GREENWICH OBSERVATIONS.

1840.

INTRODUCTION.

I. *Personal Establishment and Arrangements.*

THE establishment of Assistants, and the division of labour among them, till the month of November 1840, remained in the same state as in the year 1836. The arrangement during this period was as follows:—

Mr. Main, the First Assistant, superintended calculations and observations generally, as my confidential representative; taking immediate charge of such computations as he thought fit, and occasionally taking a part in the observations.

Mr. Henry, assisted by Mr. Ellis, had the entire charge of the Transit Instrument, the Government Chronometers, and the Signal Ball; and of all the computations connected with them. Except in the absence of one of these assistants, no part of these observations was taken by any other person.

Mr. Richardson, assisted by Mr. Rogerson and Mr. Glaisher, had the entire charge of the Circle, the Zenith Tube, and (almost entirely) of the Equatoreals and Micrometers; and of all the computations connected with them. Except in the absence of two of these assistants, no part of these observations was commonly taken by any other person.

Miscellaneous observations and calculations were divided among the assistants in the way which appeared most convenient. It is established as a rule, to be adhered to as closely as circumstances permit, that no assistant be occupied on two successive days with astronomical observations. And, as the usual time of dividing observations is 15^h astronomical (3 o'clock in the morning, civil reckoning), it is always arranged, if possible, when the Moon's time of transit passes 15^h, that the same assistant should not be required to observe the Moon and accompanying stars late in the night when the Moon passes last before 15^h, and early in the morning when the Moon passes first after 15^h.

In the departments not strictly astronomical, Mr. Ellis had charge of Stores, and Mr. Glaisher of the Library and Manuscripts.

The Lords Commissioners of Her Majesty's Treasury having assented to the recommendation of the President and Council of the Royal Society, that an active Magnetical and Meteorological Observatory should be established in connexion with the Royal Observatory (the principal building and several of the most important instruments required for this purpose being already provided), the following alterations were, in the beginning of November, made in the arrangements.

Mr. Glaisher was withdrawn from the Circle Department, and was entrusted with the immediate superintendence of the Magnetic and Meteorological Department; retaining only the care of the Library and Manuscripts. His place in the Circle Department was taken by Mr. James Paul.

Mr. Edwin Dunkin and Mr. John Russell Hind were placed under Mr. Glaisher, as assistants in the Magnetical and Meteorological Department. In other respects, the personal arrangements remain as they were.

I abstain at present from entering into any details regarding the division of labour, &c., in the Magnetical and Meteorological Department, reserving these for the account of the Magnetical and Meteorological Observations of 1841, in which I propose to include the last months of 1840.

II. *Instruments.*

No addition of important instruments has been made in the year 1840, although some alterations have been made in the suspension of the plumb-bob in the Zenith Tube, and a Double-image Micrometer was, at the end of 1839, attached to the South Equatoreal; both which will be described below.

The Cape Circle, received in 1839, was not mounted in 1840; being retained on a temporary support for examination of the form of its large pivot, and for attaching and turning a new pivot.

III. *Subjects of Observation in the Year* 1840.

The Sun, Moon, and Planets, have been observed on the meridian at every practicable opportunity, except on Sundays: the Moon and moon-culminating stars have been observed at every opportunity without exception.

The occultations of stars by the Moon, and the eclipses of Jupiter's satellites, have been regularly looked for. The immersions and emersions of the satellites behind Jupiter, and the ingresses and egresses before him, have been looked for, when occurring at convenient hours: occasionally also, the transits of shadows.

In the meridional observations of stars, it has been considered as the first object to establish with indisputable accuracy the places of those included in the Nautical Almanac list (as far as they are visible in this latitude). For this purpose, the number of observations of each star made in the two preceding years is ascertained, and the additional number necessary to make this up to twenty is considered to be the number due from the present year. In far the principal part of instances this number is exceeded: in a few (especially of stars so near the pole that their transits are considered valueless except Polaris or δ Ursæ Minoris is observed above and below on the same day), the just number is not completed.

The other stars observed are, for the most part, stars still remaining on the lists for observation last year. They are principally stars indicated by Mr. Baily, of which the places were needed for the extension of the Astronomical Society's Catalogue: there are, however, some stars whose occultation by the Moon had been observed, and some which had been compared with planets and comets, as well as some required for the Trigonometrical Survey. To these have been added, stars selected from the moon-culminating list of the Nautical Almanac, and stars compared in 1839 and 1840 with Mars, with Galle's first and second Comets, and with Bremicker's Comet.

The Zenith tube has been applied to the observations of γ Draconis at every opportunity.

The Equatoreals have been employed in comparing Mars with σ Leonis, and in comparing Galle's first and second Comets, and Bremicker's Comet, with neighbouring stars; and in taking transits of the Moon for the comparison of her diameter with that given by Burckhardt's Tables. The observations of Galle's first Comet and neighbouring stars are included in the Greenwich Observations for 1839.

The Double-image Micrometer has been used for measures of the distances and positions of a list of circumpolar double stars, and also for measures of the diameters of the planets.

IV. *Explanation of the Printed Observations.*

§ 1. *Transits as observed, and calculation of Apparent Right Ascensions,* page [2] to [133].

The *first* column on each left-hand page contains the day, which is always supposed to commence with the transit of the Sun.

The *second* column contains the numbers for convenience of reference.

The *third* column contains the name of the object observed. With respect to the Sun, Moon, and Planets, the limb whose transit is observed is always mentioned. If no limb is mentioned, it is to be understood that the estimated center was observed; this, however, is generally stated unequivocally, except where omitted from inadvertence. The center is observed only when the planet's disc is so small and so round as to make it easier to estimate the center than to determine with accuracy the place of the limb. With regard to the stars, it is to be remarked, that the proper names which have commonly been used in the Greenwich Observations and the Nautical Almanac are adopted in preference to other names. For other stars, the names have been taken in the following order of preference.

1. The Greek or Italic letter of Bayer, as adopted in Baily's Flamsteed, with the name of the constellation.
2. Flamsteed's number, with the name of the constellation.
3. The number in the Astronomical Society's Catalogue.
4. Piazzi's hour and number.
5. The number in Groombridge's Catalogue.
6. The number in Bessel's Bradley.
7. The number in Baily's edition of Flamsteed's British Catalogue.
8. The North Polar Distance; which may be a few minutes in error.

The *next seven* columns contain the seconds and decimals of seconds of time (and for several stars near the pole, the minutes) at which the object was observed to pass each of the wires: the hour and minute also being given in the *tenth* column. When the object is not observed at the 7th wire, the hour and minute are those which correspond to the last wire at which an observation was made.

With regard to the general method of observing, it may be sufficient to remark that it is the practice to take a second from the clock-face before the transit over the first wire, and to preserve the counting by listening to the beats, and not to look again at the clock-face till the transit is finished. In observing the planets, this rule is not always adhered to; the observer looking at the clock between the transits over the different wires. The fraction of the second is noted by remarking the place at which the object is seen at the successive beats of the clock. Errors in the hours and minutes are seldom alluded to in the notes of the printed observations: but every alteration of the seconds is carefully recorded.

The clocks are wound up every Monday.

In observing the Sun, a light shade is placed upon the telescope-tube, which completely screens the axis from the Sun's rays.

In observing a double star, the brighter star (if it is not otherwise expressed) is always observed. γ Virginis is seen as a single star.

The *eleventh* column contains the correction which is to be applied to the mean of the wires actually observed, in order to give the result which would have been obtained if observations had been made on all the wires (supposing the observation perfect).

The corrections applied to the transit at each wire in order to obtain the mean of the seven wires, to the 27th of May, 1840, are as follows:

For an equatoreal star.

A	+38 ·558 s
B	+25 ·672
C	+12 ·939
D	+ 0 ·046
E	—12 ·872
F	—25 ·749
G	—38 ·593

For Polaris, declination = 88°. 26′ + n''.

A	+23 m. 32 s ·80 + n × 0 s ·254
B	+15. 39 ·72 + n × 0 ·169
C	+ 7. 53 ·37 + n × 0 ·085
D	+ 1 ·67
E	— 7. 50 ·90 — n × 0 ·084
F	—15. 42 ·55 — n × 0 ·169
G	—23. 34 ·07 — n × 0 ·254

For δ Ursæ Minoris, declination = 86°. 34′ + n''.

A	+10 m. 44 s ·07 + n × 0 s ·052
B	+ 7. 8 ·74 + n × 0 ·035
C	+ 3. 36 ·07 + n × 0 ·017
D	+ 0 ·77
E	— 3. 34 ·95 — n × 0 ·017
F	— 7. 10 ·03 — n × 0 ·035
G	—10. 44 ·66 — n × 0 ·052

These numbers were derived from nineteen transits of Polaris ending with 1836, April 16.

On May 28, in consequence of the appearance of some opaque substance between the two lenses of the object-glass, it was judged desirable to have it cleaned: and Mr. Simms accordingly separated the two lenses (the first time, I believe, since the transit was mounted at Greenwich). It appeared, from Mr. Simms's examination, that the lenses were burnished into their cell, and were pressed together with so much force, that the crown lens was a little splintered. After cleaning them, Mr. Simms again burnished them together, with much less pressure than before. The definition of the image given by the object-glass was very much improved, and was, indeed, in my opinion, the finest that I ever saw. The focal length, however, was now a quarter of an inch shorter than it was before the disturbance of the lenses. The eye-tube was therefore shortened by that quantity. As the relative position of the wires had not been disturbed, it was evident that their intervals in time would not be the same as before, and a new table of corrections therefore was necessary. Sixteen complete transits of Polaris, ending with August 6, were therefore discussed in the following manner. For each transit the difference between each wire and the mean of all the wires was taken: then the mean of all these determinations relating to the same wire in the different transits was taken, and was supposed to apply to the mean of all the polar distances of the star. The equatoreal distance of each wire from the mean was then computed by the formula:

$$\text{Equatoreal distance in seconds of time} = \frac{\text{sin. star's N.P.D.} \times \text{sin. distance in time for star}}{15 \text{ sin. } 1''}:$$

and, by a reverse operation, the distances in time for a star at N.P.D. 1°. 32′ and 1°. 33′, and for a star at N.P.D. 3°. 24′ and 3°. 25′ were found. The results of these operations are contained in the following tables:

Intervals of each wire from the mean, used after 1840, May 28.

For an equatoreal star.

A	$+38^{s}\cdot566$
B	$+25\cdot674$
C	$+12\cdot917$
D	$+\ 0\cdot048$
E	$-12\cdot863$
F	$-25\cdot739$
G	$-38\cdot603$

For Polaris, declination $= 88°. 27' + n''$.

A	$+23^{m}.48^{s}\cdot33$	$+\ n \times 0^{s}\cdot260$
B	$+15.49\cdot91$	$+\ n \times 0\cdot172$
C	$+\ 7.57\cdot64$	$+\ n \times 0\cdot087$
D	$+\quad 1\cdot77$	
E	$-\ 7.55\cdot64$	$-\ n \times 0\cdot086$
F	$-15.52\cdot33$	$-\ n \times 0\cdot173$
G	$-23.49\cdot72$	$-\ n \times 0\cdot260$

For δ Ursæ Minoris, declination $= 86°. 35' + n''$.

A	$+10^{m}.47^{s}\cdot35$	$+\ n \times 0^{s}\cdot053$
B	$+\ 7.10\cdot87$	$+\ n \times 0\cdot035$
C	$+\ 3.36\cdot75$	$+\ n \times 0\cdot018$
D	$+\quad 0\cdot81$	
E	$-\ 3.35\cdot85$	$-\ n \times 0\cdot018$
F	$-\ 7.11\cdot96$	$-\ n \times 0\cdot035$
G	$-10.47\cdot98$	$-\ n \times 0\cdot053$

The signs must be changed when the illuminated end is East and the star below the pole, or when the illuminated end is West and the star above the pole.

The correction to the imperfect transit of a star is found, by adding together the equatoreal numbers from the table above for the wires observed, dividing by the number of the wires, and multiplying by the secant of the star's declination.

For a planet, the number thus obtained is multiplied by

$$1 + \frac{\text{daily increase of R.A. in seconds of time.}}{24 \times 60 \times 60}$$

For the Moon, the whole factor is calculated by the formula

$$\frac{3600 + \mathrm{I}}{3600} \times \frac{\text{sin. Moon's geocentric } Z.D.}{\text{sin. Moon's apparent } Z.D.} \times \text{secant Moon's declination,}$$

where I is the increase (in seconds of time) of the Moon's A.R., for the transit over a meridian upon the Earth distant by 1^h of terrestrial longitude, as given in the section *Moon-culminating Stars* in the Nautical Almanac.

The *twelfth* column contains the mean of the seven wires; or the mean of the wires observed, corrected by the quantity in the eleventh column. It is therefore the time of transit over an imaginary line near to the wire D.

The *thirteenth* contains the initials of the observer's name.

The *first* column on the *right-hand* page contains the value, in seconds of arc, of the error of collimation, supposed positive when it implies an additive correction to the transits of stars above the pole. For the measurement of the error of collimation, the following method has been used.

A collimator of 63 inches focal length and 3·9 inches aperture, mounted like a transit in the north opening of the transit room, is used as a fixed mark for observing with the transit in reversed positions. The wires in the field of the collimator are arranged in the form of an acute cross, or X, which admits of being observed with great accuracy, by means of the micrometer-wire of the transit eye-piece. A metallic reflector is attached to the eye-piece of the collimator, for the purpose of throwing the light of the sky upon its wires.

The value of one revolution of the micrometer-screw of the transit was found in 1836 to be 16″·266.

The following are the details of the observations for the error of collimation in 1840.

January 8, 23^h. Observations by Mr. Main. The morning frosty, but dull and calm.

Illuminated end East. $\qquad r$

Micrometer reading on coincidence with collimator (6 measures).......... 12·857

Illuminated end West.	r
Micrometer reading on coincidence with collimator (6 measures)...........	7·349
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)...........	12·887
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)...........	7·263
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)...........	12·921
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)...........	7·234
Hence, reading for true line of collimation by 1st and 2nd Sets.................	10·103
,, ,, by 3rd and 4th Sets.................	10·075
,, ,, by 5th and 6th Sets.................	10·078
Reading for true line of collimation	10·085
Micrometer reading on coincidence with *D* (10 measures)	10·130
Hence apparent error of collimation for *D*.............................	0·045

The illuminated end of the axis is left East, and the micrometer head is therefore East: and, as the readings increase when the wire is moved from the micrometer-head, it appears that the wire D is too much to the West, or the star is observed upon it when the star is too much to the East, and therefore its time of transit requires an additive or positive correction. The error of collimation, therefore, for the middle wire is $+\ 0^{r}\cdot045 = +\ 0''\cdot73$. And as, in this position of the illuminated end, stars pass the mean of the seven wires later than D by $0^{s}\cdot046$ of time, which corresponds to $0''\cdot69$ of arc, we must apply for the mean of the seven wires the correction $-\ 0''\cdot69$. For diurnal aberration we must apply $-\ 0''\cdot19$. Thus, finally, the error of collimation to be used, is $-\ 0''\cdot15$.

May 4, 23^{h}. Observations by Mr. Main. The morning gloomy and calm; but perhaps the observations were made too near to the Sun's transit.

Illuminated end East.	r
Micrometer reading on coincidence with collimator (6 measures)...........	12·649
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)...........	7·575
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)...........	12·291
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)...........	7·979
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)...........	12·078
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)...........	8·132

	r
Hence reading for true line of collimation by 1st and 2nd Sets	10·112
,, ,, by 3rd and 4th Sets	10·135
,, ,, by 5th and 6th Sets	10·105
Reading for true line of collimation	10·117
Micrometer reading on coincidence with *D* (10 measures)	10·123
Hence apparent error of collimation for *D*	0·006

The apparent error of collimation of D is $+ 0^r{\cdot}006 = + 0''{\cdot}10$. Correcting this as before by $-0''{\cdot}69$ and $-0''{\cdot}19$, the resulting error of collimation for the mean of wires is $-0''{\cdot}78$.

The following observations were made after the disturbance of the lenses of the object-glass, but before the shortening of the eye-tube.

May 28, 23ʰ. Observations by Mr. Main. Circumstances very unfavourable.

Illuminated end East.	r
Micrometer reading on coincidence with collimator (6 measures)	12·311
Illuminated end West.	
Micrometer reading on coincidence with collimator (2 measures)	8·265
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	12·048
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)	8·562
Hence reading for true line of collimation by 1st and 2nd Sets	10·288
,, ,, by 3rd and 4th Sets	10·305
Reading for true line of collimation	10·297
Micrometer reading on coincidence with *D* (from the Observations of May 4)	10·123
Hence apparent error of collimation for *D*	0·174

This gives an apparent error of collimation for D of $-0^r{\cdot}174 = -2''{\cdot}84$, which, corrected as before, gives error of collimation to be used $= -3''{\cdot}72$.

June 28, 22ʰ. Observations by Mr. Main. The morning gloomy and calm.

Illuminated end East.	r
Micrometer reading on coincidence with collimator (6 measures)	11·761
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)	7·807
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	11·728
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)	7·852

	r
Hence reading for true line of collimation by 1st and 2nd Sets	9·784
,, ,, by 3rd and 4th Sets	9·790
Reading for true line of collimation	9·787
Micrometer reading on coincidence with *D* (10 measures)	9·938
Hence apparent error of collimation for *D*	0·151

The apparent error of collimation of D is therefore + 0″·151 = + 2″·46. From the new table of intervals of wires, it appears that the correction to the mean of the seven wires is – 0″·72: that for diurnal aberration is – 0″·19. Hence the error of collimation for use is + 1″·55.

September 30, 22ʰ. Observations by Mr. Main. The morning was gloomy and calm, and generally favourable.

Illuminated end East.	r
Micrometer reading on coincidence with collimator (6 measures)	11·907
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)	7·759
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	11·878
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)	7·761
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	11·866
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)	7·779
Hence reading for true line of collimation by 1st and 2nd Sets	9·833
,, ,, by 3rd and 4th Sets	9·820
,, ,, by 5th and 6th Sets	9·823
Reading for true line of collimation	9·825
Micrometer reading on coincidence with *D* (10 measures)	9·926
Hence apparent error of collimation for *D*	0·101

The value of this is + 1·″65; which, corrected as in the last instance, gives the error of collimation for use = + 0″·74.

November 17, 22ʰ. Observations by Mr. Main. The morning was gloomy, but there was a little wind, which, perhaps, affected the position of the cross.

Illuminated end East.	r
Micrometer reading on coincidence with collimator (6 measures)	12·406
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)	7·196

The position of the collimator's cross was then altered.

Illuminated end East.	r
Micrometer reading on coincidence with collimator (6 measures)...........	13·200
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)...........	6·565
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)...........	12·887
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)...........	6·809
Hence reading for true line of collimation by 1st and 2nd Sets.................	9·801
,, ,, by 3rd and 4th Sets.................	9·882
,, ,, by 5th and 6th Sets.................	9·848
Reading for true line of collimation	9·844
Micrometer reading on coincidence with *D* (10 measures).................	9·916
Hence apparent error of collimation for *D*...........................	0·072

The apparent error of collimation is + 1″·17; which gives the error of collimation for use = + 0″·26.

On December 19, the object-glass was taken out by Mr. Simms, for the purpose of altering the cell, so as to bring the lenses together by means of a screw. It was returned on December 24. Since this alteration was made, the definition of objects, though extremely good, has not been so excellent as before it.

On December 24, Mr. Main adjusted the wire frame so that the apparent error of collimation of D was insensible. The error to be used, therefore, is only that resulting from the additional corrections, namely − 0″·91.

The numerical correction, in seconds of time, to the observed transits, is,

$$\text{error of collimation} \times \frac{1}{15.\ \text{sin. N.P.D.}}$$

Special tables of the latter factor are prepared for principal stars, and general tables for other objects: and the multiplication is performed with great ease by means of a sliding-rule.

The *second* column on the right-hand page contains the level-error: considered positive when the western pivot is too high. This is ascertained by the application of a large spirit-level which is placed upon the pivots. In the years 1839 and 1840, the correction + 0^{d}·06 has been applied for inequality of pivots, as determined in the beginning of 1839. The value of one division of the level-scales was ascertained in 1836 to be 1″·086.

The error of level is determined by applying the spirit-level 12 times (6 times in one position, and 6 times in the reversed position). The level is usually applied every Saturday: the time, however, is always mentioned in the notes.

The numerical correction of the transits is,

$$\text{error of level} \times \frac{\text{cos. zenith distance south}}{15 \text{ sin. N.P.D.}}$$

On 1st January, 1840, Mr. Main and Mr. Henry examined the state of the pivots by touching carefully with the finger and by inspecting with a lens. Every part of them was found to be in excellent condition. The dark spots noticed in the examination of 5th January, 1839, are still to be seen, and there are marks at the points which have usually been touched in applications of the level, but not the slightest inequality could be found. The level was then applied, and the readings of the ends of the bubble were taken, while the instrument was turned slowly as far as the construction of the level would permit. The following are the readings:—

Position of Object-glass.	Elevation of Object-glass.	Reading of East Scale.	Reading of West Scale.	Position of Object-glass.	Elevation of Object-glass.	Reading of East Scale.	Reading of West Scale.
S.	0°	113·4	108·0	N.	0°	113·5	105·5
	5	113·4	108·0		5	113·8	105·6
	10	112·8	108·1		10	113·9	105·3
	15	112·9	108·0		15	113·9	105·1
	20	113·0	108·1		20	113·5	105·1
	25	113·2	108·0		25	113·8	105·0
	30	112·9	108·0		30	113·9	105·0
	35	113·0	107·9		35	113·9	105·0
	40	112·9	107·9		40	113·9	105·0
	50	112·8	108·0		45	113·8	105·0
	55	112·8	107·9		50	113·5	105·1
	60	112·8	107·8		55	114·0	104·8
	0	112·8	107·2		60	113·8	104·9
	−5	112·9	107·0		0	113·7	105·0
	−10	112·9	107·0		−5	113·7	105·1
	−15	113·1	106·9		−10	113·7	105·1
	−20	113·3	106·6		−15	113·6	105·1
	−25	113·5	106·0		−20	113·6	105·0
	−30	114·0	105·5		−25	113·6	105·0
	−35	114·0	105·5		−30	113·6	105·0
	−40	113·9	105·5		−35	113·7	105·0
	−45	113·5	105·5		−40	113·7	105·0
	−50	113·8	105·4		−45	113·7	105·0
	−55	113·9	105·2		−50	113·7	105·0
	−60	113·8	105·1		−55	113·7	105·0
	0	113·5	105·4		−60	113·7	105·0

As the relation between the readings of the two ends of the bubble had sensibly changed, the first observations were repeated.

Position of Object-glass.	Elevation of Object-glass.	Reading of East Scale.	Reading of West Scale.
S.	0°	113·7	105·2
	10	113·7	105·2
	20	113·8	105·0
	30	113·7	104·9
	40	113·7	105·0
	50	113·7	105·0
	0	113·6	104·9
	−10	113·7	104·9
	−20	113·7	104·9
	−30	113·5	105·0

It appeared from these that the change which had taken place did not arise from an inequality in the transit axis, but was produced by a change in the level itself. The observations, with this remark, show that there is no appreciable irregularity of anomalous character in the form of the pivots, and no irregularity which affects, by an appreciable quantity, the relative elevation of the pivots. This observation does not exclude the possibility of an oval form, which would cause horizontal disturbance of the pivots: but it renders it extremely improbable.

The *third* column contains the transits corrected for the error of collimation and the level-error. These are set down only for those stars which are used for deducing the azimuthal error.

The *fourth* column contains the azimuthal error, considered positive when the eastern pivot is too far north. This is always determined from observations of Polaris, at consecutive passages above and below the pole, or from one observation of Polaris combined with one observation of another star. The stars used for this purpose are mentioned in the notes: the method of using them is as follows:

If two consecutive passages of Polaris have been observed, the first transit (as corrected for the error of collimation and level-error) is altered by the change of the star's A.R., and the estimated clock-rate for 12^h; and the difference, in seconds of time, between the altered first transit and the second transit (rejecting 12^h) is divided by 3·038 to obtain the azimuthal error in seconds of space.

If three transits have been observed, the difference between the first and second is taken (rejecting 12^h), and the difference between the second and third in like manner: and the mean between these is supposed to be independent of the change of A.R. and the clock's rate, and is therefore divided by 3·038.

If several transits have been observed, the same process is used for every successive set of three, and the results are used separately, or the mean of the results is taken according as there appears reason to think that the position of the instrument has or has not undergone a change.

When a single observation only can be obtained: the letter z being put for the azimuthal error, the clock-error is found by comparing the A.R. of the Nautical Almanac (with a small alteration hereafter mentioned) with the time of transit including a term multiplied by z. The clock-error therefore, from Polaris, contains a term depending on z. In like manner the clock-error from some other star not near the pole contains a term depending on z. Equating these (with the proper allowance for rate of the clock) z is found.

The error is positive when the transit of Polaris above the pole is too late.

In a few instances, δ Ursæ Minoris has been used instead of Polaris.

The numerical correction in seconds of time to each transit is,

$$\text{azimuthal error} \times \frac{\text{sin. zenith distance south}}{15 \times \text{sin. N.P.D.}}$$

On March 16, the Chingford mark was observed by Mr. Main. The mean of twelve observations gave for the reading of the micrometer wire when placed on the Chingford mark $10^{r}\cdot304$, and the mean of ten observations gave for reading on coincidence with D $10^{r}\cdot115$. The illuminated end being East, and the readings therefore increasing as the wire moved towards the West, it follows that the mark was apparently West, or really East of the line corresponding to D by $0^{r}\cdot189 = 3''\cdot08$. Now the error of collimation of D, taking a mean of the uncorrected determinations on January 8 and May 4, was $+ 0''\cdot42$, by which the line corresponding to D passed too much to the East; and therefore the mark was East of the true line of collimation by $3''\cdot08 + 0''\cdot42 = 3''\cdot50$. But the azimuthal error was $+ 2''\cdot84$, by which the line of collimation passed West of the North meridian. As Chingford is on the North side, this quantity must be subtracted from the former. Consequently, the Chingford mark is apparently $+ 0''\cdot66$ East of the true meridian.

The *fifth* column contains the seconds of every transit as affected with the three preceding corrections: and is conceived to represent the time at which each body passed the true astronomical meridian of Greenwich. The numbers to which a bracket is annexed are those resulting from the mean of two limbs.

The *sixth* column contains the seconds of the tabular A.R. of the stars which are used for determining the clock-error. These stars are taken from the list of the Nautical Almanac, those only being used whose N.P.D. exceeds 50°. The tabular A.R. of Polaris also is set down, to enable the reader to judge of the general state of adjustment of the instrument. The tabular A.R. are computed by adding to the place given in the Nautical Almanac a constant for each star, determined for the most part by the observations of the preceding year. Thus the corrections of the Nautical Almanac are adopted, without adopting the mean places of that work. For Polaris, the additional correction depending on the place of the Moon is also taken into account. The following table gives the mean A.R. for 1840, Jan. 1, which in fact are used in these computations, and the constant alterations to the places of the Nautical Almanac.

Star's Name.	Assumed Mean A.R. Jan. 1, 1840.	Correction to N.A.	Star's Name.	Assumed Mean A.R. Jan. 1, 1840.	Correction to N.A.
	h m s	s		h m s	s
α Andromedæ	0. 0. 7·83	+ 0·11	β Corvi	12. 25. 59·66	− 0·04
γ Pegasi	0. 5. 0·23	− 0·01	Spica	13. 16. 46·33	− 0·03
β Ceti	0. 35. 33·34	+ 0·06	η Bootis	13. 47. 3·98	− 0·03
θ Ceti	1. 16. 1·68	+ 0·03	Arcturus	14. 8. 21·96	− 0·01
α Arietis	1. 58. 10·12	+ 0·18	ε Bootis	14. 37. 59·97	− 0·03
γ Ceti	2. 35. 0·99	− 0·01	α Libræ	14. 42. 2·27	− 0·03
α Ceti	2. 53. 55·32	− 0·03	β Libræ	15. 8. 24·26	− 0·02
η Tauri	3. 37. 59·11	− 0·02	α Coronæ Borealis	15. 27. 54·92	+ 0·05
γ Eridani	3. 50. 34·02	+ 0·01	α Serpentis	15. 36. 23·45	+ 0·02
Aldebaran	4. 26. 44·84	+ 0·07	β¹ Scorpii	15. 56. 8·55	− 0·03
Rigel	5. 6. 51·11	+ 0·02	δ Ophiuchi	16. 5. 58·00	− 0·03
β Tauri	5. 16. 10·97	+ 0·01	Antares	16. 19. 36·48	− 0·01
δ Orionis	5. 23. 50·06	− 0·04	α Herculis	17. 7. 21·22	− 0·08
α Leporis	5. 25. 40·55	− 0·01	α Ophiuchi	17. 27. 30·58	+ 0·02
ε Orionis	5. 28. 5·83	− 0·03	μ Sagittarii	18. 4. 11·76	+ 0·04
α Columbæ	5. 33. 51·46	− 0·06	α Lyræ	18. 31. 31·31	+ 0·01
α Orionis	5. 46. 30·73	+ 0·02	β Lyræ	18. 44. 10·42	− 0·02
μ Geminorum	6. 13. 16·87	+ 0·05	ζ Aquilæ	18. 58. 3·43	+ 0·04
Sirius	6. 38. 6·01	+ 0·09	δ Aquilæ	19. 17. 25·84	+ 0·04
ε Canis Majoris	6. 52. 20·31	− 0·08	γ Aquilæ	19. 38. 39·17	+ 0·04
δ Geminorum	7. 10. 33·74	− 0·09	α Aquilæ	19. 42. 58·58	+ 0·02
Castor	7. 24. 22·93	− 0·06	β Aquilæ	19. 47. 27·20	− 0·02
Procyon	7. 30. 55·37	+ 0·02	α² Capricorni	20. 9. 10·32	+ 0·02
Pollux	7. 35. 31·05	− 0·02	ζ Cygni	21. 6. 7·78	− 0·05
15 Argûs	8. 0. 43·88	− 0·20	β Aquarii	21. 23. 7·89	− 0·03
ε Hydræ	8. 38. 17·98	− 0·04	ε Pegasi	21. 36. 19·68	− 0·04
α Hydræ	9. 19. 43·47	− 0·10	α Aquarii	21. 57. 33·82	− 0·04
ε Leonis	9. 36. 45·54	+ 0·01	ζ Pegasi	22. 33. 29·07	+ 0·07
Regulus	9. 59. 50·73	− 0·07	Fomalhaut	22. 48. 47·67	+ 0·06
δ Leonis	11. 5. 35·42	0·00	α Pegasi	22. 56. 47·72	− 0·03
δ Crateris	11. 11. 20·71	− 0·19	ι Piscium	23. 31. 43·40	+ 0·13
β Leonis	11. 40. 53·68	− 0·02			

The *seventh* column contains the error of the clock, found by subtracting the numbers in the fifth column from those in the sixth. It is therefore positive when the clock is slow.

The *eighth* and *ninth* columns contain the adopted losing rate, and the adopted error of the clock at 0^h sidereal, as found by the following process. The observations are divided into groups, marked by the bars across these columns, whose limits are (in far the greater number of instances) the same as the limits of each individual's observations. On one occasion only (April 15), the observation of a clock-star by one observer (in this instance by myself), has been combined with those by another observer. The mean of the clock-errors given by all the clock-stars in the same group is then taken, and this is held to be the clock-error corresponding to the mean of all the times of transit of the same stars. The next step is to allow for personal equation. It was found in the Introduction to the Volume of Observations for 1838, page xiii, that the clock-error given by Mr. Ellis's observations is always greater than that given by Mr. Henry's by $0^s\cdot36$. The quantity $0^s\cdot36$ is therefore subtracted from each of the mean clock-errors determined by Mr. Ellis, and it is then considered that we have a set of clock-errors justly comparable among themselves. Each mean clock-error is now compared with that which precedes and with that which follows; a preceding rate and a following rate are thus found, and by this the computer is guided in adopting the clock-rate to be used through the group of observations: this adopted clock-rate is set down in the eighth column. For facility of calculation, the proportional part of this rate corresponding to the mean sidereal time, or mean of all the times of transit for the group, is applied with changed sign to the mean clock-error (unaltered for personal equation), and thus the clock-error at 0^h sidereal is found. If it happen that any observations included in the same group are made in the sidereal day preceding or following that for which the mean error has been found, the whole adopted daily rate is subtracted from or added to the error found for 0^h, and thus the error for 0^h of the preceding or following sidereal day is obtained. These errors at 0^h are set down in the ninth column. It is to be remarked that, in the application of these errors, if the observations of small stars and planets have been made by the same person as the observations of the clock-stars (whether it be Mr. Henry or Mr. Ellis), no further computation is necessary for obtaining the right ascension of these objects than the application to the time of transit of clock-error at 0^h, and a proportional part of clock-rate corresponding to the right ascension of the object: but if the clock-stars are observed by Mr. Ellis and the other object by Mr. Henry, a further correction of $-0^s\cdot36$ must be applied: if the clock-stars are observed by Mr. Henry and the object by Mr. Ellis, $+0^s\cdot36$ must be applied. These quantities are *not* applied in the column of *Apparent Right Ascension from the Observations* in this Section.

In the Introduction for 1838 and 1839, observations were exhibited which showed that the difference between the clock-errors given by Mr. Main, Mr. Henry, and Mr. Glaisher is inconsiderable, but that the clock-error (clock slow) given by Mr. Ellis's observations is greater by $0^s\cdot36$ than that given by the other observers. In 1840, a few observations were made expressly by Mr. Main and Mr. Rogerson, for the determination of the difference between their times of observation. The names of the stars, and the order of observation, were as follows:

Stars observed alternately by Mr. Main and Mr. Rogerson, for the determination of personal equation, 1840.

Star's Name.	A. R.	N. P. D.	Day of Observation.	Ob-server.	Day of Observation.	Ob-server.
	h m	° ′				
31 Sagittarii.....	18. 42	112. 6	Sep. 17	R	Sep. 22	M
20 Aquilæ.......	19. 4	98. 12		M		M
c Aquilæ.......	19. 21	88. 22		R		M
β^1 Cygni........	19. 24	62. 22		M		M
η Sagittæ.......	19. 58	70. 28		R		M
17 Vulpeculæ....	20. 0	66. 51		M		R

The times of transit were as follows: in which it will be observed that x is the quantity which is to be added to Mr. Rogerson's time of transit, in order to make it the same as Mr. Main's time.

Star's Name.	Observed Transit on Sep. 17.		Observed Transit on Sep. 22.	
	h m s	h m s	h m s	h m s
31 Sagittarii.....		18. 42. 30·47 + x		18. 42. 21·43
20 Aquilæ.......	19. 3. 58·83		19. 3. 49·70	
c Aquilæ.......		19. 20. 54·17 + x		19. 20. 45·16
β^1 Cygni........	19. 24. 14·41		19. 24. 5·24	
η Sagittæ.......		19. 58. 2·04 + x		19. 57. 53·14
17 Vulpeculæ....	19. 59. 59·33		19. 59. 50·08 + x	

The excess of the sum of the numbers in the first column of transits on Sep. 17, over the sum of those in the second column on the same day is $26^{m}.45^{s}\cdot 89 - 3\,x$. The similar excess on Sep. 22, is $26^{m}.45^{s}\cdot 29 + x$. From these, $x = +0^{s}\cdot 15$: the quantity by which Mr. Rogerson's transits ought to be increased, or by which his uncorrected "clock slow" will be too great.

The *tenth* column contains the duration of passage of the semidiameter of a planet, &c., when both limbs have not been observed. For the Sun, this quantity is taken from the Nautical Almanac: for the Moon, from the section of Moon-culminating stars in that work: and for the Planets, from the Meridian Ephemeris. No corrections are made in this section to the semidiameters: these are noticed in a subsequent section.

The *eleventh* column contains the right ascension of the center of the body observed: it is formed by adding the time from the fifth column, the clock-error at 0^{h} next preceding from the ninth column, the proportional part of the rate in the eighth column corresponding to the right ascension, and the duration of semidiameter's passage from the tenth column. No result is set down for a clock-star, unless four clock-stars, excluding Polaris, have been observed; and no result is set down for Polaris, unless Polaris or δ Ursæ Minoris has been observed at opposite passages.

The *twelfth* column contains the correction with its proper sign, as it is to be applied for reducing the apparent right ascension at the time of observation to the mean right ascension on the 1st January, 1840. It is computed in the following way:

For the stars in the list of the Nautical Almanac, the mean A.R. of the Nautical Almanac is subtracted from the apparent A.R. of the Nautical Almanac (corrected, in the case of Polaris and δ Ursæ Minoris, for the Moon's longitude), and the sign of the quantity so found is changed.

For other stars the corrections are computed by the formula

$$\text{A a} + \text{B b} + \text{C c} + \text{D d}$$

or

$$\frac{\text{A}}{15}\cos.\ \text{A.R. cosec. N.P.D.} + \frac{\text{B}}{15}\sin.\ \text{A.R. cosec. N.P.D.} + \text{C. sin. A.R. cotan. N.P.D.} \times$$
$$\text{n}^{\circ}.\ \log.\ 0{\cdot}1259 + \frac{\text{D}}{15}\cos.\ \text{A.R. cotan. N.P.D.} + \text{C.} \times \text{n}^{\circ}.\ \log.\ 0{\cdot}4869,$$

according as the star is or is not included in the Astronomical Society's Catalogue. The logarithms of A, B, C, D, are taken from the Nautical Almanac. The sign of the quantity thus computed is then changed.

§ 2. *Apparent Right Ascensions of Polaris and δ Ursæ Minoris, and Mean Right Ascensions of Stars observed in the Year* 1840, page [136] to [149].

The apparent right ascensions of Polaris and δ Ursæ Minoris are extracted without alteration from the eleventh column of the right-hand page of the *Transits as observed*, &c.

The mean right ascensions of all the stars are found by applying to the apparent right ascensions in the eleventh column, the corrections in the twelfth column.

The resulting mean right ascensions have been increased by $0^{s}{\cdot}36$ when the star whose right ascension is determined was observed by Mr. Ellis, and the clock-stars by any other observer: or diminished by $0^{s}{\cdot}36$ when the clock-stars were observed by Mr. Ellis and the dependent star by any other observer.

The rules for the nomenclature of the stars are the same as those for the names in the section of *Transits as observed*, detailed in page iii.

§ 3. *Observations with Troughton's Mural Circle*, page (2) to (157).

The Mural Circle brought from the Cape of Good Hope not having been in a state fit for observation, Troughton's Circle has been used alone through the whole of the year 1840. Before describing the method of observing with it and explaining the printed observations in detail, I shall give those observations from which the approximate position of the instrument with regard to the meridian is inferred.

For this purpose the transits of different stars have been observed with the clock which is near the Circle. This clock is immediately compared with the transit clock, and the sidereal time of transit is therefore easily found, and admits of comparison with the right ascension, or the correct time of transit over the astronomical meridian. The following tables contain the principal steps: the parts omitted having been carefully verified.

TRANSITS FOR THE POSITION OF TROUGHTON'S CIRCLE,
Throughout the Year 1840.

DAY, 1840.	Object.	Transit by Graham 2.	Transit by Hardy.	Sidereal Time.	Sec. of A.R.	Error.
		h m s	h m s	h m s	s	s
January... 6	α Arietis........	1. 58. 32·12	1. 57. 37·12	1. 58. 10·19	10·62	− 0·43
11	α Aquilæ........	19. 43. 11·96	19. 42. 15·16	19. 42. 56·65	57·65	− 1·00
13	α Aquilæ........	19. 43. 9·84	19. 42. 11·14	19. 42. 56·61	57·67	− 1·06
19	α Aquilæ........	19. 42. 57·70	19. 41. 59·20	19. 42. 57·50	57·75	− 0·25
22	α Ceti	2. 53. 50·90	2. 52. 53·30	2. 53. 54·42	56·28	− 1·86
31	Castor (2nd star)..	7. 24. 5·78	7. 24. 9·28	7. 24. 24·73	25·49	− 0·76
February 5	Sirius	6. 37. 38·82	6. 37. 43·02	6. 38. 5·54	7·67	− 2·13
6	α Orionis........	5. 46. 3·14	5. 46. 7·43	5. 46. 31·05	32·39	− 1·34
7	Sirius...........	6. 37. 35·58	6. 37. 40·38	6. 38. 5·97	7·65	− 1·68
7	α Aquilæ........	19. 42. 26·20	19. 42. 30·60	19. 42. 56·71	58·05	− 1·34
10	α Cygni.........	20. 35. 22·00	20. 35. 26·30	20. 35. 57·94	57·19	+ 0·75
12	β Lyræ	18. 44. 29·62	18. 43. 34·82	18. 44. 9·46	9·80	− 0·34
13	α Leporis........	5. 25. 58·76	5. 25. 4·06	5. 25. 39·42	41·97	− 2·55
,,	α Columbæ......	5. 34. 9·14	5. 33. 14·44	5. 33. 49·81	52·96	− 3·15
,,	ε Canis Majoris...	6. 52. 39·20	6. 51. 44·50	6. 52. 19·96	22·09	− 2·13
March ... 4	α Cygni.........	20. 35. 48·20	20. 35. 38·00	20. 35. 57·60	57·64	− 0·04
5	α Leporis........	5. 25. 30·00	5. 25. 18·70	5. 25. 39·15	41·60	− 2·45
,,	ε Canis Majoris...	6. 52. 9·87	6. 51. 58·57	6. 52. 19·17	21·76	− 2·59
6	ζ Cygni.........	21. 5. 54·47	21. 5. 37·07	21. 6. 1·46	7·17	− 5·71
May 3	α Andromedæ....	0. 0. 20·90	23. 59. 53·30	0. 0. 7·20	7·84	− 0·64
,,	α Arietis........	1. 58. 22·80	1. 57. 55·30	1. 58. 9·34	9·96	− 0·62
16	σ Scorpii........	16. 11. 7·00	16. 10. 54·20	16. 11. 28·82	31·52	− 2·70
,,	Antares.........	16. 19. 14·50	16. 19. 1·70	16. 19. 36·33	39·69	− 3·36

TRANSITS FOR THE POSITION OF TROUGHTON'S CIRCLE—*continued.*

DAY, 1840.		Object.	Transit by Graham 2.	Transit by Hardy.	Sidereal Time.	Sec. of A.R.	Error.
			h m s	h m s	h m s	s	s
May....	22	Spica...........	13. 16. 10·10	13. 16. 2·90	13. 16. 48·55	48·89	− 0·34
	27	α Orionis........	5. 45. 39·80	5. 45. 38·20	5. 46. 32·80	31·19	+ 1·61
	28	β Libræ.........	15. 7. 29·60	15. 7. 29·60	15. 8. 26·39	27·24	− 0·85
	,,	α Serpentis......	15. 35. 29·60	15. 35. 29·60	15. 36. 26·43	26·38	+ 0·05
	,,	δ Ophiuchi......	16. 5. 3·72	16. 5. 3·72	16. 6. 0·59	1·07	− 0·48
June....	16	Aldebaran.......	4. 25. 41·60	4. 26. 16·90	4. 26. 46·42	45·51	+ 0·91
	17	ϵ^2 Bootis........	14. 36. 57·24	14. 37. 33·44	14. 38. 3·67	2·87	+ 0·80
	,,	Aldebaran.......	4. 25. 37·43	4. 26. 14·83	4. 26. 46·00	45·53	+ 0·47
	19	α Libræ.........	14. 40. 50·30	14. 41. 31·10	14. 42. 4·75	5·22	− 0·47
	,,	β Libræ.........	15. 7. 12·50	15. 7. 53·30	15. 8. 26·98	27·29	− 0·31
July.....	3	Aldebaran.......	4. 25. 34·42	4. 25. 45·92	4. 26. 46·67	45·91	+ 0·76
	14	β Tauri.........	5. 16. 42·93	5. 15. 53·93	5. 16. 13·20	12·37	+ 0·83
	,,	δ Orionis........	5. 24. 21·60	5. 23. 32·60	5. 23. 51·89	51·18	+ 0·71
	,,	α Orionis........	5. 47. 1·80	5. 46. 12·80	5. 46. 32·11	31·84	+ 0·27
	,,	Sirius...........	6. 38. 35·63	6. 37. 46·63	6. 38. 6·00	6·45	− 0·45
	27	α Herculis......	17. 8. 38·90	17. 6. 44·90	17. 7. 24·56	24·38	+ 0·18
	,,	α Ophiuchi......	17. 28. 48·26	17. 26. 54·26	17. 27. 33·94	33·74	+ 0·20
	31	α Ophiuchi......	17. 27. 23·70	17. 26. 46·30	17. 27. 32·70	33·71	− 1·01
August...	1	Antares.........	16. 19. 36·34	16. 18. 48·64	16. 19. 36·33	39·95	− 3·62
	,,	α^1 Herculis......	17. 7. 22·46	17. 6. 34·56	17. 7. 22·28	24·33	− 2·05
	,,	μ Sagittarii......	18. 4. 13·00	18. 3. 25·00	18. 4. 12·78	15·67	− 2·89
	2	Sirius...........	6. 38. 17·20	6. 37. 12·80	6. 38. 3·39	6·79	− 3·40
	,,	Procyon........	7. 31. 8·30	7. 30. 3·30	7. 30. 53·95	56·60	− 2·65
	3	Arcturus........	14. 8. 40·66	14. 7. 32·86	14. 8. 23·94	24·14	− 0·20
	,,	β Draconis......	17. 27. 11·60	17. 26. 2·50	17. 26. 53·84	51·91	+ 1·93
	,,	β^1 Lyræ.........	18. 44. 32·42	18. 43. 22·72	18. 44. 14·15	13·50	+ 0·65
	4	α Herculis......	17. 7. 50·06	17. 6. 30·56	17. 7. 23·74	24·30	− 0·56
	,,	μ Sagittarii......	18. 4. 40·40	18. 3. 20·40	18. 4. 13·64	15·66	− 2·02
	,,	α Ophiuchi......	17. 28. 59·10	17. 27. 39·40	17. 28. 32·60	33·67	− 1·07
	5	β Libræ.........	15. 8. 59·86	15. 7. 31·56	15. 8. 26·00	26·94	− 0·94
	,,	Sirius..........	6. 37. 39·80	6. 37. 10·50	6. 38. 6·26	6·86	− 0·60
	,,	Procyon........	7. 30. 27·30	7. 30. 0·10	7. 30. 55·90	56·65	− 0·75
	7	Castor..........	7. 23. 14·22	7. 23. 26·82	7. 24. 25·56	24·79	+ 0·77
	8	α Herculis.......	17. 6. 4·20	17. 6. 24·50	17. 7. 23·93	24·26	− 0·33
	,,	α Ophiuchi......	17. 26. 13·50	17. 26. 34·10	17. 27. 33·56	33·64	− 0·08
	17	μ Sagittarii......	18. 3. 4·90	18. 4. 0·70	18. 4. 14·13	15·56	− 1·43
	20	Castor..........	7. 22. 39·50	7. 24. 5·80	7. 24. 25·25	25·12	+ 0·13
	21	δ Aquilæ........	19. 16. 33·72	19. 17. 8·72	19. 17. 28·96	29·34	− 0·38
	24	δ Aquilæ........	19. 18. 2·37	19. 17. 1·87	19. 17. 26·51	29·31	− 2·80
September	16	α Hydræ........	9. 17. 32·04	9. 18. 40·24	9. 19. 44·21	45·14	− 0·93
	,,	ε Leonis.........	9. 34. 35·20	9. 35. 43·50	9. 36. 47·50	47·65	− 0·15
	,,	Regulus........	9. 57. 39·76	9. 59. 48·21	9. 59. 52·23	52·66	− 0·43
	17	α Pegasi........	22. 54. 31·64	22. 56. 46·14	22. 56. 51·03	51·58	− 0·55
	23	Regulus.........	9. 59. 11·94	9. 59. 35·54	9. 59. 52·40	52·79	− 0·39
	28	δ Leonis.........	11. 4. 53·63	11. 5. 11·93	11. 5. 37·19	37·35	− 0·16

TRANSITS FOR THE POSITION OF TROUGHTON'S CIRCLE—*concluded.*

DAY, 1840.	Object.	Transit by Graham 2.	Transit by Hardy.	Sidereal Time.	Sec. of A.R.	Error.
		h m s	h m s	h m s	s	s
October.. 8	δ Leonis.........	11. 6. 19·60	11. 4. 51·60	11. 5. 36·40	37·54	— 1·14
10	ζ Cygni.........	21. 6. 51·77	21. 5. 24·57	21. 6. 10·15	10·72	— 0·57
,,	β Aquarii	21. 23. 51·78	21. 22. 24·58	21. 23. 10·18	11·65	— 1·47
,,	ε Pegasi.........	21. 37. 3·60	21. 35. 36·40	21. 36. 22·02	23·20	— 1·18
,,	Fomalhaut.......	22. 49. 31·52	22. 48. 4·27	22. 48. 49·99	52·24	— 2·25
12	δ Leonis.........	11. 6. 14·50	11. 4. 46·50	11. 5. 37·56	37·60	— 0·04
November 10	ζ Pegasi	22. 34. 4·06	22. 32. 48·56	22. 33. 31·09	32·42	— 1·33
,,	γ Eridani	3. 51. 9·12	3. 49. 53·72	3. 50. 36·70	38·31	— 1·61
December 3	α Serpentis......	15. 36. 32·48	15. 35. 54·48	15. 36. 25·52	25·48	+ 0·04
22	α Coronæ Borealis	15. 28. 11·37	15. 27. 4·17	15. 27. 56·17	56·84	— 0·67
,,	α Serpentis......	15. 36. 39·98	15. 35. 32·78	15. 36. 24·78	25·88	— 1·10
29	α Lyræ	18. 31. 53·28	18. 31. 30·08	18. 31. 33·61	31·96	+ 1·65

I now proceed with the explanation of the columns of the printed Observations.

The *first* column on the left-hand page contains the day, always beginning with the Sun's transit: the *second* contains numbers of reference: the *third* contains the name of the object observed (the nomenclature of the stars following the same general rules as in the section of *Transits observed,* &c., except that, as a last resource, the place of the star is defined by its right ascension, which may sometimes be in error 10^s). The letters N.L. and S.L. denote the north and south limbs, and N.C. and S.C. the north and south cusps, of planets. The letter M denotes that the object is observed, not on the fixed horizontal wire, but on the wire carried by a micrometer-screw. The letter R denotes that the object is observed by reflexion from a trough of mercury. The troughs used for this purpose are about eighteen inches long and four inches broad: they are placed either on a ledge of the circle-pier, about thirty inches below the lower limb of the circle, or upon a bracket, which admits of being placed at different elevations on a carriage travelling with wheels on the ledge of the pier.

The *fourth* column contains the pointer-reading. The pointer is merely an index fixed to the pier, and pointing to the division whose reading is greater than that of microscope A by 5°. The pointer is nearer to the floor than the microscope by this quantity.

The columns from the *fifth* to the *tenth* contain the readings of the six microscopes. The application of the letters is the same as in the Observations of 1836, 1837, and 1838: the observer beginning with the northern horizontal microscope, and passing the upper microscopes, the southern horizontal, and the lower ones, in the direction of the circle's circumference, reads them in the order A, C, E, B, D, F. These readings, in the observing books, are placed in the order $\frac{\text{A, C, E}}{\text{B, D, F}}$: from which form they are easily changed into the order of printing. Each pair of adjacent readings, therefore, is the pair of readings at the opposite ends of a diameter. The minutes are given in the fifth column only.

In order to determine the mean reading of the microscopes, the mean of the seconds in these six columns must be taken. This is correct, on the supposition that the micrometer in each microscope makes exactly five revolutions in carrying its wire from the image of one division on the limb to the image of the next division. This however seldom holds. It is necessary to take into account the error, not only because it is sensible, but also because it is periodic, varying considerably with the general temperature of the season.

It is the practice now, on every Monday, to examine three intervals on the limb with each microscope, and thus to ascertain the excess of reading of the micrometer in the position commonly used (namely, when the micrometer is turned in the direction increasing its readings, from its zero till the wire coincides with the next image of a division) above its reading for the image of a division on the other side of the zero. The quantity by which this exceeds $5'$ being taken for each microscope, the sum of these excesses with sign changed is given as a correction, in the *eleventh* column, called "Correction for Runs." This number is the correction when the micrometer-reading amounts to $5'$: a proportional part is to be taken for any other reading: and it is to be applied to the sum of the microscope-readings before that sum is divided by 6. Occasionally, when the image of a division is very near the zero of the micrometer, the micrometer is turned in the opposite direction to coincide with that image: this is indicated by the mark †, denoting "the micrometers placed on the next divisions." The amount of correction then necessary is, the correction which would have been applied if the observations had been made in the usual way, diminished by the whole correction for $5'$.

The following tables contain the amount of error in each microscope for a reading of $5'$, as ascertained in various positions of the Circles in each week:

ERRORS OF EACH MICROSCOPE OF TROUGHTON'S CIRCLE, FOR A READING OF 5′, THROUGHOUT THE YEAR 1840.

Day, 1840.	Pointer Reading.	MICROSCOPES A	B	C	D	E	F	Sum.
	°	″	″	″	″	″	″	″
January..... 6	150	+ 1·3	+ 2·4	+ 1·4	− 0·7	− 0·2	+ 0·2	+ 4·4
,,	170	+ 1·9	+ 2·0	+ 0·2	− 2·0	− 0·6	− 0·2	+ 1·3
,,	190	+ 1·6	+ 2·0	+ 1·1	− 0·6	+ 0·3	− 0·5	+ 3·9
13	33	+ 2·5	+ 2·1	+ 1·2	− 1·1	+ 0·6	+ 0·2	+ 5·5
,,	66	− 0·1	+ 2·8	− 0·2	− 0·1	− 0·6	+ 0·3	+ 2·1
,,	199	+ 1·6	+ 1·1	+ 0·4	− 1·1	+ 1·6	+ 0·5	+ 4·1
20	111	+ 0·2	+ 1·4	+ 1·3	+ 0·4	− 1·5	− 0·5	+ 1·3
,,	194	+ 3·0	+ 2·9	+ 0·5	− 0·6	+ 1·7	− 1·5	+ 6·0
,,	320	+ 1·7	+ 2·3	+ 1·1	− 1·0	+ 1·4	+ 1·5	+ 7·0
27	50	+ 1·4	+ 1·9	+ 1·2	− 0·2	− 0·2	+ 1·5	+ 5·6
,,	105	+ 1·8	+ 3·2	+ 1·1	− 0·1	− 0·6	− 1·8	+ 3·6
,,	186	+ 3·4	+ 1·8	+ 0·8	− 2·8	− 0·7	− 1·1	+ 1·4
February ... 3	46	+ 0·6	+ 2·7	+ 1·0	+ 0·1	− 1·6	− 1·4	+ 1·4
,,	80	+ 2·3	+ 1·9	+ 0·7	− 2·0	+ 1·0	+ 1·3	+ 5·2
,,	157	+ 2·6	+ 0·6	+ 0·9	− 2·9	+ 1·4	− 0·8	+ 1·8
11	59	+ 1·2	+ 1·8	+ 2·4	− 1·1	0·0	− 1·4	+ 2·9
,,	93	+ 1·4	+ 1·7	+ 0·8	+ 0·6	− 0·9	− 1·2	+ 2·4
,,	200	+ 2·4	+ 1·4	+ 2·6	− 2·8	+ 1·1	− 0·8	+ 3·9
18	69	+ 3·6	+ 2·9	+ 1·1	− 1·3	+ 1·8	+ 1·5	+ 9·6
,,	103	+ 2·6	+ 2·4	+ 3·1	− 1·9	− 2·9	− 0·8	+ 2·5
,,	208	+ 1·6	+ 0·3	+ 1·5	+ 1·2	+ 1·2	− 1·8	+ 4·0
24	63	+ 2·1	+ 1·8	+ 1·4	− 1·1	+ 1·2	− 1·7	+ 3·7
,,	194	+ 2·2	+ 2·8	+ 1·7	+ 0·9	− 1·9	+ 2·3	+ 8·0
,,	217	+ 2·2	+ 0·4	+ 1·1	− 2·3	− 1·9	+ 0·8	+ 0·3
March...... 2	116	+ 3·8	+ 1·8	+ 1·0	+ 1·8	+ 1·5	+ 1·0	+10·9
,,	207	+ 0·7	+ 2·9	+ 2·1	+ 1·7	+ 1·7	+ 0·3	+ 9·4
,,	303	+ 2·3	+ 1·8	+ 2·5	+ 2·7	+ 1·7	+ 2·1	+13·1
9	50	+ 2·4	+ 0·6	− 0·9	− 1·7	+ 0·5	− 0·2	+ 0·7
,,	116	+ 1·7	+ 2·1	+ 1·0	− 2·4	+ 2·1	+ 1·9	+ 6·4
,,	208	+ 0·7	+ 0·7	+ 1·8	− 0·4	+ 1·2	− 3·6	+ 0·4
16	192	+ 4·1	+ 1·8	+ 0·3	− 1·5	+ 3·3	+ 1·6	+ 9·6
,,	263	+ 3·7	+ 0·3	+ 2·1	− 1·1	+ 2·2	+ 2·1	+ 9·3
,,	33	+ 1·7	+ 1·6	+ 0·4	− 1·2	+ 3·9	+ 1·0	+ 7·4
24	0	+ 0·1	− 0·7	+ 1·6	− 0·7	− 0·4	− 0·7	− 0·8
,,	63	+ 1·0	− 0·6	− 0·4	− 0·7	+ 0·3	+ 0·3	− 0·1
,,	159	+ 0·8	− 0·6	− 0·3	− 2·6	0·0	+ 1·9	− 0·8

TROUGHTON'S CIRCLE—*continued.*

Day, 1840.	Pointer Reading.	MICROSCOPES A	B	C	D	E	F	Sum.
	°	"	"	"	"	"	"	"
March...... 29	80	+ 2·4	+ 1·5	+ 0·8	− 1·6	− 1·4	+ 2·6	+ 4·3
,,	117	+ 1·6	+ 2·6	+ 2·1	− 1·8	− 0·2	+ 0·6	+ 4·9
,,	153	− 0·6	+ 0·1	+ 2·0	− 0·9	+ 0·6	+ 0·3	+ 1·5
April....... 6	150	+ 1·1	+ 1·7	+ 2·8	− 1·2	+ 0·2	+ 0·4	+ 5·0
,,	210	+ 1·3	− 0·3	+ 1·7	− 0·7	+ 4·1	+ 2·3	+ 8·4
,,	310	+ 3·5	+ 2·5	+ 1·0	− 1·3	+ 2·0	+ 0·3	+ 8·0
13	110	+ 2·8	+ 1·8	+ 1·7	+ 0·1	+ 3·0	+ 0·7	+10·1
,,	156	+ 3·7	+ 1·1	+ 1·5	+ 0·4	+ 2·7	+ 1·4	+10·8
,,	60	+ 2·7	+ 3·0	+ 2·0	− 0·4	+ 1·0	0·0	+ 8·3
20	100	+ 1·4	+ 4·3	+ 1·4	+ 1·1	+ 0·1	+ 0·4	+ 8·7
,,	37	+ 4·4	+ 2·9	+ 2·0	0·0	+ 1·8	+ 1·3	+12·4
,,	344	+ 0·9	+ 1·8	+ 1·1	+ 0·2	+ 0·6	+ 1·3	+ 5·9
27	153	+ 2·0	+ 2·8	+ 1·5	+ 2·0	− 0·7	+ 0·8	+ 8·4
,,	250	+ 1·5	+ 1·8	+ 2·3	− 0·9	+ 2·7	+ 3·0	+10·4
,,	5	+ 2·6	+ 1·9	+ 2·0	− 0·7	+ 1·1	+ 0·9	+ 7·7
May........ 4	252	+ 3·6	+ 1·9	+ 2·1	− 0·9	− 0·2	+ 0·8	+ 7·3
,,	183	+ 3·9	+ 3·0	+ 0·6	0·0	+ 1·0	+ 0·9	+ 9·4
,,	98	+ 3·7	+ 3·9	+ 1·8	− 0·7	+ 0·8	+ 1·8	+11·3
11	123	+ 1·8	+ 1·9	+ 2·7	− 1·1	− 0·8	+ 0·8	+ 5·3
,,	214	+ 1·2	+ 2·3	+ 4·1	− 0·3	− 0·5	+ 0·8	+ 7·6
,,	312	+ 1·5	+ 0·3	+ 2·8	− 0·9	+ 0·5	+ 0·1	+ 4·3
18	145	+ 4·1	+ 2·2	+ 3·0	− 0·5	− 1·0	+ 1·1	+ 8·9
,,	190	+ 4·0	+ 1·7	+ 2·8	+ 0·2	+ 1·7	+ 1·4	+11·8
,,	235	+ 2·7	+ 2·0	+ 1·7	− 1·0	+ 0·2	+ 1·0	+ 6·6
25	111	+ 3·0	+ 3·8	+ 1·7	+ 1·8	+ 2·8	+ 3·4	+16·5
,,	12	+ 2·2	+ 3·2	+ 2·7	− 0·5	+ 2·6	+ 2·8	+13·0
,,	250	+ 3·9	+ 3·8	+ 2·0	+ 0·1	+ 1·1	+ 1·4	+12·3
June........ 1	119	+ 2·5	+ 2·2	+ 2·7	+ 1·1	+ 4·1	+ 3·2	+15·8
,,	34	+ 4·0	+ 2·8	− 0·1	+ 1·9	+ 4·2	+ 3·8	+16·6
,,	295	+ 5·1	+ 1·8	+ 1·3	+ 1·1	+ 2·0	+ 4·3	+15·6
8	130	+ 3·6	+ 4·4	+ 2·6	0·0	+ 3·0	+ 1·3	+14·9
,,	74	+ 3·7	+ 2·7	+ 2·1	+ 1·6	+ 1·8	0·0	+11·9
,,	15	+ 2·3	+ 5·0	+ 3·4	+ 1·2	+ 2·2	+ 3·0	+17·1
15	16	+ 3·6	+ 4·0	+ 2·5	+ 0·2	+ 2·3	+ 2·2	+14·8
,,	81	+ 2·1	+ 0·2	+ 3·3	+ 1·2	+ 3·2	+ 0·5	+10·5
,,	203	+ 3·2	+ 2·5	+ 1·4	+ 0·8	+ 0·3	+ 0·3	+ 8·5

TROUGHTON'S CIRCLE—*continued.*

Day, 1840.	Pointer Reading.	MICROSCOPES A	B	C	D	E	F	Sum.
	°	"	"	"	"	"	"	"
June 22	95	+ 1·7	+ 3·1	+ 3·0	+ 0·5	+ 0·5	+ 2·1	+10·9
,,	336	+ 3·9	+ 2·5	+ 4·8	+ 2·8	+ 1·9	+ 1·8	+17·7
,,	275	+ 2·2	+ 2·2	+ 0·3	+ 2·0	+ 4·6	− 0·3	+11·0
29	18	+ 2·0	+ 1·4	+ 3·3	+ 0·8	+ 1·6	+ 0·3	+ 9·4
,,	105	+ 3·6	− 2·1	+ 1·3	+ 0·3	− 1·2	+ 0·9	+ 2·8
,,	337	+ 3·4	+ 1·4	+ 1·7	− 1·3	+ 3·0	+ 0·3	+ 8·5
July 6	3	+ 3·6	+ 2·8	+ 1·4	+ 0·1	+ 0·3	+ 0·7	+ 8·9
,,	105	+ 3·7	+ 2 9	+ 1·4	+ 0·3	+ 3·2	+ 0·2	+11·7
,,	213	+ 2·7	+ 1·9	+ 2·1	− 1·5	+ 2·4	+ 0·8	+ 8·4
13	154	+ 3·9	+ 3·4	+ 1·2	− 0·4	+ 0·6	+ 0·7	+ 9·4
,,	240	+ 3·2	+ 0·6	+ 0·9	− 1·5	+ 3·1	+ 2·6	+ 8·9
,,	350	+ 0·8	+ 0·9	+ 0·9	− 0·7	+ 1·3	+ 2·0	+ 5·2
21	20	+ 4·1	+ 3·9	+ 2·2	− 1·0	+ 4·3	+ 0·7	+14·2
,,	88	+ 2·7	+ 4·1	+ 1·8	− 1·4	+ 0·9	+ 1·5	+ 9·6
,,	142	+ 1·7	+ 3·9	+ 1·9	+ 0·3	+ 2·5	+ 0·7	+11·0
27	56	+ 1·8	+ 1·2	+ 3·0	− 1·2	+ 0·7	+ 1·7	+ 7·2
,,	116	+ 1·8	+ 1·8	+ 1·0	+ 1·0	− 0·7	+ 0·1	+ 5·0
,,	209	+ 2·9	+ 3·7	+ 1·7	− 0·6	+ 2·1	+ 0·5	+10·3
August 3	16	+ 2·6	+ 4·0	+ 2·3	+ 0·2	+ 2·2	+ 1·1	+12·4
,,	141	+ 3·1	+ 2·1	+ 4·1	− 3·0	+ 2·2	+ 0·9	+ 9·4
,,	309	+ 3·1	+ 3·8	+ 2·1	− 0·6	+ 0·7	+ 0·9	+10·0
10	51	+ 4·0	+ 2·7	+ 0·2	+ 0·6	+ 1·7	+ 1·3	+10·5
,,	90	+ 2·5	+ 3·3	+ 2·2	+ 0·1	+ 1·2	+ 1·6	+10·9
,,	188	+ 1·6	+ 3·8	+ 2·7	+ 0·1	+ 0·2	+ 0·6	+ 9·0
17	96	+ 2·4	+ 2·7	+ 2·6	+ 0·6	− 2·9	+ 1·1	+ 6·5
,,	179	+ 2·0	+ 2·9	+ 0·5	− 0·2	+ 1·2	− 0·8	+ 5·6
,,	260	+ 3·4	+ 3·7	− 0·3	− 2·2	+ 0·6	+ 0·4	+ 5·6
24	105	+ 1·4	+ 1·9	+ 1·9	+ 0·2	+ 0·2	+ 1·3	+ 6·9
,,	183	+ 2·6	+ 3·7	+ 2·8	+ 0·4	+ 0·4	+ 0·9	+10·8
,,	269	+ 1·2	+ 4·1	+ 2·4	+ 0·1	+ 2·6	+ 1·8	+12·2
31	4	+ 4·1	+ 3·3	+ 3·6	+ 0·1	+ 1·7	+ 0·6	+13·4
,,	177	+ 2·6	+ 2·7	+ 2·1	+ 0·9	+ 2·9	+ 1·2	+12·4
,,	301	+ 1·4	+ 2·4	+ 2·2	0·0	+ 1·7	+ 0·4	+ 8·1
September .. 7	109	+ 0·3	+ 2·9	+ 2·1	− 0·7	+ 1·3	0·0	+ 5·9
,,	241	+ 1·8	+ 3·1	+ 2·1	− 0·2	+ 1·9	+ 1·2	+ 9·9
,,	27	+ 3·3	+ 3·2	+ 1·9	+ 0·7	+ 0·2	+ 1·7	+11·0

TROUGHTON'S CIRCLE—*continued.*

Day, 1840.	Pointer Reading.	MICROSCOPES A	B	C	D	E	F	Sum.
	°	″	″	″	″	″	″	″
September.. 14	150	+ 1·7	+ 0·6	+ 0·8	0·0	0·0	+ 1·2	+ 4·3
,,	216	+ 2·5	+ 2·2	+ 0·4	− 0·2	+ 0·2	+ 1·5	+ 6·6
,,	280	+ 3·6	+ 2·1	+ 0·6	− 0·1	+ 0·6	+ 0·6	+ 7·4
21	149	+ 3·2	+ 2·8	+ 2·4	0·0	+ 0·4	+ 0·2	+ 9·0
,,	54	+ 3·6	+ 2·6	+ 0·9	− 1·7	+ 2·3	+ 1·4	+ 9·1
,,	230	+ 3·1	+ 2·3	+ 1·2	− 1·4	+ 1·5	+ 0·6	+ 7·3
28	358	+ 0·9	+ 2·0	+ 1·0	+ 1·0	+ 0·2	+ 0·9	+ 6·0
,,	115	+ 1·4	+ 2·9	+ 2·2	+ 1·8	+ 1·8	+ 2·9	+13·0
,,	220	+ 1·8	+ 1·8	+ 1·6	+ 0·4	+ 0·5	+ 2·0	+ 8·1
October..... 5	69	+ 2·9	+ 3·5	+ 2·1	− 0·8	+ 1·5	+ 0·9	+10·1
,,	183	+ 1·9	+ 3·3	+ 1·2	− 0·8	− 0·4	− 0·1	+ 5·1
,,	301	+ 0·4	+ 1·9	− 0·3	− 0·4	− 0·2	− 0·6	+ 0·8
12	37	+ 2·1	+ 1·4	− 0·4	− 1·4	+ 1·6	− 0·6	+ 2·7
,,	110	+ 1·4	+ 1·5	0·0	− 0·8	+ 1·2	+ 0·4	+ 3·7
,,	180	+ 2·2	+ 1·6	+ 0·9	− 0·9	− 0·1	− 0·5	+ 3·2
19	219	+ 3·1	+ 3·1	+ 2·5	− 1·7	+ 0·4	+ 2·3	+ 9·7
,,	111	+ 2·7	+ 1·3	+ 1·5	+ 1·9	− 3·4	+ 3·2	+ 7·2
,,	31	+ 2·2	+ 1·4	+ 0·8	− 0·8	+ 1·3	+ 1·3	+ 6·2
26	121	+ 1·9	+ 2·1	+ 1·1	− 2·2	+ 0·7	+ 0·8	+ 4·4
,,	72	+ 1·2	+ 3·5	+ 0·9	+ 1·8	+ 1·2	+ 1·0	+ 9·6
,,	257	+ 2·5	+ 1·9	+ 2·1	− 0·6	+ 2·2	+ 2·9	+11·0
November .. 2	150	+ 3·1	+ 2·0	+ 1·1	0·0	+ 4·7	+ 2·2	+13·1
,,	70	+ 3·0	+ 2·2	+ 5·4	+ 2·2	+ 0·3	+ 0·9	+14·0
,,	0	+ 4·4	+ 0·3	− 1·4	+ 2·2	+ 0·3	+ 3·1	+ 8·9
11	63	+ 1·4	+ 1·3	+ 1·2	+ 0·5	+ 1·2	+ 0·6	+ 6·2
,,	168	− 1·1	+ 2·4	+ 0·1	− 1·9	+ 1·6	+ 1·6	+ 2·7
,,	259	+ 3·4	+ 2·7	+ 1·5	− 1·2	+ 0·3	− 0·7	+ 6·0
17	101	+ 2·8	− 0·2	+ 2·4	+ 1·6	+ 0·5	+ 0·6	+ 7·7
,,	205	+ 2·4	+ 2·2	+ 2·7	− 1·4	+ 1·6	+ 0·7	+ 8·2
,,	299	+ 3·3	+ 1·6	+ 1·3	− 2·2	+ 0·2	+ 1·3	+ 5·5
25	3	+ 0·7	+ 1·8	+ 0·9	− 2·0	+ 1·4	+ 0·3	+ 3·1
,,	127	+ 0·2	+ 1·9	+ 1·4	− 1·4	− 0·1	+ 1·2	+ 3·2
,,	251	+ 1·5	+ 2·4	+ 0·2	− 1·3	+ 1·5	− 0·3	+ 4·0
30	351	− 0·6	+ 3·2	+ 0·8	− 0·4	+ 2·5	+ 0·5	+ 6·0
,,	55	+ 2·4	+ 0·8	+ 1·6	0·0	+ 1·8	+ 1·3	+ 7·9
,,	120	+ 1·4	+ 3·0	+ 0·3	+ 0.4	+ 0·8	+ 0·6	+ 6·5

TROUGHTON'S CIRCLE—*concluded.*

Day, 1840.	Pointer Reading.	MICROSCOPES. A	B	C	D	E	F	Sum.
	°	″	″	″	″	″	″	″
December... 7	152	+ 1·2	+ 3·0	+ 2·0	− 0·8	+ 0·8	− 0·9	+ 5·3
,,	253	+ 1·1	+ 1·6	+ 0·8	+ 0·3	+ 1·3	+ 0·8	+ 5·9
,,	25	+ 2·9	+ 1·7	+ 1·1	− 2·0	+ 1·2	+ 0·7	+ 5·6
14	108	+ 0·5	+ 0·9	+ 1·6	+ 2·1	+ 2·1	+ 0·4	+ 7·6
,,	240	0·0	+ 2·5	− 2·3	− 1·7	+ 4·0	+ 2·7	+ 5·2
,,	24	− 0·3	+ 2·1	+ 2·0	+ 2·8	− 2·4	+ 1·7	+ 5·9
22	12	+ 0·6	+ 2·9	+ 0·6	− 1·4	+ 1·4	+ 0·7	+ 4·8
,,	137	+ 1·1	+ 1·9	+ 2·5	− 0·1	− 0·9	− 0·4	+ 4·1
,,	209	+ 1·5	+ 0·4	+ 1·9	− 0·2	+ 2·8	− 0·1	+ 6·3
27	56	+ 2·0	+ 0·2	+ 0·7	− 1·2	− 0·8	− 0·6	+ 0·3
,,	136	+ 2·0	+ 1·7	− 0·3	0·0	− 0·4	+ 0·5	+ 3·5
,,	206	+ 0·6	+ 1·4	+ 0·3	− 0·4	+ 0·9	− 0·5	+ 2·3

The *eleventh* column contains the value of the correction for runs; determined, for the most part, by taking the mean of the preceding and following means from the table above.

The *twelfth* column contains the reading of the micrometer in the eye-piece of the circle-telescope. It is used either when an object is observed by reflexion and directly at the same transit (the circle being clamped and the microscopes read before the object is seen by reflexion; and the observation, when it enters the field, being made with the micrometer-wire), or when two objects pass in rapid succession in the same field, or for the observation of one limb of a planet when the other limb is observed on the fixed wire, or for the Moon when observed several times in passing the field. The reading of the micrometer when its wire coincides with the fixed wire is ascertained every week: this reading is given at the bottom of the page. The wires being not perfectly parallel, it is thought desirable to ascertain the coincidence-reading at each of the points where the horizontal wire is intersected by the five vertical wires. It does not appear necessary to give any further details of the observations for the coincidences.

The *thirteenth* column contains the value, in minutes and seconds, of the arc measured with the micrometer. The value of one revolution was found in 1836 to be $53''{\cdot}56$; and this value was used to the end of 1839. In the year 1840, a set of observations was made for ascertaining the value, which gave a result somewhat different. The details of these observations are as follows:

Observations made for determining the value of the Micrometer-screw of Troughton's Circle.

June 18ᵈ. 1ʰ. The object bisected was a window-sill of a house, on which the near North Meridian Mark is fixed. Observer Mr. Richardson.

Micrometer set at 2ʳ·000.

Circle Reading	A = 348° 0′ 50″·6	
	B = ... 43·7	
	A = ... 49·2	
	B = ... 42·6	
	A = ... 50·3	
	B = ... 43·0	
	A = ... 51·4	
	B = ... 44·6	
	A = ... 50·0	
	B = ... 44·0	
	A = ... 49·0	
	B = ... 44·2	
Mean	=	348. 0. 46·883
Correction for Runs (for 5′ = − 2″·6)	=	−0·450
Concluded Reading for Micrometer at 2ʳ·000	=	348. 0. 46·433
for Micrometer at 12ʳ·000	=	347. 51. 55·002
Difference, or value of Ten Revolutions	=	8. 51·431
One Revolution.........	=	53·1431

Micrometer set at 12ʳ·000.

Circle Reading	A = 347° 51′ 62″·7	
	B = ... 51·5	
	A = ... 63·0	
	B = ... 52·8	
	A = ... 60·4	
	B = ... 50·2	
	A = ... 62·6	
	B = ... 51·3	
	A = ... 60·2	
	B = ... 50·2	
	A = ... 58·0	
	B = ... 49·0	
Mean	=	347. 51. 55·992
Correction for Runs	=	−0·990
Concluded Reading........	=	347. 51. 55·002

These are not used in determining the mean; it being considered that the reading 12ʳ·000 is too far from the center of the field of view for accurate vision.

July 20ᵈ. 0ʰ. Observer Mr. Richardson.

Micrometer set at 3ʳ·000.

Circle Reading	A = 347° 59′ 55″·0
	B = ... 50·3
	A = ... 56·2
	B = ... 49·6
	A = ... 57·4
	B = ... 49·8

Micrometer set at 9ʳ·000.

Circle Reading	A = 347° 54′ 34″·4
	B = ... 29·8
	A = ... 38·3
	B = ... 30·3
	A = ... 37·0
	B = ... 28·4

Circle Reading	A =	347°. 59′. 55″·6
	B =	.. .. 47·0
	A =	.. .. 55·7
	B =	.. .. 48·5
	A =	.. .. 55·8
	B =	.. .. 48·8
	A =	.. .. 53·6
	B =	.. .. 47·8
	A =	.. .. 54·2
	B =	.. .. 50·4
	A =	.. .. 50·9
	B =	.. .. 47·5
Mean	=	347. 59. 51·894
Correction for Runs (for 5′ = − 3″·4)........	=	+0·091
Concluded Reading for Micrometer at 3r·000	=	347. 59. 51·985
for Micrometer at 9r·000	=	347. 54. 32·494
Difference, or value of Six Revolutions	=	5. 19·491
One Revolution	=	53·249

Circle Reading	A =	347°. 54′. 37″·0
	B =	.. .. 30·4
	A =	.. .. 36·0
	B =	.. .. 29·5
	A =	.. .. 35·5
	B =	.. .. 30·6
	A =	.. .. 33·0
	B =	.. .. 28·0
	A =	.. .. 33. 5
	B =	.. .. 30·3
	A =	.. .. 30·7
	B =	.. .. 26·5
Mean	=	347. 54. 32·177
Correction for Runs	=	+0·317
Concluded Reading	=	347. 54. 32·496

Note—In the above observations, the micrometers of the microscopes (A and B) were placed on the next divisions.

July 20d. 0h. Observer Mr. Richardson.

Micrometer set at 4r·000.

Circle Reading	A =	347°. 58′. 64″·0
	B =	.. .. 58·5
	A =	.. .. 62·6
	B =	.. .. 57·0
	A =	.. .. 60·6
	B =	.. .. 55·0
	A =	.. .. 62·8
	B =	.. .. 56·4
	A =	.. .. 62·4
	B =	.. .. 56·8
	A =	.. .. 62·2
	B =	.. .. 56·4
	A =	.. .. 67·4
	B =	.. .. 61·4

Micrometer set at 8r·000.

Circle Reading	A =	347°. 55′. 27″·0
	B =	.. .. 22·2
	A =	.. .. 27·4
	B =	.. .. 22·8
	A =	.. .. 28·2
	B =	.. .. 23·0
	A =	.. .. 27·6
	B =	.. .. 22·4
	A =	.. .. 28·9
	B =	.. .. 23·0
	A =	.. .. 29·0
	B =	.. .. 23·6
	A =	.. .. 28·5
	B =	.. .. 20·7

		° ′ ″
Circle Reading	A =	347. 58. 65·3
	B =	.. .. 58·4
Mean	=	347. 58. 60·450
Correction for Runs (for 5′ = − 3″·4)	=	−2·720
Concluded Reading for Micrometer at 4r·000	=	347. 58. 57·730
for Micrometer at 8r·000	=	347. 55. 25·419
Difference, or value of Four Revolutions	=	3. 32·311
One Revolution.........	=	53·078

		° ′ ″
Circle Reading	A =	347. 55. 31·5
	B =	.. .. 25·6
Mean	=	347. 55. 25·713
Correction for Runs	=	−0·294
Concluded Reading	=	347. 55. 25·419

July 20d. 23h. Observer Mr. Richardson.

Micrometer set at 5r·000.

		° ′ ″
Circle Reading	A =	247. 58. 8·4
	B =	.. .. 2·6
	A =	.. .. 8·3
	B =	.. .. 1·8
	A =	.. .. 7·5
	B =	.. .. 0·6
	A =	.. .. 8·3
	B =	.. .. 2·6
	A =	.. .. 8·0
	B =	.. .. 2·0
	A =	.. .. 7·5
	B =	.. .. 1·7
	A =	.. .. 7·6
	B =	.. .. 1·4
	A =	.. .. 7·4
	B =	.. .. 1·3
Mean	=	247. 58. 4·813
Correction for Runs (for 5′ = − 3″·4)	=	−2·097
Concluded Reading for Micrometer at 5r·000	=	247. 58. 2·716
for Micrometer at 12r·000	=	247. 51. 51·024
Difference, or value of Seven Revolutions	=	6. 11·692
One Revolution	=	53·099

Micrometer set at 12r·000.

		° ′ ″
Circle Reading	A =	247. 51. 57·0
	B =	.. .. 46·5
	A =	.. .. 55·5
	B =	.. .. 46·2
	A =	.. .. 58·4
	B =	.. .. 47·8
	A =	.. .. 58·4
	B =	.. .. 47·3
	A =	.. .. 57·4
	B =	.. .. 46·7
	A =	.. .. 58·0
	B =	.. .. 47·1
	A =	.. .. 56·8
	B =	.. .. 47·0
	A =	.. .. 59·0
	B =	.. .. 47·6
Mean	=	247. 51. 52·294
Correction for Runs	=	−1·270
Concluded Reading	=	247. 51. 51·024

This result is omitted in determining the final mean, for the same reason as in the first set.

July 21ᵈ. 0ʰ. Object, top of chimney on the Ranger's House,* no object being visible at Blackwall. Observer Mr. Glaisher.

Micrometer set at 2ʳ·000.

Circle Reading	A =	167° 15′ 28″·2
	B =	.. .. 19·1
	A =	.. .. 27·1
	B =	.. .. 20·5
	A =	.. .. 27·5
	B =	.. .. 20·8
	A =	.. .. 26·2
	B =	.. .. 18·9
	A =	.. .. 25·0
	B =	.. .. 19·0
	A =	.. .. 26·6
	B =	.. .. 19·8
	Mean =	167. 15. 23·225
Correction for Runs (for 5′ = — 3″·4)	=	—0·253
Concluded Reading for Micrometer at 2ʳ·000	=	167. 15. 22·972
for Micrometer at 8ʳ·000	=	167. 10. 3·608
Difference, or value of Six Revolutions	=	5. 19·364
One Revolution	=	53·227

Micrometer set at 8ʳ·000

Circle Reading	A =	167° 9′ 67″·2
	B =	.. .. 60·0
	A =	.. .. 66·0
	B =	.. .. 59·0
	A =	.. .. 66·5
	B =	.. .. 62·0
	A =	.. .. 66·7
	B =	.. .. 60·8
	A =	.. .. 66·9
	B =	.. .. 61·0
	A =	.. .. 65·5
	B =	.. .. 62·1
	Mean =	167. 10. 3·642
Correction for Runs	=	—0·034
Concluded Reading	=	167. 10. 3·608

Note.—For the readings with micrometer-wire at 8ʳ·000, the micrometers of the microscopes (A and B) were placed on the next divisions.

The distance of the house being about 2000 feet, and the half-length of the telescope being 3 feet, this result ought to be diminished by about $\frac{1}{700}$ part. It is omitted in taking the mean.

July 28ᵈ. 22ʰ. The object bisected is a window-sill of a house, on which the near meridian-mark is fixed, at Blackwall. During the observations the object was tolerably steady and quite distinct. Observer Mr. Glaisher.

Micrometer set at 2ʳ·000.

Circle Reading	A =	348° 0′ 41″·7
	B =	.. .. 34·1
	A =	.. .. 43·0
	B =	.. .. 34·3

Micrometer set at 8ʳ·000.

Circle Reading	A =	347° 55′ 22″·8
	B =	.. .. 15·6
	A =	.. .. 22·2
	B =	.. .. 15·2

* This is the house now occupied by Her Royal Highness the Princess Sophia Matilda of Gloucester, Ranger of Greenwich Park. It was formerly the residence of Lord Chesterfield, and is frequently alluded to by that name in Dr. Maskelyne's Observations.

	A	B
Circle Reading..........	348°. 0′. 44″·1	.. .. 35·3
	.. .. 42·0	.. .. 35·0
	.. .. 42·2	.. .. 35·9
	.. .. 40·0	.. .. 33·1
	.. .. 42·0	.. .. 35·1
	.. .. 43·1	.. .. 36·2
	.. .. 42·5	.. .. 35·5
	.. .. 41·0	.. .. 35·0

Mean	=	348. 0. 38·555
Correction for Runs (for $5' = -2''{\cdot}2$)	=	−0·283
Concluded Reading for Micrometer at $2^{r}{\cdot}000$	=	348. 0. 38·272
for Micrometer at $8^{r}{\cdot}000$	=	347. 55. 18·787
Difference, or value of Six Revolutions	=	5. 19·485
One Revolution	=	53·248

	A	B
Circle Reading	347°. 55′. 22″·9	.. .. 15·0
	.. .. 24·0	.. .. 18·0
	.. .. 22·8	.. .. 15·9
	.. .. 22·0	.. .. 15·1
	.. .. 21·3	.. .. 15·8
	.. .. 21·1	.. .. 15·5
	.. .. 21·2	.. .. 15·0
	.. .. 22·1	.. .. 15·0

Mean	=	347. 55. 18·925
Correction for Runs	=	−0·138
Concluded Reading........	=	347. 55. 18·787

July 28^{d}. 23^{h}. Observations continued. Object the same as in the last series; but the observations are much inferior: the image of the sill became very unsteady, and was often obscured by the smoke of steam-boats. The result will not be entitled to more than half the weight of the other set. Observer Mr. Glaisher.

Micrometer set at $3^{r}{\cdot}000$.

	A	B
Circle Reading	347°. 59′. 49″·3	.. .. 43·3
	.. .. 49·5	.. .. 42·1
	.. .. 48·5	.. .. 41·1
	.. .. 47·6	.. .. 41·7
	.. .. 50·0	.. .. 44·8
	.. .. 49·0	.. .. 43·7

Micrometer set at $9^{r}{\cdot}000$

	A	B
Circle Reading	347°. 54′. 28″·0	.. .. 23·2
	.. .. 27·4	.. .. 21·5
	.. .. 28·4	.. .. 23·0
	.. .. 26·0	.. .. 20·0
	.. .. 28·0	.. .. 22·2
	.. .. 27·2	.. .. 22·8

Circle Reading	A =	347°. 59′. 49″·9
	B =	.. .. 43·7
	A =	.. .. 49·5
	B =	.. .. 43·7
	A =	.. .. 49·1
	B =	.. .. 43·6
	A =	.. .. 49·6
	B =	.. .. 43·0
	Mean =	347. 59. 46·100
Correction for Runs (for 5′ = −2″·2)	=	+0·102
Concluded Reading for Micrometer at 3r·000	=	347. 59. 46·202
for Micrometer at 9r·000	=	347. 54. 25·375
Difference, or value of Six Revolutions	=	5. 20·827
One Revolution	=	53·471

Circle Reading	A =	347°. 54′. 28″·0
	B =	.. .. 23·0
	A =	.. .. 28·1
	B =	.. .. 23·0
	A =	.. .. 27·1
	B =	.. .. 22·5
	A =	.. .. 29·2
	B =	.. .. 23·8
	Mean =	347. 54. 25·120
Correction for Runs	=	+0·255
Concluded Reading	=	347. 54. 25·375

N. B.—The micrometers of the microscopes were placed on the next divisions.

From the preceding observations the following results are obtained:—

Day.	Part of Micrometer Scale used.	Value of Revolution.	Weight.	Fraction of Revolution Multiplied into Weight.	Observer.
	r r	″		″	
July 20	3 to 9	53·249	9	2·241	W R
	4 to 8	53·078	8	0·624	W R
28	2 to 8	53·248	10	2·480	G
	3 to 9	53·471	5	2·355	G
			32	) 7·700	

Mean value of One Revolution = 53·241

This value is used throughout the observations of 1840.

The *fourteenth* column contains the number of the vertical wire at which the object was seen when the observation with the horizontal wire was made. The telescope of the circle contains five vertical wires: the intervals between the wires have been ascertained by transits of stars, which (being entirely free from any sensible doubt) it

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is not necessary to detail here. The equatoreal interval of the wires is considered to be 20^s.

The *fifteenth* column contains the correction to be applied to the circle-reading in consequence of the object not having been observed when passing the middle wire. It consists of two parts, one due to the body's change of N.P.D. (if it be the Sun, the Moon, a planet, or a comet), the other due to the difference between the small circle described by the body and the great circle of which the horizontal wires form a part. Of the former of these no explanation is required, except that for the Moon the change is computed by the formula, change of declination for 1 hour of terrestrial longitude (from the section of Moon-culminating Stars in the Nautical Almanac) × sec. declination × n°. (log. = 7·745) × number of intervals of wires. The latter is calculated by this formula: tan. declination × n°. (log. = 9·350) × (number of intervals of wires)^2. The two numbers are combined together to form the number inthe fifteenth column.

The *sixteenth* column contains the circle-reading, as found by adding the mean of the microscopes (corrected for runs) to the pointer-reading, and applying the corrections for columns 13 and 15.

The *seventeenth* column contains the initials of the Observers' names. W. R. is Mr. Richardson's signature, and R. Mr. Rogerson's: the others explain themselves.

The *first* column on the right-hand page contains numbers for reference, corresponding to those in the second column of the left-hand page.

The *second* column contains the sums of the circle-readings when the same object has been observed by reflexion and directly at the same transit. These are necessary for the determination of the Zenith Point, or the circle-reading corresponding to a vertical position of the telescope. The observations being divided into groups (seldom exceeding four days), and each of these groups being subdivided into two parcels, one containing the stars which passed north of the zenith, and the other containing the stars which passed south of the zenith, the mean value of D + R for each parcel is ascertained: the mean between the two values of D + R for the two parcels is found, and is considered to be the value of D + R applicable to the whole group: this quantity is increased or diminished by 180° and divided by 2, and the result is adopted as the Zenith Point. It will be seen from this description, that the result as to the Zenith Distance of the objects comprehended in one group is entirely independent of the operations of any kind in any other group. It will also be seen, that the system of taking the means of the results from the north parcel and the south parcel, without respect to the number of stars in each parcel, supposing the zenith distance of the stars to be not very unequal, entirely eliminates the effect of any drop of the eye-end or object-end, or any other cause which acts symmetrically on both sides of the zenith, to increase or to diminish the telescope's angle with the vertical. In the daily observations however of 1840, care has also been taken to balance the number of stars observed by reflexion on the north side and on the south side.

The rule which has been followed in regard to the insertion of the values of D + R in the columns of the printed sheets is, to insert all that are used. A very few therefore are omitted, having been rejected as bad: and one or two have been omitted through inadvertence in the formation of D + R, and will not be found in the printed book.

In the division of groups, the general rule has been to divide if possible where a considerable interval occurred between the observations. In a few instances, after arranging the groups in conformity with this rule, it has been found necessary to depart from it, on the discovery of an evident change of Zenith Point in one of the selected groups. After the sheets were printed off, it was remarked that, on page (139), the division of groups ought to have been made between Nov. 13 and Nov. 14, instead of between Nov. 14 and Nov. 16: but the error caused by this omission is so small, that I have not thought it necessary to recompute the observations.

The *third* column contains the Adopted Zenith Point, determined by the rules just described.

The *fourth* column contains the zenith distance, which is found by subtracting the zenith point in the preceding column from the circle-reading: the negative sign denotes that the object is north of the zenith. When the Moon has been observed at several wires, the mean of all the concluded circle-readings is used to form the zenith distance.

When both limbs of the Moon are observed, it usually happens that one of them is slightly defective, from the failure of illumination by the Sun. The necessary correction (which is not applied in this column, but which must be applied with others in order to form the numbers in the column of *Geocentric N.P.D. of center*) is ascertained in the following manner. If the Moon is horned, her apparent place, on a common celestial globe, is brought to the zenith, and, a quadrant of altitude being made to pass over the Sun's place, its deviation from the East or West point is noted. If the Moon is gibbous, her place is brought to the intersection of the meridian and horizon, and the Sun's elevation above or depression below the horizon is noted. The correction to be applied is, the Moon's semidiameter × versine of angle noted: if the Sun's place is nearer the north pole than the E. or W. point in one case, or than the horizon of the globe in the other case, the correction is + for the south limb: if the contrary, it is − for the north limb. The values of the angle corresponding to the instances which occur in 1840 are given in the notes.

The *fifth* column contains the reading of the barometer. This instrument is by Newman: the raising of the index by which the upper surface of the mercury is read, depresses a plunger in the cistern of mercury, for the purpose of making the elevation of its surface invariable. The vernier is so bad as to make this barometer wholly useless for any delicate purpose: but it is sufficiently accurate for computation of refraction.

The *sixth* column contains the reading of the exterior thermometer. This is by Newman: it is mounted on the outside of the Observatory at the distance of four feet nearly from the north wall, in a tinned case, with its bulb quite free to the current of air, but protected from radiation.

The *seventh* column contains the reading of the interior thermometer: it is a small thermometer suspended between the two circle-piers.

The *eighth* column contains the refraction computed by Bessel's tables in the *Tabulæ Regiomontanæ*. These tables, altered in form (but so as to give in all cases the same result) and expanded, are given in the Appendix to the volume for 1836. The exterior thermometer only is used in the computation.

The *ninth* column contains the parallax. This is computed on the supposition that the earth's ellipticity is $\frac{1}{300}$. For the planets the formula is, log. parallax = log. sin. (zen. dist. − 11′. 12″) + ar. co. log. distance + 0·9325. For the Moon, the horizontal equatoreal parallax, as interpolated with second differences from the Nautical Almanac, is affected with a number from the following table: which is peculiar to the Moon's limb: and of which the details of computation are given in the Cambridge Observations, vol. iv. for 1831.

Correction to Moon's Horizontal Parallax, to be used when Parallax is to be applied to the Observation of a Limb.

Z. D.	South Limb.	Z. D.	South Limb.	Z. D.	North Limb.	Z. D.	North Limb.
°	″	°	″	°	″	°	″
30	+ 0·10	60	+ 0·15	30	− 0·03	60	− 0·08
35	+ 0·11	65	+ 0·15	35	− 0·04	65	− 0·08
40	+ 0·12	70	+ 0·16	40	− 0·05	70	− 0·09
45	+ 0·12	75	+ 0·16	45	− 0·06	75	− 0·09
50	+ 0·13	80	+ 0·16	50	− 0·06	80	− 0·09
55	+ 0·14			55	− 0·07		

The parallax is then computed by the formula: log. seconds of parallax = log. seconds of corrected horizontal equatoreal parallax + log. sin. (zen. dist. − 11′. 12″) + 9·9991136 + log. $\frac{\text{sin.}}{\text{arc}}$ (for hor. par.) + log. $\frac{\text{arc}}{\text{sin.}}$ (for parallax).

The *tenth* column contains the reading of the micrometer for that limb or cusp of a planet which was not observed on the fixed wire of the telescope.

The *eleventh* column contains the semidiameter used in the reduction of the observations. That of the Sun is taken from the Nautical Almanac: that of the Moon is interpolated with second differences from the Nautical Almanac: that of Mars, Jupiter, and Saturn, is half of the micrometrical measure of the diameter in the preceding section: that of Mercury and Venus is found by dividing the micrometrical measure by $1 + \cos. \theta$, where θ is found by the following process: If the planet is horned, the planet's geocentric place is brought to the zenith of a celestial globe, and the quadrant of altitude being made to pass over the Sun's place, the deviation from the E. or W. point is the measure of θ. If the planet is gibbous, the planet's geocentric place is brought to the intersection of the meridian and horizon, and the point opposite to the planet's heliocentric place being marked, its elevation above or depression below the horizon is taken for θ. If the full limb has been observed with the fixed wire of the circle, the semidiameter thus obtained is to be applied: but if the imperfect limb has been observed with the fixed wire, the difference between this semidiameter and the whole micrometrical measure is to be applied.

The *twelfth* column contains the geocentric N. P. D. of the center of each object from every observation: found by combining the Apparent Zenith Distance with the Refraction, Parallax, Semidiameter, and assumed Co-latitude $38^{\circ}.\ 31'.\ 21''$.

The *thirteenth* column contains the name of the object observed; it is described in the same manner as in the third column on the left-hand page, with the omission only of the letters indicating observation with the micrometer and observation of a limb.

The *fourteenth* column contains the corrections which are to be applied to the apparent N. P. D. of the stars in order to obtain the mean N. P. D. 1840, Jan. 1. For the stars in the list of the Nautical Almanac, the correction is found by subtracting the mean declination of the Nautical Almanac from the apparent declination of the same. For stars in the Astronomical Society's Catalogue, the correction is computed by the formula $A\,a' + B\,b' + C\,c' + D\,d'$. For other stars the correction is computed by the formula A. sin. N. P. D. × (n°. log. = 9·6375) − A. sin. A. R. cos. N. P. D. + B. cos. A. R. cos. N. P. D. + C. cos. A. R. × n°. (log. = 1·3020) − D. sin. A. R.

§ 4. *Mean North Polar Distances of Stars deduced from each day's observations,* page (160) to (180).

The mean north polar distances are found by applying to the North Polar Distances in section 3, the corrections opposite to them in that section.

The results of direct- and reflexion-observations are kept separate, with the view of ascertaining whether there is any discordance between them, as has been observed in the results of these and other circles: and the results above and below the pole are kept separate, in order to ascertain whether there is any sensible error in the assumed co-latitude.

With regard to the first of these points, the means of the groups of Direct-results and Reflexion-results have been taken for all the stars observed: and the algebraical excess of the Reflexion-result over the Direct-result (the results for stars below the pole being considered negative) is given in the subjoined tables.

EXCESS OF REFLEXION-RESULTS ABOVE DIRECT-RESULTS, WITH TROUGHTON's CIRCLE, 1840.

Name of Star.	N.P.D.	R−D	No. of Obs. D	No. of Obs. R	Name of Star.	N.P.D.	R−D	No. of Obs. D	No. of Obs. R
	° ′	″				° ′	″		
15 Lyncis ..... S. P.	−31. 23	+1 ·38	3	1	B. F. 222	26. 10	−1 ·06	4	1
γ Ursæ Minoris, S. P.	17. 36	−2 ·46	1	1	Bradley 313........	26. 24	+0 ·47	1	1
β Ursæ Minoris, S. P.	15. 11	+1 ·28	5	4	30 Cephei..........	27. 15	+2 ·14	1	1
Groomb. 283, S. P.	14. 36	+0 ·02	3	1	α Ursæ Majoris	27. 23	+0 ·01	16	15
5 Ursæ Minoris, S. P.	13. 36	+1 ·00	1	1	θ Cephei...........	27. 33	−0 ·57	1	1
Bradley 3181 .. S. P.	13. 17	+0 ·36	8	1	α Cephei...........	28. 5	+0 ·26	13	12
ζ Ursæ Minoris, S. P.	11. 43	−0 ·25	4	3	η Draconis	28. 7	−0 ·17	11	8
Bradley 2711, S. P.	11. 8	−0 ·84	4	1	4 Cassiopeiæ........	28. 36	+0 ·57	1	1
ε Ursæ Minoris, S. P.	7. 43	+2 ·06	3	3	η Cephei...........	28. 47	−0 ·32	1	1
Cephei 51 (Hev.) S. P.	2. 44	−0 ·80	8	8	Groombridge 2390...	29. 23	−0 ·06	4	4
Polaris .... S. P.	1. 33	+0 ·17	13	12	ν Cephei	29. 37	−2 ·04	1	1
λ Ursæ Minoris, S. P.	− 1. 10	+2 ·25	3	2	10 Camelopardali....	29. 48	−0 ·94	3	3
λ Ursæ Minoris	+ 1. 10	−0 ·74	3	3	Groombridge 2332 ..	29. 51	−1 ·60	1	1
Polaris	1. 33	−0 ·61	27	25	Piazzi XIV. 217....	30. 3	−0 ·59	4	4
Cephei 51 (Hev.)....	2. 44	−0 ·24	7	6	ι Draconis..........	30. 28	+0 ·17	3	3
δ Ursæ Minoris	3. 24	+0 ·59	5	4	A. S. C. 371........	30. 37	+0 ·42	4	4
ε Ursæ Minoris......	7. 43	−1 ·21	11	7	ο Draconis..........	30. 48	0 ·00	6	5
76 Draconis	8. 4	−1 ·01	3	3	θ Draconis..........	31. 0	−2 ·42	1	1
h Cephei	10. 3	−0 ·03	4	4	15 Lyncis	31. 23	−1 ·00	1	1
Bradley 2711	11. 8	−0 ·76	3	1	Piazzi XIX. 371 ...	31. 35	−0 ·58	7	5
ζ Ursæ Minoris	11. 43	−0 ·16	9	7	β Cassiopeiæ	31. 44	+1 ·64	2	2
γ Cephei	13. 16	−0 ·71	13	13	δ Ursæ Majoris	32. 5	−0 ·39	8	8
Bradley 1383.......	14. 29	−0 ·43	6	5	Bradley 222........	32. 11	+3 ·70	1	1
β Ursæ Minoris	15. 11	−0 ·85	24	23	τ Cassiopeiæ........	32. 14	−1 ·56	1	1
∗ A. R. $7^h. 7^m. 20^s$....	16. 37	+0 ·94	5	1	A. S. C. 2807	32. 20	+0 ·42	3	3
Bradley 1035	16. 37	−0 ·15	6	2	ζ Cephei	32. 35	+0 ·76	7	6
31 Cephei..........	17. 11	+0 ·05	2	2	β Ursæ Majoris	32. 46	+0 ·16	2	2
Groombridge 828 ...	17. 50	+1 ·79	1	1	78 Ursæ Majoris	32. 46	−1 ·36	2	2
κ Draconis	19. 20	+2 ·24	1	1	Piazzi VII. 311	33. 5	+0 ·99	1	1
λ Draconis	19. 47	+0 ·23	4	4	ξ Draconis	33. 6	+1 ·26	7	7
β Cephei...........	20. 8	+1 ·36	15	15	ε Ursæ Majoris	33. 10	+0 ·77	12	11
Bradley 373........	21. 3	−1 ·26	5	3	Piazzi XI. 59	33. 16	−0 ·15	1	1
ω Draconis	21. 10	+1 ·26	1	1	∗ A. R. $22^h. 25^m$......	33. 24	+3 ·99	1	1
Bradley 382........	21. 47	−0 ·86	5	3	53 Draconis	33. 25	−0 ·57	5	5
ρ Draconis	22. 35	+0 ·35	5	5	Bradley 323........	33. 30	−0 ·19	4	1
A. S. C. 247	23. 19	+1 ·13	2	2	4 Camelopardali.....	33. 32	−0 ·22	4	4
A. S. C. 552	23. 56	+1 ·94	1	1	ε Cephei	33. 45	+0 ·42	3	2
Groombridge 2034 ..	24. 22	−0 ·18	5	1	B. F. 522...........	33. 53	+0 ·25	4	3
π Draconis	24. 36	−0 ·26	1	1	A. S. C. 331........	33. 56	+0 ·36	1	1
α Draconis	+24. 51	−0 ·59	8	8	$ζ^1$ Ursæ Majoris.....	34. 14	+0 ·22	7	7

EXCESS OF REFLEXION-RESULTS ABOVE DIRECT-RESULTS, WITH TROUGHTON'S CIRCLE, 1840—*continued.*

Name of Star.	N. P. D.	R − D	No. of Obs. D	No. of Obs. R
	° ′	″		
α Cassiopeiæ	34. 20	+0·58	21	9
η Persei	34. 46	+0·76	2	2
e Ursæ Majoris	35. 19	+3·65	1	1
γ Ursæ Majoris	35. 25	+0·70	8	8
δ Aurigæ	35. 44	−0·45	4	4
54 Andromedæ	40. 7	+4·43	1	1
θ Cygni	40. 9	+2·98	2	1
α Persei	40. 43	+2·32	3	3
Groombridge 2555	40. 57	+1·18	2	2
χ Ursæ Majoris	41. 20	−0·90	1	1
ι Ursæ Majoris	41. 20	−0·05	6	5
θ Persei	41. 27	−3·10	1	1
μ Persei	42. 0	+0·63	3	3
λ Bootis	43. 10	+1·18	1	1
74 Herculis	43. 36	−0·21	7	7
φ Andromedæ	43. 37	+0·82	1	1
Groombridge 1922	43. 41	+0·88	2	2
o^2 Cygni	43. 44	+0·46	3	2
ι Herculis	43. 54	+0·46	1	1
Capella	44. 10	+0·07	16	16
2 Lacertæ	44. 16	+0·56	3	3
λ Andromedæ	44. 24	−0·96	2	1
B. F. 2060	44. 44	+0·39	6	6
δ Cygni	45. 15	+0·18	6	5
α Cygni	45. 17	−0·58	25	26
Groombridge 2135	45. 40	−0·43	3	3
Groombridge 4128	45. 54	+0·56	2	1
ω Ursæ Majoris	45. 58	−1·08	2	2
* A. R. $11^h. 54^m. 22^s.$	46. 0	−0·88	1	2
67 Ursæ Majoris	46. 4	−0·30	3	3
λ Ursæ Majoris	46. 17	+2·70	1	1
31 Lyncis	46. 18	+0·76	2	2
ε Aurigæ	46. 25	−1·84	3	2
κ Andromedæ	46. 33	+1·26	1	1
Groombridge 57	46. 37	−0·35	6	1
Piazzi 0. 93	46. 56	−0·69	5	3
Groombridge 2008	47. 4	−0·71	1	1
Groombridge 1411	47. 6	−0·95	1	1
Groombridge 2206	47. 14	+1·28	3	3
6 Lacertæ	47. 42	−0·68	3	3
δ Canum Venaticorum	47. 46	−0·66	3	3
Groombridge 2044	48. 6	+1·47	1	1
γ Andromedæ	48. 26	+0·57	1	1
2 Canum Venaticorum	48. 27	+1·02	1	1
Groombridge 4199	48. 31	−0·08	2	1
o Andromedæ	48. 32	+1·75	1	2
η Aurigæ	48. 59	−1·46	2	1
ν Cygni	49. 27	−0·03	3	3
ν Andromedæ	49. 48	−0·83	3	1
6 Canum Venaticorum	50. 6	+1·23	2	2
ϵ^1 Lyræ	50. 30	−1·21	7	1
5 Lyræ (1st star)	50. 33	+0·03	6	1
η Herculis	50. 46	+0·29	1	1
12 Can. Ven. (2nd star)	50. 49	+1·33	3	2
Groombridge 232	50. 52	−2·51	2	1
A. S. C. 1103	50. 55	+0·94	2	2
α Lyræ	51. 22	−1·02	37	35
μ Andromedæ	52. 22	+0·91	4	2
* A. R. $1^h. 14^m. 10^s.$	54. 19	+1·16	2	1
β Andromedæ	55. 14	−0·61	1	1
β Trianguli	55. 46	−0·09	2	2
β^1 Lyræ	56. 49	+1·19	7	4
β^2 Lyræ	56. 50	+0·81	1	1
ι Aurigæ	57. 6	−0·26	2	1
Castor (2nd star)	57. 46	+0·19	6	3
Castor (1st star)	57. 46	−1·32	2	1
τ Geminorum	59. 30	−1·78	1	1
ζ Cygni	60. 26	−0·05	8	5
κ Aurigæ	60. 27	−0·13	2	1
α Trianguli	61. 12	+0·21	4	1
o Herculis	61. 15	−1·57	1	1
β Tauri	61. 32	−0·38	11	9
30 Comæ Berenices	61. 34	+2·32	1	1
Pollux	61. 36	+1·17	6	4
α Andromedæ	61. 48	−0·44	10	7
ϵ^2 Bootis	62. 15	−0·20	11	5
β Cygni	62. 22	−0·32	1	1
α Coronæ Borealis	62. 45	−0·19	14	10
ε Geminorum	64. 43	−0·79	2	1
ε Leonis	65. 30	+0·36	12	8
105 Herculis	65. 37	+0·28	2	2
λ Leonis	66. 20	+0·74	2	1
α Arietis	67. 18	+0·60	14	10
δ Geminorum	67. 44	+0·74	7	4
A^1 Tauri	68. 22	+0·24	2	1
δ Leonis	68. 36	+0·12	9	6
ε Arietis	69. 18	+1·80	1	1
ζ Arietis	69. 33	+0·63	1	1
β Arietis	69. 59	−1·72	2	1
Arcturus	69. 59	−0·36	29	24
η Bootis	70. 48	−1·30	6	2
θ Arietis	70. 51	−0·90	6	3
δ Arietis	70. 53	+1·06	4	4
83 Cancri	71. 37	+1·41	1	1
27 Arietis	73. 0	−0·36	3	3
π Arietis	73. 12	+0·31	2	1
Aldebaran	73. 49	−1·29	10	6
β Leonis	74. 32	−0·31	7	5

EXCESS OF REFLEXION-RESULTS ABOVE DIRECT-RESULTS WITH TROUGHTON'S CIRCLE, 1840—*concluded.*

Name of Star.	N. P. D.	R−D	No. of Obs. D	No. of Obs. R	Name of Star.	N. P. D.	R−D	No. of Obs. D	No. of Obs. R
	° ′	″				° ′	″		
α^1 Herculis	75. 25	+0·14	8	6	δ Aquilæ	87. 12	−0·73	9	5
η Piscium	75. 29	−0·24	3	1	γ Ophiuchi	87. 14	−1·77	6	1
α Pegasi	75. 39	−0·87	12	6	* A. R. 1^h. 37^m.	87. 23	−0·05	1	1
γ Pegasi	75. 42	−1·29	5	3	γ Ceti	87. 27	−0·20	4	3
ζ Aquilæ	76. 22	−0·78	8	4	γ Piscium	87. 35	+0·37	4	1
ν Leonis	76. 48	−0·23	6	4	d^2 Serpentis	89. 54	+1·58	4	1
Regulus	77. 15	−0·67	11	5	δ Orionis	90. 25	−1·54	12	2
α Ophiuchi	77. 19	+1·07	11	9	3 Piscium	90. 40	−5·78	4	1
ξ Leonis	78. 0	+1·59	1	1	ζ Aquarii (N. star)	90. 50	−1·81	3	1
ι Leonis	78. 35	−0·02	1	1	ζ Aquarii (S. star)	90. 50	−1·52	4	1
34 Piscium	79. 45	+1·08	2	2	α Aquarii	91. 6	+0·87	7	4
ρ Leonis	79. 52	+0·42	3	1	α Aquilæ	91. 11	+0·07	1	1
ε Pegasi	80. 51	+0·96	13	5	75 Ceti	91. 45	+0·31	1	1
α Aquilæ	81. 33	−0·44	19	12	δ Ophiuchi	93. 17	+0·56	3	3
48 Leonis	82. 13	+0·05	1	1	h^2 Aquilæ	94. 16	−0·61	2	2
α Orionis	82. 38	+0·06	10	7	κ Aquarii	95. 3	−2·08	5	2
ε Piscium	82. 58	−0·98	3	2	β Aquarii	96. 16	+1·88	8	1
ε Hydræ	83. 0	+0·96	3	2	30 Aquarii	97. 18	−0·84	5	3
α Serpentis	83. 4	+0·64	10	5	α Hydræ	97. 58	−0·92	9	4
ω Piscium	84. 1	−0·78	1	1	ξ Aquarii	98. 34	+0·04	3	1
Procyon	84. 22	+1·20	4	2	θ Aquarii	98. 35	−0·17	5	1
ν Ceti	85. 6	+4·08	1	1	β Libræ	98. 47	−0·40	12	2
ι Piscium	85. 14	−0·37	9	4	λ Capricorni	102. 6	−0·68	5	1
β Ophiuchi	85. 22	+1·14	6	2	λ Virginis	102. 38	−3·97	1	1
ο Virginis	85. 39	−2·28	1	1	δ Crateris	103. 55	−0·13	3	1
α Ceti	86. 33	−0·28	5	3	Sirius	106. 30	+1·04	11	6
75 Leonis	87. 6	+0·12	1	1	μ Sagittarii	111. 6	+0·75	10	2

As the number of stars observed is too great to allow the eye to see clearly any law which may be followed by these errors, I have grouped the stars, and have taken the mean of the values of R−D for each group, giving to each star a weight proportional to the smaller of the two numbers of observations. The following table exhibits the particulars of each group, and the result for R−D.

EXCESS OF REFLEXION RESULTS ABOVE DIRECT-RESULTS,
From Groups of Stars, with Troughton's Circle, 1840.

Extent of Group.	No. of Obs.	Mean N. P. D.	R–D.
15 Lyncis S. P.	1	° ′ − 31. 23	″ +1·38
γ Ursæ Minoris S. P. to Bradley 3181 S. P.	8	− 14. 59	+0·51
ζ Ursæ Minoris S. P. to ε Ursæ Minoris S. P.	7	− 9. 55	+0·66
Cephei 51 (Hev.) S. P. to δ Ursæ Minoris	60	+ 0. 29	−0·27
ε Ursæ Minoris to β Ursæ Minoris	63	+ 12. 47	−0·71
∗ A. R. $7^h. 7^m. 20^s.$ to Bradley 382	33	+ 19. 46	+0·64
ρ Draconis to θ Cephei	37	+ 25. 40	+0·05
α Cephei to ο Draconis	47	+ 29. 14	−0·10
θ Draconis to 78 Ursæ Majoris	32	+ 32. 8	−0·02
Piazzi VII. 311 to δ Aurigæ	78	+ 34. 4	+0·53
54 Andromedæ to ι Herculis	31	+ 42. 16	+0·58
Capella to Groombridge 57	73	+ 45. 8	−0·17
Piazzi 0. 93 to η Aurigæ	20	+ 47. 42	−0·03
υ Cygni to μ Andromedæ	51	+ 51. 7	−0·61
∗ A. R. $1^h. 14^m. 10^s.$ to Castor (1st star)	14	+ 56. 40	+0·35
τ Geminorum to α Coronæ Borealis	46	+ 61. 44	−0·14
ε Geminorum to δ Arietis	69	+ 68. 39	+0·06
83 Cancri to α Ophiuchi	54	+ 75. 37	−0·28
ξ Leonis to α Serpentis	39	+ 81. 43	+0·19
ω Piscium to γ Piscium	26	+ 86. 15	−0·09
d^2 Serpentis to 75 Ceti	12	+ 90. 52	−0·56
δ Ophiuchi to β Libræ	19	+ 96. 29	−0·47
λ Capricorni to μ Sagittarii	11	+106. 21	+0·27

The values for R−D are so small, and the existence of any law among them so uncertain, that I have thought it best to adopt the circle-results without any correction for R−D.

The results from twenty-five circumpolar stars were then used for examination of the assumed co-latitude. The computations are contained in the subjoined table: of which no explanation appears necessary, except that the weight is approximately determined by multiplying $\frac{a\,b}{a+b}$ (where a is the number of observations above the pole, and b the number below) by the number 30 for the first star, 29 for the second star, 28 for the third, and so on: and then dividing by 6.

CORRECTION OF ASSUMED LATITUDE.

Star's Name, Position, and Mode of Observation.	No. of Obs.	N. P. D. from each Group.	No. of Obs.	Concluded N.P.D. in each position on assumed Latitude.	No. of Obs.	Algebraic Sum of Determinations.	Weight.	Product.
		° ′ ″		″		″		″
λ Ursæ Minoris....... D.	3	1. 10. 15 ·00	6	14 ·63	11	—1 ·48	14	— 20 ·72
R.	3	14 ·26						
S. P. . . D.	3	— 1. 10. 17 ·01	5	—16 ·11				
R.	2	14 ·76						
Polaris.............. D.	27	1. 32. 37 ·66	52	37 ·37	77	—0 ·94	82	—77 ·08
R.	25	37 ·05						
S. P. . . D.	13	— 1. 32. 38 ·39	25	—38 ·31				
R.	12	38 ·22						
Cephei 51 (Hev.)..... D.	7	2. 44. 14 ·16	13	14 ·05	29	—1 ·77	33	—58 ·41
R.	6	13 ·92						
S. P. . . D.	8	— 2. 44. 15 ·33	16	—15 ·82				
R.	8	16 ·31						
ε Ursæ Minoris....... D.	11	7. 42. 37 ·89	18	37 ·42	24	—0 ·22	20	— 4 ·40
R.	7	36 ·68						
S. P. . . D.	3	— 7. 42. 38 ·67	6	—37 ·64				
R.	3	36 ·61						
Bradley 2711 .... D.	3	11. 8. 23 ·44	4	23 ·25	9	—2 ·27	10	—22 ·70
R.	1	22 ·68						
S. P. . . D.	4	—11. 8. 25 ·35	5	—25 ·52				
R.	1	26 ·19						
ζ Ursæ Minoris....... D.	9	11. 42. 58 ·90	16	58 ·83	23	—2 ·52	20	—50 ·40
R.	7	58 ·74						
S. P. . . D.	4	—11. 42. 61 ·24	7	—61 ·35				
R.	3	61. 49						
γ Cephei .... D.	13	13. 15. 36 ·45	26	36 ·10	28	—1 ·40	8	—11 ·20
R.	13	35 ·74						
S. P. . . D.	2	—13. 15. 37 ·50	2	—37 ·50				
R.		....						
β Ursæ Minoris...... D.	24	15. 11. 25 ·26	47	24 ·84	56	—2 ·41	29	—69 ·89
R.	23	24 ·41						
S. P. . . D.	5	—15. 11. 27 ·82	9	—27 ·25				
R.	4	26 ·54						

Star's Name, Position, and Mode of Observation.	No. of Obs.	N. P. D. from each Group.	No. of Obs.	Concluded N. P. D. in each position on assumed Latitude.	No. of Obs.	Algebraic Sum of Determinations.	Weight.	Product.
Bradley 313 .... D.	1	26° 24′ 22″·13	2	″ 22·37	6	″ −0·47	5	″ − 2·35
R.	1	22·60						
S. P. . . D.	4	−26. 24. 22·84	4	−22·84				
R.		.....						
α Ursæ Majoris....... D.	16	27. 23. 12·11	31	12·11	32	−2·14	3	− 6·42
R.	15	12·12						
S. P. . . D.	1	−27. 23. 14·25	1	−14·25				
R.		.....						
ι Draconis .... D.	3	30. 28. 16·27	6	16·36	7	−1·96	3	− 5·88
R.	3	16·44						
S. P. . . D.	1	−30. 28. 18·32	1	−18·32				
R.		.....						
15 Lyncis............ D.	1	31. 22. 37·79	2	37·29	6	−2·38	4	− 9·52
R.	1	36·79						
S. P. . . D.	3	−31. 22. 40·01	4	−39·67				
R.	1	38·63						
δ Ursæ Majoris....... D.	8	32. 4. 39·74	16	39·55	19	−1·80	8	−14·40
R.	8	39·35						
S. P. . . D.	3	−32. 4. 41·35	3	−41·35				
R.		.....						
Bradley 222 .... D.	1	32. 11. 0·19	2	2·04	6	−2·48	4	− 9·92
R.	1	3·89						
S. P. . . D.	4	−32 11. 4·52	4	− 4·52				
R.		.....						
ε Ursæ Majoris....... D.	12	33. 10. 11·69	23	12·06	26	−1·35	7	− 9·45
R.	11	12·46						
S. P. . . D.	3	−33. 10. 13·41	3	−13·41				
R.		.....						
Bradley 328 .... D.	2	33. 20. 51·89	2	51·89	4	−3·63	3	−10·89
R.		.....						
S. P. . . D.	2	−33. 20. 55·52	2	−55·52				
R.		.....						
Bradley 323 .... D.	4	33. 29. 40·62	5	40·58	6	−1·28	2	− 2·56
R.	1	40·43						
S. P. . . D.	1	−33. 29. 41·86	1	−41·86				
R.		.....						

Star's Name. Position, and Mode of Observation.	No. of Obs.	N. P. D. from each Group.	No. of Obs.	Concluded N. P. D. in each position on assumed Latitude.	No. of Obs.	Algebraic Sum of Determinations.	Weight.	Product.
		° ′ ″		″		″		″
ζ¹ Ursæ Majoris...... D.	7	34. 14. 13·44	14	13·55	15	—0·35	2	— 0·70
R.	7	13·66						
S. P. .. D.	1	—34. 14. 13·90	1	—13·90				
R.		.....						
ζ² Ursæ Majoris...... D.	1	34. 14. 26·58	1	26. 58	2	—0·99	1	— 0·99
R.		.....						
S. P. .. D.	1	—34. 14. 27·57	1	—27·57				
R.		.....						
e Ursæ Majoris....... D.	1	35. 19. 17·12	2	18·95	3	—4·14	1	— 4·14
R.	1	20·77						
S. P. .. D	1	—35. 19. 23·09	1	—23·09				
R.		.....						
γ Ursæ Majoris....... D.	8	35. 24. 55·05	16	55·40	18	—1·96	3	— 5·88
R.	8	55·75						
S. P. .. D.	2	—35. 24. 57·36	2	—57·36				
R.		.....						
θ Bootis............. D.	1	37. 24. 25·93	1	25·93	2	+2·02	1	+ 2·02
R.		.....						
S. P. .. D.	1	—37. 24. 23·91	1	—23·91				
R.		.....						
β Draconis........... D.	7	37. 34. 38·24	7	38·24	8	—4·96	1	— 4·96
R.		.....						
S. P. .. D.	1	—37. 34. 43·20	1	—43·20				
R.		.....						
θ Ursæ Majoris....... D.	12	37. 35. 50·90	12	50·90	13	—2·02	1	— 2·02
R.		.....						
S. P. .. D.	1	—37. 35. 52·92	1	—52·92				
R.		.....						
γ Draconis .... D.	5	38. 29. 21·22	5	21·22	9	—3·24	2	— 6·48
R.		.....						
S. P. .. D.	4	—38. 29. 24·46	4	—24·46				
R.		.....						

If z be the correction to be applied to the colatitude, $2z$ + the algebraic sum of determinations ought to = 0. Combining the whole with the weights above attached to them, $2 z = + 1''{\cdot}53$, or $z = + 0''{\cdot}77$: and the true co-latitude is $38^\circ.31'.21''{\cdot}77$.

The correction found in different years has sometimes a little exceeded this quantity, and has sometimes fallen short of it. I have adopted $+ 0''{\cdot}70$ for the correction to be used in the reduction of the Observations of 1840.

§ 5. *Catalogue of the Mean Places of Stars observed in the Year* 1840, page 2 to 12.

The right ascensións in the catalogue are the means of all the separate determinations of the mean right ascension of each star, excluding only those which are contained in brackets. The annual variations for the Nautical Almanac Stars are taken from the Nautical Almanac (those in which proper motion is included being marked with an asterisk). The others are computed independently, with the elements given in the Nautical Almanac, 1834, 2nd edition, page xiii; which were taken from the *Tabulæ Regiomontanæ*, and which have been used for all the later volumes of the Nautical Almanac.

The north polar distances in the catalogue are the means of the daily results affected with the correction $+ 0''{\cdot}70$. The adopted seconds of N.P.D. are found by taking the mean of the groups of direct and reflexion-observations, giving to each a weight proportional to its number of observations. With regard to circumpolar stars, the following rules have been followed. For stars whose N.P.D. does not exceed 15°, the observations above and below the pole are considered equally good: from N.P.D. 15° to N.P.D. 36°, those below have the weight $\frac{2}{3}$ for each observation: from N.P.D. 36° to N.P.D. 41°, those below have the weight $\frac{1}{2}$: beyond 41° N.P.D. the observations are not combined. The annual variations are taken from the Nautical Almanac, as far as its list extends: for other stars they are computed with the elements given in the Nautical Almanac, 1834, 2nd edition, page xiii.

§ 6. *Horizontal and Vertical Diameters, Right Ascensions, and North Polar Distances, of the Sun, Moon, and Planets; deduced from the Observations and compared with the Tables,* page 14 to 36.

The duration of the passage of the Sun's diameter is found by subtracting the clock time of transit of the first limb from that of the second limb in the *Transits observed, &c.*, without any further correction. The tabular duration is found by doubling the time of passage of the semidiameter given in the Nautical Almanac. The excess of the latter over the former is set down as the Error of the Nautical Almanac. The mean of all the values is $-0^{s}\cdot18$.

The Sun's vertical diameter is found by subtracting the zenith-distance of the north limb, corrected for refraction and parallax, from that of the south limb similarly corrected. The tabular diameter is formed by doubling the semidiameter of the Nautical Almanac. The mean of all the values is $-1''\cdot60$.

For the duration of the passage of the Moon's diameter, a correction is applied (negative to the time of passage of the first limb, or positive to that of the second limb, according as the Moon had passed or had not passed the opposition in right ascension), thus investigated. The excess or defect of the difference of A. R. of the Sun and Moon from 12^{h}, at the time of the Moon's transit, being found, and expressed in arc, this quantity is multiplied by the cosine of the Sun's declination, and thus an arc θ is obtained which represents the angle, upon the Moon's surface, of the unenlightened part of the disc (with respect to right ascension); the correction required is, semidiameter × versine θ. The value of θ and the corresponding correction are given in the notes on the right-hand page of the section of *Transits as observed, &c.* The mean of the three errors (omitting that which was deduced from an observation of the unilluminated limb when the illuminated part was very small) is $-0^{s}\cdot20$.

The Moon's vertical diameter is found in the same manner as the Sun's (the correction for defective illumination having been already applied, see page xxxv). The mean of the six values of errors is $-3''\cdot56$.

The vertical diameters of Mercury and Venus are found by doubling the semidiameters given in the section of *Observations made with Troughton's Mural Circle.* These diameters, therefore, are not imperfect diameters, as observed in the first instance. The vertical diameters of the other planets are merely the measures corresponding to the micrometer readings in the 10th column of the right-hand page of the same section, or are the doubles of the semidiameters in the 11th column. The duration of passages of the planet's diameters is formed as for the Sun, &c.

The Mean Solar Time is found, in all cases, from the Right Ascension or Sidereal Time, by adding together the Mean Solar Time at the transit of the first point of Aries next preceding, and the equivalents in Mean Solar Time for the hours, minutes, and seconds, of the Sidereal Time: the whole of these numbers being taken from the Nautical Almanac. In practice this operation is made a little easier, by putting the addition in the following form:

1. Sidereal Time.
2. Mean Solar Time of Transit of first point of Aries, diminished by 4^{m}.
3. $3^{m}.\ 47^{s}\cdot00$ — hours of Sid. Time + solar equiv. for hours.
4. $10^{s}\cdot00$ — minutes of Sid. Time + solar equiv. for minutes.
5. $3^{s}\cdot00$ — seconds of Sid. Time + solar equiv. for seconds.

Small tables of the 3rd, 4th, and 5th quantities are prepared (see Appendix to Observations, 1837, Tables No. IV.), and the operation is then very simple, consisting entirely of addition, with few figures and no interpolation.

When any object is observed in N. P. D. and not in Right Ascension, the Right Ascension at Transit (for the calculation of the Mean Solar Time) is taken from the Nautical Almanac.

The Right Ascensions of the Sun are transcribed from those in the *Transits, &c.*, with no alteration, except that, when necessary, the personal equation $\pm 0^{s}\cdot36$ is applied as mentioned in a former part of this Introduction; and that, when the first limb only has been observed, the correction $+ 0^{s}\cdot09$ has been applied; and when the second limb only has been observed, the correction $- 0^{s}\cdot09$. The North Polar Distances of the Sun are the means of those deduced from the two limbs, in the 12th column of the right-hand page in the section *Observations with the Mural Circle:* the correction $+ 0''\cdot70$ for alteration of latitude being applied, and the correction $+ 0''\cdot80$ when the N. limb only was observed, and $- 0''\cdot80$ when the S. limb only was observed. The tabular places are taken from the Nautical Almanac.

The Right Ascensions of the Moon are taken from the *Transits, &c.* corrected, if necessary, for personal equation: the correction $+ 0^{s}\cdot20$ being applied when the first limb was observed, and $- 0^{s}\cdot20$ when the second limb was observed. This is the same correction which was used in 1836, 1837, 1838, and 1839: it is fully supported by all the observations hitherto made, as appears from the following collection. The equatoreal observations for 1840 will be found in a subsequent part of this volume. With regard to these and the other equatoreal observations, it is to be noted that, on account of the greater unsteadiness of the instrument, and the smaller number of wires, one set of equatoreal observations is considered equivalent only to one transit observation.

Correction of Moon's Horizontal Diameter.

Year.	Tabular Error.	Number of Observations in Results.	Error × Number.	
	s		s	
1836	— 0·41	3	— 1·23	Transit observations.
1837	— 0·38	1	— 0·38	
1838	— 0·48	2	— 0·96	
1839	— 0·56	3	— 1·68	
1840	— 0·20	2	— 0·40	
1837	— 0·37	2	— 0·74	Equatoreal observations.
1838	— 0·31	2	— 0·62	
1839	— 0·33	4	— 1·32	
1840	— 0·33	3	— 0·99	
		22	— 8·32	
Mean Tabular Error = — 0·38				

When both limbs are observed, the correction for defective illumination already mentioned (page xlvi) is first applied to the proper limb, and the mean of the two is then taken without further correction.

The North Polar Distances are taken from those in the twelfth column on the right-hand page in the section of *Observations with the Mural Circle*, with the following alterations. The correction + 0″·70 for change of latitude is applied throughout, and the correction + 2″·67 when the N. limb only is observed, and − 2″·67 when the S. limb only is observed. This correction is deduced from the following collection of observations of the Moon's vertical diameter.

Correction of Moon's Vertical Diameter.

Year.	Tabular Error.	Number of Observations.	Error × Number.
	″		″
1836	— 6·23	8	— 49·84
1837	— 5·94	7	— 41·58
1838	— 5·51	11	— 60·61
1839	— 6·02	6	— 36·12
1840	— 3·56	10	— 35·60
		42	— 223·75
		Mean Tabular Error =	— 5·33

When both limbs are observed, the mean is taken. Then there is applied $-\frac{1}{2600}$ of the lunar parallax actually employed, for the augmentation of lunar parallax deduced by Mr. Henderson, from the observations made at the Cape of Good Hope and compared with those in Europe (Mem. R. Astr. Society, vol. x). The tabular N.P.D. are taken from the 7th column in the section *Moon-culminating Stars* of the Nautical Almanac.

In the Right Ascensions of Venus, a correction for the error of semidiameter has been applied. From an investigation in the Introduction to the Observations, 1838, it appears that the error of the semidiameter in right ascension may be represented by the following formula:

$$-0^{s}\cdot05 - \cdot03 \times \text{tabular semidiameter in A.R.}$$

The corrections applied in consequence are as follows:

January	1	to	February	22	— $\overset{s}{0}$·07
February	23	to	July	15	— 0·06
August	3	to	December	24	+ 0·06

For all the other planets, the Right Ascensions are extracted from the eleventh column on the right-hand page of *Transits observed, &c.*, with no alteration except for personal equation when necessary: for all the planets, the North Polar Distances are taken from the 12th column on the right-hand page of the *Observations with the Mural Circle*, with the addition of $+0''\cdot70$ for correction of colatitude. The tabular places are taken entirely from the Nautical Almanac, excepting the places of Vesta from Feb. 23 to April 6, and on June 18 and 19: which Lieut. Stratford (Superintendent of the Nautical Almanac) obligingly computed, at my request, from the same elements as those used for the places of Vesta in the Nautical Almanac.

The N.P.D. of Bremicker's Comet are taken from the *Observations with the Mural Circle*, increased by $0''\cdot70$. The Mean Time was obtained from approximate A.R. roughly deduced from the Equatoreal Observations made on the same evenings.

The investigation of the position of the Ecliptic is conducted in the same manner as the investigations from Observations at the Cambridge Observatory, given in the Astronomical Society's Memoirs, vols. 8, 9, and 10. The mean of all the errors in each month, for A. R. and for N. P. D., is supposed to be the error for the day which is nearest to the mean of all the days of observation. When the same day was not found for A. R. and for N. P. D. an alteration of a unit has sometimes been made. From these, the error in Ecliptic Polar Distance is obtained by means of the factors R and S in the Tables forming the second part of the Appendix to the Greenwich Observations, 1836. Supposing these errors to arise from an erroneous position of the ecliptic assumed in the Nautical Almanac, they may be expressed by the formula $x \times \cos. \odot$ longitude $+ y \times \sin. \odot$ longitude $+ z$. For convenience, the weight attributed to each monthly equation is so altered, that the sums of those in opposite quarters are equal. The rest of the process needs no explanation.

For the *Errors in the Tabular Geocentric Places of the Sun and Planets*, the errors in A. R. are increased by $0^s\cdot03$, as it appears, from a comparison of the assumed A. R. of the principal clock-stars with those used in the Cambridge Observations, that the errors, thus altered, will correspond to the same equinox with those in a memoir in the 10th volume of the Royal Astronomical Society's Transactions: to which therefore these calculations may be considered as a continuation. The errors in longitude and E. P. D. are formed by the use of the numbers P, Q, R, S, in the Appendix to the Greenwich Observations, 1836. For Vesta, Pallas, and Ceres, whose latitude exceeded the limits of those tables, the longitude and E. P. D. were computed, 1st, from the A. R. and N. P. D. of the Nautical Almanac; 2nd, from these quantities affected with the errors in A. R. and N. P. D.; and the differences between these results gave the errors in longitude and E. P. D.

For the *Errors in the Tabular Heliocentric Places of the Planets*, the following formulæ are used:

For the four small planets,

Let R = radius vector of planet, L = planet's heliocentric longitude.
Δ = planet's distance from earth, λ = planet's geocentric longitude.
r = earth's radius vector, l = earth's heliocentric longitude.

Then

$$\text{Error of geoc. long.} = \frac{R \times \text{cos. hel. lat.} \times \text{cos.}\ (\lambda - L)}{\Delta \times \text{cos. geoc. lat.}} \times \text{error of hel. long.}$$

$$- \frac{\text{sin.}\ (\lambda - L)}{\Delta \times \text{cos. geoc. lat.} \times \text{sin. } 1''} \times \text{error of projection of radius vector.}$$

$$\text{Error of Hel. E. P. D.} = \frac{\Delta \times \text{cos. hel. lat.}}{R \times \text{cos. geoc. lat.}} \times \text{error of geocen. E. P. D.}$$

$$- \text{sin. hel. lat.} \times \text{cos. hel. lat.} \times \text{tan.}\ (\lambda - L) \times \text{error of geocen. long.}$$

$$- \frac{r \times \text{tan. geoc. lat.} \times \text{cos.}\ (L - l)}{R^2 \times \text{cos.}\ (\lambda - L) \times \text{sin. } 1''} \times \text{error of projection of radius vector.}$$

For the other planets, the following are used:

$$\text{Error of geoc. long.} = \frac{R \times \text{cos.}\ (\lambda - L)}{\Delta} \times \text{error of planet's heliocentric longitude.}$$

$$- \frac{\text{sin.}\ (\lambda - L)}{\Delta \times \text{sin. } 1''} \times \text{error of projection of planet's radius vector.}$$

$$- \frac{r \times \text{cos.}\ (\lambda - l)}{\Delta} \times \text{error of earth's heliocentric longitude.}$$

$$+ \frac{\text{sin.}\ (\lambda - l)}{\Delta \times \text{sin. } 1''} \times \text{error of earth's radius vector.}$$

$$\text{Error of Hel. E. P. D.} = \frac{\Delta}{R} \times \text{error of geocen. E. P. D.}$$

In the expressions above, different quantities are neglected for the small planets and for the other planets. For the small planets, it is not allowed to neglect the latitude in any part of the expressions, while, at the same time, their errors in general are so large that the earth may be supposed to move exactly in the orbit assigned by the tables. For the other planets, the latitude may be neglected in the formula, but it appears proper to retain the errors of the earth's place, as probably comparable in magnitude to those of the planets. A different form from that of preceding volumes has been adopted in the volume for the present year, for avoiding excessively large coefficients with frequent changes of sign, and for similarity with the form adopted in the Reductions of the Planetary Observations made at Greenwich from 1750 to 1830, which are now ready for press.

It is to be remarked that in the column of *Extent of Group*, the day is given which answers to the day under which the observations may be found in the sections of *Transits as Observed* and *Observations with the Mural Circle:* but in the column of *Mean Day* the day is given whose noon is nearest to the time of observation, or the mean of times of observation. This sometimes causes an appearance of discordance: thus for Mercury it will be found that a single observation on Jan. 26 is referred to Jan. 27 as the nearest noon.

The errors of the tabular Longitude and Ecliptic Polar Distance of the Moon are deduced from the errors of Tabular Right Ascension and North Polar Distance, by use of the numbers P, Q, R, S. The errors of Tabular Right Ascension are previously affected with the correction $+ 0^s{\cdot}03$, to reduce them to the same equinox as that adopted for the planets.

§ 7. *Observations of γ Draconis with the Zenith Tube, and Reduction of the Observations,* page 38 to 47.

For a description of the Zenith Tube, and an account of the steps which its construction renders necessary for the reduction of the observations, I beg to refer to the Introduction to the Observations for 1837, pages i and xlvi. It will be sufficient to state here, that the upper part and the lower part of the plumb-line are viewed by micrometer-microscopes, the observation with which detects and measures any inclination of the telescope to the vertical; and that the star while passing the field of view of the telescope is bisected by means of a wire in the field of view carried by the Grand Micrometer. The values of the several micrometer-screws have been found by a process detailed in the Introduction of 1837, and are as follows: Grand Micrometer, one revolution $= 6''{\cdot}711$; upper plumb-line micrometer, one revolution $= 4''{\cdot}168$; lower plumb-line micrometer, one revolution $= 5''{\cdot}243$. The equivalents to the readings of the several micrometers are to be added together, and they will then give the star's apparent Zenith Distance (to be diminished by a certain constant or index-error, called $-c$ in the printed Observations, which depends upon nothing whatever but the instrumental connexion between the object-glass, the upper plumb-line microscope, the grand micrometer, and the lower plumb-line microscope). The Zenith Distance thus deduced is estimated positive towards the north when the eye-piece is west, or towards the south when the eye-piece is east.

The reduction of the observations has been effected in the following manner. The principle assumes the correctness of the change only of declination in the Nautical Almanac, in the first instance: but any error even in this quantity is nearly or wholly eliminated in the subsequent process. Let z_w be the star's zenith-distance north at the time of an observation when the eye-piece was west, and z_e its zenith-distance north at the time of another observation when the eye-piece was east: (it is indifferent whether this observation was before or after the other). Let d_w and d_e be the seconds of the star's tabular declination for those times; and s_w and s_e the respective sums, for the two observations, of the equivalents for the micrometer-readings.

Then $$z_w = s_w + c$$
$$z_e = -s_e - c$$
Therefore $$z_w - z_e = s_w + s_e + 2c$$
Or $$c = \frac{z_w - z_e}{2} - \frac{s_w + s_e}{2}$$
But $z_w - z_e$ is evidently equal to $d_w - d_e$

Therefore $$c = \frac{d_w - d_e}{2} - \frac{s_w + s_e}{2}$$

In this manner, the instrument being reversed after each observation, every pair of consecutive observations gives a value of c. With regard to the mode of adopting a value to apply to the reduction of several observations, or even of a single observation, no general rule can be given.

As long as the tabular declination of the star increases uniformly, and the observations are equidistant in time, the successive values of $d_w - d_e$ will be alternately positive and negative, and with equal values. Thus the mean of two successive values of c would be wholly independent of the tabular change of declination. And even with any changes of declination and any intervals of time, and deducing the adopted value of c in any manner which makes use of every value of c found, the mutual destruction of positive and negative quantities will always render the dependence on the tables insignificantly small.

In a few instances, the sudden change in the value of c seems to show that some alteration has taken place in the relative position of some parts of the instrument. In those cases it is wrong to combine preceding and following values of c. In other instances, the fault of a single observation seems to have entailed errors on the values of c immediately preceding and immediately subsequent. The course to be pursued in these instances must be determined by a judgment of the various circumstances of the observation, without close reference to any particular rule. The instances that require attention are alluded to in the Notes.

The reduction of the apparent place to the mean place for 1840, Jan. 1, is performed with the corrections of the Nautical Almanac.

The discordance in results appears to be usually or frequently connected with a sudden change in the readings of the lower plumb-line microscope, or rather in the sum of two adjacent readings for opposite positions of the instrument. It appeared not improbable that this might be produced by a rotation of the plumb-line when the instrument is reversed; which, if the plumb-line were crooked (as it usually is) would alter the reading of the lower microscope in such a way that its indications would have no distinct relation to the verticality or non-verticality of the axis of rotation. In order to guard in some degree against this cause of error, the following construction was adopted between January and April 1840. Instead of supporting the weight of the bob upon the one long plumb-line, two plumb-lines were used, one of them being the original long plumb-line without alteration of position, the other being a wire three feet long at the distance of eleven inches from the former: the plane which passes through the two wires passing also through the axis of the telescope, and through the axis of the microscope which views the lower part of the plumb-line. These two plumb-lines support the two ends of a horizontal bar: and to this the weight is suspended. (There are, in fact, two weights, suspended on two points of the bar, but their effect is the same as that of one). It is readily seen that in this construction the principal plumb-line follows the direction of gravity, as regards motion perpendicular to the plane passing through the two plumb-lines, with the same accuracy as if there were but one plumb-line; any small error in the adjustment of the distance between the two points of attachment to the bar affecting only the focal adjustment of the microscope. I cannot positively assert that the results are more consistent since this mounting was adopted: although I am fully persuaded that it is desirable in all cases in which an instrument depending on a plumb-line is frequently reversed.

The particulars already given are sufficient for the elucidation of the process represented in the printed observations. With regard to the readings of the plumb-line micrometers at contact with the plumb-line, it is only proper to remark that the image of the plumb-line is so large that the observation of its center cannot be safely made, and its sides are therefore always observed.

§ 8. *Observations of the Duration of Transit of the Moon's Diameter, with the Eastern Equatoreal*, pages 50 to 54.

These observations were made for the purpose of ascertaining the error in the tabular semidiameter of the Moon adopted by Burckhardt. The times selected were as near as possible to the times of opposition in right ascension. As the Moon was then at a distance from the meridian, it is necessary to examine into the influence of the hour-angle upon the duration of transit, which may be done in the following manner :—

During each transit of a diameter, the Equatoreal is fixed relatively to the earth. Suppose, then, the Moon to stand still in space, while the earth and the equatoreal telescope, which is firmly attached to it, move round. The axis of the telescope produced (or rather the plane of its meridional wire) will come in contact successively with one side and with the other side of the Moon. Produce these touching positions of the plane backwards till they intersect. Their intersection will be in a line parallel to the earth's axis: when the Moon is near the meridian, the intersection will be nearly as distant from the place of observation as the earth's axis is; when the Moon is near the six-hour angle, their intersection will be near the place of observation: and generally their intersection will be at the place determined by drawing a perpendicular from the earth's axis upon the plane of the meridional wire. Consequently, the angle which the earth and telescope must describe that the plane may pass the Moon's diameter, will be found by dividing the Moon's diameter by the Moon's distance from the perpendicular dropped from the earth's axis upon the meridional plane passing through the Moon. Now, the Moon's distance here spoken of is the same as the Moon's distance from the earth's axis multiplied by the cosine of the parallax in right ascension. When the Moon is on the meridian the cosine of the parallax in right ascension is 1. Therefore the time in which the plane passes the Moon's diameter (that is, the duration of transit of the Moon's diameter) in any hour-angle is to the duration of transit on the meridian, as unity to the cosine of the parallax in right ascension. As that parallax cannot exceed 40′, whose cosine is 0·9999323, the duration of transit cannot differ from that on the meridian by the time of transit × 0·0000677: a quantity wholly insensible. The Moon's motion in right ascension produces the same effect in all cases as if the velocity of the earth's rotation were altered in a certain proportion. The duration of transit is therefore sensibly the same at all hour-angles as if the Moon were on the meridian of the place.

The columns of the printed observations need little explanation. The correction for defect of illumination is found by estimating the Sun's perpendicular distance from the meridian passing through the Moon, produced to complete the circle: and considering the defect to be equal to the Moon's semidiameter multiplied by the versed sine of that distance. The tabular duration is interpolated for the hour-angle (found by comparing the sidereal time with the Moon's right ascension) between the tabular durations of the Nautical Almanac, which correspond to hour-angles of 0^h and 12^h successively. The deduced tabular error shows (in conformity with the results obtained in other ways) that Burckhardt's semidiameter is too small by $3''$ nearly.

§ 9. *Observations of Mars and σ Leonis with the Eastern Equatoreal; and Reduction of the Observations,* page 56 to 59.

The method of observing and the elements of reduction are explained for the most part in the Notes. The mean place of σ Leonis, upon which the apparent places used in these reductions are founded, is that given in the Catalogue of Stars in the present volume.

The refractions and parallaxes used in reducing these and the other equatoreal observations in this volume (and in all the preceding volumes from 1836) are computed by the following formula:

For refraction. From Z, the zenith, draw a great circle ZQ, perpendicular to PS, the meridian passing through the pole P and the object S. Then, assuming vertical refraction $= 57'' \times$ tan. zen. dist., the refraction in N.P.D. $= 57'' \times \tan.(PS - PQ)$, and the refraction in A. R. $= \frac{57''}{15} \times \frac{\tan. ZQ}{\sin. PS \times \cos.(PS - PQ)}$. Tables are prepared, containing the values of PQ and tan ZQ for different values of the hour-angle: and the computation for each instance is then very easy.

For parallax. From Z', the geocentric zenith, draw $Z'Q'$ perpendicular to PS: let r be the ratio of the geocentric radius for Greenwich to the equatoreal radius: then the whole parallax = hor. eq. parallax $\times r \times \sin. Z'S$, and it is in the direction of $Z'S$: the parallax in N.P.D. = hor. eq. par. $\times r \cos. Z'Q' \times \sin.(PS - PQ')$, and the parallax in A.R. = hor. eq. par. $\times \frac{r \sin Z'Q'}{15} \times \frac{1}{\sin. PS}$. Tables are prepared, containing the values of PQ', $r \cos. Z'Q'$, and $\frac{r \sin. Z'Q'}{15}$, with which the calculation is easily made.

The tabular places of Mars were interpolated with second differences between the places for noon given in the Nautical Almanac.

The difference in the general values of " Error of interpolated N. P. D." for November 6 and November 7, gave rise to a suspicion that the values of the micrometer were incorrectly determined. Accordingly the following observations have been lately made:

For the value of micrometer (*a*) of eye-piece with pinion-movement:

1842, Jan. 6.	Observations by Mr. Richardson, upon a window-sill at Blackwall, with micrometer at 95ʳ and 105ʳ, 95ʳ and 120ʳ, 100ʳ and 120ʳ, and 100ʳ and 120ʳ, give for 1ʳ	″ 31·538
Jan. 24.	Observations by Mr. Main, of 10 transits of δ Orionis over the two wires placed at an interval equal to 19ʳ·716 of (*a*), give for 1ʳ	31·519

For the value of micrometer (*b*) of eye-piece with pinion-movement:

1842, Jan. 6.	Observations by Mr. Main, upon an object at Blackwall, with micrometer at 100^r and 105^r, 100^r and 110^r, 100^r and 115^r, 100^r and 120^r, 100^r and 113^r, and 100^r and 114^r, (this micrometer not being moveable to readings less than 100^r) give for 1^r	$''$ 31·107
Jan. 24.	Observations by Mr. Main, of 15 transits of δ Orionis over the two wires placed at an interval equal to 14^r·699 of (*b*), give for 1^r	31·416
Jan. 26.	Observations by Mr. Main, of a small scroll on the spire of St. Paul's Church, Deptford, with micrometer at 100^r and 115^r, 100^r and 114^r, 100^r and 115^r, 100^r and 113^r, 100^r and 112^r, 100^r and 111^r, 100^r and 110^r, 110^r and 100^r, 111^r and 100^r, 112^r and 100^r, give for 1^r	31·288

The last series of observations was made with very great care.

In all the observations with the declination circle, every correction for error of runs, &c., was duly applied.

It would seem, therefore, that the value of 1^r of (*b*) is nearly $31''$·28 instead of $31''$·58 as used in the reductions for Mars and σ Leonis. The application of this correction would diminish the diff. N.P.D. of the planet and the star on Nov. 6, by $0''$·4, and the diff. N.P.D. of the star and planet on Nov. 7 by $6''$·0. On the former day $-$ $0''$·4 must be applied to the *Error of Interpolated N.P.D.*: on the latter day + $6''$·0 must be applied. This alteration reduces the discordance in a great measure but not entirely.

The whole of the micrometrical observations with the Eastern Equatoreal in 1836 (Saturn, Venus, and the Eclipse of the Sun), those of Jupiter and χ Leonis in 1838, and those of Mars and stars near him (except on Feb. 16) in 1839, are affected by the same error.

§ 10. *Right Ascensions and North Polar Distances of Galle's Second Comet and neighbouring Stars, observed with the South and East Equatoreals: with the Reduction of the Observations*, page 62 to 108.

The methods of observation and reduction are so completely similar to those in other Equatoreal observations, that it is unnecessary to dwell upon any explanation.

In regard to the Right Ascensions, the following remarks are necessary.

The clock (Earnshaw for the South Equatoreal, and Arnold 1 for the East Equatoreal) was compared with the Transit Clock at each set of observations, and also (on the usual system of comparison) every week: and no sensible doubt remains as to the amount of clock-error.

The hour-circle-readings with the South Equatoreal are very rough: they were intended only for verifying the place of the comet sufficiently to insure finding it again: the construction of the instrument does not permit more accurate readings. The relation between the hour-circle reading and the hour-angle, in the position in which the instrument was used for these observations, is, Hour-circle-reading − Hour-angle W = 6^{h}. The hour-circle for the East Equatoreal admits of being read by its micrometer-microscopes with great accuracy. The runs of the microscopes appeared to be nearly correct. The instrument was used in the same position through all the observations, the graduated face of its declination-circle being E. The relation between the circle-reading and the hour-angle in this position is, Hour-circle-reading − Hour-angle W. = 12^{h}.

The approximate hour-angles and N. P. D. are those which are used for computing the Refraction and Parallax. The absolute amount of these corrections may, in some instances, be sensibly erroneous: but the differences between the corrections for the different objects (which alone are important here) will not, it is presumed, be ever subject to sensible error.

The log. distance employed for the computation of parallax is taken from the Ephemeris in the Astronomische Nachrichten, No. 399.

The following are the assumed mean places of the stars with which the comet was compared. The whole are taken from the Catalogue in the present volume, with the exception of the N.P.D. of ∗ *E*′, which is deduced from an observation made on 1841, Jan. 9.

MEAN PLACES OF STARS COMPARED WITH GALLE'S SECOND COMET.

Star's Name, or Letter of Reference in the Observations.	Mean A. R. 1840, Jan. 1.	Mean N. P. D. 1840, Jan. 1.	Star's Name, or Letter of Reference in the Observations.	Mean A. R. 1840, Jan. 1.	Mean N.P.D. 1840, Jan. 1.
	h m s	° ′ ″		h m s	° ′ ″
∗ (*a*′)	0. 0. 53·88	40. 5. 1·75	∗ (*f*′)	1. 16. 4·66	55. 6. 11·01
Groombridge 35	0. 9. 15·97	39. 27. 21·94	∗ (*k*′)	1. 18. 1·95	56. 27. 21·71
Piazzi 0. 93	0. 22. 37·33	46. 56. 16·62	∗ (*g*′)	1. 19. 51·82	.....
ν Andromedæ	0. 41. 0·73	49. 47. 35·52	∗ (*i*′)	1. 21. 48·68	56. 39. 16·71
μ Andromedæ	0. 47. 53·47	52. 22. 10·84	∗ (*l*′)	1. 25. 54·11	57. 41. 55·55
39 Andromedæ	0. 53. 56·18	49. 31. 0·59	∗ (*n*′)	1. 33. 9·11	59. 40. 19·68
Groombridge 232	0. 55. 37·87	50. 52. 4·22	∗ (*m*′)	1. 33. 51·53	59. 46. 56·28
∗ (*b*′)	0. 59. 0·86	51. 36. 15·53	∗ (*o*′)	1. 37. 37·84	61. 7. 50·04
φ Andromedæ	1. 0. 14·85	43. 36. 48·00	α Trianguli	1. 43. 58·68	61. 12. 13·77
β Andromedæ	1. 0. 47·70	55. 13. 46·42	∗ (*p*′)	1. 56. 1·72	67. 12. 51·83
∗ (*E*′)	1. 1. 27·23	51. 34. 21·06	α Arietis	1. 58. 10·03	67. 17. 50·90
∗ (*c*′)	1. 4. 8·45	......	β Trianguli	2. 0. 2·67	55. 46. 23·79
∗ (*d*′)	1. 5. 40·03	51. 24. 18·27	η Arietis	2. 3. 51·40	69. 32. 38·54
∗ (*e*′)	1. 14. 13·56	54. 19. 24·34	∗ (*q*′)	2. 7. 6·93	70. 2. 37·71
Piazzi I. 56	1. 14. 34·53	.....	θ Arietis	2. 9. 14·26	70. 50. 32·80

i

The corrections to apparent place for α Arietis are taken from the Nautical Almanac. For the other stars they are computed by the formulæ equivalent to A a + B b + C c + D d, or A a′ + B b′ + C c′ + D d′.

The Apparent Correction for Index Error is found by subtracting the corrected Instrumental A. R. of the stars from the Assumed A. R.

When the comet and a star are observed in the same series, the adopted index-correction applied to the comet is always that deduced from the star in the same series. In other cases, the selection of stars for the adoption of the index-correction is explained in the Notes. As a general rule, it is thought desirable to select stars observed before and after the comet, as tending in some degree to eliminate the small errors in the computation of refraction for low objects.

The Interpolated A.R. of the comet is computed from the Ephemeris in the Astronomische Nachrichten, No. 399.

The following are the corrections for runs of the micrometer of the declination-circle of the East Equatoreal:

On March 2, between 55°. 10′ and 55°. 15′, −13″·5 is adopted for the whole correction for 5′: between 56°. 25′ and 56°. 40′, −4″·8 is used.

For February 24, 25, and 28, March 1, 3, 4, 5, 6, 7, −9″·1 is used.

For March 8 and 9, −3″·5 is used.

For March 16, between 65°. 55′ and 66°. 0′, −14″·5 is used: between 67°. 10′ and 67°. 15′, −8″·0: between 67°. 15′ and 67°. 20′, −20″·6.

For March 24, between 69°. 30′ and 69°. 35′, −15″·4 is used: between 70°. 0′ and 70°. 5′ −12″·9: between 70°. 5′ and 70°. 10′, −6″·8.

On March 23 and 25, −11″·7 is used.

These are the quantities which were actually observed (in the usual manner) upon the divisions employed: their determination is liable to some error. The numbers given here are applied to the sums of the readings of the microscopes before dividing by 2.

The values of 1^d and 1^r of the Sector of the South Equatoreal, employed in the reductions, are given in the Notes.

The small irregularity in the apparent correction for index-errors undoubtedly arises in part from the failure of the formula for refraction. The selection used for the adopted correction is mentioned in the notes: in this the rule has usually been, when the apparent corrections vary according to a perceptible law, to use one preceding and one following the observation of the comet. But in all cases, when the comet and a star are observed in the same series, the index-correction from that star is used as preferable to any other.

The Mean Solar Times are the same as those for the observation of A.R., with the exception of a few series in which there were no observations of Transits. The numbers of these series, and the observed clock-times, are as follows:

	h m s
Series 13, clock time of observation ..	6. 20. 15
18	6. 52. 26
20	6. 56. 15
22	6. 59. 17
24	7. 5. 10
26	7. 7. 50
28	7. 10. 13
30	7. 13. 33
32	7. 17. 15
47	5. 27. 20
49	5. 36. 15
51	5. 47. 35
53	5. 57. 30
85	5. 36. 40
86	5. 40. 25
112	5. 32. 30
114	5. 39. 40
141	7. 35. 20
143	7. 44. 50

The Interpolated N.P.D. is computed from the Ephemeris in the Astronomische Nachrichten, No. 399.

§ 11. *Right Ascensions and North Polar Distances of Bremicker's Comet and neighbouring Stars, observed with the South and East Equatoreals; with the Reduction of the Observations,* page 110 to 157.

The general description of the methods of observing and reducing in the last section applies also to this. The following points of difference may however be noted.

The correction for runs of the microscopes of the declination-circle of the East Equatoreal used throughout is $-3''\cdot9$.

A series of observations of the sector-arc of the South Equatoreal with the telescope East of the pier, from Nov. 16 to Nov. 25, and from Nov. 27 to Dec. 10, gave $1^d = 18^r\cdot147$. Similar series on Nov. 26 and Dec. 22, gave $1^d = 18^r\cdot462$. And observations on Dec. 22, with the telescope West of the pier, gave $1^r = 18^r\cdot247$. The value of 1^d being assumed $= 333''$ (Gr. Obs. 1838, Introduction, page lx), the corresponding values of 1^r are respectively $18''\cdot350$, $18''\cdot037$, and $18''\cdot250$. These are the values used on the days mentioned above; with the telescope in the positions specified.

The apparent places of the stars of comparison are deduced from mean places of the stars for 1840, Jan. 1, obtained by meridional observations in 1840 and 1841 (the latter roughly reduced). The following are the mean places used, and the authorities.

i 2

MEAN PLACES OF STARS COMPARED WITH BREMICKER'S COMET.

Star's Name.	Mean A.R. 1840, Jan. 1.	From Greenwich Observations of	Mean N.P.D. 1840, Jan. 1.	From Greenwich Observations of
	h m s		° ′ ″	
θ Cephei	20. 26. 53 ·15	1841	27. 32. 31 ·91	1840
* (A′)	20. 27. 39 ·98	1841	30. 39. 54	1841
* (B′)	20. 30. 6 ·47	1841	30. 38. 30	1841
η Cephei	20. 42. 1 ·49	1841	28. 46. 51 ·83	1840
* (C′)	20. 47. 3 ·10	1841	31. 18. 18	1841
* (D′)	21. 7. 24 ·71	1841	32. 11. 39	1841
* (F′)	21. 8. 49 ·80	1841		
α Cephei	21. 14. 45 ·46	1840	28. 5. 26 ·35	1840
* (G′)	21. 25. 5 ·96	1841	33. 15. 34	1841
* (H′)	21. 26. 49 ·75	1841	33. 12. 7	1841
* (I′)	21. 35. 58 ·79	1841	33. 35. 21	1841
π¹ Cygni	21. 36. 25 ·37	1841	39. 32. 18 ·53	1840
Piazzi XXI. 336	21. 47. 43 ·78	1840	34. 32. 23	1841
* (L′)	21. 54. 40 ·69	1840	35. 10. 57 ·38	1840
* (M′)	22. 2. 14 ·46	1841	35. 50. 8	1841
ζ Cephei	22. 5. 19 ·03	1840	32. 35. 8 ·45	1840
Groombridge 3712	22. 6. 2 ·29	1841	33. 57. 17 ·00	1840
Groombridge 3714	22. 6. 29 ·61	1840	35. 41. 26	1841
ε Cephei	22. 9. 9 ·48	1841	33. 45. 8. 17	1840
* (N′)	22. 9. 37 ·26	1840	36. 26. 13 ·02	1840
* (O′)	22. 18. 50 ·09	1840	37. 5. 8 ·23	1840
Groombridge 3771	22. 19. 33 ·46	1840	36. 59. 40 ·71	1840
Groombridge 3773	22. 19. 45 ·19	1841	37. 1. 49	1841
Groombridge 3774	22. 20. 2 ·89	1841	36. 59. 18	1841
δ² Cephei	22. 23. 14 ·41	1840	32. 24. 8	1841
Groombridge 3901	22. 43. 19 ·20	1840	40. 10. 8 ·04	1840
Groombridge 3913	22. 45. 45 ·13	1840	40. 8. 35 ·64	1840
Groombridge 4128	23. 34. 23 ·10	1840	45. 53. 39 ·22	1840
* (P′)	0. 40. 16 ·97	1841	57. 56. 55 ·81	1840
* (R′)	0. 48. 38 ·59	1841	59. 25. 42	1841
* (Q′)	0. 48. 42 ·53	1841	59. 32. 18	1841

The Mean Solar Times are the same for N. P. D. as for A. R. with the exception of a few series in which there were no observations of Transits. The numbers of these series, and the observed clock-times, are as follows:

	h m s		h m s
Series 16, clock time of observation	0. 15. 43	Series 56, clock time of observation	23. 18. 20
27	23. 35. 0	58	23. 25. 0
29	23. 43. 25	60	23. 34. 30
31	23. 49. 30	62	23. 39. 10
54	23. 10. 30	64	23. 44. 50

The interpolated A. R. and N. P. D. of the comet, and the log. distance used for the parallaxes, were deduced from the following ephemeris, computed (from the elements given by Encke in the Astronomische Nachrichten, No. 413) by Mr. John Russell Hind, one of the Assistants in the Magnetic Department of the Royal Observatory.

EPHEMERIS OF BREMICKER'S COMET, AT GREENWICH MEAN MIDNIGHT.

Day, 1840.	Apparent Right Ascension.	Apparent North Polar Distance.	Log. of Distance from the Earth.	Log. of Distance from the Sun.
	h m s	° ′ ″		
November.... 12	20. 17. 31 ·59	30. 12. 56 ·8	9 ·98840	0 ·17282
13	20. 24. 48 ·38	30. 25. 59 ·5	9 ·98488	0 ·17283
14	20. 32. 11 ·66	30. 40. 31 ·9	9 ·98146	0 ·17285
15	20. 39. 40 ·72	30. 56. 39 ·0	9 ·97814	0 ·17289
16	20. 47. 14 ·79	31. 14. 24 ·7	9 ·97491	0 ·17297
17	20. 54. 53 ·00	31. 33. 52 ·7	9 ·97178	0 ·17308
18	21. 2. 34 ·50	31. 55. 6 ·6	9 ·96876	0 ·17324
19	21. 10. 18 ·33	32. 18. 9 ·8	9 ·96584	0 ·17343
20	21. 18. 3 ·69	32. 43. 4 ·1	9 ·96308	0 ·17367
21	21. 25. 49 ·56	33. 9. 52 ·0	9 ·96043	0 ·17394
22	21. 33. 34 ·98	33. 38. 35 ·1	9 ·95794	0 ·17425
23	21. 41. 19 ·11	34. 9. 13 ·5	9 ·95560	0 ·17459
24	21. 49. 1 ·04	34. 41. 47 ·5	9 ·95343	0 ·17498
25	21. 56. 39 ·90	35. 16. 16 ·4	9 ·95144	0 ·17540
26	22. 4. 14 ·84	35. 52. 39 ·2	9 ·94964	0 ·17586
27	22. 11. 45 ·16	36. 30. 53 ·4	9 ·94804	0 ·17636
28	22. 19. 10 ·11	37. 10. 56 ·3	9 ·94664	0 ·17690
29	22. 26. 29 ·07	37. 52. 44 ·7	9 ·94545	0 ·17747
30	22. 33. 41 ·47	38. 36. 14 ·7	9 ·94449	0 ·17807
December..... 1	22. 40. 46 ·81	39. 21. 21 ·1	9 ·94376	0 ·17872
2	22. 47. 44 ·64	40. 7. 59 ·2	9 ·94327	0 ·17939
3	22. 54. 34 ·63	40. 56. 2 ·8	9 ·94301	0 ·18011
4	23. 1. 16 ·45	41. 45. 26 ·2	9 ·94300	0 ·18086
5	23. 7. 49 ·88	42. 36. 2 ·5	9 ·94325	0 ·18164
6	23. 14. 15 ·07	43 27. 44 ·8	9 ·94375	0 ·18245
7	23. 20. 31 ·00	44. 20. 26 ·2	9 ·94451	0 ·18330
8	23. 26. 38 ·51	45. 13. 59 ·1	9 ·94552	0 ·18418
9	23. 32. 37 ·30	46. 8. 16 ·2	9 ·94679	0 ·18510
10	23. 38. 27 ·37	47. 3. 9 ·4	9 ·94832	0 ·18604
11	23. 44. 8 ·80	47. 58. 31 ·2	9 ·95010	0 ·18702
12	23. 49. 41 ·68	48. 54. 14 ·4	9 ·95213	0 ·18803
13	23. 55. 6 ·20	49. 50. 11 ·3	9 ·95441	0 ·18907
14	0. 0. 22 ·64	50. 46. 14 ·6	9 ·95694	0 ·19014
15	0. 5. 30 ·58	51. 42. 17 ·4	9 ·95970	0 ·19123
16	0. 10. 30 ·91	52. 38. 12 ·9	9 ·96270	0 ·19236
17	0. 15. 23 ·57	53. 33. 55 ·1	9 ·96590	0 ·19351
18	0. 20. 8 ·76	54. 29. 17 ·3	9 ·96933	0 ·19469
19	0. 24. 46 ·71	55. 24. 14 ·1	9 ·97298	0 ·19590
20	0. 29. 17 ·70	56. 18. 40 ·1	9 ·97682	0 ·19713
21	0. 33. 41 ·89	57. 12. 30 ·3	9 ·98083	0 ·19839
22	0. 37. 59 ·50	58. 5. 40 ·2	9 ·98504	0 ·19968
23	0. 42. 10 ·79	58. 58. 6 ·0	9 ·98941	0 ·20099
24	0. 46. 16 ·01	59. 49. 43 ·8	9 ·99394	0 ·20232
25	0. 50. 15 ·28	60. 40. 30 ·3	9 ·99861	0 ·20368
26	0. 54. 8 ·99	61. 30. 23 ·0	0 ·00343	0 ·20506
27	0. 57. 57 ·21	62. 19. 19 ·2	0 ·00837	0 ·20646
28	1. 1. 40 ·20	63. 7. 17 ·0	0 ·01343	0 ·20789
29	1. 5. 18 ·08	63. 54. 14 ·8	0 ·01860	0 ·20933
30	1. 8. 51 ·29	64. 40. 11 ·3	0 ·02388	0 ·21080
31	1. 12. 19 ·66	65. 25. 5 ·4	0 ·02924	0 ·21228

§ 12. *Eclipses, Occultations, and Transits of Jupiter's Satellites, and Occultations of Stars by the Moon; with the Equations deduced from the Occultations,* page 160 to 169.

The tabular statement of observations appears to require no remark, except that the clocks were always compared (by setting an adjustible chronometer or click in accordance with the Transit Clock, and carrying it for comparison with the clock in question), as near as possible to the time of observation, and that a regular weekly comparison of all the clocks is used to check the incidental comparisons.

For the computation, the star's place is taken from the "Elements for facilitating the Computation of Occultations" in the Nautical Almanac. The Moon's geocentric place, semidiameter, and hor. eq. parallax, are interpolated with second differences from the Nautical Almanac. The hor. eq. parallax is then corrected by a quantity taken from the following Table, depending on the zenith-distance (Z), and the angle from the vertical (on the Moon's limb), as seen in an inverting telescope, at which the occultation takes place (V). The investigation from which this table is formed, is given in the Cambridge Observations, 1831, Introduction.

Correction to the Moon's Horizontal Parallax, to be used when the Parallax is applied to the Limb.

Angle from the Vertical as seen in an inverting Telescope.		Zenith Distance.									
		0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
0°	360°	+0·04	+0·06	+0·08	+0·10	+0·12	+0·13	+0·15	+0·16	+0·16	+0·16
10	350	+0·04	+0·06	+0·08	+0·10	+0·12	+0·13	+0·15	+0·15	+0·16	+0·16
20	340	+0·04	+0·06	+0·08	+0·10	+0·11	+0·13	+0·14	+0·15	+0·15	+0·16
30	330	+0·04	+0·05	+0·07	+0·09	+0·11	+0·12	+0·13	+0·14	+0·15	+0·15
40	320	+0·04	+0·05	+0·07	+0·08	+0·10	+0·11	+0·12	+0·13	+0·13	+0·13
50	310	+0·04	+0·05	+0·06	+0·08	+0·09	+0·10	+0·11	+0·11	+0·12	+0·12
60	300	+0·04	+0·05	+0·06	+0·07	+0·08	+0·08	+0·09	+0·10	+0·10	+0·10
70	290	+0·04	+0·04	+0·05	+0·06	+0·06	+0·07	+0·07	+0·08	+0·08	+0·08
80	280	+0·04	+0·04	+0·04	+0·05	+0·05	+0·05	+0·05	+0·06	+0·06	+0·06
90	270	+0·04	+0·04	+0·04	+0·04	+0·04	+0·04	+0·04	+0·04	+0·04	+0·04
100	260	+0·04	+0·03	+0·03	+0·02	+0·02	+0·02	+0·02	+0·01	+0·01	+0·01
110	250	+0·04	+0·03	+0·02	+0·01	+0·01	0·00	0·00	−0·01	−0·01	−0·01
120	240	+0·04	+0·02	+0·01	0·00	−0·01	−0·01	−0·02	−0·03	−0·03	−0·03
130	230	+0·04	+0·02	+0·01	−0·01	−0·02	−0·03	−0·04	−0·04	−0·05	−0·05
140	220	+0·04	+0·02	0·00	−0·01	−0·03	−0·04	−0·05	−0·06	−0·06	−0·06
150	210	+0·04	+0·02	0·00	−0·02	−0·04	−0·05	−0·06	−0·07	−0·08	−0·08
160	200	+0·04	+0·01	−0·01	−0·03	−0·04	−0·06	−0·07	−0·08	−0·08	−0·09
170	190	+0·04	+0·01	−0·01	−0·03	−0·05	−0·06	−0·08	−0·08	−0·09	−0·09
180	180	+0·04	+0·01	−0·01	−0·03	−0·05	−0·06	−0·08	−0·09	−0·09	−0·09

Z is found by means of a celestial globe; V is taken from the Nautical Almanac. The eq. hor. parallax thus corrected is applicable to the point of the limb at which the occultation happens.

The following quantities are then formed:

F = log. sin. star's hour-angle + log. seconds of corrected eq. hor. parallax + 9·4942187.

G = log. sin. star's N.P.D. + log. sin. star's hour-angle + log. seconds of corrected eq. hor. parallax + 9·8913921.

(The former constant is the logarithm of half the distance of Greenwich from the earth's axis, and the latter is the logarithm of the distance of Greenwich from the plane of the equator.)

Then putting θ for the apparent hour-angle of the point of occultation = star's hour-angle,

δ for the apparent N. P. D. of the point of occultation = star's N. P. D.

θ' and δ' for the geocentric hour-angle and N. P. D. of the corresponding point on the Moon's surface (namely, the point of contact of a line drawn from the earth's center in the vertical plane passing through the point of occultation)

the following equations are solved by successive trials, assuming a value for δ':

$$\log. \tfrac{1}{2}(\theta - \theta') \text{ in seconds} = F - \log. \sin. \delta' + \log. \frac{\text{sine}}{\text{arc}} \text{ for hor. parallax} + \log. \frac{\text{arc}}{\text{sine}} \text{ for } (\theta - \theta')$$

$$\log 1^{\text{st}}\ \text{n}^{\circ} = G + \log. \text{secant } \tfrac{1}{2}(\theta - \theta') + \log. \frac{\text{sine}}{\text{arc}} \text{ for hor. parallax} + \log. \frac{\text{arc}}{\text{sine}} \text{ for } (\delta - \delta') - \log. \text{sine } \tfrac{1}{2}(\theta + \theta')$$

$$\log. 2^{\text{nd}}\ \text{n}^{\circ} = \log. \tfrac{1}{2}(\theta - \theta') \text{ in seconds} + \log. \frac{\text{tan.}}{\text{arc}} \text{ for } \tfrac{1}{2}(\theta - \theta') + \log. \sin. (\delta + \delta' - 180^{\circ}) + \log. \cot. \tfrac{1}{2}(\theta + \theta') + \log. \frac{\text{arc}}{\text{sine}} \text{ for } (\delta - \delta')$$

$$\delta - \delta' = 1^{\text{st}}\ \text{n}^{\circ} + 2^{\text{nd}}\ \text{n}^{\circ}.$$

In the first trials the log. $\frac{\text{arc}}{\text{sine}}$, &c. are omitted. The convergence of these approximations is extremely rapid. When δ' and θ' are found accurately, the distance of the corresponding point from the Moon's center is thus found:

log. tan. ψ = log. diff. A.R. of Moon's center and corresponding point + $\frac{1}{2}$ log. sin. N.P.D. of Moon's center + $\frac{1}{2}$ log. sin. δ' — log. diff. N.P.D. of Moon's center and corresponding point.

log. dist. = log. diff. N.P.D. — log. cos. ψ.
or = log. diff. A.R. + $\frac{1}{2}$ log. sin. N.P.D. of center + $\frac{1}{2}$ log. sin δ' — log. sin. ψ.

The co-efficients of small variations of the North Polar Distances, and of the Difference of Right Ascension (in the expression for distance), are computed by the formulæ,

log. 1st n° = 2 log. diff. A.R. + log. sine (sum of N.P.D.) — log. dist. + 4·0835.

log. 2nd n° = log. diff. N.P.D. — log. distance.

Co-efficient of variation of greater N.P.D. = 1st n° + 2nd n°.

Co-efficient of variation of smaller N.P.D. = 1st n° − 2nd n°.

Log. co-efficient of variation of diff. A.R. =
log. diff. A.R. + log. sin. δ' + log. sin Moon's N.P.D. — log. distance

The variation of the A.R. of the corresponding point contains the following terms:

1st. The alteration of the A.R. of the star by the quantity e'' will alter the A.R. of the corresponding point by very nearly the same quantity e''.

2nd. The alteration of the horizontal equatoreal parallax in the proportion of $1 : 1 + \frac{m}{1000}$ will alter all the deduced parallaxes (in A.R. and in N.P.D.) in nearly the same proportion: and therefore the A.R. of the corresponding point will be altered by $\frac{m}{1000} \times$ correction for parallax in A.R.

3rd. The alteration in the position of the Moon with regard to the meridian, depending on the alteration of time t^s, will introduce an alteration in the correction for parallax. It is computed by the following formula; in which P is the horizontal parallax, and l is the geocentric latitude of Greenwich.

Alteration, in correction of A.R. of corresponding point for parallax, depending on the alteration of time =

$$15'' \times t \times \left\{ \begin{array}{l} \text{sin. } P \text{. cos. } l \text{ cosec. N.P.D. cos. hour-angle.} \\ + \text{ sin.}^2 P \text{ cos.}^2 l \text{ cosec.}^2 \text{ N.P.D. cos. 2 hour-angle.} \end{array} \right\}$$

This supposes that the star's place is correct. If the Moon's place were supposed correct, the factor instead of $15'' \times t$ would be ($15''$ — Moon's change of A.R.) $\times t$.

The variation of the A.R. of the Moon's center is $x'' + t \times$ change of A.R. in 1^s.

The variation of the N.P.D. of the corresponding point contains three terms analogous to those for the A.R.: namely—

1st. The alteration of the star's N.P.D. by the quantity f'' will alter the N.P.D. of the corresponding point by f'' nearly.

2nd. The correction for parallax in N.P.D. will be altered by $\frac{m}{1000} \times$ correction for parallax in N.P.D.

3rd. The increase of hour-angle (considered positive when the Moon is west of the meridian), depending on the alteration of time t^s, will alter the correction for parallax in N.P.D. by the following quantity:

$$15'' \times t \times \left\{ \begin{array}{l} (-\sin. P. \cos. l. \cos. \text{N.P.D.} - \sin.^2 P. \sin. l. \cos. l. \cos. 2\,\text{N.P.D.}) \sin. \\ \quad \text{hour-angle.} \\ (-\tfrac{3}{2} \sin.^2 P. \cos.^2 l. \cot. \text{N.P.D.} + \sin.^2 P. \cos.^2 l. \cot. \text{N.P.D.} \\ \quad \cos.^2 \text{N.P.D.}) \sin. 2 \text{ hour-angle.} \end{array} \right\}$$

The variation of the N.P.D. of the Moon's center is $y'' + t \times$ change of N.P.D. in 1^s.

The computed distance, altered by the sum of the products of the preceding variations by their proper co-efficients, is made equal to the semidiameter altered by the term semidiameter $\times \frac{n}{1000}$: and thus the final equation is formed.

§ 13. *Observations of the Distances and Positions of Double Stars and of the Diameters of Planets, with a double-image eye-piece attached to the South Equatoreal,* page 172 to 184.

The eye-piece with which these observations are made is a four-glass erecting eye-piece, in which the lenses are so arranged that the axis of the pencil of rays, from each point of an observed object, passes through the centre of the lens which is second (as measured from the object-glass), or third (as measured from the eye). This lens is divided by a plane passing through the axis of the telescope. One half of the lens is fixed, the other is moved by means of a micrometer-screw with graduated head. The whole eye-piece is made to revolve round an axis coinciding sensibly with the axis of the telescope, by a toothed-wheel-and-pinion movement: the position circle is graduated so that the readings increase when the eye-piece revolves in the direction opposite to that of the hands of a watch.

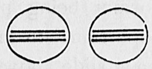
The power of the eye-piece is altered by using different lenses in the position nearest to the eye, without alteration of the other three lenses.

Since the axis of the pencil of rays, coming from any object or any point of an object, passes through the centre of the divided lens, it is evident that one half of that lens receives the light which comes from one half of the object-glass, and the other half receives the light which comes from the other half of the object-glass. When the moveable half of the lens is in that position in which its surface is continuous with the surface of the fixed half (or in the position corresponding to the zero point of its scale), the axis of every semi-pencil on either half passes through that part of the lens in which the surfaces are parallel; but when the moveable half is moved from that zero position, the axis of the semi-pencil incident on that half falls upon a part in which the two surfaces are not parallel, their inclination being proportional (with sufficient accuracy) to the distance through which that half of the lens has been slid, and the plane which is perpendicular to both surfaces being the plane passing through the line of division and the axis of the telescope. This semi-pencil therefore emerges, inclined to the other; the plane of inclination being the plane just mentioned, and the extent of inclination being proportional to the movement of the moveable half-lens. On tracing the effect of this upon the image viewed by the eye-glass, it is seen that two images of the same object are formed by the light from the two halves of the object-glass, the line joining them being (sensibly) parallel to the dividing line of the lens, and their apparent distance being (sensibly) proportional to the movement of the half-lens, in whatever part of the visible field of view they may be.

The following circumstances are worthy of remark, in estimating the value of a construction like that now described.

1. The image formed by each semi-pencil is really formed by light from only one half of the object-glass, and therefore has all the defects of an image formed by a half lens. But one of the images is formed by one half, and the other by the other half. Suppose now that the object-glass has sensible dispersion (from which no object-glass that I have ever seen is free). It is well known, in the use of an entire object-glass, that by selecting as the point for the effective image a place intermediate to the points at which the most refrangible and the least refrangible rays converge, the most refrangible rays from one half of the object-glass will be mingled with the least refrangible from the other half, and their general effect of colour will be almost destroyed. But in the separate images formed by the divided lens in this construction, no such compensation of colours exists with regard to the direction *perpendicular* to the plane of division: because, if the semi-pencil be examined with reference to that direction, it evidently comes from half an object-glass, without any opposed half whose colours may be mingled with it. If, however, the semi-pencil be examined with reference to the direction *parallel* to the plane of division,

it is easily seen that each half of the semi-pencil on one side is balanced by a half on the opposite side, whose colours will be mingled with it. Thus, the two images of the object may appear very much coloured, but they will be coloured only on those sides which are measured from the center of each image transversely to the line of separation. For instance, suppose Jupiter to be observed, and suppose the two images to be separated as in the accompanying figure.



Then, in the first image the top may be red and the bottom blue, while in the second, the top will be blue and the bottom red; but the sides will be no more and no less coloured than when the whole object-glass is used to form a single image; and thus, in spite of the colour which immediately catches the eye, the images are (for the purposes of measurement of distance) as good as it is possible to have.

2. With reference to the measurement of angle of position of the two images, the circumstance that has been mentioned may cause some uncertainty, or even some difference as estimated by different eyes, which are differently sensitive to the different colours. The last inconvenience, however, is completely overcome by the method of double observation, of which we shall presently speak; and ceases to exist on applying the method of putting the eye-piece in focus, to which we shall shortly advert.

3. In regard to the effects of diffraction on the image, the image of a star is not round, but is elongated in the direction perpendicular to the line of separation of the images. This distortion operates nearly in the same manner as that described above: it produces no uncertainty whatever on the estimation of distances, but it does introduce uncertainty in the estimation of direction of separation of images.

4. From these remarks it will be gathered, that a divided eye-piece of this construction is particularly advantageous for the estimation of the distances between the double images of objects, but it is not particularly advantageous for the estimation of their position. From the statements of Sir J. Herschel, it appears that the distance is usually the more inaccurate co-ordinate, and therefore that this eye-piece, and others on the same general principle, supply what was formerly a defect. The angles, however, are also observed, as I believe, with great accuracy.

5. The method used for putting the eye-piece (practically) in focus is founded on the following consideration, it being premised that the eye-piece tube is so constructed that on sliding the eye-piece it receives no sensible rotation. Suppose the images to be separated right and left; one of them (for instance, the fixed image) is then formed by light coming from the upper half of the object-glass, and the other (the moveable image) by light coming from the lower half. Suppose the eye-piece to be drawn away from the object-glass; then

the center of the section of the pencil forming the fixed image, (not the center of the semicircular outline, but the center of the general mass of light) which is viewed at the distance of distinct vision by the eye-piece, and on which the visible place depends, falls lower; and the center of the section of the pencil forming the moveable image, on which the visible place of the moveable image depends, rises higher. And this rise and fall may amount to a very sensible quantity within the limits in which the alteration of the visible size of the image is nearly insensible (the former being proportional to the movement of the eye-piece, while the latter is nearly proportional to the square of that movement). Thus it is possible to make the moveable image slide above the fixed one, or through it, or below it. And these different appearances may present themselves to different eyes, in the same state of the eye-piece, according to the difference of sensitiveness of the eyes to different colours. If (as may happen) one of the halves of the lens is brought by the instrument-maker a very little too near to the other, or a very little too far from it (which, separately considered, would make the moveable image slide above or below the fixed image), advantage may be taken of this principle to correct that defect by thrusting in or drawing out the eye-piece. The principle therefore upon which the adjustment to focus is determined is, to adjust the eye-piece so that the moveable image shall pass as accurately as possible *through* the fixed image: and the practical method of using this principle is, to adjust it so that the angle of position of a double star (determined as hereafter mentioned) shall be the same when the observation is made by bringing the moveable image to the right of the fixed one, as when it is made by bringing it to the left of the fixed one. If there is error of adjustment, it affects both equally, one + and the other −; and the rule therefore is: determine the apparent values of the angles of position in the two directions of separation, the mean of these is the correct value; place the position circle of the eye-piece in the position corresponding to that correct value: then thrust in or draw out the eye-piece until the line of separation of the images coincides with the line joining the two individual stars of the double star; then the adjustment to focus is completed. But after all precautions are taken, it is thought prudent always to observe angles of position with the moveable image on both sides of the fixed image, and to take the mean.

6. As the separation of the images is effected by a species of prismatic refraction, it will be different for rays of different colours, and the moved image will therefore be changed into a spectrum, in which (beyond a certain distance) the colours will be sensible. And, as the lenses of the eye-piece will produce a certain degree of distortion, it will happen that where the object observed is large, or where its images are separated widely, the apparent magnitude is slightly altered, and the line of position of the two stars of a double star is sensibly altered. The extent, at which these combined causes begin to operate sensibly, can only be judged from experience. My impression from my own observations is, that the separation ought in no case to exceed ninety seconds of arc.

These remarks on the general properties of the eye-piece being premised, I shall now proceed to describe the method of making the fundamental determinations for reduction.

7. To determine the reading of the position-circle, corresponding to that position of the eye-piece in which the separation of the two images takes place in the direction of the celestial meridian passing through any object.

A tube is prepared, containing only one lens (the eye-glass, or lens nearest to the eye), and furnished with a single wire in the focus of that eye-glass. It slides upon the tube containing the other three lenses of the eye-piece (namely, the divided lens and one on each side of it), and is held safely upon it, in the same manner as the other change-tubes with eye-glasses of different powers, by two pins and bayonet notches. This tube, however, has four bayonet notches, which permit it to be mounted, so that the wire may be placed either in the direction of separation of the images or in the direction perpendicular to that, the notches being sufficiently long to allow of considerable motion for adjustment. To determine the reading of the position-circle corresponding to separation in the direction of the astronomical meridian, the eye-tube is attached with its wire nearly parallel to the direction of separation, the telescope is directed to a star, the clock-work of the equatoreal is put in action; then the micrometer-screw is turned through a considerable number of revolutions backwards and forwards, and the eye-tube is turned by hand (without moving the rest of the eye-piece) till the moveable image of the star, as moved by the micrometer-screw, runs well upon the wire. Thus the position of the wire is made to correspond accurately to the direction of separation. Then the clock-work is stopped, the star passes the field of view by its diurnal motion, and the position circle is turned (without independent movement of the eye-glass tube), till the diurnal motion makes the star run well along the wire; then the position of the wire, and consequently the direction of separation, coincides accurately with the direction of diurnal motion: and the reading of the position circle, increased or diminished by 90°, is therefore the reading corresponding to separation in the direction of the meridian, or is the Polar point. As the defects in the equatoreal adjustment of the telescope make different planes in the telescope to coincide with the astronomical meridian in different positions of the telescope, it is necessary to ascertain the Polar point for several different positions of the telescope.

8. To determine the value of one revolution of the micrometer-screw.

The eye-glass tube carrying the wire is placed in such a position that the wire is nearly perpendicular to the line of separation (extreme accuracy is not necessary). Then, by moving the position circle, the line of separation is made to coincide pretty accurately with the direction of diurnal movement; the telescope is directed to a single star, and by turning the micrometer through a known number of revolutions, this single star is converted into two stars, which in the diurnal motion follow each other across the field of view, and whose transits across the wire can be separately observed. The interval in time is converted into arc, and is multiplied by the sine of the star's N. P. D., and thus the arc is found which corresponds to a known number of revolutions of the micrometer.

By these methods the following determinations have been made. The eye-piece tube having been accidentally injured between October 21 and November 9, it was thought necessary to re-examine the adjustments: it was found that the Polar point had been sensibly altered, but that the value of the scale was not affected.

OBSERVATIONS OF STARS IN THE YEARS 1839 AND 1840, FOR THE DETERMINATION OF THE POLAR POINT OF THE DOUBLE-IMAGE MICROMETER.

Day.	Star.	A. R.	Sidereal Time of Observation.	Polar Point for different positions of the Telescope.					
				Star near upper meridian.		Star near lower meridian.		Star nearly 6h W of meridian.	Star nearly 6h E of meridian.
				Telescope E of Pier.	Telescope W of Pier.	Telescope E of Pier.	Telescope W of Pier.		
		h m	h m	° ′	° ′	° ′	° ′	° ′	° ′
1839, Dec. 25	α Cassiopeiæ....	0. 31	0. 33		32. 30				
,,	ε Ursæ Majoris..	12. 47	1. 5				213. 15		
,,	β Ursæ Minoris..	14. 51	2. 5				212. 37		
,,	α Cassiopeiæ....	0. 31	2. 38	212. 28					
,,	ε Ursæ Majoris..	12. 47	3. 4			32. 50			
,,	β Cephei	21. 27	3. 23					212. 50	
,,	θ Ursæ Majoris..	9. 22	3. 45						32. 48
28	ζ Ursæ Minoris..	15. 50	3. 55				212. 46		
,,	Groombridge 828	4. 15	4. 10		32. 46				
,,	ζ Ursæ Minoris..	15. 50	4. 35			34. 25			
29	Groombridge 1259	6. 57	0 ·40						33. 45
,,	Groombridge 1937	12. 48	1. 30			34. 50			
,,	Groombridge 595	2. 56	1. 55		33. 45				
,,	76 Draconis	20. 54	2. 20					212. 11	
,,	ζ Ursæ Minoris..	15. 50	2. 45				212. 37		
,,	Groombridge 595	2. 56	3. 30	211. 0					
1840, Feb. 22	γ Cephei........	23. 33	6. 20					211. 46	
25	η Persei........	2. 39	8. 15					213. 12	
Mar. 3	1 Camelopardali.	4. 19	6. 0	212. 12					
Apr. 8	Groombridge 1446	8. 22	9. 0	212. 54					
,,	Groombridge 3085	20. 7	9. 15			34. 32			
,,	θ Ursæ Minoris..	15. 36	9. 30						34. 32
May 2	Groombridge 1735	10. 58	11. 30	211. 45					
,,	π Cephei	23. 3	11. 50			33. 6			
,,	Groombridge 1151	6. 16	12. 10					211. 56	
,,	41 Draconis.....	18. 12	12. 30						33. 20
22	Piazzi 0. 283....	0. 59	13. 40				212. 27		
,,	5 Ursæ Minoris..	14. 28	14. 0		33. 41				
Oct. 21	θ Ursæ Minoris..	15. 36	22. 10					211. 20	
Means				212. 4	33. 11	33. 57	212. 44	212. 23	33. 36

OBSERVATIONS OF STARS IN THE YEAR 1840—*continued.*

Day.	Star.	A. R.	Sidereal Time of Observation.	Polar Point for different positions of the Telescope. Star near upper meridian. Telescope E of Pier.	Star near upper meridian. Telescope W of Pier.	Star near lower meridian. Telescope E of Pier.	Star near lower meridian. Telescope W of Pier.	Star nearly 6h W of meridian.	Star nearly 6h E of meridian.
		h m	h m	° ′	° ′	° ′	° ′	° ′	° ′
1840, Nov. 9	Piazzi X. 126 ..	10. 31	22. 45			38. 24			
,,	ρ Cephei	22. 29	23. 15	216. 52					
,,	ψ Draconis	17. 45	23. 31					216. 52	
,,	Piazzi V. 253...	5. 46	23. 45						38. 14
,,	23 Cassiopeiæ...	0. 37	0. 0		38. 42				
,,	7 Draconis	12. 41	0. 17				218. 8		

In the reduction of the observations of double stars, &c., the value is used which corresponds to the position of the telescope, in which each double star, &c., is observed.

OBSERVATIONS FOR THE VALUE OF ONE REVOLUTION OF THE SCREW OF THE DOUBLE-IMAGE MICROMETER.

1839, December 25. Observations by the Astronomer Royal. The preparatory adjustments were made as above described. The two images coincide when the reading of the micrometer is nearly 10^r.

Micrometer set at $5^r{\cdot}000$.

The Mean of six differences of the times of transit of the two images of θ Ursæ Majoris was found to be $9^s{\cdot}43$.

Micrometer set at $15^r{\cdot}000$.

The mean of six differences of the times of transit of the two images was found to be $9^s{\cdot}23$.

Hence 10^r are equivalent to $18^s{\cdot}66$

or, 1^r is ,, ,, $1^s{\cdot}866$

Hence the value of 1^r in arc

$= 1''{\cdot}866 \times 15 \times \text{sine N.P.D.}$

$= 1''{\cdot}866 \times 15 \times \text{sine } 37^\circ.36'.0''$

$= 17''{\cdot}078$

1839, December 28. Observations by the Astronomer Royal. Adjustments as usual.

Micrometer at $5^r{\cdot}000$.

The mean of six differences of the times of transit of the two images of ζ Ursæ Minoris S. P. was found to be $27^s{\cdot}97$.

Micrometer at $15^{r}\cdot000$.

The mean of six differences of the times of transit of the two images was found to be $28^{s}\cdot07$.

Hence 10^{r} are equivalent to $56^{s}\cdot04$

or, 1^{r} is ,, ,, $5^{s}\cdot604$

Hence the value of 1^{r} in arc

$= 5''\cdot604 \times 15 \times$ sine $11^{\circ}.\ 43'.\ 22''$

$= 17''\cdot079$

1839, December 29. Observations by the Astronomer Royal. Adjustments as usual.

Micrometer at $15^{r}\cdot000$.

The mean of five differences of the times of transit of the two images of Groombridge 595 was found to be $57^{s}\cdot40$.

Micrometer at $5^{r}\cdot000$.

The mean of five differences of the times of transit was found to be $57^{s}\cdot20$.

Hence 10^{r} are equivalent to $114^{s}\cdot60$

and 1^{r} is ,, ,, $11^{s}\cdot460$

Therefore 1^{r} in arc

$= 11''\cdot460 \times 15 \times$ sin. N. P. D. of star.

For the N. P. D. of Groombridge 595, the mean N. P. D. for 1810 was taken from Groombridge's Catalogue, and the precession accurately computed by the formula $qt + q't^2$ given in the introduction to that work. The apparent N. P. D. for Dec. 29, 1839, hence results $5^{\circ}.\ 40'.\ 2''$

Hence $1^{r} = 16''\cdot975$

1840, February 25. Observations by Mr. Main. Adjustments as usual.

Micrometer at $5^{r}\cdot000$.

The mean of ten differences of the times of transit of the two images of η Persei was found to be $9^{s}\cdot81$.

Micrometer at $15^{r}\cdot000$.

The mean of ten differences of the times of transit of the two images was found to be $10^{s}\cdot27$.

Hence 10^{r} are equivalent to $20^{s}\cdot08$

or 1^{r} is ,, ,, $2^{s}\cdot008$

Therefore 1^{r} in arc $= 2''\cdot008 \times 15 \times$ sin. N. P. D. of star.

And the N. P. D. being taken from the Greenwich Observations for 1839 and reduced to 1840, the apparent N. P. D. is $34^{\circ}.\ 46'.\ 5''\cdot7$

The value of 1^{r} results $17''\cdot176$.

1840, May 2. Observations by Mr. Main. Adjustments as usual.

Micrometer at $15^{r}\cdot000$.

The mean of ten differences of the times of transit of the two images of 41 Draconis was found to be $32^{s}\cdot93$.

Micrometer at $5^{r}\cdot000$.

The mean of six differences of the times of transit of the two images was found to be $32^{s}\cdot45$.

Hence 10^{r} are equivalent to $65^{s}\cdot38$

and 1^{r} is ,, ,, $6^{s}\cdot538$

Therefore 1^{r} in arc $= 6''\cdot538 \times 15 \times$ sin. N. P. D. of star.

And the Mean N. P. D. for January 1, 1830, being taken from Pond's Catalogue of 1112 stars, and brought up by the precession there given, the apparent N. P. D. for May 2, 1840, is 10°. 1′. 53″·8.

Hence $1^{r} = 17''\cdot083$

1840, November 9. Observations by Mr. Main. Adjustments as usual.

Micrometer at $5^{r}\cdot000$.

The mean of eight differences of the times of transit of the two images of 7 Draconis was found to be $15^{s}\cdot01$.

Micrometer at $15^{r}\cdot000$.

The mean of eight differences of the times of transit of the two images was found to be $14^{s}\cdot76$.

Hence 10^{r} are equivalent to $29^{s}\cdot77$

or, 1^{r} is ,, ,, $2^{s}\cdot977$

Hence 1^{r} in arc $= 2''\cdot977 \times 15 \times$ sin. N. P. D. of star.

The Mean N. P. D. of 7 Draconis for Jan. 1, 1810 is taken from Groombridge's Catalogue, and the precession for bringing it up to 1840 is computed by the formula $q\,t + q'\,t^2$ in the Introduction to that work. The apparent N. P. D. for Nov. 9, 1840, is found to be 22°. 20′. 36″.

Hence $1^{r} = 16''\cdot976$

ABSTRACT OF ALL THE RESULTS OF THE DETERMINATIONS OF THE VALUE OF ONE REVOLUTION OF THE SCREW OF THE DOUBLE-IMAGE MICROMETER.

1839, December	25	....	1^{r} = 17·078″
,, ,,	28	....	1^{r} = 17·079
,, ,,	29	....	1^{r} = 16·975
1840, February	25	....	1^{r} = 17·176
,, May.....	2	....	1^{r} = 17·083
,, November	9	....	1^{r} = 16·976
		6)	367
From the mean of all the observations			1^{r} = 17·061

The value used throughout the year 1840 has been $17''\cdot00$.

The methods of observing the distance and position of the two stars constituting a double star, and the modes of describing them, are as follows:

When the distance of the stars is not very great (for instance, not greater than 15″)

the best of all ways is to turn the eye-piece till the direction of separation coincides with the line joining the two stars, and to separate the images till the distance between the moveable image of the larger star and the fixed image of the smaller star is sensibly the same as the distance between the two stars. The two images then have this appearance.

This observation admits of great accuracy; the fastidiousness of the eye, as regards the tolerance of any error either in distance or in position, is really surprising. This arises from the circumstance that the eye can separately contemplate two equal distances to a bright star on each side of the faint star, or two equal distances to a faint star on each side of the bright star. An error in distance gives one of these appearances,

and an error in position gives this appearance,

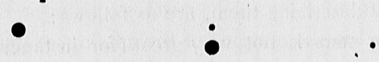
Where the distortion produced by the eye-glasses is sensible, the line of four stars, if it appears curved, is to be made uniformly curved, and the distances, if they appear unequal, are to be made progressively unequal. In this manner an accuracy is obtained scarcely inferior to that obtained when there is no sensible distortion. Then the observations are to be made with the separation of images in the opposite direction, by which the errors in the angular position (to which allusion has been made), and the zero of the micrometer reading, are eliminated from the means of results. This method of observing is described in the observations as the method of *Equal distances*.

When the stars are very distant, for instance 30″, it is found better to use two different methods (both differing from that above) for the observation of position and for that of distance. For position, the images are placed in this form,

and any error in position produces this appearance,

This method is described as *Unequal distances*.

For distance, the images are placed in this form,



and an error in distance produces one of these appearances,

This method is described as *Lozenge.*

When the stars are still more distant, the micrometrical separation is made to such a degree as to place the moveable image of one star midway between the fixed images of the two stars, thus,

The eye cannot judge so well of the accuracy of this observation as of that of the other methods, but it can be applied in cases where the other methods fail entirely. This method is called *Half distance.*

The measure has sometimes been made by causing the moveable image of the small star to coincide with the fixed image of the large star, or *vice versâ.* This is described as *Contact:* it is much inferior in accuracy to all the others.

In all cases, the separation is made alternately on one side and on the other.

In the method of *Equal distances,* the value of the micrometric separation is divided by 2 to obtain the distance of the stars; in the methods of *Lozenge* and *Contact,* it immediately gives the distance; in the method of *Half distance,* it requires to be multiplied by 2.

The mean reading of the position circle being ascertained in each observation, the reading for the Polar point is subtracted from it, and the difference is set down as the angle of position. The position circle has two opposite verniers: but that vernier which is near the micrometer head is always used for the degrees of the angle: and a record being always made as to which star is nearest to the micrometer head, the observation is always reduced as if the micrometer head were placed on the side of the smaller star. It is presumed, therefore, that the results will be sufficiently free from ambiguity. When the stars are sensibly equal, or when the star is triple, the positions of observation are explained in a note.

In the description of the double stars, the following letters are used for specifying the catalogues in which they are to be found.

Sh—Herschel (Sir J.) and South's Catalogue of 380 Double and Triple Stars, Phil. Trans. 1824, part 3.

S—South's Catalogue of 458 Double and Triple Stars, Phil. Trans. 1826, part 1.

Σ—Struve's Catalogus Novus, or Mensuræ Micrometricæ.

h—Herschel's (Sir J.) Catalogues in the Memoirs of the Royal Astronomical Society, volumes V. and VIII. (1833 and 1835).

The numbers are those placed in the margins of the catalogues by the respective observers.

In the three first, they relate to the star: in the last, they relate to the observation by that observer.

The observations of the diameters of planets seem to require no explanation. In the reduction of the observations of Jupiter's diameters, corrections have been applied for the defective illumination of Jupiter, computed thus. The angle made at Jupiter by lines drawn to the Sun and to the Earth (the difference of Jupiter's geocentric and heliocentric longitudes) being ascertained, the correction to the equatoreal diameter is, observed semi-diameter × versine of that angle. The values of this correction on March 3, March 8, and June 10, are respectively $0''\cdot28$, $0''\cdot25$, $0''\cdot16$: those from May 16 to May 25 are insensible. The correction for a diameter inclined at an angle of 45° is one half of that just found, diminished by an insignificant quantity (the boundary of the illuminated part of Jupiter being considered as a semi-ellipse whose poles coincide with the poles of Jupiter).

The diameters thus measured and corrected are compared with those computed from Struve's elements in the Memoirs of the Astronomical Society, vol. III, page 301, namely,

	"
Equatoreal diameter........	38·327
Polar diameter	35·538
The distance of Jupiter being	5·20279

$$\text{Ellipticity} = \frac{38\cdot327 - 35\cdot538}{38\cdot327} = \frac{1}{13\cdot7}$$

The polar and equatoreal diameters at the times of observation are computed from these by the inverse proportion of distance: the diameter inclined at the angle θ to the major axis is computed by the formula,

$$\text{Equatoreal diameter} \times \left\{1 - \frac{1}{13\cdot7}\sin.^2\theta - \frac{3}{2}\cdot\frac{1}{(13\cdot7)^2}\sin.^2\theta\cos.^2\theta\right\}$$

The comparison of results seems to show that Struve's ellipticity is too large.

The measures of Saturn are compared with numbers, deduced by simple alteration in the inverse proportion of distances from Struve's elements in the Mem. Ast. Society, vol. III. page 301, namely,

	"
Major axis of outside of ring	40·095
Major axis of inside of ring	26·668
Major axis of ball	8·995
The distances being supposed to be	9·53877

The diameters of Venus are compared with those given in the Nautical Almanac. The breadth of the illuminated part is compared with that computed from the diameters in the

Nautical Almanac with the values of the illuminated surface given in page 545 of the Nautical Almanac.

In terminating this account of the observations made with the Double-Image Micrometer, I have only to remark further, that the facility of observation and the consequent general accuracy of results, obtained with a double-image instrument of any construction, are so great, that a person who has once used it will scarcely ever again use a measuring instrument made upon any other principle, in cases where this can be applied. The micrometer described here is not expensive. It is constructed by any workman, and it is attached without derangement of the object-glass; in the former circumstance it has an advantage over the double-image micrometers depending on crystalline double refraction: and in the latter it is preferable to the heliometer. Its images, however, are not round or colourless, a defect which it shares with the heliometer, from which the crystalline micrometers are free; and when the distances measured are large it is affected by prismatic dispersion, a fault by which the heliometer only is not affected. The distortion by the eye-glasses produces little mischief: the most serious defect is the loss of light, produced partly by the passage of the light through several lenses, and partly by the unavoidable interruption by the section of the lens (however fine) at a place where the diameter of the pencil of rays is small.

§ 14. *Observations of the Free Magnetic Needle*, page 186 to 190.

For a general description of the magnetic observatory and the theodolite and magnet used in these observations, I refer to the Introduction to the volume for 1839.

The absolute readings are subject to the possible error produced by the magnetic properties of one of the copper bars (adverted to in the Introduction 1839, page liii, line 14), for February and May only. On July 25, the suspected bar was removed, and the other bar, which appears to be free from magnetic action, has alone been used since that time. There is no risk of the introduction of error in these observations from any torsion of the suspending skein.

The micrometer reading $100^{r}\cdot056$ was used for the line of collimation of the theodolite, for February and May. On July 30, the line of collimation appeared to be $100^{r}\cdot106$, and this value is used for August and November. One revolution = $1'.34''\cdot07$ (Introduction 1839, page lvii, line 1).

The error of level produced by inequality of pivots is assumed = $1^{p}\cdot66$ as in the Introduction 1839, page liv.

The observations and reductions for the theodolite-reading corresponding to the astronomical meridian, are made in the same manner as in 1839: the following tabular statement contains the whole operation.

Observations with the Magnetic Theodolite, for ascertaining the Reading of its Horizontal Circle corresponding to the Astronomical Meridian.

Day, 1840.	Object.	Reading of Micrometer Wire.	Reading of Circle Verniers. A	B	C	Mean.	Clock Time.	Sidereal Time.	A. R. of Object.	N. P. D. of Object.	Correction to Meridian in Azimuth.	Resulting Reading for North Meridian.	Mean.	W. end of Level High.	Corresponding Correction.	Corrected Reading for North Meridian.	Observer.
		r	° ′ ″	″	″	° ′ ″	h m s	h m s	h m s	° ′ ″	° ′ ″	° ′ ″	° ′ ″	″	″	° ′ ″	
Feb. 24	δ Ursæ Min. S.P.	100·056	89. 54. 80	42	50	89. 54. 57·33	6. 25. 34	6. 27. 15	18. 23. 38	3. 24. 56	− 4. 51·0	89. 50. 6·3					M
			89. 59. 55	15	20	89. 59. 30·00	6. 28. 45	6. 30. 26			− 9. 6·7	89. 50. 23·3					M
			90. 6. 75	40	47	90. 6. 54·00	6. 34. 29	6. 36. 10			− 16. 46·1	89. 50. 7·9					M
			90. 11. 38	5	0	90. 11. 14·33	6. 37. 42	6. 39. 23			− 21. 3·2	89. 50. 11·1	89. 50. 12·5	0·0	0·0	89. 50. 12·5	M
			90. 15. 40	0	2	90. 15. 14·00	6. 40. 41	6. 42. 22			− 25. 1·7	89. 50. 12·3					M
			90. 19. 58	20	28	90. 19. 35·33	6. 43. 58	6. 45. 39			− 29. 24·2	89. 50. 11·1					M
			90. 24. 77	45	45	90. 24. 55·67	6. 47. 56	6. 49. 37			− 34. 40·9	89. 50. 14·8					M
			90. 29. 100	60	55	90. 30. 11·67	6. 51. 55	6. 53. 36			− 39. 58·5	89. 50. 13·2					M
May 25	Polaris... S. P.	100·056	89. 49. 75	47	52	89. 49. 58·0	13. 1. 21	13. 1. 47	1. 1. 30	1. 32. 41	− 0. 10·7	89. 49. 47·3					M
			89. 52. 55	25	25	89. 52. 35·0	13. 5. 24	13. 5. 50			− 2. 43·3	89. 49. 51·7					M
			89. 54. 70	33	35	89. 54. 46·0	13. 8. 42	13. 9. 8			− 4. 48·4	89. 49. 57·6					M
			89. 56. 92	55	60	89. 57. 9·0	13. 12. 20	13. 12. 46			− 7. 4·4	89. 50. 4·6	89. 49. 56·6	+ 4·7	+ 5·6	89. 50. 2·2	M
			89. 58. 102	57	60	89. 59. 13·0	13. 15. 43	13. 16. 9			− 9. 11·8	89. 50. 1·2					M
			90. 0. 90	60	55	90. 1. 8·3	13. 18. 43	13. 19. 9			− 11. 4·1	89. 50. 4·2					M
			90. 2. 75	40	42	90. 2. 52·3	13. 21. 45	13. 22·11			− 12. 58·7	89. 49. 53·6					M
			90. 4. 75	35	32	90. 4. 47·3	13. 24. 50	13. 25. 16			− 14. 54·4	89. 49. 52·9					M
Aug. 24	δ Ursæ Minoris	100·106	89. 51. 40	10	0	89. 51. 16·7	18. 23. 10	18. 22. 57	18. 23. 52	3. 24. 20	− 1. 25·3	89. 49. 51·4					G
			89. 45. 90	50	35	89. 45. 58·3	18. 26. 33	18. 26. 20			+ 3. 49·5	89. 49. 47·8					G
			89. 42. 75	36	17	89. 42. 42·7	18. 28. 46	18. 28. 33			+ 7. 15·7	89. 49. 58·4					G
			89. 37. 90	55	40	89. 38. 1·7	18. 31. 54	18. 31. 41			+ 12. 6·8	89. 50. 8·5					G
			89. 33. 98	60	50	89. 34. 9·3	18. 34. 25	18. 34. 12			+ 16. 0·4	89. 50. 9·7					G
			89. 29. 88	40	40	89. 29. 56·0	18. 37. 1	18. 36. 48			+ 20. 1·4	89. 49. 57·4	89. 50. 4·0	+ 16·5	+ 24·7	89. 50. 28·7	G
			89. 21. 90	50	40	89. 22. 0·0	18. 42. 20	18. 42. 7			+ 28. 13·8	89. 50. 13·8					G
			89. 17. 94	60	55	89. 18. 9·7	18. 44. 45	18. 44. 32			+ 31. 57·5	89. 50. 7·2					G
			89. 13. 85	55	50	89. 14. 3·3	18. 47. 27	18. 47. 14			+ 35. 53·1	89. 49. 56·4					G
			89. 3. 105	65	57	89. 4. 15·7	18. 53. 55	18. 53. 42			+ 46. 2·6	89. 50. 18·3					G
			88. 57. 90	55	45	88. 58. 3·3	18. 57. 56	18. 57. 43			+ 52. 11·3	89. 50. 14·6					G
Aug. 26	δ Ursæ Minoris	100·106	89. 22. 40	5	12	88. 22. 19·0	19. 21. 44	19. 21. 32·5	18. 23. 51	3. 24. 21	+ 1. 28. 11·1	89. 50. 30·1					W R
			89. 13. 87	50	60	88. 14. 5·7	19. 27. 23	19. 27. 11·5			+ 1. 36. 33·6	89. 50. 39·3					W R
			88. 1. 64	30	36	88. 1. 43·3	19. 35. 46	19. 35. 34·5			+ 1. 48. 50·8	89. 50. 34·3					W R
			87. 54. 55	17	30	87. 54. 34·0	19. 40. 48	19. 40. 36·5			+ 1. 56. 8·0	89. 50. 42·0					W R
			87. 43. 80	52	60	87. 44. 4·0	19. 48. 3	19. 47. 51·5			+ 2. 6. 30·3	89. 50. 34·3	89. 50. 32·7	− 3·5	− 5·3	89. 50. 27·4	W R
			87. 29. 65	35	45	37. 29. 48·3	19. 58. 12	19. 58. 0·5			+ 2. 20. 46·4	89. 50. 34·7					W R
			87. 22. 72	42	45	87. 22. 53·0	20. 3. 9	20. 2. 57·5			+ 2. 27. 36·1	89. 50. 29·1					W R
			87. 12. 32	0	7	87. 12. 13·0	20. 10. 58	20. 10. 46·5			+ 2. 38. 13·0	89. 50. 26·0					W R
			87. 7. 64	34	47	87. 7. 48·3	20. 14. 17	20. 14. 5·5			+ 2. 42. 39·5	89. 50. 27·8					W R
			87. 2. 58	20	33	87. 2. 37·0	20. 18. 13	20. 18. 1·5			+ 2. 47. 51·7	89. 50. 28·7					W R
Nov. 21	Polaris.......	100·106	89. 56. 92	40	63	89. 57. 5·00	0. 54. 17	0. 55. 0	1. 2. 46	1. 32. 1	− 0. 5. 10·82	89. 51. 54·18					G
			89. 55. 35	0	5	89. 55. 13·33	0. 57. 29	0. 58. 12			− 0. 3. 2·79	89. 52. 10·54					G
			89. 53. 75	30	38	89. 53. 47·67	0. 58. 33	0. 59. 19			− 0. 2. 18·27	89. 51. 29·40					G
			89. 53. 45	0	10	89. 53. 18·33	0. 59. 51	1. 0. 37			− 0. 1. 27·02	89. 51. 51·31	89. 51. 50·3	− 1·3	− 1·9	89. 51. 48·4	G
			89. 52. 60	12	25	89. 52. 32·33	1. 1. 4	1. 1. 50			− 0. 0. 37·77	89. 51. 54·56					G
			89. 51. 60	23	30	89. 51. 37·67	1. 2. 28	1. 3. 14			+ 0. 0. 18·67	39. 51. 56·34					G
			89. 50. 40	10	10	89. 50. 20·00	1. 3. 57	1. 4. 43			+ 0. 1. 18·05	89. 51. 38·05					J H
			89. 48. 92	67	58	89. 49. 12·33	1. 5. 54	1. 6. 40			+ 0. 2. 36·03	89. 51. 48·36					J H

August 26. In the five first observations the Micrometer head was to the left: the others were made with the telescope in the reversed position. The telescope was levelled in both positions, and the mean error applied.

The time of vibration of the magnet is considered to be 30^s, no reason having appeared for departing from the determination obtained in 1839.

The error of collimation of the magnet was determined on November 4 (by observations similar to those in the Introduction 1839, page lviii) to be $4'.9''\cdot37$, with the same sign as in 1839. Accordingly, for the November observations, $+ 4'.9''\cdot37$ is applied as correction (the collimator being then West). The correction $- 8''\cdot75$ is applied for the error produced by the plate glass, as determined in 1839.

The method of observation is the same as in 1839, in all respects but this, that in 1840 the multiple of 5^s nearest to the Greenwich mean time corresponding to the Göttingen time of observation was taken, and the first observation of the magnet was made 45^s before this time.

The results for November are completely corrected; those for the preceding terms are nearly subject to the same remarks as those of 1839 (Introduction, page lx, line 5), except that the August observations are made without the copper bar which appeared to exercise a magnetic action.

§ 15. *Meteorological Observations made on the Days of the Equinoxes and Solstices,* page 192 to 195.

These observations were made in conformity with a recommendation of Sir John Herschel, extensively circulated in this country. The observations are given without any correction.

In the observations made at the Spring Equinox, the Summer Solstice, and the Autumnal Equinox, the barometer and thermometer of the Circle Room were used. In the observations made at the Winter Solstice, a large barometer carefully constructed by Newman (mounted in the Magnetic Observatory), and a thermometer, by Watkins and Hill, which agreed with Simms's standard, were employed.

As a general remark, applying to every class of observation above mentioned, I may state that the original entries of observations are in all cases preserved. The greater part of the regular observations are entered in small memorandum books, in which the entries are written with a metallic pencil, whose marks are not easily effaced: but some observations are written down at once with ink in the skeleton forms in which the calculations are to be made, or in the copy which is sent to the press. All, however, are preserved. The proof sheets are read with the first skeleton form in which the observations are entered (and in which, in fact, the examination for accidental errors, &c., is made).

The Board of Visitors of the Royal Observatory, being desirous that the system of calculations employed there should be published as far as possible, have directed that copies of the principal skeleton forms used in the computations should be attached to some of the volumes of observations. In the present volume, the following forms are accordingly attached:

Form No. 1.—Transits.
2.—Calculations for completing imperfect transits.
5.—Calculations for azimuthal error of the transit.
8.—Errors and Rates of the Transit Clock.
9.—Small-Star Corrections in A. R.
10.—Calculation of Mean Time.
17.—Small corrections for observations with Mural Circle.
18.—Observations with Mural Circle.
20.—Adjustments of Mural Circle.
23.—Zenith points for Mural Circle.
26.—Small-Star Corrections in N. P. D.
30.—Interpolations with Differences to the second order.
33.—Weekly arrangement of Observers.

Of the forms omitted, the following is the description:

Form No. 3.—Collimation of Transit (similar to No. 5).
4.—Levelling of Transits.
6.—Tabular A. R. of Nautical Almanac Stars.
7.—Tabular A. R. of Polaris and δ Ursæ Minoris.
11.—Adjustments of Transit (similar to No. 5).
12.—Collection of separate results for A. R. (as in page [136] &c., of the present volume).
13.—Results for Planets (as in page 17, &c., of the present volume).
14.—Copy of Transits for Press.
15.—Approximate reduction for Transits and comparison of clocks (for rating of chronometers, dropping the signal ball, &c.).
16 and 19.—Similar to 17 and 18, used when two circles were employed.
21.—Similar to 20.
22.—Difference between readings of two Circles.
24.—Computations of Moon's parallax.
25.—Corrections of Nautical Almanac stars in N. P. D. (nearly similar to 6).
27, 28, and 48.—Copies of Circle Observations for Press.
29.—Collection of separate results for N. P. D. (nearly similar to 12).
31.—Calculation of Occultations.
32.—Working Catalogues.
34, 35, 40, 41, 42, 43, 44, 47.—Forms for the transaction of business relating to Chronometers.
36, 37, 38.—Forms relating to Accounts and to admission of Visitors.
39.—Calculation of cusps in Solar Eclipse.
45.—Daily Report of Observations (made by the First Assistant, and addressed to the Astronomer Royal).
46.—Weekly or Occasional Report of the state of Calculations, giving the state to which the computations are advanced in every important stage of each of the Forms (made by the First Assistant, and addressed to the Astronomer Royal).
49, 50, 51, 52, 53, 54, 55, 56, 57.—Forms of various kinds connected with the Magnetical and Meteorological Observations.

Specimens of the most important of these forms will be given with a subsequent volume.

Royal Observatory, Greenwich,
1842, *April* 12.

G. B. AIRY.