CINCINNATI OBSERVATORY,

STATION O.

CINCINNATI, O.

Personal Equation and its Variation.

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Personal Equation and its Variation.

The observation of the time of transit of a star across a wire in the reticule of a transit instrument is often made either before the star reaches the wire or after passing it. One observer may habitually record the time of transit before, another after the star is truly bisected. The correction to be applied to the observation thus madeto reduce it to the equivalent of one made at the instant the star is truly bisected is called the personal equation of the observer.

If the sign of the correction is negative the observation is made after a true bisection, if positive it is made before the star reaches the wire. In the former case the observer may note the exact instant of bisection but requires a definite time to execute the sensation in muscular action in the act of pressing the time recording key held in the hand. He may be aware of this interval of time but believes his observation will be more consistent than it would be if he anticipated the star's arrival at the wire in an attempt to eliminate it from his observation. In the latter case it is not the star's bisection which is recorded, it is the sensation of a space interval between star and wire such that the estimated time required for the star to traverse this space will exactly equal the time for the sensation noted to be given expression in muscular action and the space is over estimated. Since stars of different declinations cross the reticule of the telescope with different velocities it would seem that the personal equation having the positive sign would be subject to greater variation than one with the negative sign.

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The personal equation of an observer varies with the magnitude of a star which gives rise to magnitude equation. Suppose θ_1, θ_2, θ_3, etc. the observed times of transit of stars of magnitudes 1, 2, 3, etc. respectively and p_1, p_2, p_3, etc. the corresponding personal equations. The true times of transit will then be $\theta_1 + p_1$, $\theta_2 + p_2$, $\theta_3 + p_3$, etc. The p's are of the same order of magnitude so that if the personal equation corresponding to a given magnitude, as p_8 be applied to all the θ's the correction still to be applied to the θ's of stars other than those of magnitude 8 will be small. These corrections are called magnitude equations. Representing them by m_1, m_2, m_3, etc. we have,

$$\begin{aligned} \theta_1 + p_8 + m_1 &= \theta_1 + p_1 & \qquad m_1 &= p_1 - p_8 \\ \theta_2 + p_8 + m_2 &= \theta_2 + p_2 \quad (1) & m_2 &= p_2 - p_8 \quad (2) \\ \theta_3 + p_8 + m_3 &= \theta_3 + p_3 & m_3 &= p_3 - p_8 \\ \text{etc.} & & \text{etc.} & \end{aligned}$$

Magnitude equation may then be defined as the outstanding correction to be applied to the observed time of transit of a star of given magnitude after the correction for personal equation of a star of different magnitude taken as a standard of comparison has been applied to it.

It may also be defined as the correction to be applied to the time observed for the transit of a star of one magnitude to reduce it to the time which would have been recorded if the star had been of another specified magnitude. Again taking θ_8 as a standard of comparison we have the equation, -

$$\begin{aligned} \theta_1 + m_1 &= \theta_8 \\ \theta_2 + m_2 &= \theta_8 \qquad (3) \\ \theta_3 + m_3 &= \theta_8 \\ &\text{etc.} \end{aligned}$$

Two methods of determining magnitude equation are thus offered. One involves the determination of the correction for personal equation corresponding to stars of each magnitude, while employing the other method this preliminary step is omitted.

Other circumstances which may cause a variation of personal equation are ,(1) variation of illumination of the field, (2) difference in the observer's position in making the observations.

The following discussion is concerned with the results of four determinations,- 1. A determination of the personal equation corresponding to stars of different magnitudes from 2+ to 8+ from which magnitude equation as defined by the first definition is deduced. 2. A direct determination of magnitude equation corresponding to the second definition above. 3. The determination of the correction to be applied to the observed time of transit of a star made when the observer faces north to reduce it to the equivalent of one made when the observer faces south. 4. The determination of the correction to be applied to the observed time of transit of a star in a bright field to reduce it to the time that would have been recorded of its transit in a faint field.

Personal Equation Employing a Movable Reticule as Transit Micrometer.

The transit micrometer is an instrument which automatically records the times of transit of a wire across certain imaginary lines in the focal plane of a transit instrument. In making an observation of the transit of a star, the observer, by means of suitable hand screws moves the wire across the field keeping the star image bisected.

The automatic records will in this case be the recorded times of transit of the star across these imaginary lines. This method of making transit observations is a more simple process than the usual method which requires the observer to note the exact instant the star image in moving across stationary wires in the field is bisected by them successively and to record these times by pressing a key held in the hand. Experience shows that by using the transit micrometer personal equation is eliminated from the observations and the following investigation is based on this assumption. (See Coast and Geodetic Survey Report for 1904 - Appendix No. 8)

The reticule of the meridian circle of the Cincinnati Observatory is provided with five transit wires and may be moved in right ascension by means of a micrometer screw. These five wires are spider threads which I mounted on a thin disc of glass, the ends being cemented to the glass with wax and shellac. By using the collimaters it was found that these wires were parallel and repeated determinations of thread intervals show that the mean wire and middle wire are exactly coincident. To convert the use of this movable reticule to that of a transit micrometer the micrometer head was provided with a lever of hard rubber which at a given reading breaks the circuit of a relay connected with the chronograph.

The method of observation is as follows,- The micrometer head is set at the given reading- in the present case 9.72- without breaking the circuit. Transits of a star across the first two wires are made with the reticule stationary. The micrometer head is then turned backward until wire III meets the star image and is then turned forward with the star image bisected until the break is made in the circuit at the given reading. The micrometer is next turned backward until the wire IV meets the star image which by again moving the micrometer head forward is kept bisected until a break is again made in the circuit of the relay. The same process is repeated for wire V.

It is to be noted that all transits are made at a given setting of the micrometer head, the first two wires being stationary the last three moving when the time records are made upon the chronograph. By employing the table of reductions each transit is reduced to the equivalent of one across the mean wire . The mean of the first two transits thus reduced is considered the mean of two observations of the time θ of transit of the star across the mean wire which value requires a correction p for personal equation so that $\theta + p$ is the true time of transit. The mean of the last three transits reduced to the mean wire is considered the mean of three observations of the time θ' of transit of the star across the mean wire and this observed time requires no correction for personal equation as it is eliminated by the method of observation. We have therefore the equation ,-

$$\theta + p = \theta'$$

from which p is determined. By observing stars of different magnitudes the personal equations corresponding are found , as p_1 p_2 p_3 etc. In the following discussion p_8 is taken as a standard personal equation to which p's derived from stars of other than magnitude 8 are compared in deriving magnitude equation. With the p's determined, corresponding magnitude equations are derived from equations (2).

In making the observations it is desirable to choose stars whose declinations are not too widely different. It was my aim to observe equatorial stars but on account of the scarcity of the brighter stars some of rather high declinations were included. It might be well to state here that the difficulties of making observations with this improvised transit micrometer are very greatly increased for stars near the zenith. No first magnitude stars were observed. In table I are given the approximate positions of the stars observed and their magnitudes. Table II gives the observed values p_2 p_3 p_4 ---- p_8 . In the column headed p_2 the values are derived from stars varying in magnitude from 2.0 to 2.9 and in the remaining columns the values are derived from stars varying in magnitude from 3.0 to 3.9 , 4.0 to 4.9 , 5.0 to 5.9, 6.0 to 6.9, 7.0 to 7.9, 8.0 to 8.9 respectively. At the foot of each column is given the mean value of the personal equations and below these the corresponding magnitude equations.

Magnitude equation corresponding to the second definition above is derived by employing suitable screens to reduce the star's magnitude. The reticule of the instrument is not moved during an observation. The image of each star of whatever magnitude, for example the 2nd, is reduced to magnitude 8+ during its transit across the first two wires. The recorded times of its transit are then those of an 8th magnitude star. The screen is now removed and the records made of its transits across the remaining wires of the reticule are those of a star of 2d magnitude. The times recorded of its transits across all the wires are reduced to the mean wire. The mean of the first two constitute an observation of its time of transit as an 8th magnitude star, the mean of the remaining records thus reduced constitutes an observation of time of transit of a star of 2d magnitude. With these observed times equations (3) give at once magnitude equation.

$$m_2 = \theta_8 - \theta_2$$
$$m_3 = \theta_8 - \theta_3$$
$$m_4 = \theta_8 - \theta_4$$
etc.

The screens employed were of silk veiling of very fine mesh. Two thicknesses of this material were required to reduce stars of 7th magnitude to 8th magnitude stars, three thicknesses reduced 6th magnitude stars to 8th magnitude stars and each additional thickness reduced stars successively brighter by one magnitude to the 8th magnitude. The images of the reduced stars appeared to be similar in all respects to those of faint stars of equal magnitudes.

Table III gives the results of the determinations of magnitude equations from screen observations for stars varying in magnitude from 2+ to 7+ assuming that the magnitude equations of stars of magnitude 8+ is zero. If the table of reductions employed were inaccurate a constant error would be introduced ~~this~~ which might have been eliminated by screening half the stars of each magnitude during their transit across the last wires of the field instead of the first, but with the room darkened for observation the difficulties of adjusting the screen during the star's transit prevented this being done. In the column headed 8+ are included the results obtained by treating the observations of 8th magnitude stars observed Sept. 17th, and Oct. 7th, the same as screened stars, the stars observed on these dates being equatorial stars. The mean value shows that the table of reductions is accurate and that no constant error is introduced by its use. The table is otherwise known to be accurate It will be noted that the preceding method of deriving magnitude equation eliminates this source of error. At the foot of each column is given the mean value of the corresponding magnitude equation. .

In table IV the magnitude equations derived by the two methods are compared. The mean values obtained by taking the means of the results derived by the two methods probably represent the actual magnitude equations more accurately than those obtained by either method separately. These indicate that stars brighter than the 8th magnitude are observed earlier by a nearly constant time interval than they would be if they were of magnitude 8+ . The footings of the columns are the mean values of the first six magnitude equations of the corresponding columns. Assuming that stars of magnitude 8+ have a magnitude equation $-0\overset{s}{.}021$ we derive the values given in column (4) from those of column(3). Accepting the results in this column as definitive the magnitude equation of all stars brighter than the 8th magnitude may be taken as zero since the values derived for these stars are of an order of magnitude equal to or less than the corresponding probable errors and show no order of progression with increase in the star's brightness. The probable error of the magnitude equation of stars of magnitude 8+ is considerably smaller than that of the brighter stars for the reason that this magnitude equation is derived from all the observations made in the two methods.

Position Equation.

In making a transit observation of a southern star the observer faces south , the star image enters the field on the observer's right crossing each wire from right to left. In making a transit observation of a northern star the observer faces north, the star image enters the field on the observer's left crossing each wire from left to right, the star being at upper culmination. It is desirable to know what effect this difference of position has upon the relative times recorded of its transit. For the first series of determinations stars as near the zenith as possible were chosen for observation. Selecting a suitable star the observer facing south makes the observation of the times of transit across the first two wires after which he changes his position making the observations of times of transit across the last two wires facing north. No observation is taken on the middle wire. The direction of facing may be changed at the beginning of each observation to avoid the possible introduction of a constant error. Assuming a correction to the observed time of transit facing north to reduce it to that of one made facing south we have,-

$$\theta_n + C = \theta_s \quad (4)$$

θ_n and θ_s are each the mean of the recorded times of transit across two wires. Employing equations (4) we derive the table Va, of c's for zenith stars.

The variation of personal equation depending upon the observer's position may be found from clock corrections. Taking a suitable list of standard stars, the observer facing south for some, north for others, makes a complete observation of the times of transit of each across the five wires of the reticule the mean of which constitute an observation of the time θ_s of transit of the star across the mean wire. If the observer faces north he observes θ_n which requires a correction c to give the time θ_s which would have been observed if he had faced south. We therefore have the equation,-

$$\theta_n + c = \theta_s$$

$$\begin{aligned} \Delta\theta_s &= \alpha - \theta_s \\ &= \alpha - (\theta_n + c) \\ &= \Delta\theta_n - c \end{aligned}$$

Whence,-

$$c = \Delta\theta_n - \Delta\theta_s$$

A careful determination of the instrumental constants is desirable when this method is employed. If ,however, all the stars are zenith stars and the mean of the declinations of the list observed facing south is equal to that of the list observed facing north this source of error will be largely eliminated. The preceding method is independent of instrumental constants. Table Vb contains the results of the determinations of c from clock corrections for stars near the zenith. In the first method four transits for each of 36 stars were observed making a total of 144 transits across individual wires. In the second method 120 individual transits were observed.

Table V indicates a very decided position equation for zenith stars, and since stars north of the zenith of increasing declinations vary greatly in the velocity with which they cross the reticule the question of variation of the position equation with declination naturally arises. To investigate this stars of high declinations were chosen for observation and the two methods outlined above were employed, the first being modified as follows,-

The micrometer head is set at such a reading that all the transit wires are on the west side of the collimation plane. Choosing a star between 75 and 80 degrees of declination the observer facing north records the times of its transit across the first four wires of the reticule. The micrometer head is then turned forward until the reticule is on the east side of the collimation plane the micrometer head being set at a definite reading. The observer then faces south and records the times of transit of the star across the four wires as before. By raising the observing chair or bench with the slope of the reclining surface toward the instrument the observations may be made in this position with comparative comfort. The mean of the four recorded transits in each position constitute an observation, θ_n and θ_s, of the times of transit with the reticule in the respective positions. The micrometer setting for the reticule west of the collimation plane was $3^r.70$: the setting for the reticule east of the collimation plane was $18^r.70$. The value of this particular interval on the micrometer screw was derived from observations on stars between +75 and +80 degrees of declination, all the observations being made facing north. Its value is $29^s.576$. Employing this value the θ's observed with the micrometer head at the reading $3^r.70$ were reduced to the equivalent of what they would have been at the reading $18^{r}.70$. A comparison of the θ's thus reduced with the θ's actually observed at $18^{r}.70$ gives the value of c for stars of high declination. The order of facing may be changed for succeeding stars to eliminate the possible introduction of a constant error. It is to be noted that c thus derived is independent of instrumental constants. Table VIa gives the values of the c's derived by this method.

In the regular programs of work southern stars and stars of high declination at both upper and lower culmination are ordinarily observed to determine and check the azimuth of the instrument.

Comparing the clock corrections derived from stars at upper culmination with those derived from standard stars south of the zenith in the same program of work for all programs from 153 to 170 we derive the table VIb giving the values of c.

In the discussion of results from these programs where the azimuth depends upon the O of an upper culmination star the correction c as derived from table VIa has been applied to it in deriving the azimuth constant a. This adds a negative term of 0.02 to clock corrections derived from upper culmination stars and a positive term of 0.04 to clock corrections derived from lower culmination stars when the azimuth constant a is derived without applying this correction. Hence the clock correction derived from a star at lower culmination will equal $\Delta\theta_n - c$ which by preceding formulae is equal to $\Delta\theta_s$.

The results given in tables Va, Vb, VIa, VIb, indicate that <u>c</u> is a constant, that is within the limits of probable errors it does not vary with the declination. If therefore we assume <u>c</u> $= \Delta\alpha \sec\delta$, it will be necessary to make the further assumption that $\Delta\alpha$ is a cosine function of the declination. On this assumption we have for stars of declination $+39^\circ.1$, $\Delta\alpha = -0^s.051$ and for stars of declination $+78^\circ.0$, $\Delta\alpha = -0.015$.

There is apparently no variation of personal equation with declination for stars south of the zenith. As an indication of this a synopsis of results derived from standard stars observed in regular programs of work is given in table VII. Residuals from the mean clock correction are considered to be of the form $\Delta\alpha \sec\delta$. In most cases these are equal to $\Delta\alpha$.

Illumination of the Field.

The observations whose results are given in table VIII were made to determine whether variation of illumination of the field causes the personal equation to vary and the order of magnitude of its variation. The absolute magnitude of its variation is not of great importance since it should be eliminated by always keeping the field at the same brightness for any series of observations, and for all series whose transit times are in any way interdependent.

In making the observations the field was dark during the star's transit across the first two wires, then made bright for the transit across the remaining wires. For some stars this order was reversed the field being made first bright then dark. The table gives the order of observation for each star. By a dark field is here meant one in which the wires are plainly visible, in which transits are easily observed without extra effort due to lack of illumination, but one which would stand no further diminution of light. The correction derived is that required to reduce the observed time of transit of a star in a bright field to the equivalent of one made in a dark field.

Although the personal equation of two observers may be different the conditions which cause a variation in the personal equation of one will in general cause a variation in that of the other. The variations may not be the same in the two cases but each will introduce its own peculiar error into the resulting determinations of position.

There may be other conditions not here investigated which cause a variation of personal equation. One of these, doubtless, is variation in <u>seeing</u> conditions, another the varying physical conditions of the observer. Both present difficulties of investigation.

In differential determination of position from meridian circle observations the absolute value of the observer's personal equation is not of importance, but it should be the same for each star observed in a given series. With the object in view of keeping it constant or equal to zero the instrument should be provided with a transit micrometer and suitable screens for reducing the brightness of stars. Provision should also be made for constant,uniform illumination of the wires of the reticule.

For the observations whose results are given in tables II,III, IV, and Va the chronograph sheet was read to the nearest $0^{s}.01$ second. Where the results are derived from clock corrections it was read to the nearest $0^{s}.05$ second. The table of reductions employed to reduce observations to the mean thread gives reduction constants to the nearest $0^{s}.01$ second. Computations have been carried to the third decimal place. The seeing conditions were nearly uniform for the series of observations from which magnitude equation was determined. Seeing conditions on each night are marked on a scale of five - five representing perfect conditions. The field was maintained uniformly dark throughout except where otherwise stated.

This investigation shows, for my observing work under normal observing conditions that variation of illumination causes a variation of personal equation, that magnitude equation is small and may be considered equal to zero except for stars of 8th magnitude and fainter, and that a very definite position equation must be taken into consideration.

Star List for Magnitude Equation Observations.

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~~Mag~~

Mag	R.A.			Decl.		Mag	R.A.			Decl.		Mag	R.A.			Decl.	
8.1	20h	07m	32s	+2°	02'	4.8	22h	20m	35s	+ 0°	54'	4.5	1h	36m	42s	+ 5°	02'
8.0		08	51	+5	02	5.2		23	13	+ 4	14	6.3		43	42	+ 3	14
6.4		11	32	+4	18	6.2		25	25	+ 3	58	3.3		46	58	-10	47
5.7		12	53	+24	23	7.1		27	42	+ 2	07	2.7		49	36	+20	21
8.0		14	59	+ 1	42	3.9		30	40	− 0	35	5.6		52	21	+17	24
7.9		16	57	+ 1	23	7.2		32	36	+ 12	06	6.3		54	30	+11	51
5.2		18	41	+ 5	04	7.3		34	12	+ 4	04	4.7		57	18	+ 2	20
6.5		19	57	+ 0	46	3.3		36	55	+ 10	21	2.0		02	02	+23	02
7.2		21	39	+ 2	40	2.9		38	44	+ 29	45						
8.7		23	33	+ 1	48	3.1		42	08	+ 23	05						
8.0		25	30	+ 4	58	4.0		44	46	− 14	04						
3.9		28	51	+11	00	3.8		47	52	− 8	03						
5.2		34	42	+ 0	10	4.9		49	49	− 16	18						
8.1		36	24	+ 1	40	6.0		54	45	+ 0	29						
6.0		39	09	+ 5	03	7.5		56	51	+ 14	23						
2.4		42	31	+ 33	38	2.4	23	00	13	+ 14	43						
4.6		43	51	+ 36	09	6.8		06	38	+ 4	32						
6.2		45	28	+ 5	12	3.7		12	28	+ 2	47						
8.5		47	19	+ 4	05	4.5		16	07	+ 23	14						
5.3		50	40	+ 27	43	4.6		20	50	+ 22	54						
8.2		52	34	+ 2	06	5.1		22	16	+ 0	45						
5.7		54	31	+ 3	56	4.7		24	33	+ 12	15						
6.4		55	46	− 5	05	4.1		35	16	+ 5	8						
6.5		58	14	− 1	16	6.3		45	32	− 10	29						
5.5	21	00	03	+ 5	08	5.4		47	51	+ 18	37						
4.6		01	48	−25	22	3.9		54	38	+ 6	22						
4.4		04	38	−11	44	4.5		59	06	−17	50						
8.1		06	48	+ 3	53	7.5	0	11	56	+ 1	21						
8.0		08	22	+ 2	25	3.5		14	47	− 9	20						
4.7		10	05	+ 9	37	6.6		20	42	+ 1	26						
8.2		12	13	+ 4	52	7.7		22	38	+ 2	19						
8.6		14	03	+ 1	31	6.1		25	23	− 4	28						
4.2		17	52	+19	24	2.1		03	40	+ 28	35						
8.5		19	08	+ 3	58	2.7		08	32	+ 14	40						
6.5		21	10	+ 0	08	6.2		27	45	+ 19	47						
6.1		23	59	+ 7	48	7.5		29	22	+ 5	27						
2.9		26	46	− 5	58	4.3		33	44	+ 28	49						
7.5		28	36	+ 4	09	8.2		36	04	+ 3	59						
5.0		32	50	− 0	48	2.2		39	01	− 18	29						
5.2		37	42	+ 5	15	4.1		42	30	+ 23	46						
2.3		39	42	+ 9	27	4.4		43	57	+ 7	05						
5.4		42	35	+ 2	15	5.4		45	34	− 11	08						
8.3		44	15	+ 2	44	5.0		48	20	− 1	38						
5.2		48	55	+25	30	7.1		52	55	+ 1	17						
8.0		51	00	+ 1	55	7.2		55	31	+ 18	12						
7.3		52	55	+ 3	43	4.2		58	13	+ 7	24						
8.3		54	50	+ 4	20	6.0	1	03	01	+ 20	15						
5.8		56	39	+12	40	2.1		04	37	+ 35	08						
7.8		58	50	+ 5	00	5.4		05	50	+ 1	58						
2.9	22	01	06	− 0	46	4.3		06	38	+ 29	36						
3.6		05	36	+ 5	45	6.3		09	14	+ 15	39						
7.8		07	40	+ 2	17	7.6		11	51	+ 2	15						
8.2		09	37	+11	43	4.6		14	26	+ 26	47						
4.2		12	01	− 8	14	3.4		19	28	− 8	39						
3.7		16	57	− 1	51	5.5				+ 5	41						

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Personal Equation and Magnitude Equation.

Transit Micrometer Method.

	Mag.	p	mag.	p	Mag.	p	Mag.	p	Mag.	p	Mag.	p	Mag.	p
Oct 6 Seeing 3	2.4 2.9 2.3 2.9 2.9 2.4	$-0^s.168$ -.133 -.110 -.083 -.133 -.092	3.9 3.6 3.7 3.9 3.3 3.9 3.8	$-0^s.080$ -.150 -.142 -.175 -.148 -.152 -.043	4.7 4.2 4.2 4.8 4.0	$-0^s.203$ -.123 -.082 -.098 -.150	5.2 5.2 5.7 5.5 5.0 5.2 5.4 5.8 5.2	$-0^s.192$ -.128 -.125 -.143 -.232 -.142 -.153 -.135 -.100	6.4 6.5 6.0 6.2 6.4 6.5 6.5 6.1 6.2	$-0^s.242$ -.155 -.153 -.180 -.015 -.125 -.068 -.102 -.107	7.2 7.5 7.3 7.8 7.8 7.1 7.2 7.5	$-0^s.042$ -.080 -.130 -.120 -.140 -.093 -.138 -.150	8.0 8.0 8.7 8.0 8.1 8.5 8.2 8.0 8.6 8.3 8.0 8.3 8.1 8.2	$-0^s.097$ -.188 -.163 -.143 -.117 -.158 -.122 -.100 -.125 -.082 -.140 -.045 -.299 -.205
Oct. 19 Seeing 3	2.9 2.4 2.1	-.057 -.140 -.168	3.6 3.7 3.9 3.3	-.162 -.093 -.080 -.152	4.8 4.2	-.148 -.212	5.2	108	6.8	172	7.2 7.8 7.1 7.2	223 075 117 158	8.5	-.125
Oct. 21 Seeing 3	2.4 2.9 2.3 2.9 2.9 2.4 2.1 2.7 2.2	-.197 -.195 -.230 -.122 -.175 -.068 -.170 -.100 -.155	3.6 3.7 3.9 3.9 3.3 3.8 3.2 3.7 3.9 3.5	-.098 -.058 -.115 -.125 -.035 -.100 -.012 -.043 -.190 -.133	4.6 4.4 4.7 4.2 4.2 4.8 4.0 4.5 4.4 4.7 4.1 4.5 4.4	-.218 -.112 -.158 -.065 +.005! -.113 -.148 -.103 -.125 -.130 +.020! -.153 -.008	5.7 5.5 5.0 5.2 5.4 5.2 5.8 5.1 5.4	095 038 055 143 110 142 103 100 025	6.2 6.5 6.5 6.1 6.2 6.0 6.8 6.6 6.1 6.2	137 117 050 102 105 123 088 082 043 085	7.5 7.3 7.8 7.8 7.1 7.2 7.3 7.5	115 200 087 103 133 090 150 120	8.5 8.2 8.1 8.0 8.2 8.3 8.2	-.133 -.182 -.160 -.140 -.160 -.130 -.073
Per. Eq.	2	$-0^s.138 \pm 8$	3	$-0^s.109 \pm 8$	4	$-0^s.116 \pm 9$	5	$-0^s.118 \pm 8$	6	$-0^s.112 \pm 8$	7	$-0^s.123 \pm 6$	8	$-0^s.140 \pm 8$
Mag. Eq.	+.002		+.031		+.024		+.022		+.028		+.017		.000	

Probable error of each determination, $\pm 0^s.008$

Probable error of one observation, $\pm 0^s.034$

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Magnitude Equation from Screen Observations.

1909	Mag.	m	Mag.	m	Mag.	m	Mag.	m	Mag.	m	Mag.	m	8th	(m
Oct. 8	2.3	+^{s}.033	3.6	-^{s}.003	4.2	-^{s}.030	5.2	+^{s}.005	6.0	+^{s}.092	7.3	+^{s}.073	Sept. 17.	+.042
	2.4	+.048	3.7	+.025	4.8	+.045	5.8	+.052	6.8	-.082	7.8	-.035		.000
	2.9	-.008	3.9	+.040	4.0	+.058	5.3	+.028	6.3	+.000	7.5	+.060		+.020
	2.7	-.020	3.3	+.048	4.5	-.093	5.1	+.050	6.6	+.030	7.5	-.047		+.040
Seeing 3			3.2	+.108	4.4	+.037	5.4	-.055	6.1	-.097	7.7	+.067		+.058
			3.9	+.077	4.7	-.010			6.2	+.050				-.047
			3.5	-.063	4.1	+.050			6.5	+.042				+.008
			3.4	-.047	4.3	+.027			6.9	-.003				-.033
			3.6	+.015	4.1	-.015			6.9	.085				-.063
					4.4	+.095								-.033
					4.6	-.005								-.033
					4.5	+.020								
					4.3	+.058								
Oct. 14	2.9	+.082	3.6	+.002	4.2	-.005	5.8	+.050	6.2	+.030	7.1	+.070	Oct. 7.	-.043
	2.4	-.035	3.7	+.048	4.8	+.027	5.2	+.027	6.0	-.045	7.1	-.023		+.062
	2.1	+.033	3.9	+.077	4.0	-.007	5.4	+.032	6.8	+.030	7.1	-.008		-.025
	2.7	+.083	3.3	+.065	4.5	-.053	5.4	+.010	6.3	+.005	7.2	+.098		+.007
	2.2	+.020	3.9	-.005	4.4	-.035	5.6	+.025	6.6	-.003	7.3	-.067		.000
	2.1	-.023	3.8	+.022	4.7	+.063			6.1	+.003	7.5	+.038		-.050
	2.7	+.007	3.2	+.018	4.1	+.028			6.2	+.038	7.7	+.090		+.075
	2.0	+.085	3.9	+.020	4.3	-.018			6.0	+.057	7.3	+.015		+.033
Seeing 3			3.4	.000	4.1	+.030			6.3	.000	7.1	+.045		-.058
			3.5	+.028	4.4	+.098			6.3	-.030	7.2	+.073		-^{s}.002±6
					4.2	+.075			6.3	-.047	7.6	+.075		
					4.3	+.025								
					4.6	-.025								
					4.5	+.037								
Mag.Eq.	+^{s}.025±8		+^{s}.024±6		+^{s}.018±6		+^{s}.022±8		+^{s}.008±7		+^{s}.033±9			.000

Probable error of one observation, ±$0^{s}.029$

CINCINNATI OBSERVATORY,
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CINCINNATI, O.

Magnitude Equation Comparison

Mag.	Micrometer Method	Screen Observations	Mean Values	Mag. Eq.
2+	+ $0^s.002 \pm 11$	+ $0^s.025 \pm 8$	+ $0^s.014 \pm 5$	− $0^s.007 \pm 6$
3+	+ $.031 \pm 11$	+ $.024 \pm 6$	+ $.027 \pm 5$	+ $.006 \pm 6$
4+	+ $.024 \pm 13$	+ $.018 \pm 6$	+ $.022 \pm 6$	+ $.001 \pm 6$
5+	+ $.022 \pm 11$	+ $.022 \pm 8$	+ $.022 \pm 6$	+ $.001 \pm 6$
6+	+ $.028 \pm 11$	+ $.008 \pm 7$	+ $.018 \pm 5$	− $.003 \pm 6$
7+	+ $.017 \pm 10$	+ $.033 \pm 9$	+ $.025 \pm 6$	+ $.004 \pm 6$
8+	$.000$	$.000$	$.000$	− $.021 \pm 3$
	+ 0.021 ± 4	+ 0.022 ± 3	+ 0.021 ± 3	$.000$

On account of the small number of wires across which transits were taken in deriving the θ's a wide divergence of values for individual wires was considered a sufficient criterion for rejecting observations. The following observations were rejected ,-

Oct. 6th. 2 observations. Individual wire values discordant, Observations questioned when made.

Oct. 8th. 2 Observations. 1, Obs. quest. 1, val. of m given as 0.4 sec. Micr. moved while adjusting screen?

Oct. 14th. 3 Obs. 1, erroneous magnitude. 1, double star. 1, micr. move?

Oct. 19th. Chronograph not read after first two hours of work. Battery on micr. short circuited giving at the end of this time a different kind of record on chronograph from that made by key.

Oct. 21st. 2 Obs. stars of high declinations. Individual wire values discordant.

V

Position Equation.

CINCINNATI OBSERVATORY.

STATION O.

CINCINNATI, O.

Position changed during Observation.

Va

1909	Mag	R.A.			Decl.		c	Pos.
Sept.22	8.4	19h	29m	20s	+39°	07'	-0.s120	SN
	8.3		31	34	+39	04	- 115	NS
	8.4		36	41	+38	42	+ 010	SN
	6.8		38	37	+39	49	- 155	SN
	7.4		42	50	+39	40	- 075	NS
	8.5		44	34	+38	41	000	SN
	8.1		48	28	+39	18	- 060	NS
	8.3		50	42	+38	52	- 075	NS
	6.8		52	35	+39	55	- 020	SN
	8.1		54	25	+38	09	- 075	SN
	8.4		55	45	+39	16	- 015	NS
	8.4		58	32	+38	29	- 050	SN
	8.3		01	37	39	05	+ 020	NS
	8		02	17	39	05	+ 015	SN
	8.3		04	18	38	22	- 120	NS
	7.1		06	36	38	52	+ 005	SN
	6.9		08	37	40	03	- 080	NS
			09	22	40	03	+ 070	SN
	6.9		10	40	38	57	- 120	NS
	6.5		12	45	38	37	- 095	SN
			13	21	38	37	- 050	NS
	6.4		16	58	39	06	- 015	NS
	6.4		18	23	40	08	- 060	SN
	8.2		20	45	39	14	- 095	NS
	6.6		22	48	40	05	- 040	SN
			23	28	40	05	- 170	NS
	7.8							
Oct.6.	7.8		12	07	38	28	- 125	SN
	8.2		14	35	39	57	- 015	NS
	6.9		22	07	39	54	- 200	NS
	7.5		25	11	38	09	- 105	SN
	7.2		27	33	40	16	- 085	NS
	8.1		33	43	40	01	- 140	NS
	7.4		37	00	40	03	- 035	SN
	7.7		52	23	40	05	- 055	NS
	7.9		58	20	39	39	- 010	SN
	6.5	0	01	35	40	24	- 115	NS
	(7.7	(23	42	10	37	00	+ 110	NS?)
	(7.4		47	20	40	15	+ 090	SN?)

-.066±7

From Clock Corrections.

Vb

1909	RA	Decl.	No S	No N	c
Nov.26	1.h8	32.°3	7		
" 26	0.8	47.9		8	-0.s056
Dec. 1	1.5	33.7	4		
" 1	1.8	47.3		4	- .083

-0.065±5

CINCINNATI OBSERVATORY,

Position Equation for Stars of High Declination:
Position Changed During Observation.

STATION OF: CINCINNATI, O.

Date	A G	Mag	R.A.			Decl.		c	Pos.
1909, Nov. 30th	346	7.4	2^h	15^m	12^s	79°	14'.5	$+^s.12$	SN
	363	7.0	2	24	45	76	19.3	-.02	SN
	380	8.2	2	33	16	78	49.0	-.16	SN
	397	7.6	2	43	02	79	44.2	-.30	NS
	430	6.0	2	54	04	79	03.9	-.24	NS
	455	6.8	3	02	47	79	47.6	-.27	NS
	489	7.5	3	15	53	78	09.7	-.29	NS
1909, Dec. 4th	361	7.7	2	24	54	79	20.0	-.12	SN
	397	7.6	2	37	12	79	44.2	+.02	SN
	439	8.2	2	57	08	79	56.9	-.27	SN
	473	6.1	3	08	51	77	24.2	-.11	SN
	491	8.2	3	17	50	76	50.6	-.28	SN
	514	8.5	3	26	35	80	10.5	-.09	SN
	537	6.3	3	35	19	80	02.3	+.12	SN
	560	7.7	3	40	50	76	20.1	-.15	SN
	578	8.2	3	46	52	76	31.9	+.01	SN
	596	8.0	3	52	54	75	53.6	-.07	SN
	635	6.3	4	02	43	80	18.2	-.11	NS
	670	7.8	4	11	21	76	23.1	+.25	NS
	698	7.8	4	21	03	75	49.9	+.11	NS
	721	7.5	4	28	07	76	22.9	+.04	NS
	735	6.1	4	33	30	76	26.6	-.01	NS
	785	7.2	4	47	28	77	38.0	+.03	NS
	818	7.9	4	55	12	76	30.5	-.05	NS
	839	6.6	5	01	55	76	21.6	-.31	NS
	868	7.4	5	10	00	75	06.1	+.21	NS

−0.075 ± .021

No obs. rejected, 670, obs. questioned.

CINCINNATI OBSERVATORY,
Residuals, from Regular Programs of Work.
STATION O.

CINCINNATI, O.

1909	Prog	No *'s	Seeing	Mean Decl.	Extremes Decl.	Mean Res.	Mean Δα	Max. Δα	
Sept. 11	153	8	3+	+26°.9	+00°.7 -- +44°.9	±0ˢ.013	±0ˢ.012	(+)0ˢ.032	
" 16	154	6	2+	+28.7	+19.2 +40.0	± .027	± .023	−) .058	
" 17	155	10	3+	04.0	−16.5 +25.5	± .027	± .026	−) .046	
" 18	156	8	2	+03.7	−11.0 +23.1	± .023	± .022	+) .041	
" 27	157	8	2+	+34.0	+15.6 +40.8	± .044	± .034	+) .072	
Oct. 2	158	9	3+	+02.3	−15.1 +24.4	± .014	± .014	−) .037	
" 7	159	9	3+	−00.1	−15.0 +33.2	± .028	± .027	+) .059	
" 16	160	7	3+	−02.4	−22.8 +25.5	± .029	± .028	−) .065	
Nov. 11	161	8	3+	−00.9	−21.4 +19.4	± .020	± .020	+) .051	
" 12	162	7	#	+02.3	−27.9 +19.0	± .044	± .041	+) .079	d
" 13	163	8	3	−02.8	−16.4 +18.6	± .030	± .029	−) .061	
" 24	164	9	3+	−03.9	−30.1 +29.7	± .048	± .036	−) .089	e
a" 26	165	7	3+	+32.3	+26.9 +38.0	± .019	± .016	−) .031	
b	165	8		+45.9	+41.8 +50.6	± .025	± .017	+) .033	
aDec. 1	166	5	2	+37.5	+29.1 +33.4	± .025	± .021	−) .033	
b	166	4		+47.3	+41.9 +50.6	± .025	± .017	−) .023	
						±0.027	±0.025	0.050	

Observations stopped because of poor seeing.

e Large change in azimuth constant during observations.

a Residuals from O .

b " " O .

Probable error of clock correction from one observation 0.020sec .

Cincinnati Observatory,

Station O.
Cincinnati, O.

Position equation from Upper culmination stars.

1909	Prog	Stars	Decl.	c
Sept. 11	153	2	72°.5	− 0ˢ.10
" 16	154	2	74.8	− .13
" 17	155	2	74.1	− .02
" 18	156	2	76.2	− .10
" 27	157	2	77.3	− .21
Oct. 2	158	2	72.6	+ .03
" 7	159	2	73.2	− .06
" 16	160	1	77.8	− .01
Nov. 11	161	2	72.4	− .11
" 12	162	1	79.1	− .14
" 13	163	2	73.7	− .14
" 24	164	2	73.8	+ .04
" 26	165	2	73.7	− .15
Dec. 1	166	1	72.6	− .22
" 18	167	1	67.5	+ .07
" 23	168	1	75.0	+ .03
1910 Jan. 7	169	1	72.6	+ .19
" 10	170	2	74.1	− .02
				−0.074±015

Effect of change of illumination.

1909	Mag.	Corr.	Order of obs.
Sept. 7	2.1	− 0ˢ.037	b - f
	8	+ .022	b - f
	7	+ .017	b - f
	6.5	.000	b - f
	7.5	+ .105	f - b
	4.6	+ .145	f - b
	2.7	+ .058	f - b
	6	+ .058	b - f
	6	+ .092	f - b
	7.5	+ .058	b - f
	2.9	− .040	b - f
	3.6	+ .022	f - b
	6	+ .095	b - f
	9	+ .080	f - b
		+0.048	

f. Field faint.

b. Field bright.