ; *log* [*pvv*] = 5.7856

p. e. = ± 0.00013

STAR NO. 997.

Date	log. r′	log. r	△	p	p △
June 7	1.45932	1.46479	+ 0.00547	4	+ 0.02188
8	1.45705	1.46879	+ 1174	4	+ 4696
9	1.45504	1.45969	+ 465	3	+ 1395
12	1.46180	1.46967	+ 787	1	+ 787
13	1.45953	1.46553	+ 600	1½	+ 900
14	1.45544	1.46120	+ 576	3	+ 1728
19	1.46676	1.47261	+ 585	3	+ 1755
21	1.45774	1.46642	+ 868	3½	+ 3038
22	1.45588	1.46509	+ 921	3½	+ 3223
27	1.45791	1.45984	+ 193	5	+ 965
28	1.45782	1.46419	+ 637	2½	+ 1592
29	1.45671	1.46315	+ 644	3½	+ 2254
30					
July 3	1.45099	1.45773	+ 674	3	+ 2022
4	1.45436	1.45712	+ 276	5	+ 1380
5	1.46049	1.47217	+ 1168	3	+ 3504
6	1.46492	1.47261	+ 769	1½	+ 1153
				△	+ 0.00652

[*p*] = 50 ; *log* [*pvv*] = 6.6325

p. e. = ± 0.00036

Star No. 1005.—(With 264 *l. c.*)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	1.87711	1.87518	— 0.00193	4	— 0.00772
8	1.87496	1.87186	— 310	4	— 1240
9	1.87269	1.86700	— 569	3	— 1707
12	1.87989	1.87697	— 292	1	— 292
13	1.87719	1.87361	— 358	2	— 716
14	1.87307	1.87454	+ 147	3	+ 441
19	1.88455	1.88138	— 317	3	— 951
21	1.87581	1.87233	— 348	4	— 1392
22	1.87378	1.86964	— 414	4	— 1656
27	1.87582	1.87489	— 93	5	— 465
28	1.87565	1.87093	— 472	2	— 944
29	1.87436	1.87256	— 180	4	— 720
30	1.87545	1.87489	— 56	4	— 224
July 3	1.86915	1.86847	— 68	3	— 204
4	1.87220	1.87157	— 63	5	— 315
5	1.87863	1.87823	— 40	3	— 120
6	1.88269	1.87881	— 388	2	— 776
				△	— 0.00215

[*p*] = 56 ; *log* [*pvv*] = 6.2452

p. e. = ± 0.00021

Star No. 1005.—(With 356 *l. c.*)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7					
8					
9	1.87269	1.87233	— 0.00036	3	— 0.00108
12	1.87989	1.87800	— 189	1	— 189
13	1.87719	1.87547	— 172	2½	— 430
14	1.87307	1.87355	+ 48	3	+ 144
19	1.88455	1.88502	+ 47	3	+ 141
21	1.87581	1.87413	— 168	4	— 672
22	1.87378	1.87268	— 110	4	— 440
27	1.87582	1.87743	+ 161	5	+ 805
28	1.87565	1.87425	— 140	2	— 280
29	1.87436	1.87512	+ 76	4	+ 304
30	1.87545	1.87714	+ 169	4	+ 676
July 3	1.86915	1.86788	— 127	3	— 381
4	1.87220	1.87326	+ 106	5	+ 530
5	1.87863	1.87547	— 316	3½	— 1106
6	1.88269	1.88064	— 205	2½	— 512
				△	— 0.00031

[*p*] = 49½ ; *log* [*pvv*] = 6.0442

p. e. = ± 0.00019

STAR NO. 1009.

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	1.27967	1.27600	— 0.00367	4	— 0.01468
8	1.27759	1.28149	+ 390	4	+ 1560
9	1.27515	1.28149	+ 634	3	+ 1902
12	1.28250	1.28240	— 10	1	— 10
13	1.27963	1.28307	+ 344	2	+ 688
14	1.27547	1.28262	+ 715	3	+ 2145
19	1.28706	1.28825	+ 119	3	+ 357
21	1.27843	1.27989	+ 146	4	+ 584
22	1.27648	1.27346	— 302	4	— 1208
27	1.27834	1.28511	+ 677	5	+ 3385
28	1.27819	1.28126	+ 307	2	+ 614
29	1.27674	1.28149	+ 475	4	+ 1900
30	1.27815	1.28375	+ 560	4	+ 2240
July 3	1.27187	1.27300	+ 113	3	+ 339
4	1.27473	1.27807	+ 334	5	+ 1670
5	1.28132	1.28466	+ 334	3	+ 1002
6	1.28519	1.29003	+ 484	2	+ 968
				△	+ 0.00298

[*p*] = 56 ; *log* [*pvv*] = 6.7629

p. e. = ± 0.00038

Star No. 1019—(With 977.)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	1.28286	1.28307	+ 0.00021	4	+ 0.00084
8	1.28075	1.28758	+ 683	4	+ 2732
9	1.27851	1.27987	+ 136	3	+ 408
12	1.28578	1.29048	+ 470	1	+ 470
13	1.28283	1.29358	+ 1075	1½	+ 1612
14	1.27867	1.28959	+ 1092	3	+ 3276
19	1.29036	1.29203	+ 167	3	+ 501
21	1.28165	1.28623	+ 458	3½	+ 1603
22	1.27970	1.28103	+ 133	3½	+ 465
27	1.28158	1.28623	+ 465	5	+ 2325
28	1.28158	1.28398	+ 240	2½	+ 600
29	1.27989	1.28466	+ 477	3½	+ 1669
30	1.28139	1.28601	+ 462	4	+ 1848
July 3	1.27536	1.28171	+ 635	3	+ 1905
4	1.27798	1.28578	+ 780	5	+ 3900
5	1.28468	1.29579	+ 1111	3	+ 3333
6	1.28837	1.28780	— 57	2	— 114
				△	+ 0.00488

[*p*] = 54½ ; *log* [*pvv*] = 6.7903

p. e. = ± 0.00040

STAR NO. 1019—(With 1009.)

Date	*log. r′*	*log. r*	△	*p*	*p* △
June 7	1.28286	1.27921	— 0.00365	4	— 0.01460
8	1.28075	1.28466	+ 391	4	+ 1564
9	1.27851	1.28466	+ 615	3	+ 1845
12	1.28578	1.28556	— 22	1	— 22
13	1.28283	1.28623	+ 340	2	+ 680
14	1.27867	1.28578	+ 711	3	+ 2133
19	1.29036	1.29137	+ 101	3	+ 303
21	1.28165	1.28307	+ 142	4	+ 568
22	1.27970	1.27669	— 301	4	— 1204
27	1.28158	1.28825	+ 667	5	+ 3335
28	1.28158	1.28443	+ 285	2	+ 570
29	1.27989	1.28466	+ 477	4	+ 1908
30	1.28139	1.28691	+ 552	4	+ 2208
July 3	1.27536	1.27623	+ 87	3	+ 261
4	1.27798	1.28126	+ 328	5	+ 1640
5	1.28468	1.28780	+ 312	3	+ 936
6	1.28837	1.29314	+ 477	2	+ 954
				△	+ 0.00290

$[p] = 56$; $log\ [pvv] = 6.7654$

p. e. = ± 0.00038

STAR NO. 264 *l. c.*

Date	*log. r′*	*log. r*	△	*p*	*p* △
June 7	1.87981	1.87783	— 0.00198	4	— 0.00792
8	1.87779	1.87466	— 313	4	— 1252
9	1.87564	1.86994	— 570	3	— 1710
12	1.88285	1.87996	— 289	1	— 289
13	1.87988	1.87628	— 360	2	— 720
14	1.87560	1.87697	+ 137	3	+ 411
19	1.88743	1.88423	— 320	3	— 960
21	1.87852	1.87500	— 352	4	— 1408
22	1.87657	1.87245	— 412	4	— 1648
27	1.87853	1.87754	— 99	5	— 495
28	1.87878	1.87408	— 470	2	— 940
29	1.87673	1.87489	— 184	4	— 736
30	1.87825	1.87766	— 59	4	— 236
July 3	1.87237	1.87163	— 74	3	— 222
4	1.87492	1.87425	— 67	5	— 335
5	1.88164	1.88121	— 43	3	— 129
6	1.88517	1.88133	— 384	2	— 768
				△	— 0.00218

$[p] = 56$; $log\ [pvv] = 6.2338$

p. e. = ± 0.00020

STAR NO. 1032.

Date	log. r′	log. r	△	p	p △
June 7					
8					
9					
12					
13	2.85820	2.86091	+ 0.00271	1	+ 0.00271
14	2.85280	2.85044	— 236	3½	— 826
19	2.86657	2.86178	— 479	3	— 1437
21	2.85637	2.85442	— 195	4	— 780
22	2.85411	2.85258	— 153	4	— 612
27	2.85620	2.85429	— 191	5	— 955
28	2.85690	2.85286	— 404	2½	— 1010
29	2.85421	2.84821	— 600	3½	— 2100
30	2.85600	2.84956	— 644	4	— 2576
July 3	2.84957	2.84596	— 361	3	— 1083
4	2.85239	2.85174	— 65	4½	— 292
5	2.86022	2.85728	— 294	4	— 1176
6	2.86417	2.85807	— 610	2½	— 1525
				△	— 0.00317

[*p*] = 44½ ; *log* [*pvv*] = 6.2854

p. e. = ± 0.00029

STAR NO. 282 *l. c.*

Date	log. r′	log. r	△	p	p △
June 7	3.03250	3.02825	— 0.00425	4½	— 0.01912
8	3.02963	3.02682	— 281	3½	— 983
9	3.02804	3.02054	— 750	3	— 2250
12	3.03690	3.03376	— 314	1	— 314
13					
14	3.02661	3.02556	— 105	3	— 315
19	3.04241	3.03855	— 386	3	— 1158
21	3.03063	3.02586	— 477	4	— 1908
22	3.02814	3.02674	— 140	3½	— 490
27	3.03018	3.02586	— 432	5	— 2160
28	3.03140	3.02319	— 821	2½	— 2052
29	3.02815	3.01847	— 968	3	— 2904
30	3.02989	3.02608	— 381	4½	— 1714
July 3					
4	3.02636	3.02069	— 567	5	— 2835
5	3.03511	3.02968	— 543	3½	— 1900
6	3.03907	3.03320	— 587	2½	— 1467
				△	— 0.00473

[*p*] = 51½ ; *log* [*pvv*] = 6.3770

p. e. = ± 0.00027

STAR NO. 1084.

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	1.40959	1.41263	+ 0.00304	5	+ 0.01520
8	1.40788	1.40157	— 631	4	— 2524
9	1.40678	1.40790	+ 112	3	+ 336
12	1.41235	1.41162	— 73	1	— 73
13	1.41026	1.41145	+ 119	2	+ 238
14	1.40551	1.40381	— 170	3	— 510
19	1.41774	1.41681	— 93	3	— 279
21	1.40831	1.40976	+ 145	4	+ 1256
22	1.40704	1.40432	— 272	4	— 1088
27	1.40883	1.40926	+ 43	5	+ 215
28	1.40783	1.40892	+ 109	2	+ 218
29	1.40587	1.40500	— 87	3	— 261
30	1.40780	1.41010	+ 230	4	+ 920
July 3	1.40181	1.39863	— 318	3	— 954
4	1.40565	1.40552	— 13	5	— 65
5	1.41159	1.40449	— 710	4	— 2840
6	1.41433	1.40993	— 440	3	— 1320
				△	— 0.00101

[*p*] = 58 ; *log* [*pvv*] = 6.7152

p. e. = ± 0.00035

STAR NO. 1094.

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	1.42207	1.42488	+ 0.00281	5	+ 0.01405
8	1.42036	1.41414	— 622	4	— 2488
9	1.41943	1.42062	+ 119	3	+ 357
12	1.42492	1.42423	— 69	1	— 69
13	1.42275	1.42374	+ 99	2	+ 198
14	1.41809	1.41631	— 178	3	— 534
19	1.43008	1.42894	— 114	3	— 342
21	1.42082	1.42210	+ 128	4	+ 512
22	1.41979	1.41714	— 265	4	— 1060
27	1.42185	1.42226	+ 41	5	+ 205
28	1.41995	1.42095	+ 100	2	+ 200
29	1.41807	1.41714	— 93	3	— 279
30	1.42033	1.42243	+ 210	4	+ 840
July 3	1.41401	1.41095	— 306	3	— 918
4	1.41844	1.41830	— 14	5	— 70
5	1.42416	1.41731	— 685	4	— 2740
6	1.42679	1.42259	— 420	3	— 1260
				△	— 0.00104

[*p*] = 58 ; *log* [*pvv*] = 6.6817

p. e. = ± 0.00034

STAR NO. 1105.

Date	*log. r′*	*log. r*	△	*p*	*p* △
June 7					
8					
9	1.96122	1.95861	− 0.00261	3½	− 0.00913
12					
13	1.96464	1.96209	− 255	2	− 510
14	1.96010	1.96468	+ 458	3½	+ 1603
19	1.97190	1.97257	+ 67	3	+ 201
21	1.96285	1.96137	− 148	4	− 592
22	1.96173	1.96114	− 59	4	− 236
27	1.96404	1.96161	− 243	5	− 1215
28	1.96169	1.96223	+ 54	3	+ 162
29	1.95990	1.95985	− 5	3	− 15
30	1.96218	1.96142	− 76	4½	− 342
July 3	1.95599	1.95650	+ 51	3	+ 153
4	1.96028	1.96099	+ 71	5	+ 355
5	1.96610	1.96577	− 33	4	− 132
6	1.96874	1.96876	+ 2	3	+ 6
				△	− 0.00029

$[p] = 50½$; *log* $[pvv] = 6.1881$

p. e. = ± 0.00023

STAR NO. 1110.

Date	*log. r′*	*log. r*	△	*p*	*p* △
June 7	2.05864	2.05998	+ 0.00134	5	+ 0.00670
8	2.05683	2.05790	+ 107	4	+ 428
9	2.05574	2.05342	− 232	3	− 696
12	2.06194	2.06017	− 177	1	− 177
13	2.05916	2.05888	− 28	1	− 28
14	2.05485	2.05778	+ 293	3	+ 879
19	2.06659	2.06446	− 213	3	− 639
21	2.05744	2.05637	− 107	4	− 428
22	2.05644	2.05319	− 325	4	− 1300
27	2.05892	2.05775	− 117	5	− 585
28	2.05622	2.05599	− 23	2	− 46
29	2.05450	2.05385	− 65	4	− 260
30	2.05679	2.05427	− 252	4½	− 1134
July 3	2.05066	2.04895	− 171	2½	− 427
4	2.05488	2.05484	− 4	5	− 20
5	2.06079	2.05964	− 115	4	− 460
6	2.06344	2.06119	− 225	3	− 675
				△	− 0.00084

$[p] = 58$; *log* $[pvv] = 6.1535$

p. e. = ± 0.00018

Star No. 349 *l. c.*

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	2.07053	2.07177	+ 0.00124	5	+ 0.00620
8	2.06871	2.06974	+ 103	4	+ 412
9	2.06761	2.06539	— 222	3	— 666
12	2.07385	2.07210	— 175	1	— 175
13	2.07104	2.07078	— 26	1	— 26
14	2.06690	2.06971	+ 281	3	+ 843
19	2.07824	2.07613	— 211	3	— 633
21	2.06933	2.06826	— 107	4	— 428
22	2.06834	2.06517	— 317	4	— 1268
27	2.07091	2.06974	— 117	5	— 585
28	2.06804	2.06781	— 23	2	— 46
29	2.06647	2.06580	— 67	4	— 268
30	2.06870	2.06622	— 248	4½	— 1116
July 3	2.06268	2.06104	— 164	2½	— 410
4	2.06687	2.06685	— 2	5	— 10
5	2.07272	2.07159	— 113	4	— 452
6	2.07535	2.07316	— 219	3	— 657
				△	— 0.00084

[*p*] = 58 ; *log* [*pvv*] = 6.1255

p. e. = ± 0.00018

Star No. 356 *l. c.*

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7					
8					
9	1.87922	1.87881	— 0.00041	3	— 0.00123
12	1.88536	1.88349	— 187	1	— 187
13	1.88248	1.88076	— 172	2½	— 430
14	1.87854	1.87898	+ 44	3	+ 132
19	1.88965	1.89009	+ 44	3	+ 132
21	1.88077	1.87910	— 167	4	— 668
22	1.87968	1.87858	— 110	4	— 440
27	1.88234	1.88395	+ 161	5	+ 805
28	1.87948	1.87806	— 142	2	— 284
29	1.87811	1.87881	+ 70	4	+ 280
30	1.88005	1.88173	+ 168	4	+ 672
July 3	1.87414	1.87280	— 134	3	— 402
4	1.87840	1.87938	+ 98	5	+ 490
5	1.88413	1.88098	— 315	3½	— 1102
6	1.88677	1.88474	— 203	2½	— 507
				△	— 0.00033

[*p*] = 49½ ; *log* [*pvv*] = 6.0359

p. e. = ± 0.00019

STAR NO. 1135.

Date	log. r′	log. r	△	p	p △
June 7	2.32700	2.32638	— 0.00062	4½	— 0.00279
8	2.32535	2.32327	— 208	4	— 832
9	2.32443	2.32087	— 356	3	— 1068
12	2.33060	2.32816	— 244	1	— 244
13	2.32766	2.32457	— 309	2	— 618
14	2.32400	2.32149	— 251	3	— 753
19	2.33465	2.33169	— 296	3	— 888
21	2.32578	2.32479	— 99	4	— 396
22	2.32463	2.32362	— 101	4	— 404
27	2.32747	2.32496	— 251	5	— 1255
28	2.32461	2.32368	— 93	2½	— 232
29	2.32347	2.31946	— 401	4	— 1604
30					
July 3	2.31931	2.31962	+ 31	3	+ 93
4	2.32378	2.32193	— 185	5	— 925
5	2.32932	2.32927	— 5	3½	— 17
6	2.33200	2.32760	— 440	2	— 880
				△	— 0.00193

[p] = 53½ ; log [pvv] = 5.9589

p. e. = ± 0.00016

STAR NO. 377 l. c.—(With 1032.)

Date	log. r′	log. r	△	p	p △
June 7					
8					
9					
12					
13	2.83400	2.83705	+ 0.00305	1	+ 0.00305
14	2.82985	2.82736	— 249	3½	— 871
19	2.84207	2.83701	— 506	3	— 1518
21	2.83180	2.82974	— 206	4	— 824
22	2.83075	2.82914	— 161	4	— 644
27	2.83356	2.83148	— 208	5	— 1040
28	2.83035	2.82600	— 435	2½	— 1087
29	2.82931	2.82296	— 635	3½	— 2222
30	2.83107	2.82425	— 682	4	— 2728
July 3	2.82480	2.82096	— 384	3	— 1152
4	2.82968	2.82900	— 68	4½	— 306
5	2.83608	2.83298	— 310	4	— 1240
6	2.83912	2.83265	— 647	2½	— 1617
				△	— 0.00336

[p] = 44½ ; log [pvv] = 6.2716

p. e. = ± 0.00028

Star No. 377 *l. c.*—(With 1156.)

Date	*log. r′*	*log. r*	△	*p*	*p* △
June 7	2.83328	2.83115	− 0.00213	5	− 0.01065
8	2.83152	2.82838	− 314	4	− 1256
9	2.83045	2.82720	− 325	3	− 975
12					
13	2.83400	2.83306	− 94	½	− 47
14	2.82985	2.82607	− 378	3½	− 1323
19	2.84207	2.83464	− 743	3	− 2229
21	2.83180	2.83048	− 132	4	− 528
22	2.83075	2.82840	− 235	4	− 940
27	2.83356	2.83081	− 275	5	− 1375
28	2.83035	2.82647	− 388	3	− 1164
29	2.82931	2.82312	− 619	4	− 2476
30	2.83107	2.82833	− 274	4	− 1096
July 3	2.82480	2.82124	− 356	3	− 1068
4	2.82968	2.82730	− 238	5	− 1190
5	2.83608	2.83239	− 369	3½	− 1291
6	2.83912	2.83502	− 410	2½	− 1025
				△	− 0.00334

[*p*] = 57 ; *log* [*pvv*] = 6.0815

p. e. = ± 0.00018

Star No. 1156.

Date	*log. r′*	*log. r*	△	*p*	*p* △
June 7	2.87524	2.87330	− 0.00194	5	− 0.00970
8	2.87296	2.87010	− 286	4	− 1144
9	2.87172	2.86876	− 296	3	− 888
12					
13	2.87557	2.87471	− 86	½	− 43
14	2.87138	2.86795	− 343	3½	− 1200
19	2.88372	2.87698	− 674	3	− 2022
21	2.87302	2.87182	− 120	4	− 480
22	2.87193	2.86980	− 213	4	− 852
27	2.87448	2.87197	− 251	5	− 1255
28	2.87189	2.86837	− 352	3	− 1056
29	2.87078	2.86516	− 562	4	− 2248
30	2.87246	2.86996	− 250	4	− 1000
July 3	2.86594	2.86271	− 323	3	− 969
4	2.87134	2.86918	− 216	5	− 1080
5	2.87773	2.87437	− 336	3½	− 1176
6	2.88028	2.87655	− 373	2½	− 933
				△	− 0.00304

[*p*] = 57 ; *log* [*pvv*] = 6.0105

p. e. = ± 0.00016

STAR NO. 1162.—(With 406 *l. c.*)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7					
8					
9	2.57666	2.57349	— 0.00317	3½	— 0.01109
12					
13	2.57998	2.57897	— 101	½	— 50
14	2.57649	2.57339	— 310	3½	— 1085
19	2.58742	2.58196	— 546	3	— 1638
21	2.57789	2.57491	— 298	4	— 1192
22	2.57681	2.57474	— 207	4	— 828
27	2.57924	2.57728	— 196	5	— 980
28	2.57699	2.57364	— 335	3½	— 1173
29	2.57604	2.57302	— 302	4	— 1208
30	2.57739	2.57226	— 513	4	— 2052
July 3	2.57156	2.56791	— 365	3½	— 1277
4	2.57727	2.57417	— 310	5	— 1550
5	2.58212	2.58006	— 206	3½	— 721
6	2.58448	2.57905	— 543	3	— 1629
				△	— 0.00330

[*p*] = 50 ; *log* [*pvv*] = 5.8169

p. e. = ± 0.00015

STAR NO. 1162—(With 444 *l. c.*)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7					
8					
9	2.57666	2.57219	— 0.00447	3½	— 0.01564
12					
13	2.57998	2.57648	— 350	½	— 175
14	2.57649	2.57545	— 104	2½	— 260
19	2.58742	2.58178	— 564	3	— 1692
21	2.57789	2.57518	— 271	4	— 1084
22	2.57681	2.57583	— 98	4	— 392
27	2.57924	2.57694	— 230	5	— 1150
28	2.57699	2.57306	— 393	4	— 1572
29	2.57604	2.57358	— 246	3½	— 861
30	2.57739	2.57309	— 430	4	— 1720
July 3	2.57156	2.56904	— 252	3	— 756
4	2.57727	2.57438	— 289	5	— 1445
5	2.58212	2.58035	— 177	3½	— 619
6	2.58448	2.58043	— 405	2	— 810
				△	— 0.00297

[*p*] = 47½ ; *log* [*pvv*] = 5.8851

p. e. ± 0.00017

STAR NO. 406 *l. c.*—(With 1162.)

Date	*log. r′*	*log. r*	△	*p*	*p* △
June 7					
8					
9	2.59357	2.59052	— 0.00305	3½	— 0.01067
12					
13	2.59683	2.59586	— 97	½	— 49
14	2.59350	2.59052	— 298	3½	— 1043
19	2.60425	2.59900	— 525	3	— 1575
21	2.59477	2.59191	— 286	4	— 1144
22	2.59366	2.59165	— 201	4	— 804
27	2.59602	2.59413	— 189	5	— 945
28	2.59420	2.59097	— 323	3½	— 1130
29	2.59315	2.59022	— 293	4	— 1172
30	2.59432	2.58939	— 493	4	— 1972
July 3	2.58842	2.58491	— 351	3½	— 1229
4	2.59297	2.58997	— 300	5	— 1500
5	2.59909	2.59711	— 198	3½	— 693
6	2.60148	2.59625	— 523	3	— 1569
				△	— 0.00318

[*p*] = 50 ; *log* [*pvv*] = 5.7810

p. e. = ± 0.00015

STAR NO. 406 *l. c.*—(With 1179.)

Date	*log. r′*	*log. r*	△	*p*	*p* △
June 7	2.59730	2.59537	— 0.00193	4	— 0.00772
8	2.59456	2.59219	— 237	4	— 948
9	2.59357	2.59002	— 355	4	— 1420
12					
13	2.59683	2.59691	+ 8	½	+ 4
14	2.59350	2.59039	— 311	4	— 1244
19	2.60425	2.60003	— 422	3	— 1266
21	2.59477	2.59104	— 373	4	— 1492
22	2.59366	2.59077	— 289	4	— 1156
27	2.59602	2.59413	— 189	5	— 945
28	2.59420	2.59084	— 336	3½	— 1176
29	2.59315	2.59041	— 274	3½	— 959
30	2.59432	2.59002	— 430	3½	— 1505
July 3	2.58842	2.58574	— 268	3½	— 938
4	2.59297	2.59112	— 185	4½	— 832
5	2.59909	2.59686	— 223	4	— 892
6	2.60148	2.59683	— 465	3	— 1395
				△	— 0.00292

[*p*] = 58 ; *log* [*pvv*] = 5.6978

p. e. = ± 0.00011

STAR NO. 1179.—(With 406 *l. c.*)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	2.58409	2.58211	— 0.00198	4	— 0.00792
8	2.58167	2.57922	— 245	4	— 980
9	2.57955	2.57590	— 365	4	— 1460
12					
13	2.58282	2.58290	+ 8	½	+ 4
14	2.57953	2.57633	— 320	4	— 1280
19	2.59007	2.58573	— 434	3	— 1302
21	2.58069	2.57682	— 387	4	— 1548
22	2.57955	2.57657	— 298	4	— 1192
27	2.58185	2.57990	— 195	5	— 975
28	2.58049	2.57703	— 346	3½	— 1211
29	2.57918	2.57635	— 283	3½	— 991
30	2.58015	2.57569	— 446	3½	— 1561
July 3	2.57417	2.57142	— 275	3½	— 962
4	2.57852	2.57661	— 191	4½	— 860
5	2.58493	2.58263	— 230	4	— 920
6	2.58735	2.58255	— 480	3	— 1440
				△	— 0.00301

[*p.*] = 58 ; *log* [*pvv*] = 5.7112

p. e. = ± 0.00011

STAR NO. 1179—(With 444 *l. c.*)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	2.58409	2.58351	— 0.00058	3	— 0.00174
8	2.58167	2.57807	— 360	4	— 1440
9	2.57955	2.57462	— 493	4	— 1972
12					
13	2.58282	2.58043	— 239	½	— 119
14	2.57953	2.57837	— 116	3	— 348
19	2.59007	2.58554	— 453	3	— 1359
21	2.58069	2.57709	— 360	4	— 1440
22	2.57955	2.57766	— 189	4	— 756
27	2.58185	2.57956	— 229	5	— 1145
28	2.58049	2.57646	— 403	4	— 1612
29	2.57918	2.57692	— 226	3	— 678
30	2.58015	2.57654	— 361	3½	— 1264
July 3	2.57417	2.57254	— 163	3	— 489
4	2.57852	2.57681	— 171	4½	— 769
5	2.58493	2.58293	— 200	4	— 800
6	2.58735	2.58392	— 343	2	— 686
				△	— 0.00276

[*p*] = 54½ ; *log* [*pvv*] = 5.9125

p. e. = ± 0.00015

STAR NO. 1182.

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	1.97645	1.97543	— 0.00102	3	— 0.00306
8	1.97288	1.97230	— 58	4	— 232
9	1.97180	1.96923	— 257	4	— 1028
12					
13	1.97496	1.97520	+ 24	2½	+ 60
14	1.97208	1.97690	+ 482	4	+ 1928
19	1.98178	1.98268	+ 90	3	+ 270
21	1.97296	1.97359	+ 63	4	+ 252
22	1.97167	1.97248	+ 81	4	+ 324
27	1.97413	1.97382	— 31	5	— 155
28	1.97291	1.97313	+ 22	4	+ 88
29	1.97153	1.97179	+ 26	3	+ 78
30	1.97242	1.97128	— 114	3½	— 399
July 3	1.96655	1.96918	+ 263	3	+ 789
4	1.97073	1.97058	— 15	5	— 75
5	1.97694	1.97520	— 174	4	— 696
6	1.97923	1.97855	— 68	3	— 204
				△	+ 0.00012

[*p*] = 59; *log* [*pvv*] = 6.2272

p. e. = ± 0.00020

STAR NO. 424 *l. c.*—(With 1105.)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7					
8					
9	1.97474	1.97216	— 0.00258	3½	— 0.00903
12					
13	1.97816	1.97571	— 245	2	— 490
14	1.97502	1.97941	+ 439	3½	+ 1536
19	1.98471	1.98534	+ 63	3	+ 180
21	1.97609	1.97465	— 144	4	— 576
22	1.97473	1.97414	— 59	4	— 236
27	1.97727	1.97488	— 239	5	— 1195
28	1.97613	1.97658	+ 45	3	+ 135
29	1.97468	1.97465	— 3	3	— 9
30	1.97549	1.97470	— 79	4½	— 356
July 3	1.96971	1.97021	+ 50	3	+ 150
4	1.97371	1.97437	+ 66	5	+ 330
5	1.98000	1.97964	— 36	4	— 144
6	1.98238	1.98236	— 2	3	— 6
				△	— 0.00031

[*p*] = 50½ ; *log* [*pvv*] = 6.1588

p. e. = ± 0.00022

STAR NO. 424 *l. c.*--(With 1182.)

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	1.97982	1.97882	— 0.00100	3	— 0.00300
8	1.97599	1.97534	— 65	4	— 260
9	1.97474	1.97220	— 254	4	— 1016
12					
13	1.97816	1.97841	+ 25	2½	+ 62
14	1.97502	1.97982	+ 480	4	+ 1920
19	1.98471	1.98556	+ 85	3	+ 255
21	1.97609	1.97672	+ 63	4	+ 252
22	1.97473	1.97552	+ 79	4	+ 316
27	1.97727	1.97695	— 32	5	— 160
28	1.97613	1.97635	+ 22	4	+ 88
29	1.97468	1.97493	+ 25	3	+ 75
30	1.97549	1.97433	— 116	3½	— 406
July 3	1.96971	1.97225	+ 254	3	+ 762
4	1.97371	1.97354	— 17	5	— 85
5	1.98000	1.97823	— 177	4	— 708
6	1.98238	1.98164	— 74	3	— 222
				△	+ 0.00010

[*p*] = 59 ; *log* [*pvv*] = 6.2248

p. e. = ± 0.00020

STAR NO. 438 *l. c.*

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	2.02896	2.02882	— 0.00014	3	— 0.00042
8	2.02529	2.02288	— 241	4	— 964
9	2.02369	2.02263	— 106	4	— 424
12					
13	2.02753	2.02727	— 26	1½	— 39
14	2.02398	2.02841	+ 443	2½	+ 1107
19	2.03351	2.03234	— 117	3	— 351
21	2.02530	2.02690	+ 160	4	+ 640
22	2.02385	2.02420	+ 35	4	+ 140
27	2.02640	2.02592	— 48	5	— 240
28	2.02535	2.02702	+ 167	4	+ 668
29	2.02403	2.02415	+ 12	3½	+ 42
30	2.02436	2.02547	+ 111	4	+ 444
July 3	2.01900	2.02057	+ 157	3	+ 471
4	2.02276	2.02333	+ 57	5	+ 285
5	2.02915	2.02958	+ 43	4	+ 172
6	2.03160	2.03338	+ 178	2	+ 356
				△	+ 0.00040

[*p*] = 56½ ; *log* [*pvv*] = 6.0647

p. e. = ± 0.00017

Star No. 444 *l. c.*—(With 1162.)

Date	*log. r'*	*log. r*	Δ	*p*	*p* Δ
June 7					
8					
9	2.62193	2.61791	— 0.00402	3½	— 0.01407
12					
13	2.62622	2.62306	— 316	½	— 158
14	2.62223	2.62129	— 94	2½	— 235
19	2.63245	2.62736	— 509	3	— 1527
21	2.62367	2.62123	— 244	4	— 976
22	2.62220	2.62132	— 88	4	— 372
27	2.62478	2.62271	— 207	5	— 1035
28	2.62369	2.62016	— 353	4	— 1412
29	2.62213	2.61992	— 221	3½	— 774
30	2.62278	2.61891	— 387	4	— 1548
July 3	2.61701	2.61475	— 226	3	— 678
4	2.62082	2.61819	— 263	5	— 1315
5	2.62782	2.62622	— 160	3½	— 560
6	2.63053	2.62688	— 365	2	— 730
				Δ	— 0.00268

[p] = 47½ ; *log* [pvv] = 5.7941

p. e. = ± 0.00015

Star No. 444 *l. c.*—(With 1179.)

Date	*log. r'*	*log. r*	Δ	*p*	*p* Δ
July 7	2.62762	2.62709	— 0.00053	3	— 0.00159
8	2.62363	2.62036	— 327	4	— 1308
9	2.62193	2.61745	— 448	4	— 1792
12					
13	2.62622	2.62405	— 217	½	— 108
14	2.62223	2.62118	— 105	3	— 315
19	2.63245	2.62834	— 411	3	— 1233
21	2.62367	2.62042	— 325	4	— 1300
22	2.62220	2.62048	— 172	4	— 688
27	2.62478	2.62270	— 208	5	— 1040
28	2.62369	2.62003	— 366	4	— 1464
29	2.62213	2.62007	— 206	3	— 618
30	2.62278	2.61950	— 328	3½	— 1148
July 3	2.61701	2.61553	— 148	3	— 444
4	2.62082	2.61927	— 155	4½	— 698
5	2.62784	2.62599	— 185	4	— 740
6	2.63053	2.62743	— 310	2	— 620
				Δ	— 0.00251

[p] = 54½ ; *log* [pvv] = 5.8266

p. e. = ± 0.00013

STAR NO. 1225.

Date	*log. r'*	*log. r*	△	*p*	*p* △
June 7	2.02116	2.02103	— 0.00013	3	— 0.00039
8	2.01757	2.01515	— 242	4	— 968
9	2.01589	2.01481	— 108	4	— 432
12					
13	2.02004	2.01978	— 26	1½	— 39
14	2.01668	2.02119	+ 451	2½	+ 1127
19	2.02602	2.02486	— 116	3	— 348
21	2.01728	2.01891	+ 163	4	+ 952
22	2.01609	2.01641	+ 32	4	+ 128
27	2.01853	2.01804	— 46	5	— 230
28	2.01726	2.01895	+ 169	4	+ 676
29	2.01634	2.01645	+ 11	3½	+ 39
30	2.01658	2.01770	+ 112	4	+ 448
July 3	2.01155	2.01322	+ 167	3	+ 501
4	2.01453	2.01511	+ 58	5	+ 290
5	2.02135	2.02181	+ 46	4	+ 184
6	2.02390	2.02576	+ 186	2	+ 372
				△	+ 0.00042

[p] = 56½ ; *log* [pvv] = 6.0780

p. e. = ± 0.00018

The next table contains the results collected from those preceding. The weights given in the column p have been derived from the probable errors as given in column r. The remaining columns are self-explanatory.

Star	△	*r*	*log. r²*	*log. p*	*p*	*p* △
948	— 205	±15	2.3522	1.0964	12.5	— 0.02562
190 *l. c.*	— 513	47	3.3442	0.1044	1.3	— 667
959(1)	— 584	53	3.4486	0.0000	1.0	— 584
959(2)	— 462	27	2.8627	0.5859	3.9	— 1802
968	+ 662	36	3.1126	0.3360	2.2	+ 1456
977	+ 476	40	3.2041	0.2445	1.8	+ 857
984	— 142	17	2.4609	0.9877	9.7	— 1377
225(1) *l. c.*	— 211	15	2.3522	1.0964	12.5	— 2637
225(2) *l. c.*	— 126	15	2.3522	1.0964	12.5	— 1675
225(3) *l. c.*	— 159	13	2.2279	1.2207	16.6	— 2639
997	+ 652	36	3.1126	0.3360	2.2	+ 1434
1005(1)	— 215	21	2.6444	0.8042	6.4	— 1376
1005(2)	— 31	19	2.5575	0.8911	7.8	— 242
1009	+ 298	38	3.1596	0.2890	1.9	+ 566
1019(1)	+ 488	40	3.2041	0.2445	1.8	+ 878
1019(2)	+ 290	38	3.1596	0.2890	1.9	+ 551
264 *l. c.*	— 218	20	2.6021	0.8465	7.0	— 1526
1032	— 317	29	2.9248	0.5238	3.3	— 1046
282 *l. c.*	— 473	27	2.8627	0.5859	3.9	— 1845
1084	— 101	35	3.0881	0.3605	2.3	— 232
1094	— 104	34	3.0630	0.3856	2.4	— 250
1105	— 29	23	2.7235	0.7251	5.3	— 154
1110	— 84	18	2.5105	0.9381	8.7	— 731
349 *l. c.*	— 84	18	2.5105	0.9381	8.7	— 731
356 *l. c.*	— 33	19	2.5575	0.8911	7.8	— 257
1135	— 193	16	2.4065	1.0421	11.0	— 2123
377(1) *l. c.*	— 336	28	2.8943	0.5543	3.6	— 1210
377(2) *l. c.*	— 334	18	2.5105	0.9381	8.7	— 2906
1156	— 304	16	2.4065	1.0421	11.0	— 3344
1162(1)	— 330	15	2.3522	1.0964	12.5	— 4125
1162(2)	— 297	17	2.4609	0.9877	9.7	— 2881
406(1) *l. c.*	— 318	15	2.3522	1.0964	12.5	— 3975
406(2) *l. c.*	— 292	11	2.0828	1.3658	23.2	— 6774
1179(1)	— 301	11	2.0828	1.3658	23.2	— 6983
1179(2)	— 276	15	2.3522	1.0964	12.5	— 3450
1182	+ 12	20	2.6021	0.8465	7.0	+ 84
424(1) *l. c.*	— 31	22	2.6848	0.7638	5.8	— 180
424(2) *l. c.*	+ 10	20	2.6021	0.8465	7.0	+ 70
438 *l. c.*	+ 40	17	2.4609	0.9877	9.7	+ 388
444(1) *l. c.*	— 268	15	2.3522	1.0964	12.5	— 3350
444(2) *l. c*	— 251	13	2.2279	1.2207	16.6	— 4167
1225	+ 42	18	2.5105	0.9381	8.7	+ 365
					△	— 0.00180

$[p] = 340.6$

$[pvv] = 0.00108489$

$\triangle = -0.00180 \pm 0.00019$

4. *The Constant of Refraction.*—The value of a deduced by Gyldén for the Pulkowa Tables, as given in his "Untersuchungen über die Constitution der Atmosphäre u.s.w.," is

$$a = 0.00027985 = 57''.723.$$

This is for $B = 29.5966$ inches at 0° and $t = 7°.44\ R$.

The Pulkowa Tables used here, however, are Gyldén's with μ systematically reduced by — 0.00124. Combining this with the value found for $\triangle a$, the correction to Gyldén's constant becomes

$$\triangle a = -\ 0.00304a$$
$$= -\ 0''.175$$

and

$$a = 57''.548.$$

This reduced to the condition of 760 mm. pressure at 0° and 0° C temperature gives

$$a = 60''.159.$$

To this value of a correspond the following:

$$c = 0.00029182$$

and

$$\mu = 1.00029178.$$

For the sake of comparison, the most important determinations of the constant of refraction are given below. These values are for the conditions $B = 760$ mm. at 0° C and external thermometer = 0° C. (These values are taken from Professor Bauschinger's "Untersuchungen über die Astronomische Refraction u.s.w.").

		a	μ
1.	Fund. Astr.	60''.320	1.00029257
2.	Tab Reg.	.440	29315
3.	Tab. Pulk.	.268	29232
4.	Fuss	.122	29161
5.	Greenw. 1857–1865	.120	29160
6.	Pulk. 1865	.209	29203
7.	Greenw. 1877–1886	.192	29195
8.	Pulk. 1885	.058	29130
9.	München	.104	29152

The first and second of these are determinations by Bessel; the third by Gyldén; the fifth by Stone; the sixth by Nyrén; the seventh by Newcomb; the eighth by Nyrén; and the last by Bauschinger.

Bauschinger gives weight zero to each of Bessel's determinations; to the first, because there was considerable uncertainty in Bradley's meteorological instruments; to the second, because of the uncertainty in reading the Meridian Circle (read by vernier to one second). He gives equal weight to the last seven, and gets for a mean

$$a = 60''.153 \quad \text{and} \quad \mu = 1.00029176.$$

5. *Latitude.*—The following table gives the value of φ deduced separately from the southern and from the northern stars. All of the stars of the list down to 84° Z. D. were used.

$\varphi = + 37° \ 20'$

Date	φ_S	p	$p\ \varphi_S$	φ_N	p	$p\ \varphi_N$
	$''$		$''$	$''$		$''$
June 7	25.38	4	101.52	24.89	4	99.56
8	25.88	4	103.52	24.71	4	98.84
9	26.49	4	105.96	24.27	4	97.08
12	26.08	1	26.08	24.96	1	24.96
13	25.99	2	51.98	25.27	2	50.54
14	25.88	4	103.52	25.26	3	75.78
19	26.55	4	106.20	24.54	3	73.62
21	25.99	5	129.95	24.66	4	98.64
22	25.65	5	128.25	24.54	4	98.16
27	25.67	7	179.69	24.59	5½	135.24
28	26.48	4	105.92	24.87	3	74.61
29	25.10	5	125.50	24.89	4	99.56
30	26.08	5	130.40	24.80	4	99.20
July 3	25.60	4	102.40	24.91	3	74.73
4	26.03	7	182.21	25.22	5½	138.71
5	25.95	5	129.75	25.07	4	100.28
6	26.80	3	80.40	24.60	3	73.80
Σ		73	1893.25		61	1513.31
Weighted mean φ			25.93			24.81

Applying the new refractions found here, the latitudes become from the

Southern Stars — $\varphi = 25''.55$

Northern Stars — $\varphi = 25\ .19$

giving for the mean φ at this epoch (1899 June 22),

$$\varphi = + 37° \ 20' \ 25''.37.$$

The remainder of the difference between the values of φ as found from the northern stars and from the southern stars ($0''.36$) is probably due to slight errors in the declinations of the stars used, and to bisection error.

CONCLUSION.

In conclusion it is desired to state that limitations of time have prevented the *complete* reduction of these observations and of the series taken during the fall months (1899 Oct.–Dec.). It is hoped that, in the near future, time will be available in which to carry out these reductions by correcting the declinations used and then repeating such portions of these computations as will be necessary. It is also desired to make reductions which will include the relative humidity and a term depending upon the zenith distance.

It will be noticed from the table (p. 189) that there is a large range in the values of $\triangle$, viz., from -0.00584 to $+0.00662$. This discordance is due partly to the values of the declinations adopted, but is also very clearly a function of the zenith distance. By introducing a term depending upon the zenith distance, and re-solving by Least Squares, this discordance can be greatly diminished.

From this investigation the following conclusions can be drawn:—

1. That this preliminary reduction gives for the Constant of Refraction

$$a = 60''.159$$

for $B = 760$ mm. at 0° (C) and $t = 0^\circ$ (C).

2. That for the epoch 1899 June 22, the latitude of the Lick Observatory Meridian Circle was

$$\varphi = +37^\circ\ 20'\ 25''.37.$$

3. That the final reduction will show that the Constant of Refraction of the Pulkowa Tables is too large.

4. That the observing room of the Lick Observatory Meridian Circle is of a very good design, and that there is no need of mounting Meridian Circles in the open air.

Addendum.

The table on page 189 shows a large range in the values of $\triangle$, viz., from $+0.00662$ to -0.00584. Upon plotting these values, using the zenith distance z for abscissa, and $\triangle$ for ordinate, it is easily seen that $\triangle$ varies quite uniformally with the zenith distance. A straight line, inclined about 145° to the zenith distance axis, and cutting it at z = about 55°, appears to represent $\triangle$ very well. Therefore, assuming Z to be the zenith distance for $\triangle = 0$, we can set up an observation equation of the following type for every star:

$$\log a = \log a_0 + [Z - z]x,$$

or

$$\log a - \log a_0 = \triangle = Zx - zx = D - zx,$$

where

$$D = Zx,$$

and where a_0 is the a of the tables used (Pulkowa).

Equations of this kind were, accordingly, formed and solved for Z and x by the method of Least Squares.

Equations of Condition.

$\triangle = D - zx.$

No.	*Star*	D	—	zx	=	△	*p*
1	948	D	—	80.00 x	=	—0.00205	12.5
2	190 l. c.		—	89.20	=	— 513	1.3
3	959		—	88.76	=	— 487	4.9
4	968		—	30.38	=	+ 662	2.2
5	977		—	21.55	=	+ 476	1.8
6	984		—	78.11	=	— 142	9.7
7	225 l. c.		—	79.70	=	— 167	41.6
8	997		—	30.59	=	+ 652	2.2
9	1005		—	57.19	=	— 114	14.2
10	1009		—	21.34	=	+ 298	1.9
11	1019		—	21.49	=	+ 386	3.7
12	264 l. c.		—	57.35	=	— 218	7.0
13	1032		—	87.05	=	— 317	3.3
14	282 l. c.		—	88.67	=	— 473	3.9
15	1084		—	27.80	=	— 101	2.3
16	1094		—	28.49	=	— 104	2.4
17	1105		—	62.21	=	— 29	5.3
18	1110		—	67.08	=	— 84	8.7
19	349 l. c.		—	67.65	=	— 84	8.7
20	356 l. c.		—	57.49	=	— 33	7.8
21	1135		—	77.37	=	— 193	11.0
22	377 l. c.		—	86.79	=	— 335	12.3
23	1156		—	87.23	=	— 304	11.0
24	1162		—	83.21	=	— 316	22.2
25	406 l. c.		—	83.50	=	— 301	35.7
26	1179		—	83.26	=	— 292	35.7
27	1182		—	62.79	=	+ 12	7.0
28	424 l. c.		—	62.96	=	— 9	12.8
29	438 l. c.		—	65.52	=	+ 40	9.7
30	444 l. c.		—	83.99	=	— 258	29.1
31	1225		—	65.13	=	+ 42	8.7

To reduce the number of equations, those nearly alike were combined, as follows: Equations No. 1, 6, 7 and 21; 2, 3 and 14; 4 and 8; 5, 10 and 11; 9, 12 and 20; 13, 22 and 23; 15 and 16; 17, 27 and 28; 18 and 19; 24, 25, 26 and 30; and 29 and 31, giving the 11 equations:—

No.	*a*	—	*b*	=	*n*	*p*	$\sqrt{p}$
1	D	—	79.20 x	=	—0.00174	74.8	8.6
2		—	88.78	=	— 485	10.1	3.2
3		—	30.48	=	+ 657	4.4	2.1
4		—	21.47	=	+ 385	7.4	2.7
5		—	57.31	=	— 117	29.0	5.4
6		—	87.00	=	— 320	26.6	5.2
7		—	27.15	=	— 103	4.7	2.2
8		—	62.75	=	— 7	25.1	5.0
9		—	67.36	=	— 84	17.4	4.2
10		—	83.49	=	— 291	122.7	11.1
11		—	65.34	=	+ 41	18.4	4.3

Weighted Observation Equations.

No.	*a*		*b*			*n*
1	8.6 D	—	681.1 x	=	—	0.01496
2	3.2	—	284.1	=	—	1552
3	2.1	—	57.9	=	+	1248
4	2.7	—	58.0	=	+	1040
5	5.4	—	309.5	=	—	632
6	5.2	—	452.4	=	—	1664
7	2.2	—	59.7	=	—	227
8	5.0	—	313.7	=	—	35
9	4.2	—	282.9	=	—	353
10	11.1	—	926.7	=	—	3230
11	4.3	—	281.0	=	+	176

To render these more nearly homogeneous, let D=D; 100x=y and multiply the absolute term by 100. Then we have the following

Weighted Homogeneous Observation Equations.

No.	*a*		*b*			*n*
1	8.6 D	—	6.811 y	=	—	1.496
2	3.2		2.841	=	—	1.552
3	2.1	—	0.579	=	+	1.248
4	2.7	—	0.580	=	+	1.040
5	5.4	—	3.095	=	—	0.632
6	5.2	—	4.524	=	—	1.664
7	2.2	—	0.597	=	—	0.227
8	5.0	—	3.137	=	—	0.035
9	4.2	—	2.829	=	—	0.353
10	11.1	—	9.267	=	—	3.230
11	4.3	—	2.810	=	+	0.176

Combining these by the method of Least Squares we obtain the following

Normal Equations.

$$+341.28\,D - 254.512\,y = -61.7188$$
$$-254.51 \quad +197.151 \quad = +53.4383$$

Solving these, remembering that the absolute terms had been multiplied by 100, we have

$$\log D = 7.75694;\ \log y = 8.00376 \text{ or } \log x = 6.00376.$$

Now since D=Zx, we have log Z=1.75318,
Whence x=+0.0001009 and $Z = 56^\circ.647 = 56^\circ 38' 49''$.

Substituting the values of D and x, thus found, in the Weighted Observation Equations, we find $[pvv] =$

0.00024690, from which the following probable errors have been deduced:

$$r_x = \pm 0.0000130 \text{ and } r_Z = \pm 0^\circ.031 = \pm 0^\circ 1' 52''.$$

We, therefore, have from this solution

$$Z = 56^\circ 38'.8 \pm 1'.9 \text{ and } x = +0.000101 \pm 0.000013,$$

giving

$$\log a = \log a_0 + 0.000101 \ [56^\circ 38'.8 - z].$$

We are, therefore, led to the conclusion that the so-called Constant of Refraction needs not only a correction, but a correction for every zenith distance. In other words, the formula from which refractions are computed needs to be modified. Or, the formula may be retained unaltered, and the desired result obtained by correcting the log μ table of the refraction tables used (Pulkowa) by the amount

$$\triangle \log \mu = 0.000101 \ [56^\circ 38'.8 - z].$$

R. T. C.