GREENWICH OBSERVATIONS,

1839.

INTRODUCTION.

I. *Personal Establishment and Arrangements.*

THE establishment of Assistants, and the division of the labours of the Observatory among them, remain in all respects in the same state as in the year 1836. I refer therefore to the statement in the Introduction to the volume for 1836 for the account of these particulars.

II. *Instruments.*

No addition of important instruments has been made in the year 1839.

Complaints of inconvenience, occasioned by the faulty divisions and ill-shaped pivot of the Mural Circle, in the Royal Observatory of the Cape of Good Hope, having long been made, and it being remarked that the dimensions of the circle were precisely the same as those of Jones's Circle at the Royal Observatory of Greenwich, it was suggested that, without prejudice to the activity of Greenwich Observatory, Jones's Circle might be sent to the Cape of Good Hope, while the Cape Circle should be sent to England for examination and repair. Accordingly, with the sanction of the Board of Admiralty, at the end of February, 1839, Jones's Circle was taken down, and sent to the Cape. The Cape Circle has, since that time, been received in England.

III. *Subjects of Observation in the Year* 1839.

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, in continuation of the observations of the preceding year. They embrace the following objects:—stars for the extension of the Astronomical Society's Catalogue, indicated by Mr. Baily; stars whose occultations by the Moon had been observed, or which had been compared by means of the Equatoreal with planets and comets; stars which had been observed with Ramsden's Zenith Sector in the Trigonometrical Survey of England; and stars observed at the request of Mr. Sheepshanks. 61 Cygni has been observed on every practicable occasion.

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

The Equatoreals have been employed in comparing Mars and Galle's Comet with neighbouring stars, and in taking transits of the Moon for comparison of her diameter with that given by Burckhardt's Tables.

IV. *Explanation of the Printed Observations.*

§ 1. *Transits as observed, and calculation of Apparent Right Ascensions,* page [2] to [109].

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 on 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: and it does not appear that ϵ Bootis is usually seen double.

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 observations perfect). The corrections which must be applied to the transit at each wire, in order to obtain the mean of the seven wires, are as follows:

For an equatoreal star.

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

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

	m s		s
A	+23. 32·80	+ n ×	0·254
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''.

	m s		s
A	+10. 44·07	+ n ×	0·052
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.

Their 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 1839.

Jan. 5, 0^{h}. Observations by Mr. Main. The day tolerably fine.

Illuminated end West.	r
Micrometer reading on coincidence with collimator (5 measures)	10·864
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	9·429
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)	11·710
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	8·556

Illuminated end West.	r
Micrometer reading on coincidence with collimator (6 measures)	11·857
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	8·433
Hence reading for true line of collimation by 1st and 2nd Sets	10·147
,, ,, by 3rd and 4th Sets	10·133
,, ,, by 5th and 6th Sets	10·145
Reading for true line of collimation	10·142
Micrometer reading on coincidence with *D* (10 measures)	10·162
Hence apparent error of collimation for *D*	0·020

The illuminated end of the axis is left West, the micrometer head is therefore West: and the micrometer readings increase as the wire is moved from the illuminated end or from the West. Hence the line of collimation is West of D, and equatoreal stars pass D after passing the line of collimation, or the correction required to the transit over D is negative, and the error of collimation of D is — $0^{r}\cdot020$ = — $0''\cdot33$. And as stars pass the mean of the wires (illuminated end West) earlier than they pass D, by the time of describing $0''\cdot69$, the quantity + $0''\cdot69$ must be applied to the above for the mean of the wires. Finally — $0''\cdot19$ is to be applied for diurnal aberration. The error of collimation to be used thus becomes + $0''\cdot17$.

May 19, 22^{h}. Observations by Mr. Main. The day gloomy and calm.

Illuminated end West.	r
Micrometer reading on coincidence with collimator (6 measures)	8·383
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	11·892
Illuminated end West.	
Micrometer reading on coincidence with collimator (10 measures)	8·464
Illuminated end East.	
Micrometer reading on coincidence with collimator (10 measures)	11·895
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)	8·473
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	11·866
Hence reading for true line of collimation by 1st and 2nd Sets	10·138
,, ,, by 3rd and 4th Sets	10·230
,, ,, by 5th and 6th Sets	10·170
Reading for true line of collimation	10·179
Micrometer reading on coincidence with *D* (10 measures)	10·159
Hence apparent error of collimation for *D*	0·020

The error of collimation of D appears to be + 0″·33: which, corrected for relative position of wires and for diurnal aberration, gives + 0″·83 for the error of collimation to be used for the mean of the wires.

September 22, 23^h. Observations by Mr. Main. The morning cold and foggy.

Illuminated end West.	*r*
Micrometer reading on coincidence with collimator (6 measures)...........	**9·315**
Illuminated end East.	
Micrometer reading on coincidence with collimator (5 measures)...........	**10·998**
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)...........	**9·287**
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)	**10·994**
Illuminated end West.	
Micrometer reading on coincidence with collimator (6 measures)...........	**9·271**
Illuminated end East.	
Micrometer reading on coincidence with collimator (6 measures)...........	**10·987**
Hence reading for true line of collimation by 1st and 2nd Sets................	**10·157**
,, ,, by 3rd and 4th Sets................	**10·141**
,, ,, by 5th and 6th Sets................	**10·129**
Reading for true line of collimation	**10·142**
Micrometer reading on coincidence with *D* (10 measures).................	**10·152**
Hence apparent error of collimation for *D*.............................	**0·010**

The error of collimation of D therefore appears to be — 0″·16: which, corrected as before, gives for the error of collimation to be used for the mean of wires + 0″·34.

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. 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 to the transits is,

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

On January 5, Mr. Main carefully examined the pivots of the Transit, and remarked as follows:—On the eastern pivot (opposite to the illuminated end) there are two slight grooves parallel to the axis of the pivot, of no importance whatever. There are also two spots on each pivot, having the appearance of rust: one on the eastern pivot corresponds to one on the western pivot, and at both these places there are marks of rubbing in the direction of the axis. There was no inequality sensible to the most delicate touch.

For examination of the roundness of the pivots, the level was placed upon them, and the following observations were made:—

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	132·0	117·0	N.	° 0	130·3	116·8
	5	132·2	116·9		10	130·3	116·5
	10	131·9	117·2		20	130·2	116·5
	15	131·9	117·2		30	130·2	116·5
	20	131·7	117·2		40	130·2	116·5
	25	131·4	117·5		50	130·0	116·5
	30	131·4	117·3		60	129·7	116·4
	35	131·4	117·2		—10	129·4	116·5
	40	131·3	117·0		—20	129·7	116·2
	45	131·5	117·0		—30	129·7	116·1
	55	131·4	117·0		—40	129·5	116·1
	65	131·3	117·0		—50	129·5	116·0
	—10	130·8	117·0		—60	129·7	116·0
	—20	131·0	116·7				
	—30	131·0	116·8				
	—40	131·1	116·6				
	—50	130·7	116·6				
	—60	130·3	116·6				
	—70	130·2	116·7				

These observations 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,

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

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

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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 1839, 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, 1839.	Correction to N. A.	Star's Name.	Assumed Mean A.R. Jan. 1, 1839.	Correction to N. A.
	h m s	s		h m s	s
α Andromedæ....	0. 0. 4·74	+ 0·09	β Corvi..........	12. 25. 56·54	− 0·03
γ Pegasi.........	0. 4. 57·13	− 0·11	Spica...........	13. 16. 43·16	− 0·05
β Ceti..........	0. 35. 30·31	− 0·03	η Bootis.........	13. 47. 1·17	− 0·12
θ Ceti..........	1. 15. 58·66	− 0·15	Arcturus.........	14. 8. 19·22	− 0·01
α Arietis.........	1. 58. 6·75	+ 0·15	ε Bootis..........	14. 37. 57·38	0·00
γ Ceti..........	2. 34. 57·91	− 0·17	α Libræ..........	14. 41. 59·00	− 0·14
α Ceti..........	2. 53. 52·21	− 0·01	β Libræ..........	15. 8. 21·06	− 0·14
η Tauri..........	3. 37. 55·61	+ 0·11	α Coronæ Borealis.	15. 27. 52·39	+ 0·05
γ Eridani........	3. 50. 31·23	+ 0·01	α Serpentis........	15. 36. 20·52	+ 0·02
Aldebaran.......	4. 26. 41·45	+ 0·10	β^1 Scorpii........	15. 56. 5·10	− 0·11
Rigel...........	5. 6. 48·21	0·00	δ Ophiuchi.......	16. 5. 54·86	− 0·04
β Tauri..........	5. 16. 7·22	+ 0·04	Antares..........	16. 19. 32·78	− 0·05
δ Orionis.........	5. 23. 47·04	− 0·07	α Herculis.......	17. 7. 18·54	− 0·02
α Leporis........	5. 25. 37·92	0·00	α Ophiuchi.......	17. 27. 27·82	+ 0·03
ε Orionis.........	5. 28. 2·79	− 0·03	μ Sagittarii.......	18. 4. 8·15	− 0·16
α Columbæ.......	5. 33. 49·24	− 0·11	α Lyræ..........	18. 31. 29·25	+ 0·08
α Orionis........	5. 46. 27·47	0·00	β Lyræ..........	18. 44. 8·21	− 0·07
μ Geminorum.....	6. 13. 13·17	− 0·02	ζ Aquilæ.........	18. 58. 0·66	− 0·03
Sirius..........	6. 38. 3·31	+ 0·20	δ Aquilæ.........	19. 17. 22·81	+ 0·12
ε Canis Majoris...	6. 52. 18·03	0·00	γ Aquilæ.........	19. 38. 36·31	− 0·05
δ Geminorum.....	7. 10. 30·15	− 0·08	α Aquilæ.........	19. 42. 55·66	− 0·03
Castor..........	7. 24. 19·12	− 0·09	β Aquilæ.........	19. 47. 24·26	− 0·07
Procyon.........	7. 30. 52·20	− 0·18	α^2 Capricorni.....	20. 9. 6·99	− 0·02
Pollux..........	7. 35. 27·36	− 0·03	ζ Cygni..........	21. 6. 5·24	− 0·04
15 Argûs.........	8. 0. 41·40	− 0·03	β Aquarii........	21. 23. 4·73	− 0·02
ε Hydræ.........	8. 38. 14·76	− 0·18	ε Pegasi.........	21. 36. 16·76	− 0·02
α Hydræ.........	9. 19. 40·52	− 0·10	α Aquarii........	21. 57. 30·78	− 0·06
ε Leonis.........	9. 36. 42·06	− 0·11	ζ Pegasi.........	22. 33. 26·04	+ 0·02
Regulus.........	9. 59. 47·54	− 0·17	Fomalhaut.......	22. 48. 44·34	− 0·02
δ Leonis.........	11. 5. 32·22	+ 0·08	α Pegasi.........	22. 56. 44·76	− 0·01
δ Crateris........	11. 11. 17·72	− 0·10	ι Piscium........	23. 31. 40·28	+ 0·07
β Leonis.........	11. 40. 50·59	− 0·05			

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. In only two instances, occurring on July 9 and July 10, are the observations of clock-stars by one observer grouped with those of clock-stars 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 $0^s{\cdot}36$. The quantity $0^s{\cdot}36$ 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 $-\ 0^s{\cdot}36$ must be applied: if the clock-stars are observed by Mr. Henry and the object by Mr. Ellis, $+\ 0^s{\cdot}36$ must be applied. These quantities are *not* applied in the column of *Apparent Right Ascension from the Observations* in this Section.

In the Introduction, 1838, observations were exhibited which showed the difference between the clock-errors given by Mr. Henry and Mr. Ellis to be about $0^s{\cdot}36$, and that between the clock-errors given by Mr. Main and Mr. Henry to be inconsiderable. The following observations, made in 1839, confirm this; and also show that the observations of Mr. Glaisher agree with those of Mr. Main and Mr. Henry.

Observations of the personal equation between Mr. Main and Mr. Glaisher.

DAY, 1839.	Interval of nearest Stars.	Order of Observations.	Clock slow at 0^h by M.	Clock slow at 0^h by G.	G. — M.
	h		s	s	s
Sep..... 15 to 17	52	G. M.	25·71	25·70	— 0·01
Dec.... 27 to 28	9	M. G.	17·09	17·08	— 0·01
28 to 29	23	G. M.	18·90	18·88	— 0·02

Observations for the personal equation between Mr. Ellis and Mr. Glaisher.

DAY, 1839.	Interval of nearest Stars.	Order of Observations.	Clock slow at 0^h by E.	Clock slow at 0^h by G.	E. — G.
	h		s	s	s
Sep..... 12 to 13	14	E. G.	21·32	20·93	+0. 39
Nov.... 29 to 30	23	G. E.	32·64	32·31	+0·33

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 it 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 1st January, 1839. 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

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

or

$$\frac{\mathrm{A}}{15}\cos.\ \mathrm{A.R.}\ \mathrm{cosec.\ N.P.D.} + \frac{\mathrm{B}}{15}\sin.\ \mathrm{A.R.}\ \mathrm{cosec.\ N.P.D.} + \mathrm{C.}\ \sin.\ \mathrm{A.R.}\ \mathrm{cotan.\ N.P.D.} \times$$

$$\mathrm{n^o.\ log.}\ 0{\cdot}1259 + \frac{\mathrm{D}}{15}\cos.\ \mathrm{A.R.}\ \mathrm{cotan.\ N.P.D.} + \mathrm{C.} \times \mathrm{n^o.\ log.}\ 0{\cdot}4869,$$

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 Mean Right Ascensions of Stars observed in the Year* 1839.

The apparent right ascensions of Polaris 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.

The places 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.

§ 3. *Observations with the two Mural Circles, from January* 1 *to February* 24, 1839, *page* (2) *to* (19).

It has been already stated, that Jones's Circle was removed (in order to be sent to the Cape of Good Hope) near the end of the month of February. The observations with the Circles are in consequence divided into two groups: one antecedent to that time, during which the two circles were used in combination, and the other following that time, during which Troughton's Circle was used alone.

The position of Troughton's Circle through the year, and that of Jones's Circle while it was used, as to the approximate coincidence of the curve described by its telescope with the astronomical meridian, has been verified by transits of different stars, as noted by the clock which is near the circles. 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. For convenience, the transits observed with the telescope of Troughton's Circle throughout the year are included in the first table.

TRANSITS FOR THE POSITION OF TROUGHTON'S CIRCLE,
Throughout the Year 1839.

DAY, 1839.	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.. 2	α Cygni	20. 35. 49·00	20. 35. 41·20	20. 35. 56·65	54·75	+ 1·90
,,	δ Ophiuchi	16. 5. 40·35	16. 5. 37·95	16. 5. 54·11	53·91	+ 0·20
4	α Aquilæ	19. 42. 31·60	19. 42. 37·60	19. 42. 53·80	54·40	— 0·60
5	α Aquilæ	19. 42. 23·50	19. 42. 38·20	19. 42. 55·20	54·41	+ 0·79
7	α Herculis	17. 6. 23·05	17. 7. 0·05	17. 7. 17·66	17·50	+ 0·16
,,	α Ophiuchi	17. 26. 32·05	17. 27. 9·05	17. 27. 26·67	26·67	0·00
8	α Aquilæ	19. 41. 58·98	19. 42. 35·98	19. 42. 53·63	54·44	— 0·81
April.... 10	ε Hydræ	8. 37. 24·52	8. 37. 57·72	8. 38. 16·32	16·30	+ 0·02
,,	δ Crateris	11. 10. 26·88	11. 11. 0·68	11. 11. 19·38	19·62	— 0·24
,,	ζ Pegasi	22. 32. 30·63	22. 33. 7·23	22. 33. 26·79	25·88	+ 0·91
,,	α Andromedæ	23. 59. 9·15	23. 59. 45·65	0. 0. 5·27	3·89	+ 1·38
May..... 18	Aldebaran	4. 26. 13·65	4. 26. 0·15	4. 26. 41·69	41·29	+ 0·40
,,	Rigel	5. 6. 20·05	5. 6. 6·55	5. 6. 48·10	48·12	— 0·02
,,	β Tauri	5. 15. 40·40	5. 15. 26·90	5. 16. 8·46	7·22	+ 1·24
,,	δ Orionis	5. 23. 19·00	5. 23. 5·50	5. 23. 47·06	47·12	— 0·06
June..... 19	Aldebaran	4. 27. 56·62	4. 25. 27·32	4. 26. 42·74	41·76	+ 0·98
20	Sirius	6. 39. 18·48	6. 36. 47·28	6. 38. 2·86	3·08	— 0·22
,,	Pollux	7. 36. 45·23	7. 34. 13·43	7. 35. 29·07	28·04	+ 1·03
July..... 16	Rigel	5. 7. 48·07	5. 6. 31·07	5. 6. 47·60	48·93	— 1·33
,,	β Tauri	5. 17. 9·05	5. 15. 52·05	5. 16. 8·59	8·20	+ 0·39
,,	δ Orionis	5. 24. 47·65	5. 23. 30·65	5. 23. 47·19	47·88	— 0·69
,,	ε Orionis	5. 29. 3·13	5. 27. 46·13	5. 28. 2·68	3·57	— 0·89
September 17	Regulus	9. 58. 55·35	9. 59. 20·65	9. 59. 48·37	49·25	— 0·88
26	γ^1 Leonis	10. 10. 32·82	10. 10. 27·02	10. 11. 6·60	7·08	— 0·48

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

DAY, 1839.		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..	15	β Leonis........	11. 40. 48·98	11. 40. 45·88	11. 40. 51·71	52·31	— 0·60
	27	β Leonis........	11. 40. 55·50	11. 40. 28·20	11. 40. 52·02	52·56	— 0·54
November	24	α Coronæ Borealis	15. 28. 7·52	15. 27. 29·12	15. 27. 53·90	53·54	+ 0·36
	29	Arcturus........	14. 8. 20·30	14. 7. 48.50	14. 8. 20·15	21·01	— 0·86
	,,	ε Bootis........	14. 37. 58·60	14. 37. 26·90	14. 37. 58·58	58·91	— 0·33
December	3	ε Bootis........	14. 37. 46·40	14. 37. 20·40	14. 37. 58·13	59·00	— 0·87
	,,	α Coronæ Borealis	15. 27. 40·95	15. 27. 14·85	15. 27. 52.65	53·67	— 1·02
	13	α Coronæ Borealis	15. 27. 14·73	15. 26. 58·43	15. 27. 53.58	53·86	— 0·28
	,,	α Herculis.......	17. 6. 40·25	17. 6. 24·05	17. 7. 19·31	20·09	— 0·78
	16	α Coronæ Borealis	15. 27. 6·60	15. 26. 53·80	15. 27. 53·41	53·93	— 0·52
	20	β Libræ.........	15. 7. 24·63	15. 8. 15·53	15. 8. 21·87	23·60	— 1·73
	,,	α Serpentis......	15. 35. 24·25	15. 36. 15·05	15. 36. 21·41	22·60	— 1·19
	,,	α Ophiuchi.......	17. 26. 31·00	17. 27. 21·70	17. 27. 28·15	29·43	— 1·28
	22	α Coronæ Borealis	15. 26. 49·85	15. 27. 43·65	15. 27. 52·69	54·08	— 1·39

TRANSITS FOR THE POSITION OF JONES'S CIRCLE,
To February 24, 1839.

DAY, 1839.		Object.	Transit by Graham 2.	Transit by Hardy.	Sidereal Time.	Sec. of A.R.	Error.
January..	2	δ Ophiuchi.......	16. 5. 42·03	16. 5. 39·63	16. 5. 55·79	53·91	+ 1·88
	,,	α Herculis.......	17. 7. 5·37	17. 7. 3·37	17. 7. 19·55	17·38	+ 2·17
	4	α Aquilæ........	19. 42. 33·67	19. 42. 39·67	19. 42. 55·87	54·40	+ 1·47
	,,	α Lyræ..........	18. 30. 59·30	18. 31. 13·60	18. 31. 30·58	27·46	+ 3·12
	7	α Herculis.......	17. 6. 23·00	17. 7. 0·00	17. 7. 17·61	17·50	+ 0·11
	,,	α Ophiuchi......	17. 26. 32·17	17. 27. 9·17	17. 27. 26·79	26·67	+ 0·12
	8	α Aquilæ........	19. 41. 59·20	19. 42. 36·20	19. 42. 53·85	54·44	— 0·59

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.). 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 $\frac{A,\ C,\ E}{B,\ D,\ F}$: 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 observation 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: including (as before) the examination of Troughton's Circle throughout 1839.

ERRORS OF EACH MICROSCOPE OF TROUGHTON's CIRCLE, FOR A READING OF 5', THROUGHOUT THE YEAR 1839.

Day, 1839.	Pointer Reading.	MICROSCOPES						Sum.
		A	B	C	D	E	F	
	°	″	″	″	″	″	″	″
January 7	200	− 0·8	+ 0·7	+ 2·4	− 2·3	+ 1·0	− 0·2	+ 0·8
,,	320	− 0·8	+ 2·2	+ 1·1	− 2·0	+ 0·9	+ 0·5	+ 1·9
,,	80	+ 1·0	+ 1·3	0·0	− 2·7	− 0·3	− 0·1	− 0·8
14	200	+ 0·7	+ 0·4	+ 1·5	− 1·2	+ 0·6	+ 0·1	+ 2·1
,,	320	+ 0·1	+ 2·4	− 0·4	+ 1·7	+ 1·1	+ 0·5	+ 5·4
,,	80	+ 1·8	+ 1·0	+ 1·0	− 1·0	− 0·5	− 0·2	+ 2·1
21	205	+ 1·7	+ 2·0	+ 1·7	− 0·5	+ 0·9	+ 0·2	+ 6·0
,,	325	+ 1·6	+ 0·8	+ 2·0	− 0·3	− 0·3	+ 1·0	+ 4·8
,,	85	+ 1·0	+ 1·3	+ 2·2	− 0·4	+ 0·7	+ 2·0	+ 6·8
28	10	+ 1·0	+ 1·5	+ 0·3	− 2·1	+ 0·7	− 0·9	+ 0·5
,,	130	− 0·4	+ 2·7	+ 0·4	− 0·5	− 2·3	+ 0·2	+ 0·1
,,	250	− 0·8	+ 1·4	+ 0·8	− 1·6	− 0·4	− 0·3	− 0·9
February 4	0	+ 0·4	+ 0·2	+ 1·1	− 0·4	− 0·7	− 0·1	+ 0·5
,,	120	− 0·2	+ 1·7	− 0·2	+ 0·1	− 0·2	+ 1·5	+ 2·7
,,	240	+ 0·7	− 0·1	+ 1·5	+ 1·5	− 0·6	+ 0·8	+ 3·8
11	200	0·0	+ 0·5	+ 0·9	− 2·3	+ 0·5	+ 0·2	− 0·2
,,	320	− 0·1	+ 3·2	+ 1·2	− 0·7	+ 1·1	+ 0·5	+ 5·2
,,	80	− 0·8	+ 0·2	+ 0·2	− 1·9	− 2·0	− 0·6	− 4·9
18	140	− 1·6	+ 2·0	+ 2·1	+ 0·2	+ 0·6	+ 1·8	+ 5·1
,,	260	+ 1·4	+ 0·4	− 0·2	− 1·2	− 1·5	− 1·8	− 2·9
,,	20	− 1·6	− 0·9	+ 0·3	− 0·4	− 0·8	+ 1·4	− 2·0
27	0	+ 0·2	− 0·9	+ 2·1	− 1·8	− 2·5	+ 0·9	− 2·0
,,	120	+ 0·4	+ 2·4	− 1·0	− 1·8	+ 0·3	− 1·3	− 1·0
,,	240	+ 2·4	+ 0·1	− 1·4	+ 1·7	− 0·5	+ 0·7	+ 3·0
March 4	10	− 1·0	+ 2·6	+ 0·2	− 0·4	− 2·1	+ 0·1	− 0·6
,,	130	+ 1·8	+ 2·1	− 1·3	− 1·9	+ 0·5	+ 0·7	+ 1·9
,,	250	− 0·6	+ 1·4	+ 0·6	− 1·6	− 0·7	+ 1·1	+ 0·2
11	180	− 0·7	+ 0·5	+ 2·5	− 0·9	+ 0·2	− 0·8	+ 0·8
,,	300	+ 0·4	+ 1·0	+ 0·1	− 1·1	+ 0·4	+ 1·7	+ 2·5
,,	60	+ 0·8	+ 0·9	+ 1·4	− 1·2	+ 1·5	+ 0·8	+ 4·2
18	190	+ 0·7	+ 1·5	− 1·1	+ 0·2	− 0·3	+ 1·2	+ 2·2
,,	310	0·0	0·0	+ 0·1	− 1·5	+ 1·1	− 0·3	− 0·6
,,	70	+ 0·9	+ 1·8	0·0	+ 1·5	+ 3·5	+ 0·3	+ 8·0
25	50	+ 0·2	− 0·6	+ 0·4	− 0·5	− 0·6	− 0·9	− 2·0
,,	170	+ 1·1	− 0·5	0·0	− 1·9	− 1·3	+ 0·9	− 1·7
,,	290	+ 0·2	− 1·4	+ 1·3	− 0·5	+ 0·3	− 1·8	− 1·9

TROUGHTON's CIRCLE—*continued.*

Day, 1839.	Pointer Reading.	MICROSCOPES A	B	C	D	E	F	Sum.
	°	"	"	"	"	"	"	"
April...... 1	60	− 1·1	+ 1·8	+ 1·4	− 2·7	− 0·9	+ 0·1	− 1·4
,,	180	− 1·1	+ 1·3	+ 0·1	+ 1·1	− 2·9	− 0·2	− 1·7
,,	300	+ 1·7	+ 0·5	+ 1·0	+ 0·2	+ 1·1	− 0·3	+ 4·2
8	70	− 0·4	− 1·5	− 1·5	− 1·4	+ 0·8	− 0·1	− 4·1
,,	190	+ 0·8	− 0·8	+ 0·8	− 0·5	+ 1·4	− 0·6	+ 1·1
,,	310	+ 1·3	+ 1·6	− 0·1	− 1·3	+ 1·1	− 0·6	+ 2·0
15	80	− 0·9	+ 2·8	− 2·8	+ 1·1	+ 0·3	0·0	+ 0·5
,,	200	+ 0·8	+ 4·2	+ 1·7	− 1·8	0·0	0·0	+ 4·9
,,	320	+ 1·1	+ 1·0	+ 1·9	− 1·1	+ 0·9	+ 1·3	+ 5·1
22	190	0·0	− 0·6	+ 0·6	+ 0·4	+ 0·7	+ 1·4	+ 2·5
,,	310	+ 1·6	+ 1·9	+ 0·1	− 0·1	+ 1·6	+ 0·1	+ 5·2
,,	70	+ 0·5	+ 0·1	0·0	− 1·4	+ 2·3	+ 0·6	+ 2·1
29	20	+ 0·3	+ 0·9	+ 1·0	− 0·6	− 0·4	+ 3·3	+ 4.5
,,	140	+ 2·1	+ 0·4	+ 2·3	+ 0·4	− 0·2	+ 0·1	+ 5·1
,,	260	+ 0·9	+ 1·9	+ 0·3	− 0·9	− 0·7	− 0·5	+ 1·0
May........ 6	70	+ 1·6	+ 3·7	+ 0·8	+ 1·4	+ 1·5	+ 1·6	+10·6
,,	190	+ 2·5	+ 2·8	+ 0·5	+ 1·2	+ 3·3	+ 1·6	+11·9
,,	310	+ 2·3	+ 0·3	+ 1·6	+ 1·0	+ 2·8	+ 0·9	+ 8·9
13	180	+ 0·9	+ 1·9	+ 2·8	0·0	+ 1·4	+ 0·9	+ 7·9
,,	300	− 0·2	+ 0·6	+ 1·6	− 0·4	+ 2·2	+ 0·7	+ 4·5
,,	60	+ 0·3	+ 1·9	+ 1·4	− 0·9	+ 1·4	+ 3·5	+ 7·6
20	100	+ 0·7	+ 2·8	0·0	− 0·5	+ 1·1	+ 2·6	+ 6·7
,,	220	+ 2·8	+ 1·9	+ 0·8	− 0·3	+ 2·2	+ 0·8	+ 8·2
,,	340	+ 2·3	+ 2·5	− 0·1	− 1·2	+ 4·2	+ 1·7	+ 9·4
27	0	− 0·4	+ 2·1	+ 1·7	− 1·6	+ 1·9	+ 0·3	+ 4·0
,,	120	+ 1·6	+ 0·7	+ 0·7	− 0·6	+ 0·2	+ 1·2	+ 3·8
,,	240	+ 2·5	+ 1·4	+ 0·2	+ 0·8	+ 2·8	+ 1·4	+ 9·1
June...... 3	110	+ 1·6	+ 1·4	+ 1·7	+ 2·5	+ 1·1	+ 1·0	+ 9·3
,,	230	+ 3·2	+ 2·2	+ 2·3	+ 0·5	+ 2·2	+ 1·2	+11·6
,,	350	+ 1·9	+ 3·8	+ 0·7	+ 0·9	+ 2·5	+ 0·8	+10·6
10	45	+ 1·5	+ 1·8	+ 2·0	+ 0·4	+ 0·7	+ 1·8	+ 8·2
,,	165	+ 2·1	+ 2·8	+ 1·7	+ 0·4	− 0·1	+ 1·1	+ 8·0
,,	285	+ 1·2	+ 2·0	+ 1·6	− 2·0	+ 0·4	+ 1·9	+ 5·1
17	190	+ 2·9	+ 2·0	+ 2·2	+ 1·7	+ 0·9	+ 0·9	+10·6
,,	310	+ 3·2	+ 2·8	+ 1·4	+ 0·2	+ 0·6	+ 1·1	+ 9·3
,,	70	+ 1·6	+ 0·9	+ 1·2	+ 0·5	+ 2·2	+ 3·0	+ 9·4

TROUGHTON's CIRCLE—*continued.*

Day, 1839.	Pointer Reading.	MICROSCOPES						Sum.
		A	B	C	D	E	F	
	°	″	″	″	″	″	″	″
June 24	50	+ 2·4	+ 0·8	+ 0·6	+ 0·3	− 0·7	+ 1·2	+ 4·6
,,	170	+ 0·8	+ 1·4	+ 2·8	− 0·4	− 0·7	+ 0·9	+ 4·8
,,	290	− 0·2	+ 2·2	+ 2·6	+ 0·2	+ 0·8	+ 1·8	+ 7·4
July 1	0	+ 1·9	+ 0·6	+ 2·4	− 0·4	+ 2·3	− 0·1	+ 6·7
,,	120	+ 0·4	+ 2·9	+ 0·4	+ 0·7	− 0·7	− 0·3	+ 3·4
,,	240	+ 1·5	− 0·7	+ 1·4	+ 1·6	+ 0·1	+ 1·8	+ 5·7
8	180	+ 2·0	+ 1·8	+ 1·1	+ 0·8	+ 0·1	+ 1·4	+ 7·2
,,	300	+ 2·5	+ 2·2	+ 2·4	− 0·6	+ 1·2	+ 0·7	+ 8·4
,,	60	+ 0·7	+ 2·8	+ 2·0	+ 0·8	+ 2·2	+ 1·2	+ 9·7
15	200	0·0	+ 2·0	+ 1·6	− 1·9	+ 1·5	+ 1·2	+ 4·4
,,	320	+ 0·5	+ 3·1	+ 2·1	+ 0·9	+ 0·8	+ 0·6	+ 8·0
,,	80	+ 2·0	+ 2·5	+ 0·6	+ 0·5	− 0·1	+ 1·5	+ 7·0
22	315	− 0·4	+ 2·3	+ 1·5	− 1·4	− 0·3	+ 0·6	+ 2·3
,,	75	+ 2·1	− 0·3	− 0·4	− 0·6	+ 1·4	− 0·1	+ 2·1
,,	195	− 1·3	− 0·8	− 0·9	− 0·7	+ 1·2	+ 0·3	− 2·2
29	150	+ 3·2	+ 3·1	− 2·4	+ 0·2	+ 3·0	+ 1·9	+ 9·0
,,	270	+ 3·1	+ 0·9	+ 2·2	0·0	+ 1·6	+ 1·5	+ 9·3
,,	30	+ 3·0	+ 3·9	+ 1·6	+ 0·6	+ 1·2	− 1·0	+ 9·3
August 5	205	− 0·3	+ 2·8	+ 3·3	+ 0·7	+ 2·2	+ 0·3	+ 9·0
,,	325	+ 0·5	+ 2·8	+ 2·7	+ 1·2	+ 1·8	+ 2·2	+11·2
,,	85	+ 1·1	+ 2·4	+ 1·7	− 0·6	+ 0·6	+ 1·0	+ 6·2
12	50	+ 1·4	+ 0·9	+ 2·4	− 1·6	− 0·5	+ 0·2	+ 2·8
,,	170	0·0	+ 0·4	+ 1·5	− 1·4	− 1·5	− 1·1	− 2·1
,,	290	+ 0·1	+ 0·6	+ 1·9	− 0·9	+ 1·4	− 0·5	+ 2·6
19	60	− 0·4	+ 1·8	+ 2·2	+ 1·4	+ 2·7	+ 0·2	+ 7·9
,,	180	+ 1·7	+ 2·9	+ 2·6	+ 0·1	+ 0·3	+ 0·9	+ 8·5
,,	300	+ 1·3	+ 1·4	+ 1·9	− 0·4	+ 1·4	− 0·4	+ 5·2
26	0	+ 0·4	+ 0·4	+ 2·0	− 0·6	+ 1·8	+ 1·1	+ 5·1
,,	120	+ 1·4	+ 2·7	+ 0·7	+ 1·6	+ 1·0	+ 1·6	+ 9·0
,,	240	+ 1·9	+ 1·2	+ 1·2	− 0·2	+ 0·5	+ 0·6	+ 5·2
September .. 2	140	+ 1·5	+ 1·9	− 1·1	− 0·2	+ 4·3	+ 2·2	+ 8·6
,,	260	+ 2·2	+ 2·0	+ 2·4	+ 1·2	+ 1·4	+ 2·3	+11·5
,,	200	+ 1·2	+ 1·8	+ 2·4	− 0·7	+ 1·3	− 0·4	+ 5·6
9	180	+ 1·2	+ 4·1	+ 3·2	+ 0·9	+ 2·2	+ 1·0	+12·6
,,	300	+ 1·8	+ 1·9	+ 3·4	+ 0·9	+ 2·1	+ 1·6	+11·7
,,	60	+ 1·9	+ 1·9	+ 1·6	+ 0·6	+ 1·9	+ 2.0	+ 9·9

TROUGHTON's CIRCLE—*continued.*

Day, 1839.	Pointer Reading.	MICROSCOPES						Sum.
		A	B	C	D	E	F	
	°	"	"	"	"	"	"	"
September.. 16	65	0·0	+ 1·5	− 0·9	− 0·6	+ 1·6	− 0·1	+ 1·5
,,	185	− 0·4	− 0·3	+ 0·6	+ 1·6	+ 0·9	+ 1·4	+ 3·8
,,	305	+ 0·8	+ 1·7	+ 2·1	+ 0·7	− 0·2	+ 0·4	+ 5·5
23	75	+ 1·7	+ 0·6	+ 1·4	+ 0·1	+ 0·3	− 0·6	+ 3·5
,,	195	+ 1·6	+ 0·6	+ 0·9	− 1·7	+ 2·4	+ 2·2	+ 6·0
,,	315	+ 0·6	− 0·2	− 0·4	− 0·2	− 0·4	− 0·2	− 0·8
30	5	+ 0·1	+ 0·3	+ 3·0	+ 0·1	− 1·0	+ 0·1	+ 2·6
,,	125	+ 1·8	+ 1·4	+ 1·6	+ 0·2	+ 2·6	− 1·2	+ 6·4
,,	245	+ 1·5	+ 1·1	+ 0·1	+ 0·7	+ 1·5	+ 1·8	+ 6·7
October..... 7	15	+ 1·8	+ 1·4	+ 0·4	− 1·4	+ 0·6	+ 1·5	+ 4·3
,,	135	+ 1·1	+ 1·6	+ 1·6	− 2·1	− 0·8	− 0·3	+ 1·1
,,	255	+ 1·9	+ 1·2	0·0	− 0·5	+ 0·6	+ 1·2	+ 4·4
14	185	+ 0·3	− 1·1	+ 1·2	− 0·7	+ 1·3	− 0·2	+ 0·8
,,	305	+ 0·8	+ 1·4	+ 0·8	+ 0·5	+ 1·4	− 0·1	+ 4·8
,,	65	+ 2·0	+ 3·1	0·0	− 1·7	+ 0·2	+ 0·7	+ 4·3
21	10	+ 0·4	+ 1·2	+ 2·4	− 0·6	+ 0·4	− 0·2	+ 3·6
,,	130	− 0·9	+ 2·0	+ 0·2	− 1·8	+ 1·9	+ 2·3	+ 3·7
,,	250	+ 0·2	+ 1·1	+ 1·2	− 0·9	+ 1·1	+ 2·3	+ 5·0
28	70	+ 1·7	+ 3·5	0·0	− 1·3	+ 0·3	− 0·1	+ 4·1
,,	190	+ 1·6	+ 3·0	+ 2·6	− 1·1	+ 2·6	+ 1·4	+10·1
,,	310	+ 3·0	+ 5·0	+ 1.7	− 1·2	+ 1·0	+ 0·3	+ 9·8
November .. 4	50	+ 0·3	+ 3·0	− 0·7	+ 0·9	+ 2·8	+ 0·7	+ 7·0
,,	170	+ 2·1	+ 4·0	+ 0·3	− 1·5	− 0·6	+ 1·3	+ 5·6
,,	290	+ 1·5	+ 2·0	+ 1·9	− 1·1	+ 2·2	+ 0·9	+ 7·4
11	195	+ 0·6	+ 0·2	+ 0·3	− 1·7	+ 0·7	+ 0·4	+ 0·5
,,	315	− 0·1	+ 1·2	+ 1·5	+ 0·4	+ 0·7	− 0·4	+ 3·3
,,	75	+ 1·5	+ 1·9	0·0	+ 1·0	− 0·2	0·0	+ 2·2
18	115	+ 0·2	+ 0·4	+ 1·8	− 1·6	− 0·6	+ 1·6	+ 1·8
,,	235	+ 2·2	+ 1·6	− 0·9	− 1·2	+ 0·1	− 0·4	+ 1·4
,,	355	+ 2·1	0·0	+ 0·4	− 1·6	+ 1·1	− 0·2	+ 1·8
25	125	+ 0·9	+ 1·6	+ 2·7	+ 1·9	− 0·8	+ 0·8	+ 7·1
,,	245	+ 0·7	+ 3·0	− 0·3	− 0·9	− 1·5	+ 1·9	+ 2·9
,,	5	+ 1·5	− 0·4	+ 0·8	− 0·5	+ 2·3	+ 2·4	+ 6·1
December... 2	185	+ 1·6	+ 2·6	+ 2·3	0·0	+ 1·2	+ 2·3	+10·0
,,	71	0·0	+ 3·2	+ 3·2	+ 1·6	+ 2·4	+ 1·0	+11·4
,,	323	+ 0·7	+ 1·2	+ 1·8	− 0·3	+ 1·4	+ 0·8	+ 5·6

TROUGHTON'S CIRCLE—*concluded.*

Day, 1839.	Pointer Reading.	MICROSCOPES A	B	C	D	E	F	Sum.
	°	"	"	"	"	"	"	"
December.. 9	0	0·0	+ 0·3	+ 1·2	+ 0·2	+ 0·7	— 1·9	+ 0·5
,,	20	+ 1·2	+ 0·1	0·0	— 0·2	— 1·4	+ 0·3	0·0
,,	40	— 0·2	— 0·7	+ 1·2	+ 1·3	+ 1·4	— 1·2	+ 1·8
16	200	+ 0·4	+ 0·6	+ 1·5	— 1·0	+ 1·6	+ 0·1	+ 3·2
,,	220	— 0·4	+ 0·7	+ 1·7	— 0·5	+ 3·4	+ 0·4	+ 5·3
,,	240	+ 1·8	+ 0·4	+ 1·0	+ 1·4	— 1·5	— 0·2	+ 2·9
23	10	+ 0·4	+ 2·8	+ 1·6	+ 0·1	— 0·3	— 0·8	+ 3·8
,,	30	— 0·4	+ 2·8	+ 0·3	— 0·9	— 1·6	+ 0·7	+ 0·9
,,	50	+ 0·2	— 0·7	— 0·1	— 2·1	— 0·2	+ 1·4	— 1·5
30	40	— 0·4	+ 0·6	+ 0·5	— 0·1	+ 1·1	— 2·5	— 0·8
,,	75	— 0·6	+ 1·4	— 1·0	— 1·7	— 0·4	— 0·2	— 2·5
,,	110	— 0·4	— 1·8	— 0·4	— 0·6	+ 0·4	— 1·6	— 4·4

ERRORS OF EACH MICROSCOPE OF JONES'S CIRCLE, FOR A READING OF 5', TO FEBRUARY 24, 1839.

Day, 1839.	Pointer Reading.	A	B	C	D	E	F	Sum.
January.... 7	75	— 1·7	— 1·8	— 1·7	— 0·4	— 0·6	— 0·7	— 6·9
,,	195	— 1·1	— 1·4	— 2·4	— 2·1	— 2·8	— 0·4	—10·2
,,	315	— 1·1	— 1·8	— 1·8	— 0·6	— 0·4	— 0·3	— 6·0
14	50	— 0·2	— 0·8	— 2·2	+ 0·7	+ 2·5	— 0·2	— 0·2
,,	170	— 0·1	+ 0·4	— 0·7	— 1·0	— 0·1	— 1·1	— 2·8
,,	290	— 1·7	0·0	— 0·8	— 0·2	— 1·0	+ 1·0	— 2·7
21	100	— 0·1	— 0·2	— 1·6	0·0	— 2·0	— 0·7	— 4·6
,,	220	— 0·2	— 0·3	— 0·5	— 0·1	— 0·3	— 1·2	— 2·6
,,	340	— 0·3	— 0·8	— 2·1	— 0·2	— 0·7	— 0·2	— 4·3
28	10	— 1·2	— 2·3	— 2·9	— 0·7	— 1·4	— 0·2	— 8·7
,,	130	— 1·9	— 1·6	— 1·4	— 1·9	— 1·3	— 0·5	— 8·6
,,	250	— 1·2	— 1·4	— 2·6	— 0·7	— 0·3	— 1·4	— 7·6
February... 4	0	— 0·4	— 1·5	— 1·1	— 1·6	— 0·9	— 1·5	— 7·0
,,	120	— 0·4	— 1·4	— 0·6	— 2·2	— 1·1	— 0·2	— 5·9
,,	240	— 1·4	— 1·7	— 1·7	0·0	— 2·3	— 0·1	— 7·2
11	20	— 0·1	— 0·5	— 2·5	— 1·6	— 1·4	— 1·6	— 7·7
,,	140	— 0·1	— 0·6	— 0·4	— 0·9	— 1·7	— 0·2	— 3·9
,,	260	— 0·6	— 0·2	— 2·2	— 0·4	— 1·1	— 0·8	— 5·3
18	60	— 1·1	+ 0.1	— 0·3	— 1·2	— 1·0	— 2·9	— 6·4
,,	180	— 2·0	+ 0·2	— 2·3	— 1·3	— 1·1	— 1·4	— 7·9
,,	240	— 1·8	— 0·2	— 0·2	— 0·7	— 1·1	— 1·0	— 5·0

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 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 of the micrometer of Troughton was found in 1836 to be $53''\cdot56$, and that of the micrometer of Jones to be $40''\cdot26$.

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 each 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 is not necessary to detail here. The interval of Troughton's wires is considered 20^s equatoreal, and that of Jones's wires 21^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., 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 in 1 hour of longitude (from the section of Moon-culminating Stars in the Nautical Almanac) $\times$ sec. declination $\times$ n°. (log. $= 7\cdot745$) $\times$ number of intervals of wires. The latter is calculated by this formula: tan. declination $\times$ n°. (log. $= 9\cdot350$) $\times$ (number of intervals of wires)^2. The two numbers are combined together to form the number in the 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 reading for the Zenith Point, as ascertained by a process subsequently to be described.

The *eighteenth* 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 same remarks apply, *mutatis mutandis*, to the columns on the right hand page, for Jones's circle (all numerical differences having been already given), except the *two last* columns. The former of these contains the value of the arc by which the reading of Troughton exceeds that of Jones when the same object is observed directly with both. The latter contains the value of the sum of the readings when the same object has been observed directly with one circle and by reflexion with the other. They 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 T + J for each parcel is ascertained, the mean between the two values of T + J for the two parcels is found, and is considered to be the value of T + J applicable to the whole group: this quantity is increased or diminished by 180°, and is divided by 2: and this result would be the Zenith Point if the readings of the two circles for the same object were identical. As they are not, it is necessary to add to this result the mean value of $\frac{T-J}{2}$ in order to obtain the Zenith Point of Troughton's circle: and the same quantity must be subtracted, to obtain the Zenith Point of Jones's circle. The value of T — J is found in the same manner as that of T + J: by taking the mean of the values for the stars in each parcel, and taking the mean of those means and using it for the whole group. 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 1839, great care has also been taken to balance the stars observed by reflexion on the north side and on the south side.

§ 4. *Calculation of Geocentric North Polar Distances from Observations with the two Mural Circles, from January* 1 *to February* 24, *page* (22) *to* (29).

The *first* and *second* columns on each page contain the day and the name of the object, as in the preceding section. For the planets, the limb or center observed with the fixed wire in each circle is noted, that for Troughton being always placed first.

The *third* and *fourth* columns contain the zenith distance, the degrees and minutes being given in the third column only. The zenith distance is found by subtracting the zenith point (in the preceding section) 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. The letter R is affixed when the object was observed by reflexion.

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 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 $\times$ 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 1839 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* and *eleventh* columns contain the semidiameter used with each circle, the minutes being given in the tenth column only. 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 only important departures from these rules occur between August 28 and October 9, and between November 10 and December 16: when the line of cusps of Venus was so much inclined to the horizon, and the cusp so difficult to observe, that it was thought more accurate to use the tabular semidiameter of Venus given in the Nautical Almanac, corrected by the quantity $0''.72 + 0·03 \times$

abular semidiameter (as found in the Introduction for 1838, page liii), and to apply this semidiameter to the observation of the illuminated limb.

The *twelfth* and *thirteenth* columns contain 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°. 31'. 21".

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. 1839, 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.

§ 5. *Observations of Zenith Distances with Troughton's Mural Circle, and Computation of Geocentric North Polar Distances, from February 25 to the end of the year*, page (32) to (155).

During this portion of the year, Troughton's circle, as has been stated, was used alone. Although the general plan of observations and reductions was the same as when two circles were used, yet a few alterations were necessary, which alone it will be needful to advert to here.

In observing the north and south limbs of the Sun, the circle is set very approximately, so that a very small range of the micrometer will be sufficient for placing the micrometer-wire upon one of the sun's limbs. The circle is then clamped, and the microscopes read before the sun enters the field. When the sun's center approaches the middle wire, the observation of the limb which is seen in the field is made with the micrometer wire. Then the clamp is relaxed, the circle is turned till the other limb of the sun is seen, and the observation of that limb is made in the usual way, a very short time after the center has passed the middle wire: the microscopes being read afterwards.

The same description applies to the method of observing the two limbs of the Moon, when both can be observed, and to the method of observing Stars by reflexion and by direct observation at the same transit.

To determine the Zenith Point, or the reading corresponding to a vertical position of the telescope, the concluded readings for the reflexion-observation of a star and the direct observation of the same star are added together: the value of the sum is set down in the *second* column of the right-hand page. The observations are then divided into groups of two or three days each, and the values of D + R for all the stars north of the zenith included in a group are collected into one parcel, and their mean is taken; and the values of D + R for the southern stars included in the same group are collected into another parcel, and their mean is taken: the mean of these two means is then taken, and the half of this quantity is adopted as the reading for the horizontal point, which is increased or diminished by 90° to obtain the adopted zenith point.

No other remark on this section appears necessary.

§ 6. *Mean North Polar Distances of Stars.*

The mean north polar distances are found by applying to the North Polar Distances in sections 4 and 5, the corrections opposite to them in those sections.

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.

TROUGHTON.

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.
	° ′	″				° ′	″		
ζ^1 Ursæ Majoris, S. P.	—34. 13	+0 ·98	1	1	λ Ursæ Minoris.....	+ 1. 10	+0 ·34	7	7
υ Ursæ Majoris, S. P.	30. 12	+0 ·69	2	2	Polaris............	1. 32	—0 ·31	20	18
α Ursæ Majoris, S. P.	27. 22	+0 ·23	1	2	Groombridge, 1871..	2. 40	—1 ·01	4	4
π Ursæ Majoris, S. P.	25. 7	—1 ·48	1	1	Cephei 51 (Hev)....	2. 44	—1 ·75	7	6
g Draconis..... S. P.	25. 6	—1 ·16	4	1	δ Ursæ Minoris.....	3. 24	—1 ·00	17	14
A. S. C. 1266.. S. P.	20. 5	+2 ·07	2	2	A. S. C. 874........	7. 18	—0 ·82	3	3
λ Draconis..... S. P.	19. 46	—0 ·54	3	3	ε Ursæ Minoris.....	7. 42	—0 ·33	12	7
γ Ursæ Minoris, S. P.	17. 35	—1 ·09	2	2	A. S. C. 1135.......	7. 58	—0 ·37	2	2
31 Cephei ..... S. P.	17. 11	+0 ·81	2	2	ζ Ursæ Minoris.....	11. 42	—0 ·21	11	8
β Ursæ Minoris, S. P.	15. 11	—0 ·63	3	4	θ Ursæ Minoris.....	12. 7	—0 ·01	3	3
γ Cephei ...... S. P.	13. 15	+0 ·53	4	4	γ Cephei	13. 15	—0 ·71	7	5
ζ Ursæ Minoris, S. P.	11. 42	—0 ·92	1	1	5 Ursæ Minoris	13. 35	—1 ·26	3	3
ε Ursæ Minoris, S. P.	7. 42	+0 ·34	2	5	β Ursæ Minoris	15. 11	+0 ·10	23	21
Polaris........ S. P.	— 1. 32	—0 ·11	25	24	π Cephei	+15. 28	—1 ·47	3	2

TROUGHTON—*continued.*

Name of Star.	N.P.D.	R − D	No. of Obs. D.	R.	Name of Star.	N.P.D.	R − D	No. of Obs. D.	R.
* A.R. $19^h. 20^m$	+16° 45′	−0″·31	1	1	χ Ursæ Majoris	+41° 19′	−0″·56	5	1
γ Ursæ Minoris	17. 35	+0·55	2	2	ι Ursæ Majoris	41. 19	+0·55	10	4
50 Cassiopeiæ	18. 21	+0·72	1	1	ψ Persei	42. 20	−0·18	1	1
λ Draconis	19. 46	−1·08	2	2	Groombridge, 2810	43. 6	+1·21	4	3
β Cephei	20. 8	+0·24	7	3	τ Herculis	43. 17	+0·68	1	1
σ Draconis	20. 36	+0·05	1	1	Capella	44. 10	−0·05	17	16
A Draconis	20. 53	−0·10	2	2	α Cygni	45. 17	+0·50	21	17
55 Camelopardali	21. 3	−0·50	3	2	ν Cygni	49. 26	+0·36	6	6
ρ Draconis	22. 35	−0·18	3	3	12^2 Canum Venat.	50. 48	+0·20	11	8
δ Draconis	22. 37	−1·13	5	2	12^1 Canum Venat.	50. 48	+1·05	6	5
* A.R. $22^h. 44^m$	24. 17	−0·96	2	1	α Lyræ	51. 21	−0·23	18	18
α Draconis	24. 51	−0·21	4	4	β^1 Lyræ	56. 49	+0·27	18	11
g Draconis	25. 6	+1·01	1	1	β^2 Lyræ	56. 49	−0·32	4	4
36 Draconis	25. 39	−0·51	8	7	Castor^2	57. 45	+0·24	11	7
B. F. 1366	26. 0	−1·20	5	1	Castor^1	57. 45	−2·65	2	1
10 Cassiopeiæ	26. 41	+0·79	4	1	53 Herculis	58. 1	−0·16	2	2
α Ursæ Majoris	27. 22	−0·50	12	12	ζ Herculis	58. 6	+1·02	4	4
26 Draconis	28. 0	+1·24	5	1	A Herculis	58. 37	+0·18	4	4
α Cephei	28. 5	+0·20	14	12	ε Herculis	58. 49	−0·07	3	3
η Draconis	28. 7	+0·19	9	8	ρ Bootis	58. 55	−0·67	1	1
4 Cassiopeiæ	28. 35	+1·64	1	1	ζ Cygni	60. 25	−0·70	11	7
6 Cassiopeiæ	28. 40	−0·15	7	3	κ Aurigæ	60. 26	+0·48	1	1
ο Ursæ Majoris	28. 45	−0·14	4	3	β Tauri	61. 32	−0·14	7	5
η Cephei	28. 47	+0·78	5	4	Pollux	61. 35	+1·09	10	4
31 Camelopardali	30. 9	−0·51	3	3	α Andromedæ	61. 47	−0·27	10	3
44 Cassiopeiæ	30. 15	+0·91	3	2	ε Bootis	62. 14	−0·25	15	10
Piazzi I. 139	30. 16	+0·74	2	2	32 Pegasi	62. 28	−2·37	1	1
15 Lyncis	31. 22	+0·59	2	2	α Coronæ Borealis	62. 44	−0·06	15	4
δ Ursæ Majoris	32. 4	+0·71	5	6	μ Leonis	63. 14	+1·47	1	1
φ Cassiopeiæ	32. 37	−0·30	4	1	Piazzi VII. 182	65. 22	−0·52	4	1
Piazzi I. 35	32. 38	−0·87	4	1	ε Leonis	65. 29	+1·47	11	4
ξ Draconis	33. 5	−0·81	3	3	28 Tauri	66. 21	−0·20	4	2
h Persei	33. 7	+0·49	3	1	η Tauri	66. 23	+0·73	4	3
ε Ursæ Majoris	33. 9	−0·76	1	1	23 Tauri	66. 33	−1·23	5	1
36 Ursæ Majoris	33. 11	−0·12	6	6	α Arietis	67. 18	+0·50	9	1
53 Draconis	33. 24	−0·10	1	1	9 Tauri	67. 19	+1·50	3	2
* A.R. $21^h. 50^m$	34. 8	+1·88	6	3	μ Geminorum	67. 24	+1·51	15	8
ζ^1 Ursæ Majoris	34. 13	−0·84	5	4	δ Geminorum	67. 43	+1·20	8	6
ζ^2 Ursæ Majoris	34. 14	−0·58	4	3	δ Leonis	68. 35	−0·01	5	3
α Cassiopeiæ	34. 20	−2·05	7	4	γ^1 Leonis	69. 20	+0·02	5	4
49 Draconis	34. 34	+1·39	4	5	γ^2 Leonis	69. 20	+1·62	1	1
Piazzi XXIII. 236	35. 3	−0·68	7	1	Arcturus	69. 58	+0·13	17	14
e Ursæ Majoris	35. 19	+0·43	1	1	η Bootis	70. 47	−0·40	11	5
γ Ursæ Majoris	35. 24	+0·03	8	8	θ Cancri	71. 21	+0·59	1	1
86 Ursæ Majoris	35. 28	+0·69	6	3	26 Geminorum	72. 12	+1·56	2	1
1 Persei	35. 39	+0·63	1	2	τ^5 Serpentis	73. 20	−0·19	3	2
ω^1 Cygni	+41. 8	+0·86	7	4	Aldebaran	+73. 49	+0·23	10	5

TROUGHTON—*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.
	° ′	″				° ′	″		
β Leonis...........	+74. 31	−0·52	12	5	α Ceti.............	+ 86. 32	+0·46	12	1
α^1 Herculis	75. 25	−0·04	15	6	δ Aquilæ	87. 12	+0·32	11	2
ζ Bootis...........	75. 34	−0·25	1	1	γ Ceti.............	87. 26	−0·38	11	3
α Pegasi	75. 39	−0·66	3	3	γ Piscium	87. 35	+0·52	1	1
γ Pegasi...........	75. 42	−0·25	8	3	κ Piscium	89. 37	+0·50	2	1
34 Ophiuchi	76. 11	−0·12	2	1	υ Leonis...........	89. 56	+1·02	2	2
ζ Aquilæ	76. 22	−0·16	14	10	δ Orionis	90. 25	+1·78	9	2
Regulus............	77. 14	+0·50	19	8	γ Virginis..........	90. 33	+2·03	2	1
α Ophiuchi	77. 19	−0·21	15	7	α Aquarii..........	91. 5	+1·05	6	4
l Leonis...........	78. 36	+0·16	2	2	δ Ophiuchi.........	93. 16	+0·09	14	2
γ Aquilæ	79. 46	−1·22	12	3	96 Aquarii.........	96. 0	+0·49	6	1
ζ Pegasi	80. 0	+0·25	7	2	β Aquarii	96. 16	−0·50	7	2
ε Pegasi	80. 51	−1·56	5	3	α Hydræ	97. 57	+1·25	10	2
A. S. C. 1322.......	81. 3	−1·64	6	2	λ Aquarii..........	98. 26	+2·16	2	1
α Orionis..........	82. 37	+1·01	16	4	β Libræ	98. 47	−0·40	12	2
ε Piscium..........	82. 58	−1·23	2	2	θ Ceti.............	99. 0	+1·94	11	1
ε Hydræ...........	82. 59	−0·12	14	4	Spica	100. 19	−0·43	11	3
α Serpentis	83. 3	−1·48	9	2	α^1 Capricorni.......	103. 0	+0·50	11	2
δ Piscium..........	83. 17	−0·80	4	1	α^2 Capricorni.......	103. 2	−0·21	16	3
β Aquilæ	83. 59	−1·10	7	3	γ Eridani..........	103. 58	+2·12	8	1
ω Piscium	84. 1	−1·21	3	1	Sirius.............	106. 29	−1·47	17	5
Procyon...........	84. 22	+1·89	11	1	β Ceti.............	+108. 52	+0·57	9	3
ι Piscium..........	+85. 14	−1·15	8	4					

JONES.

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.
	° ′	″				° ′	″		
γ Ursæ Minoris, S. P.	−17. 35	−1·66	1	1	ι Ursæ Majoris	+41. 19	+0·51	1	1
ε Ursæ Minoris, S. P.	− 7. 42	+0·45	4	1	α Cygni	45. 17	+0·32	6	3
Cephei 51 (Hev).....	+ 2. 44	−0·83	4	1	α Lyræ............	51. 21	+0·80	7	5
β Cephei	20. 8	+0·63	4	1	β Tauri............	61. 32	+1·06	5	1
δ Draconis..........	22. 37	−1·03	1	2	9 Tauri............	67. 19	+1·64	4	1
α Cephei	28. 5	−2·12	2	2	μ Geminorum......	67. 24	+1·53	4	2
31 Camelopardali....	30. 9	+0·16	1	1	ζ Arietis...........	69. 33	+0·11	1	1
44 Cassiopeiæ.......	30. 15	−3·29	2	1	Aldebaran.........	73. 49	−0·01	1	1
1 Persei	35. 39	−1·96	2	1	α Ceti.............	86. 32	+0·02	5	2
α Persei	+40. 43	+0·10	4	2	γ Ceti.............	+87. 26	+1·66	3	2

As the number of stars observed with Troughton 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.

TROUGHTON.

Extent of Group.	No. of Obs.	Mean N. P. D.	R — D.
		° ′	″
ζ¹ Ursæ Majoris S. P. to g Draconis S. P. . .	6	— 28. 42	—0 ·01
A. S. C. 1266 S. P. to γ Cephei S. P.	16	— 16. 43	+0 ·14
ζ Ursæ Minoris S. P. to δ Ursæ Minoris. . . .	76	+ 0. 37	—0 ·45
A. S. C. 874 to 5 Ursæ Minoris.	31	+ 10. 36	—0 ·47
β Ursæ Minoris to δ Draconis.	42	+ 17. 33	—0 ·11
✱ A. R. 22h. 44m to α Ursæ Majoris	27	+ 26. 16	—0 ·40
26 Draconis to η Cephei	32	+ 28. 19	+0 ·27
31 Camelopardali to 53 Draconis.	28	+ 32. 4	+0 ·06
✱ A. R. 21h. 50m to 1 Persei	32	+ 34. 43	+0 ·02
ω¹ Cygni to α Cygni.	47	+ 43. 53	+0 ·36
ν Cygni to β² Lyræ.	52	+ 52. 34	+0 ·13
Castor (2nd star) to ρ Bootis.	22	+ 58. 12	+0 ·12
ζ Cygni to μ Leonis	36	+ 61. 43	—0 ·14
Piazzi VII. 182 to Arcturus	50	+ 68. 6	+0 ·64
η Bootis to ζ Aquilæ	43	+ 74. 36	—0 ·15
Regulus to A. S. C. 1322	27	+ 78. 32	—0 ·31
α Orionis to α Ceti.	23	+ 83. 43	—0 ·41
δ Aquilæ to α Aquarii	16	+ 89. 18	+0 ·77
δ Ophiuchi to Spica.	14	+ 97. 38	+0 ·30
α¹ Capricorni to β Ceti.	14	+105. 35	—0 ·23

Although it would seem that there is a discordance following with some regularity a law, such that the value near the zenith is positive, and at a certain distance on either side of the zenith is negative: yet, considering the extreme smallness of the value and the consequent general uncertainty of its law, and remarking that any discordance which is to be divided equally between the direct and reflexion-observations will scarcely produce an effect on the latitude (the only determination on which a sufficient number of observations is accumulated to require attention to so small a quantity), I have thought it best to omit it entirely.

The values of R — D for Jones, as far as they go, appear to follow the same law as in the last year. The same table of corrections is therefore adopted as that used in 1838: it is transcribed here from the Introduction for 1838.

Correction to N. P. D. independent of Latitude-correction (to be applied algebraically) for observations with Jones.

N.P.D	D.	R.	N.P.D.	D.	R.
°	″	″	°	″	″
— 50	0·00	0·00	+ 50	+0·36	—0·36
— 40	—0·08	+0·08	+ 60	+0·70	—0. 70
— 30	—0·12	+0·12	+ 70	+0·75	—0·75
— 20	—0·21	+0·21	+ 80	+0·57	—0·57
— 10	—0·39	+0·39	+ 90	+0·32	—0·32
0	—0·50	+0·50	+100	+0·14	—0·14
+ 10	—0·63	+0·63	+110	+0·05	—0·05
+ 20	—0·70	+0·70	+120	0·00	0·00
+ 30	—0·60	+0·60	+130	0·00	0·00
+ 40	—0·16	+0·16			

The results from fifteen 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.

CORRECTION OF ASSUMED LATITUDE.

Star's Name, Name of Circle, and Mode of Observation.	No. of Obs.	N. P. D. Uncorrected.	Correction.	N. P. D. Corrected.	No. of Obs.	Concluded N. P. D. on assumed Latitude.	No. of Obs.	Algebraic Sum of Determinations.	Weight.	Product.
		° ′ ″	″	″		″		″		″
Polaris........ T. D.	20	1. 32. 56·84		56·84	38	56·67	87	—1·19	60	—71·40
T. R.	18	56·53		56·53						
S. P. T. D.	25	— 1. 32. 57·81		57·81	49	—57·86				
T. R.	24	57·92		57·92						
δ Ursæ Minoris, T. D.	17	3. 24. 31·30		31·30	33	30·88	35	—2·29	6	— 13·74
T. R.	14	30·30		30. 30						
J. D.	2	31·87	—0·54	31·33						
J. R.		....								
S. P. T. D.	1	— 3. 24. 32·64		32·64	2	—33·17				
T. R.		....								
J. D.		....								
J. R.	1	33·24	+0·46	33·70						

Star's Name, Name of Circle, and Mode of Observation.	No. of Obs.	N. P. D. Uncorrected.	Correction.	N. P. D. Corrected.	No. of Obs.	Concluded N. P. D. on assumed Latitude.	No. of Obs.	Algebraic Sum of Determinations.	Weight.	Product.
		° ′ ″	″	″		″		″		″
ε Ursæ Minoris, T. D.	12	7. 42. 31·90		32·04						
T. R.	7	31·71		31·71	21	31·91				
J. D.	2	32·44	—0·59	31·85						
J. R.		....								
S. P. T. D.	2	— 7. 42. 33·70		33·70			33	—1·56	22	—34·32
T. R.	5	33·36		33·36	12	—33·47				
J. D.	4	33·84	—0·42	33·42						
J. R.	1	33·39	+0·42	33·81						
ζ Ursæ Minoris, T. D.	11	11. 42. 48·56		48·56	19	48·47				
T. R.	8	48·35		48·35						
S. P. T. D.	1	—11. 42. 48·35		48·35	2	—48·81	21	—0·34	6	— 2·04
T. R.	1	49·27		49·27						
θ Ursæ Minoris, T. D.	3	12. 7. 1·78		1·78	6	1·78				
T. R.	3	1·77		1·77						
S. P. T. D.		—12. 7......					8	—1·12	4	— 4·48
T. R.	1	2·95		2·95	2	— 2·90				
J. D.	1	3·20	—0·35	2·85						
J. R.		....								
γ Cephei .... T. D.	7	13. 15. 56·77		56·77	12	56·47				
T. R.	5	56·06		56·06						
S. P. T. D.	4	—13. 15. 58·72		58·72			20	—1·99	12	—23·88
T. R.	4	58·19		58·19	8	—58·46				
β Ursæ Minoris, T. D.	23	15. 11. 10·74		10·74	44	10·79				
T. R.	21	10·84		10·84						
S. P. T. D.	3	—15. 11. 11·34		11·34			53	—0·98	18	—17·64
T. R.	4	11·97		11·97	9	—11·77				
J. D.	2	12·31	—0·30	12·01						
J. R.		....								
γ Ursæ Minoris, T. D.	2	17. 35. 34·45		34·45	4	34·73				
T. R.	2	35·00		35·00						
S. P. T. D.	2	—17. 35. 35·76		35·76			10	—1·53	6	— 9·18
T. R.	2	36·85		36·85	6	—36. 26				
J. D.	1	35·34	—0·25	35·09						
J. R.	1	37·00	+0·25	37·25						
λ Draconis ..... T. D.	2	19. 46. 51·77		51·77	4	51·23				
T. R.	2	50·69		50·69						
S. P. T. D.	3	—19. 46. 52·54		52·54			10	—1·58	6	— 9·48
T. R.	3	53·08		53·08	6	—52·81				

Star's Name, Name of Circle, and Mode of Observation.	No. of Obs.	N. P. D. Uncorrected.	Correction.	N. P. D. Corrected.	No. of Obs.	Concluded N. P. D. on assumed Latitude.	No. of Obs.	Algebraic Sum of Determinations.	Weight.	Product.
		° ′ ″	″	″		″		″		″
A Draconis..... T. D.	2	20. 53. 0·11		0·11	4	0·06	8	−2·04	4	− 8·16
T. R.	2	0·01		0·01						
S. P. T. D.	2	−20. 53. 2·44		2·44	4	− 2·10				
T. R.		....								
J. D.	2	1·96	−0·20	1·76						
J. R.		....								
g Draconis..... T. D.	1	25. 6. 16·22		16·22	2	16·73	12	−1·65	3	− 4·95
T. R.	1	17·23		17·23						
S. P. T. D.	4	−25. 6. 18·76		18·76	10	−18·38				
T. R.	1	19·92		19·92						
J. D.	5	17·93	−0·16	17·77						
J. R.		....								
α Ursæ Majoris, T. D.	12	27. 22. 53·19		53·19	24	52·94	27	−1·12	5	− 5·60
T. R.	12	52·69		52·69						
S. P. T. D.	1	−27. 22. 54·21		54·21	3	−54·06				
T. R.	2	53·98		53·98						
ζ[1] Ursæ Majoris, T. D.	5	34. 13. 54·66		54·66	9	54·29	11	−1·61	3	− 4·83
T. R.	4	53·82		53·82						
S. P. T. D.	1	−34. 13. 56·39		56·39	2	−55·90				
T. R.	1	55·41		55·41						
β Draconis..... T. D.	6	37. 34. 35·99		35·99	11	35·78	13	−1·21	3	− 3·63
T. R.		....								
J. D.	5	35·79	−0·27	35·52						
J. R.		....								
S. P. T. D.	1	−37. 34. 39·45		39·45	2	−36·99				
T. R.		....								
J. D.	1	34·62	−0·09	34·53						
J. R.		....								
γ Draconis..... T. D.	13	38. 29. 21·72		21·72	22	21·54	24	−0·60	3	− 1·80
J. D.	9	21·52	−0·23	21·29						
S. P. T. D.	1	−38. 29. 22·45		22·45	2	−22·14				
J. D.	1	21·92	−0·09	21·83						

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, $2z = +1''{\cdot}34$, or $z = +0''{\cdot}67$: or the true colatitude is 38°.31′.21″·67.

This determination, though differing from that found in 1836 by nearly a quarter of a second, is so well supported by those of 1837 and 1838, that I have not hesitated to adopt it in correcting all the observations of 1839. Combining it, therefore, with the correction for R — D, we have the following numbers, to be applied to all the observations :

Correction to be applied algebraically to N. P. D. for the discordance of Direct and Reflexion Results, and for the Error of Assumed Latitude, 1839.

For observations with Troughton. Correction, = + 0″·67.					
For observations with Jones.			For observations with Jones.		
N. P. D.	D.	R.	N. P. D.	D.	R.
°	″	″	°	″	″
− 50	+0·67	+0·67	+ 50	+1·03	+0·31
− 40	+0·59	+0·75	+ 60	+1·37	−0·03
− 30	+0·55	+0·79	+ 70	+1·42	−0·08
− 20	+0·46	+0·88	+ 80	+1·24	+0·10
− 10	+0·28	+1·06	+ 90	+0·99	+0·35
0	+0·17	+1·17	+100	+0·81	+0·53
+ 10	+0·04	+1·30	+110	+0·72	+0·62
+ 20	−0·03	+1·37	+120	+0·67	+0·67
+ 30	+0·07	+1·27	+130	+0·67	+0·67
+ 40	+0·51	+0·83			

The catalogue of concluded mean N. P. D. of stars contains the means of the daily results, affected with the corrections given by the last table. The adopted seconds of N. P. D. are found by taking the mean of the results of all the groups, 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.

§ 7. *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 2 *to* 22.

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 — $0^{s}\cdot14$.

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 — $0''\cdot94$.

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.* (that for April 28, which was inadvertently omitted, is supplied in the Errata). 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 — $0^{s}\cdot56$.

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 xxiv). The mean of the six values of errors is — $6''\cdot02$.

The vertical diameters of Venus are found by doubling the semidiameters given in the section of *Calculation of Geocentric North Polar Distances from Observations with the Two Mural Circles*, or in the right-hand pages of the section of *Observations of Zenith Distance with Troughton's Mural Circle, &c. &c.*: those being excepted which are included between Aug. 28 and Oct. 9, and between Nov. 10 and Dec. 16, in which the great inclination of the line of cusps of Venus to the meridian made it appear preferable (as has been mentioned, page xxv) to use a corrected tabular semidiameter instead of one deduced from the observations. These diameters, therefore, are not imperfect diameters, as observed in the first instance. The vertical diameters of the other planets are merely the measures given in the section of *Observations with the Two Mural Circles*, or are the doubles of the semidiameters given in the right-hand pages of the section of *Observations with Troughton's Mural Circle*. 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 at Transit of first point of Aries, diminished by 4^m.
3. $3^m.47^s{\cdot}00$ — hours of Sid. Time + solar equiv. for hours.
4. $10^s{\cdot}00$ — minutes of Sid. Time + solar equiv. for minutes.
5. $3^s{\cdot}00$ — 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 $\pm\, 0^s{\cdot}36$ is applied as mentioned in a former part of this Introduction; and that, when the first limb only has been observed, the correction $+\, 0^s{\cdot}07$ has been applied; and when the second limb only has been observed, the correction $-\, 0^s{\cdot}07$. The North Polar Distances of the Sun are the means of those in the *North Polar Distances, &c.*, or in the right-hand pages of the *Observations with Troughton's Circle*, the correction for discordance of direct and reflexion-results and for alteration of latitude (page xxxiv) being applied, and the correction $+\, 0''{\cdot}44$ when the N. limb only was observed, and $-\, 0''{\cdot}44$ when the S. limb only was observed. These numbers were used in consequence of an error in calculation: the correct number (page xxxv) is $\pm\, 0''{\cdot}47$. 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 $+\, 0^s{\cdot}20$ being applied when the first limb was observed, and $-\, 0^s{\cdot}20$ when the second limb was observed. This is the same correction which was used in 1836, 1837, and 1838; it is fully supported by all the observations hitherto made, as appears from the following collection. The equatoreal observations for 1839 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	
1837	— 0·37	2	— 0·74	Equatoreal observations.
1838	— 0·31	2	— 0·62	
1839	— 0·33	4	— 1·32	
		17	6·93	
	Mean Tabular Error = — 0·41			

When both limbs are observed, the correction for defective illumination already mentioned (page xxxv) 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 section of *North Polar Distances, &c.*, or from the right-hand pages in the section of *Observations with Troughton's Mural Circle*, with the following alterations. On Jan. 4 and 7, and Feb. 23 and 24, double weight is given to the result from Troughton: on Jan. 22 and 24, equal weights are given to the results from the two circles. The correction for alteration of latitude, &c., is then applied: and then the correction + 2″·94, when the N. limb only is observed, and — 2″·94 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
		32	188·15
		Mean Tabular Error = — 5·88	

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. 10). The tabular N. P. D. are taken from the 7th column in the section *Moon-culminating Stars* of the Nautical Almanac.

In addition to the usual column of Errors of Tables, there is one exhibiting the effect of the earth's oblateness. The latter is found by separately computing the parallax, considering the geocentric zenith-distance as equal to the astronomical zenith-distance, and the geocentric radius as equal to the equatoreal radius, and taking the difference between this parallax and the parallax actually used.

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:

$$-0^s{\cdot}05 - {\cdot}03 \times \text{tabular semidiameter in A. R.}$$

The corrections applied in consequence are as follows:

January	1	to	May	6	$+\overset{s}{0}{\cdot}06$
May	7	to	July	31	$+0{\cdot}07$
August	1	to	August	24	$+0{\cdot}08$
August	25	to	September	8	$+0{\cdot}09$
September	9	to	September	20	$+0{\cdot}10$
September	21	to	October	1	$+0{\cdot}11$
October	7	to	October	18	$-0{\cdot}11$
October	19	to	November	1	$-0{\cdot}10$
November	2	to	November	18	$-0{\cdot}09$
November	19	to	December	15	$-0{\cdot}08$
December	16	to	December	31	$-0{\cdot}07$

For all other planets the Right Ascensions are extracted without alteration (except for personal equation) from the *Transits, &c.*; and for all the planets, the N. P. D. are taken from the *North Polar Distances, &c.*, without alteration; except that, when observed with both circles, the means are taken; and the corrections for alteration of latitude (as determined above, page xxxiii), and for discordance of direct and reflexion-results are applied. The tabular places are taken entirely from the Nautical Almanac.

The investigation of the position of the Ecliptic is conducted in the same manner as the investigations from Observations at 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, Juno, 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.
$\Delta =$ planet's distance from earth, $\lambda =$ planet's geocentric longitude.
$r =$ earth's radius vector, $l =$ earth's heliocentric longitude.

Then

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

$$+ \frac{\text{tan.}\ (\lambda - L)}{R \times \text{cos. hel. lat.} \times \text{sin.}\ 1''} \times \text{error of projection of radius vector.}$$

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

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

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

the fault of a single observation seems to have entailed errors on the value 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 discordance in results appears to be usually 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 seems not improbable that this may 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 had no distinct relation to the verticality or non-verticality of the axis of rotation. In the year 1840 a different construction of plumb-line has been tried, for the express purpose of surmounting this difficulty: the results of the trials with it will appear in the next volume.

The reduction of the apparent place to the mean place for Jan. 1, 1839, is performed with the corrections of the Nautical Almanac.

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.

§ 9. *Observations of the Duration of Transit of the Moon's Diameter, with the Eastern Equatoreal*, pages 34 to 36.

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.

§ 10. *Observations of Mars and neighbouring Stars with the Eastern Equatoreal; and Reductions of the Observations*, page 38 to 49.

The method of observing and the elements of reduction are explained for the most part in the notes. The following points, however, require notice.

The stars distinguished by the letters (*a*), (*b*), &c., are the same as those marked by those letters in the Nautical Almanac, 1839, page 551, &c. Their mean places, however, (as well as that of A. S. C., 1322) upon which the apparent places used in these reductions are founded, are deduced from the Catalogue of N. P. D. in the present volume: excepting only those of (*d*), (*e*), and (*f*), for which the places in the Nautical Almanac have been used.

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

The reduction of the observations of Feb. 16 depends on the value of five revolutions of micrometer *a*. On examining the observations and calculations made in 1836 for deducing the value of micrometer *a*, it was found that, though several arcs had been measured, they had been injudiciously combined, so that the result was affected with the whole value of the error in one observation; and that there was ample reason for supposing the possibility of a large error in that observation. On 1840, Aug. 21, the observations were repeated with both micrometers, and the following results were obtained:

One revolution of *a* between 80^r and $90^r = 30''\cdot752$
between 90^r and $100^r = 31\cdot155$
(this micrometer does not carry its wire beyond 100^r).
One revolution of *b* between 80^r and $90^r = 30''\cdot705$
between 90^r and $100^r = 30\cdot821$
between 100^r and $110^r = 31\cdot161$
between 110^r and $120^r = 30\cdot670$

It appears from this that the adopted value for *b*, namely $30''\cdot721$, may be retained without sensible error: and that the value found for *a* coincides so nearly for that found for *b*, that it is most probable that the screws are exactly equal. Hence, from the data in the note to page 39, the position of the wire *a*, as expressed by means of *b*, ought to be $99^r\cdot711 + 5^r = 104^r\cdot711$, instead of $104^r\cdot926$: the difference is $0^r\cdot215$, or $6''\cdot60$, by which quantity the reading for the star, on February 16, ought to be diminished, or the reading for N. P. D. of Mars ought to be increased, and the error of interpolated N. P. D. ought to be diminished by the same quantity.

The only observations in preceding years whose results are affected by this error are those of Mars and neighbouring stars in 1837, Feb. 14, printed in the volume for 1837, pages 130 to 133, series 13 to 20.

§ 11. *Right Ascensions and North Polar Distances of Galle's First Comet and neighbouring Stars, observed with the South and East Equatoreals: with the Reduction of the Observations*, page 52 to 79.

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 E. = 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 E. = 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. 395.

The authorities for the assumed A. R. of the stars are the following:

δ Ophiuchi, α Lyræ, δ Aquilæ, are taken from the Nautical Almanac.

The mean places of λ Ophiuchi, γ Ophiuchi, β Ophiuchi, d^2 Serpentis, e Serpentis, are brought up from the Astronomical Society's Catalogue, and corrected by adding A a + B b + C c + D d.

The mean places of the other stars (except (*c*) which could not be found with the meridional instruments) are taken from the Observations of 1840, roughly reduced: they are as follows:

	Mean A. R. 1839, Jan. 1.	Mean A. R. 1840, Jan. 1.
	h m s	h m s
(*a*)	16. 29. 42 ·33	
(*b*)	16. 37. 42. 76	
Piazzi XVII. 177		17. 31. 4 ·21
(*d*)		17. 44. 28 ·63
(*e*)		18. 8. 57 ·05
(*f*)		18. 5. 34 ·59
(*g*)		18. 48. 4 ·05

These are corrected by the formula equivalent to A a + B b + C c + D d.

The Apparent Correction for Index Error is found by subtracting the 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-Error 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. 395.

In regard to the North Polar Distances, the following points are to be remarked:

The correction for runs of the declination-circle of the Eastern Equatoreal is given in the notes.

The value of 1^d of the Sector of the South Equatoreal is considered, as in 1838, to be 333″. For 1^r of the micrometer-microscope it was necessary to make a new determination, the microscopes having been altered since 1838. By several experiments made on Jan. 5, 1840, which agreed closely, it appeared that $18^r.668 = 1^d$. from which $1^r = 17''\cdot838$. With these numbers the computation of the column of "Pointer Reading and Micrometer Reading in Arc" has been effected.

The authorities for the assumed N. P. D. of the stars are as follows:

The places of δ Ophiuchi and δ Aquilæ are taken from the Nautical Almanac.

The mean places of all the other stars are taken from the Observations of 1840 roughly reduced: they are as follows:

	Mean N. P. D. 1839, Jan. 1.	Mean N. P. D. 1840, Jan. 1.
	° ′ ″	
(a)	86. 34. 30 ·12	
λ Ophiuchi......	87. 39. 28 ·59	
(b)	86. 48. 46. 72	
		° ′ ″
Piazzi XVII. 177		87. 52. 27 ·41
β Ophiuchi		85. 21. 36 ·40
γ Ophiuchi		87. 13. 36 ·83
(d)		88. 14. 45 ·83
(e)		89. 2. 36 ·13
(f)		89. 21. 9 ·67
d^2 Serpentis..........		89. 53. 35 ·45
e Serpentis..........		91. 6. 36 ·84
(g)..........		91. 59. 51 ·29

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-error 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 24 clock time of observation.....	13. 36. 44 ·0
25	13. 37. 59 ·5
26	13. 39. 16 ·0
29	13. 43. 46 ·0
30	13. 45. 10 ·0

The Interpolated N. P. D., as well as the log. distance used in computing the parallax, is calculated from the Ephemeris in the Astronomische Nachrichten, No. 395.

For the method of computing all the refractions and parallaxes in the Equatoreal Observations, the reader is referred to the Observations of 1836, page lxiv.

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

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, with one exception only, namely the A. R. of 96 Aquarii, October 19. The A. R. has been erroneously computed in the Nautical Almanac, and ought to be $23^h. 11^m. 6^s{\cdot}81$, instead of $23^h. 10^m. 59^s{\cdot}32$. 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. 1^{st} n° = 2 log. diff. A.R. + log. sine (sum of N.P.D.) — log. dist. + 4·0835.

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

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

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

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

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 analagous 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 Free Magnetic Needle, &c.*

In consequence of a representation of the Board of Visitors to the Lords Commissioners of the Admiralty, an additional space of ground on the south-east side of the existing boundary of the Observatory grounds was inclosed from Greenwich Park for the site of a Magnetic Observatory, in the summer of 1837. In the spring of 1838 the Magnetic Observatory was erected. Its nearest angle is about 230 feet from the nearest part of the Astronomical Observatory, and about 170 feet from the nearest outhouse. It is built of wood; iron is carefully excluded. Its form is that of a cross with four equal arms, nearly in the direction of the cardinal magnetic points: the length within the walls, from the extremity of one arm of the cross to the extremity of the opposite arm, is forty feet: the breadth of each arm is twelve feet. The height of the walls inside is ten feet, and the ceiling of the room is about two feet higher. The northern arm of the cross is separated from the central square by a partition, so as to form an ante-room. The meridional magnet is mounted in the southern arm: it is intended to mount a bifilar magnet in the eastern arm, and a magnetometer for variations of vertical force in the western arm.

The theodolite with which the meridional magnet is observed is by Simms: the radius of its horizontal circle is 8·3 inches: it is divided to 5', and read to 5" by three verniers, carried by the revolving frame of the theodolite. The fixed frame stands upon three foot-screws, which rest in brass channels let into a stone pier, that is firmly fixed in the ground and unconnected with the floor. The revolving frame carries the Y's (with vertical adjustment at one end) for a telescope with transit axis: the length of the axis is ten inches and a half: the length of the telescope twenty-one inches: the aperture of the object-glass two inches. The Y's are not carried immediately by the T head which crosses the vertical axis of the revolving frame, but by pieces supported by the ends of that T head and projecting horizontally from it: the use of this construction is, to allow the telescope to be pointed sufficiently high to see δ Ursæ Minoris above the pole. The eye-piece of the telescope carries only one fixed horizontal wire, and one vertical wire moved by a micrometer-screw. The stone pier is fixed nearly in the line which divides the southern arm of the cross from the central square: in the roof of the building an opening is made (closed by shutters), in the direction of the astronomical meridian of the pier, through which circumpolar stars can be observed, as high as δ Ursæ Minoris above the pole, and as low as β Cephei S. P.

For supporting the magnet, a braced tripod wooden stand is provided, resting on the ground and unconnected with the floor. Upon the cross-bars of the stand rests a drum (having a covering of glass), within which the magnet vibrates. On the southern side of the principal upright piece is a moveable upright bar, turning in the vertical E. and W. plane, upon a pin in its center, which is fixed in the principal upright: this moveable upright piece carries at its top the pulleys for suspension of the magnet; and this construction is adopted in order to give an E. and W. movement to the point of suspension, by giving a motion to the lower end of the bar. The top of the upright piece carries a brass frame with two pulleys: one of these pulleys projects beyond the north side of the principal upright, and from it depends the suspension skein: the other pulley projects on the south side: the suspension skein being brought from the magnet up to the north pulley is then carried over it and over the south pulley, and is then attached to a string, which passes downwards to a small windlass, that is carried by the lower part of the moveable upright. The intention of this construction is, to make it easy to alter the height of the magnet without the trouble of climbing to the top of the frame. The height of the two pulleys above the floor is about eleven feet nine inches, and the height of the magnet is about three feet: so that the length of the free suspending skein is about eight feet nine inches.

The magnet was made by Meyerstein, of Göttingen: it is a bar two feet long, one inch and a half broad, and about a quarter of an inch thick: it is of hard steel throughout. The suspension-piece was also made by Meyerstein, but it has since been altered under my direction by Simms. The magnet is not now inserted endways in its support, but sideways; a double square hook being provided for sustaining it: and (by an alteration very lately made) the upper part of the suspension-piece is simply hooked into the skein.

The suspending skein is of silk fibre, in the state in which it is first prepared by silk-manufacturers for further operations; namely, when seven or more fibres from the cocoon are united by juxtaposition only (without twist) to form a single thread. It was reeled for this purpose at my request by Mr. Vernon Royle, of Manchester. The skein is strong enough to support perhaps six times the weight of the magnet, &c.: I judged this strength to be necessary, having found that a weaker skein (furnished by Mr. Meyerstein) broke ultimately even with a smaller weight.

Upon the magnet there slide two small brass frames, firmly fixed in their places by means of pinching-screws. One of these contains, between two plane glasses, a cross of delicate cobwebs: the other holds a lens, of thirteen inches focal length and nearly two inches aperture. This combination, therefore, serves as a collimator without a tube: the cross of cobwebs is seen very well with the theodolite telescope, when the suspension bar of the magnet is so adjusted as to place the collimator object-glass in front of the theodolite object-glass, their axes coinciding. The wires are illuminated by a lamp and lens in the night, and by a reflector in the day.

In order to diminish the extent of vibrations of the magnet, a copper bar, about one inch square, is bent into a long oval form, intended to contain within itself the magnet (the plane of the oval curve being vertical). A lateral bend is made in the upper half of the oval, to avoid interference with the suspension-piece of the magnet. The effect of this copper bar is very striking: it appears, from rough experiments, that every second vibration of the magnet (that is, when a direct and reverse swing have been finished) is reduced in the proportion of 5 : 2 nearly. Two such bars were mounted, for convenience of use, in different positions of the magnet. Experiments made in the year 1840 have given reason to think that one of them (that which was used in 1839 with the collimator west) is not entirely free from magnetic action: and the determinations, therefore, when the collimator was west, may be liable to an unknown constant error from this cause.

It is proper also to mention another circumstance which may have introduced constant error in some of the observations. When the skein of silk was mounted, it was found too short to pass down to the windlass on the south side of the suspension-bar: and it was lengthened by attaching to it a piece of string at the end next the windlass. The tension caused by the weight of the magnet, &c., gave a strong twist to the string and the adjacent part of the skein. The friction upon the suspension pulleys was quite sufficient to prevent this twist from being communicated to that part of the skein to which the magnet is attached: and, as care had been used at first to take out the twist in that part by the suspension of a brass bar, and as care was habitually taken to maintain a pressure upon the suspension-hook whenever the magnet was taken out, it is extremely probable that no sensible error is caused by the transmission of the twist over the pulleys. It is, however, possible that error is caused, as it was found in 1840 that a complete relaxation of the pressure would allow a twist to be given to the suspending part of the skein. An alteration has now (1840) been made in the mounting, which will effectually prevent this twist in future.

The following are the determinations of the different elements of reduction of the observations:

1. To determine the micrometer reading for the line of collimation of the theodolite-telescope.

   On 1839, Feb. 16, the magnet, with its collimator, was placed on blocks, and the cross of cobwebs was observed as a fixed mark: the theodolite being clamped, and the telescope-axis being reversed at each observation. The results were as follows:

Position of Illuminated End.	Readings of Theodolite Micrometer.	Position of Illuminated End.	Readings of Theodolite Micrometer.	Position of Illuminated End.	Readings of Theodolite Micrometer.
W	r 99·540	W	r 99·445	W	99·463
E	100·672	E	100·631	E	100·660
W	99·475	W	99·453	W	99·450
E	100·613	E	100·612	E	100·648

The mean of these, or $100^{r}{\cdot}056$ is used for the true line of collimation.

2. To determine the inequality of the pivots of the theodolite-telescope.

On 1838, June 6, the telescope was repeatedly reversed, and the level applied in each position. The following are the results; the measures being in parts of the level scale, and each result being derived from six applications of the level, in positions alternately reversed.

Position of Illuminated End.	West End apparently High.	Position of Illuminated End.	West End apparently High.	Position of Illuminated End.	West End apparently High.
E	p − 6·21	E	p − 4·74	E	p − 2·72
W	+ 0·69	W	+ 2·94	W	+ 2·85
E	− 5·49	E	− 2·19	E	− 3·65
W	+ 3·08	W	+ 2·41	W	+ 2·87

From these it appears, that the end of the level which is placed upon the illuminated end is too high by $3^{p}{\cdot}32$. And, as the angles of the Y's and those of the level-forks are nearly equal, we may conclude that, when the level indicates the axis to be horizontal, the axis at the illuminated end is really too low by $1^{p}{\cdot}66$. One part of the level scale was found by Mr. Simms to be equal to $1''{\cdot}0526$.

3. To determine the reading of the azimuth-circle of the theodolite for the astronomical meridian.

The following table, it is presumed, will require no other explanation than this: that the error of level is determined by application of the spirit-level at the time of observation (due regard being paid, in the reduction, to the inequality of pivots already found, and to the value of its scale); and that the azimuth-reading is then corrected by the quantity, elevation of W. end of axis × tan. star's altitude. The readings of the azimuth-circle increase as the instrument is turned from N. to E. S. W.: from which it follows that the correction must have the same sign as the elevation of the W. end.

OBSERVATIONS with the MAGNETIC THEODOLITE for ascertaining the READING of its HORIZONTAL CIRCLE, corresponding to the ASTRONOMICAL MERIDIAN.

Day, 1839.	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.
		r	° ′ ″	″	″	° ′ ″	h m s	h m s	h m s	° ′ ″	° ′ ″	° ′ ″	° ′ ″	″	″	° ′ ″
Feb. 16	δ Ursæ Min. S.P.	100·056	89. 18. 70	20	30	89. 18. 40·0	5. 59. 44	6. 0. 26·2	18. 23. 57·2	3. 24. 57	+0. 31. 24·14	89. 49. 64·14	89. 49. 59·78	0·00	0·00	89. 49. 59·78
			89. 22. 90	40	55	89. 23. 1·7	6. 3. 12	6. 3. 54·0			+0. 26. 47·00	48·70				
			89. 27. 95	40	45	89. 28. 0·0	6. 6. 47	6. 7. 29·0			+0. 22. 0·52	60·52				
			89. 32. 30	5	0	89. 32. 11·7	6. 9. 57	6. 10. 39·0			+0. 17. 47·42	59·12				
			89. 36. 85	55	50	89. 37. 3·3	6. 13. 33	6. 14. 15·0			+0. 12. 59·26	62·56				
			89. 40. 100	50	55	89. 41. 8·3	6. 16. 43	6. 17. 25·0			+0. 8. 45·33	63·63				
Feb. 25	Polaris	100·056	87. 21. 25	10	5	87. 21. 13·3	6. 50. 20	6. 50. 44·0	1. 0. 59·0	1. 32. 39	+2. 28. 46·30	89. 49. 59·60	89. 50. 4·10	0·00	0·00	89. 50. 4·10
			87. 21. 40	22	15	87. 21. 25·7	6. 59. 50	7. 0. 14·0			+2. 28. 42·90	68·60				
Feb. 27	δ Ursæ Min. S.P.	100·056	89. 32. 65	25	25	89. 32. 38·3	6. 10. 37	6. 10. 54·0	18. 24. 0·0	3. 24. 59	+0. 17. 31·60	89. 49. 69·90	89. 50. 1·75	0·00	0·00	89. 50. 1·75
			89. 37. 70	40	50	89. 37. 53·3	6. 14. 35	6. 14. 52·0			+0. 12. 14·05	67·35				
			89. 44. 50	27	35	89. 44. 37·3	6. 19. 34	6. 19. 51·0			+0. 5. 34·05	71·35				
			89. 48. 88	45	55	89. 49. 2·7	6. 23. 2	6. 23. 19·0			+0. 0. 55·00	57·70				
			89. 53. 50	25	20	89. 53. 31·7	6. 26. 22	6. 26. 39·0			−0. 3. 33·34	58·30				
			89. 56. 80	53	60	89. 57. 4·3	6. 29. 1	6. 29. 18·0			−0. 7. 6·41	57·89				
			90. 0. 70	30	30	90. 0. 43·3	6. 31. 47	6. 32. 4·0			−0. 10. 48·59	54·71				
			90. 4. 73	40	45	90. 4. 52·7	6. 34. 53	6. 35. 10·0			−0. 14. 56·95	55·75				
			90. 9. 65	33	45	90. 9. 47·7	6. 38. 29	6. 38. 46·0			−0. 19. 44·91	62·79				
Mar. 13	δ Ursæ Min. S.P.	100·056	80. 44. 75	55	50	89. 45. 0·0	6. 20. 37	6. 20. 11·0	18. 24. 5·0	3. 25. 1	+0. 5. 14·02	89. 50. 14·02	89. 50. 7·71	0·00	0·00	89. 50. 7·71
			80. 50. 35	10	7	89. 50. 17·3	6. 24. 41	6. 24. 15·0			−0. 0. 13·42	3·88				
			89. 59. 85	55	45	90. 0. 1·7	6. 31. 52	6. 31. 26·0			−0. 9. 51·16	10·54				
			90. 4. 63	35	32	90. 4. 43·3	6. 35. 24	6. 34. 58·0			−0. 14. 37·08	6·22				
			90. 8. 65	35	30	90. 8. 43·3	6. 38. 25	6. 37. 59·0			−0. 18. 35·76	7·54				
			90. 12. 55	15	25	90. 12. 31·7	6. 41. 19	6. 40. 53·0			−0. 22. 27·62	4·08				
May 21	Polaris... S. P.	100·056	90. 3. 77	40	43	90. 3. 53·3	13. 22. 49	13. 22. 51·0	1. 1. 7·0	1. 33. 2	−0. 13. 40·80	89. 50. 12·50	89. 50. 12·67	8·86	10·53	89. 50. 23·20
			90. 8. 35	10	5	90. 8. 16·7	13. 29. 48	13. 29. 50·0			−0. 18. 3·80	12·90				
			90. 10. 43	5	7	90. 10. 18·3	13. 33. 3	13. 33. 5·0			−0. 20. 5·70	12·60				
May 27	Polaris... S. P.	100·056	89. 56. 70	42	45	89. 56. 52·3	13. 12. 23	13. 11. 53·0	1. 1. 11·0	1. 33. 3	−0. 6. 44·60	89. 49. 67. 70	89. 50. 3·75	9·78	11·62	89. 50. 15·37
			89. 58. 50	30	20	89. 58. 33·3	13. 15. 0	13. 14. 30·0			−0. 8. 23·50	69·80				
			90. 0. 40	7	10	90. 0. 19·0	13. 17. 58	13. 17. 28·0			−0. 10. 15·60	63·40				
			90. 2. 35	0	3	90. 2. 12·7	13. 20. 57	13. 20. 27·0			−0. 12. 8·10	64·60				
			90. 3. 60	25	25	90. 3. 36·7	13. 23. 13	13. 22. 43·0			−0. 13. 33·70	63·00				
			90. 5. 68	43	45	90. 5. 52·0	13. 27. 3	13. 26. 33·0			−0. 15. 58·00	54·00				
Aug. 28	δ Ursæ Minoris.	100·056	90. 41. 90	50	45	90. 42. 1·7	17. 51. 49	17. 50. 11·0	18. 24. 12·0	3. 24. 25	−0. 52. 27·90	89. 49. (33·8)	89·50. 5·47	0·00	0·00	89. 50. 5·47
			90. 36. 70	40	35	90. 36. 48·3	17. 55. 32	17. 53. 54·0			−0. 46. 46·80	61·50				
			90. 4. 47	5	10	90. 4. 20·7	18. 16·46	18. 15. 8·0			−0. 14. 3·20	77·50				
			90. 0. 50	5	5	90. 0. 20·0	18. 19. 17	18. 17. 39·0			−0. 10. 9·60	70·40				
			89. 56. 45	5	5	89. 56. 18·3	18. 21. 48	18. 20. 10·0			−0. 6. 15·50	62·80				
			89. 52. 87	53	50	89. 53. 3·3	18. 23. 53	18. 22. 15·0			−0. 3. 1·50	61·90				
			89. 49. 40	5	15	89. 49. 20·0	18. 26. 15	18. 24. 37·0			+0. 0. 38·80	58·80				

OBSERVATIONS with the MAGNETIC THEODOLITE for ascertaining the READING of its HORIZONTAL CIRCLE, corresponding to the ASTRONOMICAL MERIDIAN, *continued*.

Day, 1839.	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.
		r	° ′ ″	″	″	° ′ ″	h m s	h m s	h m s	° ′ ″	° ′ ″	° ′ ″	° ′ ″	″	″	° ′ ″
Sep. 2	λ Ursæ Minoris	100 ·056	90. 1.47	13	15	90. 1.25 ·0	20. 1.41	19.59.56 ·0	20.22.24 ·0	1.10.16	−0.11.20 ·00	89.49.65 ·00				
			89.58.40	10	5	89.58.18 ·3	20. 7.49	20. 6. 4 ·0			−0. 8.14 ·70	63 ·60				
			89.56.65	37	37	89.56.46 ·3	20.10.45	20. 9. 0 ·0			−0. 6.45 ·90	60 ·40	89.50. 1 ·07	4 ·02	5 ·30	89.50. 6.37
			89.55.32	0	0	89.55.10 ·7	20.13.45	20.12. 0 ·0			−0. 5.15 ·30	55 ·40				
			89.51.60	30	30	89.51.40 ·0	20.20.48	20.19. 3 ·0			−0. 1.41 ·50	59 ·50				
			89.50.40	11	5	89.50.18 ·7	20.23.37	20.21.52 ·0			−0. 0.16 ·20	62 ·50				
Nov. 26	Polaris	100 ·056	89.59.70	45	50	89.59.55 ·0	0.45.59	0.47.51 ·0	1. 2.22 ·0	1.32.20	−0. 9.42 ·90	89.49.72 ·10				
			89.56.68	45	45	89.56.52 ·7	0.50. 5	0.51.57 ·0			−0. 7. 1 ·30	51 ·40				
			89.54.80	50	55	89.55. 1 ·7	0.52.53	0.54.45 ·0			−0. 5. 8 ·10	53 ·60				
			89.52.90	60	50	89.53. 6 ·7	0.55.39	0.57.31 ·0			−0. 3.14 ·80	51 ·90	89.49.54 ·90	3 ·50	− 4 ·70	89.49.50 ·20
			89.51.40	15	15	89.51.23 ·3	0.58. 2	0.59.54 ·0			−0. 1.39 ·80	43 ·50				
			89.49.80	45	55	89.50. 0 ·0	1. 0.25	1. 2.17 ·0			−0. 0. 3 ·40	56 ·60				

4. Observations for the value of the micrometer-screw in the theodolite-telescope.

The micrometer being placed in different positions, the theodolite was turned till the micrometer-wire bisected the same object, and the verniers of the horizontal-circle were read. In the observations of Dec. 21 and Dec. 26, the magnet was supported on blocks, and its collimator-cross was observed as a fixed mark.

Day, 1838.	Object.	Reading of Micrometer.	Reading of Verners. A	B	C	Mean.	Difference.	Corresponding value of 1r.
		r	° ′ ″	″	″	° ′ ″	′ ″	′ ″
June 7	Edge of stone coping on the Library.	92 ·000	246.21.50	30	68	246.21.49 ·3	32.53 ·0	1.33 ·95
		113 ·000	246.54.40	28	59	246.54.42 ·3		
		92 ·000	246.21.58	40	78	246.21.58 ·7	32.42 ·3	1.33 ·44
		113 ·000	246.54.38	25	60	246.54.41 ·0		
		92 ·000	246.21.59	43	77	246.21.59 ·7	32.33 ·6	1.33 ·03
		113 ·000	246.54.30	17	53	246.54.33 ·3		
		92 ·000	246.21.53	38	67	246.21.52 ·7	32.47 ·0	1.33 ·67
		113 ·000	246.54.35	28	56	246.54.39 ·7		
Dec. 21	Collimator cross, fixed	95 ·000	245.32.60	30	92	245.33. 0 ·7	8. 2 ·7	1.36 ·54
		100 ·000	245.24.57	32	85	245.24.58 ·0	7.46 ·3	1.33 ·26

Day, 1838.	Object.	Reading of Micrometer.	Reading of Verniers. A	B	C	Mean.	Difference.	Corresponding value of 1r.
		r	° ′ ″	″	″	° ′ ″	′ ″	′ ″
Dec. 21	Collimator cross, fixed	105 ·000	245.16.73	47	95	245.17.11 ·7	7.46 ·3	1.33 ·26
		110 ·000	245. 9.25	9	55	245. 9.29 ·7	7.42 ·0	1.32 ·40
		114 ·000	245. 2.60	32	86	245. 2.59 ·3	6.30 ·4	1.37 ·60
Dec. 26		94 ·000	245.15.15	5	43	245.15.21 ·0	1.44 ·3	1.44 ·30
		95 ·000	245.16.53	50	93	245.17. 5 ·3	7.51 ·4	1.34 ·28
		100 ·000	245.24.44	44	82	245.24.56 ·7	7.48 ·3	1.33 ·66
		105 ·000	245.32.30	33	72	245.32.45 ·0	7.46 ·7	1.33.34
		110 ·000	245.40.20	20	55	245.40.31 ·7	7.50 ·6	1.34 ·12
		115 ·000	245.47.75	57	115	245.48.22 ·3		

The value adopted for 1^r is $1'.34''{\cdot}07$.

5. To determine the time of vibration of the magnet loaded with its collimator, &c., when suspended for observation.

The times at which the image of the cross in the collimator passed the micrometer-wire of the theodolite-telescope in a certain fixed position, were noted as follows:

Observations for the Time of Vibration of the Meridional Magnetic Needle.

Day, 1839.	Clock Time of Collimator-cross passing the Micrometer-wire.	Intervals in Sidereal Time.	Day, 1839.	Clock Time of Collimator-cross passing the Micrometer-wire.	Intervals in Sidereal Time.
	m s	s		h m s	s
Jan. 28	29. 17 ·3		Jan. 29	52. 45 ·8	31 ·0
	29. 47 ·6	30 ·3		53. 15 ·4	29 ·6
	30. 18 ·3	30 ·7		53. 48 ·2	32 ·8
	30. 48 ·3	30 ·0		54. 16 ·8	28 ·6
	31. 19 ·1	30 ·8		54. 48 ·6	31 ·8
	31. 48 ·9	29 ·8		55. 18 ·1	29 ·5
	32. 19 ·2	30 ·3	Jan. 30	21. 25. 18 ·6	
	32. 49 ·3	30 ·1		25. 49 ·2	30 ·6
	33. 19 ·7	30 ·4		26. 17 ·9	28 ·7
	33. 50 ·0	30 ·3		26. 50 ·3	32 ·4
	34. 20 ·6	30 ·6		27. 21 ·4	31 ·1
	34. 50 ·4	29 ·8		27. 53 ·1	31 ·7
Jan. 29	49. 42 ·5			28. 23 ·0	29 ·9
	50. 13 ·0	30 ·5		28. 56 ·3	33 ·3
	50. 43 ·7	30 ·7		29. 26 ·3	30 ·0
	51. 14 ·0	30 ·3		29. 58 ·3	32 ·0
	51. 45 ·0	31 ·0		30. 27 ·8	29 ·5
	52. 14 ·8	29 ·8		30. 59 ·3	31 ·5

From these it appears that 30^s may in practice be used as the time of vibration of the magnet.

The observations of the magnet, in the series to which we are about to proceed, as well as in the actual determinations in the body of the work, were made in the following manner. The hour-circle of the theodolite being clamped, and the verniers read, the collimator-cross was viewed through the theodolite-telescope, while the observer listened to the beats of a clock. At every thirtieth beat, the observer brought the wire of the telescope-micrometer upon the image of the cross, and read the micrometer. This observation can be made with great delicacy. The mean between each reading and the next is taken as the reading for the quiescent position of the magnet: which it would be if there were no change in the direction of magnetism during the vibration (the observations at intervals equal to the time of vibration necessarily finding the magnet in opposite phases of its vibration): and the operation is accurate only on the supposition that the direction does not change sensibly during the vibration. Several means between adjacent readings being taken, the mean of all is adopted as the place of the magnet for the mean of all the times. The telescope is placed so that its micrometer-head is on the left side of the telescope: in this position, the micrometer-readings increase as the North end of the magnet swings to the East; and, if the micrometer-readings are to be combined with the circle-readings, their equivalents are to be added.

6. To determine the error of collimation of the magnet-collimator, with reference to the magnetic axis of the magnet.

A magnetized bar of the same size was suspended on a tripod in the Octagon Room: a reflector was attached to its center: and a telescope with a wire in its focus was directed to the reflector, so as to view by reflection from its surface a scale which was fixed immediately below the object-glass of the telescope. The distance of the scale from the reflector was $7^{f}.\ 4^{in}\cdot 8$: each division of the scale = $\frac{12}{31}$ inch: from which it appeared that the apparent movement of one division of the scale across the wire indicated a change of position of the magnet equal to $7'.\ 29''\cdot 7$, or equal to $4^{r}\cdot 781$ of the theodolite-micrometer. The time of vibration of this magnet was nearly 20^{s}. One observer, therefore (Mr. Glaisher), observed the magnet in the Octagon Room every 20^{s}, while another (Mr. Main) observed the magnet in the Magnetic Observatory every 30^{s}, then reversed it in its hooks and again observed it, and so on. The results are contained in the following table.

Day, 1840.	Clock Time.	Position of Collimator.	Mean Micrometer Reading.	Mean Reading of Scale for temporary Magnet.	Equivalents in Revolutions of the Micrometer, — 220ʳ.	Micrometer Reading for Collimator diminished by equivalents for temporary Needle.
	h m s		r	d	r	r
July 25	7. 0. 45	West	101·431	48·89	13·737	87·694
	7. 2. 45	West	100·316	48·83	13·450	86·866
	7. 26. 45	East	106·873	48·76	13·116	93·757
	7. 28. 45	East	106·833	48·64	12·542	94·291
	7. 50. 45	West	98·346	48·44	11·586	86·760
	7. 52. 45	West	97·891	48·67	12·686	85·205
	8. 13. 45	East	105·083	48·34	11·108	93·975
	8. 15. 45	East	104·522	48·52	11·969	92·553
	8. 40. 45	West	98·021	48·51	11·921	86·100
	9. 8. 45	East	105·258	48·59	12·303	92·955

From these observations it appears that, when the collimator is East, the micrometer-reading is too great by $3^{r}\cdot491$ or $5'.28''\cdot4$. As that copper oval was employed, which appears to be without action on the magnet, this result is probably worthy of great confidence.

7. To determine the error produced by the plate-glass placed in front of the opening in the drum.

A small mark in the glass serves to define its position. This mark is usually on the western side. On July 31, 1840, the magnet being placed on blocks, and the theodolite clamped, observations of the collimator-cross were made, reversing the glass after every observation: the results are as follows:

Mean of 10 readings, mark East, $99^{r}\cdot963$
Mean of 10 readings, mark West, $100\cdot149$

Hence with the mark West, or in its usual position, the reading is too great by $0^{r}\cdot093 = 8''\cdot7$.

I may now proceed to explain the course pursued in the observations, of which the results only are given in the printed Observations.

The Göttingen mean time being converted into Greenwich mean time, the sidereal time was computed (there being only a sidereal clock in the apartment), and the clock-error being applied, the clock-time for each observation was found. The nearest even seconds were taken (in the Observations of Feb. 22, the nearest multiple of 15^{s}, in the others the nearest multiple of 10^{s}), and 45^{s} was subtracted from this, for the first observation: for the others there were added to this 30^{s}, 60^{s}, and 90^{s}. Thus four times were pre-arranged for each 5-minutely determination, the intervals of those times being the same as the time of vibration of the magnet, and the mean of the times being not more than 5^{s} distant from the required Göttingen time.

The observations were distributed among the six assistants and myself, each person taking the observations of two hours at a time.

Each observer read the verniers of the theodolite at least once during his term of observations. And if (as sometimes happened) the magnet moved so far that it was necessary to turn the theodolite, the verniers were immediately read. It was found (from a comparison of readings made at other times) that the vernier-readings of Mr. Richardson were always too great by $9''$, and they have not therefore been used.

The rest of the observation consisted simply in observing the cross with the micrometer-wire at each of the pre-arranged times.

The reduction consisted in taking the mean of each pair of adjacent-readings (which gave three means for each 5-minutely observation), taking the mean of these three, and converting it into arc by the value $1^r = 1'.34''\cdot07$: then adding this to the adopted mean of verniers, and diminishing the sum by $2°.36'.52''\cdot3$, which is the equivalent for $100^r\cdot056$, the reading for the line of collimation. The results then become comparable with the results of the astronomical observations.

It is to be observed that, in the reduced results here given, the corrections for error of collimation of the magnet and error produced by the plate-glass are not applied. The reader can apply these without difficulty : but the results will still be subject to some uncertainty from the possible effect of the (apparently) ferruginous copper bar, and from the possible effect of torsion.

§ 14. *Meteorological Observations made on the Days of the Equinoxes and Solstices.*

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.