GREENWICH
ASTRONOMICAL OBSERVATIONS,
1897.

INTRODUCTION.

I. *Personal Establishment and Arrangement.*

At the beginning of the year 1897 the Established Staff in the Astronomical Department of the Observatory consisted of the following persons :—

Chief Assistants,—Frank Watson Dyson, M.A., Fellow of Trinity College, Cambridge; Philip Herbert Cowell, M.A., Fellow of Trinity College, Cambridge.

First Class Assistants,—Edward Walter Maunder; Thomas Lewis; William Grasett Thackeray; Henry Park Hollis, B.A.

Second Class Assistants,—Andrew Claude de la Cherois Crommelin, B.A.; Walter William Bryant, B.A.

Clerical Assistant,—Henry Outhwaite.

Established Computers,—Charles Davidson; Robert Fermor Rendell, B.A.; William Bowyer.

On November 26, Mr. Herbert Henry Furner was appointed an Established Computer.

In addition to the Assistants and Established Computers, nineteen Supernumerary Computers were employed in the Astronomical Department.

The duties of the establishment are distributed in the following manner :—

The Chief Assistants, in the absence of the Astronomer Royal, are empowered to act in all respects as his representatives, and to conduct confidential as well as routine business. In the ordinary transactions, the Chief Assistants superintend the calculations generally; and observe occasionally with any of the instruments. The Chief Assistants are charged with the adoption of clock-rates, instrumental zeros, and instrumental errors.

Mr. Thackeray is charged with the deduction of the results of the meridian observations, and with the general superintendence of the Computers of the Astronomical Reductions Branch, by whom the great mass of calculations and of reading proof-sheets is effected. Mr. Bryant, assisted by Mr. Rendell, undertakes the transit and meridian zenith distance reductions.

Mr. Crommelin has charge of the altazimuth and of the Sheepshanks equatorial, and of the reduction of the observations made with them.

The charge of the sidereal and solar clocks, the distribution of time-signals, the dropping of the time-signal ball at 1^h, the management of the galvanic apparatus and connections, the receiving, rating, and issuing of chronometers, and all the computations relating to the time-department, are confided to Mr. Lewis. Mr. Lewis also has charge of the 28-inch equatorial.

Mr. Hollis superintends the astrographic observations and reductions.

The measurement of the solar photographs and the superintendence of the reductions connected with them are entrusted to Mr. Maunder.

Mr. Outhwaite has charge of the money-accounts, the stores and stationery, and distribution of the publications of the Observatory; and undertakes part of the miscellaneous correspondence. The care of the library is also entrusted to him.

The course of observations and the succession of observers are arranged every Monday by one of the Chief Assistants and sanctioned by the Astronomer Royal. It is established as a rule, to be adhered to as closely as circumstances permit, that no Assistant be occupied on two successive days with astronomical observations. In general, the Assistant who makes the observations with the transit-circle is charged with all the observations that may occur from 19^h mean solar time (7 o'clock in the morning) to the next 14^h. During the latter part of the lunation, when the moon passes the meridian in the early morning between 14^h and 19^h, it is found necessary to appoint separate observers for the morning and the evening.

The observations with the transit-circle in 1896 were generally made by Mr. Hollis, Mr. Crommelin, Mr. Bryant, Mr. Bowyer, Mr. Davidson, and Mr. Rendell. When the moon passes the meridian in the early morning, or in the absence of the regular observers, one of the supernumerary Computers is charged with the observations.

Observations of the Moon with the altazimuth during the first and last quarters of the lunation were made by Mr. Hollis, Mr. Crommelin, and Mr. Bryant.

Observations of Occultations and Phenomena of Jupiter's Satellites were generally made by the observer on duty with the transit-circle.

Photographs with the astrographic equatorial were generally taken by Mr. Hollis, Mr. Bowyer, Mr. Davidson, and Mr. Rendell, or one of the supernumerary Computers.

Observations with the 28-inch refractor were made by Mr. Lewis and Mr. Bowyer.

Photographs of the Sun with the Dallmeyer photoheliograph were taken by Mr. Maunder, or by one of the Computers under his direction.

The following are the signatures of those persons who have made observations in 1897 :—

W. H. M. Christie	WC	C. Davidson -	- CD	E. H. Banks -	- EB
F. W. Dyson	- D	D. J. R. Edney	- DE	F. Turner -	- FT
P. H. Cowell	- C	R. F. Rendell	- R	P. G. Showell	- S
E. W. Maunder	- M	W. Bowyer -	- WB	A. J. Wilkin -	- AW
T. Lewis -	- L	H. H. Furner	- HF	W. M. Witchell	- W
W. G. Thackeray	- T	H. Appleyard	- HA	J. Storey -	- JS
H. P. Hollis -	- H	R. Cheeseman	- RC	W. Stevens -	- WS
A. C. D. Crommelin	AC	C. Lacey -	- CL	J. A. West -	- JW
W. W. Bryant	- B	G. F. Johns -	- J		

II. *Instruments.*

The principal Instruments used by Halley, Bradley, Bliss, and Maskelyne are still preserved in the Royal Observatory: namely, Halley's Transit, with pivots unequally distant from the telescope; Bradley's Transit; Bradley's small Equatorial; the Zenith sector of Bradley and Maskelyne; and the two Mural quadrants, which till 1887 November 17 were both mounted on their pier, the quadrant on the western side of the pier being included in the smaller fire-proof room of the Observatory. On 1887 November 18, in the course of operations for the extension of the computing rooms, the quadrant on the western side of the pier was removed to the Transit-circle room, that on the eastern side being now included (without having been disturbed) in the Lower Computing room; and an extension of the pier was built to carry an equatorial. The ancient instruments first mentioned, together with the telescopes for investigating the parallaxes of α Aquilæ and α Cygni, formerly attached respectively to the west side of the pier of Troughton's mural circle, and to the Quadrant pier, are now, with proper labels, suspended on brackets on the western wall of the Transit-circle room.

Troughton's Transit instrument and Mural circle, used to the end of the year 1850, were dismounted in the year 1851, and are suspended, the one on the west and the other on the east wall of the Transit-circle room. The object-glass of the transit instrument is now inserted in the reflex zenith-tube.

The 25-foot zenith-sector was dismounted, and its tube was divided (at its joints) into several parts, in May 1848; and the separate portions of the instrument are stored away in frames constructed to hold them. The object-glass was removed from the tube in 1850, to be used for the collimator of the altazimuth.

Jones's Cape circle was transferred in November 1851 to the Observatory of Queen's College, Belfast.

The Lassell Reflector was dismounted in October 1897, the Dome in which it was previously mounted having been taken down in July and August 1895, and re-erected on the central portion of the new Observatory building in September 1896.

The Instruments now in use are the following :—

The Transit-circle, constructed by Messrs. Ransomes and May, as engineers, and by the late Mr. William Simms, as optician, erected in the year 1850, and brought into use at the beginning of 1851.

The room in which this instrument is mounted occupies the site of the old Circle-room, but is extended to the south, so that its entire length is 36 feet. The ridge of the roof is in the north-and-south direction. The opening in the roof, along the ridge, is 3 feet wide, and is covered by four shutters. The vertical openings in the north and south walls are also 3 feet wide, and each is covered by a single shutter. Any one of the shutters can be opened without disturbing the others.

A detailed description of the instrument, illustrated by plates, is given in Appendix I. of the volume for 1852: a reprint of which, with some modifications, is attached to the volume for 1867. The following particulars may be given here. The centre of the instrument is about $5\frac{1}{2}$ feet south and 19 feet east of the old transit-instrument. The focal length of its object glass is 11 feet 7 inches, and the clear aperture 8·1 inches. It was repolished by Messrs. Troughton and Simms in 1891 August and September. The full aperture is used in all observations, including those of the Sun. The power of the eyepiece ordinarily employed is 195, and of that used for observations of the Sun 180. The axis of the instrument is of cast-iron, in two similar pieces, the length between the extremities of the pivots being 6 feet. The mould of the pivot was made of iron, for the purpose of hardening it by the process technically called *chilling*; the moulds for the other parts were sand. The two halves are connected by bolts through flanges at the junction-plane in the middle of the cube. The two portions of the telescope-tube (also of cast-iron, with the exception of the object-glass cell and the eyepiece-work) are bolted on the central cube. The pivots are of "chilled" iron and their diameter is 6 inches, the bearing of each being upon two portions of a concave cylinder, forming the Y. The Y's are firmly screwed down to the massive piers between which the instrument is mounted, and have only been disturbed for adjustment, cleaning, &c., on the following occasions—1870 November 19, 1877 December 4, 1881 July 27–29, 1888 January.

For examination of the form of the pivots, each is perforated; within the hollow of the eastern pivot there is fixed a plate of metal perforated with a hole about 0·01 inch in diameter, behind which a light can be placed for illumination; at the distance of 6 inches from this hole is a lens of 1 inch focal length, producing an image of the hole about 0·002 inch diameter, which in fact is the real mark for collimation; and in the hollow of the western pivot there is fixed an object-glass at a distance from that image equal to its focal length. This combination forms a reversed telescope revolving with the instrument. It is viewed by a telescope of 7 feet focal length, which, when required, is placed on Y's, one of them planted in the opening of the western pier, and the other in a hole made for that purpose in the western wall of the room. On 1877 February 27, observations were made for the determination of the relative errors of the form of the pivots of the transit-circle. The process employed is fully explained in Appendix I. of the volume of *Greenwich Observations* for 1852. The following table contains the residual errors, which define the apparent changes of position of a certain line in the material axis of the instrument:—

N. P. D. Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Above.	N. P. D. Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Above.	N. P. D. Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Above.	N. P. D. Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Above.
° ′	″	″	° ′	″	″	° ′	″	″	° ′	″	″
2. 30	−0·28	+0·07	92. 30	−0·01	+0·09	182. 30	+0·14	−0·25	272. 30	−0·04	+0·10
7. 30	−0·32	+0·18	97. 30	+0·27	+0·19	187. 30	+0·05	+0·04	277. 30	0·00	+0·27
12. 30	−0·30	−0·08	102. 30	+0·25	+0·04	192. 30	−0·22	+0·16	282. 30	+0·04	+0·15
17. 30	−0·40	−0·28	107. 30	+0·22	−0·09	197. 30	−0·12	+0·13	287. 30	−0·14	+0·14
22. 30	−0·25	+0·07	112. 30	+0·24	−0·09	202. 30	−0·13	+0·22	292. 30	−0·18	+0·04
27. 30	−0·34	−0·13	117. 30	+0·16	+0·12	207. 30	−0·08	+0·02	297. 30	+0·22	+0·04
32. 30	−0·16	+0·08	122. 30	−0·20	+0·13	212. 30	+0·06	+0·18	302. 30	+0·29	+0·20
37. 30	−0·25	+0·02	127. 30	+0·26	+0·17	217. 30	−0·02	−0·02	307. 30	+0·20	+0·11
42. 30	−0·42	+0·16	132. 30	+0·08	+0·11	222. 30	+0·30	+0·13	312. 30	+0·17	+0·39
47. 30	−0·22	−0.16	137. 30	+0·26	−0·25	227. 30	−0·04	−0·03	317. 30	+0·15	+0·48
52. 30	−0·09	−0·11	142. 30	+0·08	+0·06	232. 30	−0·17	−0·26	322. 30	+0·25	+0·18
57. 30	−0·13	−0·10	147. 30	+0·06	−0·05	237. 30	+0·12	−0·11	327. 30	−0·02	+0·28
62. 30	−0·18	−0·26	152. 30	+0·34	−0·07	242. 30	−0·03	−0·07	332. 30	−0·02	−0·01
67. 30	+0·14	−0·42	157. 30	+0·31	−0·13	247. 30	+0·01	−0·07	337. 30	+0·04	−0·14
72. 30	−0·03	−0·20	162. 30	+0·20	−0·24	252. 30	+0·14	+0·07	342. 30	−0·20	+0·12
77. 30	+0·02	−0·26	167. 30	+0·20	−0·43	257. 30	−0·10	+0·22	347. 30	−0·17	−0·14
82. 30	+0·07	−0·44	172. 30	0·00	−0·18	262. 30	−0·19	+0·09	352. 30	−0·12	−0·20
87. 30	+0·33	−0·07	177. 30	+0·15	−0·21	267. 30	+0·04	+0·21	357. 30	−0·20	−0·08

No correction has been applied on account of error in the form of the pivots.

The wire frame contained originally (besides the horizontal wire, to be noticed shortly) seven vertical wires, adapted to observations of transits by eye-and-ear; to which six were added in the spring of 1854, for more convenient use in the observations of transits by galvanic contact. In 1891 October the galvanic wire system was rearranged: there are now ten wires so placed that the mean of the ten coincides nearly with the middle wire, which is also the middle wire of the eye-and-ear system. The intervals between the wires are given at the end of this Introduction.

The whole frame and whole system of vertical wires are moved horizontally by a micrometer-screw, whose graduated head is locked up in a small box attached to the eyepiece, to prevent inadvertent disturbance of the micrometer after it has been set to the reading which is adopted for the line of collimation. The micrometer-head is on the eastern side of the eyepiece, and the readings increase as the wire is moved towards the micrometer-head. In 1891 October a new screw was fitted to the micrometer by Messrs. Troughton and Simms, one revolution of which is nearly equal to the distance between two close wires, viz. 37″. The field of view is illuminated by the light from a central electric lamp of about 5 candle-power (to be mentioned hereafter), which enters the axis and is reflected by an internal annular reflector; by inclining the reflector, the illumination is diminished and finally destroyed; and by inclining it still more, the light is thrown (by means of reflecting prisms) in such a manner as to illuminate the wires, leaving the field dark, means being provided for graduating the intensity of illumination of the wires. The electric light was introduced on 1895 May 31, replacing a gas lamp.

For determining the error of collimation, two horizontal telescopes or collimators of about 6 feet 10 inches focal length and 7 inches aperture, with their axes in the same horizontal line through the centre of the instrument and their object-glasses turned towards it, are mounted on Y's carried by massive brick piers, one on the north and the other on the south side of the transit-circle. Each collimator is furnished with wires in its principal focus, to be used as collimating marks; and each may be used as presenting a distinct mark for the other, or for the transit-circle telescope. The system of wires is the same in both, consisting of two parallel wires inclined to the vertical at an angle of about $2\frac{3}{4}°$, and two other parallel wires at right angles to the former, and therefore inclined to the horizontal line at the same angle (the intersection of this pair with the former producing a square). For adjustment of the collimators accurately on each other, the plates carrying the wires are moveable by micrometer-screws: that of the south collimator in altitude only, and that of the north collimator in azimuth only. In order to view either collimator by the transit-circle telescope, it is only necessary to direct the transit-circle telescope towards that collimator; but in order to view one collimator by the other, it is necessary to place the transit telescope vertical, and to uncover the perforations in the opposite sides of its central cube, which permit one collimator to view the other through eight holes of sector-form. The opposite sides of the central cube were pierced with these perforations in August and September 1865. This arrangement was brought into use on 1866 December 17, when the collimators of 7 inches aperture were mounted in place of those of 4 inches aperture, used up to that time. To obtain a somewhat more perfect view of one collimator by the other, it is necessary to raise the transit-circle so far that there shall be no impediment to a direct view, by means of a mechanical apparatus provided for the purpose.

In June 1882 a new form of mounting the collimators was adopted, in order to obtain a greater range of observations of stars by reflexion. In the new arrangement, the two piers having been cut down, the collimators are mounted on upright cast-iron arms which turn about centres below, thus allowing them to be swung on one side when not in use. An alteration was also made in the mounting of the mercury trough, by which it is raised about a foot. It is thus found practicable to observe stars by reflexion (with the full aperture of the object-glass) from Z.D. 20° to Z.D. $67\frac{1}{4}$°, an increase of range of nearly 30° on each side of the zenith. To test the stability of the collimators during each determination of collimation-error, it is the usual practice, since the alteration, to observe the coincidence of the corresponding wires of the two collimators immediately after as well as before the observation of the two collimators with the transit-circle. When the two sets of micrometer-readings differ, a correction corresponding to the half-difference is applied to the concluded reading for line of collimation.

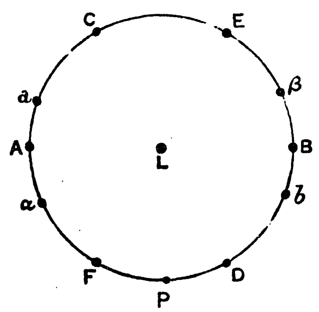
The process of adjusting the collimators, and of using them for determining the line of collimation of the transit-circle telescope, is as follows:—

The transit telescope being placed in proper position, and illumination being given to the south collimator by reflected sky-light, the eye is applied to the eyepiece of the north collimator and the systems of wires in both are distinctly seen: the nearly vertical wires of one being inclined about $5\frac{1}{2}$° to those of the other. By means of the micrometer-screw of the north collimator, the middle of one nearly vertical side of its square is made to coincide with the image of that of the south collimator, and the micrometer-reading is taken. This operation is usually repeated six times, and, the mean of all the readings being found, the micrometer is left in the position indicated by that mean. The daily observation for collimation of the transit telescope is then made by bringing, by means of its R.A. micrometer, the central vertical wire several times in succession upon the proper point of the image of the nearly vertical wire of the north collimator, and several times upon the corresponding point of the south collimator, and reading the micrometer for each coincidence. The mean of the readings for the north and south collimators gives the reading for the position of the line of collimation. The observation admits of extreme accuracy, since the eye can judge with great delicacy of the equality of the two acute-angled triangles formed by the central transit-wire and the collimator-wire in the process of observation.

Since 1884 June a reversion-prism made by Messrs. Troughton and Simms has been used in observations with the collimators as well as with the transit-circle to reverse the apparent direction of measurement or of motion, a movement towards the left (as in transits of south stars) being converted into a movement towards the right, or downwards or upwards, according to the position of the plane of reflexion of the reversion-prism.

The instrument is not adapted to the application of a spirit-level or other contrivance for determining the difference of level of the surfaces of the pivots. The error of level is ascertained by the use of a Bohnenberger's eyepiece, with three lenses, and a transparent glass reflector at an angle of 45° with the axis of the eyepiece, which is placed between the lowest lens and the wires of the telescope. A beam of light being thrown horizontally upon the reflector, and a trough of quicksilver (at first of iron, but on 1889 September 26 furnished with a bottom of amalgamated copper, with very beneficial results as regards steadiness of the images; and on 1890 June 5 replaced by an amalgamated copper trough) being placed below the object-glass of the telescope, the image of the central wire is seen by reflexion at the same time as the wire itself; by means of the micrometer-screw, the images are made to coincide, or to touch alternately on the two sides; the mean of the micrometer-readings is taken, and the difference between the mean reading and the reading corresponding to the line of collimation is the error of level. This process is perhaps in every case preferable to the use of a spirit-level.

The graduated vertical circle for zenith-distance observations is fixed on the cylindrical base of the axis-cone on the west side of the central-cube. It is shielded from the Sun's rays by the steps which are used by the observers for ascending to the upper part of the pier. It is of cast-iron, 6 feet in diameter, and has two sets of divisions: one set, on its western side, cut upon a band of silver, which is let into the internal surface of a very flat cone, is accurately divided to five-minute spaces and is read by the microscopes; the other set, on its eastern side, is roughly divided by points to every 5′, and is intended for setting the telescope to any object by means of two pointers reading respectively north polar distances and zenith distances. The tubes of the reading microscopes are inclined perforations through the western pier (not furnished with any metallic tube), pointing to the graduations on the flat internal conical surface of the graduated circle. Their eyepieces are all carried by one massive brass plate at the back of the pier, and are arranged in a circle, whose centre is 5 feet 2 inches above the floor, and whose diameter is about 21 inches. Their object-glasses are separately attached to the inner or eastern side of the pier, and are arranged in a circle of about 5 feet in diameter. Each of the microscope perforations through the pier is accompanied with a perforation for illumination: these illumination-perforations all diverge from one central electric light near the western face of the pier. Each is furnished with a lens, $3\frac{1}{2}$ inches in diameter, by adjustment of which the light from the lamp, after specular reflexion from the graduated surface, is thrown up through the microscope-perforations to the microscope eyepieces. A lining of double tin plates, inserted in the central opening of the pier, screens the stone pier, the brass plate, the micrometers, and the eyepieces. The number of microscopes is eleven; they are arranged in the following order:—



L is the electric light for illumination. P is a microscope usually furnished with an eyepiece of low power, carrying no micrometer, and intended only for reading the integral graduations; A, C, E, B, D, F are the six micrometer-microscopes at intervals of 60°, used in ordinary observations; a and b are supplementary micrometer-microscopes at 20° distance from A and B respectively, and α and β similar microscopes at 25° distance from A and B; these supplementary microscopes are used for ascertaining the errors of graduation of the circle, or occasionally in observations of zenith distance during repair of the six ordinary microscopes.

The errors of division of the circle were investigated for every 5° in 1851, 1856, 1871, and 1898, two independent determinations having been made in the last year. The mean of the determinations made in 1851 and 1856 was adopted for use up to the end of 1896, and in the sections of Zenith Distances and Star Ledgers in 1897. In the Star Catalogue and Planetary Results for 1897 the mean of the four determinations made in 1856, 1871, and 1898 respectively was adopted, giving a result in which each of the 5° divisions is equally well determined. The determination made in 1851 was rejected as being discordant. The errors of the single degrees were determined in 1851, 1856, and 1898, the mean of the first two being used in the earlier sections in 1897, and the mean of the three in the final sections for 1897. Full information on the subject is given in a paper by Mr. Dyson and Mr. Thackeray in the *Memoirs of the Royal Astronomical Society*, vol. liii., and in the *Transit-Circle Tables* at the end of this Introduction.

At the end of 1875 new micrometer-screws were applied by Mr. Simms to the six ordinary micrometers A, B, C, D, E, F. In March 1878 the micrometers A, C, and F were reversed (their heads being at the same time re-figured to read in the opposite direction), so that any effect of wear on the micrometer-screws might be eliminated for each pair of microscopes. At the end of 1885 new screws made of steel instead of gun-metal were applied by Mr. Simms to the six ordinary micrometers A, B, C, D, E, F; and were brought into use on 1886 January 1. Observations for determining the errors of these screws are given in the Transit-Circle Tables at the end of the Introduction for 1886 (p. cxxxv). Similar observations were made in 1893, and are given in the Transit-Circle Tables in the volume for 1894. The errors of the screws were again determined in 1896 November. The observations are given in the Transit-Circle Tables at the end of this Introduction, and show that the wear of the screws is small, and its effect almost entirely eliminated by the reversal of three of the screws.

There are two clamps attached to the eastern pier, at the same height as the centre of the circle (one on the north side, the other on the south side), which can take hold of the clamping circle of the instrument; but they have no slow motion. The eye-piece of the telescope contains only one horizontal wire, moveable by a micrometer, with which all observations of zenith-distance are made. For reducing every observation, therefore, it is necessary to combine the value of the reading of the telescope-micrometer with that of the mean of readings of the microscope-micrometers. When the telescope points vertically upwards, the head of the telescope-micrometer is on the north side; and the telescope-micrometer-readings increase as the wire is moved towards the head. The reading $20^{rev.}$ corresponds nearly to the centre of the field of view. A new screw was applied to the micrometer by Messrs. Troughton and Simms in 1891 October, of the same pitch as that of the right ascension micrometer.

Observations for the determination of the value of $1^{rev.}$ of the telescope-micrometer screw are given at the end of the Introduction of the 1891 volume. Observations made at the same time showed the screw to be sensibly uniform. Subsequent observations made between 1896 December and 1897 March, which are given in the Transit-Circle Tables for 1896, showed that the screw had worn considerably. The corrections for wear of the screw at different readings are given in the Transit-Circle Tables at the end of this Introduction.

In 1873 an apparatus was attached to the telescope-micrometer for mechanical registration of its readings. In this arrangement, punctures corresponding to each bisection of an object, in its passage across the field, are made on a strip of paper, fixed on a light drum immediately above the divided head of the micrometer, and turning with it. To distinguish the several bisections, the pricker by which the punctures are made is, after each puncture, moved through a definite space in the direction of the axis of the drum, by turning a screw, which carries it, through a quarter turn. After a set of bisections the punctures are successively brought up to a straight edge, $0^{r}\cdot050$ from the pricker, and the micrometer-head is read off; each is then marked with a pencil to distinguish it from any which may be made afterwards. By this arrangement several bisections of an object can be made without the observer having to move his eye from the telescope, and a permanent record is obtained, giving facilities for the correction of mistakes.

The reading (consisting of the combination of telescope-micrometer-reading and mean of microscope-readings), corresponding to the nadir-position of the telescope, is found by the use of the Bohnenberger's eyepiece and the trough of mercury; the direct and reflected images of the horizontal wire being made to coincide or to touch alternately on the two sides, and the mean of the readings of the micrometer being taken.

Other explanations necessary for the understanding of the process of reduction of the observations will be given under the proper heads. In this place it may be useful to explain briefly the methods employed in making the various classes of observations which are required.

For star-observing generally, the telescope is directed approximately towards the object by the indications of the N.P.D. pointer, and, the telescope being moved by hand till the star is brought near the horizontal micrometer-wire at or near the reading of $20^{rev.}$, the clamping circle is fastened. The transit of the star is then observed over the vertical wires in the usual way, either by galvanic contact or by eye-and-ear; and, during the transit, by means of the micrometer-screw which acts on the horizontal wire, that wire is made to bisect the star near the passage over one or more of the vertical wires. The telescope-micrometer, and the pointer and the six microscope-micrometers, are afterwards read, and the observation is complete. If the star be too faint to allow of illumination of the field, the wires are illuminated, and the observation is made in a field perfectly dark.

For observations of stars by reflexion, the telescope is placed, some minutes previously to the transit of the star, in the direction which is proper for viewing the reflected image of the star, and is clamped; the mercury-trough is carefully placed in the requisite position, and the microscope-micrometers are read. The observer then ascends to the eyepiece of the telescope, and by means of the micrometer-screw which carries the horizontal wire, bisects the reflected image of the star at the passage of the first and second vertical wires (if the star has large polar distance), or of two or three of the galvanic wires (if the star is circum-polar), and reads the revolution-counter of the telescope-micrometer. He then descends rapidly into the pit, unclamps the instrument, turns the telescope to the position proper for direct view of the star, and fastens the clamping circle; bisects the star near its passage over one or more of the vertical wires by means of the micrometer-screw, and completes the direct observation in the usual way, by reading the microscope-micrometers for the second observation, and the punctures on the telescope-micrometer register for both observations.

In observing the Sun, the transits of both limbs are taken for right ascension, and observations are made both of the upper and lower limb for north polar distance in the following manner. The observer at the telescope is aided by two assistants (usually two of the computers), who are stationed in readiness to read the microscope-micrometers. After the transit of the first limb is completed, the telescope is moved by hand till one of the limbs (upper or lower) is brought near to the horizontal wire, when near the reading $20^{\text{rev.}}$; then the instrument is clamped, and the horizontal wire is moved, by means of the micrometer-screw which carries it, to touch the limb while passing one or more of the vertical wires (the Nos. of which are noted), corresponding punctures being made on the micrometer-register. The revolution-counter of the telescope-micrometer is then read by the observer, and the microscope-micrometers by the assistants, who in fact had commenced to read the micrometers as soon as the instrument was clamped. The instrument is then unclamped, the telescope is directed to the other limb (lower or upper), the instrument is clamped, the telescope-micrometer is turned to place its wire upon the limb in its passage across one or more of the vertical wires, and the micrometers are all read again. Finally, the instrument is unclamped, and the transit of the second limb over the vertical wires is taken. The punctures on the micrometer-register are then read off at the observer's leisure. This operation requires readiness and expertness in the observers; but when the transits are made by galvanic contact, it is found perfectly easy to take those of the first and second limb over all the wires, still leaving time enough for the observations of both limbs in N.P.D.

For the Moon before opposition (that is, when the transit of the first limb is observed) after the transit is completed, the telescope is moved till the limb (upper or lower), which is to be observed in zenith distance, is brought near to the middle of the field; the instrument is clamped; and the telescope-micrometer wire is made to touch the limb (upper or lower) at its passage over the seven original vertical wires at wide intervals, the punctures on the micrometer-register being read afterwards. The microscope-micrometers are then read, and the observation is complete.

After the opposition in right ascension, the setting for the full limb (upper or lower) is accurately computed beforehand; the instrument is set with care, and is clamped; and the microscope-micrometers are read previously to the passage. The telescope-micrometer wire is brought on the limb at the passage over each of the vertical wires, as explained above; then the clamp is relaxed, and the telescope is turned by hand to a position proper for observing the transits of the second limb in right ascension, and the transits over the vertical wires are taken. The punctures on the micrometer-register are afterwards read off, and the observation is complete.

When both the upper and the lower limbs are so nearly full as to admit of observation, as also when the first and second limbs are very nearly full at the opposition of the Moon, another person is employed to read the microscope-micrometers as in the case of the Sun; and the mode of observation will be readily understood from the preceding explanations, applying to the observation of the Sun. In this case, however, the aid of one person is sufficient.

The Chronograph.—A detailed account of this apparatus, illustrated by engravings, is given in the Appendix to the volume for 1856, and a brief description of the chief parts will be found in the *Introduction* for 1880 and preceding years.

The Personal Equation Machine, constructed by Messrs. Troughton and Simms, and mounted in the Front Court on a brick pier, directly in view of the transit-circle telescope when horizontal and pointing north.—This instrument has been devised in order to determine absolute personal equations in the observation of slow moving as well as of quick moving stars of various magnitudes (whether the motion be from right to left or the reverse), and of limbs of the Sun, Moon, or planets. Its construction is as follows :—A vertical plate with a circular aperture 6 inches in diameter (to represent the Sun or Moon) and carrying several small pin-holes (to represent stars of different magnitudes) is carried smoothly by clock-work from east to west, or west to east, at a rate which may be varied at will from that of a very close circumpolar star to three or four times that of an equatorial star. The contrivance for variation of rate, devised by Mr. James Simms, is as follows :—A horizontal circular brass plate is made to rotate with uniform velocity about its centre by a driving clock (belonging to one of the photoheliographs), and drives by rolling friction a brass disk turning about a horizontal axis, and placed with its rim in contact with the surface of the plate. This disk can be slipped along its spindle and clamped at any point, so that the point of contact of the wheel and plate can be adjusted at will to any distance from the centre of the latter, the angular velocity of the wheel varying directly as this distance, and changing sign at the centre. At the further end of the spindle is a screw, which communicates the motion to the vertical plate by means of a pulley wheel and cord. The vertical plate is placed in the focus of an object-glass of $7\frac{1}{2}$ inches aperture and about 51 feet focal length, which is attached to the dew cap of the transit-circle when horizontal and pointing north ; and the apertures in the plate are illuminated by direct sunlight or moonlight reflected by a plane mirror in the direction of the object-glass, so that the transits of the artificial Sun or Moon and stars can be observed with the transit-circle under practically the same conditions as the real objects. At the same time the transits are registered automatically on a small chronograph by means of the contacts between two sets of platinum studs, one set corresponding to the artificial objects and carried with the plate, the other set fixed and corresponding to the wires of the transit-circle. The adjustment is secured by observations before and after the transits, in which the stud corresponding to the star or limb under observation is brought carefully into contact with those corresponding to each of the wires in succession, and the reading of the R.A. micrometer noted for bisection of the star with that wire. For observations of transit, the micrometer is then set to the mean of these readings.

The Altazimuth, constructed by Messrs. Ransomes and May (as engineers), and by the late Mr. William Simms (as instrument-maker and optician), and erected in 1847.

This instrument is mounted in a tower (47 feet west and 29 feet south of the transit-circle), which is raised to such a height that the instrument commands the horizon in all directions above the buildings of the Observatory, except the Sheepshanks dome, the great Equatorial dome, and the Octagon room.

The diameter of each of the two circles (horizontal and vertical) is 3 feet; the length of the telescope is 4 feet 2 inches; the aperture of its object-glass 4 inches.

The instrument can be firmly clamped in azimuth and in zenith-distance, each clamp being furnished with a slow motion. For each movement there is also a moderately-slow motion, by rack and pinion.

In March 1880 the horizontal circle was re-divided by Mr. James Simms, the divisions in some places having been obliterated in course of time, and at the same time new double compound object-glasses, with adjustment for focus, were applied to the microscopes of the horizontal circle. A metal cover, with circular openings under the microscopes, was also fixed to the lower part of the revolving frame to protect the divisions of the horizontal circle from dirt or injury.

For a detailed account of this instrument, illustrated by engravings, and for a description of the processes gone through in its adjustment, reference may be made to the volume of Astronomical Observations for 1847. The description, with some modifications, is reprinted, and attached to the volume for 1867.

On 1883 January 11 a new system of nine horizontal and nine vertical wires was inserted. The seven interior wires of each set are placed at equal intervals for use in chronographic transits; the exterior wires, together with the first and last of the interior wires and the middle wires, form a system of five horizontal and five vertical wires at equal intervals, suitable for eye-and-ear observations; and the middle wires, which are thicker than the others, are available for observations of comets. On 1894 November 19 the wires were found broken, and a new set similar to the former was inserted by Messrs. Troughton and Simms on the following day.

From 1888 November the observations of distant church spires have been used in combination with those of stars for determining the zero of azimuth. The first (Mark I.) is the spire of St. John's Church, Lewisham High Road, distant 6,600 feet from the altazimuth; the second (Mark II.) is that of the Roman Catholic Church, Croom's Hill, distant 1,060 feet, for the observation of which a long-focus lens was mounted by Messrs. Troughton & Simms on 1889 May 24.

In 1894 June the upper pivot and bearing of the vertical axis were found worn and rusty. The pivot was re-ground and new bearings made by Messrs. Troughton and Simms.

In 1873 May the pivots of the axis of the vertical circle of the altazimuth were examined. The method employed is the same as that explained in detail in the Introduction to the *Greenwich Observations* for 1847, and in the Description of the Altazimuth attached to the volume for 1867, page 14. The residual errors, showing the movements of certain points on the ends of the two pivots, are given in the following tables :—

Pivot on the side opposite to the Graduated Face.

Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Below.	Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Below.	Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Below.	Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Below.
°	r	r	°	r	r	°	r	r	°	r	r
5	−0·002	−0·020	95	+0·026	−0·007	185	−0·045	+0·020	275	+0·029	+0·020
15	−0·007	+0·006	105	+0·008	−0·012	195	−0·026	+0·012	285	+0·021	−0·019
25	+0·004	+0·017	115	+0·001	+0·005	205	−0·014	−0·002	295	+0·022	−0·015
35	+0·006	+0·008	125	0·000	+0·012	215	−0·044	+0·004	305	+0·010	−0·014
45	+0·008	+0·012	135	+0·004	−0·007	225	−0·015	+0·021	315	−0·006	−0·020
55	+0·032	+0·017	145	−0·014	+0·012	235	+0·010	−0·001	325	−0·022	−0·022
65	+0·018	+0·014	155	−0·001	+0·010	245	+0·019	+0·028	335	−0·034	−0·025
75	+0·048	−0·003	165	−0·027	+0·003	255	+0·033	+0·002	345	−0·032	−0·033
85	+0·030	+0·003	175	−0·024	+0·010	265	+0·025	−0·013	355	−0·040	−0·033

Pivot on the same side as the Graduated Face.

Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Above.	Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Above.	Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Above.	Pointer Reading.	Horizontal Error, Micrometer Head to Right.	Vertical Error, Micrometer Head Above.
°	r	r	°	r	r	°	r	r	°	r	r
5	+0·061	+0·038	95	+0·002	−0·042	185	+0·029	+0·016	275	−0·041	−0·009
15	+0·031	−0·003	105	−0·005	−0·021	195	+0·032	+0·024	285	−0·043	−0·022
25	+0·051	−0·017	115	−0·012	−0·001	205	+0·032	+0·043	295	−0·044	−0·020
35	+0·045	−0·015	125	+0·013	+0·020	215	+0·032	+0·043	305	−0·019	−0·043
45	+0·045	−0·042	135	+0·026	+0·026	225	+0·003	+0·037	315	−0·017	−0·016
55	+0·018	−0·040	145	+0·011	+0·044	235	−0·034	+0·010	325	−0·023	−0·011
65	+0·023	−0·060	155	+0·021	+0·061	245	−0·056	−0·004	335	−0·024	+0·002
75	−0·019	−0·025	165	+0·020	+0·047	255	−0·073	−0·010	345	−0·015	−0·014
85	−0·005	−0·023	175	+0·023	+0·053	265	−0·059	−0·006	355	−0·032	−0·022

Value of one revolution of the micrometer = 22″·45.

Observations with this instrument were discontinued after 1897 November 29.

The Reflex Zenith-Tube, constructed under the direction of Sir G. B. Airy by the late Mr. William Simms.—A detailed description of this instrument is given in Appendix I. to the volume for 1854; in this place the following account will suffice. The object-glass (aperture 5 inches, focal length about 9 feet 8 inches) is mounted upon a fixed tube, which is in a vertical position; upon this tube it can be turned in azimuth. To the cell of the object-glass is firmly fixed the micrometer-frame (with its plane horizontal), revolving with the object-glass when the latter is turned. The bearing of the screw of micrometer A is on the fixed micrometer-frame. The moving frame of micrometer A carries the bearing of the screw of micrometer B. Micrometer B carries the wires by which the star's image is bisected. The eyepiece is a four-glass diagonal eyepiece bent at right angles between its third lens and its fourth lens (counting from the eye), and having a diagonal-prism-reflector at the place where it is bent; and so placed that the fourth lens can receive rays of light from the direction of the nadir, and can, by means of the diagonal prism, transmit them horizontally to the eye. The fourth lens (which looks vertically downwards) and the diagonal prism are placed nearly over the centre of the object-glass, being carried by arms which are fixed to the large tube; the small horizontal tube which carries the remaining lenses of the eyepiece is supported by the large tube of the telescope, and does not project over any part of the object-glass. Below the object-glass, at a distance nearly equal to half its focal length, is a trough of quicksilver, which till the end of 1888 was protected from tremors, with only moderate success, by an arrangement of caoutchouc supports, described in previous Introductions to 1880. From 1889 Feb. 13 an amalgamated copper trough has been used, with the result that the steadiness of the images has greatly improved. A prismatic focussing rod with scale reading to 1-200th of an inch and ivory point for contact with the surface of the mercury has been applied to the instrument in place of the former light brass rod and wooden float; the focussing rod and the micrometer-frame are both of gun-metal. The image of the star, as it passes near to the zenith, is formed in the plane of the micrometer wires. It will easily be seen that, to ensure accuracy of result, no firmness of construction is requisite in this instrument except in the connection between the micrometer and the object-glass. The instrument is mounted in a building erected for it in the Middle garden, in the angle between the passage behind the Astronomer Royal's Official room and the south projection of the Transit-circle room.

The Shuckburgh Equatorial.—This instrument was constructed by Ramsden, and is one of that class usually called the "English equatorial." It was originally the property of Sir George Shuckburgh, and is fully described by him in the *Philosophical Transactions* for 1793. It was presented to the Observatory in the year 1811. The telescope is 5 feet 4 inches in length, and has an object-glass of 4·1 inches aperture. It is mounted in the North Dome, the situation of which is most unfavourable, as the south-western sky is concealed by the Octagon room.

The Sheepshanks Equatorial.—This instrument was erected in the year 1838. The aperture of the object-glass is about 6·7 inches, and its focal length about 8 feet 2 inches. The object-glass was made by M. Cauchoix, of Paris, and was presented to the Observatory by the Rev. R. Sheepshanks. Its definition is good: a small quantity of colour from the secondary spectrum, and a diffusion of light from brilliant objects, being the principal defects.

It is mounted in a dome, 19 feet east and 1½ feet north of the transit-circle. The mounting, particulars of which are given in the Introductions to the Greenwich Observations for former years, is similar in general form to that known as the "German equatorial," and was constructed by the late Mr. T. Grubb, of Dublin. Besides several negative eyepieces unfurnished with wires, this telescope has a wire micrometer, and a comet eyepiece with thick wires and position circle, which was supplied on 1890 November 10. On 1892 November 18 a new set of wires was mounted in this eyepiece, as the wires were found to be bent.

The Great Equatorial.—This instrument now carries an object-glass of 28 inches aperture and 28 feet focal length on the mounting which was originally designed for the Merz object-glass of 12·8 inches aperture and 17 ft. 10 in. focal length. This mounting was constructed by Messrs. Ransomes and Sims (as engineers), and the late Mr. William Simms (as instrument-maker), and a complete description of it, with engravings, is attached as Appendix to the volume for 1868. The form of the instrument is the "English equatorial," the polar-axis turning on pivots at its extreme ends, and including between its two sides the telescope and declination-circle, which are mounted on a declination-axis with pivots at its opposite extremities. The object-glass of 28 inches clear aperture and 27 ft. 10 in. focal length was made by Sir Howard Grubb from discs supplied by Messrs. Chance, of Birmingham. It is of special form, adapted to photography as well as to eye-observation, on the plan proposed by Sir George Stokes (in a letter to me dated 1886 August 16) of reversing the crown lens to correct for the spherical aberration introduced by the further separation of the lenses necessary for photographic correction. Mechanical means are provided for readily effecting this reversal and separation without risk. It is found by trial that the further separation required for photographic correction is about 3·5 inches, and that the focus is thereby shortened by about 23 inches. When the crown lens is in the position for visual observation, the radii of curvature of the surfaces are :—

1st surface—	146 in. convex	Crown.	3rd surface—	138 in. concave	Flint.
2nd ,,	134 in. ,,		4th ,,	1000 in. convex	

and the edges of the lenses are separated by 0·4 inch, the minimum focal length being for rays about midway between D and E.

The telescope tube, made of steel and cast-iron by Sir Howard Grubb, is specially adapted to the conditions, being provided with a sliding eye-end arranged for either direct or diagonal view, and permitting of observations near the zenith and the pole, when the eye-end is shortened sufficiently by the sliding motion to clear the floor and the inside of the polar frame. The Corbett telescope, of $6\frac{1}{2}$ inches aperture and 8 feet focal length, is mounted on the tube as a finder or guiding telescope. The position and transit-micrometers and various eyepieces supplied for the 12·8-inch Merz refractor have been adapted to the new 28-inch telescope, and have been fitted with electric illumination of the field and wires.

The Dome was constructed by Messrs. T. Cooke and Sons and erected in 1893 April, replacing a cylindrical wooden dome. It is of a form specially adapted to accommodate the new 28-inch refractor, whose diameter is greater than that of the tower on which it is carried. A description with diagrams is given in the *Monthly Notices*, R.A.S., vol. li. p. 436. The diameter of the dome is 36 feet at a height of 7 feet above the rail, contracting to 31 feet at the base, and the shutter-opening is 7 feet wide throughout on both sides of the zenith down to the horizon. The framework is of **T**-iron vertical and horizontal ribs bolted to a circular girder forming the base, the opening being framed with curved vertical girders, and the whole is covered with papier-mâché. The shutter is in two parts, with a division right down the middle, each half being a balanced shutter 3 ft. 6 in. wide, extending right over the dome from the curb, through the zenith, to the opposite part of the curb, and carried by a wheel running on a rail at the zenith. The dome rotates on a system of vertical rollers running freely on the planed surface of the wall-curb, as in the Lassell Dome.

The Spectroscope, carried by the Great Equatorial.—The direct-vision "half-prism" spectroscope, constructed by Mr. Hilger, has been used from 1877 July to 1891 November in connection with the 12·8-inch Merz refractor mounted on the Great Equatorial. In this form of spectroscope, either great dispersion or great purity of spectrum is obtained by the use of "half-prisms,"* according as the incident pencil falls first on the perpendicular or on the oblique face. Either one, two, or three "half-prisms" can be used at pleasure, according to the dispersion required, and each "half-prism" is compound, being composed of a flint "half-prism" and a crown prism cemented on the oblique face so as to form the half of a direct-vision prism, as cut by a plane perpendicular to the base. With one "half-prism" a dispersion of about $18\frac{1}{2}°$ from A to H, equivalent

* A "half-prism" is the half of an isosceles prism cut by a plane perpendicular to the base, so that the rays fall perpendicularly on the face so formed. The general theory of this form of spectroscope is given in the *Proceedings of the Royal Society*, vol. xxvi. p. 8.

to that given by four flint prisms of 60°, is obtained, with two "half-prisms" a dispersion of about 80° from A to H, equivalent to that given by sixteen flint prisms of 60°, with three "half-prisms" a dispersion of about 300°, equivalent to that given by about sixty flint prisms of 60°, the pencil in each case being incident on the perpendicular face of each "half-prism" and emerging at the oblique face. For observations of the Solar prominences, where great purity of spectrum is desired, the slit and eyepiece are interchanged, so that the pencil is incident on the oblique face and emerges at the perpendicular face of each prism. The cross-section of the first prism is 2 inches in height by 2 inches in breadth, of the second prism 2 inches in height by 0·6 inch in breadth, and of the third prism 1 inch in height by 0·4 inch in breadth, the pencil being made narrower by the oblique emergence at each prism. The collimator and viewing telescopes have focal lengths of about 23·2 and 11·6 inches respectively with apertures of $2\frac{1}{4}$ inches. Different parts of the spectrum are brought into the field by turning the "half-prisms," each through the same angle, about fixed centres, by means of a micrometer-screw acting on a lever. For delicate measures a micrometer eyepiece is used.

The spectroscope was mounted on the 28-inch refractor in 1894 June. It is planted with its axis parallel to the tube and below it (in the position for objects south of the zenith), the rays being thrown into the collimator by two reflexions, first from the mirror for diagonal view in the telescope tube, placed about 26 inches within the focus, and then from a small rectangular prism close to the slit and 24 inches from the axis of the refractor, mounted in an adapter carried by the sliding eye-end. The spectroscope is firmly attached to the telescope tube by strong castings with suitable collars, having sliding adjustment for focus, and allowing of rotation of the spectroscope for orientation of the slit parallel or perpendicular to the equator. By this arrangement the spectroscope is permanently mounted on the refractor, the mirror in the tube being inserted for spectroscopic observations and withdrawn for eye-observations.

Occasionally for faint objects another spectroscope of smaller dispersive power is used. This spectroscope has a single prism of flint glass, with a collimator of about 20 inches focal length and a viewing telescope of about 10 inches.

Ample provision is made of the necessary auxiliary apparatus; namely, a Sprengel air-pump, with Crookes' improvements, made by Hicks; an induction-coil, by Browning; and a battery, by Ladd.

The Double Image Micrometer.—The general form of the Airy double-image eyepiece, together with the mode of use, and the advantages and disadvantages attending the use of it, are described fully by Sir G. B. Airy in the volumes for 1840 and for 1843 to 1849. It is a four-glass erecting eyepiece, in which the lenses are so arranged that the axis of the pencil of rays from each point of an observed object passes through the centre of the second lens (as measured from the object-glass), so that in fact an image of the object-glass is formed on this lens, which is divided by a plane passing through the axis of the telescope. The two halves of this lens are moved by a micrometer-screw in opposite directions, and the whole eyepiece is made to revolve round the axis of the telescope by a toothed-wheel and pinion movement. The arrangement of the eyepiece actually adopted is described in the *Memoirs of the Royal Astronomical Society*, vol. xv. page 199.

The double-image micrometer is adapted for use either with the Great or the Sheepshanks Equatorial.

The Astrographic Telescope, with 10-inch guiding telescope, mounted in a dome over the upper Computing room.—This instrument was constructed by Sir Howard Grubb, F.R.S., on the lines laid down by the *Congrès Astrophotographique International pour le levé de la Carte du Ciel* in 1887. The 13-inch photographic telescope and a 10-inch visual telescope are firmly connected, the tubes being of iron. The apertures of the object-glasses are $0^{m}\cdot33$, or $13^{in}\cdot0$, and $10^{in}\cdot0$, and the focal lengths of both telescopes $3^{m}\cdot43$ or $135^{in}\cdot1$, so that $1^{mm}\cdot0$ on the plate corresponds to $1'\cdot0$. The photographic telescope is corrected, as regards spherical and chromatic aberration, for rays near Fraunhofer's line G. It is arranged to carry a plate $16^{cm.}$ square, with special provision for exact focussing and orientation. The eyepiece of the 10-inch visual telescope is mounted on cross-slides (parallel and perpendicular respectively to the equator) which are furnished with scales reading to 1-12th of a millimetre or $5''$, and permit of the observation of a guiding star up to a distance of about $45'$ from the centre of the field. The mounting is of the German form, the details being such as to allow a range of $1\frac{1}{2}$ hours' motion on each side of the meridian without reversing the telescope. A large counterpoise is thus necessary, both because of the double weight, and of the distance from the polar axis of the two telescopes; but the movement in right ascension is very easy, owing to the arrangement adopted to relieve the friction of the polar axis. The greater part of both the transverse and end thrusts of the polar axis is received on a single anti-friction bearing, carried by a separate vertical column, disposed directly under the centre of gravity of the instrument. The rollers of the bearing turn round horizontal axes, and a bevelled collar on the polar axis rests on them. The column transmits the weight to counterweight levers. The driving clock is placed inside the stand and is controlled electrically by a seconds pendulum. The detector of the control is similar in principle to that used in Dr Gill's form; and the system of correctors by differential wheels was devised by Sir Howard Grubb (vide *Proceedings, Institute of Mechanical Engineers*, 1888 July 31, page 311).

The Thompson Photographic Telescope by Sir H. Grubb is a refractor of 9 inches aperture and 8 feet 10 inches focal length, presented to the Observatory by Sir Henry Thompson. It is corrected for photographic rays and is provided with a prism of 9 inches diameter by Mr Hilger, which can be mounted in front of the object-glass for photographing spectra of stars. It was mounted below the Merz Refractor on the Lassell Equatorial and was in regular use as a photoheliograph till 1894 October 15, when the progress of building operations on the new Physical Observatory prevented its further use. A camera with a new doublet by Ross (mounted on 1892 December 13), and an exposing shutter specially designed to give very short exposures, are attached to it. The image of the Sun in the primary focus is about one inch in diameter, and this is enlarged by the Ross doublet to nearly 8 inches on the photographic plate, the whole length of the instrument being about 12 feet 4 inches. The exposure is given (as in the Dallmeyer photoheliograph, *see* below) by a shutter at the primary focus, having a slit in it of adjustable width; but whilst the shutter of the Dallmeyer photoheliograph travels in a groove, and is drawn downwards by the pull of a strong spring, in the Thompson photoheliograph the shutter, which is made of aluminium for the sake of lightness, turns about a pivot 18 inches from the exposing slit, under the action of a spring placed about midway between the pivot and the slit, and giving a very rapid motion to the latter.

The Dallmeyer Photoheliograph has an object-glass of 4 inches aperture and 5 feet focal length, forming an image of the Sun half an inch in diameter; this image is enlarged by a secondary magnifier to 4 inches on the camera screen, where the sensitive plate is inserted, the whole length of the instrument being about 8 feet. From 1884 April 2 a new secondary magnifier has been used, by which the image is enlarged to 8 inches diameter on the camera screen, the whole length of the instrument being increased to 9 feet 7 inches. The exposure is given by a shutter having a slit of adjustable width, which is carried by a spring across the primary image. At the principal focus cross-wires are placed, which give facilities for determining the position angles of spots on the photographs. The instrument is equatorially mounted and provided with a driving clock, though this is not absolutely necessary to its efficient action, as the exposure is practically instantaneous, amounting only to a few thousandths of a second in ordinary cases.

The Dallmeyer photoheliograph tube, which had been temporarily mounted on the tube of the new 28-inch telescope on 1893 October 12, was established on its equatorial mounting on the terrace roof of the South wing of the new Physical Observatory on 1894 April 24.

Two detached telescopes, one of which is 46 inches in focal length, and the other 30 inches.—The diameters of the object-glasses of these telescopes are 3·6 inches and 2·7 inches respectively. The telescope formerly belonging to the Western equatorial has also been mounted for use as a detached telescope; its focal length is 36 inches, and the aperture of its object-glass 3·6 inches. The 62-inch telescope mentioned in former years, and that of the transit-instrument formerly used as a collimator to Troughton's transit, are now mounted on tripod stands for general use.

Two Newtonian reflecting telescopes, the largest being one of 10 feet, by Sir W. Herschel.

A portable transit-instrument with axis-view by Brauer of St. Petersburg and *a portable* 18-*inch altazimuth* by Troughton and Simms, obtained in the year 1866.

The following instruments, used in the Transit of Venus Expeditions, 1874 and 1882, are now transferred to the Observatory:—

Five 6-inch equatorials complete, viz.: the "Lee," "Hodgson," "Cooke," "Simms No. 1" and "Simms No. 2;" two 4-inch portable telescopes by Troughton and Simms; five 3-inch portable transit-instruments by Troughton and Simms; a 14-inch altazimuth and two 14-inch vertical circles or altitude instruments also by Troughton and Simms; and five photoheliographs by Dallmeyer. Several of these are, at the present time, lent to other Institutions. The Naylor 6-inch equatorial and a 14-inch altitude instrument, which had been employed at Bermuda for the observation of the Transit of Venus, 1882, were lost on the return voyage in the wreck of the "City of Brussels" at the entrance of the River Mersey. The "Cooke" equatorial used in the Transit of Venus Expedition, 1882, was transferred to the Observatory in 1884 to replace the Naylor equatorial.

One of the portable transit-instruments is generally mounted in the *Transit Pavilion*, a brick building in the Front Court, the centre of which lies in Bradley's meridian. The roof of the building, which was completed in 1891 October, consists of a pair of semi-domes, which slide apart to leave an opening of uniform width (2 feet 6 inches) in the meridian. The pier for the transit is 19 feet west and 67 feet 10 inches north of the centre of the Transit-Circle. The instrument is available for longitude operations without interrupting the work of the Transit-Circle: or for practice observations by officers of the Royal Navy and others: or for time determinations on occasions when the Transit-Circle is under repair, as in the period 1891 August 10 to October 3.

The Sidereal Standard Clock, constructed by Messrs. E. Dent and Co., is fixed to the north wall of the Magnet Basement, as in this apartment the temperature is kept nearly uniform. The escapement will be found described in vol. iii. of the *Transactions of the Cambridge Philosophical Society*: it is a detached escapement very closely analogous to the ordinary chronometer-escapement, the pendulum receiving impulse only at each alternate vibration; consequently, the escape wheel and seconds hand move only at alternate seconds (the even seconds). The pendulum is compensated in the following way. A central steel rod is encircled by a zinc tube, which rests on the rating nut on the steel rod; the zinc tube is in its turn encircled by another steel tube, which rests at its upper end on the zinc tube, and carries at its lower end the cylindrical leaden pendulum bob attached at its centre. Slots are cut in the outer steel tube, and holes made in the intermediate zinc tube, with the object of exposing equally all parts of the compound pendulum rod to the action of temperature. For final adjustment of the rate there is placed on the crutch rod a sliding weight, which can be raised or lowered by a nut at the level of the crutch-axis without disturbing the pendulum. The rate of the clock is so steady that, when first mounted, the barometric inequality was indicated with the greatest regularity, the daily losing rate of the clock being increased by $0^{s}\cdot3$ for an increase of 1 inch of barometer reading.

In the autumn of 1873 an apparatus for correction of this inequality was applied to the clock by Messrs. E. Dent and Co., and has been in action regularly since that time. This new compensating apparatus of the Sidereal Standard is founded on the magnetic principle, long previously in use for daily adjustment of the Mean Solar clock. Two bar magnets, each about six inches long, are fixed vertically to the bob of the clock pendulum, one in front, the other at the back, their lower ends being nearly level with the bottom of the pendulum bob. The lower pole of the front magnet is a north pole, and the lower pole of the back magnet a south pole. Below these a horseshoe magnet, having its poles precisely under those of the pendulum magnets, is carried transversely at the end of a lever, the opposite arm of which is attached by a connecting rod to a float in the lower leg of a syphon barometer, placed in one corner of the clock-case. The area of the cistern in which the float rests is four times as great as that of the upper tube. For change of one inch of barometer reading the horseshoe magnet is thus shifted two-tenths of an inch; and as the average distance between its poles and those of the pendulum magnets is about $3\frac{3}{4}$ inches, the change of rate produced by increase or decrease of the magnetic action is sensibly uniform. As the clock gained with low barometer reading, it was necessary to place the horseshoe magnet so that there should be attraction between its poles and the adjacent poles of the pendulum magnets. The action of this apparatus is found to be quite successful.

Galvanic contact for registration of the clock-beats is made by a wheel of 30 teeth on the escape-wheel arbor, a tooth of which at every beat of the clock presses together two light springs. Another pair of springs is also pressed together at the beginning of each minute by an arm on the same arbor, and a supplementary signal is thus sent through a galvanometer as a check on the numeration of seconds. This arrangement was substituted in the latter part of 1881 for that formerly employed (in which a pin on the pendulum was used to press together the contact springs) in order to avoid any effect on the pendulum, contact being made in the part of the beat when the pendulum is quite detached from the clock-train, after the impulse has been given. The currents obtained from the Sidereal Standard at every alternate second are used to drive a relay, from which three independent circuits are derived. One of these is appropriated to the seconds-magnet of the chronograph; another regulates the pendulum of a half-seconds clock placed on the foundation frame upon the south pier of the Great Equatorial, drives a tapper in that room for making audible the beats of the clock, and drives also a galvanic chronometer placed, in the Computing room, on the desk of the Superintendent of the Time Department; and the third is at present out of use. No practical difficulty is found in subdividing the interval of two seconds between the clock-beats on the chronograph. The numeration of seconds on the chronograph is readily obtained from an automatic signal from the Sidereal Standard clock on an independent circuit, or from occasional comparisons with the clock Hardy, as explained on page xxxi.

The clock Hardy, in the Transit-circle room, was originally furnished with Hardy's escapement, for which a dead-beat escapement was substituted by Dent in the year 1829. The jewelled holes were removed by Dent in 1836, and the pivots now turn in brass holes. The clock is provided with contact-springs for the purpose of occasional registration of its seconds on the chronograph. Upon the escape-wheel-arbor a wheel having 59 teeth is mounted (that is, 60 teeth with one cut away), and at each second the start of a tooth of this wheel presses together two springs during a very small portion of a second. The omitted tooth in the wheel corresponds to the 1^s of each minute.

There is also a clock marked "Arnold 1," having contact apparatus similar to that in the clock Hardy, in order that the clock may, if required, be temporarily used either in the place of Hardy or of the Sidereal Standard clock; one in the Sheepshanks Dome, marked "Earnshaw," with a zinc and steel compensation pendulum; one in the Altazimuth Dome, marked "Graham 1," with a mercurial pendulum; one in the Astrographic Dome, marked "Dent 2017," with a zinc and steel pendulum; one marked "Dent 2009," with a wood rod pendulum in the Great Equatorial Dome; one marked "Mudge and Dutton," in the Reflex-Zenith-Tube room; and one marked "Graham 2," fitted with contact springs and with a zinc and steel pendulum, which is in the Transit Pavilion, and is available for use in Longitude determinations.

The Mean Solar Clock, "Dent 2012," is placed in the lobby at the foot of the Octagon room staircase, near to the trigger of the ball-apparatus. This clock (which has been substituted for the electrical clock "Shepherd" formerly in use) has a zinc and steel pendulum, and is fitted with springs for sending out hourly signals to the Post Office and for working the Mean Solar dials distributed throughout the Observatory. On the Escape-wheel-arbor are two wheels, each containing 30 teeth, which close contact-springs alternately, one wheel at the even, the other at the odd seconds. The currents thus set up actuate a relay, by means of which various electro-magnetic clocks in different parts of the Observatory are driven synchronously with the Mean Solar clock. Arrangements are made so that in the case of failure of the clock "Dent 2012," the circuit can be readily shunted on to the electrical clock "Shepherd."

One of the synchronous clocks has a large dial exposed to public view on the east boundary wall of the Observatory; three are in the Chronometer room, and are used in the daily comparisons of chronometers; one is in the lower and one in the upper Computing room; one (of the dimensions of a chronometer) is upon the desk of the Superintendent of the Time Department; and one is in the hall of the Astronomer Royal's dwelling-house. A comparison of the mean time chronometer with the chronometer on the same desk synchronous with the sidereal standard clock (as mentioned in a preceding paragraph) is, in fact, a comparison of the mean solar clock with the sidereal standard. The time shown by the sidereal standard at comparison being corrected for its error (as ascertained from star-transits), the true sidereal time at the comparison is found; and this is converted, by calculation, into true mean solar time at the comparison. The difference between this and the time shown by the mean solar clock is the error of the latter. Then, by means of a commutator on the same desk, the superintendent of clocks completes the circuit of a galvanic current, which, passing through a galvanic coil (with no iron core) in the clock-case, can be made either to attract or to repel a magnet attached to the pendulum, and thus to accelerate or retard the mean solar clock as long as may be necessary for its correction. The clocks connected with the mean solar clock necessarily receive the same correction. The arrangement for giving hourly signals is as follows. The mean solar clock closes a circuit precisely at each hour: that at 1^h, by the intervention of electro-magnets, pulls automatically the ball-trigger and drops the time-ball at Greenwich. Until 1885 October 27 there was an automatic arrangement for reversing the direction of the current through this apparatus; but as this sometimes caused failure in the signal, it was removed on that day, and the direction of the current is now reversed by hand from time to time. At every hour also the primary clock-current by relay-action causes galvanic currents to pass on a line of wire to the central station of the Post Office Telegraphs, St. Martin's-le-Grand, London, where they are distributed daily, by automatic action of the "Chronopher," on some of the principal lines of railway and to important provincial towns. The hourly currents pass also to the clock tower of Westminster Palace for the guidance of the superintendent of the clock, which is not regulated or corrected by any direct galvanic action; and return-currents are received at definite times from the clock, which show daily at Greenwich the deviation of the clock from true time. At 1^h the current drops a time-ball at Deal, the property of the Admiralty; and from this ball a return galvanic current is automatically communicated to Greenwich at the instant that the ball has completed its descent. At Devonport and Portsmouth, local clocks, giving hourly time signals, are corrected daily by the help of the current at 10^h a.m. This time signal automatically starts an auxiliary seconds' pendulum, suspended freely just behind the clock pendulum, which is brought into coincidence of beat with the free pendulum by an attendant (by means of electro-magnetic action as in the Greenwich mean solar clock). The Devonport clock sends a return signal to Greenwich daily at $1^h. 0^m. 39^s{\cdot}0$, and the Portsmouth clock at $1^h. 0^m. 20^s{\cdot}0$, to serve as a test of the accuracy with which the local clocks have been corrected.

The following clocks are also in use in the Observatory as Mean Solar Clocks:—"Dent 2," with a mercurial pendulum, in the Upper Chronometer Room; "Dent 2016," with a zinc and steel pendulum, in the Lower Chronometer Room; "Graham 3," with a mercurial pendulum, in the Ball Lobby, occasionally used for facilitating the regulation of the Mean Solar Clock (described below); "Dent 2014," with a wooden-rod pendulum, now in the South wing of the new Physical Observatory; and "Molyneux," with a wooden-rod pendulum, in the Magnetic Basement. Several chronometers are also kept in the Lower Computing Room for occasional use. Besides these there are two journeymen or assistant clocks; an electric clock by Shepherd, formerly used at Ashford; and a watchman's clock.

The following clocks are on loan:—"Dent 1916" and "Dent 2013" at the Cape Observatory; "Dent 2011" at the Kew Observatory; "Arnold" at the Oxford Observatory; and "Dent 2010" at Devonport, where it is employed to drop the Time-Ball.

III. *Subjects of Observation in the Year* 1897.

The Sun, Moon, and Moon-culminating stars have been observed on the meridian at every practicable opportunity.

With regard to the planets, the following rules have been observed:—The inferior planets, Mercury and Venus, have been observed on the meridian at every practicable opportunity, excepting Sundays. The superior large planets, Mars, Jupiter, Saturn, Uranus, and Neptune, have not generally been observed when their solar time of meridian passage is greater than 14^h, excepting at times when the moon passes the meridian later than 14^h. The small planets have been observed only when the time of meridian passage is earlier than 13^h. The observations of all planets are intermitted on Sundays.

In the meridian observations of the 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), together with 56 other stars which are used in connection with the Nautical Almanac stars, for determining clock-error, and the circumpolar stars of which Ephemerides are given in the *Connaissance des Temps*, or in M. Loewy's *Ephémérides des Etoiles de culmination lunaire et de longitude.*

The other stars observed are taken from a new Working Catalogue containing all stars down to the ninth magnitude (inclusive) within 26° of the Pole, these stars being the reference stars for the Astrographic Catalogue; stars used for determination of zenith-points; Moon-culminating stars from the list in the Appendix to the Nautical Almanac for 1897; stars whose occultations by the Moon are visible at Greenwich; variable stars; stars which pass near the north or south horizon; stars suspected or known to have large proper motions; and stars of which observations have been requested for special purposes.

The observations of the Moon with the Altazimuth have been generally restricted to the first and last quarters of each lunation, it being considered that the intermediate semi-lunation is sufficiently provided for by the meridian observations. The telescope of the Altazimuth has also been occasionally used for observing occultations of stars by the Moon, and phenomena of Jupiter's satellites.

The Reflex-zenith-tube has been used throughout the year for observations of γ Draconis. The observations are made at every opportunity (Sundays excepted), unless when γ Draconis passes the meridian very early in the morning. In these cases the observation is only made when the moon also passes in the early morning.

The Sheepshanks equatorial has been used for observing occultations of stars by the Moon, and for the phenomena of Jupiter's satellites. It has also been used for the observation of comets, and in 1890 November a new positive eyepiece with position circle was applied to it for the improvement of such observations.

The 28-inch refractor has been in use with the object-glass in the visual position for micrometric observations of double stars.

Photographs of the Sun have been taken with the Dallmeyer photoheliograph on every day when the weather permitted.

IV. *Explanation of the Printed Observations.*

§ 1. *Transits observed with the Transit-Circle, and Computations of Apparent Right Ascension.*

The observations here printed in detail are those of the Sun, Moon, Planets, Fundamental and Adjustment Stars. Commencing with the year 1897, the printing of the details of observations of other stars has been discontinued, the daily results only being given in the Ledgers of Mean Right Ascensions and Mean North Polar Distances of Stars.

The *first* column on each 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, and if the limb is defective the requisite correction for defect of illumination is given in the notes. If no limb is mentioned, it is to be understood that the estimated centre was observed. The centre is observed only when the planet's disk is so small and so round as to make it easier to estimate the centre than to determine with accuracy the place of the limb. In the case of Mercury (and more rarely of Venus), whose limbs are sometimes very badly defined, a correction for defective illumination is applied when the estimated centre of the illuminated portion is observed, to reduce to the centre of the disc, see p. xxxiii. With regard to the stars, 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. Flamsteed's constellation-No. and constellation, with Bayer's letter ; taken from Baily's edition of Flamsteed, or the British Association Catalogue.
2. The No. in Bessel's Fundamenta, &c., deduced from Bradley's Observations, referred to as "Bradley."
3. The hour and No. in Piazzi's Catalogue, edition 1814.
4. The No. in Groombridge's Catalogue.
5. The No. in Baily's edition of Flamsteed's Catalogue, referred to as "B.F."
6. The hour and No. in Weisse's two Catalogues of the Stars in Bessel's Zones, referred to as "W.B." and "W.B. (2)" respectively.
7. The No. in Lalande's Catalogue, published by the British Association, or in that edited by Fedorenko, or in the Supplement, referred to as Lalande, Lalande F., and Lalande F. (2) respectively.

8. The No. in Lacaille's Catalogue of Southern Stars, published by the British Association.
9. The No. in Oeltzen's two Catalogues of Argelander's Zone Observations, referred to as "Oeltz. Arg. (N.)" or "(S.)" respectively.
10. The No. in the First and Second Radcliffe Catalogues.
11. The No. in Carrington's Red Hill Catalogue.
12. The No. in the Washington Catalogue of Stars (1860).
13. The Zone and No. in Argelander's Bonn *Durchmusterung* or in Schönfeld's continuation of the *Durchmusterung* (Bonn Catalogue, Sections I., II., III., and IV.; Bonn Observations, Vols. III., IV., V., and VIII.) referred to as "B.D."
14. The No. in the Greenwich Catalogues; in the British Association Catalogue; referred to as B. A. C.; in the Cape Catalogue for 1880; or in the Harvard "General Catalogue of 4,260 Stars, with their approximate magnitudes, "reduced to the Epoch 1880," referred to as H.P.
15. As a last resource the star is defined by its approximate N.P.D.

In observing a double star, the brighter star (if it is not otherwise expressed) is always observed.

When no mark is attached to the name of the object observed, it is to be understood that the observations were made by the galvanic or chronographic method, which was generally in use throughout the year. In any exceptional case where the eye-and-ear method is employed, the observation is distinguished by having the letters (E & E) affixed to it. The letter R. denotes that the object was observed by reflexion in the trough of mercury. The letters *r* and *l* indicate cases where a reversion-prism eyepiece was used, the apparent motion of the star being towards the right and towards the left of the observer respectively.

The *fourth* column contains the initials of the observer's name.

The next *ten* columns contain the clock-times (seconds and decimals of a second only) at which the object was observed to pass each of the wires. For eye-and-ear transits, the wires used are denoted by the letters M, N, O, T, X, Y, Z. The wires used for galvanic transits are denoted by the letters O, P, Q, R, S, T, U, V, W, X; O, T, and X being wires of the eye-and-ear system, and the others new wires inserted between O, T, and X. The intervals O-P, P-Q, R-S, S-T, U-V, V-W, W-X are nearly equal; the interval Q-R is nearly double, and the interval T-U nearly treble the former. This system of ten wires for the galvanic transits was introduced on 1891 October 28, in substitution for the system of nine wires previously in use.

Polaris and other stars very near the pole are generally observed by turning the R.A. micrometer-screw with the right hand until the star is bisected by the middle wire T (or sometimes one of the other wires), the instant of accurate bisection being recorded on the chronograph with the left hand. The reading of the micrometer is then recorded, and the operation repeated until ten observations are obtained. The readings of the R.A. micrometer are always mentioned in the notes. As the "reduction to the centre wire" in this case depends on the value of successive revolutions of the micrometer-screw, the errors of this screw were investigated on 1891 November 14 by Mr. Thackeray and Mr. Hollis after the introduction of a new screw. The eyepiece of the transit-circle was rotated through 90°, and the instrument was turned on the S. Collimator. Successive intervals of $3^{rev.}$ of the transit-micrometer were compared with the same interval ($4^{r}\cdot600$) of the S. Collimator micrometer; and likewise successive intervals of $1^{rev.}$ and $0^{r}\cdot333$ of the transit-micrometer with intervals $1^{r}\cdot540$ and $0^{r}\cdot510$ of the S. Collimator micrometer, these intervals of the S. Collimator micrometer being nearly equal to the intervals of the R.A. micrometer with which they were compared. The results are given in the Transit-Circle Tables at the end of the Introduction for 1891, page cxii. It is considered that the errors are too small to necessitate correction, and this is confirmed by comparing the times of transit of circumpolar stars for intervals of successive revolutions.

In observing by galvanic contact, the observer merely makes contact of the galvanic spring at the instant of the object passing the wire. Occasionally, when no object is under observation, he makes contacts in any arbitrary manner (usually by a commutator which puts the contact-springs of the clock Hardy into circuit with the "observations" pricker-magnet of the chronograph), recording in his book the time by the clock Hardy; and thus the numeration of hours, minutes, and seconds on the punctured sheets (referred to the Sidereal Standard clock) is easily established. The punctured sheets are examined the next day, the numeration of minutes and seconds is written upon them, and the transits are read into the transit-book.

In observing by eye-and-ear, 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 of the clock, and not to look again at the clock-face till the transit is completed. The fraction of the second is estimated 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. Stars very near the pole are sometimes observed by the eye-and-ear method over the wires intended for the galvanic transits, but more generally over wire T (the middle wire) set to a series of readings of the transit-micrometer as described above. The actual readings are always mentioned in the notes.

All transits of stars observed by galvanic contact are usually referred to the Sidereal Standard clock; but for stars observed by eye-and-ear, the clock Hardy is necessarily still used. The times printed in the columns "Seconds of Transit over the Wires" are those of the observations as made, the letters (E & E) in the third column indicating when the clock Hardy was used. The difference between the indications of the two clocks is given in the notes.

The *fifteenth* column contains the Concluded Transits, giving the hour and minute of the time of meridian passage (which have not been given in the preceding columns), as well as the mean of seconds.

For stars observed by eye-and-ear by the clock Hardy, the *Concluded Transit* includes the correction for reduction of the transit as observed by Hardy to such as would have been observed by use of the Sidereal Standard clock. The correction applied in each instance is given in the footnotes.

When transits have not been observed over all the wires, a correction is applied to the mean of those actually observed, in order to give the mean of the transits as it would have resulted if each had been reduced separately to the centre wire. When transits have been observed over all the wires, the same process of correction is used, but the amount of correction for the mean is very small.

The adopted equatorial intervals of the wires used are given in the Transit-Circle Tables at the end of this Introduction.

For stars above the pole, the designations of Wires I., II., III., &c. at the heads of the columns of printed transits correspond to O, P, Q, &c. (or to M, N, O, &c. when the object is observed by eye-and-ear (E & E), in all cases excepting Polaris, &c.). For stars below the pole, the designations I., II., III., &c. correspond to X, W, V, &c., or to Z, Y, X, &c.

The signs of the intervals must be changed when the star is below the pole.

The correction to the imperfect transit of a star can be found by adding together the equatorial intervals from the table for the wires observed, then dividing by the number of wires, and multiplying by the secant of the star's declination.

For a planet, the correction, computed as for a star, is to be multiplied by

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

but it has generally been found easier to add, to the computed interval between the mean of wires and the centre wire, the amount of the planet's increase of right-ascension for that interval, which is very readily determined from the numbers given in the Nautical Almanac.

For the Moon, the equatorial intervals for the wires observed are added together, and the sum is divided by the number of wires; this quotient is then multiplied by

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

where I is the increase (in seconds of time) of the Moon's R.A. 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.

In cases where a defective limb of a planet has been observed, a correction for defect of illumination (negative to the time of passage of the first limb, or positive to that of the second limb, according as the planet had passed or had not passed the opposition in right ascension) is applied in forming the concluding transit, and is thus investigated :—The excess or defect of the difference of R.A. of the Sun and planet from 12^h, at the time of the planet's transit, expressed in arc, is multiplied by the cosine of the Sun's declination, to form an arc θ which represents the angle upon the planet's surface of the unenlightened part of the disk (with respect to right ascension); the correction required is, Duration of passage of semidiameter $\times$ versed sine θ.

Occasionally the limb of Mercury is so ill-defined that the observer records a transit of the "centre." This is considered to be the centre of gravity of the illuminated portion of the disc, and a correction of $\frac{4}{3\pi}$ $(=0{\cdot}424)$ $\times$ defect of illumination should be applied for reduction to the centre of the actual disc. In practice this is applied in forming the concluded transit as $0{\cdot}4$ $\times$ correction for defect of illumination in R.A., calculated as for a transit of a defective limb.

The *sixteenth* column contains the numerical values, in seconds of arc, of the errors of collimation, level, and azimuth; the last two being distinguished from the first by a round and a square bracket respectively. These errors will be treated separately as follows :—

Error of Collimation.

The value of this error is given in seconds of arc. The sign of the error is considered positive when it implies an additive correction to the time of observed transits of stars above the pole.

The method of determining the position of the line of collimation by means of the north and south collimators has been fully explained above in the description of the instrument. The reading of the micrometer of the north collimator, for coincidence of its nearly vertical wire with the image of that of the south collimator, is ascertained every day, and the micrometer-wire of the north collimator is then left in that position. The reading of the R.A. micrometer of the transit-circle, for coincidence with the image of the wire of each collimator, is then found; the mean of these two readings gives the reading for the line of collimation for the day; and the mean of these determinations, usually for a week, is adopted as the reading for the geometrical line of collimation of the transit-telescope. A correction of + $0^{r}\cdot008$ has been applied to the "Adopted mean of group," to reduce the collimation-readings resulting from the observations of the collimator made through the central cube of the transit-circle to those resulting from observations made when the instrument is raised, this being the discordance found from a comparison of the two methods of observation during the years 1871–80, the annual means for which were sensibly accorded. But since 1880 the discordance has increased, though no satisfactory reason can be given for the change (*see* discussions by Mr. Turner in the *Monthly Notices of the Royal Astronomical Society*, vol. xlvi. p. 329, and vol. lii. p. 146). It has not, however, been considered advisable to alter the correction at present.

During the year 1851 the observations of the collimators with the transit-circle telescope were usually made twice in every day. Upon examination of the results it did not appear that there was any discoverable difference at different hours of the day, and therefore generally, since that time, the observations have been made only once a day.

The R.A. micrometer is left at some convenient reading near to that of the geometrical collimation, but not necessarily coinciding with it. This reading is given at the foot of every page of transits. The algebraical excess of the reading for collimation above this is the error of collimation, with the sign as explained above. This excess is converted into arc at the rate of $37''\cdot10$ for one revolution of the micrometer. The determination of the value of a revolution was made in 1891 November after the introduction of a new screw. The investigation is given in the Transit-Circle Tables at the end of the Introduction for 1891, page cxi. The errors of the screw were also investigated and found to be insensible. To the excess thus converted into arc is then applied—$0''\cdot19$ for diurnal aberration; and the result is the quantity which is given in the sixteenth column of the *Transits* as the error of collimation, and which is adopted for correction of the observed transits.

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

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

Error of Level.

The error of level of the axis of revolution is considered positive when the western end of the axis is too high.

The process of determining the error of level consists in taking the reading of the transit-micrometer which makes the image of the wire as seen by reflexion from the surface of quicksilver to coincide with the wire as seen directly, as is explained in the description of the instrument above, and comparing this reading with the reading for the geometrical line of collimation. The excess of the reading for the line of collimation above the reading for coincidence of direct and reflected images gives the error of level, with the sign mentioned above. It is converted into arc at the rate of $37''\cdot10$ for $1^{\text{rev.}}$ The mean of the results is adopted sometimes for a week, sometimes for a shorter time, as the instrument appears to have been more or less steady in level.

The result adopted for the error of level is given in the sixteenth column of the *Transits*, in curved brackets.

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

$$\text{Error of level} \times \frac{\text{cosine zenith distance}}{15 \sin \text{N.P.D.}}$$

The error of level has usually been observed twice every day, and in some instances where there appeared to be a considerable change, the separate results have been used for the morning and evening observations respectively.

As a check on the general system of correction for error of level, transits of stars have been occasionally observed by reflexion, and the results have been compared with those of direct observations. A table exhibiting this comparison, together with the apparent correction to the error of level deduced from each star observed, is given at the end of this Introduction.

Error of Azimuth.

This error is considered positive when the eastern pivot is too far north. It is generally determined from observations of the following stars:—Polaris, Cephei 51, Groombridge 1119, Bradley 1672, Groombridge 2283, δ Ursæ Minoris, λ Ursæ Minoris, Groombridge 3548, and Bradley 3147. The stars used are mentioned in the table of Determinations of the Error of Azimuth following this section; the method of using them is as follows:—

If two consecutive passages of one of these stars above and below the pole have been observed, the second transit (as corrected for the errors of collimation and level) is altered by the change of the star's R.A. and by the estimated clock-rate through 12^h; and the difference, in seconds of time, between the first transit and the altered second transit (rejecting 12^h) is divided by the azimuth factor corresponding to the apparent declination of the star for the day, to obtain the azimuthal error in seconds of arc.

When only one observation of a circumpolar star can be obtained, the following process is used:—The letter z being put for the azimuthal error, the time of true transit of any star consists of an observed time (corrected for errors of collimation and level) with an additional term multiplied by z; and, therefore, the clock-error, as given by comparison of that transit with the star's tabular R.A., contains a term multiplied by z. The clock-error given thus by a star near the pole contains a large multiple of z. The clock-error given by a star far from the pole contains a small multiple of z. Equating these, with proper allowance for the rate of clock, z is found.

When two stars, both near the pole, but one above and the other below the pole, are observed, the combination is more favourable, as both factors of z are large and have opposite signs.

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

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

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

The numerical values of the three corrections for the errors of collimation, level, and azimuth have been obtained throughout the year by means of sliding logarithmic scales (one for each error) constructed by Mr. Simms. These scales give by simple inspection the numerical corrections in seconds of time for each transit by means of the north polar distances engraved on the scales. The value of the error in collimation, level, or azimuth on the slider is set to a brass pin which is let into the scale; and the value of the correction to transits, with its proper sign, is then taken out very readily at sight.

A table of factors for the three errors, having for argument the N.P.D. of the object, which may be found convenient for the verification of the computed corrections, is given in the Transit-Circle Tables at the end of this Introduction.

The *seventeenth* column contains the seconds of every transit, corrected for the three preceding errors; and is conceived to represent the clock-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 the two limbs of the Sun or a planet.

The *eighteenth* column contains the seconds of the tabular R.A. of the stars which are used for determining clock-errors. In addition to 155 clock-stars taken from the Nautical Almanac, whose N.P.D. exceeds 50°, there has been used another list, consisting of 56 stars, selected and observed for this purpose, and lying beyond the same limit of N.P.D. The tabular right ascensions of the nine close polar stars used for azimuth are set down, whenever they have been actually used in determining the azimuthal error, to be used in conjunction with the number in the sixteenth column, in order to enable the reader to judge of the general state of adjustment of the instrument, but not to assist in determining clock-errors.

The right ascensions are computed from the *Five-Year Catalogue of* 258 *Fundamental Stars for* 1890 (Appendix to *Greenwich Observations*, 1891) by the use of the precessions of that Catalogue. The proper motions used are taken from Prof. Auwers' *Neue Reduction der Bradleyschen Beobachtungen, Erster Band,* for all stars contained in that work, except μ Andromedæ, for which Mr. Main's proper motion has been used as heretofore. For Cephei 51, the proper motion is taken from Prof. Auwers' *Catalog der Fundamental Sterne*, and for α Columbæ and δ Sculptoris from the Cape Catalogue, 1880. The corrections necessary to bring up the stars' right ascensions to the day of observation are computed by the formula $A\,a + B\,b + C\,c + D\,d + f + \mu\,t$, given in Professor Turner's *Tables for facilitating the Computation of Star Constants.* For stars near the pole, the additional correction depending on the place of the Moon is also taken into account. In the Transit-Circle Tables, at the end of this Introduction, page cvii, are given the Mean Right Ascensions for 1897·0 of all the stars which have been used for determining clock-errors or azimuth-errors, together with the corrections to the right ascensions of the Nautical Almanac stars for 1897·0.

The *nineteenth* column contains the error of the clock, found by subtracting the numbers in the seventeenth column from those in the eighteenth. The error is therefore positive when the clock is slow. The apparent clock-errors given by the nine close polar stars used for azimuth-error, as has been remarked above, are not employed in determining the clock-errors available for computations of right ascensions.

The *twentieth* column contains 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, defined by bars across this column (in all instances the same as the limits of the observations of each observer). The mean of the clock-errors given by all the clock-stars in each group is then taken, and this is considered to be the clock-error corresponding to the mean of all the times of transit of those stars. The next step is to investigate the clock-rate, making allowance for personal equation between the transits of successive observers; and it will be sufficient to explain the personal equation existing between any two observers, but more especially between Mr. Bryant and some other observer—for example, between Mr. Bryant and Mr. Hollis—since it has been the practice from the beginning of 1896 to reduce all the clock-times of observation with the altazimuth to sidereal time by means of errors of the transit-clock referred to Mr. Bryant as the standard. Suppose, then, that transits have been observed on successive days by Mr. Bryant and Mr. Hollis, and that, for the set of observations on each day, the mean is taken as described above, it will be seen by a table in the Introduction to the *Greenwich Observations*, 1896, page cxxv, that the clock-error given by Mr. Hollis' observations is less than that given by Mr. Bryant's observations by $0^s{\cdot}23$, as deduced from observations suitable for the determination of this quantity in the year 1896; and this is the last determination of personal equation which is available for the daily reduction of observations in 1897. The quantity $0^s{\cdot}23$ is therefore added to Mr. Hollis' clock-errors, and it is then considered that we have two sets of clock-errors (namely, Mr. Bryant's as unaltered, and Mr. Hollis' as modified) justly comparable. Each mean clock-error, properly modified, is now compared with that which precedes and with that which follows; a preceding rate and a following rate are thus found, and by these the Chief Assistant is guided in adopting the clock-rate to be used through the group of observations: this adopted clock-rate is set down in the twentieth 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; 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 the following sidereal day is obtained. These errors at 0^h for all the different sidereal days are also set down in the twentieth 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. Bryant or Mr. Hollis), no further computation is necessary for obtaining the right ascensions of those objects than the application, to the time of transit, of the clock-error at 0^h, and of a proportional part of the clock-rate corresponding to the right ascension of the object; but, if the clock-stars are observed by Mr. Hollis, and the other object by Mr. Bryant, a further correction + $0^s{\cdot}23$ must be applied: if the clock-stars are observed by Mr. Bryant, and the object by Mr. Hollis, − $0^s{\cdot}23$ must be applied. The personal equations are *not* applied in the column of *Apparent Right Ascensions from the Observations* in this Section.

The observations which are available in the year 1897 for determining personal equations in the use of the chronographic method of recording transits are discussed in a table at the end of this Introduction. They have been treated in the same manner as in preceding years, by comparing the clock-error at the same sidereal hour given by two different groups of stars observed by different persons.

The following are the personal equations as applicable to the chronographic method of observing, deduced from the observations made in 1897 and referred to Mr. Bryant as Standard Observer:—

	s		s		s
B − D	= + 0·12	B − WB	= + 0·01	B − W	= + 0·06
B − C	= − 0·01	B − HF	= + 0·07	B − HA	= + 0·03
B − H	= + 0·27	B − RC	= + 0·08	B − WS	= 0·00
B − AC	= − 0·02	B − J	= + 0·02	B − JS	= + 0·07
B − CD	= + 0·04	B − EB	= + 0·07		
B − R	= + 0·14	B − S	= + 0·25		

These have been applied to the collected results of transits for the Sun, Moon, and planets, whenever they were needed throughout the year 1897.

But those used in the adoption of clock-rate as explained above, and in the reduction of altazimuth observations, referred to Mr. Bryant as Standard, have been deduced from the observations in 1896. The investigation of these is given in the *Introduction to the Greenwich Astronomical Observations*, 1896, page cxv.

It has been the practice on favourable nights for the transit-circle observer to observe two "clock stars" by the eye-and-ear method, at the same time making a careful comparison between the clock "Hardy" (used in observing by this method) and the Sidereal Standard, which is used in chronographic transits. It is then an easy matter to compare the values of the quantity "clock slow" as found by the same observer using the different methods. The discussion of these results is given in a table at the end of this Introduction.

Discussions of results obtained with the reversion prism eyepiece, for personality depending on the direction of motion, are given in the tables at the end of this Introduction.

In the standing footnote on each page is given the duration of passage for the semidiameter of a planet when only one limb has been observed. It is found as follows:—

For the Sun, the following corrections, depending on the respective observers, are applied to the Nautical Almanac semidiameter:—

	s		s
Mr. Hollis	+0·09	Mr. Rendell	−0·03
Mr. Crommelin	−0·01	Mr. Bowyer	−0·06
Mr. Bryant	+0·01	Other Observers	−0·01
Mr. Davidson	−0·07		

These corrections have been determined from the observations of the respective observers during the current year.

The following table exhibits the results of observations for recent years:—

	H	AC	B	CD	R	WB	Other Observers.
	s	s	s	s	s	s	s
1892	+0·02	−0·04	−0·05				−0·09
1893	+0·03	−0·07	−0·05				−0·04
1894	+0·03	−0·05	−0·06				−0·07
1895	+0·03	−0·03	−0·06				−0·07
1896	+0·05	−0·01	−0·01				−0·01
1897	+0·09	−0·01	+0·01	−0·07	−0·03	−0·06	−0·01

From 1896 January 1 the value adopted in the Nautical Almanac for the Sun's semidiameter at the Earth's mean distance was changed from 16′. 1″·82 to 16′. 1″·18.

For the Moon and Mercury, the duration is taken without alteration from the Nautical Almanac.

For Venus, a correction is applied to the Nautical Almanac semidiameter, determined from observations made with the transit-circle from 1851 to 1862. The investigation by Mr. Stone will be found in the *Monthly Notices of the Royal Astronomical Society*, vol. xxv. No. 3. The correction, which has been applied additively to the Nautical Almanac semidiameter during the year, is:—

$$+ \overset{s}{0}{\cdot}026 + \overset{s}{0}{\cdot}027 \times \text{tabular duration of passage of semidiameter.}$$

For Jupiter and Saturn, both limbs are always observed, if possible; but if, through accident or necessity, only one limb is observed, the duration of passage of the semidiameter is obtained by applying to the value given in the Nautical Almanac a correction derived from a view of the neighbouring observations. The elements of computation are given in the notes.

The *twenty-first* column contains the right ascension of the centre of the body observed: it is formed by adding the time from the seventeenth column, the clock-error at 0^h next preceding from the twentieth column, the proportional part of the rate in the same column corresponding to the right ascension, and the duration of the passage of the semidiameter from the footnotes. No result is set down for a clock-star, unless at least four clock-stars, distributed over six hours of right ascension, have been observed; no result is set down for an azimuth star unless at least one of the nine azimuth stars has been observed at opposite passages; and no result is set down for other close circum-polar stars, unless there has been a good determination of the azimuthal error on the day of observation.

Whenever the concluded result in this or other sections is obviously erroneous, it is enclosed within brackets, and is not used in subsequent computations.

§ 2. *Determinations of the Errors of Collimation, Level, and Azimuth of the Transit-Circle.*

With regard to these tables, the following remarks, in addition to the explanation which has been given, in the description of the instrument, and in the account of the methods of determining the errors of collimation and level, will be sufficient.

OBSERVATIONS FOR COINCIDENCE OF COLLIMATORS.

These observations are made on every week-day. For those made on Monday, the transit-circle is raised to admit an uninterrupted view of the South Collimator by the North Collimator. On all days the view is taken through the pierced cube of the transit-circle.

Immediately before the observations of the collimators with the transit-circle for determination of collimation-error, six readings of the micrometer of the North Collimator, for coincidence of the middle of the nearly vertical side of its square with the corresponding point of the square in the South Collimator, are taken, and the wire is then left at a reading corresponding to the mean of the six. Since the alteration in the form of mounting of the collimators, referred to on page vii, this observation has been usually repeated immediately after the observations of the collimators with the transit-circle. The means of both sets of micrometer-readings are printed in the table, and will give a satisfactory idea of the firmness of the collimators.

OBSERVATIONS OF THE COLLIMATORS FOR DETERMINATION OF THE ERROR OF COLLIMATION.

The way in which these observations are made has been fully explained (pages vi and xxxiii). The means of the readings for the separate collimators are set down in the second and third columns. The mean of these gives, after the application of a correction " + 0·16 × excess of first reading over second reading of North Collimator for coincidence with South Collimator," the concluded reading set down in the fourth column. The next column gives the reading which has been adopted for the period of time limited by the bars above and below; and the last column gives the adopted reading for the line of collimation after the application of a correction of $+0^{r}\cdot008$ to reduce the result to that which would have been obtained if the instrument had been raised when the observation for coincidence of the collimators was made. By comparing the numbers in this column with the *Readings of Transit-Micrometer* given in the footnotes of the section *Transits observed*, &c., and applying $-0''\cdot19$ for diurnal aberration, the errors of collimation actually used will be deduced. For determination of the sign of the error, it must be observed that the micrometer-head is east, and that the readings of the micrometer increase as the wire moves towards the head.

Since the reversion-prism was applied in 1884 June, it has been the practice, in each set of observations for coincidence of the collimators with each other, and of the transit-circle with either of them, to take three readings with the direction for increasing readings apparently towards the right, and three with the direction apparently towards the left, in order to eliminate any personality depending on the apparent direction of measurement. A series of observations for the investigation of this personality was made by different observers, with the direction for increasing readings apparently towards the right, towards the left, downwards and upwards respectively. The discussion of these observations, given in the Transit-Circle Tables for the year 1885, shows that the apparent direction of measurement has no appreciable influence on the results.

DETERMINATION OF THE LEVEL-ERROR.

The method of making these observations has been described (pp. viii and xxxv). A comparison of the transit-micrometer-reading for coincidence of the direct and reflected images of the central wire (printed in the second column) with the adopted reading for the line of collimation gives the error of level in terms of revolutions of the micrometer; and the numbers in the third column exhibit the errors of level in arc. The last column gives the adopted values of the error and the limits of time during which they have been used. The determination of the sign of the errors has been previously explained.

DETERMINATION OF THE ERROR OF AZIMUTH.

The method of finding the error of azimuth has been fully explained on p. xxxvi. The hour given in the first column is the mean of the times of the two observations with weights proportional to their respective azimuth factors, and thus expresses the approximate mean solar time (astronomical reckoning) to which the determination of azimuth-error refers. The names of the stars in the second column are given in the order of observation. The correction for clock-rate and change of R.A. in the fifth column is that which is applicable to the second observation in order to reduce it to the epoch of the first. In the eighth column is given the factor of z (the azimuth-error), by which the difference of the two quantities in the sixth and seventh columns is to be divided in order to determine the Resulting Error of Azimuth, expressed in seconds of arc. This factor is the algebraic difference of the two multiples of z referred to on p. xxxvi.

§ 3. *Observations of Zenith Distance with the Transit-Circle.*

The observations here printed in detail are those of the Sun, Moon, Planets, Fundamental and Adjustment Stars. Commencing with the year 1897, the printing of the details of observations of other stars has been discontinued, the daily results only being given in the Ledgers of Mean Right Ascensions and Mean North Polar Distances of Stars.

In order to include the whole of the reductions belonging to a single observation on one page, the elements for those reductions which are not frequently changed, and which do not require tabular arrangement, are given in the footnotes. These are :— correction for runs; formulæ used in computing micrometer-corrections, corrections for curvature of path, and inclination of wire; and zenith-point corrections.

The corrections for planets, including change of N.P.D. for reduction to the meridian, parallax, and semidiameter, and also the corrections for reducing the apparent places of stars to mean places, are exhibited in tabular arrangement at the lower part of each page, opposite to the reference numbers which correspond to the observations in the upper part of the page.

DAY.—The day of observation always begins with the Sun's transit.

No. FOR REFERENCE.—This column requires no explanation.

NAME OF OBJECT.—The nomenclature of stars follows the same general rule as in the section of *Transits observed*, &c., except that, as a last resource, the place of the star is defined by its right ascension, which is generally accurate to 1^s. The letters N. L. and S. L. denote North and South limbs of planets, and N. C. and S. C. the north and south cusps of Mercury or Venus. The words *Nadir Observation* indicate an observation of the image of the horizontal or zenith-distance wire as seen by reflexion in a trough of mercury, as is described in page viii. For other objects, the letter R. denotes that the object is observed by reflexion in the trough of mercury.

READINGS OF THE MICROSCOPE-MICROMETERS.—The application of the letters for the six ordinary microscope-micrometers is the same as in the Observations of preceding years: 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 (see diagram, page ix). These readings in the observing books are placed in the order $\begin{matrix} A, C, E \\ B, D, F \end{matrix}$; 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 number of integral revolutions is given in the fifth column only. Occasionally the number of revolutions expressed in this column does not apply unchanged to all the microscopes, on account of the difference of their readings; but since the readings never differ by more than three or four tenths of a revolution, this will occasion no ambiguity. On a few occasions the cross-wires have fallen on the negative side of the micrometer-zero; in such cases (which are always mentioned in the notes) the fractional part of the reading given is positive, being that taken from the micrometer-head, but the integer 9 represents -1. The reading of the pointer-microscope is omitted for the sake of economy of space, but it may be inferred from the zenith-point given in full at the bottom of each page, and from the deduced zenith-distance.

It is proper now to explain how the revolutions and parts of revolutions of the microscope-micrometers are converted into arc, when the six ordinary microscopes are used.

First, it may be premised that, as one revolution of each microscope-micrometer does not differ extravagantly from $1'$ on the limb of the circle, we may consider each revolution as a nominal minute. Next, supposing the number of integral revolutions, as shown by each microscope, to be the same for all, we ought, in order to obtain the mean of the fractions of a revolution, to add together the subdivisions as shown by the different micrometer-heads, and divide the sum by 6. Thirdly, as the subdivisions are in the decimal scale, we should then multiply this mean by 60, to reduce it to sexagesimal seconds. It is evident thus that the number of nominal seconds to be attached to the nominal minute will be found by simply adding together the subdivisions on the micrometer-heads, and shifting the decimal point.

When the four supplementary microscopes are used, the subdivisions are added together, and the sum is multiplied by 3 and divided by 2; it is then only necessary to shift the decimal point.

From the ordinary observations of runs it is known that the screws of the micrometers are so sensibly equal that, in the reduction of the observations, it is sufficient to take the mean of the six readings, and to apply to it the mean correction for runs. To do this, the following process is employed. The sum of the runs for the six micrometers never differs materially from $29^{r}\cdot3$. Now, if the correction, by the addition of which each revolution of a micrometer may be converted into a minute of arc, were exactly $\frac{1}{50}$ part of the reading, then the sum of the runs would be $\frac{50}{51} \times 30^{r}\cdot000$, or $29^{r}\cdot4118$. If the sum of the runs is not exactly equal to this quantity, there will be a variable correction after adding $\frac{1}{50}$ part of the mean of the readings of the microscopes. To determine this quantity, let the sum of the runs be $29^{r}\cdot412 - x$. Then the true reading in seconds of space, corresponding to a nominal reading of r'' (including the value both of the nominal minutes and of the subdivisions of the nominal minute) will be

$$r'' \times \frac{30\cdot000}{29\cdot412 - x}$$

or

$$r \left\{ 1 + \frac{1}{50} + 0\cdot03468 \times x \right\}$$

Hence the correction, after adding $\frac{1}{50}$ part of the mean of readings, will be $+ \; r \; x \times 0''\cdot03468$. For the purpose of calculating this quantity easily by the ordinary proportional scale, it is convenient, in the first place, to compute its value when $r = 100''$. This value, which is evidently $+ \; 3''\cdot468 \times x$, is tabulated for different values of x. Let X be the number taken from this table; then, for any actual reading r, the correction will be $\frac{rX}{100}$: a quantity which can easily be taken from the ordinary sliding-rule.

For the four supplementary microscopes the constant for the sum of the runs would be $\frac{50}{51} \times 20^{r}\cdot000 = 19^{r}\cdot608$. Hence the true reading in seconds of space will be

$$r'' \times \frac{20\cdot000}{19\cdot608 - x}$$

or

$$r'' \left\{ 1 + \frac{1}{50} + 0\cdot05202 \times x \right\}$$

and the correction, after adding $\frac{1}{50}$th part of the mean of readings, will be $+ \, r\,x \times 0''\cdot05202$.

CORRECTIONS FOR ERROR OF DIVISION AND FOR FLEXURE OF TELESCOPE.—The corrections for errors of division applied in this section and in section of Ledgers of Mean Right Ascensions, &c., are the means of the determinations made in 1851 and 1856. But in the subsequent sections of Star Catalogue and Planetary Results the means of the four determinations made in 1856, 1871, and 1898 were adopted, corrections being applied to these results representing the differences between the two sets of division-corrections.

The observations for determination of the horizontal astronomical flexure of the transit-circle telescope are given at the end of this Introduction. In making these observations, the nearly horizontal wire of the South Collimator was brought upon the image of the corresponding wire of the North Collimator by looking through the cube of the transit-circle; and the micrometer-head was set at the mean of 10 successive readings. After each complete set of 5 observations of the collimating wires, the observations for coincidence of these wires were repeated; and a correction has been applied, when required, to the mean circle-reading at bisection of the wire of South Collimator, for the half-difference in the two sets of observations for coincidence.

From April 1879 no correction for flexure has been applied, the flexure correction being virtually included in the correction for discordance of direct and reflexion observations.

READINGS OF TELESCOPE-MICROMETER.—This column contains the reading of the micrometer in the eyepiece of the telescope, corresponding to the several bisections of an object during its passage across the field of view. The instrument is furnished with two clamps, one north and the other south, for fixing it, but with no slow-motion screw; the object must therefore be bisected by means of the micrometer-screw, and the micrometer must be read for every observation. The reading of $20^{r\cdot}$ corresponds pretty nearly to the middle of the range of the screw, and the wire is then tolerably near the centre of the field of view; observations are, therefore, generally made with a position of the wire not greatly different from this.

In 1891 October a new steel screw was applied to the micrometer by Messrs. Troughton & Simms. Observations for the determination of the value of $1^{rev.}$ of this screw are given in the Transit-Circle Tables at the end of the Introduction for 1891, p. cxi, the resulting value being 37″·05. The errors of the screw were also investigated and found to be insensible. (Transit-Circle Tables, 1891, p. cxv.)

The value of $1^{rev.}$ of this screw and its errors were re-determined from 1896 December to 1897 February. The screw was found to have worn considerably, and corrections were obtained to the equivalents of the micrometer-readings belonging to a uniform screw with $1^{rev.}$ = 37″·05. An account of the observations is given in the Transit-Circle Tables for 1896, and a table of the corrections is given in the Transit-Circle Tables at the end of this Introduction.

VERTICAL WIRES IN THE TELESCOPE-FIELD AT WHICH CIRCLE-OBSERVATIONS ARE TAKEN.—Omitting, in this section, all reference to the wires P, Q, R, S, U, V, W, adapted to galvanic observation of transits, the telescope contains seven vertical or transit wires M, N, O, T, X, Y, Z, here called 1, 2, 3, 4, 5, 6, 7, placed at sensibly equal intervals of about $14^{s}·8$ for transit of an equatorial star; and the central or 4th wire is so nearly in the meridian as to prevent the necessity of any correction to the observed circle-reading when the body is observed at the passage over that wire. In that case, the only corrections which are required to the mean of the microscope-micrometer-readings (when converted into arc and combined with the equivalent for the telescope-micrometer-reading) are those arising from errors of division of the graduated circle, and from astronomical flexure of the telescope.

When the object has not been observed at the central wire, corrections are required for reduction to the meridian. These consist of three, viz.:—First, for want of horizontality of the micrometer-wire; secondly, for curvature of path of the object, or for difference between the small circle described by the body and the great circle of which the horizontal wire forms a part; and thirdly, in the case of the Sun, Moon, and planets, for the change of N.P.D. in the interval between the time of observation and the meridian passage.

The correction due to inclination of wire was found by bisections of stars (by the telescope-micrometer) at the first and seventh, or second and sixth, vertical wires. Its numerical value, additive before transit and subtractive after transit, for stars above the pole, is given in the notes at the beginning of the section.

The general formula for the correction for curvature is given also in the notes at the beginning; its value is easily interpolated from a table constructed for convenient intervals of N.P.D. In the case of stars very near the pole, when the place of observation does not coincide with a vertical wire, the correction for curvature is computed from the formula :—

Correction for curvature = number (log. = 6·43569) × sin 2 N.P.D. × t^2, t being the interval between the time of meridian passage and the time of transit expressed in seconds of time.

The formulæ for correction for motion are the following. In the case of the Moon, the correction for the change of N.P.D. in passing from one wire to the next is computed from the formula, "Change of declination for one hour of terrestrial longitude (from the section of Moon-culminating Stars in the Nautical Almanac) × sec. declination × $\frac{\text{Sin Geoc. Z.D.}}{\text{Sin App. Z.D.}}$ × $\frac{14 \cdot 8}{3600}$ (the logarithm of the last factor being 7·61396)." In the case of the other planets, the correction for motion is deduced immediately from the hourly motion in declination given in the Nautical Almanac; or, in the case of newly discovered planets, from their peculiar Ephemerides.

SECONDS OF CONCLUDED MERIDIAN CIRCLE-READING.—The numbers in this column are found by adding together the mean of the microscope-readings corrected for runs, the equivalent for the mean of the telescope-micrometer-readings, corrected for curvature and inclination of the wire, and the correction for motion in the case of the Sun, Moon, or planets. The degrees and minutes may be ascertained, when required, by subtracting the "Correction for zenith-point" given in the notes from the Apparent zenith-distance.

ZENITH-POINT CORRECTION.—The observations for this purpose are those of the reflected image of the horizontal wire, and those of the direct and reflected images of stars made at the same transit.

From 1886 January 1 to 1896 December 31 no correction has been applied to nadir-observations for discordance between the results of this observation and the mean of those of North and South stars. From 1897 January 1 a correction of $-0''\cdot25$ has been applied to the nadir-observations in forming the adopted zenith-point, when there are no reflexion observations of North and South stars; but when the observation of Nadir is combined with reflexion observations of stars no correction is applied. From observations in former years a connexion was traced between this discordance and the errors of the screws of the microscope-micrometers, and it was hoped that the application of the new steel screws (one of each pair being reversed) would remove the discordance. This was found to be the case till 1892, the mean apparent correction to the nadir-observation as found from reflexion observations of stars since 1886 being as follows:—

	″		″
1886	− 0·09	1892	− 0·26
1887	+ 0·01	1893	− 0·34
1888	− 0·12	1894	− 0·27
1889	+ 0·07	1895	− 0·31
1890	+ 0·08	1896	− 0·34
1891	+ 0·07	1897	− 0·27

In consequence of the discordance shown in 1892, the errors of the microscope-micrometer-screws were redetermined in 1893. The observations on which these depend are given in the Transit-Circle Tables for 1894. Although signs of wear were shown, the errors arising from this cause are so nearly eliminated by the reversal of three of the screws, that it has not been considered advisable to apply any correction to the circle-reading for apparent error of the screws. Similar observations made in 1896 November confirm these results. These observations are given in the Transit-Circle Tables for 1896.

With a view of obtaining information as to the cause of this discordance, observations of the Nadir have been taken since 1895 July three times each day when practicable.

The following differences were found from observations in 1895, 1896, and 1897 respectively:—

	21^{h}—3^{h} G.M.T.	3^{h}—9^{h} G.M.T.	9^{h}—15^{h} G.M.T.	No. of Days.
	″	″	″	
1895	+ 0·29	0·00	+ 0·27	54
1896	+ 0·20	0·00	+ 0·16	84
1897	+ 0·11	0·00	+ 0·17	108

The + sign indicates a greater circle-reading. The reflexion observations of stars are made between 3^{h} and 9^{h}, and the discordance will be diminished if Nadirs taken about this time are alone used in the comparison.

The details of the computation of zenith-point are given in a subsequent table. The adopted corrections for zenith-point are given in the footnotes to this section.

From an investigation made in 1887 it appears that the probable error of a complete determination of Zenith-Point (four stars and a nadir-observation) was about $\pm 0''{\cdot}20$. The introduction of an amalgamated copper bottom for the trough in 1889 September greatly improved the steadiness of the images, and it was found that the probable error of a bisection was reduced by one third; but the probable error of a complete determination of Zenith-Point has not been recomputed.

APPARENT ZENITH-DISTANCE.—The numbers in this column are found by adding the Zenith-point correction to the Concluded meridian circle-reading; when the sum exceeds 270° (denoting that the object is between the zenith and the north horizon), the difference from 360° is taken, and the negative sign is attached to it; for stars observed by reflexion, the sum is subtracted from 180°, and the remainder, with its algebraical sign, is the apparent zenith-distance.

When both limbs of the Moon are observed, it usually happens that one of them is slightly defective from the want of illumination by the Sun. The necessary correction (which is not applied in this column, but which must be applied with others in order to form the numbers in the column of *Geocentric N.P.D. of Centre*) is ascertained by computation in the following manner:—When the Moon is horned, let θ be the angle which the great circle joining the cusps makes with the meridian; δ_s the Sun's declination, δ_m the Moon's declination as seen at Greenwich; P the Sun's hour-angle at the Moon's Transit: then

$$\text{Tan}\ \theta = \text{Cosec}\ P.\ \text{Cos}\ \delta_m.\ \text{Tan}\ \delta_s. - \text{Cot}\ P.\ \text{Sin}\ \delta_m;$$

and the correction to be applied to the Geocentric N.P.D. will be

$$\text{Moon's geocentric semidiameter} \times \text{versin}\ \theta.$$

For Mercury and Venus, when horned, the investigation of the correction for defective illumination assumes the same form as for the Moon.

If the Moon be gibbous, as is the case in the greater number of instances, draw a great circle through the centre of the Moon, at right angles to the meridian passing through the Moon, and let it meet the meridian passing through the Sun; then the intersection of this circle with the Sun's meridian will determine the place of a fictitious Sun, which would equally illuminate both limbs of the Moon when on the meridian; and the elevation or depression of the true Sun above or below the great circle joining the Moon and fictitious Sun, measured in a plane at right angles to that circle, will represent the angle by which the lowest or highest part of the illuminated hemisphere is distant from the limb, and therefore the angle whose versed sine multiplied into the Moon's semidiameter is the correction required.

Let then P be the North Pole of the heavens, M the Moon on the meridian of Greenwich, and S and S_1 the true and fictitious Suns, and imagine triangles formed by great circles joining these. Let also δ_1 be the declination of the fictitious Sun, θ_1 the arc joining the true and fictitious Suns, and θ the perpendicular arc before mentioned.

Then $$\text{Tan } \delta_1 = \text{Tan } \delta_m . \text{ Cos } MPS_1.$$

And $$\theta_1 = \delta_s - \delta_1.$$

Also $$\text{Sin } \theta = \text{Sin } \theta_1 . \text{ Sin } MS_1P.$$

$$= \text{Sin } \theta_1 \frac{\text{Sin } MP}{\text{Sin } S_1P}$$

$$= \text{Sin } \theta_1 \frac{\text{Cos } \delta_m}{\text{Cos } \delta_1}.$$

From which θ is found.

The Correction required to Geocentric N.P.D. is

Moon's geocentric semidiameter $\times$ versin θ.

In either case the North limb is fully illuminated if θ is positive, and the South limb if θ is negative.

In the cases of Mercury and Venus when gibbous, or of Mars and other planets sensibly gibbous, the investigation takes the following form. The angle θ being found as above, the length of the straight line drawn from the Sun perpendicular to the plane represented by the great circle above mentioned is equal to Distance of Earth from Sun $\times$ sin θ; and therefore if ϕ be the apparent angular distance of the Sun from that plane as seen from the planet, the value of ϕ is determined by the equation

$$\text{Sin } \phi = \frac{\text{Length of perpendicular line}}{\text{Dist. of Planet from Sun}} = \frac{\text{Dist. of Earth from Sun}}{\text{Dist. of Planet from Sun}} \times \sin \theta.$$

The angle ϕ represents in this case the angle by which the lowest or highest point of the illuminated hemisphere is distant from the limb as viewed by an observer anywhere in the plane of this great circle, and the correction therefore will be

Planet's semidiameter $\times$ versin ϕ.

In cases where the "centre" of Mercury is observed, a correction of 0·4 $\times$ ordinary correction for defect of illumination in N.P.D. is applied for reduction to the actual centre of the disc. See p. xxxiii.

BAROMETER.—The barometer is by Horne and Thornthwaite, marked "No. 389," with metallic scale and graduation modified for change of mercury-surface in the cistern.

Its scale is divided by vernier to 0·002 inch; but it is not usually necessary to read it to a smaller quantity than 0·01 inch for the computation of refraction. This barometer was substituted in April 1879 for the barometer by Newman, which had been in use to that date. From comparisons with the Standard Barometer made between 1879 March 19 and May 6 (allowance being made for the difference of temperature of the two barometers), it appears that the correction required to the barometer "Horne and Thornthwaite, No. 389," is only −0·007 inch. No correction has been applied to the readings of this barometer.

EXTERIOR THERMOMETER.—From 1897 January 1 the thermometer, Negretti and Zambra, No. 70661, has been used as the Exterior Thermometer for all observations with the Transit-Circle. This thermometer was mounted in the Front Court in a screen allowing a free circulation of air on 1896 July 18.

The following are the results of comparisons with the Standard Thermometer made on 1896 July 15 and 1897 December 21:—

1896 July 15.		1897 December 21.	
Temperature.	Error.	Temperature.	Error.
65°·5	+0°·2	15°·0	+0°·1
80·0	+0·2	27·1	+0·2
93·9	+0·2	32·1	+0·1
		46·0	+0·2
		62·0	+0·2
		76·6	+0·2
		87·8	+0·1

Simultaneous readings of the Exterior Thermometer and of the North Wall Thermometer have been made throughout the year at various hours of the day. The results of these comparisons are given in the Transit-Circle Tables at the end of this Introduction. A summary comparison is given in the Transit-Circle Tables for 1896 and 1897.

INTERIOR THERMOMETER.—This thermometer is No. 12264 by Negretti and Zambra.

The following are the results of comparisons with the Standard Thermometer made on 1889 March 15, 1892 May 23, 1894 December 28, and 1897 December 21:—

1889 March 15.		1892 May 23.		1894 December 28.		1897 December 21.	
Temperature.	Error.	Temperature.	Error.	Temperature.	Error.	Temperature.	Error.
32°·0	+0°·4	32°·0	+0°·6	38°·7	+0°·5	15°·9	+0°·9
51·4	+0·6	59·5	+0·7	64·0	+0·7	27·6	+0·7
67·5	+0·5	84·9	+0·7	64·9	+0·6	32·6	+0·6
88·7	+0·4			89·7	+0·5	46·4	+0·5
						61·3	+0·6
						74·7	+0·6
						89·6	+0·7

A correction of $-0^{\circ}\cdot5$ has been applied to the readings of the Interior Thermometer from 1889 March 15 to 1894 December 31, and of $-0^{\circ}\cdot6$ from 1895 January 1.

NORTH WALL THERMOMETER.—This thermometer is No. 45357 by Negretti and Zambra. It is mounted on the north front of the Observatory, where it is carried by an arm projecting from the wall to a distance of $4\frac{1}{2}$ feet, at a height of nearly 7 feet from the ground.

The following are the results of comparisons with the Standard Thermometer made on 1889 March 15, 1892 May 23, 1894 December 28, 1895 February 12, and 1897 December 21:—

1889 March 15.		1892 May 23.		1894 December 28.		1895 February 12.		1897 December 21.	
Temperature.	Error.	Temperature.	Error.	Temperature.	Error.	Temperature.	Error.	Temperature.	Error.
°	°	°	°	°	°	°	°	°	°
32·0	+0·1	32·0	+0·2	39·1	+0·3	14·3	+0·1	17·0	+0·4
51·9	+0·1	57·9	+0·2	64·1	+0·3	23·4	+0·1	27·4	+0·5
70·9	+0·2	83·8	+0·2	83·7	+0·2	32·0	+0·1	32·5	+0·5
93·0	+0·2			89·9	+0·2			46·0	+0·4
								61·3	+0·3
								75·9	+0·3
								83·3	+0·1
								85·5	+0·1

A correction of $-0^{\circ}\cdot1$ has been applied to the readings of the North Wall Thermometer from 1886 February 9 to 1894 December 31, and of $-0^{\circ}\cdot2$ from 1895 January 1.

The thermometer on the North Wall was used as the ordinary Exterior Thermometer till 1896 December 31. A thermometer, Negretti and Zambra, No. 44520, was mounted till 1891 March 3 on a revolving stand in the Front Court, and occasionally read as a check on this thermometer. From the beginning of 1887, Negretti and Zambra, No. 44520, was used instead of the North Wall Thermometer for observations of southern objects made in the day-time, as it was considered that the temperature of the air on the southern side of the Transit-circle room would be represented better by the reading of this freely exposed thermometer than by that of the thermometer which is mounted near the north wall of the building. On 1891 March 3 the post carrying the thermometer was removed in the course of the building of the New Transit Pavilion. From that date till 1896 December 31 the reading of the Meteorological Standard Thermometer, with which that of the thermometer in the Front Court had been found to agree well, was similarly used for observations of the Sun.

REFRACTION.—The refraction is computed as in former years fundamentally from 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 an Appendix to the *Greenwich Observations*, 1853. The Exterior Thermometer only is used in the computation, excepting in cases when the zenith-distance exceeds 85°. For such cases the refraction is derived from Bessel's *Fundamenta*, the Supplementary Table being no longer used.

The mean refractions used are the mean refractions of Bessel's *Tabulæ Regiomontanæ*, or those of Bessel's *Fundamenta* increased in the proportion of 1 : 1·003282.

PARALLAX.—The parallaxes of the Sun, Moon, and planets actually employed are given in the lower part of the page, as previously stated; the assumed ellipticity of the Earth being $\frac{1}{300}$.

For the planets the formula is—

$$\text{log. parallax} = \text{log. sin (Z.D.} - 11'.12'') + \text{ar. co. log. distance} + 0{\cdot}94596.$$

For the Moon, the horizontal equatorial parallaxes are interpolated, without alteration, from the Nautical Almanac, for the time of observation. The formula employed for the computation of the parallax to be applied to the observed zenith-distance is—

Parallax = Hor. Equat. Par. from N.A. × Sin Dist. from Geoc. Zenith × Geocentric Radius (Log. = 9·9991136) + Corr. derived from the following table :—

Z.D.	Correction for South Limb.	Z.D.	Correction for South Limb.	Z.D.	Correction for North Limb.	Z.D.	Correction for North Limb.
° 30	" −0·01	° 60	" +0·10	° 30	" −0·08	° 60	" −0·10
35	0·00	65	+0·11	35	−0·09	65	−0·10
40	+0·02	70	+0·13	40	−0·09	70	−0·10
45	+0·03	75	+0·15	45	−0·10	75	−0·10
50	+0·05	80	+0·16	50	−0·10	80	−0·09
55	+0·07			55	−0·10		

The correction tabulated above is the sum of two corrections, viz.: of one peculiar to the Moon's limbs, for which the numbers may be inferred from the table of corrections given in a subsequent part of this Introduction for the Moon's parallax in occultations, by supposing V (the angle, from the vertical, of the point of the

Moon's limb under observation) = 0° or 180°; and of another due to the employment of the arc of equatorial parallax instead of its sine, for which the formula is,

$$\frac{(\text{Seconds of hor. parallax})^3}{6} \times \text{Sin Z.D.} \times \text{Cos}^2\text{ Z.D.} \times \text{Sin}^2\ 1'.$$

For the computation of the parallaxes of the small planets, the distances are taken from the Supplement to the Nautical Almanac, or from the *Berliner Jahrbuch,* for planets given in those works.

SEMIDIAMETER.—The semidiameters of the Sun, Moon, and planets are given in the lower part of the page. For the Moon, Mercury, and Uranus, they are taken unchanged from the Nautical Almanac. For the Sun, Venus, Mars, Jupiter, and Saturn, the semidiameters are also taken unchanged from the Nautical Almanac, except in cases where only one limb has been observed. In these cases, for the Sun, the following corrections have been applied to the tabular semidiameter:—

Mr. Hollis	$+0''\cdot26$	Mr. Rendell	$+0''\cdot40$
Mr. Crommelin	$+0\cdot12$	Mr. Bowyer	$+0\cdot05$
Mr. Bryant	$-0\cdot09$	Other Observers	$+0\cdot21$
Mr. Davidson	$-0\cdot54$		

These corrections have been derived from the observations of the respective observers for the current year. The following table exhibits the results of recent observations:—

	H	AC	B	CD	R	WB	Other Observers.
1892	$-0''\cdot66$	$-0''\cdot36$	$-0''\cdot74$	$''$	$''$	$''$	$-1''\cdot01$
1893	$-0\cdot32$	$-0\cdot77$	$-0\cdot55$				$-0\cdot14$
1894	$-0\cdot32$	$-0\cdot76$	$-0\cdot97$				$-0\cdot48$
1895	$-0\cdot24$	$-0\cdot71$	$-1\cdot33$				$-0\cdot43$
1896	$+0\cdot18$	$-0\cdot05$	$-0\cdot32$				$+0\cdot20$
1897	$+0\cdot26$	$+0\cdot12$	$-0\cdot09$	$-0\cdot54$	$+0\cdot40$	$+0\cdot05$	$+0\cdot21$

From 1896 January 1 the value adopted in the Nautical Almanac for the Sun's semidiameter at the Earth's mean distance was changed from 16′ 1″·82 to 16′ 1″·18.

For Venus, the correction + 0″·392 + 0·027 × tabular semidiameter, derived from an investigation mentioned at page xl, has been applied to the semidiameter given in the Nautical Almanac; and for Mars, Jupiter, and Saturn, a correction usually derived from neighbouring observations, and specified in the notes, has been similarly applied.

GEOCENTRIC N.P.D. OF CENTRE.—The numbers in this column are found by combining the Apparent Zenith-distance with the Refraction, Parallax, Semidiameter, and Assumed Colatitude 38°.31′.21″·90.

§ 4. *Runs of each Microscope-Micrometer of the Transit-Circle; and Zenith-Points of the Transit-Circle, in the Year* 1897.

With regard to the *Runs of the Microscopes*, the columns under A, B, C, D, E, F contain respectively the number of revolutions of each micrometer which measures an arc of 5′ on the circle; and the last columns give the sums of these numbers for the six microscopes, and exhibit the number of revolutions which, for the mean of the six microscopes, measures an arc of 30′, on the supposition that the screws of the micrometers have sensibly equal values. In the first calculations for the reduction of the observations it is assumed that the space of 30′ corresponds approximately to $\frac{50}{51} \times 30^{r}{\cdot}000$, or to $29^{r}{\cdot}4118$; and the fiftieth part of the micrometer-reading for the mean of the microscopes being added to the micrometer-reading, the remaining correction, depending on the difference between the values in the last columns of the tables in question and $29^{r}{\cdot}4118$, is computed in the way that has been explained (page xlv).

With regard to the Table of *Zenith-Points*, the following explanation will be sufficient.

Whenever observations of stars have been made by reflexion, the results for zenith-point derived from them have been combined with those derived from the observations of the reflected image of the wire, see page xlviii. The results are always divided into three groups, viz.: those resulting from North stars, those from South stars, and those from nadir-observations, and the mean of each group is taken. In combining these a weight 2 is attributed to each of the means of the two groups of star-observations, and a weight 1 to the mean of the group of wire-observations, in order to prevent too much weight being given to those divisions of the circle which are always under the microscopes for the wire-observations. From the pains taken to equalize the number of observations of stars north and south of the zenith, no undue weight is, on the average, given to either of these positions; and, on the whole, it is presumed that, by this method of combination, the best possible average result is obtained. In the few cases where observations of only North or only South stars have been obtained, a correction is applied for the R—D discordance in obtaining the Zenith-point. The value of this correction, which is given in a footnote in the tables of Zenith-points, is derived from the correction found in the previous year for the R—D discordance.

To obtain information as to the cause of the R—D discordance, observations were made between 1893 December 3 and 1894 April 22 of the zenith-distances of stars directly and by reflexion, the direct observation being taken first. The observations were in other respects similar to the regular reflexion observations. These observations are printed in the Transit-Circle Tables for 1894 (pp. cxl–i), and a discussion of them is given in a paper by Prof. Turner and Mr. Thackeray in the *Memoirs of the Royal Astronomical Society*, vol. li.

During the years 1895 and 1896 a new series of observations were made with a view of obtaining further information on the cause of the R—D discordance. Pairs of stars were chosen of nearly the same zenith-distance and a few minutes apart in right ascension. One star of each pair was observed by reflexion, the other directly at the same transit; on the next night of observation the order was reversed, the star which had been observed previously by reflexion being observed directly. In this way a value of 2 (R—D) was derived. In order to test whether any change was taking place in the instrument, two readings of the circle were taken, one just before the star entered the field and the second just after the bisections with the telescope-micrometer had been made. The results of the observations are given in the Transit-Circle Tables at the end of this Introduction, together with a comparison with the R—D discordance obtained in the usual way. These observations were continued in 1897, and the results are given in the Transit-Circle Tables at the end of this Introduction.

§ 5. *Ledgers of Mean Right Ascensions and Mean North Polar Distances of Stars, deduced from each day's observation in the Year* 1897.

The mean right ascensions and mean north polar distances for 1897·0 are found by applying to the apparent right ascension and north polar distances (given in the last columns of sections 1 and 2 for the Fundamental Stars) the star corrections required to reduce from apparent to mean place.

For stars in the lists of the Nautical Almanac and the *Connaissance des Temps*, the correction is found by subtracting the apparent R.A. or N.P.D. from the mean R.A. or N.P.D., as given in those Ephemerides, and similarly for polar stars which are in the *Ephémérides des Étoiles de Culmination lunaire et de Longitude pour* 1897, *par M. Loewy*. To the quantity so found a correction is applied for the difference between the adopted proper motion and that used in the Ephemeris, when the correction amounts to more than 0″·05 in N.P.D., or its equivalent in R.A.

For other stars the labour of computing the star corrections has been much diminished by the use of Prof. Turner's *Tables for facilitating the Computation of*

Star Constants, 1897, modified from those arranged by Mr. Stone. In these tables a great saving is effected by restricting the computation to three figures in the logarithms, and a careful comparison of star corrections computed in duplicate with Mr. Stone's original tables and Prof. Turner's modified tables has shown that no sensible loss of accuracy results from the limitation to three figures.

The values of the day constants required for use with these tables are given in the Nautical Almanac for mean midnight of each day, and it has been the practice to interpolate values of these quantities for noon, $6^{h.}$ and $18^{h.}$ on each day, and to use for any star the values corresponding to the epoch nearest to the time of observation. For stars near the pole the additional correction depending on the longitude of the moon is also taken into account.

The proper motion for the fraction of the year elapsed since 1897·0 is also applied in computing the *R.A. and N.P.D. for* 1897·0. The proper motion adopted is given in the *Catalogue of Mean R.A. and N.P.D. for* 1900 *of Stars observed in* 1897, Section 9.

Half-weight has been given to the result for right ascension in cases where the transit was observed at two or three wires only, observations at a single wire only being rejected. When a star is observed with the reversion-prism *r* and *l* in right ascension at the same transit, the whole transit is treated as a complete observation, half-weight being given to each of the results *r* and *l*; but a reflexion and a direct observation at the same transit are considered as separate observations with full weight.

The corrections for personal equation have been invariably applied in this section when the observations of stars for clock-error have been made by one observer, and those of any other object requiring reduction, on the same day, by another observer.

The rules for the nomenclature of stars are the same as those in the section of the *Transits observed*, detailed in page xxix, but they are more rigorously followed.

§ 6. *Observations of Azimuth with the Altazimuth.*

The *first twelve* columns, on the left-hand page, require little explanation, except that in observing the transit the instrument is clamped in azimuth, and the slow-motion pinion of the vertical circle is used to make the transit of the object take place over the middle of each vertical wire. The observations have in general been made by the chronographic method, excepting at times when the galvanic apparatus has been out of order. Such cases are always distinctly noted whenever they occur.

The *thirteenth* column is occupied by the personal equation of each observer, referred to Mr. Bryant as a standard, deduced from the observations of transits in the year

1896 (see Introduction to Greenwich Observations, 1896, page cxxvi), as the observations of 1897 are not available for the daily reductions of 1897.

The column "clock slow" contains the error of the clock—that is, of the Sidereal Standard clock—when the observations are made by galvanic contact; or of Graham 1 when they are made by eye-and-ear. The number of seconds by which the Sidereal Standard is slow is, before application, corrected by the quantity $-0^{s}\cdot03$ for the difference of longitude between the position of the transit-circle and that of the altazimuth. This difference of longitude has been obtained by measurement on the plan of the Observatory, of which a reduced copy is attached to the volume for 1862.

By the application of the personal equation and clock-error to the mean of observed transits the Sidereal time in the *next* column is formed.

The *next four* columns contain the readings of the micrometers of the four microscopes of the horizontal circle. Occasionally the cross-wires fall on the negative side of the micrometer-zero; in such cases the fractional part of the reading given is positive, being taken from the micrometer-head, but the integer 9 represents -1. The designations, a, b, c, d, are so distributed among these microscopes that the observer, walking round the pier in the direction of the Sun's diurnal movement, passes them in the order a, b, c, d.

From the readings of the microscope-micrometers, together with the pointer-reading (which is not inserted in the printed columns), the concluded reading of horizontal circle is formed in this manner:—Suppose it is found, on examining the runs, that an arc of $5'$ requires $8^{\text{rev.}}\cdot5 - p$ of micrometer a, $8^{\text{rev.}}\cdot5 - q$ of micrometer b, $8^{\text{rev.}}\ 5 - r$ of micrometer c, and $8^{\text{rev.}}\cdot5 - s$ of micrometer d, then p, q, r, s are very small quantities. Now, suppose that the micrometer-readings in any observation are w, x, y, z—these four quantities being very nearly equal—then the Concluded Circle-reading ought to be

$$\frac{5'}{4} \times \left\{ \frac{w}{8\cdot5-p} + \frac{x}{8\cdot5-q} + \frac{y}{8\cdot5-r} + \frac{z}{8\cdot5-s} \right\}$$

or

$$\frac{5'}{4 \times 8\cdot5} \left\{ (w + x + y + z) + \frac{1}{8\cdot5}(wp + xq + yr + zs) \right\}$$

From the near equality of w, x, y, z, and the smallness of p, q, r, s, the factors of p, q, r, s may be considered equal: and the whole expression then becomes

$$\frac{5'}{4 \times 8\cdot5}(w + x + y + z)\left(1 + \frac{p + q + r + s}{4 \times 8\cdot5}\right)$$

or

$$\frac{5'}{4 \times 8\cdot5}(w + x + y + z)\left(1 + \frac{1}{100} \times \text{correction for runs for } 100''\right)$$

which is readily computed by the help of a table of micrometer-equivalents.

In March 1880 the horizontal circle was redivided by Mr. James Simms, and on July 14, 15, and 16 observations were made for the determination of the errors of its divisions. In this investigation the errors of the four primary divisions 0°, 90°, 180°, 270° referred to one of them, say 0°, were first determined by taking twenty sets of readings of the four microscopes a, b, c, d, with each of these divisions successively under each of the microscopes. Secondly, two supplementary microscopes p, q were mounted at a distance of 30° from a and c respectively, and the errors of the divisions 30°, 60°, 120°, 150°, &c. referred to the four primary divisions were determined by ten sets of readings of a, p, c, q. Thirdly, the microscopes p, q were mounted at a distance of 20° from a and c respectively, and thus, by steps of 20° in combination with the two preceding operations which gave the errors for every 30°, the errors for every 10° were found, ten sets of readings of a, p, c, q for each arc being taken. Fourthly, the microscopes p, q were mounted at a distance of 25° from a and c respectively, giving the means, in combination with the preceding results, of determining the division-errors for every 5°. In this operation five sets of readings of a, p, c, q for each arc of 25° were taken. The errors for every degree were then deduced from those for every 5° by interpolation. The following table contains the final corrections for errors of division applicable to the circle-reading as given by the mean of the four microscopes for every degree in the first quadrant. In the three succeeding quadrants the same corrections are applicable, commencing in the table respectively with pointer readings 90°, 180°, or 270°, instead of 0°.

DIVISION CORRECTION.

Pointer Reading.	Correction.	Pointer Reading.	Correction.	Pointer Reading.	Correction.	Pointer Reading.	Correction.	Pointer Reading.	Correction.	Pointer Reading.	Correction.
°	″	°	″	°	″	°	″	°	″	°	″
0	+1·01	15	+0·02	30	+0·34	45	+0·70	60	+0·94	75	+1·10
1	1·00	16	0·02	31	0·36	46	0·74	61	0·97	76	1·06
2	1·00	17	0·01	32	0·37	47	0·78	62	1·01	77	1·03
3	0·99	18	0·01	33	0·39	48	0·82	63	1·04	78	0·99
4	0·99	19	0·00	34	0·40	49	0·86	64	1·08	79	0·96
5	0·98	20	0·00	35	0·42	50	0·90	65	1·11	80	0·92
6	0·89	21	0·04	36	0·43	51	0·90	66	1·14	81	0·92
7	0·80	22	0·07	37	0·44	52	0·90	67	1·16	82	0·92
8	0·71	23	0·11	38	0·45	53	0·90	68	1·19	83	0·92
9	0·62	24	0·14	39	0·46	54	0·90	69	1·21	84	0·92
10	0·52	25	0·18	40	0·47	55	0·90	70	1·24	85	0·92
11	0·42	26	0·21	41	0·52	56	0·91	71	1·21	86	0·94
12	0·32	27	0·24	42	0·56	57	0·92	72	1·18	87	0·96
13	0·22	28	0·28	43	0·61	58	0·92	73	1·16	88	0·97
14	+0·12	29	+0·31	44	+0·65	59	+0·93	74	+1·13	89	+0·99

When the Pointer of the Horizontal Circle reads 0°, the division under Microscope *a* is 65° 0′; under Microscope *b*, 155° 0′; under Microscope *c*, 245° 0′; and under Microscope *d*, 335° 0′.

From 1880 April 15 these corrections have been applied in forming the concluded reading of the horizontal circle.

Another correction is occasionally necessary. When the transit of the object has not been observed across every one of the seven vertical wires, the mean of the times actually observed is retained unaltered; but a correction is applied to the Circle-reading, representing the difference between the azimuth of the mean of the wires actually observed and the azimuth of the mean of the seven vertical wires. This correction is equal to the angular distance between the mean of the wires observed and the mean of the seven wires, multiplied by the cosecant of zenith-distance.

The following are the angular distances from the several wires to the mean which have been used in the year 1897. The designation of wires are the same as in preceding years: the signs given suppose the face of the vertical circle to be to the right, and are changed when the face is left:—

For wires used in chronographic observations:

	″
Wire *s*	− 180·9
t	− 119·7
u	− 61·2
v	− 0·3
w	+ 59·4
x	+ 121·3
y	+ 181·4

For wires used in observations by eye-and-ear:

	″
Wire *r*	− 363·6
s	− 180·8
v	− 0·1
y	+ 181·2
z	+ 363·3

In the observations of the marks, the correction to be made to the Circle-reading for reduction to the mean of the seven wires used in chronographic observations is $\mp 0''\cdot 3$. When transits are observed by eye-and-ear over the five wires *r*, *s*, *v*, *y*, *z*, the correction required to the Circle-reading is $\mp 0''\cdot 1$.

By the application of these corrections, when necessary, the concluded Circle-reading is formed.

The *twentieth* column contains the approximate apparent zenith-distance taken from the tabular computations.

The *first* column on the right-hand page contains the correction to be applied to the concluded Circle-reading on account of the error of collimation (the term having the same meaning as for a transit-instrument) of the imaginary point in the field of view, which corresponds to the mean of the seven vertical wires. The amount to be applied is error of collimation × cosec. Z.D. The sign will change according as the face of the vertical circle is right or left. The value of error of collimation, face right, is given at the bottom of the page; the method by which it is obtained will be explained in a subsequent section.

The next *eight* columns on the right-hand page contain the readings of the level-scales of the four levels which are parallel to the axis of the vertical circle, e and f being the readings of the two ends of one of the lower levels, g and h those of the other lower level, i and k, l and m, those of the two upper levels. As the reading of each level-scale proceeds in continuous order from the end next the graduated face of the vertical circle to the other end, it follows that the equivalents for the scale-values of both end-readings must be added; and that, when their mean is diminished by the reading corresponding to the horizontal position of the horizontal axis, the excess must be used (multiplied by the appropriate factor, viz., the cotangent of zenith-distance) with its proper sign when the graduated face is right, and with sign changed when the graduated face is left.

The *tenth* column contains the concluded level-indication. It is assumed from careful determinations with a level-prover in 1893 that for the mean of the four levels each division represents $1''\cdot082$.

From this concluded level-indication is subtracted the level-indication for horizontal position of axis of vertical circle given at the foot of every page (the method of obtaining which will be explained in a subsequent section); and the remainder, which represents the angular elevation of that end of the horizontal axis which is farthest from the graduated face, is multiplied by the cotangent of zenith-distance. When the graduated face is left, the sign of the product is changed. The resulting number is given in the *eleventh* column as the Correction of level.

The corrected reading of horizontal circle, as affected by all these corrections, is then readily formed.

The *twelfth* column contains the concluded azimuth, measuring from the south towards the west, which is formed by subtracting the zero of azimuth given at the bottom of the page from the corrected reading of horizontal circle. The method of determining the zero of azimuth will be explained in a subsequent section.

In cases where both limbs of the Moon have been observed, one of the limbs is usually defective through want of illumination. A correction to the azimuth (always mentioned in the footnotes) is applied in all such cases; this correction is computed by finding first the azimuth of a point opposite the Sun, and then multiplying the difference between the azimuth of this point and that of the Moon's limb by the sine of the Sun's zenith-distance; the correction is, versin of this difference multiplied by the Moon's azimuthal semidiameter.

The Hour-angle in the *thirteenth* column is the difference (without respect of sign, but taken less than 180°) between the Tabular R.A. and the Sidereal time. The east or west side of the meridian is indicated by the letter E or W in this column.

The Tabular R.A. is thus formed. For stars in the list of the Nautical Almanac, corrections are applied to the places given in the Nautical Almanac deduced from the *Five-Year Catalogue of* 258 *Fundamental Stars for* 1890. In the case of Nautical Almanac stars which are not Greenwich Clock-stars, the places are taken from the Nautical Almanac without correction. For the Moon, the Tabular R.A. of Centre is formed by interpolating with second differences between the hourly places of the Moon given in the Nautical Almanac, using as argument the Mean Solar Time deduced from the Sidereal time given in the *fifteenth* column of the first page.

The *fourteenth* column contains the correction to the Moon's N.P.D. necessary for referring her place to the point of the Earth's axis at which the normal drawn from Greenwich meets the axis. It is thus investigated: Let a and b be the semi-major and semi-minor axes of the terrestrial ellipse, in the proportion of 300 to 299; x and y the co-ordinates parallel to them, their equation being $\frac{x^2}{a^2}+\frac{y^2}{b^2} = 1$; then the subnormal upon the minor axis $= -x\frac{dx}{dy}=\frac{a^2}{b^2}y$, and the part of this included between the origin of co-ordinates and the foot of the normal is $\frac{a^2-b^2}{b^2}y$. To find y, we remark that the tangent of the astronomical latitude of Greenwich, or tan l, $= -\frac{dx}{dy}=\frac{a^2}{b^2}\cdot\frac{y}{x}=\frac{a}{b}\cdot\frac{y}{\sqrt{(b^2-y^2)}}$, whence $y = \frac{b^2}{\sqrt{\{b^2+a^2\cot^2 l\}}}$; and the distance from the centre of the spheroid to the foot of the normal, measured along the Earth's axis, is $\frac{a^2-b^2}{\sqrt{\{b^2+a^2\cot^2 l\}}}$; or, in parts of the semi-major axis, it is $\frac{a^2-b^2}{a\sqrt{\{b^2+a^2\cot^2 l\}}}$. The logarithm of this quantity is 7·7174788. Now if, from the Earth's centre, we draw a perpendicular to the Moon's radius vector to meet the line drawn from the Moon to the foot of the normal, the length of that perpendicular will sensibly be $a \times [7{\cdot}7174788] \times$ sin Moon's N.P.D.; the angle which it subtends as seen from the Moon will be $\frac{a}{\text{Moon's distance}} \times [7{\cdot}7174788] \times$ sin Moon's N.P.D. = $[7{\cdot}7174788] \times$ sin Moon's hor. equat. parallax $\times$ sin Moon's N.P.D.; and the value of this in seconds of arc will be $[3{\cdot}0319039] \times$ sin Moon's hor. eq. par. $\times$ sin Moon's N.P.D.; or $[7{\cdot}7174788]$ $\times$ seconds of Moon's hor. eq. par. $\times$ sin Moon's N.P.D. In this manner the number in the fourteenth column has been computed. It is always subtractive.

The assumed colatitude $38^\circ.31'.22''{\cdot}2$ is deduced from that assumed for the Transit-Circle, corrected by the quantity $+ 0''{\cdot}3$ for the difference of latitude of the positions of the two instruments as found by measurement on the plan of the Observatory before mentioned.

With the hour-angle unaltered, and the N.P.D. altered (for the Moon) by the correction just described, and with the colatitude $38^\circ.31'.22''{\cdot}2$, the Tabular azimuth and the Tabular normal-centric zenith-distance are computed by the following formulæ:—

Log. tan α = log. cos hour-angle + log. tan normal-centric N.P.D.

$\beta = \alpha -$ colatitude.

Log. tan zenithal angle = log. sin α + log. tan hour-angle − log. sin β.

Log. cotan zen. dist. = log. cotan β + log. cos zenithal angle.

As a check upon the accuracy of a large part of this computation, the terms of the following equation are computed numerically:—

Log. sin zenithal angle + log. sin zen. dist. = log. sin hour-angle + log. sin N.P.D., and if the numbers are not strictly equal, the computation is again examined.

A discussion of the observed diameters of the Moon to the end of 1879, both in azimuth and zenith-distance, has shown that there is considerable personality in the observations of diameter. It has therefore been considered advisable, from the beginning of 1880, to apply to the semidiameter interpolated from the Nautical Almanac the following corrections depending on the respective observers, determined in this investigation:—

Observer.	Correction to Tabular Semidiameter. Azimuth.	Correction to Tabular Semidiameter. Zenith-Distance.
	$''$	$''$
Mr. Christie	− 0·94	− 1·54
Mr. Criswick	+ 1·18	+ 0·98
Mr. Thackeray	+ 0·32	+ 0·75
Other Observers	+ 0·24	+ 0·69

The *fifteenth* column contains the correction to tabular azimuth for Moon's semi-diameter. There is then applied the correction required for the difference between the distance of the Moon from the foot of the normal and her distance from the Earth's centre. The former distance is greater than the latter by $a \times [7{\cdot}71748]$ cos Moon's N.P.D., and therefore her angular semidiameter is diminished in the proportion of Moon's distance to Moon's distance $- a \times [7{\cdot}71748] \times$ cos Moon's N.P.D., or $1 : 1 -$ sin hor. eq. par. $\times [7{\cdot}71748] \times$ cos Moon's N.P.D.; or using the mean parallax $57'$, the proportion is $1 : 1 - [5{\cdot}93708] \times$ cos Moon's N.P.D. The correction required is taken out from a small table. The Correction to azimuth is computed by the formula $\frac{\text{Corrected semidiameter}}{\text{Sine normal-centric zenith-distance}}$ + small correction. The small correction $\frac{\Delta^3}{6} \sin 1'' \times \cot^2$ Z.D. $\times$ cosec. Z.D. (where Δ is the Moon's semidiameter) depending on the difference between the sine of semi-diameter and the arc, is insensible except when the Moon's zenith-distance is less than 35°.

By application of these corrections to the tabular azimuth in the case of the Moon, the tabular azimuth of limb is formed. This azimuth is necessarily the same at the place of observation as at the foot of the normal, for which the computation has been made.

The apparent error of tabular azimuth in the *last* column but one is formed by subtracting the observed azimuth from the tabular azimuth (for a star), or from the tabular azimuth of limb (for the Moon).

§ 7. *Observations of Zenith-Distance with the Altazimuth.*

The *first twelve* columns on the left-hand page require no explanation, except that in the observation the vertical circle is clamped, and the slow-motion pinion of the horizontal circle is used to make the transit of the object take place over the middle of each horizontal wire. The methods of observing and recording the times of transit are the same as for the horizontal transits.

The *thirteenth* column contains a correction which exists theoretically in all cases, but which in the azimuths is practically insensible, although for the zenith-distances, more especially those which are observed near the meridian, it sometimes becomes important. The nature of it is this: In the subsequent calculations it is tacitly assumed that at the mean of the observed times of passage across the seven horizontal wires (supposed free from error of observation), the body was at the point which represents the mean of all the seven wires. This, however, is true only on the supposition that the vertical movement of the body is uniform. The correction is investigated in the following manner. In the spherical triangle whose sides are a, b, c, and where C is the angle opposite to c, let a and b be respectively the co-latitude of the zenith, and the north polar distance of the object; then C is the hour-angle, and c the zenith-distance. Suppose these letters to correspond truly to the position of the object when it passes the geometrical mean of the seven horizontal wires: then if $\delta\ C$ be the addition (expressed in parts of the radius), or $\delta\ C_s \times 15 \sin 1''$ ($\delta\ C_s$ being expressed in seconds of time), which must be made to C in order to express the hour-angle when the object passes one wire, and if $\delta\ c$ (expressed in parts of the radius), or $\delta\ c_{''} \times \sin\ 1''$ ($\delta\ c_{''}$ being expressed in seconds of arc), be the addition which must be made to c in order to give the zenith-distance of the same wire, we have

$$C+\delta\ C_s \times 15 \sin 1'' = C + \frac{d\ C}{d\ c} \cdot \delta\ c + \frac{d^2\ C}{d\ c^2} \frac{(\delta\ c)^2}{2}.$$

Now $\cos a \cdot \cos b + \sin a \cdot \sin b \cdot \cos C = \cos c.$

Therefore $\sin a \cdot \sin b \cdot \sin C. \frac{d\ C}{d\ c} = \sin c.$

And $\sin a \cdot \sin b \left\{\cos C. \left(\frac{d\ C}{d\ c}\right)^2 + \sin C. \frac{d^2\ C}{d\ c^2}\right\} = \cos c.$

Whence $\frac{d\ C}{d\ c} = \frac{\sin c}{\sin a \cdot \sin b \cdot \sin C}$

and $\frac{d^2\ C}{d\ c^2} = -\frac{\cos C}{\sin C}\left(\frac{\sin c}{\sin a \cdot \sin b \cdot \sin C}\right)^2 + \frac{\cos c}{\sin a \cdot \sin b \cdot \sin C}$

In the case before us C is a small quantity, but no other quantity is small. Hence the first term of $\frac{d^2\ C}{d\ c}$ is the principal term, and the second may be neglected in comparison with it. And thus the equation becomes,

$$C+\delta\ C_s \times 15 \sin 1'' = C + \frac{\sin c}{\sin a \cdot \sin b \cdot \sin C}\,\delta\ c - \frac{\cos C}{\sin C}\left(\frac{\sin c}{\sin a \cdot \sin b \cdot \sin C}\right)^2 \frac{(\delta\ c)^2}{2}.$$

An approximate solution gives $\delta\ C_s \times 15 \sin 1'' = \frac{\sin c}{\sin a \cdot \sin b \cdot \sin C}\,\delta\ c.$

Substituting this in the last term, we have

$$C + \delta\ C_s \times 15 \sin 1'' = C + \frac{\sin c}{\sin a \cdot \sin b \cdot \sin C}\,\delta\ c - \frac{\cot C}{2} \cdot (\delta\ C_s)^2 \cdot (15 \sin 1'')^2;$$

or, putting C_s for the value of C in seconds of time,

$$C_s + \delta\ C_s = C_s + \frac{\sin c}{\sin a \cdot \sin b \cdot \sin C \cdot 15 \sin 1''}\,\delta\ c - \frac{\cot C}{2} \cdot (\delta\ C_s)^2 \cdot 15 \sin 1'';$$

and taking the mean of both sides, attributing successively to each the value which it has for each of the seven wires, we have,

Mean of observed hour-angles in seconds of time =

$$C_s + \frac{\sin c}{7 \sin a \cdot \sin b \cdot \sin C \cdot 15 \sin 1''}\,\Sigma \cdot \delta\ c - \frac{\cot C \cdot 15 \sin 1''}{14} \cdot \Sigma \cdot (\delta\ C_s)^2.$$

As c refers to the point which is the mean of the seven wires, $\Sigma \cdot \delta\ c = 0$, for the convenient expression of the last term, let I be the interval in seconds of time from the first wire to the last; then, for the first wire, $\delta C_s = -\frac{1}{2}$ I; for the second, $\delta C_s = -\frac{1}{3}$ I; for the third, $\delta C_s = -\frac{1}{6}$ I; for the fifth, $\delta C_s = +\frac{1}{6}$ I; for the sixth it is $+\frac{1}{3}$ I; for the seventh, $+\frac{1}{2}$ I.

Hence the equation becomes,

$$\text{Mean of observed hour-angles in seconds of time} = C_s - \frac{\cot C \,.\, 15 \sin 1''}{14} \frac{28}{36} \times \mathrm{I}^2,$$

$$= C_s - \tfrac{5}{6} \,.\, \sin 1'' \times \cot C \times \mathrm{I}^2.$$

Hence the correction to be applied to the mean of the observed hour-angles, in order to obtain the true hour-angle corresponding to the zenith-distance at the mean of the wires, is :—

$$+ \tfrac{5}{6} \,.\, \sin 1'' \times \cot C \times \mathrm{I}^2.$$

If the transit be imperfect, but the wires observed be consecutive, the following corrections will be applicable, being easily deduced from the preceding investigation :—

When the first or last three wires are observed, if I_3 be the interval in seconds of time from the first to the third, the correction in seconds of time will be $+ \frac{5}{4} \sin 1'' \times \cot \mathrm{C} \times (\mathrm{I}_3)^2$.

When the first or last four wires are observed, if I_4 be the interval from the first to the fourth, the correction will be $+ \frac{25}{24} \sin 1'' \times \cot C \times (\mathrm{I}_4)^2$.

When five consecutive wires are observed, if I_5 be the interval from the first to the fifth, the correction will be $+ \frac{15}{16} \sin 1'' \times \cot C \times (\mathrm{I}_5)^2$.

When six consecutive wires are observed, if I_6 be the interval from the first to the sixth, the correction will be $+ \frac{7}{8} \sin 1'' \times \cot C \times (\mathrm{I}_6)^2$.

If the wires are not consecutive, the corresponding correction will be found in a similar manner.

This correction will be subtractive from the mean of times when the hour-angle is diminishing, or before the object has passed the meridian, and additive to the mean of times when the object has passed the meridian. A small table of double entry is prepared with arguments C and I, and from this the correction is readily taken.

The *fourteenth* column is occupied by the personal equation (referred to Mr. Lewis as standard), and the *next* column by the error of the clock. By the application of the personal equation and clock-error to the mean of observed transits (corrected where necessary for inequality of motion) the Sidereal time of transit in the *sixteenth* column is formed.

The *last four* columns give the readings of the four microscope-micrometers, which are converted into arc by the aid of the numbers given at the bottom of the page, in the same manner as the similar numbers in the section of Azimuths.

When the observer views the graduated face of the vertical circle, the microscopes are seen in the position $\begin{matrix} A & D \\ B & C \end{matrix}$.

From 1880 April 15 corrections for the errors of the divisions of the vertical circle have been applied in forming the concluded reading of vertical circle. These corrections, given in the following table for every degree in the first quadrant, have been derived from the investigation made in April 1847. (Introduction to *Greenwich Observations*, 1847, page xix.) The same corrections are applicable in the three succeeding quadrants, commencing in the table respectively with pointer readings 90°, 180°, or 270°, instead of 0°.

DIVISION CORRECTION.

Pointer Reading.	Correction.	Pointer Reading.	Correction.	Pointer Reading.	Correction.	Pointer Reading.	Correction.	Pointer Reading.	Correction.	Pointer Reading.	Correction.
°	″	°	″	°	″	°	″	°	″	°	″
0	+0·49	15	+0·09	30	+0·74	45	+0·30	60	+0·56	75	+0·43
1	0·52	16	0·06	31	0·78	46	0·28	61	0·64	76	0·36
2	0·56	17	0·03	32	0·82	47	0·25	62	0·73	77	0·28
3	0·59	18	0·00	33	0·86	48	0·22	63	0·81	78	0·20
4	0·56	19	0·05	34	0·82	49	0·20	64	0·83	79	0·19
5	0·54	20	0·10	35	0·78	50	0·19	65	0·85	80	0·18
6	0·51	21	0·14	36	0·74	51	0·17	66	0·86	81	0·17
7	0·49	22	0·19	37	0·70	52	0·16	67	0·88	82	0·16
8	0·46	23	0·24	38	0·66	53	0·14	68	0·90	83	0·15
9	0·40	24	0·32	39	0·60	54	0·19	69	0·84	84	0·20
10	0·34	25	0·41	40	0·54	55	0·24	70	0·78	85	0·26
11	0·27	26	0·49	41	0·48	56	0·29	71	0·71	86	0·31
12	0·21	27	0·58	42	0·42	57	0·34	72	0·65	87	0·37
13	0·15	28	0·66	43	0·36	58	0·39	73	0·59	88	0·42
14	+0·12	29	+0·70	44	+0·33	59	+0·47	74	+0·51	89	+0·45

Errors of Division of Vertical Circle of Altazimuth; Intervals of Horizontal Wires.

On 1889 May 14 it was found that there was rather a deep cut on the Vertical Circle of the Altazimuth between the divisions 249° 0′ and 249° 5′. It was accordingly decided to examine the divisions from 248° 50′ to 249° 15′ inclusive to ascertain whether the errors of division of the circle were sensibly affected by the cut. This was done on 1889 May 28 by means of a supplementary microscope furnished with two sets of cross-wires distant from each other 5′ nearly, and it was found that the division 249° 5′ appeared to be slightly affected. No correction, however, has been applied to the observations on this account.

When the Pointer of Vertical Circle reads 0°, the division under Microscope A is 166° 55′; under Microscope B, 256° 55′; under Microscope C, 346° 55′; and under Microscope D, 76° 55′.

When the transits over any number of wires are omitted, the time of transit retained is the mean of the transits actually observed, corrected if necessary for personal equation; but a correction in arc is applied to the circle-reading, corresponding to the interval between the mean of the wires actually observed and the mean of the seven wires. Calling the whole system of wires (including both the eye-and-ear and the galvanic wires) in the order in which a star on the west side of the meridian passes them when the graduated face of the vertical circle is right, *R*, *S*, *T*, *U*, *V*, *W*, *X*, *Y*, *Z*, then the corrections to reduce the several wires to the mean of the system of wires in use since 1894 November 19 are:—

For wires used in chronographic observations, and in eye-and-ear observations of objects near the meridian,

	″
S	− 104·9
T	− 69·0
U	− 35·1
V	− 1·1
W	+ 34·3
X	+ 69·6
Y	+ 106·2

For wires used in observations by eye-and-ear:

	″
R	− 214·5
S	− 104·1
V	+ 0·1
Y	+ 107·1
Z	+ 211·4

The concluded circle-reading is readily formed, in the instances when the celestial body's transit has been observed over all the wires, by the simple mean of the equivalents for readings of microscope-micrometers (duly corrected for runs and errors of division); in the instances in which the transits over a part only of the wires are obtained, by applying to the mean of equivalents the correction (stated in the footnotes) for the difference between the mean of all the wires and the mean of the wires observed; and in observations of the marks, by applying to the mean of equivalents the entire correction corresponding to the single wire V.

The *first four* columns on the right-hand page give the readings of the two ends of the two levels which are parallel to the plane of the vertical circle, E and F being the readings of the two ends of the lower level, and G and H those of the two ends of the upper level. As, when the graduated face is right, the circle-readings increase with the increasing zenith-distance, and as in the same case the numeration of the levels increases from the end next the object to the end next the observer, it follows that the indication of the levels is in all cases additive to the circle-reading, and that the equivalents for the two ends of each level are to be combined additively. In forming the level-indication in the *fifth* column it is assumed (from a careful determination with a level-prover in 1893) that for the mean of the two levels each division represents $1''\cdot038$.

The Barometer "Horne and Thornthwaite, No. 388," whose reading is given in the *sixth* column, has a metallic scale and graduation for modified change of mercury surface in the cistern. From comparisons with the Standard Barometer made between 1879 June 17 and September 8 (the two barometers hanging side by side), it appears that the readings of the altazimuth barometer require a correction of $-0^{\text{in}}\cdot01$, which has therefore been applied to the readings of the barometer throughout the year.

The Exterior Thermometer, by Browning, whose reading is printed in the *seventh* column, is placed on the east side of the tower carrying the Dome, where its case is carried by long iron rods attached to the brickwork; it is mounted with its bulb inclosed by a zinc case, allowing a perfectly free passage for the air, and is read from a window pierced in the eastern side of the altazimuth Observing room.

The following are the results of comparisons with the Standard Thermometer made on 1889 March 15, 1892 May 23, and 1894 December 28:—

1889 March 15.		1892 May 23.		1894 December 28.	
Temperature.	Error.	Temperature.	Error.	Temperature.	Error.
32°·0	+ 0°·7	32°·0	+ 0°·7	40°·1	+ 0°·8
51·0	+ 0·8	59·5	+ 0·8	68·1	+ 0·6
66·6	+ 0·6	85·2	+ 0·8	87·9	+ 0·8
87·9	+ 0·8				

A correction of $-0^\circ{\cdot}7$ has been applied to the readings of the Exterior Thermometer from 1889 March 15.

The Interior Thermometer, "Negretti and Zambra, No. 7981," whose reading is contained in the *eighth* column, is placed in a recess in the south-east part of the Dome, near the face of the clock Graham 1, and its readings are used in the calculation of the refractions when the Moon is observed at a zenith-distance greater than 85°.

The following are the results of comparisons with the Standard Thermometer made on 1889 March 15, 1892 May 23, and 1894 December 28:—

1889 March 15.		1892 May 23.		1894 December 28.	
Temperature.	Error.	Temperature.	Error.	Temperature.	Error.
32°·0	+ 1°·3	32°·0	+ 1°·5	38°·7	+ 1°·5
52·2	+ 1·4	56·5	+ 1·5	63·3	+ 1·5
70·3	+ 1·2	84·0	+ 1·3	85·5	+ 1·2
88·7	+ 1·0				

A correction of $-1^\circ{\cdot}4$ has been applied to the readings of the Interior Thermometer from 1895 January 1.

An approximate zenith-distance being obtained by the use of an approximate zenith-point, the refraction in the *ninth* column is computed for zenith-distances less than 82° by the use of the tables printed in an Appendix to the *Greenwich Observations*, 1853. These tables give the same results as the tables in Bessel's *Tabulæ Regiomontanæ*; the mean refractions used being those of the *Tabulæ Regiomontanæ*, which are equivalent to those of Bessel's *Fundamenta*, increased in the proportion of 1 : 1·003282. From 82° to 85° zenith-distance the log. refractions are also taken from that appendix, but diminished by ·00100. For zenith-distances greater than 85°, the mean log. refractions of Bessel's *Fundamenta* are employed diminished by ·00066, the other quantities being taken from the same appendix. These refractions have been thus computed since 1881 January 1, though by inadvertence it is stated, in the Introductions for the years 1881 to 1884, that the refractions of the *Tabulæ Regiomontanæ* have been used throughout, as was really the case in the years 1879 and 1880. During the years 1868 to 1878 inclusive, the mean refractions of the *Tabulæ Regiomontanæ* diminished in the proportion of 1 : 0·99469 were used (*see* the Introductions for these years). In the years 1857 to 1868 inclusive the same refractions were adopted as at present; and previous to that the refractions of the *Tabulæ Regiomontanæ* were used throughout. The refraction being always additive to the observed zenith-distance, it is added to the reading of the vertical circle when the graduated face is right, and subtracted when it is left.

By the combination of these various quantities, the Corrected circle-reading is formed. It is to be remarked that this corrected reading contains implicitly a constant depending on the assumed zeros of the level-scales, and equal to the level-indication when the axis of azimuthal rotation is vertical. In this respect it differs from the Corrected reading of the horizontal circle, which contains no such constant.

The Zenith-point, whose value is given at the foot of each page, is obtained by a process which will be explained hereafter: it is sufficient here to state that it also contains implicitly the same constant depending on the assumed zeros of the level-scales. The concluded zenith-distance, therefore, in the *tenth* column, which is formed by subtracting the zenith-point from the contracted reading when the graduated face is right, and by subtracting the corrected reading from the zenith-point when the graduated face is left, is freed from this constant.

In cases where both the upper and the lower limb of the Moon have been observed, one limb is usually defective through want of illumination. A correction for this defect is applied, computed by a method analogous to that used for correcting the zenith-distance of the defective limb of the Moon when observed on the meridian. The correction is, Moon's augmented semidiameter $\times$ versin θ, to be applied to the observed zenith-distance. The corrections for defect of illumination are always mentioned in the notes.

The *next two* columns require no explanation beyond that given in the section of Azimuths.

The Normal-centric semidiameter for zenith-distances in the *thirteenth* column is interpolated from the Nautical Almanac, corrected by the numbers in the third column of the table on page lxv. The correction for reduction to the foot of the Normal is $-930'' \times [5{\cdot}93708] \times$ cos Moon's N.P.D., which never exceeds $0''{\cdot}05$, and has therefore not been applied.

For computation of the Parallax; in the first place, the horizontal equatorial parallax is interpolated from the Nautical Almanac without alteration. It is then necessary to deduce from this the parallax referred to the foot of the normal (the Moon's centre having been referred to that point): and for this purpose, first, the equatorial horizontal parallax must be corrected so as to make the horizontal parallax depend on the normal-centric radius, and must therefore be multiplied by $\frac{\text{Normal-centric Radius of Greenwich}}{\text{Earth's semi-major axis}}$. Using the same notation as before, the factor is found to be $= \frac{1}{a \sin l} \cdot \frac{a}{b^2} y = \frac{a}{\sqrt{\{b^2 \sin^2 l + a^2 \cos^2 l\}}}$; the logarithm of which is 0·0008851, Secondly, it must be made to depend on the Moon's distance from the foot of the normal, and for this must therefore be multiplied by 1 − [5·93708] × cos Moon's N.P.D. These two corrections are embodied in one logarithmic table with argument N.P.D., the number for 60° being 0·0008664, that for 90° being 0·0008851, and that for 120° being 0·0009037. By the addition of this logarithm to the logarithm of the seconds of parallax (corrected as above) which is interpolated from the Nautical Almanac with second differences, the logarithm of the normal-centric horizontal parallax is formed.

The parallax in the *fourteenth* column is computed by the formula, Normal-centric horizontal parallax × sine of observed zenith-distance of limb + small correction. The small correction is the sum of two terms, namely, $-\frac{P^3}{6}\sin^2 1''.\sin \mathrm{Z.D.} \times \cos^2 \mathrm{Z.D.}$ (which gives the correction for the error produced by using the parallax instead of its sine, P being $= 3420''$ = number of seconds in Moon's mean parallax), and sin Z.D. × Airy's correction as given in the section of Occultations. The table of corrections used is given on page lxxxvii.

By application of the semidiameter and parallax, the Tabular apparent zenith-distance of limb is formed; and by subtracting from this the Observed zenith-distance, the Apparent error of tabular zenith-distance in the *last* column but one is deduced.

§ 8. *Clock-Comparisons and Instrumental-Errors for the Altazimuth.*

In general, the times of the transits taken with the altazimuth by means of the method of galvanic contact are those of the Sidereal Standard clock, and no comparisons of clocks are necessary. The errors of the Sidereal Standard clock are obtained for the time of each observation, and after correction by $-0^{s}\cdot03$ for difference of longitude and for personal equation, are applied to the registered times of transit to form the sidereal time. When, however, through failure of the galvanic apparatus, it is necessary to observe by eye-and-ear, the comparisons of the clock Hardy and the clock Graham 1 of the South Dome used with the altazimuth are usually made by means of a mean solar chronometer, whose name is mentioned. The chronometer is brought close to each of the clocks, and the time of accurate coincidence of beats is noted; the chronometer-interval between the comparisons, which is expressed as an interval of mean solar time, is converted into an interval of sidereal time; and the sidereal time at the comparison with the transit-clock being found by correcting the transit-clock time for error and rate of the transit-clock, for personal equation, and also for difference of longitude, the sidereal time at the comparison with the South Dome clock is found, and thus the error of that clock is ascertained. From the successive errors, rates of the clock are deduced; and the errors applicable to the observations, and which are given in the sections of Azimuth and Zenith-Distance, are computed.

The instrumental constants of correction in azimuth are thus investigated:—Let w be the correction to the computed tabular azimuth of a high star, depending upon the error in the star's assumed place: w will be an exceedingly small quantity, and will not sensibly vary between the observations made in reversed positions of the instrument. Let x be the constant of correction for error of collimation, taken with that sign which corresponds to the position of the instrument with graduated face right; y the level-indication corresponding to horizontal position of the horizontal axis; and z the zero of azimuth. Also, let O_r and O_l be the concluded readings of horizontal circle from observations of a high star, with face right and face left; C_r and C_l the corresponding computed azimuths; L_r and L_l the level-indications; D_r and D_l the zenith-distances; and let o_r, o_l, c_r, c_l, l_r, l_l, d_r, d_l be the similar quantities for a low star. Then the true azimuth of the high star deduced from observation, face right, is

$$O_r + x \text{ cosecant } D_r + (L_r - y) \,.\, \text{cotangent } D_r - z\,;$$

the computed azimuth corrected is

$$C_r + w\,;$$

hence this observation gives the equation

$$O_r + L \,.\, \text{cotan } D_r - C_r = -x \,.\, \text{cosec } D_r + y \,.\, \text{cotan } D_r + z + w.$$

The true azimuth determined from observation, face left, is

$$O_l - x \,.\, \text{cosecant. } D_l - (L_l - y) \,.\, \text{cotangent } D_l - z:$$

and this observation therefore gives the equation,

$$O_l - L_l \,.\, \text{cotan } D_l - C_l = +x \,.\, \text{cosec } D_l - y \,.\, \text{cotan } D_l + z + w$$

Subtracting the first equation from the second,

$$(O_l - L_l \,.\, \text{cotan } D_l - C_l) - (O_r + L_r \,.\, \text{cotan } D_r - C_r) =$$
$$x \,.\, (\text{cosec } D_l + \text{cosec } D_r) - y \,.\, (\text{cotan } D_l + \text{cotan } D_r).$$

Or $$\frac{(O_l - L_l \,.\, \text{cotan } D_l - C_l) - (O_r + L_r \,.\, \text{cotan } D_r - C_r)}{\text{cotan } D_l + \text{cotan } D_r} = x \times \frac{\text{cosec } D_l + \text{cosec } D_r}{\text{cotan } D_l + \text{cotan } D_r} - y.$$

A similar treatment of the observations of the low star gives

$$\frac{(o_l - l_l \,.\, \text{cotan } d_l - c_l) - (o_r + l_r \,.\, \text{cotan } d_r - c_r)}{\text{cotan } d_l + \text{cotan } d_r} = x \times \frac{\text{cosec } d_l + \text{cosec } d_r}{\text{cotan } d_l + \text{cotan } d_r} - y.$$

Subtracting the former from the latter, x is given by a simple equation.

From 1888 November 26 the collimation-error has been deduced from observations of Marks, which are sensibly in the horizontal plane; the error is simply half the excess of the circle-reading with face right over that with face left (with 180° added), and is unaffected by the level-indication.

The construction of the instrument gives us reason to believe that the error of collimation is probably less variable than any other instrumental constant: it is usual, however, to make a new determination of the value of this element at the end of every lunation, founded on the observations of that lunation.

Every set of four azimuths like those above will give a value of y; implying that for that determination, the varying or slightly erroneous value of x, deduced from that individual combination, has been employed in the preliminary correction for collimation. But as, on account of the steadiness of collimation, it appears better to use a mean value of x throughout, a fresh investigation of y is afterwards made from every pair of observations. Thus, let O'_r, O'_l be the concluded readings of horizontal circle corrected for the adopted error of collimation, then the first equations are,

$$O'_r + L_r \,.\, \text{cotan}\, D_r - C_r = + y \,.\, \text{cotan}\, D_r + z + w\,,$$
$$O'_l - L_l \,.\, \text{cotan}\, D_l - C_l = - y \,.\, \text{cotan}\, D_l + z + w\,.$$
$$\text{Whence } \frac{(O'_r + L_r \,.\, \text{cotan}\, D_r - C_r) - (O'_l - L_l \,.\, \text{cotan}\, D_l - C_l)}{\text{cotan}\, D_r + \text{cotan}\, D_l} = y.$$

A high star for this determination is best; and high stars (at an altitude of about 45°) have been exclusively used throughout the year.

The number y, it is to be observed, corresponds strictly with the horizontal position of the axis of the vertical circle, and has no relation whatever to the level-zero corresponding to a vertical position of the axis of azimuthal rotation: except that supposing the workmanship of the vertical pivots to be perfectly good, and the position of the horizontal axis in its Y's to be invariable, there ought to be a constant difference between them. The latter level-zero would be the mean of the level-indications in opposite positions of the instrument; and it would be found with sufficient accuracy for this purpose by taking the mean of the level-indications for positions used in successive observations of the same object (though the instrument was not exactly reversed). The following are the results of comparisons of these level-zeros since the erection of the altazimuth. In March 1859 the discordance between the two level-zeros was corrected by filing away the surfaces of the Y of the pivot on the same side as the graduated face. In September 1872 the instrument was dismounted for alteration of the Y bearings, and was again erected in January 1873, but was not at first sufficiently adjusted for perpendicularity of the two axes of rotation. The discordance was reduced on 1873 April 23 by placing two pieces of paper under one of the Y's, and again on 1873 May 26 by adding another piece of paper. In June 1894 the upper pivot of the vertical axis was reground as it was found to be worn.

EXCESS OF THE LEVEL-INDICATION FOR HORIZONTAL POSITION OF THE AXIS OF THE VERTICAL CIRCLE ABOVE THE LEVEL-INDICATION FOR VERTICAL POSITION OF THE AXIS OF REVOLUTION, SINCE THE ERECTION OF THE ALTAZIMUTH.

Year.	Mean Excess.	Year.	Mean Excess.
1848	+ 1″·13	1873 Apr. 29 to May 19	+ 16″·45
1849	+ 2·33	1873 May 27 to Dec. 31	− 2·26
1850	+ 6·67	1874	− 1·96
1851	+ 8·75	1875	− 0·94
1852	+ 10·50	1876	+ 0·25
1853	+ 11·36	1877	+ 0·51
1854	+ 11·71	1878	+ 2·15
1855	+ 12·51	1879	+ 4·14
1856	+ 13·23	1880	+ 3·68
1857	+ 13·59	1881	+ 4·36
1858	+ 13·70	1882	+ 4·40
1859 Jan. & Feb.	+ 13·75	1883	+ 4·71
1859 Mar. to Dec.	− 4·23	1884	+ 4·10
1860	− 4·91	1885	+ 4·21
1861	− 5·48	1886	+ 7·29
1862	− 6·24	1887	+ 8·20
1863	− 5·39	1888	+ 5·49
1864	− 5·01	1889	+ 9·40
1865	− 4·56	1890	+ 10·13
1866	− 5·07	1891	+ 8·13
1867	− 4·30	1892	+ 5·84
1868	− 5·94	1893	+ 3·29
1869	− 5·06	1894 Jan. 10 to June 9	+ 6·95
1870	− 3·28	1894 July 4 to Dec. 31	+ 5·53
1871	− 3·02	1895	+ 4·34
1872	+ 3·47	1896	+ 3·74
1873 Jan. 8 to Apr. 19	+ 38·52	1897	+ 5·44

The comparison of the observed circle-reading for a star, corrected for collimation and level, with the computed azimuth for the same star, gives the zero of azimuth. It has been thought best to use, for each day's observations, the zero of azimuth determined by the star-observations of that day, whenever the changes appear greater than would warrant the combination with other days.

From 1880 October 7 to 1887 November 26 the adopted zero of azimuth was formed by combining the observations of the stars with those of the azimuth-mark fixed to the parapet of the Royal Naval College. On 1887 November 27 the observations of this mark were discontinued in consequence of the obstruction of the view by the extension of the upper Computing room, and the zero of azimuth was deduced from observations of stars alone until 1888 November 25, when three church spires were selected as new marks for observation, viz., the spire of St. John's Church, Lewisham High Road, distant 6,600 feet (referred to as Mark I.), that of the Roman Catholic Church, Croom's Hill, distant 1,060 feet (referred to as Mark II.), and that of the

Congregational Church, Brockley Road, distant 6,930 feet, referred to as Mark III. Observations of Mark III. were, however, discontinued after 1889 June 5.

The tabular azimuth of a mark is deduced from observations of the mark and of stars made on the same days, the results obtained in any lunation being combined with those of the previous two lunations to form the adopted value for that lunation, provided the result for the lunation in question does not differ by more than 2″·5 (*i.e.*, twice the probable error of the difference of results for two lunations) from that of the previous lunation; otherwise the result for the lunation in question is combined with those for the preceding and following lunations, giving weights in proportion to the number of observations.

In the zenith-distances the only instrumental constant deduced from observation is the zenith-point (including so much of the level-indication as corresponds to a vertical position of the axis of azimuthal rotation). It is found by taking half the sum of the circle-readings for two successive observations of a mark, face right and face left respectively; or from observations of a star in the following manner:—

In two successive observations of the same star, face right and face left, let O_r and O_l be the observed circle-readings of the vertical circle corrected for level; C_r and C_l the computed Zenith-Distances; e the possible error in star's place, which will be sensibly the same for both; Z the zenith-point. Then we have

$$O_r - Z = \text{true Zenith-distance with face right} = C_r + e.$$
$$Z - O_l = \text{true Zenith-distance with face left} = C_l + e.$$
$$\text{Thus } 2\,Z - (O_r + O_l) = C_l - C_r$$
$$\text{And } Z = \frac{(O_r + O_l) + (C_l - C_r)}{2}$$

§ 9. *Catalogue of Mean R.A. and N.P.D. for* 1900·0 *of Stars observed in* 1897.

The mean right ascensions and north polar distances of stars observed in 1897 have for convenience been reduced to 1900·0 the epoch of the new Ten-Year Catalogue, of which 1897 is the first year.

The right ascensions in the catalogue are the means (reduced to 1900·0) of all the separate determinations of the mean right ascension of each star, excluding those which are contained in brackets, and giving half-weight to those marked with an asterisk.

The north polar distances in the catalogue are the means (reduced to 1900·0) of the separate determinations (those contained in brackets being excluded) affected with the new corrections for errors of division of the transit-circle (as explained on page ix.) for discordance of direct and reflexion results, and in the case of reflexion observations, for inclination of the verticals at the surface of the mercury and at the centre of the transit-circle. As has been previously explained, Bessel's Refractions of the *Tabulæ Regiomontanæ*, and the Assumed Colatitude 38°.31′.21″·90, have been used in the reductions. The adopted seconds of N.P.D. are found by taking the means of the groups of direct and reflexion observations, giving to each a weight proportional to its number of observations. In the case of circumpolar stars, these 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 pole have the weight $\frac{2}{3}$ for each observation; from N.P.D. 36° to N.P.D. 41°, those below pole have the weight $\frac{1}{2}$; beyond 41° N.P.D. the observations are not combined.

The precessions and secular variations for 1900 have been computed by the help of M. Folie's *Douze Tables pour le Calcul des Reductions stellaires*, in which Struve's Constant of Precession is used.

The proper motions given in the following column are generally taken from Prof. Auwers' determinations, or from Dr. Porter's *Catalogue of Proper Motions*.

The nomenclature of the stars is identical with that described at page xxix.

§ 10. *Horizontal and Vertical Diameters, Right Ascensions, and North Polar Distances of the Sun, Moon, and Planets, deduced from the Observations, and compared with the Nautical Almanac and other Ephemerides: with the inferred Position of the Ecliptic, the Geocentric Errors of the Sun, Moon, and Planets, in Longitude and Ecliptic Polar Distance, and the Equations between the Geocentric Errors of the Planets and the Heliocentric Errors of the Earth and Planets.*

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 the passage of the semidiameter given in the Nautical Almanac. The excess of the latter above the former is set down as the apparent error of the Nautical Almanac. The mean of 160 measures of the value of this error made in 1897 is $+0^{s}{\cdot}011$. The values obtained by the several observers are given on p. xl.

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 found by doubling the semidiameter of the Nautical Almanac. The excess of the latter above the former is set down as the error of the Nautical Almanac, and the mean of 170 measures of the value of this error made in 1897 is $-0''{\cdot}35$. The values obtained by the several observers are given on p. lv.

For the duration of the passage of the Moon's diameter, the correction for defect of illumination is investigated as on p. xxxiii. From four determinations the error of the Moon's tabular duration of passage made in 1897 is $0^{s}\cdot00$.

The Moon's vertical diameter is found in the same manner as that of the Sun (the correction for defective illumination having been already applied, see page l). The mean of 13 determinations of the error of the Moon's tabular vertical diameter made in 1897 is $-1''\cdot57$.

For the planets, the duration of passage of diameter is found by subtracting the clock-time of transit of the first limb from that of the second limb in the section, *Transits observed*, the correction for defect of illumination being applied where necessary. This correction is double the amount applicable to the mean of limbs, which is stated in the notes to that section.

The vertical diameters of Mercury, Venus, and Mars are found by subtracting the N.P.D. of the North limb from that of the South limb, after the correction for defective illumination has been applied, as explained at page l. The vertical diameters of the other planets are obtained in a similar way, excepting that there is no correction for defective illumination.

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 sidereal time: the whole of these numbers being taken from the Nautical Almanac. In practice, this operation is made a little easier by putting the addition in the following form:—

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

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

In any case where the N.P.D. has been observed without the corresponding R.A., the R.A. at transit (for the calculation of the mean solar time) is taken from the Nautical Almanac for the Sun and for planets included in that work, and from other ephemerides for planets not included in the Nautical Almanac; but in all cases as near an approximation as possible is made to the correct R.A. by the application of corrections derived from neighbouring observations.

The observed right ascensions of the Sun's centre are generally the means of those deduced from the observations of the two limbs; but when one limb only has been observed, the R.A. of the centre is deduced from that of the limb, by application of the duration of transit of semidiameter given in the Nautical Almanac, corrected by the quantities given on page xl. The right ascensions are transcribed from those in the section of *Transits observed*, without alteration, except that, when necessary, the personal equation is applied, as mentioned in a former part of this Introduction (page xxxix).

The tabular errors of right ascension of the Sun's centre, deduced from the mean of two limbs, are for the different observers:—

	H	AC	B	CD	R	WB	Other Observers.
	s	s	s	s	s	s	s
1895	+ $0·049_{34}$	+ $0·073_{24}$	+ $0·119_{32}$				+ $0·127_{100}$
1896	+ $0·040_{15}$	+ $0·034_{27}$	+ $0·155_{27}$	+ $0·129_{12}$	+ $0·110_{8}$	+ $0·128_{9}$	+ $0·123_{48}$
1897	+ $0·060_{18}$	+ $0·027_{29}$	+ $0·156_{26}$	+ $0·167_{10}$	+ $0·156_{11}$	+ $0·226_{12}$	+ $0·123_{56}$

the subscript numbers denoting in each case the number of observations.

The observed north polar distances of the Sun are taken from the section of *Zenith-Distances*, &c., the correction for discordance of direct and reflexion results being applied. As has been previously explained, Bessel's refractions of the *Tabulæ Regiomontanæ* and assumed colatitude 38°.31′.21″·90 have been used throughout in the reductions. The tabular right ascensions and north polar distances are taken without correction from the Nautical Almanac.

The tabular errors of N.P.D. of the Sun's centre, deduced from the mean of two limbs, are for the different observers:—

	H	AC	B	CD	R	WB	Other Observers.
	″	″	″	″	″	″	″
1895	+ $0·10_{36}$	+ $0·24_{29}$	+ $0·23_{31}$				+ $0·26_{99}$
1896	− $0·54_{16}$	$0·00_{27}$	− $0·11_{30}$	+ $0·30_{14}$	+ $0·15_{10}$	+ $1·25_{11}$	+ $0·05_{55}$
1897	+ $0·26_{17}$	+ $0·04_{30}$	+ $0·28_{26}$	+ $0·56_{10}$	+ $0·53_{12}$	+ $0·82_{15}$	+ $0·04_{59}$

The observed right ascensions of the Moon's centre are taken from the *Transits observed*, corrected, when necessary, for personal equation, and also for the Moon's motion in R.A. during the passage from the mean of wires to the true meridian. When both limbs of the Moon are observed, the correction for defective illumination (page xxxiii) is first applied to the proper limb, and the mean of the two is then taken without any further alteration.

The tabular right ascension of the Moon's centre is found by applying to the right ascension of the limb (given in the section, *Moon-culminating Stars*, of the

Nautical Almanac) the sidereal duration of passage of semidiameter, which is given in the same section of the Nautical Almanac.

The tabular errors of Right Ascension of the Moon's centre from observations of the first and second limbs are, for the different observers :—

	H	AC	B	CD	R	WB	Other Observers.
				1 L.			
	s.	s.	s.	s.	s.	s.	s.
1895	$-0{\cdot}120_{15}$	$-0{\cdot}196_{14}$	$-0{\cdot}135_{15}$				$-0{\cdot}170_{28}$
1896	$-0{\cdot}201_{8}$	$-0{\cdot}300_{15}$	$-0{\cdot}150_{13}$	$-0{\cdot}208_{4}$	$-0{\cdot}218_{4}$	$-0{\cdot}177_{3}$	$-0{\cdot}175_{12}$
1897	$-0{\cdot}243_{6}$	$-0{\cdot}254_{14}$	$-0{\cdot}140_{9}$	$-0{\cdot}235_{6}$	$-0{\cdot}183_{4}$	$-0{\cdot}158_{9}$	$-0{\cdot}272_{11}$
				2 L.			
1895	$-0{\cdot}113_{16}$	$-0{\cdot}011_{18}$	$+0{\cdot}149_{11}$				$+0{\cdot}113_{17}$
1896	$-0{\cdot}114_{5}$	$-0{\cdot}081_{10}$	$+0{\cdot}088_{16}$	$+0{\cdot}126_{5}$	$+0{\cdot}028_{8}$	$+0{\cdot}058_{4}$	$+0{\cdot}094_{14}$
1897	$-0{\cdot}185_{2}$	$-0{\cdot}135_{8}$	$-0{\cdot}066_{14}$	$-0{\cdot}030_{5}$	$+0{\cdot}080_{7}$	$+0{\cdot}023_{4}$	$-0{\cdot}099_{6}$

The observed north polar distances of the Moon's centre are taken from the section of *Zenith-Distances observed*, &c., corrected for the values of $\frac{1}{2}$ (R−D) and for the motion in N.P.D. during the passage from the mean of wires to the true meridian.

The tabular north polar distances of the Moon's centre are taken from the section *Moon-culminating stars* of the Nautical Almanac.

The tabular errors of North Polar Distance of the Moon's centre from observations of the North and South limbs are, for the different observers :—

	H	AC	B	CD	R	WB	Other Observers.
				N. L.			
	"	"	"	"	"	"	"
1895	$+0{\cdot}02_{17}$	$+0{\cdot}18_{24}$	$-0{\cdot}50_{15}$				$-0{\cdot}49_{15}$
1896	$+0{\cdot}33_{7}$	$-0{\cdot}35_{14}$	$+0{\cdot}18_{19}$	$+0{\cdot}16_{8}$	$-0{\cdot}92_{6}$	$-0{\cdot}52_{4}$	$-0{\cdot}59_{15}$
1897	$-0{\cdot}28_{6}$	$+0{\cdot}21_{13}$	$+0{\cdot}24_{12}$	$+0{\cdot}02_{8}$	$+1{\cdot}16_{9}$	$-0{\cdot}11_{8}$	$+0{\cdot}13_{9}$
				S. L.			
1895	$-0{\cdot}06_{23}$	$+0{\cdot}47_{18}$	$+0{\cdot}54_{12}$				$-0{\cdot}82_{21}$
1896	$+0{\cdot}32_{9}$	$+1{\cdot}01_{16}$	$+1{\cdot}44_{15}$	$+0{\cdot}13_{4}$	$+0{\cdot}55_{4}$	$+1{\cdot}93_{3}$	$+0{\cdot}63_{16}$
1897	$-0{\cdot}21_{6}$	$+0{\cdot}65_{12}$	$+0{\cdot}99_{10}$	$+0{\cdot}30_{8}$	$-0{\cdot}56_{4}$	$+0{\cdot}74_{6}$	$-0{\cdot}20_{8}$

For all the planets, the right ascensions are extracted from the twenty-first column of *Transits observed*, with no alteration, except for personal equation when necessary; the north polar distances are taken from the last column in the upper part of the page of the *Zenith-Distances observed*, &c., corrected for the values of $\frac{1}{2}$ (R − D). The tabular places are taken from the Nautical Almanac, for such planets as are given in that work and its appendices. For others the tabular places are taken from the *Berliner Jahrbuch*, or its Circulars; or occasionally from MS. ephemerides mentioned in the notes.

When only one limb of a planet is observed, the number I. or II., or the letter N, S, or C, in Columns 4 and 8, indicates that the first, second, North, or South limb, or the estimated centre, was observed.

The investigation of the position of the Ecliptic has been made in the following manner. The mean of all the errors in each month, for R.A. and for N.P.D., supposed to be the error for the day which is nearest to the mean of all the days of observation. When the same day is not found for R.A. and for N.P.D., an alteration of a unit or more has sometimes been made. From these, the error in the 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 $x \cos l + y \sin l + z$, where l is the Sun's longitude. Weights are then assigned proportional to the number of observations of N.P.D., and the equations solved by the ordinary method of least squares. This method has been used since 1888, instead of the method of weighting and grouping the observations previously adopted.

For the *Mean Errors of the Tabular Geocentric Places of the Sun and Planets*, the observations have been collected into groups rarely exceeding a month in duration, and the mean of all the errors in each group, for R.A. and for N.P.D., giving half weight to observations of a single limb of the Sun in either element, is supposed to be the error for the day which is nearest to the mean of all the days of observation in the group, an alteration of a unit or more being sometimes made, in order to refer R.A. and N.P.D. to the same day. 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 any of the four small planets, Ceres, Pallas, Juno, and Vesta, whose latitude exceeds the limits of the tables, the longitude and E.P.D. are computed, 1st, from the R.A. and N.P.D. of the Nautical Almanac; 2nd, from these quantities affected with the errors in R.A. and N.P.D.; and the difference between these results gives 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 small planets, Ceres, Pallas, Juno, and Vesta.

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

Then,

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

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

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

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

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

For the other planets, the following are used :—

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

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

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

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

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

In the expressions above, different quantities are neglected for the small planets and for the other planets. For the small planets, the latitude cannot be neglected in any part of the expressions; while, at the same time, their errors in general are so large that, in comparison with them, the Earth may be supposed to move exactly in the orbit assigned by the tables. For the other planets, the latitude may be neglected in the formula; but it appears proper to retain the errors of the Earth's place, as probably comparable in magnitude with those of the planets.

It is to be remarked that, in the column *Extent of Group*, the day given is, as in past years, the civil day (commencing at midnight) on which the observation was made, and that this occasionally differs by a unit from the astronomical day under which the observations may be found in the sections of *Transits observed* and *Observations of Zenith-Distance*: also in the column *Mean Day* the day given is the civil day corresponding to the time of observation, or to the mean of times of observation.

The errors of Tabular Longitude and Ecliptic Polar Distance of the Moon are deduced from the errors of Tabular R.A. and N.P.D. by the use of the numbers, P, Q, R, S, for all the meridian observations as well as for the observations made with the altazimuth.

Commencing with the year 1884, corrections representing the Moon's motion in R.A. and N.P.D. in the interval between the observed and tabular times of transit have been applied in forming the "Errors of the Moon's tabular place in R.A., N.P.D., Longitude, and E. N.P.D." The Apparent Errors of R.A. and N.P.D. in the section, "Right Ascensions and North Polar Distances of the Centre of the Moon," are formed, as in past years, by simple subtraction of the "R.A. or N.P.D. from Observation" from the "R.A. or N.P.D. in Nautical Almanac," without application of the above-mentioned corrections.

For the altazimuth, the errors of Tabular R.A. and N.P.D. are formed thus from the errors of azimuth and zenith-distance given in the sections of Azimuths and Zenith-Distances.

Let $\delta . R.A.$, $\delta . N.P.D.$, $\delta . A.$, $\delta . Z$ be the errors of Tabular R.A. (expressed in arc), N.P.D., azimuth, and zenith-distance in any observation; and (supposing the Moon to be west of the meridian) let S be the angle at the Moon made by the great circles drawn to the pole and to the zenith. Then we have,

$$\delta . Z = -\sin S . \sin N.P.D. \times \delta . R.A. + \cos S \times \delta . N.P.D. \quad ,$$
$$\delta . A = -\frac{\cos S}{\sin Z} \sin N.P.D. \times \delta . R.A. - \frac{\sin S}{\sin Z} \times \delta . N.P.D. \quad ,$$

Let $\sin S = p$, $\cos S = q$, $\frac{\cos S}{\sin Z} = r$, $\frac{\sin S}{\sin Z} = s$; then

$$\delta . Z = -p . \sin N.P.D. \times \delta . R.A. + q \times \delta . N.P.D. \quad ,$$
$$\delta . A = -r . \sin N.P.D. \times \delta . R.A. - s \times \delta . N.P.D. \quad ,$$

and taking the sum of a series of equations in each element, and observing that p, q, r, s will vary considerably during the observations,

$$\Sigma(\delta Z) = -\delta . R.A. \times \sin N.P.D. \times \Sigma(p) + \delta . N.P.D. \times \Sigma(q) ,$$
$$\Sigma(\delta A) = -\delta . R.A. \times \sin N.P.D. \times \Sigma(r) - \delta . N.P.D. \times \Sigma(s) .$$

By solution of these equations,

$$\delta . R.A. = \frac{\Sigma(s) . \Sigma(\delta Z) + \Sigma(q) . \Sigma(\delta A)}{-\sin N.P.D. \times \{\Sigma(p) . \Sigma(s) + \Sigma(q) . \Sigma(r)\}} ,$$
$$\delta . N.P.D. = \frac{\Sigma(r) . \Sigma(\delta Z) - \Sigma(p) . \Sigma(\delta A)}{\Sigma(p) . \Sigma(s) + \Sigma(q) . \Sigma(r)}$$

The expression for $\delta . R.A.$ must be divided by 15 to give the error of Tabular R.A. in seconds of time.

A table of double entry, appended to the Introduction to the *Greenwich Observations* of 1854, is prepared, from which the values of p, q, r, s are taken out at sight, with arguments Hour-angle and N.P.D. of the Moon; and then the calculation is made by means of these formulæ.

§ 11. *Differences of Right Ascension and North Polar Distance of Comet b* 1897, (*Perrine*), *and Neighbouring Stars, observed with the Sheepshanks Equatorial.*

The observations of Comets with the Sheepshanks equatorial are made by taking transits over two thick cross-wires at right angles to each other, and each inclined

45° to the parallel of declination. The system of wires contains also a thin wire bisecting one of the angles between the inclined wires. The adjustment for inclination of the cross-wires is tested on each occasion by allowing the diurnal motion to carry a star along the bisecting wire.

In 1895 November new wires were inserted; the inclinations of the thick wires were found to be 45° 6′, and 135° 7′; the corrections for transits taken over these wires are, when the object is north of the centre,

$$+ \frac{i^s}{2}\left(6 + 7\right) \sin 1' = + i^s \times {\cdot}0019 \text{ in R.A.}$$

$$\text{and } + \frac{15}{2}\, i'' \left(6 - 7\right) \sin 1' \sin \text{N.P.D.}$$

i^s being the interval between the transits over the two wires.

The sign of the correction in R.A. is reversed when the object is south of the centre.

On and after 1892 December 23 corrections for motion in the interval between crossing the wires were applied to the observed R.A. and N.P.D. of comets. If the increase of the comet's R.A. and N.P.D. in 1 second of time be a^s, δ'' respectively, then the correction in R.A. is $\frac{+ i \delta}{30 \sin \text{N.P.D.}}$ when it crosses north of the centre, the sign being reversed when it crosses south of the centre.

The correction in N.P.D. is $- \frac{15\, i\, a \sin \text{N.P.D.}}{2}$ when the comet is north of the centre, the sign being reversed when it is south of the centre.

Corrections are also applied for refraction.

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

The clocks used in these observations are in general compared with the Sidereal Standard or with the clock Hardy near the time of the observation, and the mean solar time is computed in the usual way.

For the computation of the Occultations, the star's place is taken from the "Elements for facilitating the Computation of Occultations" in the Nautical Almanac when given there. A supplementary list of other stars whose occultations were observed is given on p. 104. The Moon's geocentric place, semidiameter, and horizontal equatorial parallax are interpolated with second differences from the Nautical Almanac, and are used without alteration. The correction to be applied to the parallax of the Moon's centre, in order to obtain that for the point of the limb at which the occultation takes place, is derived from the following table, the principles of the formation of which are given in the volumes of the *Greenwich Observations* from 1843 to 1849 :—

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

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

Let now δ and θ be the N.P.D. and hour-angle of the star, which are the same as the apparent N.P.D. and hour-angle of the point of the Moon's limb; δ' and θ' those of the corresponding point of the limb as seen from the Earth's centre; l the geocentric latitude of the place; and P' the corrected horizontal parallax; then, by an investigation similar to that given in the Introductions to preceding volumes, from 1843 to 1849, it may be shown that

$$\sin(\theta - \theta') = \frac{\text{Radius of parallel for Greenwich}}{\text{Moon's distance from the Earth's axis}} \times \sin\theta.$$

$$\sin(\delta - \delta') = \frac{\sin l \,.\, \sin\delta \,.\, \sin\theta \,.\, \sin P'}{\sin\frac{1}{2}(\theta+\theta') \,.\, \cos\frac{1}{2}(\theta-\theta')} - \cot\tfrac{1}{2}(\theta+\theta') \,.\, \tan\tfrac{1}{2}(\theta-\theta') \,.\, \sin(\delta+\delta').$$

For the first step of the computation the following quantities are formed :—

F = log. sin star's hour-angle + log. seconds of corrected eq. hor. parallax + 9·4942224.

G = log. sin star's N.P.D. + log. sin star's hour-angle + log. seconds of corrected eq. hor. parallax + 9·8913935.

(The former numerical 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; supposing the Earth's ellipticity $= \frac{1}{300}$).

The preceding formulæ are then adapted to logarithmic computation, and the equations are solved by successive trials, assuming a value for δ', in the following manner :—

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

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

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

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

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 centre is thus found, by means of a subsidiary angle ψ :—

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

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

The coefficients of small variations of the north polar distance and of the difference of right ascension (in the expression for distance) are computed by the formulæ :—
log. 1st number = 2 log. diff. R.A. + log. sine (sum of N.P.D.) − log. dist. + 4·0835.
log. 2nd number = log. diff. N.P.D. − log. distance.
Coefficient of variation of greater N.P.D. = 1st number + 2nd number.
Coefficient of variation of smaller N.P.D. = 1st number − 2nd number.
Log. coefficient of variation of diff. R.A. =

log. diff. R.A. + log. sin δ' + log. sin Moon's N.P.D. − log. distance.

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

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

2nd. The alteration of the horizontal equatorial parallax in the proportion of $1 : 1 + \frac{m}{100}$ will alter all the deduced parallaxes (in R.A. and in N.P.D.) in nearly the same proportion: and therefore the R.A. of the corresponding point will be altered by $\frac{m}{1000}$ × correction for parallax in R.A.

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 :—

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

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

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

The variation of the N.P.D. of the corresponding point contains three terms analogous to those for R.A. : 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 $\frac{m}{1000}$ × 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 :—

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

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

The computed distance, with addition of the sum of the products of the preceding variations by their proper coefficients, is made equal to the semidiameter increased by the term, semidiameter × $\frac{n}{1000}$; and thus the final equation is formed.

For a planet, the R.A. and N.P.D. of the centre are used to find those of the corresponding point of the limb; the planetary parallax is subtracted from that of the moon; and the distance of the corresponding point is equated to the sum (or difference) of the semidiameters.

The following table contains the values of log. $\left(\frac{\text{arc}}{\text{sin}}\right)$, log. $\left(\frac{\text{sin}}{\text{arc}}\right)$, and log. $\left(\frac{\text{tan}}{\text{arc}}\right)$ to the extent to which they are needed for these computations.

′	Log. $\left(\frac{\text{Arc}}{\text{Sin}}\right)$	Log. $\left(\frac{\text{Sin}}{\text{Arc}}\right)$	′	Log. $\left(\frac{\text{Arc}}{\text{Sin}}\right)$	Log. $\left(\frac{\text{Sin}}{\text{Arc}}\right)$
1	0 ·0000000	0 ·0000000	31	0 ·0000058	9 ·9999942
2	0 ·0000000	0 ·0000000	32	0 ·0000062	9 ·9999938
3	0 ·0000000	0 ·0000000	33	0 ·0000066	9 ·9999934
4	0 ·0000001	9 ·9999999	34	0 ·0000070	9 ·9999930
5	0 ·0000001	9 ·9999999	35	0 ·0000074	9 ·9999926
6	0 ·0000002	9 ·9999998	36	0 ·0000078	9 ·9999922
7	0 ·0000003	9 ·9999997	37	0 ·0000083	9 ·9999917
8	0 ·0000004	9 ·9999996	38	0 ·0000088	9 ·9999912
9	0 ·0000005	9 ·9999995	39	0 ·0000093	9 ·9999907
10	0 ·0000006	9 ·9999994	40	0 ·0000098	9 ·9999902
11	0 ·0000007	9 ·9999993	41	0 ·0000103	9 ·9999897
12	0 ·0000008	9 ·9999992	42	0 ·0000108	9 ·9999892
13	0 ·0000010	9 ·9999990	43	0 ·0000113	9 ·9999887
14	0 ·0000012	9 ·9999988	44	0 ·0000118	9 ·9999882
15	0 ·0000014	9 ·9999986	45	0 ·0000124	9 ·9999876
16	0 ·0000016	9 ·9999984	46	0 ·0000129	9 ·9999871
17	0 ·0000018	9 ·9999982	47	0 ·0000135	9 ·9999865
18	0 ·0000020	9 ·9999980	48	0 ·0000141	9 ·9999859
19	0 ·0000022	9 ·9999978	49	0 ·0000147	9 ·9999853
20	0 ·0000024	9 ·9999976	50	0 ·0000153	9 ·9999847
21	0 ·0000026	9 ·9999974	51	0 ·0000159	9 ·9999841
22	0 ·0000029	9 ·9999971	52	0 ·0000165	9 ·9999835
23	0 ·0000032	9 ·9999968	53	0 ·0000171	9 ·9999829
24	0 ·0000035	9 ·9999965	54	0 ·0000178	9 ·9999822
25	0 ·0000038	9 ·9999962	55	0 ·0000185	9 ·9999815
26	0 ·0000041	9 ·9999959	56	0 ·0000192	9 ·9999808
27	0 ·0000044	9 ·9999956	57	0 ·0000199	9 ·9999801
28	0 ·0000047	9 ·9999953	58	0 ·0000206	0 ·9999794
29	0 ·0000051	9 ·9999949	59	0 ·0000213	9 ·9999787
30	0 ·0000055	9 ·9999945	60	0 ·0000221	9 ·9999779

′	Log. $\left(\frac{\text{Tan}}{\text{Arc}}\right)$	′	Log. $\left(\frac{\text{Tan}}{\text{Arc}}\right)$	′	Log. $\left(\frac{\text{Tan}}{\text{Arc}}\right)$	′	Log. $\left(\frac{\text{Tan}}{\text{Arc}}\right)$
2	0 ·0000000	8	0 ·0000008	14	0 ·0000024	20	0 ·0000049
3	0 ·0000001	9	0 ·0000010	15	0 ·0000027	21	0 ·0000054
4	0 ·0000002	10	0 ·0000012	16	0 ·0000031	22	0 ·0000059
5	0 ·0000003	11	0 ·0000015	17	0 ·0000035	23	0 ·0000065
6	0 ·0000004	12	0 ·0000018	18	0 ·0000039	24	0 ·0000071
7	0 ·0000006	13	0 ·0000021	19	0 ·0000044	25	0 ·0000077

§ 13. *Micrometric Observations of Double Stars.*

With a few exceptions these observations were made with a position-micrometer on the 28-inch refractor. The method of observation consists in turning the micrometer till its fixed wire is parallel to the line joining the stars (so that they can be simultaneously bisected by it, by moving the telescope with one of the slow-motion rods) and reading the position-circle. The two movable wires, which are perpendicular to the fixed wire, are then moved till they bisect the two stars, and the readings of the micrometer-heads are taken. This may be done in two ways, the wire moved by the right hand screw bisecting the star on the right or left, as the observer wishes, and the wire moved by the left hand screw bisecting the other star in each case. The zero of position-angle is obtained by placing the fixed wire so that the diurnal motion carries a star along it. As the values of $1^{\text{rev.}}$ of the micrometer-screws are equal, and their readings increase in opposite directions, the distance between the stars is obtained by taking the sum of the readings of the micrometer-heads and subtracting the sum of the corresponding readings when the wires coincide; or if the measure has been made with wires reversed, by subtracting the sum of the readings from the reading for coincidence. When the observation has been made both *directly* and with wires reversed, the distance is half the difference of the sum of the micrometer-readings in the two cases.

The value of one revolution of each micrometer-screw is $12''\cdot06$. It was determined in 1894 November from transits of stars near the pole. The observations are given in the volume for 1894.

The stars observed are known or suspected binaries, and such double stars as could not be well separated with a smaller instrument.

The nomenclature of the stars in column 1 refers to the original observer's catalogue viz. :—Σ to the Dorpat Catalogue of W. Struve, 1837; OΣ to the Pulkova Catalogue, 1843; β to the various catalogues of Mr. Burnham. Column 2 gives the name adopted for the star in the Greenwich Catalogues. Columns 3 and 4 contain the approximate R.A. and N.P.D. for 1900. These have been derived from Dr. Romberg's Catalogue of 8634 stars, epoch 1875. Columns 5 and 6 give the measured position-angle and distance on different nights, and the means. Column 7 gives the number of measures of each element on the separate nights. Column 8 gives the magnitudes derived from the Dorpat, Pulkova, or Mr. Burnham's Catalogues referred to above, Column 9 gives the epoch of the observations, or the fraction of the year from the beginning of 1897. In Column 10 the magnifying power used is given, and in Column 11 such remarks as appear necessary.

§ 14. *Measures of Positions and Areas of Sun Spots and Faculæ on Photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn in India, and at the Royal Alfred Observatory, Mauritius, in the year* 1897; *with the deduced Heliographic Longitudes and Latitudes.*

The photographs from which these measures were made were taken either at Greenwich; at Dehra Dûn, North-West Provinces, India; or at the Royal Alfred Observatory, Mauritius.

The photographs of the Greenwich series were taken with the Dallmeyer Photoheliograph returned from the Transit of Venus expedition to New Zealand, which, as now adapted, gives a solar image of 8 inches diameter on the photographic plate.

The photographs have been taken throughout the year on gelatine dry plates, "Lantern" plates supplied by R. W. Thomas and Co. being used, with hydroquinone development.

The Indian photographs, which have been forwarded by the Solar Physics Committee to fill the gaps in the Greenwich series, were taken under the superintendence of the Deputy Surveyor-General, Trigonometrical Survey of India, with a Dallmeyer Photoheliograph giving an image of the Sun nearly 8 inches in diameter. In the process adopted at Dehra Dûn bromo-iodized collodion has been used in connexion with iron development.

The Mauritius photographs were taken under the superintendence of Dr. C. Meldrum, Director of the Royal Alfred Observatory, Mauritius, and of his successor, Mr. T. F. Claxton, with a Dallmeyer Photoheliograph, giving an image of the Sun about 8 inches in diameter. At the Mauritius Observatory bromo-iodized gelatine dry plates have been used with alkaline development.

Photographs of the Sun were taken at Greenwich on 183 days, and Indian photographs on 156 days with Mauritius photographs on 25 days have been received from the Solar Physics Committee to complete the total of 364 days for which there are either Greenwich, Indian, or Mauritius photographs of the Sun available for measurement in 1897.

The *first* column on each page contains the Greenwich Civil Time at which each photograph was taken, expressed by the day of the year and decimals of a day, reckoning from Greenwich mean midnight January 1d. 0h., and also by the day of the month (civil reckoning), which latter is placed opposite the total area of Spots and Faculæ for the day. The photographs taken in India are distinguished by the letter I, and those taken in Mauritius by the letter M.

The *second* column contains the initials of the two persons measuring the photograph; the initial on the left being that of the person who measured the photograph on the left of the centre of the measuring instrument, and that on the right being that of the person who measured on the right of the centre.

The following are the signatures of those persons who measured the photographs for the year 1897 :—

P. H. Cowell	C	C. F. Turner	FT
E. W. Maunder	M	A. J. Wilkin	AW
C. C. Lacey	CL	J. A. West	JW

The *third* column gives the No. of the group, and the letter for the spot. The groups are numbered in order of their appearance.

The *next two* columns give the Distance from the Centre of the Sun in terms of the Sun's Radius, and the Position-Angle from the Sun's Axis, reckoned from the Sun's North Pole in the direction *n*, *f*, *s*, *p*, both results being corrected for the effects of astronomical refraction.

The measures of the photographs were made with a large position-micrometer specially constructed by Messrs. Troughton and Simms for the measurement of photographs of the Sun up to 12 inches in diameter. In this micrometer the photograph is held with its film-side uppermost on three pillars fixed on a circular plate, which can be turned through a small angle, about a pivot in its circumference, by means of a screw and antagonistic spring acting at the opposite extremity of the diameter. The pivot of this plate is mounted on the circumference of another circular plate, which can be turned by screw-action about a pivot in its circumference, 90° distant from that of the upper plate, this pivot being mounted on a circular plate with position-circle which rotates about its centre. By this means small movements in two directions at right angles to each other can be readily given, and the photograph can be accurately centred with respect to the position-circle. When this has been done, a positive eyepiece, having at its focus a glass diaphragm ruled with cross-lines into squares, with sides of one-hundredth of an inch (for measurement of areas), is moved along a slide diametrically across the photograph, the diaphragm being nearly in contact with the photographic film, so that parallax is avoided. The distance of a spot or facula from the centre of the Sun is read off by means of a scale and vernier to 1-250th of an inch (corresponding to 0·001 of the Sun's radius for photographs having a solar diameter of 8 inches). The position-angle is read off on a large position-circle which rotates with the photographic plate. The photograph is illuminated by diffused light reflected from white paper placed at an angle of 45° between the photograph and the plate below.

The following is the process of measurement of a photograph:—By means of the screws attached to the circular plates carrying the pillars which hold the photograph, the image of the Sun is centred as accurately as possible by rotation. The position-circle is then set to the readings 0°, 90°, 180°, and 270° in succession, and the scale readings taken for the two limbs. The scale being so adjusted that its zero coincides with the centre of rotation of the position-circle, the mean of the eight readings for the limb gives the mean radius of the Sun directly.

At the principal focus of the photoheliograph are two cross-spider-lines which serve to determine the zero of position-angles on the photograph.

The zero of position-angles for the Dallmeyer Photoheliograph, employed at Greenwich, has been determined by the measurement of a plate which had been exposed to the Sun's rays twice, with an interval of about 100 seconds between the two exposures, the instrument being firmly clamped. Two images of the Sun, overlapping each other by about a fifth part of the Sun's diameter, were therefore produced upon the plate, and the exposures having been so given that the line joining the cusps passed approximately through the centre of the plate, the inclination of the wires of the photoheliograph to this line was measured with the position-micrometer, and a small correction for the inclination of the Sun's path was then applied. The following table gives the correction for zero of position for the mean of the two wires as thus determined :—

Date, Greenwich Civil Time.			Correction for Zero.
		d h	° ′
1896	December	15. 14	+ 3. 14
		31. 11	+ 2. 48
1897	February	17. 11	+ 2. 52
		17. 12	+ 2. 57
	March	11. 10	+ 2. 53
	May	12. 16	+ 3. 0
	June	11. 10	+ 3. 5
	July	24. 13	+ 3. 5
	August	12. 16	+ 3. 3
	September	6. 15	+ 3. 0
	October	5. 15	+ 3. 3
	December	2. 12	+ 2. 53
1898	February	21. 15	+ 3. 5

The Dallmeyer Photoheliograph has been mounted throughout the year on the terrace roof of the South wing of the new Physical Observatory.

In the use at Greenwich of the Dallmeyer Photoheliograph the position-circle has usually been set to some convenient reading near that for zero, so that the wires are respectively very nearly parallel and perpendicular to the circle of declination, and a correction for zero of position of the photoheliograph for the mean of the two wires has been applied to the zero of the position-circle of the micrometer. The position-circle was set to the reading 354°·0 throughout 1897.

The zero of the position-circle of the micrometer has been determined from the readings of the position-circle for the four extremities of the two wires. The resulting combined correction is applied to all position-circle readings for spots and faculæ, so as to give true position-angles.

In the use of the Photoheliographs at Dehra Dûn and in Mauritius the position-circle has always been set to the zero as determined by allowing the diurnal motion to carry a spot or the Sun's limb along the horizontal wire, and the accuracy of the adjustment has been tested at short intervals. No correction for zero of position of the wires has therefore been applied for the reduction of the photographs taken in India or in Mauritius.

The uncorrected distance from the Sun's centre for spots and faculæ is read off directly to 1-250th of an inch by means of a scale and vernier, the zero of the scale of the new micrometer being adjusted to coincide with the centre of the instrument.

Two sets of measures of the Sun's limb and of spots and faculæ on each photograph have been taken, and the mean of the two sets adopted.

No correction has been applied to the photographs on account of distortion.

The correction for the effect of refraction has been thus found, the Sun's image being assumed to be sensibly an ellipse. The refraction being sensibly $c \tan z$ where $c = \sin 57''\cdot 5 = \frac{1}{3600}$ nearly, and z is the apparent zenith-distance, we shall have—

$$\frac{\text{Vertical Diameter}}{\text{Horizontal Diameter}} = \frac{1 - c \sec^2 z}{1 - c} = 1 - c \tan^2 z\,;$$

and thus the effect of refraction will be to diminish any vertical ordinate y by the quantity $c \tan^2 z$. Resolving this along and perpendicular to the radius vector r, and putting v for the position-angle of the vertex, we have for $\delta\, r$ and $\delta\, \theta$, the corrections to radius vector and position-angle for the effect of refraction—

$$\delta\, r = +\, c\,.\tan^2 z \times r\,.\cos^2(\theta - v) = +\, c\,.\tan^2 z \times r \times \frac{1 + \cos 2\,(\theta - v)}{2},$$

$$\delta\, \theta = -\, c\,.\tan^2 z\,.\sin(\theta - v)\,.\cos(\theta - v) = -\, c\,.\tan^2 z\, \frac{\sin 2\,(\theta - v)}{2}.$$

The quantity $\delta\, r$ thus found is the correction, on the supposition that a horizontal diameter of the Sun is taken as the scale. But, as the mean of two diameters at right angles has been used, the scale itself requires the correction $\delta\, \mathrm{R} = +\, c\,.\tan^2 z \times \mathrm{R} \times \frac{1}{2}\left\{\frac{1 + \cos 2\,(\theta_0 - v)}{2} + \frac{1 + \cos 2\,(\theta_0 + 90^\circ - v)}{2}\right\} = +\, \frac{1}{2}\, c\, \mathrm{R}\,.\tan^2 z$, where R is the Sun's mean radius and θ_0, $\theta_0 + 90^\circ$ the position-angles of the two diameters measured. Thus the final correction to r becomes—

$$\delta\, r = +\, c\,.\tan^2 z \times r \times \frac{\cos 2\,(\theta - v)}{2}.$$

The quantities $c \tan^2 z$, $-\frac{\sin 2\,(\theta - v)}{2}$, and $\frac{\cos 2\,(\theta - v)}{2}$ have been tabulated for use as follows, $c \tan^2 z$ being expressed in circular measure and in arc for application to distances and position-angles respectively :—

$c \tan^2 z$.

z.	In Circular Measure.	In Arc.	z.	In Circular Measure.	In Arc.	z.	In Circular Measure.	In Arc.
°		′	°		′	°		′
80	·0089	31	70	·0021	7	60	·0008	3
79	·0073	25	69	·0019	6½	58	·0007	2
78	·0061	21	68	·0017	6	56	·0006	2
77	·0052	18	67	·0015	5½	54	·0005	2
76	·0045	15	66	·0014	5	52	·0005	2
75	·0039	13	65	·0013	4½	50	·0004	1
74	·0034	11½	64	·0012	4	45	·0003	1
73	·0030	10	63	·0011	4	40	·0002	1
72	·0026	9	62	·0010	3	30	·0001	0
71	·0023	8	61	·0009	3			

Factors for Refraction.

$\theta - v$	$\theta - v$	$-\frac{\sin 2(\theta - v)}{2}$	$\frac{\cos 2(\theta - v)}{2}$	$\theta - v$	$\theta - v$	$-\frac{\sin 2(\theta - v)}{2}$	$\frac{\cos 2(\theta - v)}{2}$
°	°			°	°		
0	180	·00	+ ·50	95	275	+ ·09	− ·49
5	185	− ·09	+ ·49	100	280	+ ·17	− ·47
10	190	− ·17	+ ·47	105	285	+ ·25	− ·43
15	195	− ·25	+ ·43	110	290	+ ·32	− ·38
20	200	− ·32	+ ·38	115	295	+ ·38	− ·32
25	205	− ·38	+ ·32	120	300	+ ·43	− ·25
30	210	− ·43	+ ·25	125	305	+ ·47	− ·17
35	215	− ·47	+ ·17	130	310	+ ·49	− ·09
40	220	− ·49	+ ·09	135	315	+ ·50	·00
45	225	− ·50	·00	140	320	+ ·49	+ ·09
50	230	− ·49	− ·09	145	325	+ ·47	+ ·17
55	235	− ·47	− ·17	150	330	+ ·43	+ ·25
60	240	− ·43	− ·25	155	335	+ ·38	+ ·32
65	245	− ·38	− ·32	160	340	+ ·32	+ ·38
70	250	− ·32	− ·38	165	345	+ ·25	+ ·43
75	255	− ·25	− ·43	170	350	+ ·17	+ ·47
80	260	− ·17	− ·47	175	355	+ ·09	+ ·49
85	265	− ·09	− ·49	180	360	·00	+ ·50
90	270	·00	− ·50				

The position-angle of the Vertex v is readily taken from a globe.

The distance from centre in terms of the Sun's radius given in the *fourth* column is then readily found by dividing the measured distance r_0, as corrected for refraction, by the measured mean radius of the Sun, R; and the Position-Angle from the Sun's Axis given in the *fifth* column is obtained by applying to the Position-Angle (from the N. point) corrected for refraction the Position-Angle of the Sun's Axis derived from the "Auxiliary Tables for determining the Angle of Position of the Sun's Axis, and the Latitude and Longitude of the Earth referred to the Sun's Equator," by Warren De La Rue, F.R.S.

The *sixth* and *seventh* columns give the heliographic longitude and latitude of the spot, which are thus computed.* Let r be the measured distance of a spot from the centre of the Sun's apparent disk, R the measured radius of the Sun on the photograph, (R) the tabular semidiameter of the Sun in arc, and ρ, ρ' the angular distances of a spot from the centre of the apparent disk as viewed from the Sun's centre and from the Earth respectively. Then we have—

$$\rho' = \frac{r}{R}(R)\text{; and } \sin(\rho + \rho') = \frac{r}{R},$$

$$\text{whence } \rho = \sin^{-1}\frac{r}{R} - \rho'.$$

Log. sin ρ and log. cos ρ, as computed from this formula, are given in "Tables for the Reduction of Solar Observations No. 2," by Warren De La Rue, F.R.S. Then, if D, λ are the heliographic latitudes of the Earth and the Spot respectively, referred to the Sun's Equator, and L, l the heliographic longitudes reckoned from the ascending node of the Sun's Equator on the ecliptic, and χ the position-angle from the Sun's axis, we have by the ordinary equations of spherical trigonometry—

$$\sin\lambda = \cos\rho \sin \mathrm{D} + \sin\rho \cos \mathrm{D} \cos\chi$$
$$\sin(\mathrm{L} - l) = \sin\chi \sin\rho \sec\lambda.$$

The quantities L and D are derived from Warren De La Rue's Auxiliary Tables before referred to, in the computation of which the following formulæ have been used—

$$\tan \mathrm{L} = \cos \mathrm{I} \tan(\odot - \mathrm{N})$$
$$\sin \mathrm{D} = \sin \mathrm{I} \sin(\odot - \mathrm{N})$$

where I is the inclination of the Sun's Equator to the ecliptic, N the longitude of the ascending node, and $\odot$ the longitude of the Sun.

* "Researches on Solar Physics: Heliographical Positions and Areas of Sun Spots observed with the Kew Photoheliograph during the years 1862 and 1863," by W. De La Rue, B. Stewart, and B. Loewy. *Phil. Trans.*, 1869.

The position-angle χ is given by the formula—

$$\chi = P + G + H$$

where P is the position-angle from the north point of the Sun, and G and H two auxiliary angles given by the formulæ—

$$\tan G = \tan \omega \cos \odot$$
$$\tan H = \tan I \cos (\odot - N)$$

where ω is the obliquity of the ecliptic.

It will be seen that G is the inclination of two planes through the line joining the centres of the Earth and Sun passing through the poles of the Earth and of the ecliptic respectively, and that H is the inclination of two planes through the same line and the poles of the Sun and of the ecliptic. The values assumed for I, N, ω in the computation of the tables are 7° 15′, 74° 22′, and 23° 27′·5 respectively.

The Heliographic Longitude of the Spot is found from l, the Heliographic Longitude from Node, by subtracting the Reduction to the Prime Meridian, which is the Longitude of the Node at the epoch of the photograph, referred to the assumed Prime Meridian, the latter being the meridian which passed through the ascending node at mean noon, 1854 Jan. 1. The period of rotation assumed is 25·38 days.

The Heliographic Longitude and Latitude of the Centre of the Sun's Disk at the time of the exposure of each photograph are also given (in brackets) in the *sixth* and *seventh* columns respectively. The Longitude of the Centre of the Disk is found by subtracting the Reduction to the Prime Meridian from L, the Longitude of the Centre from the Node. The Latitude of the Centre is of course the same as D, the Heliographic Latitude of the Earth.

The measures of areas given in the *last three* columns were made with a glass diaphragm ruled into squares, with sides of one-hundredth of an inch, and placed as nearly as possible in contact with the photographic film. The integral number of squares and parts of a square contained in the area of a spot or facula was estimated by the observer, two independent sets of measures being made by two observers. The mean of the two sets of measures has been taken for each photograph. The factor for converting the areas, as measured in ten-thousandths of a square inch, into millionths of the Sun's visible hemisphere, allowing for the effect of foreshortening, has been inferred by means of a table of double entry, giving the equivalent of one square for different values of the Sun's radius, and for different distances of the spot or facula from the Sun's centre as measured by means of the position-micrometer.

The individual spots in a group have in some cases not been measured separately, but combined into a cluster of two or three small spots close together, the position of the centre of gravity and the aggregate area of the cluster being given. The actual number of individual spots is usually stated in the notes.

§ 15. *Ledgers of Areas and Heliographic Positions of Groups of Sun Spots deduced from the measurement of the Solar photographs for each day in the year* 1897.

In these Ledgers the daily results for each group are collected together from the measures of the individual spots and given in a condensed form. The first column gives, for each day on which the group was observed, the Greenwich civil time at which each photograph was taken, expressed by the day of the month (civil reckoning) and the decimals of a day reckoning from Greenwich mean midnight. The second and third columns give the sums, for each day, of the projected areas of all the umbræ and whole spots comprised in the group, the projected area being the area as it is measured upon the photograph, uncorrected for foreshortening, and expressed in millionths of the Sun's apparent disk. The fourth and fifth columns give the sums for each day of the areas of all the umbræ and whole spots comprised in the group, corrected for foreshortening, and expressed in millionths of the Sun's visible hemisphere. The sixth and seventh columns give the mean longitude and latitude of the group, found by multiplying the longitude and latitude of each separately measured component of the group by its area, and dividing the sum of the products by the sum of the areas. The last column gives the mean longitude of the group from the central meridian, and is found by subtracting the longitude of the centre of the disk from the mean longitude of the group. At the foot of these daily results for each group are given the mean areas of umbræ and whole spots and the mean longitude and latitude for the period of observation.

§ 16. *Total Projected Areas of Sun Spots and Faculæ for each day, and mean Areas and Mean Heliographic Latitude of Sun Spots and Faculæ for each Rotation of the Sun, and for the year* 1898.

This section requires no further explanation.

As a general remark applying to every class of observation above mentioned it is proper to state that the original entries of observations are in all cases preserved. The greater part of the regular observations with the transit-circle are entered in small memorandum books, in which the entries are made with a metallic pencil whose marks are not easily effaced; those with the altazimuth are entered in small books arranged for the purpose; and some observations are written down at once with ink in the skeleton forms in which the calculations are to be made, or in the copy which is sent to the press. The sheets punctured by the prickers of the electro-magnets in registration of transits by the chronographic method are also preserved. The proof-sheets are read with the first skeleton forms in which the observations are entered; and in which, in fact, the examination for accidental errors, &c. is made. The solar photographs which have been measured are preserved.

W. H. M. CHRISTIE.

Royal Observatory, Greenwich.
1899, *August* 4.

TRANSIT-CIRCLE TABLES.

ROYAL OBSERVATORY, GREENWICH.

TRANSIT-CIRCLE TABLES, 1897.

EQUATORIAL INTERVALS OF THE TRANSIT WIRES.

The following are the intervals from the middle wire determined from measures with the transit-micrometer on the North and South Collimators respectively, which were in use to March 8 :—

		r			s
For Wire M	+	17·968	=	+	44·441
N	+	11·990	=	+	29·655
O	+	5·990	=	+	14·815
P	+	5·003	=	+	12·374
Q	+	3·989	=	+	9·866
R	+	2·018	=	+	4·991
S	+	1·019	=	+	2·520
T		0·000	=		0·000
U	−	2·953	=	−	7·304
V	−	3·955	=	−	9·782
W	−	4·966	=	−	12·283
X	−	5·993	=	−	14·823
Y	−	11·933	=	−	29·514
Z	−	17·947	=	−	44·389

On February 23 wire N was found broken, and was renewed on March 8, as well as wire X which was broken while the new wire was being inserted. The following are the intervals of the new wires from the middle wire determined with the transit-micrometer from measures on the North and South Collimators.

		r			s
For Wire N	+	11·999	=	+	29·678
X	−	5·985	=	−	14·803

The adopted value of $1^{rev.}$ of the micrometer is $37''\cdot10 = 2^{s}\cdot4733$.

APPARENT CORRECTIONS TO ADOPTED LEVEL-ERRORS, DEDUCED FROM A COMPARISON OF REFLEXION AND DIRECT OBSERVATIONS OF RIGHT ASCENSION MADE IN THE YEAR 1897.

Name of Star.	Approx. N.P.D.	Approx. R.A.	Seconds of		R. – D.	Deduced Correction to Level-Error.	Number of Observations.		Weight.
			R.	D.			R.	D.	
	° ′	h m	s	s	s	″			
o Ursæ Majoris S.P.	–28. 56	8. 21	42·360	42·450	–0·090	+ 0·84	1	1	1
Lalande F. 1744 S.P.	–24. 19	10. 41	57·330	56·970	+0·360	– 2·41	1	2	1
α Camelopardi S.P.	–23. 50	4. 43	48·350	48·513	–0·163	+ 1·06	1	3	1
16 Cassiopeiæ S.P.	–23. 48	0. 28	24·610	24·685	–0·075	+ 0·49	1	2	1
38 Ursæ Majoris S.P.	–23. 45	10. 34	55·190	55·400	–0·210	+ 1·36	1	1	1
δ Draconis S.P.	–22. 31	19. 12	31·910	31·780	+0·130	– 0·77	1	1	1
42 Camelopardi S.P.	–22. 19	6. 40	12·740	12·565	+0·175	– 1·02	1	2	1
43 Camelopardi S.P.	–21. 0	6. 42	35·630	35·775	–0·145	+ 0·76	1	2	1
Groombridge 1350 S.P.	–20. 36	7. 36	19·540	19·790	–0·250	+ 1·27	1	1	1
Bradley 2331 S.P.	–18. 32	18. 20	42·040	42·470	–0·430	+ 1·86	1	1	1
Groombridge 1374 S.P.	–15. 48	7. 47	51·730	52·240	–0·510	+ 1·77	1	1	1
21 Cassiopeiæ S.P.	–15. 34	0. 38	50·490	50·630	–0·140	+ 0·48	1	1	1
Groombridge 3857 S.P.	–15. 10	22. 35	59·590	60·130	–0·540	+ 1·77	1	1	1
Piazzi XXIII. 218 S.P.	–15. 2	23. 47	22·990	23·100	–0·110	+ 0·36	1	3	2
Oeltz. Arg. (N.) 13411 S.P.	–14. 16	13. 6	36·040	36·250	–0·210	+ 0·63	1	1	1
γ Cephei S.P.	–12. 57	23. 35	6·550	7·199	–0·649	+ 1·75	½	3½	2
ζ Ursæ Minoris S.P.	–11. 53	15. 47	43·760	44·010	–0·250	+ 0·60	1	1	1
Groombridge 1735 S.P.	–11. 39	11. 2	11·440	12·130	–0·690	+ 1·62	1	2	1
Groombridge 1747 S.P.	–11. 8	11. 8	33·320	33·880	–0·560	+ 1·23	1	1	1
Piazzi IV. 269 S.P.	–10. 53	5. 5	34·550	34·770	–0·220	+ 0·48	1	2	1
Lalande F. 1745 S.P.	–10. 6	10. 45	30·440	31·120	–0·680	+ 1·33	1	1	1
Lalande F. 624–5 S.P.	– 9. 44	4. 0	35·670	35·680	–0·010	+ 0·02	1	1	1
Lalande F 659–60 S.P.	– 9. 21	4. 18	37·080	37·860	–0·780	+ 1·41	1	½	1
Lalande F. (2) 137 S.P.	– 8. 24	10. 56	22·030	22·650	–0·620	+ 0·98	1	1	1
Bradley 3147 S.P.	– 3. 16	23. 27	49·420	48·856	+0·564	– 0·31	1	20	2
Cephei 51 S.P.	– 2. 47	6. 52	13·750	14·972	–1·222	+ 0·57	1	31	2
Bradley 1672	1. 44	12. 14	18·910	22·951	–4·041	– 1·14	1	27½	2
δ Ursæ Minoris	3. 23	18. 5	31·680	31·742	–0·062	– 0·02	1	36	2
ε Ursæ Minoris	7. 48	16. 56	30·370	31·180	–0·810	– 0·95	1	4	3
Lalande F. 1629	10. 33	10. 5	29·580	29·920	–0·340	– 0·52	1	1	2
Piazzi XIII. 133	10. 49	13. 26	4·510	4·420	+0·090	+ 0·14	1	1	2
Cephei 47	10. 59	2. 52	24·040	24·020	+0·020	+ 0·03	½	½	1
Oeltz. Arg. (N.) 9756	11. 7	9. 13	50·580	50·320	+0·260	+ 0·42	1	2	2
Bradley 1634	11. 49	12. 7	22·930	22·535	+0·395	+ 0·68	1	2	2
ζ Ursæ Minoris	11. 53	15. 47	43·830	43·953	–0·123	– 0·21	½	3	2
Groombridge 1151	11. 55	6. 24	28·900	29·170	–0·270	– 0·46	1	½	2
Lalande F. 2618	12. 14	15. 6	23·260	23·130	+0·130	+ 0·19	1	1	2
Lalande 34738	12. 30	18. 29	10·770	10·760	+0·010	+ 0·02	1	1	2
Groombridge 1852	12. 31	12. 0	0·880	0·975	–0·095	– 0·17	1	2	2
Bradley 1446	13. 45	10. 26	20·450	20·537	–0·087	– 0·17	1	3	3
19 Ursæ Minoris	13. 52	16. 13	45·600	45·285	+0·315	+ 0·62	1	2	2
Piazzi XXII. 96	14. 2	22. 17	6·010	5·865	+0·145	+ 0·28	1	2	2
Lalande F. 1950	14. 4	11. 45	13·230	12·840	+0·390	+ 0·77	1	2	2
17 Ursæ Minoris	14. 8	15. 57	27·850	28·040	–0·190	– 0·38	1	2	2
Lalande 39950	14. 11	20. 29	44·570	44·810	–0·240	– 0·48	1	1	2
Oeltz. Arg. (N.) 9576	14. 18	9. 2	30·340	30·375	–0·035	– 0·07	1	2	2
Groombridge 2398	14. 27	16. 52	42·900	43·230	–0·330	– 0·67	1	1	2
Lalande 39363	14. 55	20. 15	56·200	56·230	–0·030	– 0·06	1	2	2

APPARENT CORRECTIONS TO ADOPTED LEVEL-ERRORS, DEDUCED FROM A COMPARISON OF REFLEXION AND DIRECT OBSERVATIONS OF RIGHT ASCENSION MADE IN THE YEAR 1897—*continued.*

Name of Star.	Approx. N.P.D.	Approx. R.A.	Seconds of R.	Seconds of D.	R. – D.	Deduced Correction to Level-Error.	Number of Observations. R.	Number of Observations. D.	Weight.
	° ′	h m	s	s	s	″			
Lalande F. 1537	14. 57	9. 34	20·240	20·055	+0·185	+ 0·39	1	2	2
β Ursæ Minoris	15. 25	14. 50	59·880	59·938	−0·058	− 0·13	1	4	3
Bradley 417	16. 0	3. 0	46·570	46·105	+0·465	+ 1·03	1	2	2
Bradley 3085	16. 20	23. 10	57·630	57·760	−0·130	− 0·29	1	1	2
Groombridge 3085	16. 23	20. 5	54·000	53·860	+0·140	+ 0·31	1	1	2
χ Draconis	17. 19	18. 23	55·000	54·770	+0·230	+ 0·51	1	6	3
Groombridge 3147	17. 25	20. 14	14·650	14·245	+0·405	+ 0·96	1	2	2
Piazzi IX. 91	17. 28	9. 27	36·750	36·630	+0·120	+ 0·29	1	1	2
Groombridge 1262	18. 1	7. 1	58·220	58·140	+0·080	+ 0·20	½	½	1
Oeltz. Arg. (N.) 5800	18. 10	5. 18	45·870	45·770	+0·100	+ 0·25	1	1	2
11 Cephei	19. 10	21. 40	25·680	24·493	+1·187	+ 3·04	½	1½	2
42 Leonis Minoris	58. 47	10. 40	8·290	8·310	−0·020	− 0·13	1	1	2
ε Herculis	58. 55	16. 56	20·760	20·883	−0·123	− 0·82	1	4	3
48 Aurigæ	59. 27	6. 21	56·720	56·855	−0·135	− 0·92	1	2	2
φ Cygni	60. 5	19. 35	18·460	18·393	+0·067	+ 0·47	1	3	3
ζ Cygni	60. 12	21. 8	33·160	33·092	+0·068	+ 0·47	1	17	3
η Pegasi	60. 20	22. 38	10·390	10·377	+0·013	+ 0·10	1	3	3
32 Vulpeculæ	62. 20	20. 50	10·190	10·178	+0·012	+ 0·09	1	6	3
ε² Boötis	62. 29	14. 40	29·320	29·268	+0·052	+ 0·37	1	12	3
μ Leonis	63. 30	9. 46	54·357	54·384	−0·027	− 0·21	6	5	6
16 Pegasi	64. 34	21. 48	22·505	22·471	+0·034	+ 0·25	2	11	4
δ Herculis	65. 2	17. 10	47·940	48·020	−0·080	− 0·60	1	1	2
υ¹ Cancri	65. 8	8. 20	32·245	32·350	−0·105	− 0·80	2	1	2
α Vulpeculæ	65. 33	19. 24	25·130	25·124	+0·006	+ 0·05	1	5	3
ε Leonis	65. 45	9. 40	0·325	0·283	+0·042	+ 0·32	2	6	4
η Tauri	66. 13	3. 41	21·610	21·602	+0·008	+ 0·06	1	11	3
β Herculis	68. 17	16. 25	47·415	47·450	−0·035	− 0·28	4	2	3
1 Vulpeculæ	68. 47	19. 11	47·240	47·260	−0·020	− 0·16	1	2	2
δ Leonis	68. 55	11. 8	37·870	37·833	+0·037	+ 0·31	1	11	3
γ Herculis	70. 36	16. 17	22·455	22·536	−0·081	− 0·66	4	7	6
γ Serpentis	74. 0	15. 51	41·640	41·673	−0·033	− 0·30	2	11	4
β Leonis	74. 51	11. 43	48·360	48·331	+0·029	+ 0·27	1	16	2
ε Aquilæ	75. 4	18. 54	56·730	56·817	−0·087	− 0·78	1	9	2
ν Orionis	75. 13	6. 1	41·370	41·380	−0·010	− 0·09	1	3	2
α Pegasi	75. 21	22. 59	37·760	37·715	+0·045	+ 0·41	1	6	2
α¹ Herculis	75. 30	17. 9	56·970	56·983	−0·013	− 0·13	1	7	2
ζ Boötis	75. 50	14. 36	13·780	13·733	+0·047	+ 0·43	1	3	2
Piazzi XVI. 136	76. 6	16. 33	3·135	3·208	−0·073	− 0·69	4	4	5
ζ Aquilæ	76. 17	19. 0	40·538	40·518	+0·020	+ 0·18	8	14	8
B. F. 2318	76. 34	16. 44	49·288	49·210	+0·078	+ 0·71	4	3	4
α Ophiuchi	77. 22	17. 30	9·160	9·126	+0·034	+ 0·32	1	16	2
ω Aquilæ	78. 35	19. 12	58·900	58·876	+0·024	+ 0·25	4	12	5
ε Delphini	79. 3	20. 28	17·450	17·478	−0·028	− 0·27	1	4	2
γ Aquilæ	79. 38	19. 41	21·713	21·726	−0·013	− 0·13	4	14	6
ζ Pegasi	79. 43	22. 36	19·495	19·458	+0·037	+ 0·36	2	12	4
B. F. 2359	79. 50	17. 4	48·865	48·839	+0·026	+ 0·25	6	7	6

APPARENT CORRECTIONS TO ADOPTED LEVEL-ERRORS, DEDUCED FROM A COMPARISON OF REFLEXION AND DIRECT OBSERVATIONS OF RIGHT ASCENSION MADE IN THE YEAR 1897—*continued.*

Name of Star.	Approx. N.P.D.	Approx. R.A.	Seconds of		R. – D.	Deduced Correction to Level-Error.	Number of Observations.		Weight.
			R.	D.			R.	D.	
	° ′	h m	s	s	s	″			
ρ Leonis	80. 10	10. 27	23·330	23·248	+0·082	+ 0·79	1	4	2
72 Ophiuchi	80. 27	18. 2	28·000	27·904	+0·096	+ 0·94	1	10	2
κ Ophiuchi	80. 28	16. 52	47·543	47·530	+0·013	+ 0·14	3	11	4
β Cancri	80. 30	8 10	55·830	55·772	+0·058	+ 0·58	1	6	2
ο Virginis	80. 42	11. 59	57·580	57·774	−0·194	− 1·91	1	5	2
α Aquilæ	81. 24	19. 45	45·436	45·433	+0·003	+ 0·04	5	25	6
ξ² Ceti	82. 0	2. 22	41·010	40·868	+0·142	+ 1·45	1	4	2
χ Leonis	82. 6	10. 59	42·330	42·175	+0·155	+ 1·58	1	2	1
ε Piscium	82. 39	0. 57	35·765	35·750	+0·015	+ 0·16	2	8	4
π Virginis	82. 49	11. 55	35·675	35·678	−0·003	− 0·04	2	5	3
ζ¹ Piscium	82. 58	1. 8	20·870	20·895	−0·025	− 0·27	1	4	2
ε Hydræ	83. 12	8. 41	19·322	19·320	+0·002	+ 0·02	2½	4	3
ζ Hydræ	83. 40	8. 49	56·950	56·960	−0·010	− 0·10	1	3	2
β Aquilæ	83. 51	19. 50	15·220	15·190	+0·030	+ 0·32	1	6	2
ι Piscium	84. 56	23. 34	39·210	39·042	+0·168	+ 1·80	1	6	2
ε Serpentis	85. 13	15. 45	40·810	40·837	−0·027	− 0·30	2	12	4
σ Ophiuchi	85. 46	17. 21	24·207	24·196	+0·011	+ 0·13	3	9	4
δ Aquilæ	87. 5	19. 20	18·280	18·295	−0·015	− 0·18	1	8	2
λ Ophiuchi	87. 47	16. 25	43·080	43·081	−0·001	0·00	1	9	2
τ Virginis	87. 57	13. 56	24·170	24·198	−0·028	− 0·32	1	6	2
44 Piscium	88. 37	0. 20	7·300	7·315	−0·015	− 0·19	1	4	2
κ Piscium	89. 19	23. 21	39·110	39·060	+0·050	+ 0·58	1	5	2
δ Orionis	90. 23	5. 26	44·620	44·601	+0·019	+ 0·24	1	7	2
η Aquarii	90. 39	22. 30	3·760	3·784	−0·024	− 0·29	1	9	2
α Aquarii	90. 49	22. 0	29·610	29·590	+0·020	+ 0·24	1	9	2
η Serpentis	92. 56	18. 15	58·798	58·753	+0·045	+ 0·59	4	16	4
δ Ophiuchi	93. 26	16. 8	56·760	56·794	−0·034	− 0·46	1	11	2
λ Aquarii	98. 8	22. 47	14·470	14·438	+0·032	+ 0·46	1	6	2
α Hydræ	98. 13	9. 22	31·470	31·517	−0·047	− 0·70	1	7	2
θ Aquarii	98. 18	22. 11	23·930	23·931	−0·001	− 0·00	1	10	2
1 Aquilæ	98. 19	18. 29	36·128	36·074	+0·054	+ 0·78	4	5	3
ξ Aquarii	98. 19	21. 32	16·180	16·114	+0·066	+ 0·97	1	5	2
2 Aquilæ	99. 9	18. 36	38·016	37·989	+0·027	+ 0·42	7	11	4
ι Ceti	99. 23	0. 14	10·780	10·747	+0·033	+ 0·51	1	3	2

The weights used have been determined as follows:—

Putting m and n for the number of reflexion and direct observations respectively, the weight to be given to each star, in deducing the mean correction to level-error, is $\frac{4\,mn}{m + n + \frac{1}{5}\,mn} \times \cos \text{Z.D.}$, which has been adopted for use to the nearest integer.

Combining these with the weights above attached to them, we have—

From 69 South Stars, Mean Correction to Level-Error + 0″·07, weight 204

„ 59 North Stars, „ „ „ „ „ + 0″·30, „ 98

FACTORS FOR INSTRUMENTAL-ERRORS.

N.P.D.	Collimation.	Level.	Azimuth.	N.P.D.	Collimation.	Level.	Azimuth.
	$\frac{1}{15 \text{ Sin N.P.D.}}$	$\frac{\text{Cos Z.D.}}{15 \text{ Sin N.P.D.}}$	$\frac{\text{Sin Z.D.}}{15 \text{ Sin N.P.D.}}$		$\frac{1}{15 \text{ Sin N.P.D.}}$	$\frac{\text{Cos Z.D.}}{15 \text{ Sin N.P.D.}}$	$\frac{\text{Sin Z.D.}}{15 \text{ Sin N.P.D.}}$
° ′				° ′			
−45. 0	−0·094	−0·011	+0·094	− 7. 30	−0·511	−0·355	+0·368
−44. 0	−0·096	−0·013	+0·095	− 7. 0	−0·547	−0·383	+0·390
−43. 0	−0·098	−0·014	+0·096	− 6. 30	−0·589	−0·416	+0·417
−42. 0	−0·100	−0·016	+0·098	− 6. 0	−0·638	−0·455	+0·447
−41. 0	−0·102	−0·018	+0·100				
−40. 0	−0·104	−0·021	+0·102	6. 0	+0·638	+0·538	−0·343
−39. 0	−0·106	−0·023	+0·104	6. 30	+0·589	+0·499	−0·312
−38. 0	−0·108	−0·025	+0·105	7. 0	+0·547	+0·466	−0·286
−37. 0	−0·111	−0·027	+0·107	7. 30	+0·511	+0·438	−0·263
−36. 0	−0·113	−0·030	+0·109	8. 0	+0·479	+0·413	−0·243
−35. 0	−0·116	−0·033	+0·111	8. 30	+0·451	+0·391	−0·226
−34. 0	−0·119	−0·036	+0·114	9. 0	+0·426	+0·371	−0·210
−33. 0	−0·122	−0·039	+0·116	9. 30	+0·404	+0·353	−0·196
−32. 0	−0·126	−0·042	+0·119	10. 0	+0·384	+0·337	−0·183
−31. 0	−0·129	−0·045	+0·121	10. 30	+0·366	+0·323	−0·172
−30. 0	−0·133	−0·049	+0·124	11. 0	+0·349	+0·310	−0·161
−29. 0	−0·138	−0·053	+0·127	11. 30	+0·334	+0·298	−0·152
−28. 0	−0·142	−0·057	+0·130	12. 0	+0·321	+0·287	−0·143
−27. 0	−0·147	−0·061	+0·133	12. 30	+0·308	+0·277	−0·135
−26. 0	−0·152	−0·065	+0·137	13. 0	+0·296	+0·267	−0·128
−25. 0	−0·158	−0·070	+0·141	13. 30	+0·286	+0·259	−0·122
−24. 0	−0·164	−0·076	+0·145	14. 0	+0·276	+0·251	−0·116
−23. 0	−0·171	−0·082	+0·150	14. 30	+0·266	+0·244	−0·111
−22. 0	−0·178	−0·088	+0·155	15. 0	+0·257	+0·236	−0·105
−21. 0	−0·186	−0·094	+0·160	15. 30	+0·249	+0·230	−0·099
−20. 0	−0·195	−0·102	+0·166	16. 0	+0·242	+0·224	−0·093
−19. 30	−0·200	−0·106	+0·170	16. 30	+0·235	+0·218	−0·088
−19. 0	−0·205	−0·110	+0·173	17. 0	+0·228	+0·212	−0·084
−18. 30	−0·210	−0·114	+0·176	17. 30	+0·222	+0·207	−0·080
−18. 0	−0·216	−0·119	+0·180	18. 0	+0·216	+0·202	−0·076
−17. 30	−0·222	−0·124	+0·184	18. 30	+0·210	+0·197	−0·072
−17. 0	−0·228	−0·129	+0·188	19. 0	+0·205	+0·193	−0·068
−16. 30	−0·235	−0·134	+0·192	19. 30	+0·200	+0·189	−0·065
−16. 0	−0·242	−0·140	+0·197	20. 0	+0·195	+0·185	−0·062
−15. 30	−0·249	−0·146	+0·202	21. 0	+0·186	+0·177	−0·056
−15. 0	−0·257	−0·153	+0·207	22. 0	+0·178	+0·171	−0·051
−14. 30	−0·266	−0·160	+0·213	23. 0	+0·171	+0·164	−0·046
−14. 0	−0·276	−0·168	+0·219	24. 0	+0·164	+0·159	−0·041
−13. 30	−0·286	−0·176	+0·225	25. 0	+0·158	+0·153	−0·037
−13. 0	−0·296	−0·184	+0·232	26. 0	+0·152	+0·148	−0·033
−12. 30	−0·308	−0·194	+0·240	27. 0	+0·147	+0·144	−0·029
−12. 0	−0·321	−0·204	+0·248	28. 0	+0·142	+0·140	−0·026
−11. 30	−0·334	−0·214	+0·256	29. 0	+0·138	+0·136	−0·023
−11. 0	−0·349	−0·227	+0·266	30. 0	+0·133	+0·131	−0·020
−10. 30	−0·366	−0·240	+0·276	31. 0	+0·129	+0·128	−0·017
−10. 0	−0·384	−0·254	+0·288	32. 0	+0·126	+0·125	−0·014
− 9. 30	−0·404	−0·270	+0·300	33. 0	+0·122	+0·122	−0·012
− 9. 0	−0·426	−0·288	+0·314	34. 0	+0·119	+0·119	−0·009
− 8. 30	−0·451	−0·308	+0·330	35. 0	+0·116	+0·116	−0·007
− 8. 0	−0·479	−0·330	+0·348	36. 0	+0·113	+0·113	−0·005
− 7. 30	−0·511	−0·355	+0·368	37. 0	+0·111	+0·111	−0·003

FACTORS FOR INSTRUMENTAL-ERRORS—*continued.*

N.P.D.	Collimation. $\frac{1}{15 \sin \text{N.P.D.}}$	Level. $\frac{\cos \text{Z.D.}}{15 \sin \text{N.P.D.}}$	Azimuth. $\frac{\sin \text{Z.D.}}{15 \sin \text{N.P.D.}}$	N.P.D.	Collimation. $\frac{1}{15 \sin \text{N.P.D.}}$	Level. $\frac{\cos \text{Z.D.}}{15 \sin \text{N.P.D.}}$	Azimuth. $\frac{\sin \text{Z.D.}}{15 \sin \text{N.P.D.}}$
37° 0'	+0·111	+0·111	−0·003	82° 0'	+0·067	+0·049	+0·046
38. 0	+0·108	+0·108	−0·001	83. 0	+0·067	+0·048	+0·047
39. 0	+0·106	+0·106	+0·001	84. 0	+0·067	+0·047	+0·048
40. 0	+0·104	+0·104	+0·003	85. 0	+0·067	+0·046	+0·048
41. 0	+0·102	+0·101	+0·004	86. 0	+0·067	+0·045	+0·049
42. 0	+0·100	+0·099	+0·006	87. 0	+0·067	+0·044	+0·050
43. 0	+0·098	+0·097	+0·007	88. 0	+0·067	+0·043	+0·051
44. 0	+0·096	+0·096	+0·009	89. 0	+0·067	+0·042	+0·052
45. 0	+0·094	+0·094	+0·011	90. 0	+0·067	+0·041	+0·052
46. 0	+0·093	+0·092	+0·012	91. 0	+0·067	+0·040	+0·053
47. 0	+0·091	+0·090	+0·013	92. 0	+0·067	+0·040	+0·054
48. 0	+0·090	+0·088	+0·015	93. 0	+0·067	+0·039	+0·054
49. 0	+0·088	+0·087	+0·016	94. 0	+0·067	+0·038	+0·055
50. 0	+0·087	+0·085	+0·017	95. 0	+0·067	+0·037	+0·056
51. 0	+0·086	+0·084	+0·018	96. 0	+0·067	+0·036	+0·057
52. 0	+0·085	+0·082	+0·020	97. 0	+0·067	+0·035	+0·057
53. 0	+0·083	+0·081	+0·021	98. 0	+0·067	+0·034	+0·058
54. 0	+0·082	+0·080	+0·022	99. 0	+0·067	+0·033	+0·059
55. 0	+0·081	+0·078	+0·023	100. 0	+0·068	+0·032	+0·060
56. 0	+0·080	+0·077	+0·024	101. 0	+0·068	+0·031	+0·060
57. 0	+0·080	+0·075	+0·025	102. 0	+0·068	+0·030	+0·061
58. 0	+0·079	+0·074	+0·026	103. 0	+0·068	+0·029	+0·062
59. 0	+0·078	+0·073	+0·027	104. 0	+0·069	+0·028	+0·063
60. 0	+0·077	+0·072	+0·028	105. 0	+0·069	+0·027	+0·063
61. 0	+0·076	+0·070	+0·029	106. 0	+0·069	+0·027	+0·064
62. 0	+0·076	+0·069	+0·030	107. 0	+0·070	+0·026	+0·065
63. 0	+0·075	+0·068	+0·031	108. 0	+0·070	+0·025	+0·066
64. 0	+0·074	+0·067	+0·032	109. 0	+0·071	+0·024	+0·066
65. 0	+0·073	+0·066	+0·033	110. 0	+0·071	+0·023	+0·067
66. 0	+0·073	+0·065	+0·034	111. 0	+0·072	+0·022	+0·068
67. 0	+0·072	+0·064	+0·035	112. 0	+0·072	+0·021	+0·069
68. 0	+0·072	+0·063	+0·035	113. 0	+0·073	+0·020	+0·070
69. 0	+0·071	+0·061	+0·036	114. 0	+0·073	+0·018	+0·071
70. 0	+0·071	+0·060	+0·037	115. 0	+0·074	+0·017	+0·072
71. 0	+0·071	+0·059	+0·038	116. 0	+0·075	+0·016	+0·072
72. 0	+0·070	+0·058	+0·039	117. 0	+0·075	+0·015	+0·073
73. 0	+0·070	+0·057	+0·039	118. 0	+0·076	+0·014	+0·074
74. 0	+0·069	+0·056	+0·040	119. 0	+0·076	+0·013	+0·075
75. 0	+0·069	+0·055	+0·041	120. 0	+0·077	+0·012	+0·076
76. 0	+0·069	+0·054	+0·042	121. 0	+0·078	+0·011	+0·077
77. 0	+0·068	+0·053	+0·043	122. 0	+0·079	+0·009	+0·078
78. 0	+0·068	+0·053	+0·043	123. 0	+0·080	+0·008	+0·079
79. 0	+0·068	+0·052	+0·044	124. 0	+0·080	+0·007	+0·080
80. 0	+0·068	+0·051	+0·045	125. 0	+0·081	+0·005	+0·081
81. 0	+0·067	+0·050	+0·045	126. 0	+0·082	+0·004	+0·082
82. 0	+0·067	+0·049	+0·046				

ASSUMED MEAN RIGHT ASCENSIONS OF CLOCK STARS AND CIRCUMPOLAR STARS, WITH THE CORRECTIONS TO THE R.A. OF THE NAUTICAL ALMANAC, FOR 1897·0.

Star's Name.	Assumed Mean R.A. 1897·0.	Correction to N.A.	Approx. N.P.D.	Star's Name.	Assumed Mean R.A. 1897·0.	Correction to N.A.	Approx. N.P.D.
	h m s	s	° ′		h m s	s	° ′
α Andromedæ...	0. 3. 3·716	+ 0·001	61. 29	α Columbæ.......	5. 35. 55·214	+ 0·022	124. 8
γ Pegasi.........	0. 7. 55·830	0·000	75. 23	κ Orionis.........	5. 42. 52·243	+ 0·001	99. 42
ι Ceti.............	0. 14. 10·730	− 0·001	99. 24	α Orionis.........	5. 49. 35·695	0·000	82. 37
44 Piscium.......	0. 20. 7·301		88. 38	1 Geminorum ...	5. 57. 51·498		66. 44
12 Ceti...........	0. 24. 46·884	0·000	94. 32	ν Orionis.........	6. 1. 41·402	0·000	75. 13
ε Andromedæ ...	0. 33. 6·646		61. 15	η Geminorum ...	6. 8. 39·589	0·000	67. 28
β Ceti............	0. 38. 25·144	0·000	108. 33	μ Geminorum ...	6. 16. 43·712	+ 0·001	67. 26
δ Piscium.........	0. 43. 20·207	+ 0·001	82. 59	β Canis Majoris.	6. 18. 9·774		107. 54
20 Ceti...........	0. 47. 44·558		91. 42	ν Geminorum....	6. 22. 50·816		69. 43
μ Andromedæ...	0. 51. 1·943		52. 4	γ Geminorum....	6. 31. 45·664	− 0·009	73. 31
ε Piscium........	0. 57. 35·756	0·000	82. 40	ξ Geminorum....	6. 39. 30·468	0·000	77. 0
β Andromedæ...	1. 3. 57·773	0·000	54. 56	θ Canis Majoris..	6. 49. 24·206	0·000	101. 55
ζ^1 Piscium........	1. 8. 20·863		82. 58	Cephei 51.........	6. 52. 15·094	+ 0·031	2. 47
θ Ceti............	1. 18. 52·429	− 0·003	98. 43	ε Canis Majoris..	6. 54. 34·607	− 0·016	118. 50
Polaris...........	1. 21. 18·365	+ 0·058	1. 15	ζ Geminorum....	6. 57. 59·969		69. 17
η Piscium.........	1. 25. 58·182	+ 0·004	75. 11	γ Canis Majoris.	6. 59. 5·840	0·000	105. 29
ν Piscium.........	1. 36. 4·160	− 0·001	85. 2	51 Geminorum..	7. 7. 27·385		73. 40
ο Piscium.........	1. 39. 57·148	+ 0·001	81. 22	δ Geminorum....	7. 13. 58·277	0·000	67. 50
β Arietis.........	1. 48. 56·869	+ 0·001	69. 42	β Canis Minoris.	7. 21. 33·874	− 0·005	81. 30
α Arietis.........	2. 1. 21·908	− 0·002	67. 1	Castor............	7. 28. 1·703	0·000	57. 53
ξ^1 Ceti...........	2. 7. 32·313		81. 38	Procyon..........	7. 33. 54·689	+ 0·018	84. 31
67 Ceti...........	2. 11. 50·679	− 0·001	96. 54	Pollux............	7. 39. 0·819	+ 0·001	61. 44
ξ^2 Ceti...........	2. 22. 40·846	0·000	82. 0	ξ Argûs...........	7. 44. 57·689	0·000	114. 36
ν Ceti............	2. 30. 28·029		84. 51	Groomb. 1119...	7. 54. 44·654		1. 4
δ Ceti............	2. 34. 12·105		90. 6	6 Cancri..........	7. 57. 11·545	− 0·001	61. 55
γ^2 Ceti...........	2. 37. 57·706	0·000	87. 12	ρ Argûs...........	8. 3. 9·393	0·000	114. 0
σ Arietis.........	2. 45. 48·230	0·000	75. 21	β Cancri..........	8. 10. 55·735	0·000	80. 30
ε Arietis.........	2. 53. 19·215		69. 4	d^1 Cancri.........	8. 17. 27·955		71. 20
α Ceti............	2. 56. 53·624	0·000	86. 19	η Cancri..........	8. 26. 45·167	0·000	69. 13
δ Arietis.........	3. 5. 44·215	− 0·001	70. 40	γ Cancri..........	8. 37. 19·540	− 0·001	68. 10
τ^1 Arietis.........	3. 15. 16·704		69. 13	ε Hydræ..........	8. 41. 19·236	0·000	83. 12
ο Tauri...........	3. 19. 16·110	0·000	81. 20	α Cancri..........	8. 52. 51·255	− 0·001	77. 45
f Tauri...........	3. 25. 11·076		77. 25	κ Cancri..........	9. 2. 10·124	0·000	78. 55
ε Eridani.........	3. 28. 4·577	− 0·001	99. 48	83 Cancri.........	9. 13. 13·961	0·000	71. 52
11 Tauri..........	3. 34. 37·084		65. 0	α Hydræ..........	9. 22. 31·518	+ 0·001	98. 13
δ Eridani.........	3. 38. 18·764		100. 7	ξ Leonis..........	9. 26. 23·620		78. 15
η Tauri...........	3. 41. 21·597	− 0·001	66. 13	ο Leonis..........	9. 35. 39·191	+ 0·001	79. 38
γ^1 Eridani........	3. 53. 13·345	0·000	103. 48	ε Leonis..........	9. 40. 0·307	− 0·001	65. 45
A^1 Tauri..........	3. 58. 36·255	− 0·001	68. 12	μ Leonis..........	9. 46. 54·362	0·000	63. 30
ω^1 Tauri..........	4. 3. 9·808		70. 40	π Leonis..........	9. 54. 46·213	0·000	81. 28
o^1 Eridani........	4. 6. 50·184	− 0·001	97. 6	Regulus...........	10. 2. 53·199	0·000	77. 32
γ Tauri...........	4. 13. 55·787	0·000	74. 37	γ^1 Leonis.........	10. 14. 17·654	+ 0·001	69. 38
ε Tauri...........	4. 22. 36·047	− 0·002	71. 3	μ Hydræ..........	10. 21. 6·471	0·000	106. 19
Aldebaran........	4. 30. 0·530	+ 0·002	73. 42	ρ Leonis..........	10. 27. 23·264	0·000	80. 10
τ Tauri...........	4. 36. 3·684		67. 14	34 Sextantis.....	10. 37. 18·345		85. 53
μ Eridani.........	4. 40. 21·072	0·000	93. 27	l Leonis...........	10. 43. 50·595	0·000	78. 55
ι Aurigæ..........	4. 50. 17·075	+ 0·001	57. 0	d Leonis..........	10. 55. 14·442	− 0·001	85. 50
ε Leporis.........	5. 1. 5·997	0·000	112. 31	χ Leonis..........	10. 59. 42·209	0·000	82. 6
Rigel.............	5. 9. 35·220	− 0·001	98. 19	δ Leonis..........	11. 8. 37·868	0·000	68. 55
β Tauri...........	5. 19. 46·795	− 0·001	61. 29	δ Crateris.........	11. 14. 11·383	0·000	104. 13
δ Orionis.........	5. 26. 44·565	0·000	90. 23	τ Leonis..........	11. 22. 38·385	0·000	86. 35
α Leporis.........	5. 28. 11·196	+ 0·001	107. 54	υ Leonis..........	11. 31. 40·435	0·000	90. 15
ε Orionis.........	5. 30. 59·170	0·000	91. 16	β Leonis..........	11. 43. 48·345	0·000	74. 51

NOTE.—The Right Ascensions are deduced from the adopted Mean R.A. 1890·0 in the *Five-Year Catalogue of 258 Fundamental Stars for* 1890, with the exception of the five polar stars, Groombridge 1119, Bradley 1672, Groombridge 2283, Groombridge 3548, and Bradley 3147, for which the Mean R.A. has been deduced from all the observations in the years 1887–1894. The Proper Motions are taken from Prof. Auwers' *Neue Reduction der Bradleyschen Beobachtungen*, erster Band, for all stars contained in that work except μ Andromedæ, for which Mr. Main's Proper Motion is used. For Cephei 51 the Proper Motion is taken from Prof. Auwers' *Catalog der Fundamental Sterne*, and for α Columbæ and δ Sculptoris from the *Cape Catalogue*, 1880. For Groombridge 1119, Groombridge 2283, and Groombridge 3548, provisional Proper Motions derived from a comparison with Groombridge's, the Radcliffe and Carrington's Catalogues have been adopted, viz. :— $-0^s{\cdot}1126$ for Groombridge 1119, $+0^s{\cdot}0070$ for Groombridge 2283, and $+0^s{\cdot}0334$ for Groombridge 3548.

ASSUMED MEAN RIGHT ASCENSIONS OF CLOCK STARS AND CIRCUMPOLAR STARS, WITH THE CORRECTIONS TO THE R.A. OF THE NAUTICAL ALMANAC, FOR 1897·0—*continued.*

Star's Name.	Assumed Mean R.A. 1897·0.	Correction to N.A.	Approx. N.P.D.	Star's Name.	Assumed Mean R.A. 1897·0.	Correction to N.A.	Approx. N.P.D.
	h m s	s	° ′		h m s	s	° ′
β Virginis	11. 45. 19·760		87. 39	μ Sagittarii	18. 7. 36·156	0·000	111. 5
π Virginis	11. 55. 35·656	− 0·001	82. 49	η Serpentis	18. 15. 58·726	0·000	92. 56
o Virginis	11. 59. 57·718		80. 42	λ Sagittarii	18. 21. 36·780	− 0·047	115. 29
ε Corvi	12. 4. 49·551	+ 0·001	112. 3	α Lyræ	18. 33. 27·037	0·000	51. 19
Bradley 1672	12. 14. 22·975		1. 44	2 Aquilæ	18. 36. 37·988		99. 9
η Virginis	12. 14. 38·103	0·000	90. 6	β¹ Lyræ	18. 46. 16·602	0·000	56. 45
δ² Corvi	12. 24. 32·014	+ 0·001	105. 57	ε Aquilæ	18. 54. 56·811	− 0·001	75. 4
β Corvi	12. 28. 58·495	0·000	112. 50	ζ Aquilæ	19. 0. 40·517	− 0·001	76. 17
ρ Virginis	12. 36. 40·232		79. 12	ψ Sagittarii	19. 9. 13·463		115. 26
35 Virginis	12. 42. 36·686		85. 52	ω Aquilæ	19. 12. 58·862	0·000	78. 35
31 Comæ	12. 46. 40·896		61. 54	δ Aquilæ	19. 20. 18·270	0·000	87. 5
δ Virginis	12. 50. 24·860	0·000	86. 3	α Vulpeculæ	19. 24. 25·137		65. 33
ε Virginis	12. 57. 2·960	0·000	78. 29	λ Ursæ Minoris	19. 25. 52·939	+ 0·039	1. 1
θ Virginis	13. 4. 36·920	0·000	94. 59	μ Aquilæ	19. 29. 3·430		82. 51
Spica	13. 19. 45·919	0·000	100. 37	h² Sagittarii	19. 30. 26·359	+ 0·036	115. 7
ζ Virginis	13. 29. 26·600	− 0·002	90. 4	e¹ Sagittarii	19. 34. 49·311		106. 31
m Virginis	13. 36. 12·245		98. 10	γ Aquilæ	19. 41. 21·722	0·000	79. 38
τ Boötis	13. 42. 22·012	0·000	72. 2	α Aquilæ	19. 45. 45·426	0·000	81. 24
η Boötis	13. 49. 46·800	+ 0·001	71. 5	β Aquilæ	19. 50. 15·163	0·000	83. 51
τ Virginis	13. 56. 24·193	+ 0·001	87. 57	c Sagittarii	19. 56. 19·449		118. 0
94 Virginis	14. 0. 50·410		98. 25	θ Aquilæ	20. 5. 59·379	0·000	91. 8
κ Virginis	14. 7. 23·972		99. 48	α² Capricorni	20. 12. 20·382	0·000	102. 52
Arcturus	14. 10. 57·762	0·000	70. 17	β Capricorni	20. 15. 13·431		105. 6
f Boötis	14. 21. 39·874	0·000	70. 19	ρ Capricorni	20. 22. 59·147	0·000	108. 9
ρ Boötis	14. 27. 23·435	0·000	59. 11	ε Delphini	20. 28. 17·485	− 0·003	79. 3
ε² Boötis	14. 40. 29·292	0·000	62. 30	α Delphini	20. 34. 51·191	0·000	74. 27
α Libræ	14. 45. 10·722	+ 0·001	105. 37	ε Aquarii	20. 42. 5·996	0·000	99. 52
ξ² Libræ	14. 51. 10·657		101. 0	μ Aquarii	20. 47. 5·878		99. 22
ψ Boötis	15. 0. 1·920	0·000	62. 39	32 Vulpeculæ	20. 50. 10·177	+ 0·001	62. 20
ι¹ Libræ	15. 6. 20·893		109. 25	θ Capricorni	21. 0. 9·445	0·000	107. 39
Groomb. 2283	15. 10. 22·628		2. 22	ζ Cygni	21. 8. 33·116	0·000	60. 12
β Libræ	15. 11. 27·746	0·000	99. 0	α Equulei	21. 10. 40·473		85. 11
σ² Libræ	15. 17. 16·968		104. 46	ι Capricorni	21. 16. 30·678		107. 16
ζ¹ Libræ	15. 22. 26·755		106. 22	Groomb. 3548	21. 20. 9·392		3. 23
α Coronæ	15. 30. 19·568	+ 0·003	62. 56	β Aquarii	21. 26. 8·176	0·000	96. 1
α Serpentis	15. 39. 11·623	+ 0·001	83. 15	ξ Aquarii	21. 32. 16·103		98. 19
ε Serpentis	15. 45. 40·831	0·000	85. 13	ε Pegasi	21. 39. 7·565	0·000	80. 36
γ Serpentis	15. 51. 41·690		74. 0	δ Capricorni	21. 41. 21·331	− 0·002	106. 36
β¹ Scorpii	15. 59. 26·703	− 0·005	109. 31	16 Pegasi	21. 48. 22·449	− 0·001	64. 34
δ Ophiuchi	16. 8. 56·757	0·000	93. 26	α Aquarii	22. 0. 29·567	− 0·001	90. 49
γ Herculis	16. 17. 22·510	0·000	70. 36	ι Pegasi	22. 2. 12·896		65. 9
Antares	16. 23. 5·411	+ 0·005	116. 12	θ Aquarii	22. 11. 23·879	+ 0·002	98. 18
λ Ophiuchi	16. 25. 43·032		87. 48	γ Aquarii	22. 16. 20·122	0·000	91. 54
ζ Ophiuchi	16. 31. 29·139	0·000	100. 22	σ Aquarii	22. 25. 11·770		101. 12
ξ Herculis	16. 37. 24·157	+ 0·001	58. 13	η Aquarii	22. 30. 3·749	− 0·001	90. 39
κ Ophiuchi	16. 52. 47·508	0·000	80. 28	ζ Pegasi	22. 36. 19·438	+ 0·001	79. 42
ε Herculis	16. 56. 20·864		58. 55	μ Pegasi	22. 45. 1·843		65. 57
η Ophiuchi	17. 4. 28·142	+ 0·005	105. 36	λ Aquarii	22. 47. 14·423	0·000	98. 8
α¹ Herculis	17. 9. 56·995	− 0·003	75. 30	Fomalhaut	22. 51. 57·542	+ 0·048	120. 10
θ Ophiuchi	17. 15. 40·924	− 0·001	114. 54	α Pegasi	22. 59. 37·739	0·000	75. 21
σ Ophiuchi	17. 21. 24·177	0·000	85. 46	γ Piscium	23. 11. 49·487	− 0·001	87. 17
α Ophiuchi	17. 30. 9·136	+ 0·002	77. 22	κ Piscium	23. 21. 39·092	0·000	89. 18
β Ophiuchi	17. 38. 22·996	+ 0·002	85. 23	Bradley 3147	23. 27. 48·916		3. 16
μ Herculis	17. 42. 25·586	0·000	62. 13	ι Piscium	23. 34. 39·059	0·000	84. 56
89 Herculis	17. 51. 15·840		63. 56	δ Sculptoris	23. 43. 33·713	+ 0·029	118. 42
72 Ophiuchi	18. 2. 27·941	− 0·001	80. 27	ω Piscium	23. 54. 1·248	− 0·001	83. 42
δ Ursæ Minoris	18. 5. 31·169	− 0·018	3. 23	2 Ceti	23. 58. 27·799		107. 54

The correction to the R.A. of Procyon for the effect of orbital motion from 1890 (the epoch of the Five-Year Catalogue) to 1897 is $+0^s{\cdot}017$. This correction is derived from Prof. Auwers' Elements (*Astronomische Nachrichten*, Nos. 1371, 1372, 1373).

The Right Ascensions of the Nautical Almanac for 1897·0 are derived from an advance MS. copy of the Greenwich Five-Year Catalogue, epoch 1890, except for stars south of N.P.D. 115°.

DETERMINATION OF THE PERSONAL EQUATIONS OF THE VARIOUS OBSERVERS USING THE CHRONOGRAPHIC METHOD OF OBSERVING TRANSITS.

The Observers in order of seniority are :—

D, C, L, H, A C, B, C D, R, W B, H F, R C, J, E B, S, W, H A, W S, J S.

When a result depends on a single observation by one of the observers, half weight is given to it. Such cases are denoted by an asterisk.

Day, 1897.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
Mar.	28	9	D	B	+ 0·18*
April	18	0	D	H F	+ 0·04
Oct.	17	3	H F	D	+ 0·07*
Oct.	24	9	D	W	+ 0·02
Mar.	5	2	H	C	− 0·33
Oct.	3	5	A C	C	+ 0·08
Mar.	5	2	C D	C	− 0·06*
Jan.	1	1	H F	C	− 0·20
Jan.	1	0	C	E B	− 0·14
Jan.	1	4	W	C	− 0·10
July	17	3	H A	C	+ 0·09
Feb.	7	2	A C	H	+ 0·31*
Mar.	29	7	H	A C	+ 0·28
May	18	6	H	A C	+ 0·31*
Oct.	30	0	H	A C	+ 0·26
Nov.	29	1	H	A C	+ 0·44
Jan.	26	2	B	H	+ 0·20
April	28	6	B	H	+ 0·24
May	4	2	B	H	+ 0·27
July	16	1	H	B	+ 0·32
Aug.	2	3	H	B	+ 0·33*
,,	4	3	B	H	+ 0·17
Sept.	30	1	H	B	+ 0·33
Nov.	21	0	B	H	+ 0·21
Dec.	2	7	B	H	+ 0·31
Mar.	5	0	C D	H	+ 0·27
Oct.	30	5	H	C D	+ 0·16
Feb.	7	1	H	W B	+ 0·20
April	24	3	H	W B	+ 0·25
July	25	0	W B	H	+ 0·18
Oct.	19	4	H F	H	+ 0·11
April	22	9	W	H	+ 0·16
Nov.	29	3	W	H	+ 0·24
Dec.	16	11	W	H	+ 0·25
April	24	5	W S	H	+ 0·32*
Nov.	29	5	H	W S	+ 0·38
April	28	4	J S	H	+ 0·24
May	1	1	H	J S	+ 0·29
,,	4	4	J S	H	+ 0·32
July	21	2	J S	H	+ 0·19
Sept.	28	3	H	J S	+ 0·16

OBSERVATIONS FOR PERSONAL EQUATIONS—*continued.*

Day, 1897.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
Oct.	19	1	J S	H	+ 0·06
Dec.	16	6	J S	H	+ 0·16
April	5	1	B	A C	+ 0·10
,,	23	1	B	A C	− 0·04*
May	9	1	A C	B	+ 0·03
,,	28	6	B	A C	− 0·02
Dec.	11	7	A C	B	+ 0·03
Jan.	25	0	A C	C D	− 0·13
Mar.	10	3	A C	C D	− 0·09
May	3	1	C D	A C	− 0·05
,,	9	3	C D	A C	+ 0·02
Sept.	2	4	A C	C D	− 0·12
Oct.	11	1	A C	C D	− 0·03
,,	30	5	A C	C D	− 0·10
,,	31	5	A C	C D	+ 0·01
Mar.	8	3	A C	R	− 0·18
June	16	5	R	A C	− 0·11
Feb.	7	3	A C	W B	− 0·11*
June	2	4	A C	W B	+ 0·14*
Sept.	14	9	W B	A C	+ 0·01
Jan.	28	10	A C	H F	− 0·10
June	5	1	A C	H F	− 0·15
,,	16	9	A C	H F	− 0·16
July	1	5	H F	A C	− 0·18
,,	3	2	H F	A C	− 0·03
Oct.	31	6	A C	H F	− 0·07*
Dec.	6	9	H F	A C	− 0·04*
Mar.	6	3	A C	R C	− 0·13
Sept.	20	2	R C	A C	− 0·04
May	6	1	J	A C	− 0·03
Mar.	23	8	E B	A C	− 0·13
Jan.	25	10	S	A C	− 0·36
April	23	12	S	A C	− 0·24*
Dec.	6	8	S	A C	− 0·31*
Mar.	18	5	W	A C	− 0·19*
Aug.	30	0	W	A C	− 0·10*
Nov.	29	4	W	A C	− 0·20
April	23	9	H A	A C	− 0·06*
June	13	2	H A	A C	− 0·02
Aug.	16	5	H A	A C	− 0·02
Dec.	31	0	H A	A C	− 0·05
Jan.	25	10	W S	A C	− 0·10
,,	28	2	A C	W S	+ 0·09
Mar.	8	2	A C	W S	0·00
,,	10	1	A C	W S	− 0·01
July	1	2	W S	A C	− 0·07*
Sept.	3	2	A C	W S	+ 0·01
Nov.	29	4	A C	W S	− 0·06
May	6	2	J S	A C	− 0·07
Mar.	15	4	B	C D	+ 0·02
May	5	1	B	C D	− 0·10
,,	7	0	B	C D	− 0·08
,,	9	4	C D	B	− 0·01

OBSERVATIONS FOR PERSONAL EQUATIONS—*continued.*

Day, 1897.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.	Day, 1897.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.
	h		s		h		s
Sept. 27	4	B CD	− 0·07	July 22	0	HA B	0·00
Oct. 25	1	B CD	− 0·10	Oct. 25	3	HA B	− 0·07
May 2	1	B R	− 0·07*	Dec. 8	4	B WS	+ 0·06
,, 5	2	B R	− 0·14	April 28	2	B JS	0·00
July 26	5	WB B	+ 0·06*	May 4	2	JS B	+ 0·05
Oct. 27	0	WB B	− 0·02	,, 12	0	JS B	− 0·07
Dec. 22	5	WB B	+ 0·06	Nov. 13	6	JS B	− 0·17
Mar. 22	6	HF B	− 0·05	Mar. 24	10	CD R	− 0·15
July 24	10	HF B	− 0·05*	May 5	1	CD R	− 0·04
Aug. 21	10	HF B	− 0·13	,, 21	6	CD R	− 0·23
Oct. 20	5	B HF	− 0·09	Feb. 16	1	WB CD	+ 0·02
,, 25	2	HF B	− 0·11	Mar. 30	0	WB CD	+ 0·08
Dec. 8	3	B HF	− 0·08	Aug. 3	0	WB CD	+ 0·05
,, 20	2	B HF	− 0·03				
,, 22	1	B HF	+ 0·04	April 26	7	HF CD	− 0·04
				May 21	5	HF CD	− 0·13
Jan. 26	10	RC B	− 0·08	Aug. 24	5	CD HF	− 0·09
Dec. 15	3	RC B	− 0·11	Sept. 10	4	CD HF	+ 0·10
Jan. 26	10	S B	− 0·31	Oct. 25	3	HF CD	− 0·01
				,, 31	1	CD HF	− 0·08
April 23	11	S B	− 0·20	May 19	2	RC CD	− 0·06
Sept. 9	3	S B	− 0·36	April 26	8	EB CD	+ 0·02*
Feb. 18	3	W B	− 0·11	Jan. 25	10	S CD	− 0·23
Oct. 15	1	B W	− 0·14	Mar. 24	2	CD S	− 0·20
Dec. 15	3	W B	− 0·12	June 18	4	S CD	− 0·13
,, 20	4	B W	+ 0·03				
,, 22	8	W B	− 0·02	July 23	1	CD S	− 0·11
April 23	8	HA B	− 0·02				
,, 25	10	HA B	+ 0·09	Aug. 3	8	W CD	− 0·03*

OBSERVATIONS FOR PERSONAL EQUATIONS—*continued.*

Day, 1897.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
May	21	2	H A	C D	− 0·14
Aug.	15	7	C D	H A	+ 0·04*
Oct.	25	4	H A	C D	+ 0·03
Jan.	25	10	W S	C D	+ 0·03
Mar.	10	2	W S	C D	+ 0·08
,,	24	2	C D	W S	+ 0·04
May	25	0	C D	W S	0·00
July	23	6	W S	C D	− 0·03
April	29	7	J S	C D	+ 0·07
May	17	3	C D	J S	− 0·14
,,	19	8	J S	C D	+ 0·04
Jan.	15	2	R	H F	+ 0·12
May	21	11	H F	R	+ 0·10
June	23	8	H F	R	+ 0·09
Jan.	22	7	S	R	− 0·12
Feb.	17	0	S	R	+ 0·02
Mar.	24	8	S	R	− 0·05
June	23	11	S	R	− 0·11
July	12	0	R	S	− 0·16
Oct.	26	3	S	R	(− 0·26)
Mar.	16	10	W	R	+ 0·05*
,,	25	12	R	W	+ 0·17
Jan.	22	10	H A	R	− 0·13
May	21	8	H A	R	− 0·09

Day, 1897.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
Mar.	8	1	W S	R	+ 0·18
	24	8	W S	R	+ 0·19
June	23	11	W S	R	+ 0·10
Nov.	19	2	R	W S	+ 0·11
Dec.	22	6	W B	H F	− 0·02
	28	1	H F	W B	− 0·01
May	20	10	W	W B	+ 0·10
Aug.	3	8	W	W B	− 0·08*
Dec.	22	3	W	W B	− 0·08
April	25	12	W B	H A	+ 0·09*
Oct.	16	11	H A	W B	+ 0·02
Aug.	19	10	H A	W B	− 0·05
April	24	8	W S	W B	+ 0·07*
Aug.	19	8	W S	W B	− 0·05
	28	5	W B	W S	+ 0·05
Oct.	16	4	W S	W B	− 0·04
Oct.	16	9	J S	W B	− 0·15
Dec.	28	2	J S	W B	− 0·17
July	15	4	R C	H F	− 0·01
Jan.	1	1	H F	E B	+ 0·06
April	26	1	E B	H F	+ 0·06*
June	23	3	S	H F	− 0·20
July	20	4	H F	S	− 0·15
	24	2	S	H F	− 0·19
Dec.	6	1	H F	S	− 0·27

OBSERVATIONS FOR PERSONAL EQUATIONS—*continued.*

Day, 1897.	Interval between Mean of Groups of Clock Stars	Observers.	Excess of Clock Slow by Junior Observer.	Day, 1897.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.
	h		s		h		s
Jan. 1	3	W HF	+ 0·10	Jan. 13	1	S W	+ 0·24*
Dec. 20	2	HF W	+ 0·06				
Dec. 22	9	W HF	− 0·06	Jan. 22	3	HA S	+ 0·25
May 21	3	HF HA	− 0·01	Feb. 23	1	HA S	+ 0·21
Oct. 25	1	HA HF	+ 0·04	April 23	3	S HA	+ 0·18
Jan. 28	8	WS HF	+ 0·19	Jan. 25	0	WS S	+ 0·26
June 23	3	WS HF	+ 0·01	Mar. 24	0	WS S	+ 0·24
July 1	3	HF WS	+ 0·11*	June 23	0	WS S	+ 0·21
Dec. 8	1	HF WS	+ 0·14	July 23	7	WS S	+ 0·08
Aug. 21	3	JS HF	+ 0·02				
Oct. 19	3	HF JS	− 0·05	Aug. 27	1	JS S	+ 0·09
Dec. 28	1	JS HF	− 0·16	Sept. 18	5	JS S	+ 0·31
Jan. 26	0	RC S	− 0·23	Nov. 29	8	W WS	+ 0·14
Dec. 15	0	W RC	− 0·01	Dec. 16	5	W JS	− 0·09
May 19	6	JS RC	+ 0·10	Aug. 19	2	HA WS	0·00
Jan. 21	0	J S	− 0·22	Oct. 16	7	HA WS	− 0·06
May 6	1	JS J	− 0·04	Oct. 16	2	HA JS	− 0·17
Jan. 1	4	W EB	+ 0·04	Oct. 16	5	JS WS	− 0·11

PERSONAL EQUATIONS, 1897.

For D.

	s
D − B	= − 0·18
3 (D − H F)	= − 0·15
2 (D − W)	= − 0·04

For C.

	s
2 (C − H)	= + 0·66
2 (C − A C)	= − 0·16
C − C D	= + 0·06
2 (C − H F)	= + 0·40
2 (C − E B)	= + 0·28
2 (C − W)	= + 0·10
2 (C − H A)	= − 0·18

For H.

	s
2 (H − C)	= − 0·66
8 (H − A C)	= − 2·58
17 (H − B)	= − 4·43
4 (H − C D)	= − 0·86
6 (H − W B)	= − 1·26
2 (H − H F)	= − 0·22
6 (H − W)	= − 1·30
3 (H − W S)	= − 1·08
14 (H − J S)	= − 2·84

For A C.

	s
2 (A C − C)	= + 0·16
8 (A C − H)	= + 2·58
9 (A C − B)	= − 0·23
15 (A C − C D)	= + 0·99
4 (A C − R)	= + 0·58
4 (A C − W B)	= − 0·05
12 (A C − H F)	= + 1·35
4 (A C − R C)	= + 0·34
2 (A C − J)	= + 0·06
2 (A C − E B)	= + 0·26
4 (A C − S)	= + 1·27
4 (A C − W)	= + 0·69
7 (A C − H A)	= + 0·24
13 (A C − W S)	= + 0·21
2 (A C − J S)	= + 0·14

For B.

	s
B − D	= + 0·18
17 (B − H)	= + 4·43
9 (B − A C)	= + 0·23
12 (B − C D)	= + 0·68
3 (B − R)	= + 0·35
5 (B − W B)	= − 0·14
15 (B − H F)	= + 0·95
4 (B − R C)	= + 0·38
6 (B − S)	= + 1·74
10 (B − W)	= + 0·72
8 (B − H A)	= 0·00
2 (B − W S)	= − 0·12
8 (B − J S)	= + 0·38

For C D.

	s
(C D − C)	= − 0·06
4 (C D − H)	= + 0·86
15 (C D − A C)	= − 0·99
12 (C D − B)	= − 0·68
6 (C D − R)	= + 0·84
6 (C D − W B)	= − 0·30
12 (C D − H F)	= + 0·50
2 (C D − R C)	= + 0·12
C D − E B	= − 0·02
8 (C D − S)	= + 1·34
(C D − W)	= + 0·03
5 (C D − H A)	= + 0·18
10 (C D − W S)	= − 0·24
6 (C D − J S)	= + 0·06

For R.

	s
4 (R − A C)	= − 0·58
3 (R − B)	= − 0·35
6 (R − C D)	= − 0·84
6 (R − H F)	= − 0·62
10 (R − S)	= + 0·84
3 (R − W)	= − 0·39
4 (R − H A)	= + 0·44
8 (R − W S)	= − 1·16

For W B.

	s
6 (W B − H)	= + 1·26
4 (W B − A C)	= + 0·05
5 (W B − B)	= + 0·14
6 (W B − C D)	= + 0·30
4 (W B − H F)	= + 0·06
5 (W B − W)	= + 0·04
5 (W B − H A)	= − 0·03
7 (W B − W S)	= + 0·01
4 (W B − J S)	= + 0·64

For H F.

	s
3 (H F − D)	= + 0·15
2 (H F − C)	= − 0·40
2 (H F − H)	= + 0·22
12 (H F − A C)	= − 1·35
15 (H F − B)	= − 0·95
12 (H F − C D)	= − 0·50
6 (H F − R)	= + 0·62
4 (H F − W B)	= − 0·06
2 (H F − R C)	= + 0·02
3 (H F − E B)	= − 0·18
8 (H F − S)	= + 1·62
6 (H F − W)	= − 0·20
4 (H F − H A)	= − 0·06
7 (H F − W S)	= − 0·79
6 (H F − J S)	= + 0·38

For R C.

	s
4 (R C − A C)	= − 0·34
4 (R C − B)	= − 0·38
2 (R C − C D)	= − 0·12
2 (R C − H F)	= − 0·02
2 (R C − S)	= + 0·46
2 (R C − W)	= + 0·02
2 (R C − J S)	= − 0·20

For J.

	s
2 (J − A C)	= − 0·06
2 (J − S)	= + 0·44
2 (J − J S)	= + 0·08

For E B.

	s
2 (E B − C)	= − 0·28
2 (E B − A C)	= − 0·26
E B − C D	= + 0·02
3 (E B − H F)	= + 0·18
2 (E B − W)	= − 0·08

For S.

	s
4 (S − A C)	= − 1·27
6 (S − B)	= − 1·74
8 (S − C D)	= − 1·34
10 (S − R)	= − 0·84
8 (S − H F)	= − 1·62
2 (S − R C)	= − 0·46
2 (S − J)	= − 0·44
S − W	= − 0·24
6 (S − H A)	= − 1·28
8 (S − W S)	= − 1·58
4 (S − J S)	= − 0·80

For W.

	s
2 (W − D)	= + 0·04
2 (W − C)	= − 0·10
6 (W − H)	= + 1·30
4 (W − A C)	= − 0·69
10 (W − B)	= − 0·72
W − C D	= − 0·03
3 (W − R)	= + 0·39
5 (W − W B)	= − 0·04
6 (W − H F)	= + 0·20
2 (W − R C)	= − 0·02
2 (W − E B)	= + 0·08
W − S	= + 0·24
2 (W − W S)	= − 0·28
2 (W − J S)	= + 0·18

For H A.

	s
2 (H A − C)	= + 0·18
7 (H A − A C)	= − 0·24
8 (H A − B)	= 0·00
5 (H A − C D)	= − 0·18

For H A—*continued.*

4 (H A − R)	$= -0^{\mathrm{s}}.44$
5 (H A − W B)	$= +0.03$
4 (H A − H F)	$= +0.06$
6 (H A − S)	$= +1.28$
4 (H A − W S)	$= +0.12$
2 (H A − J S)	$= +0.34$

For W S.

3 (W S − H)	$= +1^{\mathrm{s}}.08$
13 (W S − A C)	$= -0.21$
2 (W S − B)	$= +0.12$
10 (W S − C D)	$= +0.24$
8 (W S − R)	$= +1.16$
7 (W S − W B)	$= -0.01$
7 (W S − H F)	$= +0.79$
8 (W S − S)	$= +1.58$

For W S—*continued.*

2 (W S − W)	$= +0^{\mathrm{s}}.28$
4 (W S − H A)	$= -0.12$
2 (W S − J S)	$= -0.22$

For J S.

14 (J S − H)	$= +2^{\mathrm{s}}.84$
2 (J S − A C)	$= -0.14$
8 (J S − B)	$= -0.38$
6 (J S − C D)	$= -0.06$
4 (J S − W B)	$= -0.64$
6 (J S − H F)	$= -0.38$
2 (J S − R C)	$= +0.20$
2 (J S − J)	$= -0.08$
4 (J S − S)	$= +0.80$
2 (J S − W)	$= -0.18$
2 (J S − H A)	$= -0.34$
2 (J S − W S)	$= +0.22$

Now, since one of the quantities denoted by D, &c. must evidently remain indeterminate, we will refer all the rest to B as a standard; and putting B = 0, the initials D, &c. will represent the value of "clock slow" which would be given by the observations of Mr. Dyson, &c., when that given by Mr. Bryant = 0.

Then, adding all the equations in each, we get the following equations, in which each observer's personal equation is successively affected by a large co-efficient.

$$6\,D - B - 3\,HF - 2\,W = -0^{\mathrm{s}}.37$$

$$13\,C - 2\,H - 2\,AC - CD - 2\,HF - 2\,EB - 2\,W - 2\,HA = +1.16$$

$$62\,H - 2\,C - 8\,AC - 17\,B - 4\,CD - 6\,WB - 2\,HF - 6\,W - 3\,WS - 14\,JS = -15.23$$

$$92\,AC - 2\,C - 8\,H - 9\,B - 15\,CD - 4\,R - 4\,WB - 12\,HF - 4\,RC - 2\,J - 2\,EB - 4\,S - 4\,W - 7\,HA - 13\,WS - 2\,JS = +8.59$$

$$100\,B - D - 17\,H - 9\,AC - 12\,CD - 3\,R - 5\,WB - 15\,HF - 4\,RC - 6\,S - 10\,W - 8\,HA - 2\,WS - 8\,JS = +9.78$$

$$89\,CD - C - 4\,H - 15\,AC - 12\,B - 6\,R - 6\,WB - 12\,HF - 2\,RC - EB - 8\,S - W - 10\,WS - 5\,HA - 6\,JS = +1.64$$

$$44\,R - 4\,AC - 3\,B - 6\,CD - 6\,HF - 10\,S - 3\,W - 8\,WS - 4\,HA = -2.66$$

$$46\,WB - 6\,H - 4\,AC - 5\,B - 6\,CD - 4\,HF - 5\,W - 5\,HA - 7\,WS - 4\,JS = +2.47$$

$$92\,HF - 3\,D - 2\,C - 2\,H - 12\,AC - 15\,B - 12\,CD - 6\,R - 4\,WB - 2\,RC - 3\,EB - 8\,S - 6\,W - 4\,HA - 7\,WS - 6\,JS = -1.48$$

18 R C−4 A C−4 B−2 C D−2 H F−2 W−2 S−2 J S	= − 0·58 s
6 J−2 A C−2 S−2 J S	= + 0·46
10 E B−2 C−2 A C−C D−3 H F−2 W	= − 0·42
59 S−4 A C−6 B−8 C D−10 R−8 H F−2 R C−2 J−W−6 H A−8 W S 4 J S	= −11·61
48 W−2 D−2 C−6 H−4 A C−10 B−C D−3 R−5 W B−6 H F−2 R C −2 E B−S−2 W S−2 J S	= + 0·55
47 H A−2 C−7 A C−8 B−5 C D−4 R−5 W B−4 H F−6 S−4 W S −2 J S	= + 1·15
66 W S−3 H−13 A C−2 B−10 C D−8 R−7 W B−7 H F−8 S−2 W−4 H A −2 J S	= + 4·69
54 J S−14 H−2 A C−8 B−6 C D−4 W B−6 H F−2 R C−2 J−4 S−2 W −2 H A−2 W S	= + 1·86

Solving these equations by successive approximation, that is by first substituting in each equation the approximately known values of all the personal equations, except that which has the largest co-efficient, thence deducing the value of that one personal equation, then using that deduced value for substitution in the other equations and repeating the process, we get finally the following values of the corrections for personal equation for the several observers referred to B :—

	s		s		s
B − D	= + 0·12	B − W B	= + 0·01	B − W	= + 0·06
B − C	= − 0·01	B − H F	= + 0·07	B − H A	= + 0·03
B − H	= + 0·27	B − R C	= + 0·08	B − W S	= 0·00
B − A C	= − 0·02	B − J	= + 0·02	B − J S	= + 0·07
B − C D	= + 0·04	B − E B	= + 0·07		
B − R	= + 0·14	B − S	= + 0·25		

From 1885 March 14 it has been the practice for the observer with the transit-circle to observe each night the transits of two clock stars by the eye-and-ear method as well as with the chronographic method. The following table gives the comparison of the clock-errors deduced from these eye-and-ear transits with those deduced from the chronographic transits by the same observer, these latter being referred to the Standard Observer, Mr. Bryant, by applying the personal equations for chronographic transits found from the observations of 1897.

DETERMINATION OF THE PERSONAL EQUATIONS OF THE VARIOUS OBSERVERS USING THE EYE-AND-EAR METHOD OF OBSERVING TRANSITS AS REFERRED TO THE STANDARD OBSERVER USING THE CHRONOGRAPHIC METHOD.

OBSERVER H.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
Jan.	27. 12	+ 0·23
Mar.	3. 9	+ 0·27
	29. 10	+ 0·18
Apr.	4. 8	+ 0·24
	14. 11	+ 0·21
	28. 17	+ 0·29
May	1. 10	+ 0·26
	4. 9	+ 0·21
	10. 11	+ 0·29
	18. 6	+ 0·20
	26. 11	+ 0·23
	27. 15	+ 0·30
June	12. 9	+ 0·12
	30. 11	+ 0·36
Aug.	4. 9	+ 0·20
Sept.	28. 12	+ 0·21
	30. 6	+ 0·18
Oct.	6. 9	+ 0·24
	30. 10	+ 0·24
Nov.	29. 6	+ 0·27
Dec.	2. 9	+ 0·30
	9. 6	+ 0·25
	Mean........	+ 0·24

OBSERVER A C.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
Mar.	10. 1	+ 0·15
April	15. 7	+ 0·11

OBSERVER A C—*continued.*

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
May	3. 8	+ 0·12
	9. 9	+ 0·18
June	13. 11	+ 0·03
Sept.	3. 6	− 0·07
	11. 10	+ 0·07
	14. 15	− 0·03
	23. 7	+ 0·03
Oct.	7. 11	+ 0·11
	11. 10	+ 0·17
	30. 6	+ 0·10
Nov.	29. 11	− 0·01
Dec.	3. 8	+ 0·12
	24. 5	+ 0·21
	31. 10	+ 0·11
	Mean........	+ 0·09

OBSERVER B.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
Jan.	26. 18	+ 0·06
Mar.	15. 12	+ 0·05
	19. 11	− 0·07
	21. 7	− 0·03
	22. 16	+ 0·03
	27. 9	− 0·06
April	5. 11	− 0·03
	23. 17	− 0·06
	25. 17	− 0·01
	28. 10	− 0·02
	30. 10	− 0·01
May	2. 9	+ 0·07
	4. 9	− 0·01

OBSERVER B—*continued.*

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
May	5. 8	+ 0·04
	9. 10	+ 0·04
	12. 9	+ 0·02
	16. 10	+ 0·07
	28. 11	+ 0·01
June	2. 14	+ 0·05
	10. 11	+ 0·01
July	22. 13	+ 0·08
	26. 15	+ 0·02
Aug.	2. 8	+ 0·04
	4. 13	− 0·02
	12. 13	− 0·01
	17. 17	+ 0·05
	21. 19	+ 0·03
Sept.	1. 15	+ 0·09
	9. 14	+ 0·08
	16. 17	+ 0·06
	30. 7	+ 0·02
Oct.	4. 9	+ 0·01
	12. 13	+ 0·04
	20. 8	− 0·01
	25. 8	+ 0·03
	27. 10	+ 0·09
	29. 3	0·00
Nov.	6. 11	+ 0·01
	10. 7	+ 0·03
	13. 6	+ 0·07
Dec.	8. 12	+ 0·09
	11. 16	+ 0·06
	20. 9	+ 0·04
	22. 10	+ 0·08
	Mean........	+ 0·03

OBSERVATIONS FOR PERSONAL EQUATIONS—*continued.*

OBSERVER C D.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
Feb.	16. 12	+ 0·13
Mar.	24. 8	+ 0·09
	30. 9	+ 0·12
April	26. 16	− 0·02
	29. 12	+ 0·09
May	5. 9	+ 0·19
June	11. 5	+ 0·07
July	23. 16	+ 0·13
Aug.	15. 14	+ 0·09
Sept.	10. 7	+ 0·06
	27. 6	− 0·05
Oct.	25. 8	+ 0·13
	Mean.........	+ 0·09

OBSERVER R.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
Mar.	24. 18	− 0·01
April	2. 12	− 0·01
	10. 11	+ 0·11

OBSERVER R—*continued.*

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
May	2. 10	− 0·03
	5. 11	+ 0·05
June	16. 12	− 0·12
July	28. 9	+ 0·03
Aug.	14. 12	+ 0·03
	23. 10	− 0·05
	31. 10	+ 0·03
Sept.	24. 7	+ 0·12
Oct.	26. 8	+ 0·09
Nov.	19. 7	+ 0·07
	Mean........	+ 0·02

OBSERVER W B.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
Mar.	30. 12	+ 0·03
April	16. 11	+ 0·28
Aug.	3. 12	+ 0·11
	28. 13	− 0·06
Dec.	22. 11	+ 0·08
	Mean	+ 0·09

OBSERVER H F.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
	d h	s
May	21. 4	+ 0·02

OBSERVER E B.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
Mar.	12. 12	+ 0·04

OBSERVER W.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
Jan.	1. 4	+ 0·12
May	20. 11	+ 0·04
Aug.	30. 7	− 0·08
Oct.	24. 12	+ 0·02
Nov.	30. 14	+ 0·08
Dec.	16. 2	− 0·13
	20. 12	+ 0·03
	Mean.........	+ 0·01

OBSERVER H A.

Date of Observation, 1897.		Excess of Clock Slow by Eye-and-Ear Observer.
June	13. 9	+ 0·07

Collecting these results together, the following are the values of the corrections for personal equation for the observers using the Eye-and-Ear method referred to the Standard Observer using the Galvanic method:—

	s		s
B − H	= − 0·24	B − H F	= − 0·02
B − A C	= − 0·09	B − E B	= − 0·04
B − C D	= − 0·09	B − W	= − 0·01
B − R	= − 0·02	B − H A	= − 0·07
B − W B	= − 0·09		

DIVISION-ERRORS.

Redeterminations of the division-errors for every 5° and for every 1° were made in 1898 to supplement those made in 1851, 1856, and 1871.

The Transit-Circle being read by six microscopes placed at distances of 60° apart, the determination of the division-errors consists essentially in subdividing arcs of 60°. By means of two supplementary microscopes placed at opposite ends of a diameter at a distance of 20° from two of the six microscopes used in reading the circle, the arc 60° is subdivided at 20° and 40°. By means of two more supplementary microscopes placed at 25° from two of the regular microscopes, the arcs, 0° to 20°, 20° to 40°, 40° to 60°, are subdivided into arcs of 5°.

The corrections for division-error in use up to 1897 were determined from the mean of the observations made in 1851 and 1856, in both of which investigations the 0° division was taken as the initial division. The errors of the divisions at 20° and 40° are consequently the best determined, and the divisions at 10°, 30°, and 50° are most likely to be affected by cumulative error. A redetermination of the errors of the 5° divisions was made in 1871, in which the 10°, 30°, 50° divisions were taken as the initial divisions.

Two independent determinations of the 5° divisions were made in 1898 June and August, the 15°, 35°, 55° and 5°, 25°, 45° divisions being taken as the respective initial divisions. As the same correction is applied for division-error for all the divisions within 30′ on both sides of the whole degrees, it is clearly advantageous to use such a mean of a number of divisions instead of simply the divisions belonging to the whole degrees. Instead of repeating measures of the same divisions of the circle, the observations were extended to the three divisions on both sides of the principal division, and the mean for the seven divisions, −15′, −10′, −5′, 0, +5′, +10′, +15′, was considered as the division-error of the principal division.

When the separate determinations made in 1851, 1856, 1871, and 1898 were compared, it was seen that the 1851 determination was discordant, and therefore it was considered that it would be well to reject this and to make a fresh one, taking 5° as the initial division.

There are thus now four determinations, making a complete and symmetrical series, viz:—

1856	with	0°, 20°, 40°,	as primary	divisions.
1871	„	10°, 30°, 50°,	„	„
1898 (*a*)	„	15°, 35°, 55°,	„	„
1898 (*b*)	„	5°, 25°, 45°,	„	„

The mean of these four will give a result in which each of the 5° divisions is equally well determined. The separate determinations are given below, the quantities tabulated being the corrections to circle-reading, all considered positive :—

Reading of Mic. A.	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°
1851	0″·21	0″·33	0″·84	0″·56	0″·33	0″·18	0″·25	0″·34	0″·44	0″·78	0″·85	0″·66
1856	0·21	0·32	0·62	0·79	0·45	0·29	0·20	0·33	0·43	0·67	1·14	0·67
1871	0·32	0·32	0·61	0·54	0·47	0·26	0·10	0·19	0·35	0·73	1·01	0·74
1898 (*a*)	0·22	0·16	0·47	0·65	0·43	0·34	0·18	0·21	0·55	0·66	1·14	0·75
1898 (*b*)	0·25	0·27	0·54	0·63	0·43	0·31	0·18	0·24	0·44	0·68	1·06	0·69
Mean of four	0·25	0·27	0·56	0·65	0·45	0·31	0·17	0·24	0·44	0·69	1·09	0·71

Microscope A + 89°·30′ = pointer reading.

As these four determinations are quite independent, and the different divisions are equally well determined, their accordance gives a reliable indication of the accuracy of the result. From the above figures the mean discordance is found to be $\pm 0''{\cdot}040$, and the probable errors of the resulting division-errors are $\pm 0''{\cdot}040 \times \sqrt{\frac{1}{4-1}} \times 0{\cdot}845 =$ $\pm 0''{\cdot}020$.

A redetermination of the errors of the single degrees was next made by subdividing each arc of 5°. Five separate sets of measures were made, and instead of using only the principal division, the observations were extended to the divisions at 10′ and 20′ on each side of it, and the mean for the five divisions, −20′, −10′, 0, +10 +20′, was taken as the division-error of the principal division.

The determinations which were made in 1851 and 1856, and which consisted of four sets of measures of the 1° divisions, were re-reduced, with the new determination of the errors of the terminal 5° divisions. The mean of the three determinations made in 1851, 1856, and 1898 was then taken, giving equal weights to the three determinations.

SEPARATE DETERMINATIONS OF CORRECTIONS FOR DIVISION-ERROR OF SINGLE DEGREES MADE IN 1851, 1856, AND 1898, REDUCED WITH THE NEW VALUES OF THE 5° DIVISIONS, ARRANGED FOR READINGS OF MICROSCOPE A.

(Microscope A + 89° 30′ = Pointer reading.)

Reading of Mic. A.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°
1851	″	0″·22	0″·38	0″·16	0″·02	″	0″·37	0″·41	0″·43	0″·46	″	0″·54	0″·80	0″·79	0″·73	″	0″·56	0″·49	0″·47	0″·57
1856		·18	·24	·16	–·13		·30	·37	·53	·56		·46	·55	·65	·42		·37	·60	·62	·67
1898		·38	·48	·29	·24		·17	·32	·46	·38		·58	·36	·34	·48		·74	·75	·52	·54
Mean	·27	·26	·37	·20	·04	·29	·28	·37	·47	·47	·56	·53	·57	·59	·54	·65	·56	·61	·54	·59
Reading of Mic. A.	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°
1851	″	0″·34	0″·40	0″·25	0″·30	″	0″·32	0″·17	0″·27	0″·28	″	0″·23	0″·26	0″·25	0″·25	″	0″·27	0″·49	0″·49	0″·44
1856		·62	·30	–·20	·08		·27	·32	·14	·22		·23	·22	·26	·08		·31	·51	·48	·43
1898		·50	·70	·55	·46		·35	·20	·42	·31		·19	·38	·26	·21		·24	·51	·42	·43
Mean	·45	·49	·47	·20	·28	·33	·31	·23	·28	·27	·20	·22	·29	·26	·16	·26	·27	·50	·46	·44
Reading of Mic. A.	40°	41°	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	58°	59°
1851	″	0″·51	0″·40	0″·44	0″·61	″	0″·66	0″·77	0″·79	0″·80	″	1″·06	0″·84	0″·58	0″·66	″	0″·73	0″·54	0″·58	0″·44
1856		·65	·41	·55	·64		·66	·84	·73	·58		1·04	·97	·79	·82		·72	·56	·49	·45
1898		·64	·65	·61	·63		·68	·88	1·10	·98		·87	·82	·78	·67		·43	·44	·42	·34
Mean	·46	·60	·49	·53	·63	·70	·67	·83	·87	·79	1·08	·99	·88	·72	·72	·71	·63	·51	·50	·41

From a discussion of the results it was found that the probable error of the corrections for division-error for 1°, 4°, &c. was ± 0″·044, and for 2°, 3°, 7°, 8°, &c., ± 0″·051.

The divisions used for the close polar stars, namely, 45° to 55°, were determined with additional accuracy. For all the single degrees there were three determinations, consisting of 4, 4, and 5 sets of measures respectively, but for these divisions two additional determinations were made, consisting of 10 sets of measures each. The probable error of the division-correction for 46°, 49°, 51°, and 54° is accordingly reduced to ± 0″·031, and for 47°, 48°, 52°, and 53°, to ± 0″·034.

The finally adopted values of the corrections for division-error were obtained by taking the mean of all the sets of division-errors for each microscope, and combining the errors of the six microscopes afterwards; the means thus found were then smoothed by taking the sums of each pair, and then of these pairs again, and dividing the resulting values by four; but the values of the 5° divisions were not smoothed, being considerably more accurate than the others.

NEW ERRORS OF DIVISION.

In use from 1897.

The following table contains the adopted result for errors of division for every degree. The errors are always considered in the nature of reading too much. $1^{r} = 61''.4$ nearly.

Degree.	Excess of Reading.	Degree.	Excess of Reading.	Degree.	Excess of Reading.	Degree.	Excess of Reading.	Degree.	Excess of Reading.	Degree.	Excess of Reading.	Degree.	Excess of Reading.	Degree.	Excess of Reading.	Degree.	Excess of Reading.	Degree.	Excess of Reading.
°	r	°	r	°	r	°	r	°	r	°	r	°	r	°	r	°	r	°	r
0	0·051	36	0·054	72	0·053	108	0·059	144	0·087	180	0·067	216	0·064	252	0·075	288	0·073	324	0·081
1	·049	37	·050	73	·049	109	·065	145	·084	181	·069	217	·064	253	·078	289	·078	325	·082
2	·047	38	·047	74	·048	110	·059	146	·079	182	·069	218	·064	254	·082	290	·077	326	·082
3	·051	39	·050	75	·053	111	·056	147	·089	183	·067	219	·064	255	·085	291	·080	327	·077
4	·051	40	·051	76	·056	112	·059	148	·089	184	·067	220	·063	256	·089	292	·081	328	·081
5	·049	41	·051	77	·052	113	·060	149	·089	185	·061	221	·062	257	·088	293	·079	329	·085
6	·053	42	·056	78	·053	114	·067	150	·084	186	·056	222	·063	258	·090	294	·088	330	·080
7	·052	43	·055	79	·054	115	·066	151	·083	187	·059	223	·064	259	·089	295	·092	331	·077
8	·055	44	·049	80	·060	116	·071	152	·086	188	·063	224	·063	260	·096	296	·087	332	·078
9	·056	45	·045	81	·063	117	·071	153	·090	189	·063	225	·062	261	·103	297	·085	333	·083
10	·052	46	·050	82	·067	118	·070	154	·096	190	·053	226	·065	262	·099	298	·081	334	·091
11	·052	47	·057	83	·068	119	·074	155	·100	191	·049	227	·071	263	·106	299	·085	335	·082
12	·053	48	·060	84	·070	120	·082	156	·096	192	·056	228	·069	264	·108	300	·096	336	·082
13	·052	49	·058	85	·069	121	·088	157	·082	193	·061	229	·071	265	·105	301	·097	337	·075
14	·057	50	·052	86	·070	122	·090	158	·075	194	·058	230	·071	266	·107	302	·093	338	·072
15	·047	51	·050	87	·073	123	·095	159	·078	195	·057	231	·071	267	·108	303	·096	339	·071
16	·046	52	·055	88	·072	124	·099	160	·080	196	·058	232	·078	268	·104	304	·101	340	·075
17	·044	53	·065	89	·069	125	·092	161	·078	197	·054	233	·082	269	·099	305	·097	341	·069
18	·050	54	·065	90	·068	126	·095	162	·075	198	·057	234	·081	270	·098	306	·102	342	·075
19	·050	55	·071	91	·067	127	·095	163	·075	199	·064	235	·080	271	·094	307	·102	343	·069
20	·052	56	·071	92	·072	128	·093	164	·082	200	·060	236	·076	272	·085	308	·099	344	·062
21	·043	57	·069	93	·069	129	·091	165	·088	201	·061	237	·080	273	·085	309	·093	345	·068
22	·043	58	·072	94	·071	130	·088	166	·088	202	·062	238	·085	274	·083	310	·092	346	·064
23	·046	59	·071	95	·069	131	·094	167	·079	203	·064	239	·093	275	·092	311	·099	347	·062
24	·044	60	·067	96	·067	132	·089	168	·070	204	·063	240	·091	276	·090	312	·098	348	·062
25	·045	61	·063	97	·064	133	·085	169	·063	205	·063	241	·089	277	·095	313	·097	349	·058
26	·050	62	·061	98	·071	134	·085	170	·062	206	·062	242	·084	278	·105	314	·097	350	·052
27	·048	63	·060	99	·077	135	·084	171	·065	207	·063	243	·093	279	·098	315	·090	351	·054
28	·045	64	·065	100	·074	136	·087	172	·058	208	·061	244	·095	280	·092	316	·090	352	·052
29	·049	65	·061	101	·071	137	·092	173	·055	209	·063	245	·092	281	·090	317	·090	353	·052
30	·059	66	·059	102	·071	138	·087	174	·053	210	·072	246	·089	282	·093	318	·091	354	·047
31	·064	67	·054	103	·070	139	·082	175	·056	211	·075	247	·082	283	·095	319	·083	355	·045
32	·061	68	·052	104	·069	140	·081	176	·066	212	·070	248	·071	284	·092	320	·087	356	·048
33	·063	69	·057	105	·062	141	·082	177	·070	213	·067	249	·075	285	·086	321	·079	357	·055
34	·059	70	·058	106	·063	142	·085	178	·071	214	·063	250	·082	286	·084	322	·078	358	·052
35	·052	71	·056	107	·058	143	·090	179	·067	215	·060	251	·078	287	·076	323	·087	359	·050

DIVISION-CORRECTION.

Applicable to Observations made with the six Microscopes.

(*Always Additive.*)

In use from 1897.

The corrections recur after every 60° of pointer reading.

Pointer Reading.	Corr.	Pointer Reading.	Corr.	Pointer Reading.	Corr.	Pointer Reading.	Corr.	Pointer Reading.	Corr.	Pointer Reading.	Corr.
° °	″	° °	″	° °	″	° °	″	° °	″	° °	″
0– 1	0·25	10–11	0·56	20–21	1·06	30–31	0·31	40–41	0·57	50–51	0·50
1– 2	0·28	11–12	0·54	21–22	0·99	31–32	0·32	41–42	0·59	51–52	0·43
2– 3	0·26	12–13	0·57	22–23	0·91	32–33	0·22	42–43	0·59	52–53	0·31
3– 4	0·24	13–14	0·65	23–24	0·82	33–34	0·16	43–44	0·60	53–54	0·29
4– 5	0·28	14–15	0·72	24–25	0·73	34–35	0·31	44–45	0·67	54–55	0·35
5– 6	0·35	15–16	0·73	25–26	0·64	35–36	0·32	45–46	0·61	55–56	0·32
6– 7	0·46	16–17	0·80	26–27	0·56	36–37	0·39	46–47	0·60	56–57	0·29
7– 8	0·49	17–18	0·88	27–28	0·50	37–38	0·47	47–48	0·59	57–58	0·29
8– 9	0·47	18–19	0·95	28–29	0·42	38–39	0·51	48–49	0·56	58–59	0·28
9–10	0·48	19–20	1·10	29–30	0·29	39–40	0·58	49–50	0·47	59–60	0·22

When the Pointer reads 0°.30′ the division under Microscope A is 271°; under Microscope C, 211°; under Microscope E, 151°; under Microscope B, 91°; under Microscope D, 31°; and under Microscope F, 331°.

The corrections for division-errors with the transit-circle have been changed four times since its erection; from 1851 to 1856 the values were derived from the observations made in 1851; from 1857 to 1867 the values were derived from the observations made in 1856; from 1868 to 1879 the values were derived by taking the mean of the observations made in 1851 and 1856; from 1880 to 1896 the last values were still used, but in order to allow for the distance between Microscope A and the pointer being 89°.30′ instead of 90°, as it had till then been assumed to be, what had been taken as the correction for 1°—that was, for all pointer readings between 0°.30′ and 1°.30′—was considered to be the correction for all pointer readings between 0° and 1°, and so on.

TABLE OF NEW CORRECTIONS FOR DIVISION-ERROR TO THE MEAN READING OF THE SIX MICROSCOPES, AND OF CORRECTIONS TO THE VALUES PREVIOUSLY ADOPTED.

The corrections recur after every 60°.

Pointer Reading.	Approximate N.P.D.	Approximate N.P.D.	Approximate N.P.D.	New Correction for Division-Error.	Corrections to Greenwich Obs. 1851–56.	Corrections to Greenwich Obs. 1857–67.	Corrections to Greenwich Obs. 1868–79.	Corrections to Greenwich Obs. 1880–96.
° °	° °	° °	° °	″	″	″	″	″
0 to 1	39 to 40	99 to 100	−20 to −21	0·25	−0·06	+0·01	−0·03	−0·06
1 ,, 2	40 ,, 41	100 ,, 101	−19 ,, −20	0·28	− ·05	+ ·01	− ·03	− ·06
2 ,, 3	41 ,, 42	101 ,, 102	−18 ,, −19	0·26	− ·10	− ·03	− ·08	− ·06
3 ,, 4	42 ,, 43	102 ,, 103	−17 ,, −18	0·24	− ·11	− ·03	− ·08	− ·07
4 ,, 5	43 ,, 44	103 ,, 104	−16 ,, −17	0·28	− ·08	+ ·03	− ·03	− ·07
5 ,, 6	44 ,, 45	104 ,, 105	−15 ,, −16	0·35	− ·02	+ ·03	·00	− ·08
6 ,, 7	45 ,, 46	105 ,, 106	−14 ,, −15	0·46	+ ·05	+ ·03	+ 0·3	− ·06
7 ,, 8	46 ,, 47	106 ,, 107	−13 ,, −14	0·49	− ·02	− ·03	− ·03	− ·04
8 ,, 9	47 ,, 48	107 ,, 108	−12 ,, −13	0·47	− ·07	− ·05	− ·06	− ·02
9 ,, 10	48 ,, 49	108 ,, 109	−11 ,, −12	0·48	− ·02	+ ·01	− ·01	− ·02
10 ,, 11	49 ,, 50	109 ,, 110	−10 ,, −11	0·56	+ ·06	+ ·06	+ ·06	+ ·03
11 ,, 12	50 ,, 51	110 ,, 111	− 9 ,, −10	0·54	+ ·03	+ ·00	+ ·01	+ ·03
12 ,, 13	51 ,, 52	111 ,, 112	− 8 ,, − 9	0·57	+ ·07	+ ·07	+ ·06	+ ·02
13 ,, 14	52 ,, 53	112 ,, 113	− 7 ,, − 8	0·65	+ ·10	+ ·11	+ ·10	− ·02
14 ,, 15	53 ,, 54	113 ,, 114	− 6 ,, − 7	0·72	+ ·03	+ ·09	+ ·05	− ·01
15 ,, 16	54 ,, 55	114 ,, 115	− 5 ,, − 6	0·79	− ·04	+ ·05	·00	− ·02
16 ,, 17	55 ,, 56	115 ,, 116	− 4 ,, − 5	0·85	+ ·03	+ ·06	+ ·05	+ ·02
17 ,, 18	56 ,, 57	116 ,, 117	− 3 ,, − 4	0·86	+ ·13	+ ·07	+ ·10	+ ·13
18 ,, 19	57 ,, 58	117 ,, 118	− 2 ,, − 3	0·91	+ ·22	+ ·18	+ ·20	+ ·17
19 ,, 20	58 ,, 59	118 ,, 119	− 1 ,, − 2	1·10	+ ·36	+ ·29	+ ·32	+ ·16
20 ,, 21	59 ,, 60	119 ,, 120	− 0 ,, − 1	1·01	+ ·22	+ ·04	+ ·14	+ ·07
21 ,, 22	60 ,, 61	120 ,, 121	0 ,, 1	0·88	+ ·13	− ·10	·00	+ ·14
22 ,, 23	61 ,, 62	121 ,, 122	1 ,, 2	0·77	+ ·20	− ·08	+ ·06	+ ·18
23 ,, 24	62 ,, 63	122 ,, 123	2 ,, 3	0·74	+ ·24	− ·06	+ ·09	+ ·11
24 ,, 25	63 ,, 64	123 ,, 124	3 ,, 4	0·73	+ ·13	− ·07	+ ·02	+ ·02
25 ,, 26	64 ,, 65	124 ,, 125	4 ,, 5	0·64	− ·04	− ·10	− ·07	− ·03
26 ,, 27	65 ,, 66	125 ,, 126	5 ,, 6	0·56	− ·11	− ·10	− ·11	− ·02
27 ,, 28	66 ,, 67	126 ,, 127	6 ,, 7	0·50	− ·09	− ·06	− ·08	·00
28 ,, 29	67 ,, 68	127 ,, 128	7 ,, 8	0·42	− ·09	− ·05	− ·08	+ ·01
29 ,, 30	68 ,, 69		8 ,, 9	0·29	−0·12	−0·10	−0·12	0·00

TABLE OF NEW CORRECTIONS FOR DIVISION-ERROR TO THE MEAN READING OF THE SIX MICROSCOPES, AND OF CORRECTIONS TO THE VALUES PREVIOUSLY ADOPTED—*continued.*

The corrections recur after every 60°.

Pointer Reading.	Approximate N.P.D.	Approximate N.P.D.	Approximate N.P.D.	New Correction for Division-Error.	Corrections to Greenwich Obs. 1851–56.	Corrections to Greenwich Obs. 1857–67.	Corrections to Greenwich Obs. 1868–79.	Corrections to Greenwich Obs. 1880–96.
° °	° °	° °	° °	"	"	"	"	"
30 to 31	69 to 70		9 to 10	0·31	+0·03	+0·04	+0·02	+0·06
31 ,, 32	70 ,, 71		10 ,, 11	0·32	+ ·05	+ ·12	+ ·07	+ ·06
32 ,, 33	71 ,, 72		11 ,, 12	0·22	− ·08	+ ·01	− ·04	+ ·04
33 ,, 34	72 ,, 73	−47 to −48	12 ,, 13	0·16	− ·06	+ ·03	− ·02	+ ·02
34 ,, 35	73 ,, 74	−46 ,, −47	13 ,, 14	0·31	+ ·13	+ ·24	+ ·17	+ ·02
35 ,, 36	74 ,, 75	−45 ,, −46	14 ,, 15	0·32	− ·01	+ ·08	+ ·03	− ·12
36 ,, 37	75 ,, 76	−44 ,, −45	15 ,, 16	0·39	− ·10	+ ·01	− ·05	− ·14
37 ,, 38	76 ,, 77	−43 ,, −44	16 ,, 17	0·47	− ·11	+ ·01	− ·06	− ·15
38 ,, 39	77 ,, 78	−42 ,, −43	17 ,, 18	0·51	− ·14	− ·06	− ·11	− ·19
39 ,, 40	78 ,, 79	−41 ,, −42	18 ,, 19	0·58	− ·17	− ·06	− ·12	− ·15
40 ,, 41	79 ,, 80	−40 ,, −41	19 ,, 20	0·57	− ·25	− ·06	− ·16	− ·17
41 ,, 42	80 ,, 81	−39 ,, −40	20 ,, 21	0·59	− ·27	− ·03	− ·15	− ·21
42 ,, 43	81 ,, 82	−38 ,, −39	21 ,, 22	0·59	− ·32	− ·09	− ·21	− ·21
43 ,, 44	82 ,, 83	−37 ,, −38	22 ,, 23	0·60	− ·30	− ·10	− ·20	− ·13
44 ,, 45	83 ,, 84	−36 ,, −37	23 ,, 24	0·67	− ·09	− ·01	− ·06	+ ·02
45 ,, 46	84 ,, 85	−35 ,, −36	24 ,, 25	0·61	− ·01	− ·07	− ·04	+ ·03
46 ,, 47	85 ,, 86	−34 ,, −35	25 ,, 26	0·60	+ ·09	− ·04	+ ·02	+ ·05
47 ,, 48	86 ,, 87	−33 ,, −34	26 ,, 27	0·59	+ ·16	− ·07	+ ·04	+ ·01
48 ,, 49	87 ,, 88	−32 ,, −33	27 ,, 28	0·56	+ ·13	− ·15	− ·02	·00
49 ,, 50	88 ,, 89	−31 ,, −32	28 ,, 29	0·47	+ ·03	− ·19	− ·09	− ·02
50 ,, 51	89 ,, 90	−30 ,, −31	29 ,, 30	0·50	+ ·13	− ·08	+ ·01	+ ·09
51 ,, 52	90 ,, 91	−29 ,, −30	30 ,, 31	0·43	+ ·13	− ·09	+ ·02	+ ·16
52 ,, 53	91 ,, 92	−28 ,, −29	31 ,, 32	0·31	+ ·05	+ ·04	+ ·04	+ ·20
53 ,, 54	92 ,, 93	−27 ,, −28	32 ,, 33	0·29	+ ·09	+ ·29	+ ·18	+ ·15
54 ,, 55	93 ,, 94	−26 ,, −27	33 ,, 34	0·35	+ ·16	+ ·28	+ ·21	+ ·11
55 ,, 56	94 ,, 95	−25 ,, −26	34 ,, 35	0·32	+ ·10	+ ·07	+ ·08	+ ·06
56 ,, 57	95 ,, 96	−24 ,, −25	35 ,, 36	0·29	+ ·08	− ·01	+ ·03	+ ·05
57 ,, 58	96 ,, 97	−23 ,, −24	36 ,, 37	0·29	+ ·09	+ ·02	+ ·05	+ ·04
58 ,, 59	97 ,, 98	−22 ,, −23	37 ,, 38	0·28	+ ·02	+ ·06	+ ·03	+ ·01
59 ,, 60	98 ,, 99	−21 ,, −22	38 ,, 39	0·22	−0·09	+0·01	−0·05	−0·06

Redeterminations were also made of the errors of some of the divisions used in the observations of the close Polar Stars and of the Nadir, and previous determinations were collected together. These were re-reduced with the new values of the terminal divisions. The resulting determinations were smoothed by taking means and means again, just as in the case of the whole degrees.

From a discussion of the discordances of the separate measures it is found that the probable error of one measure of a 5′ space is ±0″·190, from which it results that, taking the probable error of the terminal 1° divisions as ±0″·050, the probable errors of the corrections for the respective 5′ divisions, as found from 12 sets of measures, would be :—

0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	60′
± ″·050	± ″·070	± ″·083	± ″·091	± ″·097	± ″·100	± ″·101	± ″·100	± ″·097	± ″·091	± ″·083	± ″·070	± ″·050

Comparison of these probable errors with the observed quantities given on the opposite page shows the excellence of the subdivision of the 1° spaces on the circle. It results that the probable outstanding error introduced by taking the same division-correction for 30′ on each side of any 1° division would be very small.

The correction for division-error for these divisions is given on the opposite page together with the number of sets of observations on which they depend.

The following table gives the corrections to the values previously in use.

CORRECTIONS TO VALUES PREVIOUSLY ADOPTED FOR 5′ DIVISIONS.

Nadir.	
Pointer Reading.	Corr.
° ′ 179.35	″ − 0·07
.40	+ 0·17

Polaris.	
Pointer Reading.	Corr.
° ′ 322.30	″ + 0·22
.25	+ 0·25
.20	+ 0·28
Polaris S.P.	
° ′ 319.50	″ + 0·05
.45	0·00

Cephei 51.	
Pointer Reading.	Corr.
° ′ 323.55	″ − 0·02
.50	− 0·02
Cephei 51 S.P.	
° ′ 318.25	″ + 0·25
.20	+ 0·31
.15	+ 0·31

δ Ursæ Min.	
Pointer Reading.	Corr.
° ′ 324.30	″ − 0·01
.25	− 0·03
δ Ursæ Min. S.P.	
° ′ 317.45	″ + 0·36
.40	+ 0·28

λ Ursæ Min.	
Pointer Reading.	Corr.
° ′ 322.10	″ + 0·28
. 5	+ 0·33
λ Ursæ Min. S.P.	
° ′ 320. 5	″ − 0·02
. 0	+ 0·04

The new corrections for division-error have been applied in the Star Catalogue and Planetary Results for 1897, the old corrections having been already used for the earlier sections in the *Greenwich Observations* for 1897.

TABLE OF CORRECTIONS FOR 5′ DIVISIONS.

FOR NADIR.

Pointer Reading ...	179° 30′	35′	40′	45′	50′	55′	180° 0′	5′	10′	15′	20′	25′	30′	No. of Sets.
Division-Correction	0″·22	0″·30	0″·35	0″·38	0″·40	0″·45	0″·45	0″·41	0″·38	0″·32	0″·29	0″·26	0″·25	10

FOR COLLIMATORS.

Pointer Reading	89° 30′ or 269·30	35′	40′	45′	50′	55′	90° 0′ or 270·0	5′	10′	15′	20′	25′	30′	No. of Sets.
Division-Correction	0″·29	0″·28	0″·38	0″·40	0″·41	0″·43	0″·46	0″·50	0″·43	0″·34	0″·26	0″·19	0″·24	10

FOR POLAR STARS.

Pointer Reading ...	317° 30′	35′	40′	45′	50′	55′	318° 0′	5′	10′	15′	20′	25′	30′	No. of Sets.
Division-Correction	0″·88	0″·98	1″·03	1″·04	1″·07	1″·12	1″·14	1″·11	1″·03	0″·94	0″·91	0″·92	0″·95	9

Pointer Reading ...	319° 30′	35′	40′	45′	50′	55′	320° 0′	5′	10′	15′	20′	25′	30′	No. of Sets.
Division-Correction	1″·10	1″·09	1″·14	1″·13	1″·09	1″·05	1″·03	1″·06	1″·09	1″·11	1″·15	1″·15	1″·06	14

Pointer Reading ...	321° 30′	35′	40′	45′	50′	55′	322° 0′	5′	10′	15′	20′	25′	30′	No. of Sets.
Division-Correction	0″·99	1″·06	1″·02	0″·99	1″·01	1″·02	1″·02	1″·03	1″·02	0″·99	0″·94	0″·92	0″·91	18

Pointer Reading ...	322° 30′	35′	40′	45′	50′	55′	323° 0′	5′	10′	15′	20′	25	30′	No. of Sets.
Division-Correction	0″·91	0″·98	0″·97	0″·90	0″·87	0″·92	0″·98	1″·00	1″·02	0″·99	0″·92	0″·86	0″·82	4

Pointer Reading ...	323° 30′	35′	40′	45′	50′	55′	324° 0′	5′	10′	15′	20′	25′	30′	No. of Sets.
Division-Correction	0″·82	0″·74	0″·77	0″·82	0″·82	0″·81	0″·83	0″·83	0″·77	0″·73	0″·73	0″·76	0″·73	9

ERRORS OF TELESCOPE-MICROMETER-SCREW.

The observations for determining the value of the screw of the telescope micrometer through the range used, *i.e.*, from 11^r to 29^r are given in the *Transit-Circle Tables* for 1896. The micrometer is never used beyond these limits and rarely outside 16^r and 24^r.

The equivalents of the readings of the micrometer are taken from a Table computed by the addition of the following corrections to the adopted value of $1^{rev} = 37''{\cdot}05$.

CORRECTIONS FOR ERRORS OF TELESCOPE-MICROMETER-SCREW.

	12^{rev}	13^{rev}	14^{rev}	15^{rev}	16^{rev}	17^{rev}	18^{rev}	19^{rev}	20^{rev}	
·0	+ 1″·39	+ 1″·25	+ 1″·13	+ 0″·98	+ ″·080	+ 0″·52	+ 0″·35	+ 0″·16	0″·00	·0
·1	+ 1·38	+ 1·24	+ 1·12	+ 0·96	+ 0·77	+ 0·51	+ 0·33	+ 0·15	0·00	·1
·2	+ 1·36	+ 1·23	+ 1·10	+ 0·94	+ 0·74	+ 0·49	+ 0·31	+ 0·14	0·00	·2
·3	+ 1·35	+ 1·21	+ 1·08	+ 0·93	+ 0·72	+ 0·48	+ 0·29	+ 0·12	0·00	·3
·4	+ 1·33	+ 1·20	+ 1·07	+ 0·91	+ 0·69	+ 0·46	+ 0·27	+ 0·11	0·00	·4
·5	+ 1·32	+ 1·19	+ 1·05	+ 0·89	+ 0·66	+ 0·45	+ 0·25	+ 0·10	0·00	·5
·6	+ 1·30	+ 1·18	+ 1·04	+ 0·87	+ 0·63	+ 0·43	+ 0·23	+ 0·08	0·00	·6
·7	+ 1·29	+ 1·17	+ 1·02	+ 0·85	+ 0·60	+ 0·41	+ 0·21	+ 0·06	0·00	·7
·8	+ 1·27	+ 1·15	+ 1·01	+ 0·84	+ 0·58	+ 0·39	+ 0·20	+ 0·04	0·00	·8
·9	+ 1·26	+ 1·14	+ 0·99	+ 0·82	+ 0·55	+ 0·37	+ 0·18	+ 0·02	0·00	·9

	21^{rev}	22^{rev}	23^{rev}	24^{rev}	25^{rev}	26^{rev}	27^{rev}	28^{rev}	
·0	+ 0″·02	+ 0″·07	+ 0″·20	+ 0″·32	+ 0″·44	+ 0″·65	+ 0″·86	+ 1″·10	·0
·1	+ 0·02	+ 0·08	+ 0·21	+ 0·33	+ 0·46	+ 0·67	+ 0·88	+ 1·12	·1
·2	+ 0·03	+ 0·09	+ 0·22	+ 0·34	+ 0·48	+ 0·69	+ 0·91	+ 1·14	·2
·3	+ 0·03	+ 0·11	+ 0·24	+ 0·36	+ 0·51	+ 0·72	+ 0·93	+ 1·16	·3
·4	+ 0·04	+ 0·12	+ 0·25	+ 0·37	+ 0·53	+ 0·74	+ 0·95	+ 1·18	·4
·5	+ 0·04	+ 0·13	+ 0·26	+ 0·38	+ 0·55	+ 0·76	+ 0·98	+ 1·20	·5
·6	+ 0·05	+ 0·14	+ 0·27	+ 0·39	+ 0·57	+ 0·78	+ 1·00	+ 1·22	·6
·7	+ 0·05	+ 0·16	+ 0·28	+ 0·40	+ 0·59	+ 0·80	+ 1·03	+ 1·24	·7
·8	+ 0·06	+ 0·17	+ 0·30	+ 0·42	+ 0·61	+ 0·82	+ 1·05	+ 1·26	·8
·9	+ 0·06	+ 0·19	+ 0·31	+ 0·43	+ 0·63	+ 0·84	+ 1·07	+ 1·28	·9

EXCESS OF REFLEXION RESULTS ABOVE DIRECT RESULTS, FOR OBSERVATIONS OF ZENITH-DISTANCES WITH THE TRANSIT-CIRCLE, 1897, CORRECTED FOR ERRORS OF THE TELESCOPE-MICROMETER-SCREW.

In this table the reflexion observations are not corrected for inclination of the vertical at the surface of the mercury to that at the centre of the instrument.

Star's Name.	Approx. R.A.	Approx. N.P.D.	R—D.	No. of Obs. R. and D.	Weight.	Star's Name.	Approx. R.A.	Approx. N.P.D.	R—D.	No. of Obs. R. and D.	Weight.
	h m	°	″				h m	°	″		
o Ursæ Majoris S.P.	8. 22	−28. 9	−0·39	1	1	Groombridge 1747 S.P.	11. 8	−11. 1	−0·22	1	1
9 Cephei S.P.	21. 35	−28. 4	+1·07	1	1	Piazzi IV. 269 S.P.	5. 6	−10. 9	−0·22	1	1
α Ursæ Majoris S.P.	10. 57	−27. 7	−1·52	1	1	Lalande F. 856 S.P.	6. 15	−10. 5	−1·18	1	1
Lalande F. 1744 S.P.	10. 42	−24. 3	−2·75	1	1	Lalande F. 1745 S.P.	10. 46	−10. 1	−0·85	1	1
α Camelopardi S.P.	4. 44	−23. 8	+0·92	1	1	B. D. + 80° No. 350 S.P.	11. 9	− 9. 9	+1·20	1	1
16 Cassiopeiæ S.P.	0. 28	−23. 8	+0·34	1	1	Lalande F. 2537 S.P.	14. 42	− 9. 8	+0·10	1	1
38 Ursæ Majoris S.P.	10. 35	−23. 7	−0·61	1	1	Lalande F. 6245 S.P.	4. 1	− 9. 7	+1·62	1	1
Groombridge 1299 S.P.	7. 17	−23. 5	+1·13	1	1	Piazzi III. 160 S.P.	3. 53	− 9. 6	−0·34	1	1
O. A. (N.) 14625 S.P.	14. 26	−23. 2	+1·34	1	1	Lalande F. 65960 S.P.	4. 18	− 9. 3	+0·63	1	1
O. A. (N.) 11310 S.P.	10. 55	−23. 0	+1·58	1	1	Groombridge 3887 S.P.	22. 39	− 9. 1	−0·84	1	1
δ Draconis S.P.	19. 12	−22. 5	+0·59	1	1	Bradley 344 S.P.	2. 33	− 9. 0	−1·15	2	2
42 Camelopardi S.P.	6. 40	−22. 3	+0·63	1	1	Piazzi VI. 285 S.P.	7. 6	− 8. 6	−1·14	1	1
						Lalande F. 2351 S.P.	13. 42	− 8. 4	+2·07	1	1
Groombridge 2263 S.P.	15. 34	−21. 8	+0·05	1	1	Lalande F. (2) 137 S.P.	10. 56	− 8. 4	+1·53	1	1
Bradley 2636 S.P.	20. 20	−21. 4	+0·54	1	1	Bradley 48 S.P.	0. 32	− 8. 1	−0·20	1	1
43 Camelopardi S.P.	6. 43	−21. 0	−0·31	2	2	Lalande F. 1995 S.P.	11. 58	− 7. 8	+1·63	1	1
Groombridge 1350 S.P.	7. 36	−20. 6	−0·46	1	1	Piazzi VI. 292 S.P.	7. 9	− 7. 4	−0·68	1	1
σ Draconis S.P.	19. 32	−20. 5	+0·96	1	1	Carrington 1761 S.P.	11. 45	− 6. 8	+0·80	1	1
Bradley 42 S.P.	0. 27	−19. 6	+0·21	1	1	Piazzi XIII. 263 S.P.	13. 45	− 6. 7	+1·87	1	1
κ Draconis S.P.	12. 29	−19. 6	+0·32	1	1						
Bradley 2331 S.P.	18. 21	−18. 6	+0·29	1	1	Bradley 1399 S.P.	10. 14	− 5. 2	−1·18	1	1
O. A. (N.) 13022 S.P.	12. 44	−18. 5	−0·03	1	1	Groombridge 750 S.P.	4. 4	− 4. 7	−1·68	1	1
Groombridge 1489 S.P.	8. 54	−18. 3	−1·89	1	1	Bradley 3194 S.P.	23. 55	− 3. 9	−0·20	1	1
						Groombridge 642 S.P.	3. 34	− 3. 7	−1·35	1	1
γ Ursæ Minoris S.P.	15. 20	−17. 8	+0·27	1	1	δ Ursæ Minoris S.P.	18. 5	− 3. 4	+0·01	10	6
Lalande F. 1008 S.P.	7. 0	−17. 2	+0·03	1	1	Groombridge 3548 S.P.	21. 20	− 3. 4	+1·07	2	2
O. A. (N.) 12758–9 S.P.	12. 29	−17. 0	−0·71	1	1	Bradley 3147 S.P.	23. 27	− 3. 3	+0·42	4	3
79 Draconis S.P.	21. 51	−16. 8	−1·13	1	1	Cephei 51 S.P.	6. 51	− 2. 8	−0·03	23	8
Groombridge 612 S.P.	3. 4	−16. 5	−3·16	1	1	Bradley 1672 S.P.	12. 14	− 1. 7	−0·04	1	1
Bradley 3085 S.P.	23. 11	−16. 3	−0·40	1	1	Polaris S.P.	1. 15	− 1. 2	−0·26	10	6
Groombridge 1374 S.P.	7. 48	−15. 8	−0·69	1	1	Groombridge 1119 S.P.	7. 55	− 1. 1	+0·31	7	5
Groombridge 962 S.P.	5. 23	−15. 7	+0·76	1	1	λ Ursæ Minoris S.P.	19. 26	− 1. 0	+1·26	4	3
Radcliffe 1242 S.P.	4. 26	−15. 7	−0·43	1	1	λ Ursæ Minoris	19. 26	1. 0	+0·17	16	7
21 Cassiopeiæ S.P.	0. 39	−15. 6	+0·18	2	2	Groombridge 1119	7. 55	1. 0	−0·50	1	1
Groombridge 3857 S.P.	22. 35	−15. 2	+0·07	1	1	Polaris	1. 21	1. 2	+0·64	11	6
Piazzi XXIII. 218 S.P.	23. 47	−15. 0	+0·40	2	2	Bradley 1672	12. 14	1. 7	+0·27	5	4
						Groombridge 2283	15. 10	2. 4	+0·19	1	1
O. A. (N.) 13411 S.P.	13. 6	−14. 3	+2·86	1	1	Cephei 51	6. 52	2. 8	−0·32	7	5
O. A. (N.) 9576 S.P.	9. 3	−14. 3	−1·71	1	1	Bradley 3147	23. 27	3. 3	+0·22	2	2
Piazzi IV. 112 S.P.	4. 35	−14. 2	−0·77	1	1	δ Ursæ Minoris	18. 5	3. 4	+0·38	11	6
Lalande F. 2307 S.P.	13. 31	−13. 4	−0·69	1	1	Groombridge 3548	21. 20	3. 4	−0·81	2	2
γ Cephei S.P.	23. 35	−12. 9	+0·52	2	2	Bradley 1399	10. 14	5. 2	+0·62	2	2
Groombridge 2391 S.P.	16. 47	−12. 3	−0·72	1	1						
ζ Ursæ Minoris S.P.	15. 47	−11. 9	+0·05	1	1	Groombridge 2213	15. 2	5. 7	−1·00	1	1
28 Cephei S.P.	22. 26	−11. 7	−0·51	1	1	Lalande F. 1556	9. 51	5. 7	+0·93	1	1
Groombridge 1735 S.P.	11. 2	−11. 7	+0·50	1	1	Piazzi XIII. 263	13. 45	6. 7	+0·65	1	1

EXCESS OF REFLEXION RESULTS ABOVE DIRECT RESULTS, FOR OBSERVATIONS OF ZENITH-DISTANCES WITH THE TRANSIT-CIRCLE, 1897—*continued.*

Star's Name.	Approx. R.A.	Approx. N.P.D.	R—D.	No. of Obs. R. and D.	Weight.
	h m	°	″		
Piazzi X. 22	19. 18	6. 9	−0·99	1	1
Piazzi VI. 292	7. 9	7. 4	+1·22	1	1
ε Ursæ Minoris	16. 56	7. 8	−0·64	1	1
Piazzi VI. 285	7. 6	8. 5	−0·12	2	2
Groombridge 1845	11. 55	8. 6	+0·39	1	1
Carrington 2452	16. 17	9. 0	+0·33	1	1
Lalande F. (2) 231	16. 54	10. 3	+0·61	1	1
Lalande F. 1629	10. 5	10. 4	−0·07	1	1
Piazzi XIII. 133	13. 26	10. 8	+0·97	1	1
Bradley 2894	21. 53	10. 9	−1·24	1	1
Cephei 47	2. 52	11. 0	−0·26	1	1
O. A. (N.) 9756	9. 14	11. 1	+0·66	1	1
Bradley 1508	10. 51	11. 7	+0·20	1	1
Bradley 1634	12. 7	11. 8	+0·63	2	2
ζ Ursæ Minoris	15. 47	11. 9	+0·10	1	1
Groombridge 1151	6. 24	11. 9	+0·61	1	1
Groombridge 2382	16. 40	12. 0	+0·22	1	1
Lalande F. 2618	15. 6	12. 2	+0·93	1	1
Groombridge 1852	12. 0	12. 5	+1·28	1	1
Lalande 34738	18. 29	12. 5	+0·83	1	1
Bradley 1446	10. 26	13. 7	+0·79	2	2
Bradley 1147	8. 7	13. 9	+1·73	1	1
Piazzi XXIII. 96	22. 17	14. 0	−0·09	1	1
Lalande F. 1950	11. 45	14. 1	+0·08	1	1
17 Ursæ Minoris	15. 57	14. 1	+0·81	1	1
Lalande 39950	20. 30	14. 2	+0·58	1	1
O. A. (N.) 9576	9. 2	14. 3	+0·24	1	1
Groombridge 2398	16. 53	14. 4	+0·63	1	1
Groombridge 2427	17. 5	14. 6	+0·46	1	1
Lalande F. 1537	9. 34	14. 9	+1·90	1	1
Lalande 39363	20. 16	14. 9	+1·15	1	1
Lalande F. 4051	22. 6	15. 0	+0·51	1	1
β Ursæ Minoris	14. 5	15. 4	+1·32	1	1
Groombridge 710	3. 33	15. 8	+0·48	1	1
Groombridge 2930	19. 37	15. 8	+0·74	1	1
Bradley 417	3. 1	16. 0	+0·46	1	1
Groombridge 3085	20. 6	16. 4	+0·73	1	1
Lalande 32224	17. 28	17. 1	−0·54	1	1
O. A. (N.) 16408	16. 33	17. 2	−0·09	1	1
χ Draconis	18. 22	17. 3	−0·42	2	2
Groombridge 3147	20. 14	17. 4	+0·46	1	1
Piazzi IX. 91	9. 27	17. 4	+1·34	1	1
ψ^1 Draconis	17. 44	17. 8	+0·08	1	1
Lalande 37418	19. 31	17. 8	−0·11	1	1
Groombridge 1262	7. 1	18. 0	+0·13	1	1
O. A. (N.) 5800	5. 19	18. 1	+0·36	1	1
Radcliffe 3968	18. 27	18. 3	−1·49	1	1
11 Cephei	21. 40	19. 1	−0·99	1	1
Groombridge 2438	17. 20	19. 1	−1·55	1	1
42 Leonis Mincris	10 40	58. 8	−1·17	1	1
ε Herculis	16. 56	58. 9	0·00	1	1
η Coronæ	15. 19	59. 3	+0·74	1	1

Star's Name.	Approx. R.A.	Approx. N.P.D.	R—D.	No. of Obs. R. and D.	Weight.
	h m	°	″		
48 Aurigæ	6. 22	59. 4	+0·44	2	2
φ Cygni	19. 35	60. 1	+0·44	1	1
ζ Cygni	21. 8	60. 2	−1·46	1	1
η Pegasi	22. 38	60. 3	+0·42	1	1
β Coronæ	15. 23	60. 5	+0·56	1	1
12 Trianguli	2. 22	60. 8	+1·02	1	1
α Trianguli	1. 47	60. 9	−1·15	1	1
ε Andromedæ	0. 33	61. 2	−0·96	1	1
β Tauri	5. 20	61. 4	+0·34	1	1
α Andromedæ	0. 3	61. 4	+1·55	1	1
Pollux	7. 39	61. 7	−0·01	1	1
μ Herculis	17. 42	62. 2	+0·53	2	2
32 Vulpeculæ	20. 50	62. 3	+0·01	2	2
136 Tauri	5. 47	62. 4	−0·66	1	1
ϵ^2 Boötis	14. 40	62. 5	−0·23	2	2
ψ Boötis	15. 0	62. 6	+0·90	1	1
α Coronæ	15. 30	62. 9	+1·31	1	1
μ Leonis	9. 47	63. 5	+0·12	6	4
89 Herculis	17. 51	63. 9	−0·86	2	2
d Boötis	14. 6	64. 4	+0·42	1	1
16 Pegasi	21. 48	64. 5	+0·36	4	3
57 Herculis	16. 53	64. 5	+1·62	1	1
ε Geminorum	6. 38	64. 7	+0·61	1	1
21 Comæ	12. 25	64. 8	−1·42	1	1
δ Herculis	17. 10	65. 0	−0·59	3	3
ι Pegasi	22. 2	65. 1	+0·90	1	1
α Vulpeculæ	19. 24	65. 5	−0·66	1	1
ε Leonis	9. 40	65. 7	+0·09	3	3
30 Arietis	2. 31	65. 8	−0·88	1	1
μ Pegasi	22. 45	65. 9	+1·13	1	1
121 Tauri	5. 29	66. 0	−0·69	1	1
η Tauri	3. 41	66. 2	−0·85	2	2
μ Geminorum	6. 17	67. 4	+1·29	1	1
ο Tauri	5. 21	68. 1	+0·38	1	1
γ Cancri	8. 37	68. 1	+0·42	1	1
β Herculis	16. 25	68. 3	+0·70	4	3
1 Vulpeculæ	19. 11	68. 8	+0·26	1	1
δ Leonis	11. 8	68. 9	+0·21	3	3
ζ Geminorum	6. 58	69. 2	+0·64	1	1
β Arietis	1. 49	69. 6	−0·06	1	1
ν Geminorum	6. 23	69. 7	−0·76	1	1
Arcturus	14. 10	70. 2	+0·34	3	3
f Boötis	14. 21	70. 3	+1·19	2	2
γ Herculis	16. 17	70. 6	+0·30	6	4
η Boötis	13. 49	71. 1	+0·90	2	2
φ Pegasi	23. 47	71. 4	−0·30	1	1
m Tauri	5. 2	71. 5	−0·31	1	1
τ Boötis	13. 42	72. 0	−0·91	1	1
111 Tauri	5. 18	72. 7	−0·04	1	1
η Leonis	10. 1	72. 7	−0·10	1	1
3 Arietis	1. 41	73. 1	−0·39	1	1
γ Geminorum	6. 32	73. 5	−0·14	3	3

EXCESS OF REFLEXION RESULTS ABOVE DIRECT RESULTS, FOR OBSERVATIONS OF ZENITH-DISTANCES WITH THE TRANSIT-CIRCLE, 1897—*continued.*

Star's Name.	Approx. R.A.	Approx. N.P.D.	R—D.	No. of Obs. R. and D.	Weight.
	h m	°	″		
Aldebaran	4. 30	73. 7	−0·07	3	3
68 Geminorum	7. 27	73. 9	−0·51	1	1
γ Serpentis	15. 51	74. 0	−0·80	3	3
α Delphini	20. 35	74. 4	−0·16	2	2
β Leonis	11. 44	74. 8	−0·21	1	1
ν Orionis	6. 2	75. 2	+2·00	1	1
σ Arietis	2. 46	75. 3	−0·01	1	1
W.B.[1] 0·39	0. 8	75. 3	−1·06	1	1
α Pegasi	22. 59	75. 3	−0·24	1	1
α¹ Herculis	17. 10	75. 5	+0·48	4	3
π Tauri	4. 21	75. 5	−0·32	1	1
ζ Boötis	14. 36	75. 8	−1·36	1	1
ζ Aquilæ	19. 0	76. 3	+0·05	6	4
7 Serpentis	15. 17	77. 0	−1·90	1	1
ξ Geminorum	6. 39	77. 0	+0·27	2	2
α Ophiuchi	17. 30	77. 3	+0·90	5	4
34 Virginis	12. 42	77. 4	+0·22	1	1
Regulus	10. 3	77. 5	−0·61	1	1
75 Piscium	1. 1	77. 6	−0·91	1	1
ω Aquilæ	19. 13	78. 6	+1·11	3	3
ι Leonis	11. 18	78. 9	−1·19	2	2
κ Cancri	9. 2	78. 9	−1·10	1	1
ε Delphini	20. 28	79. 0	+0·36	2	2
Bradley 2191	17. 12	79. 0	−0·79	2	2
γ Aquilæ	19. 41	79. 6	−0·43	6	4
ζ Pegasi	22. 36	79. 7	+0·05	4	3
B. F. 2359	17. 5	79. 8	−1·38	1	1
ρ Leonis	10. 27	80. 1	−1·78	1	1
72 Ophiuchi	18. 2	80. 4	+0·22	2	2
κ Ophiuchi	16. 53	80. 4	+0·36	3	3
β Cancri	8. 11	80. 5	+0·14	2	2
ε Pegasi	21. 39	80. 6	+0·42	4	3
ο Virginis	12. 0	80. 7	+0·15	2	2
α Aquilæ	19. 45	81. 4	−0·69	6	4
31 Boötis	14. 36	81. 4	+1·58	1	1
π Leonis	9. 55	81. 4	−0·21	1	1
β Canis Minoris	7. 22	81. 5	−0·33	1	1
17 Monocerotis	6. 42	81. 8	−0·37	1	1
ξ² Ceti	2. 23	82. 0	−1·02	1	1
χ Leonis	10. 59	82. 1	−0·65	1	1
α Orionis	5. 50	82. 6	+0·09	1	1
ε Piscium	0. 58	82. 6	−0·15	5	4
π Virginis	11. 55	82. 8	+0·01	3	3
ζ¹ Piscium	1. 8	82. 9	+0·32	2	2
δ Piscium	0. 43	82. 9	+1·44	1	1
ε Hydræ	8. 41	83. 2	−0·81	1	1
α Serpentis	15. 39	83. 2	+2·32	1	1
88 Piscium	1. 9	83. 5	+0·54	1	1
ζ Hydræ	8. 50	83. 6	+1·50	2	2
ω Piscium	23. 54	83. 7	+1·95	1	1
δ Hydræ	8. 32	83. 9	−0·27	2	2
ι Piscium	23. 35	84. 9	+0·06	1	1
α Equulei	21. 11	85. 1	+0·83	2	2
ε Serpentis	15. 45	85. 2	−0·52	4	3
β Ophiuchi	17. 38	85. 3	+0·60	4	3
σ Ophiuchi	17. 21	85. 7	+0·42	4	3
d Leonis	10. 55	85. 8	−0·62	2	2
η Hydræ	8. 37	86. 2	−1·09	1	1
δ Aquilæ	19. 20	87. 0	+0·67	2	2
γ² Ceti	2. 38	87. 1	+0·38	1	1
γ Piscium	23. 11	87. 2	0·00	1	1
θ Hydræ	9. 9	87. 2	−0·20	1	1
110 Virginis	14. 57	87. 5	−0·50	1	1
α² Piscium	1. 57	87. 7	−0·14	1	1
χ Ophiuchi	16. 26	87. 8	+1·76	1	1
τ Virginis	13. 56	87. 9	+0·09	2	2
79 Leonis	11. 19	88. 0	+0·91	1	1
44 Piscium	0. 20	88. 6	+0·28	1	1
κ Piscium	23. 21	89. 3	−0·80	1	1
p² Leonis	10. 59	89. 4	−0·28	1	1
υ Leonis	11. 31	90. 2	+0·88	1	1
δ Orionis	5. 27	90. 3	+0·23	2	2
η Aquarii	22. 30	90. 6	+0·45	1	1
γ¹ Virginis	12. 36	90. 8	+0·98	2	2
α Aquarii	22. 0	90. 8	+1·60	2	2
γ² Virginis	12. 36	90. 8	+1·75	2	2
θ Aquilæ	20. 6	91. 1	+2·24	1	1
φ Virginis	14. 23	91. 7	+0·47	1	1
γ Aquarii	22. 16	91. 9	−0·72	1	1
ζ Orionis (1st star)	5. 36	92. 0	0·00	2	2
29 Monocerotis	8. 3	92. 6	−0·74	2	2
η Serpentis	18. 16	92. 9	+0·04	5	4
μ Eridani	4. 40	93. 4	+0·19	1	1
δ Ophiuchi	16. 9	93. 4	−0·16	1	1
27 Piscium	23. 53	94. 1	+2·05	1	1
80 Virginis	13. 30	94. 8	−0·07	1	1
θ Virginis	13. 4	94. 9	+0·19	1	1
μ Virginis	14. 37	95. 2	−0·30	1	1
Piazzi XXII. 279	22. 56	95. 2	−0·31	1	1
12 Aquilæ	18. 56	95. 8	+0·48	1	1
67 Ceti	2. 12	96. 8	+0·56	1	1
λ Aquarii	22. 47	98. 1	+0·85	1	1
θ Aquarii	22. 11	98. 2	+0·79	1	1
α Hydræ	9. 22	98. 2	+0·43	1	1
41 Sextantis	10. 44	98. 3	+0·68	2	2
ξ Aquarii	21. 32	98. 3	+0·43	3	3
ψ Virginis	12. 50	98. 9	+2·66	1	1
2 Aquilæ	18. 36	99. 1	+0·29	4	3
ι Ceti	0. 14	99. 3	−2·12	1	1
κ Orionis	5. 43	99. 7	−0·37	1	1
ψ Scorpii	16. 6	99. 7	+0·88	1	1
9 Puppis	7. 47	103. 6	−0·15	1	1

The weights used have been determined as follows:—Putting m and n for the number of Reflexion and Direct observations respectively, e for the probable error of one observation, e_2 for the probable systematic error affecting all observations of the same star, the weight to be given to that star is proportional to $\frac{mn}{me^2 + ne^2 + 2\,mne_0^2}$; or assuming $e_0^2 = \frac{1}{10}e^2$, which would make $e_0 = 0''\cdot16$, the weight becomes $\frac{4\,mn}{m + n + \frac{1}{5}\,mn}$, which has been adopted. If $m = n$, as is usually the case, the weight becomes $\frac{20\,m}{10 + m}$.

EXCESS OF REFLEXION RESULTS ABOVE DIRECT RESULTS FROM GROUPS OF STARS OBSERVED WITH THE TRANSIT-CIRCLE.

Extent of Group, 1897.	Weight.	Mean N.P.D.	Mean Z.D. South.	Mean Value of R—D, corrected for Inclination of Verticals.	R—D computed by the Formula + 0″·136 + 0″·208 × sin Z.D.	Apparent Error of Formula.
		°	°	″	″	″
ο Ursæ Majoris S.P. to α Ursæ Majoris S.P.	3	−28. 4	−66. 9	− 0·43	− 0·06	+ 0·37
Lalande F. 1744 S.P. to 42 Camelopardi S.P.	9	−23. 3	−61. 8	+ 0·21	− 0·05	− 0·26
Groombridge 2263 S.P. to Groombridge 1489 S.P.	11	−20. 1	−58. 6	− 0·20	− 0·04	+ 0·16
γ Ursæ Minoris S.P. to Piazzi XXIII. 218 S.P.	14	−16. 1	−54. 6	− 0·43	− 0·03	+ 0·40
Oeltz. Arg. (N.) 13411 S.P. to Lalande F. 856 S.P.	13	−12. 5	−51. 0	− 0·24	− 0·03	+ 0·21
Lalande F. 1745 S.P. to Piazzi XXIII. 263 S.P.	17	− 8. 7	−47. 2	+ 0·18	− 0·02	− 0·20
Bradley 1399 S.P. to λ Ursæ Minoris S.P.	38	− 2. 5	−41. 0	− 0·05	0·00	+ 0·05
λ Ursæ Minoris to Bradley 1399	36	2. 3	−36. 2	+ 0·09	+ 0·01	− 0·08
Groombridge 2213 to Oeltz. Arg. (N.) 9756	16	8. 7	−29. 8	0·00	+ 0·03	+ 0·03
Bradley 1508 to Lalande 39363	21	13. 3	−25. 2	+ 0·62	+ 0·05	− 0·57
Lalande F. 4051 to Groombridge 1262	19	17. 2	−21. 3	− 0·01	+ 0·06	+ 0·07
42 Leonis Minoris to μ Leonis	28	61. 4	22. 9	+ 0·20	+ 0·22	+ 0·02
89 Herculis to η Tauri	22	65. 1	26. 6	− 0·03	+ 0·23	+ 0·26
μ Geminorum to γ Herculis	22	69. 4	30. 9	+ 0·50	+ 0·24	− 0·26
η Boötis to γ Serpentis	18	73. 0	34. 5	− 0·12	+ 0·25	+ 0·37
α Delphini to 75 Piscium	26	76. 2	37. 7	+ 0·14	+ 0·26	+ 0·12
ω Aquilæ to ε Piscium	46	80. 4	41. 9	− 0·02	+ 0·28	+ 0·30
π Virginis to 79 Leonis	40	85. 2	46. 7	+ 0·45	+ 0·29	− 0·16
44 Piscium to η Serpentis	24	91. 2	52. 7	+ 0·61	+ 0·30	− 0·31
μ Eridani to 67 Ceti	9	94. 8	56. 3	+ 0·42	+ 0·31	− 0·11
λ Aquarii to 9 Puppis	16	99. 0	60. 5	+ 0·55	+ 0·32	− 0·23

In forming the mean values of R—D for groups in the last column but two of the above table, a correction of $+0''\cdot16$ sin Z.D. has been applied to the mean of each group for inclination of the vertical at the surface of the mercury used in reflexion observations to that at the centre of the transit-circle, the mercury trough being mounted so as to describe a circle of 8 feet radius.

Assuming that the R—D correction can be represented by

$$x + y \sin \text{Z.D. south},$$

it is found by calculation that the following expressions, when tabulated, will give the values which best agree with the errors in the above, namely :—

For direct observations,

$$+ 0''{\cdot}068 + 0''{\cdot}104 \sin \text{Z.D.}$$

For reflexion observations,

$$- 0''{\cdot}068 - 0''{\cdot}104 \sin \text{Z.D.} + 0''{\cdot}16 \sin \text{Z.D.}$$

or $$- 0''{\cdot}068 + 0''{\cdot}056 \sin \text{Z.D.}$$

For use, these formulæ have been tabulated as follows; and the corrections have been applied to the mean results for N.P.D. of Sun, Moon, and Planets in the section of Planetary Results throughout the year.

N.P.D.	Corrections to Results of Direct Observations.	Corrections to Results of Reflexion Observations.
°	"	"
− 45	− 0·04	− 0·12
40	− 0·03	0·12
30	− 0·03	0·12
20	− 0·02	0·12
− 10	− 0·01	0·11
0	0·00	0·10
+ 10	+ 0·02	0·10
20	+ 0·04	0·09
30	+ 0·05	0·08
40	+ 0·07	0·07
50	+ 0·09	0·06
60	+ 0·11	0·05
70	+ 0·12	0·04
80	+ 0·14	0·03
90	+ 0·15	0·02
100	+ 0·16	0·02
110	+ 0·17	0·02
120	+ 0·17	0·01
125	+ 0·17	− 0·01

SECONDS OF DIFFERENCE OF N.P.D. OF PAIRS OF STARS, ONE BEING OBSERVED BY REFLEXION AND THE OTHER DIRECTLY.

Date, 1897.	ζ Hydræ R. − ε Hydræ D.	ζ Hydræ D. − ε Hydræ R.
	"	"
Feb. 27	...	32·00
Mar. 30	33·97	...
Apr. 5	...	33·34
13	34·11	...
Mean ...	34·04	32·67

Date, 1897.	κ Ophiuchi R. − B.F. 2359 D.	κ Ophiuchi D. − B.F. 2359 R.
	"	"
June 1	18·74	...
10	...	19·11
11	19·71	...
23	18·92	...
July 3	...	18·28
7	19·05	...
9	...	19·14
10	20·72	...
15	...	20·65
23	18·89	...
Mean ...	19·34	19·30

Date, 1897.	λ Cancri R. − υ^1 Cancri D.	λ Cancri D. − υ^1 Cancri R.
	"	"
Mar. 30	35·18	...
Apr. 5	...	35·69
Mean ...	35·18	35·69

Date, 1897.	2 Aquilæ R. − 1 Aquilæ D.	2 Aquilæ D. − 1 Aquilæ R.
	"	"
Aug. 25	...	5·63
30	6·63	...
Sept. 3	...	4·78
4	6·68	...
9	...	4·85
11	5·47	...
25	5·26	...
Mean ...	6·01	5·09

Date, 1897.	B.F. 2318 R. − Piazzi XVI. 136 D.	B.F. 2318 D. − Piazzi XVI. 136 R.
	"	"
June 1	...	16·30
10	17·27	...
11	...	15·97
23	17·86	...
July 7	16·72	...
9	...	16·54
10	18·84	...
15	...	15·18
Mean ...	17·67	16·00

Date, 1897.	ω Aquilæ R. − ζ Aquilæ D.	ω Aquilæ D. − ζ Aquilæ R.
	"	"
Aug. 25	1·55	...
30	...	2·74
Sept. 3	1·72	...
7	1·69	...
9	...	2·10
11	...	3·15
23	2·94	...
Oct. 7	2·89	...
20	2·26	...
25	...	2·60
Mean ...	2·18	2·65

VALUES OF 2 (R—D) DEDUCED FROM ABOVE OBSERVATIONS.

The weight below is the number of complete sets of four observations.

Name of Star.	Approx. N.P.D.	2 (R—D).	No. of Obs.	Weight.	Name of Star.	Approx. N.P.D.	2 (R—D).	No. of Obs.	Weight.
	°	"							
λ Cancri — υ^1 Cancri	65·7 65·1	−0·51	1 1	1	κ Ophiuchi — B.F. 2359	80·5 79·8	+0·04	6 4	4
B.F. 2318 — Piazzi XVI. 136	76·6 76·1	+1·67	4 4	4	ζ Hydræ — ε Hydræ	83·7 83·2	+1·37	2 2	2
ω Aquilæ — ζ Aquilæ	78·6 76·3	−0·47	6 4	4	2 Aquilæ — 1 Aquilæ	99·2 98·3	+0·92	4 3	3

RESULTS FOR R—D DISCORDANCE WHEN THE REFLEXION AND DIRECT OBSERVATIONS WERE MADE ON DIFFERENT NIGHTS COMPARED WITH THOSE TAKEN IN THE ORDINARY MANNER, AND WITH THE VALUES COMPUTED FROM THE FORMULA, + 0″·136 + 0″·208 SIN Z.D.

Approx. N.P.D.	Approx. Z.D. South.	R—D. R and D Observation on Different Nights.	Weight.	R—D. R Observation immediately before D.	From Formula. R—D.
°	°	"		"	"
+ 65·4	26·9	− 0·26	1	− 0·03	+ 0·23
76·4	37·9	+ 0·84	4	+ 0·14	+ 0·26
77·5	39·0	− 0·24	4	+ 0·06	+ 0·27
80·1	41·6	+ 0·02	4	− 0·02	+ 0·27
83·5	45·0	+ 0·69	2	+ 0·36	+ 0·28
+ 98·8	60·3	+ 0·46	3	+ 0·55	+ 0·31

SIMULTANEOUS READINGS AT APPARENT NOON OF THE TRANSIT-CIRCLE EXTERIOR THERMOMETER, THE NORTH WALL THERMOMETER, THE METEOROLOGICAL STANDARD THERMOMETER, AND THE THERMOMETER ON THE ROOF OF THE MAGNET HOUSE.

Date, 1897.	Meteoro-logical Standard Thermom.	Excess of			Date, 1897.	Meteoro-logical Standard Thermom.	Excess of		
		North Wall Thermom.	Transit-Circle Exterior Thermom.	Magnet House Thermom.			North Wall Thermom.	Transit-Circle Exterior Thermom.	Magnet House Thermom.
d h	°	°	°	°	d h	°	°	°	°
Jan. 1. 0	43·8	− 0·8	− 0·9	− 0·6	Apr. 24. 0	48·9	+ 0·2	+ 0·6	+ 1·0
4. 0	38·7	+ 0·1	− 0·3	+ 0·9	26. 0	62·7	− 2·8	− 1·0	+ 1·1
6. 0	45·0		− 0·3	+ 0·8	27. 0	65·0	− 3·7	− 0·5	+ 0·4
22. 0	34·7	− 0·2	− 0·3	− 1·1	28. 0	59·8	0·0	− 0·1	+ 2·0
23. 0	30·8	− 0·3	− 0·7	− 0·4	29. 0	63·1	− 3·1	− 1·4	− 0·6
24. 0	30·7	− 0·6	− 1·0	− 0·9					
25. 0	39·4	− 0·6	− 0·1	0·0	May 3. 0	56·5	− 0·2	− 0·1	+ 0·5
26. 0	34·5	− 0·9	− 0·6	− 0·2	4. 0	56·2	− 2·9	− 1·5	− 1·3
27. 0	36·0	− 0·8	− 0·7	− 0·1	9. 0	55·0	− 1·2	− 0·7	− 0·8
28. 0	36·7	− 0·1	− 0·1	+ 0·3	10. 0	55·7	− 1·9	− 2·0	− 0·7
29. 0	35·8	− 0·1	− 0·4	0·0	11. 0	48·5	− 1·0	− 0·7	+ 0·2
					13. 0	48·6	− 1·1	− 1·2	− 0·2
Feb. 4. 0	47·9	− 0·4	− 0·3	+ 0·9	14. 0	54·5	+ 0·3	0·0	+ 0·5
7. 0	40·2	− 0·6	− 0·8	− 0·4	17. 0	69·9	− 4·7	− 4·0	− 1·9
8. 0	41·8	− 0·1	− 0·9	− 1·0	18. 0	77·2	− 5·7	− 3·8	− 3·7
17. 0	47·0	− 0·4	− 0·3	+ 0·5	19. 0	64·9	− 3·4	− 1·2	− 0·1
18. 0	49·7	− 2·5	− 0·6	− 0·1	20. 0	68·7	− 7·1	− 4·9	− 5·8
23. 0	50·7	− 0·3	− 0·6	+ 0·2	21. 0	67·3	− 3·7	− 2·1	− 1·4
26. 0	56·0	− 1·2	− 0·5	− 0·2	22. 0	61·6	− 3·1	− 2·1	− 2·0
27. 0	50·6	− 2·2	− 0·9	− 0·4	23. 0	62·9	− 5·1	− 3·6	− 2·3
28. 0	48·9		+ 0·5	+ 0·6	25. 0	69·4	− 2·5	− 1·6	− 0·5
					27. 0	62·8	− 3·0	− 1·8	− 1·6
Mar. 1. 0	48·9	− 1·8	− 0·7	− 0·3	31. 0	67·0	− 1·5	− 0·2	− 0·6
2. 0	46·4	− 1·9	− 1·5	− 0·4					
5. 0	46·8	− 1·6	− 0·1	− 1·7	June 1. 0	64·3	+ 0·3	+ 0·2	+ 1·4
7. 0	40·1	− 1·3	− 0·4	0·0	2. 0	63·7	+ 0·3	− 0·2	+ 1·3
8. 0	43·7	− 1·5	+ 0·2	− 0·2	5. 0	64·7	− 0·7	− 1·1	− 0·4
10. 0	48·5	− 2·5	− 1·3	− 0·9	6. 0	70·2	− 0·9	− 1·1	0·0
12. 0	47·8	− 0·6	− 0·1	0·0	11. 0	74·3	− 2·3	+ 0·2	+ 0·3
13. 0	45·6	− 0·2	+ 0·2	− 0·3	12. 0	78·9	− 2·9	0·0	+ 0·1
18. 0	52·1	− 6·1	− 0·2	− 0·3	13. 0	80·4	− 3·3	− 0·5	− 1·1
19. 0	54·7	− 1·0	− 0·2	− 0·3	15. 0	72·8	− 3·6	− 2·1	− 1·4
23. 0	57·1	− 1·0	+ 0·1	+ 0·3	19. 0	58·2	− 1·2	− 1·3	− 0·4
24. 0	57·0	+ 0·5	+ 0·4	+ 0·5	22. 0	72·5	+ 0·9	+ 0·6	+ 1·1
25. 0	56·8	− 1·0	− 0·1	0·0	23. 0	81·0	− 2·4	+ 0·5	− 1·2
27. 0	53·8	+ 0·2	+ 0·1	+ 0·4	24. 0	87·0	− 4·3	− 0·2	+ 0·2
29. 0	46·4	− 1·6	− 1·6	− 0·9	26. 0	69·0	− 1·9	− 1·3	− 0·4
30. 0	48·4	− 2·6	+ 0·3	+ 0·6	29. 0	71·6	+ 0·9	+ 1·5	+ 0·6
					30. 0	75·9	− 0·1	+ 0·2	+ 1·3
Apr. 4. 0	46·8	− 2·0	− 0·3	+ 0·5					
5. 0	46·1	− 1·1	+ 0·8	+ 1·5	July 1. 0	73·9	− 5·1	− 3·2	− 1·9
6. 0	46·8	− 0·4	+ 0·2	+ 1·0	3. 0	69·1	− 0·3	+ 0·8	− 0·1
7. 0	45·1	+ 0·3	− 0·1	+ 0·4	6. 0	64·8	+ 1·2	− 0·1	+ 0·8
9. 0	54·6	− 0·1	− 0·9	− 0·1	7. 0	63·6	+ 0·2	+ 0·1	− 0·5
11. 0	50·2	− 1·5	+ 0·9	− 0·3	8. 0	70·2	− 1·4	− 1·5	− 0·4
14. 0	54·1	− 0·1	− 0·1	+ 0·3	9. 0	67·8	+ 0·6	− 0·6	+ 0·2
15. 0	51·6	+ 0·5	− 1·7	+ 0·6	10. 0	75·5	− 5·1	− 2·5	− 2·2
18. 0	54·4	− 2·6	− 2·6	− 1·1	11. 0	71·8	− 3·1	− 1·2	− 0·9
19. 0	52·8	+ 1·5	+ 1·6	+ 1·7	13. 0	76·8	− 4·0	− 2·4	− 1·8

SIMULTANEOUS READINGS AT APPARENT NOON OF THE TRANSIT-CIRCLE EXTERIOR THERMOMETER, THE NORTH WALL THERMOMETER, THE METEOROLOGICAL STANDARD THERMOMETER, AND THE THERMOMETER ON THE ROOF OF THE MAGNET HOUSE—*continued.*

Date, 1897.	Meteorological Standard Thermom.	Excess of		
		North Wall Thermom.	Transit-Circle Exterior Thermom.	Magnet House Thermom.
d h	°	°	°	°
July 14. 0	79·2	− 4·6	− 3·1	− 1·6
15. 0	79·0	− 6·5	− 2·9	− 4·4
16. 0	74·5	− 5·2	− 2·2	− 2·7
17. 0	79·0	− 1·8	− 1·3	+ 1·8
18. 0	79·4	− 5·0	− 2·7	− 4·3
19. 0	77·2	− 2·8	− 2·4	− 0·6
20. 0	76·8	− 4·3	− 3·7	− 1·0
21. 0	71·1	− 0·9	− 0·4	− 0·5
23. 0	74·5	− 1·6	− 0·6	− 0·2
24. 0	82·2	− 2·4	− 1·2	− 2·3
25. 0	75·6	− 2·0	− 1·9	− 1·7
27. 0	64·1	− 6·4	− 4·8	− 2·8
28. 0	68·9	+ 0·3	− 0·6	− 0·1
30. 0	77·4	− 4·1	− 1·2	− 2·4
31. 0	73·7	− 4·6	− 2·1	− 3·0
Aug. 1. 0	64·6	+ 0·1	+ 2·0	+ 0·6
2. 0	80·4	− 6·1	− 2·4	− 3·7
4. 0	86·2	− 4·7	− 0·9	− 1·2
5. 0	85·5	− 1·7	0·0	− 0·5
10. 0	77·5	− 3·6	− 1·8	+ 0·3
12. 0	71·9	− 2·4	− 2·2	− 0·5
14. 0	75·1	− 4·9	− 2·7	− 0·6
16. 0	73·6	− 3·8	− 1·9	0·0
18. 0	72·7	− 2·9	− 2·1	− 0·3
19. 0	68·3	− 3·5	− 1·5	− 1·7
21. 0	70·0	− 2·5	− 0·3	0·0
23. 0	62·7	+ 0·2	− 0·2	+ 0·7
26. 0	67·5	+ 1·0	+ 0·2	+ 0·5
28. 0	67·3	+ 1·2	+ 0·6	+ 1·1
30. 0	69·9	− 3·9	− 2·8	− 1·3
Sept. 2. 0	66·0	− 1·2	− 1·0	+ 0·2
3. 0	59·3	− 0·9	+ 0·2	+ 0·1
8. 0	61·0	− 1·4	− 0·8	− 1·1
9. 0	56·8	− 0·4	− 0·7	0·0
10. 0	60·9	− 2·1	− 1·2	− 1·6
14. 0	62·1	− 1·3	− 0·3	− 0·9
15. 0	65·9	− 3·1	− 0·2	− 0·3
17. 0	59·6	+ 1·1	+ 1·9	+ 1·2
19. 0	54·5	− 2·9	− 1·9	− 0·9
20. 0	57·4	− 2·6	− 1·9	− 0·5
21. 0	62·9	− 0·5	− 0·6	+ 0·3
22. 0	57·2	+ 0·6	+ 0·2	+ 0·5
23. 0	64·8	− 2·7	− 0·7	− 0·7
25. 0	65·8	− 4·0	− 0·2	0·0
26. 0	64·6	− 1·0	− 0·9	− 0·1
27. 0	60·4	− 2·4	+ 0·2	− 0·1
29. 0	69·6	− 0·1	+ 0·3	+ 1·2

Date, 1897.	Meteorological Standard Thermom.	Excess of		
		North Wall Thermom.	Transit-Circle Exterior Thermom.	Magnet House Thermom.
d h	°	°	°	°
Oct. 2. 0	58·3	− 2·2	− 0·7	− 0·5
3. 0	58·4	− 1·7	− 1·3	+ 1·1
7. 0	49·8	− 0·5	− 2·8	+ 0·1
8. 0	54·8	0·0	− 0·9	+ 1·0
9. 0	55·2	− 1·5	− 1·2	− 0·1
12. 0	51·1	− 2·2	− 0·6	− 0·5
14. 0	60·7	− 1·2	+ 0·7	+ 0·7
15. 0	64·0	− 0·2	− 0·3	− 0·8
16. 0	64·4	− 1·7	− 0·7	+ 0·2
17. 0	66·5	− 1·9	+ 0·7	+ 0·3
18. 0	62·8	− 1·8	− 0·5	+ 0·7
19. 0	62·8	− 2·3	− 0·4	+ 0·1
20. 0	51·8	− 1·8	− 1·3	− 1·0
21. 0	56·0	− 1·4	− 1·0	+ 0·6
24. 0	52·2	− 0·7	− 0·7	+ 0·5
25. 0	55·2	− 3·6	− 0·6	− 4·4
28. 0	50·5	− 2·4	− 1·6	− 1·6
29. 0	62·9	− 5·8	+ 0·1	+ 0·9
30. 0	61·2	− 4·0	+ 0·5	+ 0·8
31. 0	51·8	− 2·6	− 1·9	− 0·9
Nov. 1. 0	53·6	− 3·8	− 2·6	− 1·8
2. 0	47·2	− 0·7	− 0·7	+ 0·1
3. 0	50·8	− 2·1	− 1·5	0·0
6. 0	49·3	− 1·5	− 1·4	− 0·5
10. 0	50·1	− 2·3	− 1·6	− 0·1
16. 0	47·0	− 0·4	− 0·3	+ 0·6
19. 0	45·6	− 3·0	− 1·4	− 1·4
20. 0	49·6	− 0·7	− 0·5	+ 0·1
22. 0	48·8	− 1·9	− 1·1	0·0
26. 0	40·8	− 2·0	− 1·0	+ 0·7
29. 0	42·5	− 0·1	− 0·8	− 0·1
Dec. 1. 0	43·4	− 1·8	− 1·0	− 0·2
2. 0	40·4	− 1·5	− 1·7	− 1·0
3. 0	39·5	− 0·2	− 0·7	0·0
8. 0	43·6	+ 0·2	− 0·2	− 0·2
9. 0	43·3	− 0·7	− 0·6	0·0
11. 0	45·9	− 0·2	− 0·2	− 0·1
14. 0	50·8	− 1·2	− 0·9	0·0
15. 0	51·2	− 2·1	− 1·3	− 0·4
16. 0	55·4	− 0·4	− 0·2	+ 0·4
17. 0	55·2	− 2·3	− 1·5	+ 0·6
22. 0	37·8	− 1·4	− 1·1	+ 0·2
23. 0	35·3	− 1·7	− 1·1	0·0
24. 0	32·8	− 1·5	− 1·6	− 1·0
25. 0	39·7	− 4·3	− 2·8	0·0
26. 0	40·2	− 2·6	− 0·8	+ 1·0
27. 0	48·8	− 0·5	− 0·3	+ 0·5

MEANS OF SIMULTANEOUS READINGS AT APPARENT NOON OF THE METEOROLOGICAL STANDARD THERMOMETER, AND EXCESS OF THE NORTH WALL THERMOMETER, THE TRANSIT-CIRCLE EXTERIOR THERMOMETER, AND THE MAGNET-HOUSE THERMOMETER, ARRANGED IN MONTHS.

1897.	January.	February.	March.	April.	May.	June.
	°	°	°	°	°	°
Meteorological Standard....	36·9$_{11}$	48·1$_{9}$	49·6$_{16}$	53·5$_{15}$	61·6$_{17}$	72·3$_{15}$
Excess of North Wall.......	− 0·4	− 1·0	− 1·5	− 1·0	− 2·8	− 1·4
Excess of Exterior...........	− 0·5	− 0·5	− 0·3	− 0·3	− 1·9	− 0·3
Excess of Magnet House....	− 0·1	0·0	− 0·2	+ 0·6	− 1·3	+ 0·1

1897.	July.	August.	September.	October.	November.	December.	Mean for Year.
	°	°	°	°	°	°	°
Meteorological Standard....	73·6$_{24}$	72·9$_{15}$	61·7$_{17}$	57·5$_{20}$	47·8$_{11}$	44·0$_{16}$	56·6
Excess of North Wall.......	− 2·9	− 2·5	− 1·5	− 2·0	− 1·7	− 1·4	− 1·7
Excess of Exterior...........	− 1·7	− 1·1	− 0·4	− 0·7	− 1·2	− 1·0	− 0·8
Excess of Magnet House...	− 1·4	− 0·4	− 0·2	− 0·1	− 0·2	0·0	− 0·3

EXCESS OF READINGS OF NORTH WALL THERMOMETER OVER THOSE OF THE TRANSIT-CIRCLE EXTERIOR THERMOMETER FOR EACH HOUR OF THE DAY, DEDUCED FROM SIMULTANEOUS READINGS.

(ASTRONOMICAL TIME.)

1897.	0^h	1^h	2^h	3^h	4^h	5^h
	°	°	°	°	°	°
January	+ 0·1$_{11}$	...	...	+ 0·1$_{1}$	+ 0·5$_{2}$	+ 0·2$_{2}$
February	− 0·6$_{8}$	...	− 0·5$_{2}$	− 0·4$_{7}$	+ 0·3$_{2}$	− 0·8$_{3}$
March	− 1·2$_{18}$	...	− 0·3$_{12}$	− 0·4$_{4}$	− 0·3$_{1}$	0·0$_{1}$
April...	− 0·7$_{17}$	− 0·6$_{6}$	− 1·2$_{2}$	− 0·4$_{5}$	− 0·3$_{5}$	+ 0·4$_{8}$
May	− 1·0$_{19}$	− 1·9$_{3}$	− 1·4$_{2}$	− 0·1$_{8}$	+ 0·4$_{2}$	...
June	− 1·3$_{18}$	− 2·1$_{2}$	− 1·1$_{1}$	...	...	...
July	− 1·1$_{15}$	...	− 1·3$_{3}$	− 0·3$_{2}$	...	+ 1·7$_{2}$
August	− 1·4$_{15}$	− 2·0$_{5}$	− 1·3$_{5}$	− 0·5$_{12}$	0·0$_{6}$	...
September	− 1·2$_{18}$	− 2·3$_{2}$	0·0$_{1}$	− 3·1$_{1}$	...	+ 0·2$_{5}$
October	− 1·8$_{30}$	− 2·4$_{5}$	− 0·6$_{7}$	− 1·1$_{7}$	− 0·9$_{19}$	− 0·5$_{14}$
November	− 0·6$_{14}$	− 0·1$_{6}$	+ 0·1$_{8}$	+ 0·3$_{10}$	+ 0·1$_{9}$	− 0·4$_{6}$
December	− 0·4$_{19}$	− 0·2$_{3}$	− 0·2$_{4}$	− 0·2$_{6}$	0·0$_{15}$	− 0·1$_{8}$
Means ...	− 0·9	− 1·4	− 0·7	− 0·6	0·0	+ 0·1

EXCESS OF READINGS OF NORTH WALL THERMOMETER OVER THOSE OF THE TRANSIT-CIRCLE EXTERIOR THERMOMETER FOR EACH HOUR OF THE DAY, DEDUCED FROM SIMULTANEOUS READINGS—*continued.*

1897.	6h		7h		8h		9h		10h		11h	
January	+ 0°.7	2	+ 0°.4	6	+ 0°.2	13	+ 0°.3	12	+ 0°.5	10	+ 0°.3	7
February	− 0.5	7	− 0.7	10	− 0.3	9	− 0.5	8	− 0.3	4	− 0.4	5
March	− 0.1	19	− 0.3	16	− 0.1	19	− 0.1	19	− 0.3	16	− 0.1	19
April	− 0.1	12	− 0.1	21	0.0	15	0.0	15	− 0.2	13	0.0	16
May	+ 0.2	6	+ 0.1	20	+ 0.1	28	+ 0.2	23	+ 0.1	27	+ 0.1	26
June	− 0.2	2	− 0.1	7	− 0.1	9	− 0.2	13	− 0.2	20	− 0.1	18
July	+ 0.9	3	− 0.2	10	− 0.1	27	+ 0.1	33	0.0	32	+ 0.2	27
August	+ 0.2	6	− 0.3	16	− 0.3	24	− 0.2	31	0.0	27	− 0.2	20
September	0.0	13	+ 0.1	16	+ 0.2	11	0.0	16	0.0	16	0.0	14
October	− 0.4	14	+ 0.1	12	− 0.3	21	− 0.1	21	− 0.2	20	0.0	29
November	− 0.2	6	0.0	9	+ 0.4	12	+ 0.2	17	0.0	12	0.0	14
December	− 0.4	15	− 0.1	15	0.0	20	0.0	22	− 0.2	15	− 0.2	15
Means ...	0.0		− 0.1		0.0		0.0		− 0.1		0.0	

1897.	12h		13h		14h		15h		16h		17h	
January	+ 0°.5	4	...°		+ 0°.6	1	+ 0°.6	2	+ 0°.6	1	+ 0°.3	2
February	− 0.5	4	− 1.0	1	...		...		...		...	
March	− 0.1	18	− 0.3	10	− 0.3	2	− 0.2	2	+ 0.1	2	− 0.2	1
April	− 0.1	18	0.0	13	...		...		...		+ 0.4	2
May	+ 0.1	20	+ 0.1	4	− 0.2	1	...		...		+ 0.7	1
June	+ 0.1	17	+ 0.1	12	+ 0.3	5	+ 0.2	3	...		...	
July	0.0	19	0.0	4	− 0.5	1	+ 0.2	1	− 0.2	2	...	
August	− 0.1	16	0.0	8	− 0.1	6	0.0	3	− 0.1	4	...	
September	0.0	20	+ 0.2	11	+ 0.1	4	+ 0.2	5	+ 0.2	2	− 0.1	1
October	0.0	20	− 0.2	7	− 0.9	2	...		− 0.4	1	− 0.2	1
November	+ 0.1	13	− 0.2	6	− 0.5	3	− 0.4	2	− 0.5	2	− 0.2	3
December	0.0	15	0.0	10	− 0.3	4	− 0.8	2	− 1.0	1	− 0.6	2
Means ...	0.0		− 0.1		− 0.2		0.0		− 0.2		0.0	

1897.	18h		19h		20h		21h		22h		23h	
January	+ 0°.2	1	+ 0°.2	3	...°		...°		+ 0°.2	2	0°.0	1
February	+ 0.5	1	...		...		+ 0.1	1	− 0.6	2	...	
March	...		...		...		− 1.1	6	...		− 0.9	2
April	− 0.1	1	+ 1.6	1	+ 0.6	1	+ 0.8	1	− 1.1	2	− 1.6	3
May	...		...		+ 4.6	1	− 1.0	7	− 1.1	9	− 1.7	3
June	...		+ 2.1	1	+ 0.5	2	+ 2.0	1	− 1.1	3	+ 0.2	1
July	...		...		+ 1.8	6	− 0.3	4	− 1.3	4	− 0.6	5
August	+ 1.7	2	+ 1.0	1	...		− 0.3	14	− 2.1	6	...	
September	...		+ 0.2	1	...		− 1.1	8	...		− 2.4	2
October	...		...		...		− 0.9	11	− 1.0	11	− 3.8	8
November	...		...		+ 0.1	1	+ 0.1	5	− 0.5	5	− 1.2	1
December	− 0.6	1	− 0.3	2	+ 0.1	4	− 0.5	4	− 0.1	7	− 0.4	3
Means ...	+ 0.3		+ 0.8		+ 1.3		− 0.2		− 0.9		− 1.2	

CORRECTION TO ASSUMED COLATITUDE, 38° 31′.21″·90.

FROM OBSERVATIONS IN THE YEAR 1897.

(Using Bessel's Refractions, as given in the *Tabulæ Regiomontanæ*; and corrected for Errors of Division, as adopted in 1898.)

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	Below Pole.	Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	Below Pole.	Weight.
	h m	° ′	″					h m	° ′	″			
λ Ursæ Minoris	19. 26	1. 1	+0·16	62	19	28	Bradley 3181	23. 47	12. 58	+0·53	1	1	3
Groombridge 1119	7. 3	1. 4	+0·04	12	36	24	Groombridge 1728	10. 57	13. 0	+1·54	1	1	3
Polaris	1. 20	1. 14	+0·48	82	90	34	35 Draconis	17. 54	13. 1	−0·25	1	1	3
Bradley 1672	12. 14	1. 44	+0·80	28	14	24	Lalande 5145	2. 47	13. 20	+1·05	1	1	3
Groombridge 2283	15. 10	2. 22	+0·15	16	13	21	Lalande F. 1998	11. 58	13. 22	+1·40	1	1	3
Cephei 51	6. 53	2. 47	+0·25	26	69	30	Groombridge 1687	10. 43	13. 28	+0·01	1	1	3
Bradley 3147	23. 27	3. 16	+0·31	18	27	25	Groombridge 1059	6. 1	13. 29	+1·17	2	1	3
δ Ursæ Minoris	18. 26	3. 23	−0·11	55	33	30	B. D. + 76° No. 664	17. 51	13. 37	+0·42	1	1	3
Groombridge 3548	21. 21	3. 23	+0·38	16	11	20	Lalande 37241	19. 24	13. 39	+1·02	1	2	4
Bradley 1399	10. 15	5. 13	+0·02	4	2	7	Oeltz. Arg. (N.) 1726	1. 32	13. 41	+1·13	1	1	3
Piazzi XIII. 263	13. 45	6. 44	−0·02	2	2	5	Groombridge 512	2. 24	13. 44	+0·27	1	1	3
Piazzi VI. 292	7. 10	7. 23	+0·23	3	2	6	19 Ursæ Minoris	16. 14	13. 52	+0·24	3	1	3
Piazzi VI. 285	7. 5	8. 33	−0·34	5	2	7	Groombridge 758	3. 53	13. 52	+1·52	1	1	3
Bradley 344	2. 34	8. 59	−0·14	1	4	5	Bradley 1147	8. 6	13. 56	+0·71	3	1	3
Lalande F. 1745	10. 45	10. 6	−1·44	1	2	4	Groombridge 784	4. 9	14. 9	+1·74	1	1	3
Lalande F. 856	6. 16	10. 28	−1·19	1	1	3	Piazzi IV. 112	4. 35	14. 15	−0·83	1	2	4
Groombridge 2900	19. 28	10. 36	+0·19	1	1	3	Lalande F. 490	2. 59	14. 18	+1·50	1	1	3
Groombridge 445	2. 1	10. 48	+0·99	1	1	3	Oeltz. Arg. (N.) 9576	9. 3	14. 18	+0·19	2	1	3
Piazzi XVI. 182	16. 31	10. 49	−0·11	1	1	3	Groombridge 993	5. 38	14. 20	−0·32	1	1	3
Bradley 117	1. 3	10. 52	+0·69	1	1	3	Oeltz. Arg. (N.) 6857	6. 23	14. 22	+0·61	1	1	3
Piazzi IV. 269	5. 4	10. 53	+0·86	1	3	5	Oeltz. Arg. (N.) 15766	15. 50	14. 24	−0·14	1	1	3
Groombridge 1747	11. 7	11. 8	+0·54	1	2	4	Groombridge 861	4. 39	14. 28	−0·72	1	1	3
Oeltz. Arg. (N.) 2917	2. 32	11. 15	+0·80	1	1	3	Bradley 2748	20. 56	14. 28	+2·25	1	1	3
Groombridge 452	2. 4	11. 18	+1·64	1	2	4	Bradley 473	3. 28	14. 36	+0·96	1	3	5
Lalande F. 1027–8	7. 10	11. 33	−0·49	1	1	3	Groombridge 126	0. 38	14. 37	−0·77	1	1	3
Groombridge 1735	11. 3	11. 39	−0·36	1	3	5	Groombridge 2424	17. 4	14. 38	−0·54	1	2	4
ρ Cephei	22. 27	11. 42	+1·03	1	4	5	Groombridge 3384	20. 57	14. 41	+0·61	1	1	3
Groombridge 1803	11. 30	11. 50	+0·18	1	1	3	50 Draconis	18. 50	14. 41	−0·31	1	1	3
ζ Ursæ Minoris	15. 48	11. 53	−0·08	5	2	6	Lalande 33393–7	17. 58	14. 49	+1·01	1	1	3
Bradley 1633	12. 7	11. 59	+1·32	3	1	4	3 Ursæ Minoris	14. 6	14. 55	+2·07	1	1	3
Groombridge 1137	6. 20	12. 0	−0·40	1	2	4	Groombridge 379	1. 42	14. 55	+1·71	1	2	4
Lalande F. 2015	12. 5	12. 2	+0·84	2	1	3	Oeltz. Arg. (N.) 14328	14. 4	14. 56	+2·14	1	1	3
Groombridge 1361	7. 43	12. 9	+1·03	1	1	3	Piazzi XXIII. 1	23. 1	14. 59	+0·59	1	2	4
Groombridge 469	2. 10	12. 13	−0·27	1	1	3	Oeltz. Arg. (N.) 13950	13. 40	15. 0	−0·33	1	1	3
Groombridge 2391	16. 48	12. 18	−1·37	1	2	4	Groombridge 3857	22. 34	15. 10	+0·39	1	2	4
Bradley 230	1. 45	12. 19	+0·23	1	1	3	π Cephei	23. 5	15. 10	+1·43	1	2	4
Piazzi XVI. 195	16. 35	12. 21	+0·56	1	1	3	Lalande F. (2) 90	8. 44	15. 12	+0·73	1	1	3
Lalande 3523–5	18. 43	12. 25	+0·58	3	1	4	Radcliffe 1476	5. 24	15. 23	−0·17	1	1	3
Oeltz. Arg. (N.) 18126	18. 12	12. 26	−0·47	1	1	3	73 Draconis	20. 33	15. 24	+0·87	1	1	3
Oeltz. Arg. (N.) 18134	18. 13	12. 28	+0·27	1	1	3	Piazzi XVII. 369	17. 54	15. 25	+0·86	1	2	4
Piazzi XIX. 81	19. 6	12. 29	+2·66	1	1	3	β Ursæ Minoris	14. 51	15. 25	+1·27	4	4	9
Groombridge 2655	18. 34	12. 32	−0·60	1	2	4	Groombridge 986	5. 32	15. 26	+1·74	1	1	3
Oeltz. Arg. (N.) 5094	4. 41	12. 34	−0·51	1	1	3	Oeltz. Arg. (N.) 6411	5. 58	15. 28	+0·84	1	1	3
Lalande F. 701	4. 58	12. 37	−0·47	1	2	4	Bradley 2897	21. 57	15. 30	+0·05	1	1	3
Piazzi VI. 201	6. 45	12. 54	+2·34	1	1	3	Lalande F. 3638–9	20. 53	15. 38	+1·64	1	1	3
γ Cephei	23. 35	12. 57	−0·58	1	8	6	Oeltz. Arg. (N.) 2007–9	1. 43	15. 42	+0·30	1	1	3
							Groombridge 1342	7. 35	15. 42	+1·27	1	1	3

CORRECTION TO ASSUMED COLATITUDE—*continued.*

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	Below Pole.	Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	Above Pole.	Weight.
	h m	° ′	″					h m	° ′	″			
23 Cassiopeiæ	0. 41	15. 43	+0·23	1	1	3	Oeltz. Arg. (N.) 847	0. 49	17. 25	+1·05	1	1	3
Radcliffe 1242	4. 26	15. 44	−0·55	1	2	4	Oeltz. Arg. (N.) 21378–9	20. 5	17. 27	−1·69	1	1	3
Lalande 47031	23. 54	15. 46	−1·63	1	1	3	Lalande 21235	11. 2	17. 29	−0·09	2	1	3
Lalande 46673	23. 44	15. 47	+0·82	1	1	3	Lalande F. 1961	11. 50	17. 30	+1·28	4	1	3
Groombridge 1374	7. 48	15. 48	+0·37	1	1	3	Lalande F. 442	2. 40	17. 31	+0·92	1	1	3
51 Cassiopeiæ	1. 57	15. 55	+0·41	1	1	3	Oeltz. Arg. (N.) 20711	20. 27	17. 31	−0·34	2	1	3
Groombridge 2719	18. 48	16. 2	+0·91	3	1	3	B. D. + 72° No. 288	5. 40	17. 33	+0·90	1	1	3
Groombridge 3891	22. 43	16. 7	0·00	1	1	3	Groombridge 37	0. 12	17. 38	+1·84	1	1	3
Lalande F. 1957	11. 47	16. 8	+1·74	1	1	3	Oeltz. Arg. (N.) 9826	9. 17	17. 38	−0·63	1	1	3
Groombridge 609	3. 3	16. 9	+2·32	1	1	3	Oeltz. Arg. (N.) 2779	2. 22	17. 39	+1·06	1	1	3
Groombridge 4163	23. 49	16. 10	+2·10	1	1	3	Lalande F. 2295	13. 28	17. 41	−1·92	1	1	3
Piazzi IV. 254	4. 59	16. 11	+0·76	2	1	3	Piazzi XVIII. 186	18. 36	17. 41	+1·82	1	1	3
Lalande F. (2) 28	6. 26	16. 14	−0·59	2	1	3	Groombridge 828	4. 22	17. 42	−0·75	1	1	3
Lalande F. 131	0. 47	16. 15	+2·10	1	1	3	Piazzi XVIII. 199	18. 38	17. 43	−0·22	2	1	3
Lalande F. 1349	8. 35	16. 20	−0·25	1	1	3	Lalande F. 4329–30	22. 54	17. 43	−0·67	1	1	3
Lalande F. 3169	19. 17	16. 21	−0·46	1	1	3	Groombridge 3156	20. 15	17. 43	+0·17	1	1	3
Bradley 282	2. 4	16. 27	+1·01	1	1	3	Groombridge 569	2. 48	17. 45	−1·84	1	1	3
Lalande F. 482	2. 55	16. 28	+1·01	1	3	5	Oeltz. Arg. (N.) 10038	9. 32	17. 47	+1·23	1	1	3
Oeltz. Arg. (N.) 6762	6. 17	16. 28	−0·17	1	1	3	γ Ursæ Minoris	15. 20	17. 48	−0·19	8	3	8
Lalande F. (2) 62	7. 4	16. 30	−0·58	1	1	3	ψ Draconis	17. 44	17. 48	+0·49	3	1	3
Groombridge 612	3. 4	16. 31	+0·33	1	3	5	Oeltz. Arg. (N.) 11091	10. 39	17. 48	+0·16	1	1	3
Groombridge 2400	16. 53	16. 32	+0·21	1	1	3	11 Ursæ Minoris	15. 6	17. 48	−0·27	1	1	3
Lalande F. 2747	16. 7	16. 35	+0·41	1	1	3	Lalande F. 480	2. 52	17. 49	−0·47	1	1	3
Groombridge 1974	13. 11	16. 39	−0·68	1	1	3	Oeltz. Arg. (N.) 18555	18. 37	17. 49	+2·68	1	1	3
Groombridge 2418	17. 4	16. 40	+3·37	1	1	3	Bradley 2673	20. 30	17. 49	+1·37	1	1	3
79 Draconis	21. 51	16. 47	+0·07	2	3	6	Oeltz. Arg. (N.) 6606	6. 9	17. 49	+1·21	1	1	3
Oeltz. Arg. (N.) 18575	18. 38	16. 49	+0·07	1	1	3	B. D. + 72° No. 213	4. 7	17. 50	+0·46	1	1	3
Oeltz. Arg. (N.) 6211	5. 44	16. 50	−1·12	1	1	3	Lalande 7634	4. 7	17. 51	+1·00	2	2	4
Lalande 33054	17. 49	16. 50	+0·58	1	1	3	Lalande F. 2165–6	12. 49	17. 52	+1·46	1	1	3
τ Draconis	19. 18	16. 50	+0·42	4	2	6	Lalande F. 1568	9. 45	17. 50	+0·73	1	1	3
Groombridge 4040	23. 14	16. 52	+1·48	1	1	3	Lalande 33682	18. 11	17. 52	+1·21	1	1	3
Groombridge 1865	12. 11	16. 53	−1·11	1	1	3	B. D. + 72° No. 322	6. 24	17. 54	+1·84	2	1	3
31 Cephei	22. 33	16. 53	+1·24	2	1	3	Oeltz. Arg. (N.) 9614	9. 3	17. 55	+1·76	2	1	3
Oeltz. Arg. (N.) 3933–4	3. 32	16. 56	−0·57	1	1	3	Lalande 36519	19. 10	17. 56	+0·35	1	1	3
Lalande F. 385–6	2. 15	16. 58	+0·38	1	3	4	Groombridge 1363	7. 42	17. 57	+1·03	1	1	3
Oeltz. Arg. (N.) 2611	2. 14	16. 59	+0·48	1	1	3	Lalande F. 3353	19. 57	17. 58	+0·39	1	1	3
Bradley 471	3. 25	17. 0	+0·06	1	1	3	ψ² Draconis	17. 57	17. 59	−0·26	2	2	5
Groombridge 558	2. 45	17. 3	+1·26	1	1	3	Lalande F. 3898	17. 25	18. 2	+0·02	3	1	3
Oeltz. Arg. (N.) 5136	4. 42	17. 7	+0·19	1	1	3	Lalande 443	2. 40	18. 5	+0·58	1	1	2
Piazzi XVIII. 221	18. 40	17. 8	+0·57	1	1	3	Lalande 36381	19. 8	18. 6	+1·80	1	1	2
Groombridge 552	2. 43	17. 9	+0·77	1	1	3	Oeltz. Arg. (N.) 7280	6. 46	18. 7	+0·22	1	1	2
Lalande F. 1008	7. 0	17. 10	−0·43	1	2	4	Lalande 37702	19. 22	18. 6	+0·46	1	1	2
B. D. + 72° No. 427	8. 36	17. 15	−0·22	1	1	3	24 Cephei	22. 7	18. 10	+2·17	2	1	3
16 Cephei	21. 58	17. 19	+0·39	2	1	3	Lalande 6061	3. 17	18. 10	+1·54	1	1	2
χ Draconis	18. 23	17. 19	+0·94	8	1	3	Oeltz. Arg. (N.) 6978	6. 28	18. 10	−0·71	1	1	2
Lalande 32901	17. 47	17. 20	+1·29	2	2	5	Oeltz. Arg. (N.) 3762	3. 22	18. 10	+0·89	2	2	5
Piazzi I. 194	1. 50	17. 21	+0·22	1	1	3	Lalande F. 2062	12. 17	18. 11	+2·98	1	1	2
Lalande F. 1311	8. 20	17. 22	+0·38	2	1	3	Oeltz. Arg. (N.) 20415	20. 15	18. 11	−0·46	1	1	2
Groombridge 3946	22. 54	17. 25	−0·66	1	1	3	Oeltz. Arg. (N.) 3755	3. 21	18. 11	+0·75	2	2	5

CORRECTION TO ASSUMED COLATITUDE—*continued.*

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	No. of Observations. Below Pole.	Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	No. of Observations. Below Pole.	Weight.
	h m	° ′	″					h m	° ′	″			
Oeltz. Arg. (N.) 6979	6. 28	18. 13	+0·20	1	1	2	Groombridge 1413 ...	8. 7	19. 31	+1·75	1	1	2
Groombridge 3701 ...	22. 5	18. 17	+0·34	1	1	2	Lalande 35232........	18. 44	19. 32	+0·55	1	1	2
Radcliffe 3968.........	18. 27	18. 20	+0·27	5	1	3	Lalande F. 1144	7. 38	19. 33	−0·37	1	1	2
Groombridge 2356...	16. 26	18. 23	−0·77	4	1	3	B. D. + 70° No. 651	11. 4	19. 33	+0·18	1	1	2
Bradley 2934.........	22. 8	18. 24	+1·47	1	2	4	Lalande F. 3405......	20. 9	19. 33	−1·54	1	1	2
Lalande F. 1653......	10. 7	18. 26	+0·19	2	1	3	B. D. + 70° No. 908	17. 7	19. 34	+1·76	1	1	2
Lalande F. 1654......	10. 8	18. 26	−0·35	2	1	3	Oeltz. Arg. (N.) 11184	10. 47	19. 34	−1·07	1	1	2
Oeltz. Arg. (N.) 3041 .	2. 36	18. 28	−0·61	1	1	2	Bradley 42	0. 27	19. 35	−0·27	2	3	5
Oeltz. Arg. (N.) 13022	12. 44	18. 29	+0·81	1	2	4	48 Cassiopeiæ.........	1. 54	19. 36	−0·10	1	2	3
Bradley 2331.........	18. 21	18. 32	−0·84	1	2	4	Oeltz. Arg. (N.) 9623–5.	9. 4	19. 36	−1·44	1	1	2
Groombridge 2917...	19. 36	18. 37	+0·35	1	1	2	Groombridge 1697 ...	10. 47	19. 36	−0·15	3	1	3
Oeltz. Arg. (N.) 2324	2. 0	18. 39	−0·11	1	2	4	Groombridge 3422 ...	21. 10	19. 36	+1·90	1	1	2
Lalande F. 1631......	10. 2	18. 39	−0·78	1	1	2	Groombridge 2312 ..	16. 3	19. 36	−0·26	1	1	2
Oeltz. Arg. (N.) 17350	17. 33	18. 41	−0·61	1	1	2	Oeltz. Arg. (N.) 9621–2.	9. 4	19. 38	−0·26	1	2	3
Oeltz. Arg. (N.) 9196–8.	8. 36	18. 41	+1·87	1	1	2	κ Draconis..............	12. 29	19. 39	+0·19	3	2	5
Oeltz. Arg. (N.) 5253	4. 49	18. 42	−0·10	1	1	2	Bradley 3086.........	23. 11	19. 40	+1·62	1	2	3
Oeltz. Arg. (N.) 4874	4. 26	18. 44	+0·96	1	1	2	Oeltz. Arg. (N.) 2120–1.	1. 50	19. 41	+0·56	1	1	2
Lalande F. 688.......	4. 27	18. 45	+0·98	2	1	3	B. D. + 70° No. 353	5. 17	19. 42	+0·02	1	1	2
Oeltz. Arg. (N.) 6159	5. 40	18. 45	+3·20	1	1	2	Lalande F. 4162......	22. 24	19. 44	+1·80	1	1	2
Lalande 36832........	19. 19	18. 51	+1·54	3	1	3	Lalande 35399........	18. 48	19. 44	+0·24	1	1	2
Oeltz. Arg. (N.) 6462	6. 0	18. 51	+0·15	1	1	2	Groombridge 127.....	0. 38	19. 44	−0·76	2	1	3
Oeltz. Arg. (N.) 7148	6. 38	18. 53	+0·78	1	1	2	Oeltz. Arg. (N.) 2135–6.	1. 50	19. 44	+0·55	1	1	2
Oeltz. Arg. (N.) 7616	7. 8	18. 54	−1·71	1	1	2	Lalande F. 4151–9...	22. 23	19. 45	+0·28	1	1	2
Oeltz. Arg. (N.) 803..	0. 46	18. 55	+0·07	1	1	2	Oeltz. Arg. (N.) 25372–3	23. 12	19. 45	−0·90	1	1	2
Bradley 3140.........	23. 30	18. 56	−0·38	1	2	3	Oeltz. Arg. (N.) 7696	7. 12	19. 47	−0·23	1	1	2
54 Cassiopeiæ.........	2. 0	18. 56	−0·01	1	2	4	Oeltz. Arg. (N.) 7276	6. 46	19. 47	+0·91	1	1	2
Piazzi XIV. 285......	15. 0	18. 59	+1·49	1	1	2	Groombridge 148.....	0. 43	19. 47	−1·56	1	1	2
Lalande F. 4571......	23. 43	19. 5	+0·05	1	1	2	Oeltz. Arg. (N.) 7708	7. 12	19. 49	+0·47	1	1	2
Lalande F. 1986......	11. 54	19. 5	−1·81	1	1	2	Groombridge 519.....	2. 26	19. 49	−0·58	1	1	2
Oeltz. Arg. (N.) 9317	8. 43	19. 9	−0·10	1	2	3	Oeltz. Arg. (N.) 26171–2	23. 49	19. 49	−0·79	1	1	2
B. D. + 70° No. 417	6. 34	19. 9	+0·19	2	1	3	B. D. + 70° No. 736	13. 19	19. 49	+1·69	1	1	2
11 Cephei	21. 40	19. 10	+0·88	3	1	3	Lalande F. 3368......	20. 2	19. 50	−2·39	1	1	2
Lalande 34050–4.....	18. 16	19. 12	−0·15	2	2	4	Oeltz. Arg. (N.) 7271 .	6. 45	19. 50	+0·46	1	1	2
Groombridge 1863...	12. 10	19. 14	−0·14	3	1	3	Oeltz. Arg. (N.) 20910	20. 35	19. 51	−0·85	1	1	2
Oeltz. Arg. (N.) 19454	19. 33	19. 14	−1·81	1	1	2	Oeltz. Arg. (N.) 11300	10. 54	19. 52	+0·38	1	1	2
B. D. + 70° No. 1313	23. 15	19. 14	+1·49	1	1	2	Oeltz. Arg. (N.) 5741..	5. 16	19. 52	+0·56	1	1	2
Groombridge 868.....	4. 39	19. 15	+0·63	1	2	4	Lalande F. 4596......	23. 50	19. 53	+0·15	1	1	2
Groombridge 433.....	1. 57	19. 17	+0·97	1	1	2	β² Cephei..............	21. 27	19. 53	+0·63	1	1	2
Oeltz. Arg. (N.) 2301	1. 58	19. 19	−0·11	1	1	2	Oeltz. Arg. (N.) 2312	1. 59	19. 54	−0·50	1	1	2
Bradley 2382..........	18. 44	19. 19	+1·13	1	1	2	Oeltz. Arg. (N.) 11416–7	11. 1	19. 54	+3·03	1	1	2
Groombridge 1470...	8. 41	19. 19	+1·06	1	1	2	Oeltz. Arg. (N.) 11387–8	10. 59	19. 55	+1·64	1	1	2
Lalande F. 2305–6...	13. 32	19. 21	+0·62	1	1	2	Lalande F. 3359......	19. 59	19. 55	−0·36	1	1	2
Lalande F. 2773......	16. 19	19. 23	+1·25	2	1	3	Lalande F. 3355–6...	19. 58	19. 55	−0·34	1	1	2
6 Draconis............	12. 30	19. 25	−0·34	2	1	3	Piazzi XXI. 173......	21. 25	19. 58	−0·02	1	1	2
Groombridge 1727...	10. 56	19. 25	+2·30	4	1	3	Lalande F. 3744......	21. 19	19. 59	+0·67	1	1	2
Lalande F. 189.......	1. 7	19. 27	−0·17	1	2	4	ε Draconis............	19. 48	20. 0	−0·84	1	1	2
Oeltz. Arg. (N.) 2916	2. 30	19. 29	+1·00	1	1	2	Groombridge 97......	0. 30	20. 0	+0·97	1	1	2
Oeltz. Arg. (N.) 2919	2. 30	19. 29	+1·49	1	1	2	Oeltz. Arg. (N.) 2077	1. 47	20. 1	+2·27	1	1	2
Oeltz. Arg. (N.) 5212	4. 46	19. 31	−0·79	1	1	2	B. D. + 69 No. 150	2. 21	20. 3	+0·06	1	1	2

CORRECTION TO ASSUMED COLATITUDE—*continued.*

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	No. of Observations. Below Pole.	Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	No. of Observations. Below Pole.	Weight.
	h m	° ′	″					h m	° ′	″			
Groombridge 186	0. 51	20. 4	+0·52	1	1	2	Lalande 5578	3. 0	20. 37	−0·15	1	1	2
Oeltz. Arg. (N.) 26187	23. 50	20. 4	−0·64	1	1	2	Piazzi XX. 359	20. 44	20. 37	+0·04	2	1	3
Groombridge 1440	8. 26	20. 4	+0·20	1	1	2	Oeltz. Arg. (N.) 3338	2. 54	20. 39	−0·50	1	1	2
Oeltz. Arg. (N.) 5954	5. 29	20. 5	+1·01	1	1	2	Groombridge 1947	12. 55	20. 40	+0·91	2	1	3
Groombridge 2091	14. 10	20. 5	+0·42	2	1	3	Lalande F. 1336	8. 30	20. 41	−0·15	1	2	3
Groombridge 172	0. 50	20. 6	−0·08	1	1	2	B. D. + 69° No. 816	15. 49	20. 42	+1·93	1	1	2
Groombridge 2441	17. 22	20. 6	+0·67	1	2	3	Lalande 19480	9. 56	20. 43	−1·86	1	1	2
Groombridge 145	0. 42	20. 7	+1·25	1	1	2	Piazzi X. 26	10. 13	20. 44	−0·26	1	1	2
Oeltz. Arg. (N.) 17178–9	17. 24	20. 8	+0·57	1	2	3	Groombridge 1946	12. 55	20. 44	+0·60	2	1	3
Groombridge 2439	17. 20	20. 9	+0·17	1	1	2	Groombridge 1425	8. 13	20. 45	−0·96	1	1	2
Lalande F. 3998	21. 58	20. 9	+1·77	1	1	2	Oeltz. Arg. 18659–61	18. 44	20. 46	+0·48	1	1	2
Oeltz. Arg. (N.) 7236–7	6. 44	20. 12	+1·26	1	1	2	Lalande F. 2446	14. 15	20. 46	+0·39	2	1	3
Bradley 3125	23. 23	20. 12	+0·76	1	2	3	B. D. + 69° No. 450	7. 50	20. 47	+0·72	1	1	2
Lalande F. 1841	11. 10	20. 13	+0·50	2	1	3	Lalande 660	0. 25	20. 47	+0·10	1	1	2
Groombridge 226	0. 59	20. 14	+1·32	1	1	2	Lalande 19422	9. 53	20. 47	+0·53	1	1	2
Oeltz. Arg. (N.) 11619	11. 11	20. 15	+2·46	1	1	2	Bradley 373	2. 40	20. 48	+1·34	2	1	3
Lalande F. 4319	22. 52	20. 15	−0·68	1	1	2	B. D. + 69° No. 235	3. 56	20. 49	−0·14	1	1	2
Oeltz. Arg. (N.) 7109	6. 35	20. 16	+1·16	1	1	2	Lalande 32719	17. 43	20. 49	−0·18	1	1	2
B. D. + 69° No. 78	1. 9	20. 17	+0·76	1	1	2	Piazzi XIII. 306	14. 0	20. 50	−0·38	2	1	3
Groombridge 3842	22. 32	20. 17	+1·56	1	2	3	Lalande 19653	10. 1	20. 50	+0·61	1	1	2
Lalande F. 2448	14. 16	20. 18	−0·14	2	1	3	Lalande 8101	4. 19	20. 51	+0·40	1	1	2
Groombridge 1564	9. 33	20. 18	+0·29	1	1	2	Lalande 1917	1. 2	20. 52	+0·99	2	3	6
Oeltz. Arg. (N.) 17399	17. 36	20. 18	+2·63	1	1	2	Lalande 5328	2. 51	20. 55	+1·80	2	1	3
Oeltz. Arg. (N.) 8644–5	8. 5	20. 19	+1·88	2	1	3	Lalande 3625	1. 56	20. 55	−0·80	1	1	2
Groombridge 3590	21. 46	20. 20	+1·15	1	1	2	Groombridge 2952	19. 44	20. 55	+0·04	1	1	2
Piazzi VIII. 52	8. 22	20. 20	−0·45	2	3	5	B. D. + 68° No. 75	1. 3	20. 56	+0·46	1	1	2
Oeltz. Arg. (N.) 17433–4	17. 37	20. 22	+0·89	1	1	2	Oeltz. Arg. (N.) 17193	17. 25	20. 56	−1·27	2	1	3
Lalande 33223	17. 56	20. 22	+1·51	1	1	2	Oeltz. Arg. (N.) 6281	5. 50	20. 58	+0·24	1	1	2
Groombridge 3719	22. 8	20. 23	+0·32	1	1	2	B. D. + 68° No. 329	4. 21	20. 59	+0·18	1	1	2
10-yr. Cat., 1880, No. 3712	22. 9	20. 23	+0·62	1	1	2	43 Camelopardi	6. 43	21. 0	−0·13	3	4	7
Lalande 17780	9. 0	20. 23	+0·99	2	1	3	Lalande 18801	9. 32	21. 0	+0·14	1	1	2
Piazzi X. 126	10. 36	20. 23	−0·91	2	1	3	Oeltz. Arg. (N.) 11760	11. 21	21. 0	−0·03	1	1	2
Piazzi XXI. 88	21. 13	20. 24	+0·08	1	1	2	Lalande 30667	1. 37	21. 1	−0·24	1	1	2
Lalande F. 513	3. 7	20. 24	+1·89	1	1	2	Groombridge 1669	10. 35	21. 1	+0·11	1	1	2
Lalande F. 632	3. 57	20. 25	+2·90	1	1	2	Oeltz. Arg. (N.) 1009	0. 57	21. 2	+0·69	1	1	2
Oeltz. Arg. (N.) 5861	5. 23	20. 25	−0·72	1	1	2	Lalande F. 2236	13. 15	21. 3	−0·69	1	1	2
Lalande F. 4104–6	22. 14	20. 27	+1·06	3	1	3	Groombridge 888	4. 49	21. 3	+1·21	1	1	2
Groombridge 3297	20. 41	20. 28	−0·18	1	1	2	Lalande 6168	3. 29	21. 5	−0·34	1	1	2
B. D. + 69° No. 793	15. 15	20. 28	−3·21	1	1	2	Oeltz. Arg. (N.) 6665	6. 11	21. 5	+0·64	1	1	2
Groombridge 711 (1st Star)	3. 32	20. 29	+1·15	1	1	2	B. D. + 68° No. 1174	20. 59	21. 5	+0·40	1	1	2
Oeltz. Arg. (N.) 15502	15. 31	20. 30	−2·10	1	1	2	Lalande F. 3133	19. 9	21. 5	−0·93	1	1	2
Oeltz. Arg. (N.) 5424	4. 59	20. 30	+1·31	4	1	3	Oeltz. Arg. (N.) 14774	14. 35	21. 6	−0·53	1	1	2
Oeltz. Arg. (N.) 12680	12. 24	20. 31	+0·66	1	1	2	Oeltz. Arg. (N.) 32196	17. 29	21. 6	+1·56	2	1	3
σ Draconis	19. 32	20. 31	+0·48	3	2	5	B. D. + 68° No. 301	3. 53	21. 7	+2·45	1	1	2
Oeltz Arg. (N.) 23575	22. 6	20. 31	−0·98	2	3	6	B. D. + 68° No. 153	2. 5	21. 7	+1·18	1	2	3
B. D. + 69° No. 325	5. 19	20. 36	+0·50	1	2	3	Lalande 4698	2. 29	21. 9	+0·22	1	1	2
Oeltz. Arg. (N.) 17312–3	17. 31	20. 36	+1·07	2	1	3	Lalande F. 1411	8. 57	21. 9	+0·75	1	1	2
Lalande 19247	9. 46	20. 37	−0·33	1	1	2	Lalande 31185	16. 58	21. 9	−1·24	2	1	3
Lalande 35905	18. 59	20. 37	+1·83	1	1	2	Oeltz. Arg. (N.) 22947	21. 46	21. 9	+1·13	1	1	2

CORRECTION TO ASSUMED COLATITUDE—*continued.*

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	No. of Observations. Below Pole.	Weight.
	h m	° ′	″			
B. D. + 68° No. 535	8. 31	21. 10	+0·80	1	1	2
Oeltz. Arg. (N.) 11509	11. 7	21. 10	+1·19	4	1	3
Lalande 32270	17. 31	21. 11	+2·51	2	1	3
Oeltz. Arg. (N.) 15697	15. 46	21. 11	−2·30	1	1	2
Lalande F. 3187	19. 23	21. 11	+0·51	2	1	3
Lalande 1676	0. 55	21. 12	−0·69	1	2	3
Groombridge 2338	16. 18	21. 12	−0·49	1	1	2
Lalande 5264	2. 49	21. 13	+1·33	3	1	3
Lalande 1177	0. 40	21. 14	−2·17	2	1	3
Oeltz. Arg. (N.) 21250	20. 47	21. 15	+0·25	1	1	2
B. D. + 68° No. 447	6. 31	21. 16	+0·42	1	1	2
B. D. + 68° No. 1399	23. 45	21. 16	+1·19	1	1	2
Oeltz. Arg. (N.) 7668	7. 10	21. 16	+0·65	1	1	2
Lalande 32987–8	17. 50	21. 17	+1·89	1	1	2
38 Draconis	18. 18	21. 18	+0·51	2	1	3
Oeltz. Arg. (N.) 1390	1. 15	21. 18	−0·37	1	1	2
Oeltz. Arg. (N.) 8003	7. 27	21. 19	+1·49	1	1	2
Lalande F. 4223	22. 33	21. 20	−0·58	1	1	2
Lalande 4656	2. 29	21. 24	+0·98	1	1	2
Oeltz. Arg. (N.) 2959	2. 32	21. 24	+0·10	1	1	2
Piazzi XXI. 293	21. 41	21. 25	+0·91	1	1	2
Lalande 7155	3. 53	21. 27	+0·76	1	1	2
Bradley 2636	20. 20	21. 27	−0·47	2	2	5
Piazzi XVII. 237	17. 36	21. 27	+0·10	2	1	3
Groombridge 2129	14. 29	21. 28	−0·76	1	1	2
B. D. + 68° No. 1003	18. 33	21. 28	+0·70	1	1	2
Oeltz. Arg. (N.) 9502	8. 56	21. 29	+2·44	1	1	2
Oeltz. Arg. (N.) 390	0. 24	21. 30	+0·24	1	2	3
Oeltz. Arg. (N.) 7337	6. 47	21. 30	−1·85	1	1	2
Oeltz. Arg. (N.) 5656	5. 10	21. 31	+0·58	1	1	2
Bradley 382	2. 43	21. 32	+0·51	3	1	3
Lalande 1806	0. 59	21. 34	+1·29	1	2	3
Bradley 2655	20. 26	21. 35	−1·82	1	1	2
Oeltz. Arg. (N.) 14139	13. 53	21. 35	−2·22	1	1	2
Lalande 7284	3. 55	21. 36	+1·64	2	1	3
Lalande F. 1977	11. 54	21. 37	+0·98	2	1	3
Lalande F. 2137	12. 39	21. 40	−0·15	1	1	2
Lalande 13022	6. 46	21. 41	−0·79	1	1	2
Oeltz. Arg. (N.) 13251–2	12. 58	21. 41	+2·06	1	1	2
Lalande 332	0. 15	21. 44	−0·31	1	1	2
Groombridge 2108	14. 19	21. 44	−0·68	4	1	3
Groombridge 2105	14. 17	21. 45	−2·46	3	1	3
Oeltz. Arg. (N.) 10795–6	10. 20	21. 48	+1·10	1	1	2
Lalande 6858	3. 43	21. 48	+2·22	1	1	2
Piazzi XVII. 220	17. 35	21. 49	+0·21	1	1	2
Oeltz. Arg. (N.) 21380	20. 52	21. 50	+0·77	1	1	2
Oeltz. Arg. (N.) 12006	11. 39	21. 51	+0·70	1	1	2
Oeltz. Arg. (N.) 7652–3	7. 8	21. 51	+0·25	1	1	2
Lalande F. 3077	18. 57	21. 51	+2·46	1	1	2
Groombridge 2263	15. 33	21. 51	+0·23	1	2	3
Lalande 5727	3. 5	21. 52	−0·41	1	2	3
B. D. + 67° No. 242	2. 56	21. 52	−1·27	1	1	2
Oeltz. Arg. (N.) 25298–9	23. 10	21. 55	+1·27	1	1	2
Lalande 30981	16. 52	21. 55	−0·12	1	1	2
Groombridge 2320	16. 6	21. 55	−0·01	1	1	2
Lalande 8394	4. 27	21. 56	+0·56	1	1	2
Groombridge 876	4. 44	21. 57	+0·11	2	1	3
ρ Ursæ Majoris	8. 54	21. 58	+0·66	2	1	3
Oeltz. Arg. (N.) 20594	20. 24	21. 58	+0·47	1	1	2
Lalande F. 3954	21. 51	21. 59	+3·05	2	1	3
Oeltz. Arg. (N.) 5592	5. 7	22. 1	+0·57	1	1	2
Oeltz. Arg. (N.) 11067	10. 37	22. 3	−0·09	4	1	3
Oeltz. Arg. (N.) 20618	20. 24	22. 3	−0·35	1	1	2
Oeltz. Arg. (N.) 5856	5. 23	22. 4	+0·28	1	1	2
Oeltz. Arg. (N.) 13271	13. 0	22. 5	+1·00	1	1	2
Lalande F. 1827	11. 7	22. 7	−1·03	4	1	3
Oeltz. Arg. (N.) 377	0. 23	22. 8	0·00	1	1	2
Lalande F. 4371	23. 1	22. 9	+1·99	1	1	2
Piazzi VIII. 8	8. 10	22. 9	+0·72	2	1	3
Lalande 22452	11. 50	22. 10	+0·23	1	1	2
Groombridge 3497	21. 29	22. 10	+0·87	3	1	3
Oeltz. Arg. (N.) 14638	14. 27	22. 11	+0·84	1	1	2
Lalande F. 1293	8. 12	22. 12	+0·22	1	1	2
Lalande F. 1133–4	7. 32	22. 12	+0·42	1	1	2
Lalande F. 4033	22. 5	22. 12	+0·71	1	1	2
Lalande F. 1614	9. 57	22. 13	+0·22	2	1	3
Lalande 30895	16. 51	22. 14	+1·81	1	1	2
Groombridge 3527	21. 34	22. 15	+0·13	1	2	3
Lalande 7088	3. 48	22. 17	+0·80	1	1	2
Groombridge 3538	21. 35	22. 17	+1·04	1	1	2
Oeltz. Arg. (N.) 10584–6	10. 5	22. 17	+0·63	1	1	2
Lalande F. 2982	18. 33	22. 18	+2·54	1	1	2
42 Camelopardi	6. 43	22. 19	+0·37	3	3	6
Oeltz. Arg. (N.) 17642	17. 50	22. 20	−0·21	1	1	2
Piazzi XI. 34	11. 14	22. 20	+0·74	4	2	5
Lalande 22517	11. 52	22. 21	+0·55	1	1	2
Lalande 6446	3. 29	22. 21	+0·38	1	1	2
Lalande 11206	5. 55	22. 21	−0·32	2	1	3
Lalande F. 3602–3	20. 47	22. 21	+2·10	3	1	3
Lalande 3349	1. 47	22. 21	+1·35	1	1	2
Piazzi VIII. 46	8. 19	22. 22	+0·92	1	3	4
Lalande 7774	4. 10	22. 22	+0·74	1	2	3
Bradley 358	2. 34	22. 23	+1·51	2	2	5
Groombridge 1428	8. 18	22. 23	+1·44	2	1	3
Lalande 6398	3. 27	22. 24	+1·28	1	2	3
B. D. + 67° No. 1293	21. 9	22. 26	−0·39	1	1	2
Groombridge 2025	13. 35	22. 26	+2·12	1	1	2
σ^2 Ursæ Majoris	9. 1	22. 27	−0·18	1	2	3

CORRECTION TO ASSUMED COLATITUDE—*continued.*

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Below Pole.	No. of Observations. Above Pole.	Weight.
	h m	° ′	″			
*	23. 15	22. 27	+1·83	2	1	3
o Cephei	23. 14	22. 27	+1·90	2	1	3
Oeltz. Arg. (N.) 9019	8. 24	22. 28	+0·92	1	1	2
Oeltz. Arg. (N.) 7452	6. 55	22. 29	−1·34	1	1	2
Lalande 31708	17. 16	22. 30	+0·51	3	2	5
Lalande 27522	14. 58	22. 30	−0·51	1	1	2
δ Draconis	19. 12	22. 31	−0·37	5	3	7
Lalande 7925	4. 14	22. 32	+0·11	1	1	2
Lalande F. 4301	22. 48	22. 33	+1·22	1	1	2
Lalande F. 4303	22. 49	22. 33	+0·40	1	1	2
Groombridge 2326	16. 12	22. 36	−0·18	2	1	3
Bradley 366	2. 36	22. 37	−1·25	1	1	2
Piazzi XVIII. 93	18. 20	22. 37	+0·11	2	1	3
Oeltz. Arg. (N.) 7232	6. 43	22. 39	+0·69	1	1	2
Oeltz. Arg. (N.) 11740	11. 20	22. 40	+1·57	1	1	2
Oeltz. Arg. (N.) 11462	11. 4	22. 41	+2·08	3	1	3
B. D. + 67° No. 532	8. 9	22. 42	+1·06	1	1	2
Lalande 4576–7	2. 26	22. 43	−0·41	1	1	2
σ^1 Ursæ Majoris	8. 59	22. 43	−0·48	2	1	3
B. F. 141	1. 11	22. 43	+0·55	2	3	6
Lalande 30250	16. 28	22. 44	−0·28	3	1	3
B. D. + 67° No. 1599	23. 59	22. 44	+0·84	1	1	2
Oeltz. Arg. (N.) 7831	7. 18	22. 44	+0·29	1	1	2
Radcliffe 2348	9. 27	22. 45	−0·80	1	1	2
Oeltz. Arg. (N.) 9959	9. 26	22. 45	−0·48	1	1	2
Lalande F. 1848	11. 13	22. 45	−1·52	3	1	3
Oeltz. Arg. (N.) 9020	8. 24	22. 45	+0·30	1	1	2
Groombridge 667	3. 23	22. 46	+1·11	1	1	2
Oeltz. Arg. (N.) 8904	8. 18	22. 47	−0·82	1	1	2
Lalande 37935	19. 45	22. 47	+1·35	1	1	2
Lalande F. 1679	10. 21	22. 47	+0·47	1	1	2
Oeltz. Arg. (N.) 7154	6. 38	22. 48	+1·44	1	1	2
B. D. + 67° No. 244	3. 0	22. 49	−1·48	1	1	2
B. D. + 67° No. 535	8. 11	22. 49	+1·16	1	1	2
Oeltz. Arg. (N.) 4551–2	4. 6	22. 50	+0·77	1	1	2
Oeltz. Arg. (N.) 5960	5. 29	22. 50	−0·29	1	1	2
Oeltz. Arg. (N.) 13091	12. 48	22. 50	+3·00	1	1	2
B. D. + 67° No. 436	6. 25	22. 51	+2·40	1	1	2
Groombridge 3259	20. 36	22. 51	−0·70	1	1	2
Oeltz. Arg. (N.) 5577	5. 6	22. 52	+0·88	1	1	2
Oeltz. Arg. (N.) 1677	1. 29	22. 55	−0·15	2	1	3
Piazzi VIII. 137	8. 39	22. 55	−0·56	1	1	2
Oeltz. Arg. (N.) 11143–5	10. 44	22. 55	−1·06	1	2	3
Lalande 915	0. 32	22. 55	−0·59	1	1	2
Groombridge 405	1. 51	22. 55	+2·03	1	1	2
Lalande F. 2829	16. 46	22. 56	−0·03	2	1	3
Groombridge 666	3. 23	22. 56	+1·41	2	2	5
Groombridge 526	2. 28	22. 56	+0·89	1	1	2
Groombridge 858	4. 36	22. 58	+1·41	1	1	2

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	No. of Observations. Below Pole.	Weight.
	h m	° ′	″			
Oeltz. Arg. (N.) 15009	14. 54	22. 58	+0·15	1	1	2
Lalande 34968	18. 39	22. 58	−0·35	1	1	2
Oeltz. Arg. (N.) 797	0. 45	22. 59	−0·58	1	1	2
Oeltz. Arg. (N.) 14552	14. 20	22. 59	−1·20	1	1	2
Lalande F. 495	2. 58	22. 59	−1·35	2	1	3
Oeltz. Arg. (N.) 11310	10. 54	22. 59	−1·46	2	2	5
Oeltz. Arg. (N.) 6870	6. 22	23. 1	+2·73	1	1	2
Lalande F. 404	2. 21	23. 2	+1·85	2	1	3
Oeltz. Arg. (N.) 16888	17. 7	23. 2	+0·35	1	1	2
Oeltz. Arg. (N.) 2766	2. 21	23. 3	+3·15	1	1	2
Bradley 332	2. 20	23. 4	+1·98	2	1	3
7-year Cat., 1860, No. 156	1. 21	23. 4	+1·37	1	1	2
B. D. + 66° No. 232	2. 40	23. 4	+2·93	2	1	3
Lalande 13875	7. 9	23. 4	+0·65	1	1	2
B. D. + 66° No. 387	5. 11	23. 5	+1·71	1	1	2
Oeltz. Arg. (N.) 10455	9. 57	23. 5	−0·22	1	1	2
Oeltz. Arg. (N.) 14597	14. 24	23. 10	−1·56	1	1	2
Lalande 7714	4. 8	23. 10	+0·37	1	1	2
Oeltz. Arg. (N.) 864	0. 50	23. 10	+0·75	1	1	2
Oeltz. Arg. (N.) 10490	9. 59	23. 11	−0·27	1	1	2
Oeltz. Arg. (N.) 21168	20. 45	23. 12	−0·27	1	1	2
Oeltz. Arg. (N.) 14625	14. 26	23. 12	+0·36	2	2	5
Lalande 36822	19. 20	23. 13	−0·36	1	1	2
Lalande 34198	18. 20	23. 15	−0·21	2	1	3
B. D. + 66° No. 1422	21. 36	23. 17	−0·31	1	1	2
Oeltz. Arg. (N.) 20530	20. 22	23. 17	−0·81	1	1	2
Lalande 22600	11. 56	23. 18	+1·01	1	1	2
Oeltz. Arg. (N.) 6834	6. 20	23. 19	−0·44	1	1	2
Oeltz. Arg. (N.) 1953	1. 40	23. 19	+1·43	1	1	2
Lalande F. 3461	20. 22	23. 19	+1·23	1	1	2
B. D. + 66° No. 1357	21. 5	23. 20	−1·52	1	1	2
Bradley 3054	23. 0	23. 21	+1·74	1	1	2
B. D. + 66° No. 1239	19. 45	23. 21	−1·08	1	1	2
Lalande F. 2383	13. 55	23. 23	+1·55	1	1	2
Lalande 1133	0. 39	23. 24	+1·01	1	1	2
Lalande F. 1823	11. 5	23. 24	+0·16	1	1	2
Oeltz. Arg. (N.) 2406	2. 3	23. 25	+0·12	1	1	2
Lalande F. 1822	11. 5	23. 25	+1·11	1	1	2
Groombridge 1299	7. 17	23. 28	−0·61	1	3	4
Oeltz. Arg. (N.) 10508	10. 1	23. 28	−0·84	2	1	3
Lalande F. 504	3. 0	23. 29	−0·84	2	1	3
Lalande F. 2133–4	12. 38	23. 29	+1·95	2	1	3
Lalande F. 2355	13. 46	23. 31	−2·25	1	1	2
Lalande 1128	0. 38	23. 31	+0·08	1	1	2
Lalande 37715	19. 40	23. 32	−1·40	1	1	2
Oeltz. Arg. (N.) 21483	20. 56	23. 32	−0·47	1	2	3
Oeltz. Arg. (N.) 16812–3	17. 2	23. 32	−1·42	1	1	2
Lalande F. 2473–5	14. 24	23. 33	−0·06	2	1	3
B. D. + 66° No. 491	7. 6	23. 33	−0·34	1	1	2

CORRECTION TO ASSUMED COLATITUDE—*continued.*

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	No. of Observations. Below Pole.	Weight.
	h m	° ′	″			
Lalande 33922	18. 14	23. 33	+0·04	1	1	2
Lalande 33083	17. 52	23. 34	+1·57	1	1	2
Oeltz. Arg. (N.) 11397	11. 0	23. 34	+0·56	4	1	3
B. D. + 66° No. 467	6. 40	23. 36	+2·71	1	1	2
B. D. + 66° No. 208	2. 16	23. 37	+0·18	1	1	2
Oeltz. Arg. (N.) 11381	10. 58	23. 38	+0·76	1	2	3
Oeltz. Arg. (N.) 20484	20. 20	23. 38	+0·16	1	1	2
Lalande F. 4470	23. 20	23. 38	−2·10	1	1	2
Oeltz. Arg. (N.) 7890	7. 21	23. 39	+1·08	2	1	3
Lalande F. 509	3. 3	23. 39	−0·34	2	1	3
Oeltz. Arg. (N.) 16564	16. 47	23. 40	−1·00	1	1	2
Lalande F. 4576	23. 46	23. 40	+0·71	2	1	3
Oeltz. Arg. (N.) 14845	14. 41	23. 40	−4·30	1	1	2
Oeltz. Arg. (N.) 8609	8. 3	23. 41	+0·65	1	1	2
Oeltz. Arg. (N.) 11423	11. 0	23. 42	+0·05	1	1	2
B. D. + 66° No. 470	6. 44	23. 42	+1·96	1	1	2
Oeltz. Arg. (N.) 11222	10. 48	23. 43	+0·19	1	1	2
Oeltz. Arg. (N.) 6467	6. 0	23. 43	−0·09	1	1	2
Groombridge 4195	23. 55	23. 44	+0·52	2	1	3
Oeltz. Arg. (N.) 6444–5	5. 59	23. 44	−0·58	1	1	2
38 Ursæ Majoris	10. 36	23. 45	+0·55	1	2	3
B. D. + 66° No. 455	6. 30	23. 45	+1·40	1	1	2
Lalande F. 362	2. 6	23. 45	−0·05	1	1	2
Oeltz. Arg. (N.) 13317–8	13. 2	23. 46	+0·97	1	1	2
Lalande F. 1439	9. 5	23. 47	+1·30	1	1	2
Lalande F. 4562	23. 42	23. 47	+0·84	2	1	3
Lalande F. 4293–4	22. 47	23. 48	+2·46	1	1	2
16 Cassiopeiæ	0. 29	23. 49	−0·17	2	3	5
Groombridge 2199	15. 10	23. 49	−0·04	1	1	2
α Camelopardi	4. 45	23. 50	−0·12	2	4	6
35 Ursæ Majoris	10. 25	23. 51	+0·72	3	2	5
Oeltz. Arg. (N.) 21015	20. 40	23. 51	−0·01	1	1	2
B. D. + 66° No. 479	6. 57	23. 52	+2·28	1	1	2
B. D. + 65° No. 71	0. 29	23. 52	+1·42	2	1	3
Bradley 1429	10. 17	23. 55	+0·98	1	1	2
Oeltz. Arg. (N.) 19158	19. 15	23. 55	−0·98	1	1	2
B. D. + 66° No. 413	5. 49	23. 55	+1·42	1	1	2
Groombridge 1579	9. 42	23. 56	−0·62	2	1	3
Oeltz. Arg. (N.) 10994–5	10. 32	23. 56	+0·14	1	1	2
Lalande F. 3663	20. 58	23. 59	+0·24	1	1	2
Lalande 38832	20. 6	23. 59	+1·12	1	1	2
Bradley 442	3. 7	24. 0	+0·50	1	1	2
Piazzi VII. 282	8. 2	24. 2	−0·28	2	1	3
13 Cassiopeiæ	0. 25	24. 3	+1·03	1	1	2
Lalande 33406	18. 2	24. 3	−0·06	2	1	3
Oeltz. Arg. (N.) 26367	23. 59	24. 3	+0·41	1	1	2
B. D. + 65° No. 11	0. 6	24. 4	+0·20	1	2	3
B. D. + 65° No. 16	0. 8	24. 5	+1·15	1	1	2
Oeltz. Arg. (N.) 6158	5. 39	24. 6	+2·02	1	1	2
Piazzi XIV. 274	14. 58	24. 7	−1·42	1	1	2
Oeltz. Arg. (N.) 17	0. 4	24. 7	−1·33	1	2	3
B. D. + 65° No. 1964	23. 49	24. 7	+1·43	1	1	2
Lalande F. 4633	23. 56	24. 8	+0·08	1	1	2
Oeltz. Arg. (N.) 26399	0. 1	24. 9	−0·56	1	1	2
Oeltz. Arg. (N.) 3513	3. 5	24. 9	−1·17	1	1	2
ζ Draconis	17. 8	24. 9	−0·30	1	1	2
Lalande F. 512	3. 6	24. 10	−0·74	2	1	3
Lalande F. 2457	14. 18	24. 10	−1·69	2	1	3
Oeltz. Arg. (N.) 5179–80	4. 42	24. 10	+0·31	1	1	2
Lalande F. 1298	8. 14	24. 10	+1·61	1	1	2
Lalande F. 4055–6	22. 7	24. 12	+2·52	1	1	2
Groombridge 192	0. 52	24. 12	−1·53	1	1	2
Groombridge 2035	13. 39	24. 12	−1·27	1	1	2
B. D. + 65° No. 1912	23. 29	24. 13	+1·08	1	1	2
Lalande F. 1292	8. 12	24. 14	+0·42	1	1	2
Lalande F. 2525	14. 44	24. 14	−0·31	2	1	3
36 Camelopardi	6. 6	24. 16	−0·29	3	1	3
Lalande F. 3503–4	20. 27	24. 18	−1·14	1	1	2
Lalande F. 2531	14. 45	24. 19	−1·99	1	1	2
Lalande F. 1744	10. 42	24. 19	−1·15	2	3	5
Lalande F. 303	1. 46	24. 20	+0·13	1	1	2
B. D. + 65° No. 1607	21. 33	24. 20	+0·24	1	1	2
Groombridge 3637	21. 55	24. 20	+0·91	4	1	3
ι Cephei	22. 47	24. 20	+0·87	1	2	3
B. D. + 65° No. 1812	22. 46	24. 21	−1·59	1	1	2
Groombridge 3639	21. 55	24. 21	+0·23	4	1	3
Oeltz. Arg. (N.) 25881	23. 35	24. 23	−0·30	1	1	2
Lalande 36936	19. 22	24. 24	−0·95	1	1	2
Lalande 29197	15. 54	24. 25	−0·65	1	1	2
B. D. + 65° No. 134	1. 4	24. 25	−0·85	1	1	2
Groombridge 120	0. 35	24. 25	−1·48	1	1	2
Oeltz. Arg. (N.) 8002	7. 27	24. 27	+0·72	1	1	2
Lalande 28583	15. 33	24. 27	−1·20	1	1	2
Lalande F. 60	0. 22	24. 27	+1·24	2	1	3
Oeltz. Arg. (N.) 6850	6. 22	24. 28	−0·45	1	1	2
Oeltz. Arg. (N.) 26322	23. 59	24. 28	+0·83	1	3	4
Bradley 3202	23. 57	24. 28	+0·60	1	3	4
π Draconis	19. 20	24. 29	+0·31	2	1	3
Oeltz. Arg. (N.) 6752	6. 16	24. 29	+1·01	1	1	2
B. D. + 65° No. 1974	23. 53	24. 29	−0·57	1	1	2
B. D. + 65° No. 528	6. 17	24. 29	+2·60	1	1	2
42 Draconis	18. 26	24. 30	−0·12	2	1	3
A Ursæ Majoris	8. 25	24. 30	+1·55	1	2	3
Oeltz. Arg. (N.) 870	0. 50	24. 32	+0·06	3	1	3
Lalande 21469	11. 9	24. 31	+0·10	1	1	2
B. D. + 65° No. 1821	22. 48	24. 32	−0·34	1	1	2
B. D. + 65° No. 1321	19. 6	24. 33	+0·84	2	1	3
Lalande 36039	19. 3	24. 34	+2·06	1	1	2

CORRECTION TO ASSUMED COLATITUDE.—*continued.*

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	Below Pole.	Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	Below Pole.	Weight.
	h m	° ′	″					h m	° ′	″			
Bradley 114	0. 59	24. 35	−0·18	3	1	3	Groombridge 1809	11. 32	25. 5	+0·13	1	1	2
Oeltz. Arg. (N.) 6424–5	5. 55	24. 36	+0·99	1	1	2	Lalande F. 1620	9. 58	25. 5	+1·13	1	1	2
Piazzi VII. 160	7. 36	24. 36	+0·05	2	1	3	Oeltz. Arg. (N.) 6172	5. 41	25. 5	−0·49	1	1	2
Piazzi VII. 159	7. 35	24. 36	−1·47	1	1	2	Oeltz. Arg. (N.) 290	0. 18	25. 5	+1·12	1	1	2
B. D. + 65 No. 688	8. 59	24. 36	+1·84	1	1	2	Lalande 3467	1. 50	25. 6	+0·41	2	1	3
Groombridge 570	2. 47	24. 37	−0·17	1	1	2	Lalande F. 1279	8. 8	25. 6	−1·69	1	1	2
Oeltz. Arg. (N.) 160	0. 11	24. 37	+0·09	1	1	2	B. D. + 64° No. 470	4. 32	25. 6	+0·08	1	1	2
Lalande 35990	19. 2	24. 37	+0·32	1	1	2	Piazzi IV. 10	4. 11	25. 7	−0·05	1	3	4
B. D. + 65° No. 817	10. 59	24. 38	−0·05	3	1	3	Piazzi XIII. 285	13. 56	25. 7	+0·87	1	1	2
Lalande F. 918	6. 23	24. 38	−0·04	1	2	2	α Draconis	14. 2	25. 8	+0·75	4	1	3
Groombridge 2617	18. 32	24. 38	−1·29	1	1	2	Lalande F. 4652	23. 59	25. 9	+1·61	1	1	2
Oeltz. Arg. (N.) 3445	3. 1	24. 39	+0·24	1	1	2	Oeltz. Arg. (N.) 6998	6. 28	25. 11	+0·74	1	1	2
Piazzi XIII. 184	13. 38	24. 39	+1·27	1	1	2	Oeltz. Arg. (N.) 325	0. 20	25. 11	−0·57	1	1	2
Lalande 13889	0. 47	24. 40	+0·53	1	1	2	B. D. + 34° No. 154	1. 16	25. 11	+1·55	1	1	2
B. D. + 65° No. 684	8. 55	24. 41	+0·41	1	1	2	Oeltz. Arg. (N.) 9309	8. 42	25. 12	+0·23	1	1	2
Groombridge 118	0. 35	24. 42	−1·23	1	1	2	Lalande 9428	5. 0	25. 12	+0·60	1	1	2
Oeltz. Arg. (N.) 13027	12. 46	24. 42	+1·59	1	1	2	Groombridge 4056	23. 19	25. 13	+1·65	2	1	3
Lalande 4188–9	2. 13	24. 42	+0·28	1	1	2	Piazzi XX. 295	20. 38	25. 13	+0·01	1	1	2
Piazzi XXI. 229	21. 31	24. 43	+0·08	1	1	2	Lalande 4246	2. 14	25. 14	−0·38	1	1	2
Groombridge 3608	21. 49	24. 43	−0·43	2	1	3	Oeltz. Arg. (N.) 661	0. 39	25. 15	+1·24	1	1	2
B. D. + 65° No. 28	0. 10	24. 45	−0·78	1	1	2	Oeltz. Arg. (N.) 9994	9. 28	25. 16	+1·03	1	1	2
B. D. + 65° No. 163	1. 18	24. 46	−0·41	1	2	3	Lalande 10580	5. 38	25. 16	+2·49	1	1	2
Oeltz. Arg. (N.) 6841	6. 21	24. 46	+1·93	1	1	2	Lalande 33900–1	18. 13	25. 17	+0·10	1	1	2
B. D. + 65° No. 500	5. 43	24. 46	+1·98	1	1	2	Lalande 7544	4. 3	25. 18	+0·50	1	1	2
Oeltz. Arg. (N.) 1612	1. 24	24. 46	+0·63	1	1	2	π Ursæ Majoris	8. 31	25. 19	−0·58	2	1	3
Oeltz. Arg. (N.) 26151	23. 49	24. 47	+1·29	1	1	2	B. D. + 64° No. 1460	20. 39	25. 19	−0·31	1	1	2
Groombridge 557	2. 44	24. 47	−0·88	1	1	2	Oeltz. Arg. (N.) 11205	10. 49	25. 20	+0·23	1	1	2
Oeltz. Arg. (N.) 20860	20. 34	24. 48	−0·16	1	1	2	Oeltz. Arg. (N.) 3280	2. 50	25. 20	+0·16	1	1	2
Lalande 34366	18. 24	24. 48	+0·20	1	1	2	B. D. + 64° No. 374	3. 1	25. 21	−1·76	1	1	2
Lalande 29369	15. 59	24. 49	−1·86	1	1	2	Lalande F. 1378	8. 40	25. 21	−0·50	1	1	2
Lalande 37651	19. 39	24. 52	−0·66	1	1	2	Oeltz. Arg. (N.) 21662–3	21. 2	25. 22	+1·11	1	1	2
Lalande 4109	2. 10	24. 53	+1·66	1	1	2	Lalande 7848	4. 13	25. 22	+0·11	1	1	2
Lalande F. 2600	15. 8	24. 53	−1·07	1	1	2	Oeltz. Arg. (N.) 5746	5. 15	25. 22	+0·67	1	1	2
Lalande F. 1767	10. 49	24. 54	+1·68	1	1	2	Lalande 2933	1. 32	25. 22	+0·84	3	1	3
Oeltz. Arg. (N.) 6029	5. 33	24. 55	+1·09	1	1	2	Lalande F. 2509–10	14. 37	25. 24	+2·36	1	1	2
B. D. + 64° No. 130	1. 7	24. 56	−0·35	1	1	2	Lalande 1657	0. 54	25. 26	+0·96	1	2	3
B. D. + 64° No. 1758	23. 3	24. 56	+0·96	1	1	2	Lalande 1244	0. 42	25. 27	−0·41	1	1	2
Groombridge 4070	23. 23	24. 57	+2·18	2	1	3	B. D. + 64° No. 68	0. 35	25. 27	−1·04	1	1	2
Oeltz. Arg. (N.) 10575	10. 3	24. 57	−0·51	1	1	2	Lalande 3822	2. 0	25. 27	+2·99	1	1	2
Lalande F. 3509	20. 30	24. 57	−0·28	2	1	3	Oeltz. Arg. (N.) 7798	7. 16	25. 28	−0·25	2	1	3
Oeltz. Arg. (N.) 6840	6. 21	24. 57	−0·92	1	1	2	Groombridge 3895	22. 44	25. 28	+0·66	1	1	2
B. D. + 64° No. 122	1. 1	24. 58	+1·20	1	1	2	B. D. + 64° No. 587	6. 18	25. 29	+0·74	2	1	3
Oeltz. Arg. (N.) 16142	16. 18	24. 58	−2·12	1	1	2	Oeltz. Arg. (N.) 25681	23. 27	25. 30	+0·48	1	1	2
Lalande 30237	16. 29	24. 59	−2·20	1	1	2	Oeltz. Arg. (N.) 2526	2. 10	25. 31	+0·65	2	1	3
Oeltz. Arg. (N.) 5904	5. 25	25. 1	+1·83	1	1	2	B. D. + 64° No. 125	1. 3	25. 31	+0·63	1	1	2
Groombridge 1824	11. 43	25. 2	+0·82	2	1	3	B. D. + 64° No. 603	6. 41	25. 32	−0·96	1	1	2
Lalande F. 1153	7. 35	25. 2	+0·82	1	1	2	Lalande F. 4416	23. 11	25. 33	−0·05	1	1	2
Lalande F. 1036–7	7. 6	25. 2	+1·06	3	1	3	Oeltz. Arg. (N.) 12947	12. 40	25. 33	−0·21	1	1	2
B. D. + 64° No. 245	1. 44	25. 3	+1·29	1	1	2	Oeltz. Arg. (N.) 15135	15. 3	25. 34	−1·10	1	1	2

CORRECTION TO ASSUMED COLATITUDE—*continued.*

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	No. of Observations. Below Pole.	Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations. Above Pole.	No. of Observations. Below Pole.	Weight.
	h m	° ′	″					h m	° ′	″			
Oeltz. Arg. (N.) 18834	18. 56	25. 36	+1·13	2	1	3	Groombridge 446	1. 59	25. 53	+0·56	2	3	5
52 Cassiopeiæ	1. 56	25. 36	−0·37	2	2	4	Lalande 33099	17. 53	25. 54	+0·44	2	1	3
Oeltz. Arg. (N.) 13904	13. 38	25. 37	+1·28	1	1	2	B. D. + 63° No. 2061 (1st star)	23. 45	25. 55	−0·44	2	1	3
B. D. + 64° No. 563	5. 55	25. 37	−0·01	1	1	2	Lalande F. 1091	7. 20	25. 55	−0·03	1	1	2
Lalande 3961	2. 5	25. 37	+1·88	1	2	3	B. D. + 63° No. 161	1. 7	25. 55	+0·76	2	1	3
Lalande F. 1746	10. 43	25. 39	+1·33	1	1	2	B. D. + 63° No. 156	1. 6	25. 55	+0·48	2	1	3
Lalande F. 1071	7. 15	25. 39	+0·80	1	1	2	B. D. + 63° No. 5	0. 5	25. 55	+1·62	1	1	2
Oeltz. Arg. (N.) 25963	23. 38	25. 39	+0·54	1	1	2	Lalande 4505	2. 23	25. 56	+0·73	1	1	2
Lalande 3216	1. 41	25. 40	+1·21	1	1	2	B. D. + 63° No. 1936	23. 5	25. 56	+1·40	1	1	2
Oeltz. Arg. (N.) 26049	23. 44	25. 41	−0·47	1	1	2	Oeltz. Arg. (N.) 317	0. 19	25. 56	−0·10	1	1	2
Oeltz. Arg. (N.) 20498	20. 21	25. 41	−0·84	1	1	2	B. D. + 63° No. 2086	23. 54	25. 56	+0·37	1	1	2
Groombridge 4144	23. 44	25. 42	−1·08	2	1	3	Lalande 8416	4. 27	25. 57	+0·55	2	1	3
B. D. + 64° No. 553	5. 45	25. 42	+0·48	1	1	2	Oeltz. Arg. (N.) 5726	5. 13	25. 58	+0·77	1	1	2
Lalande F. 2844	16. 51	25. 43	−0·28	1	1	2	B. D. + 63° No. 2044	23. 39	25. 59	−0·82	1	1	2
Lalande 8369	4. 25	25. 43	+0·40	1	1	2	Piazzi XX. 280	20. 35	26. 0	+0·37	1	1	2
Oeltz. Arg. (N.) 1778	1. 33	25. 43	+0·41	1	1	2	B. D. + 63° No. 1989	23. 20	26. 1	+1·56	2	1	3
Oeltz. Arg. (N.) 2673	2. 16	25. 43	+2·49	1	1	2	B. D. + 63° No. 2046	23. 40	26. 1	+0·20	1	1	2
Oeltz. Arg. (N.) 6772	6. 17	25. 44	+0·67	1	1	2	Lalande F. 3740	21. 12	26. 1	+2·88	1	1	2
Lalande F. 4407	23. 8	25. 45	+1·49	1	1	2	Oeltz. Arg. (N.) 3941	3. 30	26. 3	+1·91	2	1	3
Oeltz. Arg. (N.) 7011	6. 29	25. 45	−0·62	1	1	2	B. D. + 63° No. 511	4. 24	26. 3	−0·10	1	1	2
Oeltz. Arg. (N.) 5237	4. 48	25. 46	+0·35	1	1	2	Groombridge 4130	23. 37	26. 3	+0·52	3	4	7
Lalande 5067	2. 42	25. 48	−2·06	2	2	4	B. D. + 63° No. 2035	23. 37	26. 3	+0·47	1	1	2
Lalande F. 1172	7. 42	25. 48	+0·35	1	1	2	τ Ursæ Majoris	9. 2	26. 4	+0·34	2	2	4
Oeltz. Arg. (N.) 7563	7. 2	25. 49	+2·28	1	1	2	Oeltz. Arg. (N.) 9662	9. 8	26. 4	−0·57	1	1	2
Lalande 34166	18. 19	25. 51	−0·04	2	1	3	*h* Ursæ Majoris	9. 23	26. 29	−0·96	1	1	2
Lalande 33230	17. 59	25. 51	+0·49	1	1	2	α Ursæ Majoris	10. 59	27. 41	−0·96	4	2	4
Lalande 33232	17. 59	25. 51	+0·73	1	1	2	9 Cephei	21. 34	28. 23	+0·05	1	2	3
B. D. + 63° No. 2052	23. 42	25. 51	+0·49	1	1	2	o Ursæ Majoris	8. 21	28. 56	−1·45	1	2	3
Groombridge 429	1. 55	25. 51	−1·19	1	2	3	ι Draconis	15. 22	30. 40	+1·57	1	1	2
ξ^1 Cephei	22. 1	25. 52	+0·28	1	1	2	α Cassiopeiæ	0. 34	34. 2	+2·47	1	1	2
ξ^2 Cephei	22. 1	25. 52	−1·21	1	1	2	γ Draconis	17. 53	38. 30	−0·30	9	1	2
B. F. 522	1. 52	25. 53	+1·22	1	1	2							

Limits of N.P.D.	Weight.	Excess of N.P.D. above Pole.
0° to 5°	236	+ 0″·27
5 ,, 10	30	− 0·05
10 ,, 15	219	+ 0·37
15 ,, 20	603	+ 0·43
20 ,, 25	1078	+ 0·32
25 ,, 30	263	+ 0·37
30 ,, 35	9	+ 0·34

The weights used in the above table are determined by use of the "Probable Errors of the Greenwich Observations in Zenith-Distance," given by Mr. Stone in the *Monthly Notices of the Royal Astronomical Society* for 1869 June, page 324. Putting n for the number of observations of a star above the pole, e for the probable error of one observation; n_1 and e_1 the similar quantities for the observations below the pole; e_0 the probable systematic error affecting all observations of the same star, and depending on outstanding division-error, uncertainty in the constant of refraction, &c.; the formula employed to determine the weight to be given to that star is $\frac{2\,nn_1}{n_1e^2 + ne_1^2 + 2\,nn_1e_0^2}$; or assuming $e_0^2 = \frac{1}{10}e_1^2$, which would make $e_0 = 0''{\cdot}16$, the weight becomes $\frac{2\,nn_1}{n_1e^2 + ne_1^2 + \frac{1}{5}\,nn_1e^2}$, which has been adopted in the investigation.

If z be the correction to the assumed colatitude 38° 31'.21''·90, $2z$ + the algebraic sum of determinations ought to be equal to 0. Combining the whole with the weights above attached to them, $2z = -\ 0''{\cdot}348$, or $z = -\ 0''{\cdot}174$.

The colatitude determined from the observations of 1897 is therefore 38° 31'. 21''·73.